Enacting and Safeguarding Digital Intangible Heritage with Emerging Technologies and Speculative Design

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A thesis submitted to Charles Sturt University in fulfilment of the requirements for the degree of Doctor of Philosophy

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January 2022

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Acknowledgements

I express my genuine gratitude to those who have contributed to my research and encouraged me in one way or another throughout this fantastic journey. Without them, this study would not have been possible.

First and foremost, I would like to express my sincere gratitude to my supervisor Dr Eleanor Gates-Stuart and co-supervisor Dr Jessie Lymn, for providing me with an opportunity to complete my doctoral thesis. I am thankful to Dr Gates-Stuart for her willingness to be my principal, even on short notice after my previous supervision. I wholeheartedly honour my supervisors' contributions of time and ideas, which kept me productive and inspired. Their important instructions, commentaries and supervision encouraged me to acquire more knowledge day by day. I appreciated their valuable feedback and thank them for keeping me on track. Their help has been the most valuable experience in my life. I am also indebted to Dr Peter Pocock and the research staff for the guidance and support that they offered me during my tenure at Charles Sturt University. In addition, I extend my thanks to all the researchers, academicians and experts that I was connected to during this journey.

It is impossible to fully express the sentiments I have for my daughter, Sarah, and my wife, Minakshi, for their continuous unlimited support both in my life and career. My deepest gratitude goes out to my entire family and friends. Finally, I extend my thanks and appreciation to my parents: it would have been impossible to be here at this stage of my life without their prayers.

Professional Editorial Assistance

Paid editorial assistance was obtained, and written permission was granted before obtaining the editorial assistance. Services provided were limited to formatting and editing for spelling, grammar and style (according to the Australian Standard for Editing Practice ASEP Standard D—Language and Illustrations and ASEP Standard E—Completeness and Consistency).

Abstract

This doctoral study aimed to not only summarise the literature on Intangible Cultural Heritage (ICH), but also to speculate on how emerging technologies can facilitate the enactment, sustainability and transformation of ICH for future generations. Cultural heritage, both physical and intangible, and emerging interactive technologies, are now considered to be established academic domains, with dedicated journals, conferences and educational programs—along with more recent and still-emerging associated sub-domains such as Digital Intangible Heritage (DIH). Research shows that these fields have enjoyed growing recognition and accompanying institutionalisation over the past decade.

Nevertheless, despite the rapid growth of ICH and DIH, especially in recent years, it is difficult to ensure its sustainable preservation, especially in terms of DIH-related content. Hence, in the form of a literature review and speculative/critical design approach, along with the presentation of six of my published juried papers and two case studies, this study conducted an in-depth analysis of these emerging areas, resulting in some proposed arguments and frameworks, as well as two proposed installations/applications and a portal.

The key argument that arose from the study was that the intangible forms of heritage embodiments—with their interesting objective and subjective representations—will be beneficial for ICH-related sustainable documentation, transmission and transformation for future generations. Moreover, this study explored the innovative usage of emerging technologies to exemplify the idea that fictitious, subjective and playful enactment of the intangible cultural elements of a community will be an effective means of preserving and perpetuating the culture for future generations.

Two installations/applications were proposed in this study to safeguard ICH-related content for future generations: the Virtual Immersion with Pulsation (VIP) heritage installation and the "Mimicry Understanding and Safeguarding Environment" (MUSE) application. In addition, the crowdsourced "FolkAir" portal was proposed to preserve ICH in the digital realm and make it accessible to future generations.

Finally, the study also proposed an intervention and framework for DIH content selection and creation, as well as a new theoretical domain—Digital Emerging Communication (DEC)—which is compiled from various creative disciplines to assist content creators who would like to use emerging technologies to communicate, express and represent the past.

List of Abbreviations

AI	Artificial Intelligence
AL	Augmented Learning
AR	Augmented Reality
DCMI	Dublin Core Metadata Initiative
DEC	Digital Emerging Communication
DIH	Digital Intangible Heritage
ICH	Intangible Cultural Heritage
MUSE	Mimicry Understanding and Safeguarding Environment
TK	Traditional Knowledge
VIP	Virtual Immersion with Pulsation
VE	Virtual Environment
VR	Virtual Reality
XR	Extended Reality

Introduction

This concise introduction is followed by an extended presentation of the critical concepts covered in this thesis—Heritage, Intangible Cultural Heritage (ICH) and Digital Intangible Heritage (DIH), along with their future transformation with emerging technologies. These concepts are explored through a literature review, the inclusion of six of my published papers and two in-depth case studies. Based on my research into future emerging technologies and content creation, I propose a new domain for DIH—Digital Emerging Communication (DEC)—and present a framework I developed for DIH content selection and creation - "Intangible Probes" or "iProbes". Subsequently, as an analysis and synthesis, for the sustainability and interoperability of archived data for the preservation of heritage, I introduce relevant concepts related to the archiving of DIH content for new generations, particularly standardised metadata schemas, such as the Dublin Core Metadata Initiative (DCMI or "Dublin Core"). The final section proposes guidelines and recommendations for the transmission, sustainability and future of DIH.

There are various manifestations of intangible heritage within a community—for example, oral tradition, expression, language and poetry. Because of these different manifestations, each community makes specific choices which sets them apart from other communities and, as a result, a particular culture comes into being (Arizpe, 2004). These decisions contribute to the various forms of ICH. For example, the memory of an individual or community, or the collective memory of a nation, develops social interaction and cultural norms. Furthermore, it is even a piece of recorded information related to the nation's memories, such as Australia's migration histories (Lymn, 2019). Sometimes memories bring people together, and sometimes they can trigger bitterness among them (Gandhi & Gandhi, 2009). Music is another type of ICH, and besides other effects, its evolutionary study can help to categorise communities (Fitch, 2005). It is imperative to preserve the culture of a community, and preservation can only be achieved through continuance and perpetuation of some sort (Simpson, 2009). In the same way, cultural craftsmanship and indigenous methodologies play an important role in categorising and distinguishing various communities (Conan, 2009).

Research Aim

This doctoral study aimed to examine the link between the use of emerging interactive technologies and the protection of traditional knowledge from indigenous communities—

through a literature review (of the general literature plus my own published papers), case studies and drawing on my own experiences.

Research Objectives

The main objectives in the current study were to:

- extract information, knowledge and experiences from the known historical and published record of Intangible Cultural Heritage;
- examine, transform and fabricate the characteristics of and information about indigenous methodology and cognition into physical and virtual cultural embodiments through six of my juried (peer-reviewed) publications and two case studies; and
- synthesise the learning elicited from the above two objectives in order to establish the notion of the emerging future digital domain, emerging content creators' characteristics/adjectives, methods/frameworks for retrieving traditional knowledge, and recommendations in the context of sustainable Digital Intangible Heritage.

In this study, as a researcher, I drew on my own experiences as well as published literature in order to conceptualise the effort required to achieve acceptable levels of digital preservation for the accessibility and sustainability of DIH content through standardised metadata structure. In this context, DIH is the cultural representation of intangible heritage through the medium of digital technologies. I claim that the understanding and acquisition of DIH content, content agency and a systematic workflow may help to conceptualise the presentation, sustainability and transformation of DIH for future generations. This study, while discussing ICH, also examined the various roles of knowledge acquisition for DIH content creators. It includes thinking/working styles, heritage data retrieval and handling, curatorial issues and recommendations through analysis of my published papers, case studies and my own experiences. I also argue that the careful conception of DCMI metadata elements for DIH content will make it easier to archive heterogeneous digital cultural resources for unified access, data exchange and interoperability. DCMI is the modern form of a catalogue card; it is a set of multiple elements that explain resources in a complete package (Baker, 2000). It is also represented as an exchange format for sharing library records among multiple collections.

There are two overarching factors that justify this doctoral study:

1) Lack of theoretical understanding of the challenges embedded in preserving ICH (Bonn, Kendall & McDonough 2016) and lack of public engagement despite its importance in safeguarding ICH (Kim, Im, Lee, & Choi 2019).

2) Lack of exploration of emerging interactive technologies, such as wearable devices and sensor-based gadgets (Gale, Mirza-Babaei, & Pedersen 2015) for playful, educational and emotional content (Barbieri, Bruno, & Muzzupappa 2018). Moreover, it has been recognised by archivists to have unique archival interfaces for engaging audiences (Hendery & Burrell 2019).

This investigation will address various curiosities for future digital content creators, and outline some recommendations related to the use of emerging technologies in the context of ICH, traditional knowledge and indigenous communities—particularly for future generations of youth. This study will not look into or measure the financial elements of museums or exhibitions, nor will it look into or measure crucial issues connected to the functional and practical usage of future developing technologies for museums. Furthermore, it is difficult to manage the practical realities of using new technology in museums on a day-to-day basis. These everyday challenging situations related to museum management are not addressed in this study. Some of the questions this thesis will attempt to address are:

- What are the emerging technologies which are suitable for knowledge transfer of ICH content for young people in a heritage-related physical and online environment?
- What are the various multi-domain benefits for the awareness of ICH content?
- Do such emerging technologies lead to more exceptional learning outcomes than existing heritage online and physical exhibits and/or cultural embodiments?
- How does innovative emerging technology-based user interaction intervene in the perception of authentic and engaging learning environments for young minds?
- What are the perceived outcomes of creative emerging technology-based user interaction, in terms of learning effects?

- How effectively does innovative and emerging technology-based user interaction preserve ICH for future generations?
- What are the sustainable, scalable and interoperable issues related to the fabrication of reusable and transferable ICH content?
- In the case of innovative emerging technology-based user interaction, what rules and regulations are there?
- What different devices exist to allow ICH content to be refreshed, revived and improved by archivists and users?
- What strategies and approaches are needed to guarantee the sustainability of ICH digital content in the long term?

Hence, the following possible hypothesises were formulated for this study:

1) Young people are more likely to interact with exhibits/installations if innovative emerging technology-based user interaction is utilised for cultural embodiments;
2) The interface, appearance and user interaction of DIH content should be aligned with current trends that are universal and ubiquitous among youth;
3) Visitors' engagement time will be longer when they are exposed to and interact with novel and immersive user interaction for DIH content;
4) Without the involvement or in-depth analysis of the indigenous community and empathetic search and acquisition of the knowledge, it will not be possible for future digital designers to fabricate authentic and meaningful DIH content; and
5) Content creators should be completely in sync with the embedded technology they choose to use as an interface, and they should be familiar with the vocabularies around the system. This will help them to search and isolate the right technology for the specific ICH content.

Research Question

The overarching research question in this doctoral study was:

> How do we use the nexus of emerging interactive technologies and traditional knowledge from indigenous communities to create

engaging, playful and viable content for future minds for the documentation, transmission and sustainability of intangible heritage?

The evaluation criteria for the study are primarily based on the two successful case studies that have been presented. For the authentic and sustainable preservation of DIH content, in this thesis I propose the following three arguments:

1) **Content creators should not just know the content but also understand the community it belongs to.**

   Content creators should acquire a deep understanding of heritage agencies; this understanding must be amalgamated to ensure authenticity.

2) **Content can vary from the depiction of present or past reality to fictitious representation.**

   Content need not be an exact representation of its original form; it may vary in its depiction, whether subjective manifestation, peculiar embodiment or distorted restoration. However, it should culminate in an entertaining, emotional interaction for the end-user.

3) **A known recording mechanism should be used to capture content, so one is able to find, use, preserve and re-use it in the future.**

   Content should have its own standard sets of metadata, to make it easier to distinguish and archive its heterogeneous resources for unified access, data exchange and/or interoperability.

Through a literature analysis and my own published articles and personal experiences, the study aimed to investigate the relation between the usage of emerging interactive technologies and the safeguarding of traditional knowledge from indigenous groups. The study's evaluation criteria are based on the two case studies presented. First, how could I retrieve and combine emerging technologies and ICH and transform them into the digital realm? (This was the key research question.) Second, what are the implications of this culminated and manifested approach for young minds? Furthermore, I wanted to investigate the actions that may be taken to make the proposed module/emerging discipline sustainable and enjoyable for future generations.

The two lengthy case studies are explorations of traditional medicine and martial arts, and the discussion integrates profound insights on the subject with suggestions for how they can be incorporated into the heritage environment or possibly over the internet with some modifications. This kind of in-depth thought is the bedrock of effective exhibit design for heritage content, and it demonstrates an awareness of how to best communicate traditional knowledge.

This study has been analysed in the context of Virtual Reality (VR), Augmented Reality (AR) and sensor-based heritage interventions—particularly from the perspective of my own experimentation and analysis. It stresses the need for more interesting and pleasurable user interaction for future ubiquitous distributed forms of heritage environment, such as physical and virtual museums. The activity should be fabricated with a notion of kinaesthetic, systematic and peculiar cultural learning for future generations. This is essential as communities continue to embrace emerging technologies in their daily lives and are now recognising the invisible aspects of their heritage content and the importance of sustainability.

As shown in Appendix A, I have over a dozen juried (peer-reviewed) publications (six of these publications are included in Section 1 of this thesis). They all address emerging technologies, particularly VR/AR and sensor-based heritage embodiments. The central idea in each publication is shown in red text, while purple represents adjacent topics covered. It is apparent from the table in Appendix A that the central idea in all these publications is Digital Intangible Heritage (DIH) (Economou, 2015). DIH is a new branch or sub-category of Intangible Cultural Heritage (ICH) (Kurin, 2004). As indicated in Figure 2, the common denominator is ICH. The remaining categories are DIH (13 publications), Indigenous Methodology (9 publications) and Indigenous Cognition (6 publications). All of these topics will be addressed in detail throughout the thesis, with examples and proposed standardised metadata for online resource discovery and shared semantics. The Dublin Core Initiative has been selected because of its simplicity and expandability. I justify and expand on DCMI's 15 metadata elements with their associated values.

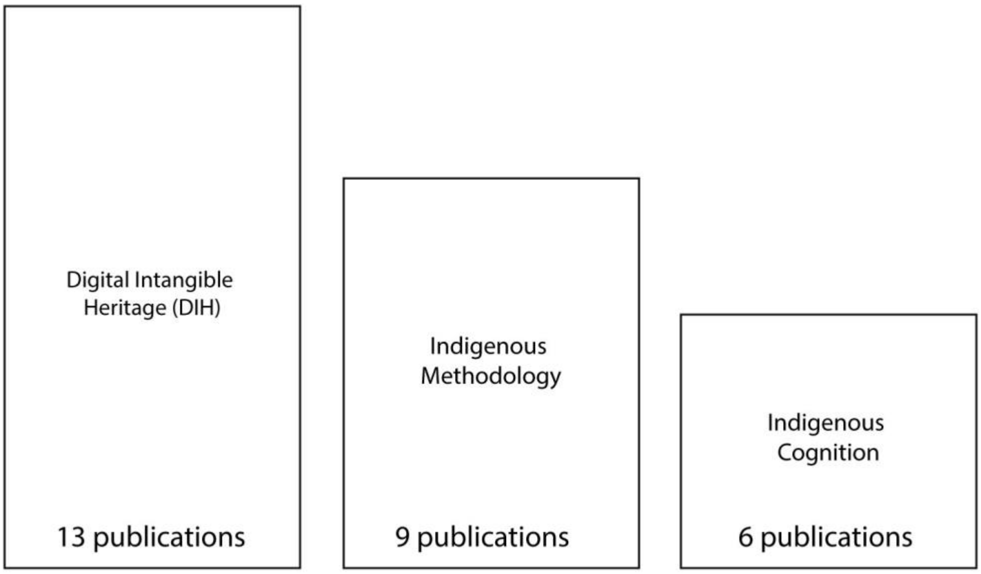

Figure 2. The central theme contained in my juried publications.

In addition to discussing the ICH representation through emerging technologies, my study also touches upon the possible future of DIH and its content creators. I examined the sustainability aspects of DIH through the use of standardised metadata, such as DCMI (a common set of metadata schemas that describe the existence of explicit and tacit things in the physical world). These schemas are based on simple and shared semantics, which are extensible and international. There is already an established community working on DCMI and cultural heritage— the DCMI: Cultural Heritage Metadata Task Group (Ruehle, 2013).

It is important to consider research paradigms and ontological/epistemological assumptions, to assist in comprehending all the steps and components of a research study. Blaikie (2000) notes that if the selected philosophies and goals are not correctly interlinked, then an investigation would be debatable due to lack of suitable reason and rationality. Since my study involved the interpretation of my own mind and experiences, I selected the phenomenological approach to qualitative research (Cohen, Kahn, & Steeves, 2000). Phenomenological research methods seek to understand abstract forms of interpretation, and it is thus well suited to my research in this context.

In this research study, I hold the philosophical assumption that VR/AR and sensor-based technologies can help in the interpretation of ICH content. Hence, the assumption in this research is that reality exists internally - in my mind. Therefore, the ontological position for this research was subjective (Saunders, Lewis, & Thornhill, 2007). Since ontological assumption is based on subjectivism, a qualitative methodology was selected, which included observation and my own experiences.

The epistemological position in this current research study is suitable in terms of the ontological assumption; therefore, the research approach is phenomenological (Easterby-Smith, Thorpe, & Jackson, 2008). It is also a qualitative methodology, which is in harmony with my philosophical position (Bockmon & Rieman, 1987). The qualitative research method allows for the explanation of phenomena and events in order to comprehend and explain them. In this study, some indigenous communities' viewpoints about methodology, their cognitive explanation and available literature searches have been examined in order to achieve the polarity of the research objectives (Orlikowski & Baroudi, 1991). Consequently, the approach of the current study was inductive (Hussey & Hussey, 1997), reflecting my personal passion and enquiry into knowledge, and suitable to the interpretation of cultural knowledge with emerging technologies.

For several years, I have been examining ICH and emerging technologies from the perspective of speculative/critical design thinking. I have published several papers in these domains and have been invited to various research venues to represent my ideas. I strongly believe that with the emergence of new tools and gadgets, Artificial Intelligence (AI), "big data" and interactive technologies, we can be at the forefront of creating awareness about ICH and its new ubiquitous emerging form, along with the novel tools being utilised around the world. The idea is to create a community of learning and some methods, so that people can interact with each other while engaging in serious gaming through emerging technology and DIH content. Communal interaction is vital in the process of "making meaning" (Barnes & Todd, 2021). In the context of ICH, the use of these technologies provides not only tremendous showcasing opportunities but also guarantees spontaneous and undirected learning experiences for people of all ages, particularly youngsters.

Intangible Cultural Heritage (ICH) is a phrase that was coined to describe living cultural manifestations and activities that communities recognise as distinct components of their identity. Because of the activity of the United Nations Educational, Scientific and Cultural Organization (UNESCO), the protection of ICH has become an issue of worldwide concern. However, little research has been done on the function of new technologies in intangible heritage preservation and transmission. In regard to technologies inside museums, museums provide an excellent setting for informal cultural learning on historical artifacts, as visitors are intrinsically motivated to learn. Visitors who share the museum space can participate in group learning activities and socialise (Nofal, et al.,2020). Museums want to adopt interesting user interfaces to include the physical materiality of items into the visitor experience. These innovative user interfaces are seen to be more interactive, attracting more guests and persuading them to go deeper into the experience. Heritage item learning is essential when opinions and attitudes are formed from a young age.

Gamification in museums is also a fantastic approach that combines museum information dissemination theory with gamification theory (Weng et al., 2019). The idea of museum information dissemination highlights the evolution of the interaction design concept and the upgrading of equipment and technology. The research reveals that gamification in exhibit design is favourable for learning inside museums. On the other hand, the philosophy of gamification transforms the problem of museums' intangible cultural assets into a motivation, with rewards and internal motivation from visitors' participation.

Museums adopt a gamification strategy to provide a collaborative and interesting learning experience for young visitors (i.e., using game components in a non-gaming setting). Cultural learning is strengthened by incorporating historical items into the experience and learning into the reward system. Creating a sense of ownership and developing various goals encourages visitors to engage and collaborate. An example can be seen in an application called TouchTomb. It is a physical gamification project that attempts to improve informal cultural learning and increase engagement and collaboration among young visitors. It is embedded in a 1:1 scale recreation of an original ancient Egyptian tomb-chapel wall. A shared progress bar and three games with varying spatial configurations form the foundation of the artwork in this application.

Gamification and its unique ways have emerged as one of the essential instruments for advanced communication and interaction with users in several industries, including finance, marketing, business training, education and entertainment. The study of the game's capabilities reveals that the game has a significant and positive impact on the development of essential skills and competencies required for success in education, real life, and professional realisation (Khan et al., 2020). In gaming cultural heritage training, incorporating historical-culture heritage could be one of the most promising learning ways for visitors of all ages. Gaming methods for cultural heritage studies include creating digital learning situations and paths based on important historical themes and allowing visitors to learn about cultural heritage. As part of gamification, user-centred design (Anim, & Omar, 2021; Nicholson, 2015; Zichermann & Cunningham, 2011) is an iterative design approach that focuses on understanding user wants and expectations to create highly useable products (Benito-Santos et al., 2021). In the past, user-centred design has been used to successfully drive the creation of serious games in various contexts (Spors & Kaufman, 2021; Müller et al., 2020; Dimitriadou et al., 2021), including cultural heritage (Bastian et al., 2021). The increased importance of gamification and user-centred design in the cultural site and museum collections benefits cultural organisations (Bonacini & Giaccone 2021). In addition to their typical "learning by playing" purpose, serious games are being used as strategic digital marketing tools to promote cultural heritage and tourism, according to research.

Games, in any form, increase motivation by enticing players to participate. When it comes to educating and immersing people in their own and other cultures' heritages, digital games are a well-known way of engagement and education (O'Connor et al., 2020). Education is the only place where this is more vital (Murodillaevich et al., 2021). Gamification approaches, defined as adding game aspects to an existing process, have also been successfully used to supplement current resources and programmes. The numerous examples of gamification or serious games concentrating on cultural heritage also demonstrate the potential benefits of applying these ideas to preserve and learn.

User-centred design in a gaming environment (Anim, & Omar, 2021; Nicholson, 2015; Zichermann & Cunningham, 2011) is an iterative design approach that focuses on understanding user wants and expectations to create highly useable products (Benito-Santos et al., 2021). In the past, user-centred design has been used to successfully drive the creation of serious games in various contexts (Spors & Kaufman, 2021; Müller et al., 2020; Dimitriadou et al., 2021), including cultural heritage (Bastian et al., 2021). In this context, Rankin et al. [43] identify observational research, conceptualisation, prototyping, and usability playtesting as 1+3 stages in their user-centred game design iterative model.

This study combines ICH, emerging interactive technologies and speculative/critical design thinking. My published papers (included in Section 1) and two extended case studies (included in Section 2) mentioned here can manifest transdisciplinary thought processes and cross-pollination for sustainable cultural heritage.

The thesis's golden thread is the Digital Intangible Heritage (DIH) discipline's future state. Several scholarly exegeses have utilised the term DIH (Bai & Boo, 2011; Howell & Chilcott, 2013; Pietrobruno, 2017; Wang & Shen, 2018; Alivizatou, 2019; Yang, & Su, 2021). This multidisciplinary thesis investigates the implications of DIH enactment, documentation and representation by drawing on discussions surrounding DIH. The thesis delves into the literature on heritage and its layered meaning. It then looks at two case studies to successfully and hypothetically create a DIH-related exhibit. The final section considers how emerging technologies influence indigenous communities and DIH in order to ensure its long-term viability and transformation. The discussion speculates how DIH may be defined in the future. How does this affect the uses and meanings of DIH exhibits by (local and virtual) practising communities and future content creators in terms of user interaction design and content retrieval? It also addresses how this relates to participation in the safeguarding process by examining the concepts of iProbes and FolkAir.

In this thesis, I discuss a challenging situation that I believe will arise soon when ICH-related content is transferred to the digital domain and then exhibited in a heritage institution or GLAM (galleries, libraries, archives and museums). As a design problem, this challenge is a significant theme in the thesis, and it is discussed in the context of cultural heritage documentation, preservation and transmission. I present the research-creation process and then several case studies, schematic diagrams, framework and methodology. This thesis results from extensive research into heritage, my own publications and a speculative design approach. I speculate and discuss DIH and the emerging domain's prospective futures together with its content creators. Research creation – or, arguably, any research – is always an experiment, and this one took on a shape I had not anticipated before embarking on my investigation.

I assess the convergence of new technologies with ICH and the future amalgamation's dilemma as a design problem using speculative design. Speculative design is used to solve problems that are too difficult to solve with a single solution. As a result, it can be materially solved, or at the very least, interacted with. Furthermore, it allows the ontological viability of ICH's future emergence with upcoming interactive technologies to be assessed. Designers sometimes refer to "wicked problems", in which the design intervention appears to address the problem while highlighting the deeper intricacies at play (Sweeting, 2018). This method, which is based on design theory and the humanities' "spatial turn", falls under the larger umbrella of research creation, which is, to put it simply, exploration through creative processes; what anthropologist Tim Ingold refers to as "thinking through making" (Ingold, 2013).

In order to deal with wicked challenges and find answers, society increasingly requires specialists to cross boundaries (Veltman, Van Keulen, & Voogt, 2019). However, little is known about how multidisciplinary approaches facilitate learning through boundary crossing in addressing wicked situations. This study aims to generate conjectures for a future DIH discipline that I speculate about to foster ICH's enactment, sustainability and transformation for future generations. Through emerging technologies, the literature on ICH, case studies and my juried publications, 1 assert that objective and subjective representations of ICH through emerging technologies will be an effective means of perpetuating culture for future generations.

Like other design-related activities, speculative design (Dunne & Raby, 2007), discursive design (Tharp & Tharp, 2019), design probing (Auger, 2013) and design fictions (Bosch, 2012) can help solve problems and identify solutions. There is much overlap between these methods. The distinctions are minor and mostly depend on regional or contextual usage: all remove the commercial restrictions that define normative design processes; all employ models and prototypes at the heart of the investigation; and all use fiction to illustrate alternative goods, systems or universes.

The term “design” is used frequently and is part of our everyday language. However, despite its pervasiveness, the design concept appears to be indeterminate. What designers perform and what constitutes design are not well defined. Architectural design, interior design, product design and graphic design are just a few examples of professions with design as a suffix. It also appears to be purely aesthetic. Other professions, such as information design, design management, software design, urban design, services design and user experience design, engage with thought processes. In a nutshell, design appears to be an activity that necessitates critical thought and collaboration in order to solve challenges in the physical world.

It is UX design when one considers a company's psychological, sociological and behavioural characteristics and values. UX designers study consumers and predict what will happen to a product, service or place in the near future. Like UX design, according to research, speculative design is thinking about the probable, plausible and possible features of a product, place, service, or even an unknown notion (Candy, 2018; Fu & Zhu, 2020; Candy & Kornet, 2019). Probability is more related to classic design and conveys the current state of affairs. It describes what we can expect to happen based on the current state of the world. The “plausible” begins to investigate scenario planning and foresight in greater depth. It describes alternative futures as well as the possibilities of what might have been. The “possible” extends beyond what is scientifically possible in extreme cases.

According to Stuart Candy, this covers utopias and dystopias but never goes into fantasy or science fiction territory.

The term "emerge" or "emergent" refers to "the process of coming into being, or of being important and prominent" (New Oxford American Dictionary) or "to rise up or come forth to become apparent to come into existence" (The American Heritage Desk Dictionary and Thesaurus; Rotolo, Hicks, & Martin, 2015). “Becoming” - coming into existence — is the primary attribute of emergence. Emergent is a label for a process, not a static quality. A certain amount of significance is required to justify the use of the term emergence. The process's endpoint is referred to as noticeable, evident, essential or prominent. As a result, there is some debate among dictionaries as to whether acknowledged presence is sufficient for the emergence or whether anything else is required. The emergence of newer technologies has sparked great and growing attention, particularly among policymakers. On the other hand, emerging technologies lack essential core elements, such as agreement on what qualifies a technology as emergent and robust research designs that operationalise central theoretical notions. The definition is based on basic knowledge of the term and, in particular, the notion of emergence and a review of significant innovation studies that deal with technological emergence definitional challenges.

The definition that emerges outlines five characteristics that are present in the creation of novel technologies. These are (i) radical novelty, (ii) relatively fast growth, (iii) coherence, (iv) noticeable impact and (v) uncertainty and ambiguity. The proposed features are then used to develop a framework for operationalising emergent technologies. Analysts have divided emerging technologies into two categories since 1980, based on their originality and predicted socioeconomic impact, while others may perceive the same technology as a natural development of existing technology. Furthermore, emergent technologies are sometimes bundled under “generic labels” (e.g., nanotechnology, synthetic biology). In contrast, their socio-technical characteristics suggest that they should be considered independently (e.g., technical difficulties, involved actors, applications, uncertainties).

Drawing on concerns about ICH, my multidisciplinary inquiry investigates the implications of DIH enactment, documentation and representation. Although I will hypothesise and explore how visitors interact with the display, a comprehensive examination of human-computer interaction (HCI) is outside the scope of this thesis. Moreover, this thesis is the product of a combination of significant heritage research, my own publications and a speculative design approach. As a result, research papers from prestigious conferences, such as the ACM digital library and CHI PLAY-style papers, are not covered in depth here. When ICH-related content is transferred to the digital domain and then shown in a heritage institution or GLAM (galleries, libraries, archives and museums), I discuss a wicked challenge (quite notorious in the discipline of design) that I anticipate will occur soon. This challenge is a major theme in the thesis as a design problem. It is examined in the context of speculative design and cultural heritage documentation, preservation and transmission. The thesis gives less attention to big data, artificial intelligence (AI), player-computer interaction and other highly technical subjects. This study will not examine or measure critical concerns linked to human-machine interaction, nor will it look into or measure in-depth analyses on gamification and embedded technologies related to software programming.

While the thesis does not discuss human-computer interaction, human-machine interaction and artificial intelligence in detail, it is worth mentioning the platforms for researchers. One of them is CHI PLAY. A variety of research efforts have been launched to address human-computer interaction (HCI), and CHI PLAY is one of them (Gerling, Mekler & Mandryk, 2021). It is an annual worldwide and interdisciplinary conference series for researchers and professionals in all areas of play, games and HCI. "Player-computer interaction" is another name for it. CHI PLAY aims to highlight and promote current high-quality research in games and HCI as the foundation for the future of digital play. CHI PLAY has established itself as a premier forum for cutting-edge research on novel games and playful interaction, gamification, player experience evaluations, tangible play, serious games, exertion games, games user research, user experience design in games, player psychology, social game and play systems, play-and-game-developer applications, personalised and adaptive play, and theoretical contributions. The conference's goal is to bring together developers, researchers and designers to exchange their knowledge in-game interaction design and analysis and user experience. The conference identifies new research and development directions in HCI and games.

Moreover, the two most essential information technologies in the era of intelligent information are human-computer interface (HCI) and artificial intelligence (AI) (Fan, Tian, & Dai, 2019). According to the evolving histories of HCI and AI, the relationship between them has evolved from a competitive to a mutual promotion condition. From a research standpoint, intelligent user interfaces combining HCI and AI approaches, such as natural gesture interaction, emotional computing and voice dialogue systems, have gradually become commercial applications. Human-computer interaction and human-machine interaction generate research ideas for AI, and human intelligence drives the development of both. It is expected that the current reciprocal promotion and the driving relationship between AI and human-machine interaction to continue, if not even grow, in the future. The ACM CHI Conference on Human Factors in Computing Systems (or CHI for short) is the world's leading HCI conference (SIGCHI, n.d.). This flagship conference is widely regarded as the most renowned in HCI, attracting thousands of worldwide participants each year. Since 1983, the ACM Special Interest Group on Computer-Human Interaction (SIGCHI) has sponsored CHI. However, CHI began in 1982 as the "Conference on Human Factors in Computing Systems", and it has been conducted yearly since 1985, following the 1983 CHI conference.

Thesis Overview

In Section 1, I present the notion of cultural heritage and its various forms. I also introduce UNESCO and explain how this organisation defines and categorises world heritage. Based on these definitions and categories, I discuss the lack of representations of intangible heritage inside physical/online heritage sites and their significance for a sustainable culture. Various forms of technology interventions for cultural representation are included in this section.

I also discuss the emerging discipline of Digital Intangible Heritage (DIH), which facilitates the intangible aspects of heritage content in the digital domain. As well as a detailed literature review about heritage and emerging technologies, I also present six of my own published and juried (peer-reviewed) papers to support the use of new tools for heritage representation. (A rectangular border distinguishes my published papers from the surrounding text.)

Section 1 also includes my literature review into Intangible Cultural Heritage (ICH) and its categories. Various agents that are helpful in transferring ICH will also be discussed. The section concludes with an examination of emerging digital tools, together with archiving methodologies.

Section 2 presents two case studies to examine and speculate on future technologies in heritage representation. As traditional professions within the realm of ICH, the first case study (Case Study A) focuses on human pulse reading knowledge and its various practices around the world. In this case study, qualitative analysis and human health are considered from the sensual/perceptual expertise of pulse reading practitioners. The case study ends with a proposed concept I developed (the Virtual Immersion with Pulsation [VIP] installation) to document and perpetuate this form of traditional knowledge using emerging interactive technologies.

The second case study (Case Study B) combines a literature search and museum installation idea for the field of martial arts. In this study, I review the literature and analyse the human body, body movements and various technologies involved in the assessments of sports and martial arts. Similar to Case Study A, in Case Study B I describe an application I created (Mimicry Understanding and Safeguarding Environment [MUSE]) for the documentation and transmission of martial arts.

Section 3 contains my recommendations. It proposes a crowdsourced archiving portal, "FolkAir". In addition, based on the exponential growth of new technologies and new methods for communication, this section proposes a new domain: Digital Emerging Communication (DEC). It also describes the challenging scenarios when DEC content creators embark on creating content for heritage-related installations/applications. It discusses future unpredictability and considers how new generations will shape heritage content for serious gaming, edutainment, playfulness and cultural production. Finally, Section 3 outlines the main conclusions of the study, and it identifies both limitations and recommendations for further research.

Section 1: Literature Review and Juried Publications

It has already been envisioned that the future will include Artificial Intelligence (AI), "big data" and increasingly connected humans (Frank, Roehrig, & Pring, 2017). Virtual Reality (VR) and Augmented Reality (AR) may have a broad social impact and could possibly trigger a range of technological/societal advances (Chakareski, 2017). Moreover, the combination of intelligent responses from various emerging sensor-based technologies, expressions and representations will also lead to new forms of communication (Mulder, 1995).

By reflecting on these spectacular developments, I see a promising future for the application of technology to cultural heritage. For instance, the screens that we currently use (computer, mobile, television, cinema) may be replaced by holography, AR and VR devices. Emerging sensor-based technologies and a new breed of devices using our alpha brain waves would give us the ability to control objects around us with our minds and perception. Soon we may be able to hold virtual meetings, using our senses to demonstrate our livelihood, culture and way of interacting with other communities around the world.

Our future will be built by "Generation Z" and the "Millennial" generation. Millennials are digital natives. Researchers posit that people from these generations will have sharp mental acuity, and like experiential, interactive, and collaborative learning with multitasking abilities. They will and be constantly on the lookout for mental challenges (Becker Jr, 2012). They will need active mental interaction with devices around them, and they will also continue to search for and solve problems from multiple disciplines. During this discourse, these generations will form new types of language, communities, community rules, physical activities and interaction methods. Their minds will transform the notion of culture in a highly connected world and, along with the use of emerging gadgets, they will create unseen peculiarities for future heritage embodiments. They will either forget or transform already known conventions from their individual and community engagements. Therefore, it is imperative that people from these generations be exposed to their cultural traditions and ancestral thought processes in either its actual, modified or unusual embodiments.

As part of my research, I have been developing many customised applications (apps) on various platforms to accomplish this important aim of exposing future generations to these traditions and thought processes. I started my journey by learning scripting in C++, Perl and other languages. Then I moved onto learning "patch" programming environments, such as Quartz Composer, Jitter and Flash. I have created valuable connections with researchers, technicians, programmers and enthusiasts around the world. This exposure helped me to learn a wide variety of useful technological tools. While I was learning, I satisfied my internal desire to create something that our young minds can gain knowledge from while they play with these novel gadgets. In 2012, I gave a TED talk on using "Playful Technology to Keep Cultural Heritage Alive" (Khan, 2012). An image from this talk is depicted in Figure 5 and the transcript from the talk is included in the appendix B at the end of the thesis. This five-minute presentation presents some of the tools and apps that I developed.

Figure 5. Muqeem Khan's 2012 TED talk demonstrating motion sensing and augmented tools for preserving Intangible Cultural Heritage.

According to the Merriam-Webster dictionary, preservation is an act of preserving things (Merriam-Webster, 2021). It is an activity or process of keeping something valued alive, intact or free from damage or decay. On the other hand, heritage documentation is a continual process that provides relevant and timely information to enable the monitoring, maintenance and knowledge required for preservation (Santana Quintero et al., 2008).

The recording and preservation of cultural assets is a well-established issue in today's society (Lezzerini et al., 2016). I perceive that the documentation and preservation processes will completely change their form in the context of Digital Intangible Heritage (DIH)-related content. Since this content, which has to be recorded and retrieved, will be digital in nature, its management, monitoring and maintenance will be controlled by digital assistance or AI. In this thesis, I am speculating this in the context of DIH-only content.

It is important to note that this study speculates about new digital technologies, such as AR/VR and emerging sensor-based technologies, to foster and engage the younger generation with DIH-related content. It is also assumed that DIH dissemination, engagement and preservation will be automated because of big data and AI. The framework has already been illustrated in both of the case studies with schematic diagrams.

Emerging technology, such as mobile devices, have been suitable for developing AR applications for several years. Furthermore, the Massachusetts Institute of Technology (MIT) considers AR to be one of the 10 most important technologies to emerge (Gonzalez et al., 2020). It may be used by students learning about the past and researchers and artists. Several publications state that interest in developing technology, such as AR for education, has grown and that this technology increases motivation and engagement in the topic being taught. Youngsters become more engaged in explanations when AR is employed, and interactive learning is expanded, boosting perception and understanding of the real world through virtual information.

To document cultural and library-related data, web archiving technologies are already in existence. In the article "Web Archiving of Indigenous Knowledge Systems in South Africa", one example is given. This research focuses on the digitisation of Indigenous Knowledge Systems (IKS) in South African institutional archives in order to create a framework for web archiving of IKS-related websites in the country (Balogun & Kalusopa, 2021). Furthermore, another long-term effort may be seen in Australia, where national libraries have been at the forefront of web archiving since the mid-1990s (Koerbin, 2021). Their long-term strategic focus, curatorial experience and mandate to gather a nation's documentary heritage supports and sustains this work. Nonetheless, the objectives and achievements of national online archiving programmes will be influenced by their legislative mandate, resources and strategic priorities. The National Library of Australia's web archiving initiative, one of the oldest and most well-established, serves as a case study for developing and implementing a practical approach to complete national collecting and access.

A variety of approaches have been used or are being researched to archive and retrieve erased web data in the case of deleted, inactive or blocked URLs. The article "Automatic Identification and Preservation of R&D Websites" explains one of them (Bicho & Gomes, 2016). It demonstrates a practical methodology for automatically identifying and preserving web pages. It mixes open data sets with free search services so that it may be used right away in situations when resources are limited. Moreover, as we adopt networked platforms and applications in our daily lives, social media plays an increasingly vital role (Thomson, 2016). Users' activities on these web-based platforms leave significant traces of human communication and behaviour, which are uncovered by more advanced computer analytics. The data generated by social media users is a great resource for scholars as well as a significant cultural record of life in the twenty-first century. Researchers and collecting institutions will need new approaches for gathering web-based content as the programming and infrastructures of social media expands.

The above article provides an overview of strategies for archiving social media for long-term access for both policy and execution. The methodology can also be applied to emergent DIH content in the context of this thesis. It focuses on social networking platforms and platforms with a lot of user-generated content and marketing sites, which are important to be archived. Along with potential solutions for archiving social media, the obstacles that non-commercial institutions have in preserving it have also been investigated in this research. This report draws on recent research on heritage and government archives in the UK, Ireland and Germany in the lack of set standards and best practices. Recommendations for the future development of social media preservation for research and cultural collections have been made based on the existing state of social media data and the lessons learned from a variety of case studies explained in this research.

1.1 Playful Technology to Keep Cultural Heritage Alive

In future, new and emerging technologies will be the platform for all kinds of human activities. Our lifestyles will be filled with the "Internet of Things" which will surround us. Machines may read our alpha brain waves then instruct and communicate with us. Our process of seeing the environment will be flooded with instructions and cues for everyday decisions, and will be transformed into perceptual cues to trigger our senses. We will be one community of the world, one nation carrying a unique culture governed by binary instructions, big data and AI. In this context, it will be important to revive our ancestral everyday wisdom and learn from our past heritage.

1.1.1 Speculative Design

Learning how to break, bend and inspire a completely new understanding – a new way of thinking – is more vital than learning conventions. New ideas that push the boundaries question our norms, and help us explore open streams of creativity that are sometimes discarded as unrealistic because they are perceived as costly, unproven or simply unattainable. As an artist and designer, I worked as a visual effect artist and an instructor in the field of heritage representations. As my exposures to constructing cultural exhibitions increased, I noticed that the spontaneity that had provided me joy through my profession was gradually fading away, replaced by excessive caution, procedures and logical answers. That has prevented me from experimenting freely with cultural substance and the blend of subjectivism and rationalised heritage depiction. If I wanted to thrive as a professional exhibit designer, I had to adhere to a rigorous and binary method of looking at heritage content rather than playing with its lovely cultural events and happenings. I wanted to explore a current or contemporary perspective on our past, and I wanted my younger audience to interact with the content somehow.

Speculative design, also known as design fiction or critical design, established by designers like Anthony Dunne and Fiona Raby and many others in design programmes and practice around the world, is at the heart of this form of investigation and critique that I was looking into. Speculative design methodologies have become a niche and provocative feature of design practice and education due to their influence and effort. Dunne and Raby coined the phrases "critical design" and "speculative design" in the mid-1990s to describe a process in which design helps to reimagine not only a reality but also our connection to it. Their experimental works, and other prominent designers such as

Lebbeus Woods, Perry Kulper and Daniel Libeskind, exemplify this rethinking of reality (John, 2021). Designers, according to Dunne and Raby, should not just handle current difficulties, but also look to the future and ask, "How might we address future challenges?". Speculative design seeks to resolve challenges and provide answers to difficult questions that we have created for ourselves. Businesses and brands must ensure that they are in the greatest position to adapt to and develop with technological advancements as they accelerate. This entails inventing in whatever business they are in, putting them in a position to capture a substantial portion of future markets. This is not a figment of the imagination, either. For example, Visa, Pepsi, Ford, and even NATO, have begun to hire science fiction writers to assist businesses in developing more inventive goods and strategies. They all understand how critical it is to stay ahead of the curve in technology and services.

By separating itself from traditional commercially driven and market-friendly design trends, speculative design may enable the development of new, innovative concepts that exist outside of the restrictive paradigms of exhibition design, advocating for true innovation without the convention's comforts and constraints. Despite criticism that speculation and speculative design are not sensible, genuine or practical, Dunne and Raby contend that they have always been an essential component of the design process. As a digital designer, I am confident that our future generation will engage heavily with museums and their heritage content due to the ever-changing paradigm of developing technologies, notably augmented and virtual reality, with new sensor-based gadgets and techniques.

While not generally acknowledged or adopted by all designers, speculative design thinking has been a recognised design practice focus in design domains as a result of these initiatives. Curricula and programmes inspired by speculative design are currently available at schools like the Bartlett School of Architecture at University College London and the Royal College of Arts (RCA) in London. These programmes consistently yield outstanding student work and visually stunning presentations. Their departure from traditional presentation approaches highlights their exceptional skill and rigour.

Integrating speculative design thinking into display design and practice seemed natural to begin with. According to the Cambridge Dictionary, speculating is the process of making educated guesses about probable answers to a subject when there is insufficient evidence to be certain. This study investigated this possibility by investigating, analysing and applying the conceptual, methodological approach of speculative design to cultural exhibits. The study aspired to determine how speculative design may be used to criticise future technology-based exhibition design and how to expand and enrich the creativity involved in the design process, among other things.

Dunne and Raby published “Speculative Everything: Design Fiction and Social Dreaming” in 2013, which established their methodology and approach. Speculative design is presented as an academic and professional methodology in this book. The speculative methodology lays the groundwork for establishing an inquiry practice, challenging the status quo and exploring alternatives:

> to use design as a means of speculating how things could be [is] speculative design. This form of design thrives on imagination and aims...to create spaces for discussion and debate about alternative ways of being, and to inspire and encourage people’s imaginations to flow freely. Design speculations can act as a catalyst for collectively redefining our relationship to reality. (Dunne & Raby, 2013)

Ivica Mitrovic (2017) extends Dunne and Raby's speculative design in practice by establishing a space for a type of "new designer" who "acts on the margins of previously designated disciplines, erasing the boundaries between them.” The new designer is more interested in presenting questions and inquiries for discussion or debate than addressing them through design. Mitrovic quotes Ramia Mazé on the importance of internal critique in the development of a discipline:

> Criticality has an important role to play within design on many levels...criticality within our own personal practice can be seen in how we reflect upon our methods in order to locate our voice and articulate our position; criticality within a community of practice or discipline can be about trying to challenge or change traditions or paradigms… (Mazé, 2009)

Because speculative design interacts with a wide range of related activities and disciplines, Mitrovic argues that the methodologies available to it are any that are accessible and relevant. Fictional narratives, films, screenplays, storyboards, user testing, interviews, questionnaires, games, and media and pop culture phenomena are examples of these approaches (Mitrovic, 2017). The flexibility of speculative design as a tool for design research offers an opportunity to push disciplinary boundaries and, in the words of speculative architect Liam Young, "to operate in the gap between design, fiction, and futures” (Young, 2017).

Complementary design techniques like speculative design, beyond understanding needs and solving issues, inspired me. Designers Anthony Dunne and Fiona Raby from the United Kingdom are pioneers of the academic practice of speculative design. According to them, design has become so entrenched in business, so familiar with its ideals, that it is practically impossible to imagine its ambitions. Moreover, the Royal College of Art pioneered speculative design, which could engage with future situations and issues to raise crucial questions about alternate possibilities and "what if" scenarios. The purpose was to investigate speculative design to extend and translate social science research into future disciplines (Dunne, 2008; Bleecker, 2009; DiSalvo, 2012). Speculation is a well-known but still relatively new design method (Nooney, & Brain, 2019). Designers who use speculative and critical design to envisage future possibilities for discursive purposes are known as speculative and critical designers. In this context, my goal was to see how speculative design could be used as a springboard for further DIH inquiry. What emerging technology-based opportunities are created at GLAM institutions when speculative design thinking is combined with cultural practice – future thinking?

Throughout the thesis, I shall make every effort to keep speculation under control. I do not want to project myself too far into the future to convey improbable thoughts or alien technical advancements. I am aware that doing so will result in a loss of engagement or connection. In reality, I sought to link the audience's sense of their environment and the concept's fictional element. The thesis examines the importance of experimentation in DIH to go past the discipline’s constraints. It focuses on speculative design thinking, which was popularised in the late twentieth century by designers such as Dunne and Raby. According to Tony Ho Tran, designers can use speculative design to stretch their imaginations and create innovative and cutting-edge systems and concepts for the future (Tran, 2019).

In the context of speculative design, Dunne and Raby wonder what role design may play in sparking new dreams for the twenty-first century, and they make a case for design as a means of imagining how things might be (Dunne, & Raby, 2013). Dunne and Raby's method for speculative design, as a future-oriented design practice, draws inspiration from the 1960s and 1970s radical architecture and builds on Dunne's earlier work that argues for design to be used as a critical medium for reflecting on the cultural, social and ethical dimensions of technologies (Dunne 2006). Speculative design is a method that usually engages with new scientific research. In my thesis, it is used to research tools, strategies and trends to create a future scenario for DIH, which is then realised through the creation of future sustainable GLAM products, particularly future exhibits. The stated goal is to provoke questions and produce pluralism in inquiry, not of style but of ideology and values related to DIH enactment and protection. Fiction, aesthetics and narrative are strategically employed with the stated goal of provoking questions.

My thesis attempts to depict DIH and its long-term viability using speculative design thinking to debunk the assumption that speculative design somehow only aestheticises the notion of dystopia, as proposed by various scholars, including its supposed inability to picture living outside of a neoliberal framework, as well as its struggle to envision futures that decentralise norms and fears about the future. In short, it is accused of neglecting to examine ideological norms by failing to move beyond narratives of technical advancement. Speculative design thinking, while well-intentioned, frequently fail in centralising the designer as the creator of the future, disregarding broader social, economic and geopolitical concerns. Indeed, as Prado and Oliveira point out, while speculative design shows a desire to engage fully with scientific research, it overlooks social science and humanities research on the nature of societal transformation (Prado & Oliveira, 2015). As a result, this study aims to connect speculative design thinking to the social sciences in a relevant way. Moreover, this study will address specific issues about how evolving interactive technologies provide a place for thinking about how intangible digital heritage might thrive and be preserved for future generations.

The following section includes a detailed survey of and discussion about knowing and understanding the notion of heritage, particularly intangible heritage, and its various manifestations around the world. I will also discuss the new form of ICH which is a digital manifestation of intangible heritage or DIH. Indigenous methodology and indigenous cognition are described in detail in the literature search.

1.2 Heritage

The term "heritage" stems from the French word "eritage", which generally means property, passed on by ancestors to their heirs (AlSayyad, 2001). Heritage defines the identity of a person and what that person's ancestors have done in the past. It is essential for a person to know about their heritage to live in the community, just as it is important for a child to know about his or her family or relations (Graburn, 2001). From a contemporary perspective, heritage or the concept of heritage includes selective artifacts from the past, landscapes, mythologies, memories and traditions that become a culture or an economic resource in the current time (McDowell 2016). Heritage can be immovable, such as archaeological sites or historical buildings; however, it may also include modern monuments with high cultural and symbolic values (Benhamou, 2020). It can be understood as a tradition that engages people, communicates the past and ascertains the meaning of the present. Heritage is a cultural process which acts as a basis for constructing and regulating the range of values (L. Smith, 2006). Moreover, heritage study is now an interdisciplinary field (Smith & Akagawa, 2009). It is about places, artifacts and cultural expressions from the past. These factors become an identity for an individual, group of people and community – and, sometimes, migration history and national memory. History is heritage but heritage is not history; instead, heritage categorises individuals and masses into various compartments with similarities and differences. Various entities use this term to segregate biases and foster diversities within a community. On the other hand, the same notion can be utilised to ignite conflicts among groups and nations.

Cultural heritage enables a community to understand its ancestor's identities, eliciting a strong sense of belonging (M. Zhang, 2010). The preservation of heritage is also important from an economic perspective in terms of creating employment opportunities and providing financial assistance to communities through heritage sites, historical museums and the exhibition of tangible artifacts (Bowitz & Ibenholt, 2009). However, heritage is not limited to tangible artifacts only; the intangible dimension is also very significant. UNESO defines ICH as expressions, skills, knowledge, practices and representations recognised by communities or groups as their cultural heritage (Kurin, 2004).

The significance of ICH can be understood from, for example, the disappearance of famous physical monuments such as the Jewish people's Millennial in Jerusalem, Babri Masjid in Ayodhya and the World Trade Center's Twin Towers in the United States, where rituals and ceremonies are still performed by people (Ruggles & Silverman, 2009). The evolvement of the heritage is the result of the disappearance of the cultural element or norm (Cheung, 1999). However, to communicate the past it is necessary to preserve the heritage for future generations (Logan, 2007). Fortunately, this issue has become more prominent and people have been more vocal after the Second World War, where the world witnessed a great loss of heritage sites and monuments (Ruggles & Silverman, 2009).

Museums play a vital role in representing the past, and therefore are considered to be very significant all over the world. But showcasing the past through museums often overlooks the ICH because it mainly represents tangible artifacts from the past or history. Only viewing physical manifestations diverts visitors' focus from non-physical manifestations of the past. Although museums generally showcase heritage in diverse and innovative ways (Kreps, 2003), they still tend to focus more towards physical or tangible artifacts, as exemplified by Hagia Sophia in Istanbul and the restitution of SS Sergius and Bacchus (Papagiannakis, Foni, & Magnenat-Thalmann, 2003). Due to this, the history or story associated with such artifacts is often neglected by visitors. Following are some further examples that illustrate this point:

- The showcasing of the beautiful pearls in the Baroda Carpet Museum in Qatar is an example of the exhibition of the cultural heritage, but the conversation about pearl hunters is not emphasizsed (The Pearl Carpet of Baroda., (n.d.).

- Similarly, the livelihoods and environments of the indigenous families and their surrounding are featured through visual presentations which cannot communicate the information about their interaction patterns, collaborative actions, their fears, happiness, sadness, and social challenges and so on ("What Makes Us Human", 2010).

- One of the world's ancient universities in the world, Takshila (located in modern-day Pakistan), also organises the exhibitions paraphernalia, but is unable to depict the complex interactions between the instructors and their students (Takshila, 2010).

According to Adams et al. (2004), museums are meant to provide a meaningful experience to visitors because their heritage-related artifacts or assets are now represented differently due to changed paradigms in terms of tangible into intangible and non-interactive to interactive. Preservationists know that preserving cultural heritage does not only mean showcasing heritage-related artifacts in museum settings. They have recognised the need for change so that heritage value can be represented both by acknowledging and including cultural values as well as material showcasing. The indigenous community, along with their festive performances, can exemplify the need for a shift; in the recent past, indigenous peoples have been more vocal about their cultural identity compared to the earlier past. This cultural renewal of community has positively affected indigenous peoples (Simpson, 2019). Further, the related literature shows the positive impacts of elevating and preserving cultural activities on indigenous peoples (Chandler, Lalonde, Sokol, & Hallett, 2003).

Interactive and narrative-based technologies or applications are also effective in communicating heritage content. However, although these applications render visualisation and create as well as represent faster and better three-dimensional (3D) models, they are still unable to appeal to visitors entirely. Further, these applications or installations are also often focused only on the display of artifacts through digital representation, such as showcased in the Hagia Sophia in Istanbul or in the restitution of SS Sergius and Bacchus, as mentioned above (Papagiannakis et al., 2003).

According to Kaufman (2002), emerging technologies have been used for transferring heritage-related knowledge, such as “Studierstube”, an Interactive Media System Group developed system based on mobile collaborative AR, developed at the Vienna University of Technology. The developers claim that their system is easy to use in terms of learning, and that it helps improve spatial skills because it encourages experimentation with geometric constructions. Similarly, Beckett and David (2005), from the University of Wisconsin, researched the development of students’ understanding of ecology through participation in a technology-driven urban planning simulation. This was further explained in David S. Shaffer’s research (2004), in which he discussed the theory of pedagogical praxis, where students’ use of computers and other technologies helps them become active participants in meaningful projects and practices. Dewey (1958) additionally explained how knowing and doing are tightly and coherently linked.

According to Dewey (1958), one attempts to learn while undertaking an activity related to a meaningful goal while addressing obstacles and hurdles in the accomplishment process. The work and research of museum practitioners and researchers is grounded in human development related theories, such as a three-phase museum visitor’s study which was carried out by Minda Borun (from the Franklin Institute Science Museum) and funded by the US National Science Foundation (Borun, Chambers, & Cleghorn, 1996; Borun et al., 1998). This study was a collective effort from four institutions: the Franklin Institute Science Museum, the New Jersey State Aquarium, the Academy of Natural Sciences, and the Philadelphia Zoological Gardens. One phase of the study explored seven significant characteristics of successful family exhibits, including those that are multi-sided, multi-user, accessible, multi-outcome, multi-modal, readable and relevant (Borun, Chambers, Dritsas, & Johnson, 1997).

According to Nina Simon (2010), it is very disappointing to see people who are not interested when they visit museums, despite being engaged in other fields such as politics, culture and so on. In a cultural environment, people of all ages need to be actively interested, not just passive users. When it comes to museums, cultural activities and meetings are not only about attending the events, but also about being more involved so that people can learn from each other. The transfer of knowledge happens as people share and discuss their ideas, which leads to further learning and involvement. In a very logical sequence, the author of the content introduces the terms, creates, shares and connects. When they create their own ideas, they also create other people’s imaginations. They share these ideas not only with fellow visitors, but also with the staff in the museums. When people with diverse views meet and engage in a museum, they socialise new ideas with historical contexts. Everyone should be welcomed by the contemporary form of a museum, which should encourage visitors’ thoughts and opinions, creating a conducive atmosphere so they can express their ideas in a relaxed and engaging way.

Participatory heritage could be defined as a space where people participate in cultural activities outside of formal institutions for the purpose of sharing knowledge and co-creating with others (Roued-Cunliffe & Copeland, 2017). Those involved in participatory heritage collaborations tend to value content over medium, process or professional skill; as a result, they recognise a diversity of expertise and work from a shared authority assumption. Because of social media, user-generated content and crowdsourcing, various participatory groups exist, such as Wikipedia, Old Copenhagen, Sydney Opera House Flickr group, Ravelry, and Ancestry.

Bringing heritage institutions and participatory heritage groups together has proven effective in overcoming limits in both areas. Heritage institutions strengthen their potential to produce more inclusive and culturally relevant collections by forming relationships. Institutions are exposed to a greater range of heritage themes due to these connections and are better positioned to assist communities that cannot tell their own stories. In this thesis and in the context of DIH, I assume that DIH exhibits in the future will join some of these participatory groups, and new communities will be originated. These exhibits may have the potential to foster communities at large and assist intangible heritage to be further sustained.

In their efforts to better engage visitors, the Exploratorium (a museum of Art, Science and Human perception) conducted research that focused on promoting Active Prolonged Engagement (APE); likewise, PISEC was also funded by the US National Science Foundation (n.d.) in 2005. This research led to an interactive and immersive experience that encouraged APE. This study also discovered five successful exhibit characteristics – some of which are relevant for the current study. These characteristics are:

- being enjoyable;
- engaging visitors on the basis of prior knowledge;
- being multi-use, (i.e., the exploration of one visitor should not interfere with another's);
- offering a challenging environment instead of providing instructions; and
- being based on a limited number of choices to avoid overwhelming visitors.

Bedigan (2016) emphasises the physical engagements and emotional attachments of visitors with the artifacts inside a museum. He argues that it helps in evoking the active role and curiosity of the visitors; thus, they can find significance in the museum environment. The purpose and institutional mission of the museum in society is hence accomplished if exhibits have an emotional value. Further, performance measures have been mandated by the emergence of global culture as well as budget-related constraints for museums (Goulding, 2000). Customer satisfaction, in terms of fulfilment of expectations and curiosities, is greatly emphasised and signified in the new trends. Therefore, museum planners are now more focused on experiences rather than instructions (Sachatello-Sawyer et al., 2002). According to Van Dijk et al. (2012), visitors are now more attracted towards museums that provide new experiences, recreation, enjoyment, socialisation and fun. Considering this fact, museum planners need to focus on creating more motivated and playful visitor experiences (Paris, 2002). According to Leavitt (1968) and citing Vogel (1965), an effective exhibit must contain:

- the stimulation of interest;
- the stimulation of thought;
- instruction;
- development of a sense of historical development and continuity; and
- establishment of the relationship of the subject area globally.

However, the overall discussion in regard to theories and arguments related to the interaction, learning and emergence of technologies has not been sufficient for a detailed examination or investigation of heritage–related applications or installations, particularly in regard to VR and especially in the context of ICH. Consequently, it is important to develop immersive and interactive experiences that encourage visitors to both learn from the past and enjoy ICH-related content in the present.

1.3 Emerging Museums and Heritage Environments

Museums around the world are adopting Augmented Learning (AL) in their environments (Kondo, 2006). AL is a learning strategy in which the learning environment adapts itself to the individual learner (Biggs, 2012). It is also a pedagogy whereby the real world is adapted with props and contextual information to provide an immersive learning environment for students while sustaining student–student and teacher–student social interaction. Although an emerging issue for education, action research is needed to ensure optimal use of AL in a variety of contexts. AL environments provide unique, hitherto impossible, opportunities to change the nature of learning and teaching experiences. First, AL environments enhance interactivity with content and processes through simulations and role-plays (Oblinger, 2004). Moreover, they support interpersonal interactivity (with individuals or groups of individuals) while immersed within another activity (Rosenbloom, 2004). Second, AL environments are able to deliver rich conceptual resources and thoughtfully act in playful spaces; thus, participants can more easily engage with the subject matter (Roschelle & Pea, 2002). Third, AL environments encourage students to build their own activities and experiences and to take control of their own learning (Meiguins, de Souza Junior, de Brito Garcia, & Gonclaves, 2004). In this way AL, much more than "traditional" learning environments (digital non-augmented learning environments included), can support individual differences among students' learning styles, physical abilities, intelligence levels and background knowledge.

There are two theories of learning that are particularly relevant to smartphones and digital users: constructivism (Piaget, 1977) and situated learning (Lave & Wenger, 1991). In constructivism, learning happens as people develop their own interpretation of concepts and phenomena. Their previous experiences and values play an essential role in their awareness. In their perception, current and past circumstances play a crucial role. Progress and failure, feedback and interactivity in real time, and suggestions, help them understand the new situation. Therefore, to solve the problem and to learn along the way, learners are more involved and inspired. Situated learning happens through social conditions and group interactions that are highly social. Dynamic groups and cultures learn from each other, and hence, situated learning can be complementary to constructivism. With GPS-enabled phones, visitors can interact with the information provided (self-interaction) within a heritage-related environment and also interact with each other to explain the data presented (social interaction). This is contrary to the “fixed marker” and to the mere visuals produced by the curator. Research also indicates that the perception and learning of an exhibit inside museums is enhanced through visitors' social communication and social interaction (vom & Heath, 2016). Therefore, the careful creation of interactive information to present cultural awareness in the context of museums and heritage-related information is much more impactful than the fixed and static information provided by management.

Augmented Reality (AR) combines real and virtual interactivity in real-time, and it operates in three dimensions. In other words, it is a promising field developed on the basis of Virtual Reality (VR), which superimposes computer generated virtual information onto surrounding real environments to augment users’ perceptions in real-time and interactively (Su, Kang, & Tang, 2008). In addition to virtual objects, more information related to touch, smell and taste could also be embedded or augmented to produce richer experiences (D. Yu, Jin, Luo, Lai, & Huang, 2010).

AR is a 3D technology that integrates the physical and digital worlds in real-time. AR differs from VR in that it allows users to see the real world while also seeing virtual layered graphics; VR shows a digitised version of the real world. To put it another way, digital data like text, photos and video are layered and blended into our view of the real world. AR is most commonly used and viewed using a handheld or head-mounted display unit. These portable and head-mounted devices can be utilised outside the classroom, removing the requirement for training to be restricted to a particular setting.

To understand augmented learning (AL) or augmented mobile learning, we need to understand its technology. VR is all digital vision in front of our eyes, whereas AR is the mixing of digital and real vision through virtual and real things. These technologies are now combined with a variety of sensors, making them more fascinating and enjoyable. Emerging optical gadgets, compact integrated circuits, portable batteries and the Internet of Things will make these technologies even more amazing for human experiences. All of these devices and tools will be transparent and able to be embedded in our eyeglasses and clothing, and they will even be able to interact with our minds and thoughts.

Aside from AR, no other digital technology can transform the educational experience completely (Kidd & Crompton, 2016). AR is an interactive technology that combines computer-generated content with comprehensive information about real-world locations or activities (Yuen et al., 2011). For some, AR is a world between reality and VR that offers a plethora of educational opportunities (Pasaréti et al., 2011).

The use of smartphones among young people is rapidly expanding (Boulos et al., 2013). Today's youth spend more time on their smartphones than on their desktop computers. Advances in wireless technologies and smartphone capabilities have resulted in inappropriate usage. Mobile applications, such as games, social networking, entertainment, and personal and business applications, are exploding in popularity. These applications are continuously competing for the interest and time of users (Dirin et al., 2013). As a result, applications require a thoughtful design that creates an emotional bond with its users. Furthermore, VR/AR applications must suit students' basic educational needs while encouraging them to use the programme on their smartphones (Seong, 2006).

Learning is a basic biological ability that humans have developed significantly more than other living creatures (Illeris, 2018). As a result, humans are designed to be learners—we will never be able to avoid collecting a massive quantity of knowledge during our lives. Learning theory is a large field with hazy boundaries and several methods that overlap in various areas and ways. It is critical to recognise that all learning consists of two simultaneous processes that the learner does not experience separately: an interaction process between learners and their social and physical environment, which provides them with some impressions, and an acquisition process in which these impressions are assessed and elaborated. Furthermore, in modern society we are compelled to study. Compulsory schooling lasts several years in practically all nations, and we must all master a variety of skills to deal with our daily lives.

Learning theory, as developed primarily in the discipline of learning psychology, but with supplementary input from other psychological disciplines and adjacent disciplines of sociology, pedagogy and biology, including modern brain research, is concerned with how various types of learning take place in the human brain and body (Onyema, 2019). In the context of educational learning, the growth of emerging technologies is transforming many aspects of the educational process, including classroom design, content quality, methodology, student participation and evaluation. The incorporation of developing technology into the teaching and learning process raises learner interest and improves the quality of educational outcomes. It fosters innovation, creativity and flexibility in the classroom, providing both educators and students with the problem solving and survival skills required in today's digital world.

The evolutionary ability for inquiry, discovery, sharing and understanding for the skilled use of tools is emphasised by Larreamendy-Joerns and Leinhardt (Anderson, 2016). It is most closely related to Dewey, Mead and Piaget's social constructivist learning theories. Constructivism, like many other popular theories, has been described and characterised in a variety of ways. According to all variations of this theory, individuals' construction of knowledge depends on individual and collective understandings, backgrounds and tendencies. According to this view, active engagement by learners is vital, and effective learning requires different perspectives and prolonged dialogue. The importance of scaffolds supplied by both human and nonhuman entities in assisting more able or knowing learners or teachers to prompt and support learners in obtaining their own competence has been emphasised in social constructivist theories (Vygotsky & Luria, 1981).

In his article, Anderson (2016) further talks about this theory and say that constructivists also emphasise the importance of context in learning, arguing that learning is most effective when the task and setting are authentic and meaningful. Problem-based learning tasks are common in constructivist learning and necessitate active inquiry strategies. When these challenges are ill-structured, open-ended and "messy," they frequently work best. Such issues force learners to think beyond formulaic solutions to build the ability to solve problems effectively in various situations.

Furthermore, the study of living systems gave rise to complexity theory, or more recently, the "science of complexity", which has attracted the interest of a wide range of disciplines (Turner & Baker, 2019). The most well-known instances of complexity theory come from evolutionary biology, in which animals adapt to and even influence complicated environments, resulting in remarkably stable but complex systems. Educators and researchers can use complexity theory to explore for emergent behaviours that occur when autonomous yet interdependent entities interact. Complexity theory, like constructivist theory, emphasises the acquisition of skills and power by the individual learner so that he or she can express and realise personal learning goals. When disruptive technologies are utilised in previously stable systems, complexity theory helps us comprehend and manage the inevitable unanticipated events that arise.

Other learning theories of emerging technologies and the internet include the net-aware theory of learning (Blaschke & Hase, 2019), which deals with context-created learning environments, and the heutagogical theory of learning (Blaschke & Hase, 2019), which is named after the Greek word for self. The heutagogical theory emphasises self-directed learning and views the learner as a primary development and control agent in his or her learning. Understanding various forms of learning – including when devices are becoming handheld, allowing the user to walk around and engage with other objects inside a particular location – is necessary to assess the impact of learning through these VR/AR gadgets. Hence, it is important to understand learning from mobile devices or devices that combine unique perceptual and interactive data while moving around.

Learning with various electronic gadgets is a collection of methodologies, structures and networked electronic instruments coordinated into systems that produce or are meant to produce learning. The three main research fields are users who interact with emerging digital systems, evolving hardware and software, direct or indirect interaction of diverse users, and learning theories and pedagogical methods. According to research, there are four major and most influential pedagogical approaches to learning: behaviourism and cognitivism, both developed in the first half of the twentieth century, and constructivism and the on-line collaborative earning theory, both developed more recently, and perhaps more capable of accounting for the emergence of technology in everyday life. The above learning theories are not the only ones out there. Many new learning theories have emerged in recent years as online learning and technology-based teaching have progressed. No one theory appears capable of accounting for all possible learning experiences, given the variety of learning and teaching styles, the different ways technology might be deployed, and how educational technology itself is continually changing. As a result, it is realistic to expect that several theories will continue to coexist. They will be used to meet various people's various demands, utilising various techniques in various learning environments.

Augmented learning (AL) is a type of standalone learning that takes place in AR environments, that gives users 3D, interactive and immersive learning experiences in some instances (Cicconi & Marchese, 2019). Researchers have been looking into the possibilities of AR in learning contexts for years. Many argue that fully functional AL environments deployed as AR applications can help to change, enrich and improve the learning experience in a variety of ways, including facilitating visual content learning, encouraging the process of learning through doing, increasing the user's involvement in the learning process, encouraging collaboration and social interaction, and connecting the user's personal experience to the content to be learned. Although current research in AR for education is still in its early stages, it is a mature technology that is already on the market. As a result, the researcher can seriously consider AR uses in teaching. In conclusion, I believe it is challenging to classify AL as either evolutionary or revolutionary; nonetheless, the platform may provide a chance to create a more convergent form of learning in which many educational learning frameworks collaborate to manifest knowledge acquisition and learning.

There have been several research-oriented efforts to bring emerging motion detecting and AR-related technologies into their fullest possible use in the context of cultural heritage. For example, the ARCHEOGUIDE systems (Gleue & Dähne, 2001, Vlahakis et al., 2001) provide onsite personalised cultural guides. These guides, based on position and orientation in the cultural site, virtually assist visitors and provide AR-based reconstructions of ancient ruins. ARCHEOGUIDE is a cultural heritage project focused on AR. It is sponsored by the EU and aims to provide tourists to cultural sites with a customised electronic guide and tour assistant. The device provides on-site assistance and VR reconstructions of ancient ruins, based on the location and orientation of the user in the cultural site. It includes a digital cultural content database for online access to cultural data, virtual visits and information on restoration. The old audiovisual aids used to illustrate and educate tourists about the heritage site and its historical value have been revolutionised by this system.

Traditionally, in older audio help devices inside a museum, visitors could only communicate and retrieve information in a linear way. The visitor's curiosities were not discussed, and there were not many options. In addition, a single person could communicate with audio-visual equipment, and social or group interaction was not possible. Multiple users can now communicate and retrieve data with highly sophisticated and engaging user interaction via ARCHEOGUIDE or a similar enhanced framework. Based on the age bracket of the visitor, a similar future framework can also adjust itself to reflect user interaction so that information delivery can be entertaining and playful for younger audiences.

There are also many tourism-based AR applications (apps). For example, the augmented binocular (Fritz, Susperregui, & Linaza, 2005) is a coin-operated binocular system found in many places. This AR-based binocular offers an overview of the buildings and streets of an area. Other systems use mobile devices integrated with freely available Google 3D models to augment vision by placing virtual objects with historical significance in situ over live visions of the real world (Honkamaa, Siltanen, Jäppinen, Woodward, & Korkalo, 2007). More recently and for augmented reality, an outdoor tracking system has also been developed for handheld devices. This system can easily handle unpredictable and complex outdoor visual information Yu, Ong, & Nee, 2016).

AR improves existing static and non-interactive real-world artifacts and multimedia presentations by heightening visitors' understanding and appreciation of cultural heritage. Many museums have already integrated AR into their educational offerings. While handheld devices are flooding the market, AR-related apps are available for consumers to immerse themselves in AR. For example, an iPhone app (Streetmuseum, 2010) was developed for the Museum of London to enhance the view of old London (M. Zhang, 2010). The app uses a GPS coordinate system to allow viewers to see 200 historical images from different parts of London.

We are challenged to find new and dynamic ways to link individuals, ideas and artifacts as museums step into the twenty-first century. Mobile technologies provide a rare opportunity to give tourists more access to museums' intellectual and cultural resources. At the touch of a button, digital images of works in storage and from other collections, interviews with curators and artists, contextual content in the form of photographs, video footage, music and extracts from relevant textual materials, can all be made accessible to the visitor. The opportunity for the visitor to personalise the experience and make connections with previous information, experience or preferences comes with the availability of these tools. In addition, mobile technology will help museums fulfil their function as public interaction and discussion forums; visitors are now able to share their experiences and information with the museum and other visitors. Museum space is thus starting to extend beyond the walls of the gallery and into colleges, families and campuses, as well as into other states and nations across boundaries.

As part of a more comprehensive study on interpretation, the Blanton Museum, in partnership with the University of Texas at Austin's Information Technology Services, developed, introduced and assessed an interactive handheld museum guide (Manning & Sims, 2004). The iTour handheld computers, which were made accessible to visitors during three months, contained rich content, including artist video, curator audio, textual material and components of creative play.

A majority of visitors (67 per cent) were very pleased with their encounter with iTour; 28 per cent were moderately satisfied; and 5 per cent were only a little satisfied. They were able to view more data and had access to contextualised data. Visitors also pointed out that they had self-paced and self-directed information retrieval. They could see and hear the artists talk about their work as well.

Technology has been extensively introduced into the everyday lives of students (Jones, Ramanau, Cross, & Cure, 2010), and educational institutions are gradually delivering interactive learning for learners, thus supporting opportunities for active learning (Johnson et al., 2016). Many research studies on the use of eBooks and their impact on learning have already been carried out. Recently, higher educational goals have changed quite a lot, and higher education institutions are constantly looking at the introduction of new interactive technology, improving the standard of teaching and testing, and reducing costs. There is an opportunity for eBooks to engage with all these strategic goals (Fyfe, 2014). Research shows that participants have considered the availability of multimedia interactive eBooks in class to be advantageous to their learning (Morris & Lambe 2017). Unfortunately, while there are numerous emerging technology-based exhibits, they do not focus on ICH. These systems, for cultural presentations, do not explore the full potential of AL and its power to support immersive and engaging experiences. Furthermore, these installations continue to rely on conventional methods when presenting tangible heritage-related representations from the past (East County Magazine, 2011). Systems like ARCHEOGUIDE (mentioned above) do reconstruct the physical past reality—however, ICH is not addressed.

1.3.1 Museums and Digital Culture: Current Practices and shortcoming/Challenges

Archaeology has a long history of using information and digital technology in novel ways. Research, preservation, education, outreach, publication, and scholarly communication are all influenced by digital technologies in archaeology and heritage. In general, these initiatives have taken place along several distinct tracks: electronic and digital data, storage, retrieval, analysis, and so on, GIS, and computer-assisted drafting, to name a few (Watrall et al., 2016). As mentioned in an article, one of the key researchers in digital heritage study is Ross Parry (Myrczik et al., 2019). He wrote a book titled Museums in a digital age (Parry, 2013). He also described a case study of the use of chatbots in museum communication at four historic house museums in Milan, addressing one of the most widely debated emergent technologies in the field of cultural institutions.

Museums and Digital Culture encapsulate current practice and research on how technology and digital culture are changing present and future museum and creative work

(Giannini, & Bowen, 2019). Various issues, trends, and theories that shape cultural institutions now and in the future are discussed in this book. According to the book, many individuals worked in the underlying theoretical assumptions and trends that define scholarly and practice-based museums and digital culture approaches. Prof. Tula Giannini is an American academician with musicology, digital culture, and digital heritage expertise. She founded the New York Pratt School of Information and created a Master's degree, also played a crucial role in investigating and guiding developments in museums and digitalism. Bowen represents the computer science perspective as an Emeritus Professor at the London School of Engineering. Giannini and Bowen seek to imagine the museum's digital future despite some reservations. One way to approach the issue is to look at the problems museums may encounter in dealing with audience views of the past and the future (Bowen, & Giannini, 2021). In general, they have a positive attitude toward technology, perceiving and explaining the potentials of the "digital ecosystem" while placing the obstacles in the context of museums. Their approach focuses on the impact of technology and digital culture on museums and visitors. They claim to have entered the next phase of the digital revolution. The layout shows the numerous angles and perspectives from which this shift might be understood from this standpoint of fundamental change.

Another chapter by influential practitioners Seb Chan (ACMI Australia) and Courtney Johnston (Te Papa New Zealand) appears in Museums and Digital Culture: New Perspectives and Research. They talked about the current digital practice at museums. They both have primary responsibilities for audience experience and development, but much of that responsibility appears to be heavily influenced by digital techniques. The discussion in their article is thought-provoking, as it examines outstanding career trajectories for digital museum executives who began their careers in technology outside of the museum field and have changed roles and positions as museums and technology have evolved.

Herbert Bruderer is a retired lecturer at the ETH Zurich Department of Computer Science and a technology historian. In his article Preserving the Technical Heritage, he discussed the use of technology and its shortcomings (Bruderer, 2020). According to him, rapid technological advancements have resulted in a loss of material and immaterial cultural heritage. Gadgets and devices have long been discarded due to a lack of space, the fact that they were no longer functional, and no one wanted them, or their value was not acknowledged. The tools and technologies commonly used in the past are now obsolete.

International Business Machines (IBM) and Remington Rand are two of the few original manufacturers that have survived. Furthermore, human resources might be a concern because equipment can end up in private hands, such as former employees.

The article "Preserving the Technical Heritage" discusses the shortcomings of technological use and cites other articles (Schärlig, 2001) to indicate that regular copying of electronic documents to current high-quality storage media is essential for reliable long-term archiving. The required programmes or multimedia applications must be available when texts, tables, drawings, and diagrams are handled later. These must be installed regularly and matched to the environment's platform, operating system, or device. Electronic storage media, such as magnetic, optical, and semiconductor storage, are inappropriate for long-term archiving. Migration, which involves moving to new file formats, storage mediums, operating systems, or programming languages, is one of the fundamental approaches for long-term preservation. Emulation, a device and software simulation, is the other method.

Another article contributes to the concept by looking at how digital technologies transform the museum value chain in the Internet world. In this information environment, the lines between the offline and online worlds are fast blurring (Simone, Cerquetti & La Sala, 2021). The article's detailed literature review depicts the current situation of museums' usage of digital technologies. The current evolving environment discusses the impact of Information and Communication Technologies (ICT) on museums' fundamental production processes. Lastly, the article addresses four approaches to digital transformation: a back-office approach to improving cultural heritage preservation, an onsite approach to enhance museum experience quality, an online approach to extend museum experience beyond museum doors, and an onlife approach based on multisensorial and interactive technologies. The ultimate goal is to make museums more accessible and create a hybrid museum experience.

Another essay discusses the essential – and sometimes overlooked – aspects of what it means to be "digital" in the cultural context and findings on strategic planning for the growth of digital museums (Kamariotou, Kamariotou & Kitsios, 2021). Another article also acknowledges that museums undergo substantial changes in their content and operations due to the ever-changing world (Chepurda & Tomiuk, 2020). The function of museums in preserving and interpreting cultural heritage, in complicated processes of social adaptation and cultural identity, in educational settings, for example, and in organising leisure is clear.

The Routledge International Handbook of New Digital Practices in Galleries, Libraries, Archives, Museums, and Heritage Sites paints a fascinating picture of how today's cultural institutions are changing due to creative digital technology applications (Lewi, Smith, Vom Lehn, & Cooke, 2020). The Australian Research Council Discovery Grant and a University of Melbourne Cultural Engagement Grant supported the Routledge International Handbook of New Digital Practices in Galleries, Libraries, Archives, Museums, and Heritage Sites, as well as the DigitalGLAM symposium. Several professors and practitioners in heritage and technology are featured in the book. The book brings together a diverse group of academics and practitioners who contribute to developing new digital practices in galleries, libraries, archives, museums, and cultural sites worldwide. The Handbook offers a breath of fresh air in terms of new ideas and directions for the upcoming digital problems and opportunities. As a result, reading should be required for scholars, students, designers, and professionals interested in post-digital culture production.

Fiona Cameron's chapter in the book, 'Theorising heritage collection digitisations in global computational infrastructures,' lays the groundwork for re-thinking fundamental theoretical notions that run across the entire handbook collection. Andrew Dewdney similarly rejects binary classifications favouring a significantly more complex depiction of the post-digital state. He proposes that culture is becoming increasingly technological and technologised and that, as a result, technology can no longer be differentiated from the culture. Ed Rodley's chapter 'The distributed museum is already here: it's just not very equally distributed' expands on the idea of the post-digital museum in the twenty-first century. Rodley examines a museum structure that is more rhizomatic in view and thus lacks clear definitions of cultural delivery from the centre to the periphery and from the museum custodians to the visitor, based on Nancy Proctor's formative thought on the distributed museum.

Even though it had nothing to do with museums, the handbook includes an edited version of Bethany Nowviskie's keynote speech on 'Speculative collections and the emancipatory library,' which she gave at Harvard University in 2016. Furthermore, Andrew White and Eugene Ch'ng examine the acceptance of digital technology in China's museums and cultural heritage institutions, questioning its value-add to the current museum-going experience in China through a close examination of technical currency and adoption. In his chapter 'From planned oblivion to digital exposition: the digital museum of Afro-Brazilian heritage,' Livio Sansone from Brazil gives a fascinating account of how a digital cultural museum came to be. Sara Perry and colleagues tackle a fresh set of obstacles in another collaborative initiative that transcended digital and physical international borders. They remark on the importance of shared story-telling while visiting heritage sites in their chapter 'Shared digital experiences promoting collaborative meaning-making at heritage sites.'

The book also discusses the digital's challenges and prospects for archives and archival practice, including creative reuse, digitalisation, and ethical engagement with users and other stakeholders. The practical and ethical shift that feminist ethics of care brings to the process of digital archiving is discussed by Michelle Caswell and Marika Cifor. Ola Uduku writes on the Alan Vaughan Richards Archive digitisation project in Lagos, Nigeria. Richards was a well-known architect in Lagos until he died in 1989, and his assignments included homes, universities, and industrial structures. Furthermore, Thomas Kvan, Peter Neish, and Naomi Mullumby discuss the more practical aspects of digitising the William J. Mitchell collection's "hybrid archives" at the University of Melbourne. Tin-Kai Chen's chapter highlights the work he and others have done at Taiwan's Kaohsiung Museum of Shadow Puppet to preserve and bring back to life an archive of videotapes and other documents from the dying art of shadow puppetry. Gregory Markus, Maarten Brinkerink, and Brigitte Jansen's work explore the idea of repurposing or remixing heritage artefacts in an aesthetic approach to generate new methods of cultural knowledge.

John Hindmarch, Melissa Terras, and Stuart Robson investigate if digitised items may have the same aura as real objects when creating compelling experiences. Based on their research at the Science Museum in London's Shipping Gallery, they believe that 3D-scanned artefacts can effectively impact if presented in the right way and contextualised by the information that comes with them. The chapter 'Configuring slow technology through social and embodied interaction' by Areti Galani and Rachel Clarke explores the findings of a research-through-design study of people's engagement with a digital interactive display. The chapter 'Exhibition design and professional theories' by Kate Sang, Richard Glassborow, and Louise King take a distinct exhibit design approach. From conception to implementation in an observatory, the authors examine the evolution of an interactive exhibit. Jeffrey Levin, Robert Checchi, Lori Wong, Garson Yu, and Edwin Baker use the Buddhist cave temple at China's Mogao Grottoes to demonstrate how immersive technology may enable the experience of an immoveable site in their paper 'Meeting the challenge of the immoveable.' In a completely different global setting, Adam

Muller's chapter addresses the Embodying Empathy project, which was carried out in Canada and looked into the history of Indigenous Indian residential schools. Moreover, Sarah Kenderdine describes the DomeLab, a hemispheric projection that generates immersive visualisation through digital media, as a remarkable endeavour to build a fruitful relationship between numerous international research and GLAM organisations.

The book describes exhibition design initiatives from the designers' perspective. Indigo Hanley discusses the work of Sydney-based studio Lightwell in 'Human-centred design in digital media,' which analyses the relationship between exhibition design, technology, and the visitor experience. In 'Unlocking the glass case,' Peter Higgins continues his study of the possibilities presented by digital technologies. Paul Gurrumuruwuy and Jennifer Deger explain an approach to exhibition design that incorporates technology to generate 'dhäkayanawuy from,' a social aesthetics that strives to transform visitors' interactions with the museum and each other; in 'The law of feeling: experiments in a Yolngu museology.' The exhibition Henry VR, displayed at the Art Gallery of New South Wales, is examined by Andrew Yip, Paula Dredge, Anne Gerard-Austin, and Simon Ives. Gurrumuruwuy and Deger also conclude their chapter by encouraging museum professionals to employ this technique in the design of their shows, so enriching all of our lives.

Tim Jones and David Simpson explore how the Christchurch Art Gallery Te Puna o Waiwhet in New Zealand expanded the scope of their online offering in the aftermath of the terrible earthquakes in 2010. Jones and Simpson discuss the website's remarkable transition into a magazine-style publication that pulls together the wide range of textual and visual content generated by museum personnel every month. Julia S. Kuehn's talks about how the open-source digital publishing platform. 'Interpreting the future,' Tony Holzner's last discussion piece, examines the opportunity that emerging technology provides GLAM organisations to produce value for people.

Digital technology and our relationship with place are also discussed in the book. This book contains several authors who elaborate on this topic. Anthea Gunn outlines how the Australian War Memorial created Art of Nation, an online exhibition of WWI paintings. Mitchell Whitelaw presents Succession,' a project in the northeast of England that exploits digitally created unpredictability. Whitelaw's account demonstrates the generative techniques by mixing images from several internet sources to create new collages that offer further readings and responses to location. Hannah Lewi and Andrew Murray also adopt a historical approach to tracing the roots of rephotographing, a method that juxtaposes historical and current photos of the same viewpoint.

Finally, Cristina Garduno Freeman explores how Google Maps has become the primary medium through which we experience sites of heritage and significance. Wally Smith, Dirk von Lehn, Hannah Lewi, Katie Best, and Dora Constantinidis look at how people use digital walking tours to learn about cities' histories, using examples from GLAM and historical organisations in Melbourne and London. Sara Huws, Alison John, and Jenny Kidd talk about creating a unique audio guide for Cardiff's St Fagans National Museum of History. Steven Cooke and Dora Constantinidis explain an examination of a web program called PastPort, which provides an online platform for citizen-generated heritage when discussing the potential of digital heritage as a resource for communities to grow. Diego Merizalde and Jon Voss describe how the National Library of Colombia and the worldwide digital history platform collaborated on a project to help Colombians recover after decades of internal violence. Alicia Marchant also tells the narrative of how she designed and built a website to capture people's emotional attachment to the Derbal and Djarlgarro river systems in Perth, Western Australia.

1.4 Intangible Cultural Heritage

Heritage includes both tangible and intangible artifacts/objects such as man-made items, natural resources and customs, the practices of the ancestors respectively. Tangible heritage is further divided into movable and non-movable artifacts, as shown in Figure 6. When we talk about heritage, we imagine physical objects and artifacts: the tangible heritage. Because of appearance, we rarely think of the connected events, people and behaviours when we see these physical objects. Heritage preservationists acknowledge the importance of these non-physical aspects, leading to the notion of intangibility of a culture: therefore, the term Intangible Cultural Heritage (ICH) emerged. In 1972, a comprehensive concept of world heritage came into existence via UNESCO, in the form of the “World Heritage Convention” (Ruggles & Silverman, 2009). UNESCO defines ICH as the practices, representations and expressions—as well as the cultural knowledge skillset—that a community or individual form as a cultural representation (Kurin, 2004). Various manifestations of ICH include memories (Gandhi & Gandhi, 2009), music and arts (Fitch, 2005), practices, rituals and festive events (Simpson, 2009), and traditional craftsmanship (Conan, 2009). It is a body of knowledge and the process of remembering, forgetting and communicating (Harrison, 2013).

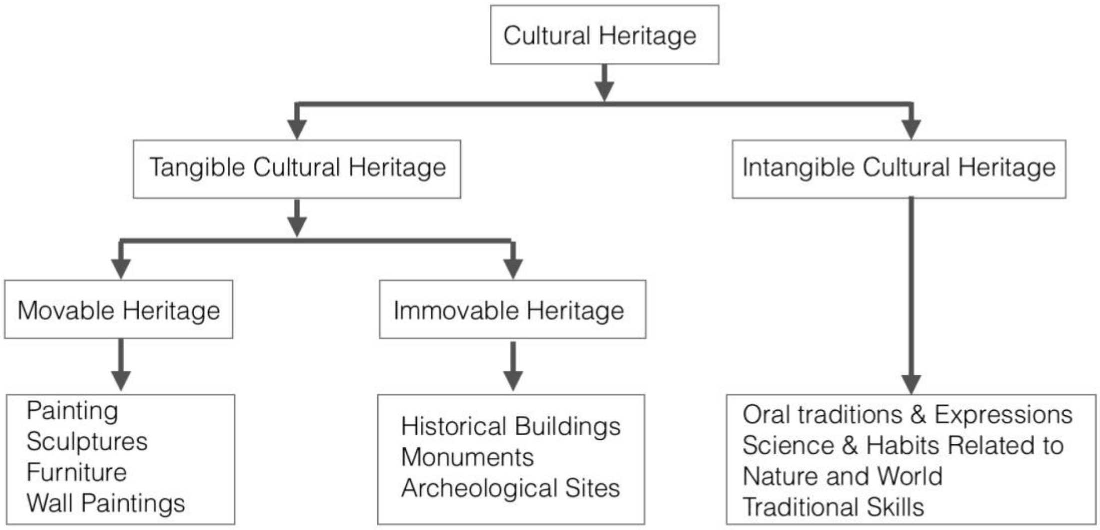

Figure 6. The various forms of heritage as defined by UNESCO.

Although, it is the fact that the past cannot be created as it was actually because once it becomes the past it loses its 'presentness' (Silberman, 2004) but there is still a need of taking measures for the preservation of both tangible and intangible heritage assets to ensure their true essence. That is why the concept of ICH has been developed on the basis of the concept of 'folklore' and now the masterpieces are emphasized along with the masters of the past. It was quoted by William Logan that heritage is something related to the people more than the tangible and inanimate objects and this quote defines the concept of ICH (Ruggles and Silverman, 2009).

ICH considers human's imagination, their actions as well as their thoughts. Even it is believed that if the actions of the past or present are not being mimicked then it is likely to influence the future actions in ICH scenario. As it is being discussed that ICH includes intangibility also which has been defined by UNESCO in a very understanding way. It defined intangibility as the representations, practices, expressions, skills, knowledge and capabilities recognised as a part of the cultural heritage by the individuals (sometimes) or the groups of individuals (Ruggles and Silverman (2009). Similarly, the term ICH has been defined by the department of Tourism, Culture and Recreation, Government of Newfoundland and Labrador in Canada, as living heritage which is also known as intangible cultural heritage (intangible aspects indicating the culture) (Intangible cultural heritage, 2001) which generally include viewpoints, customs, traditional skills, languages, music dance, oral traditions etc. These are some representations of ICH. It may also include the songs sung in the community, the knowledge of stars, the spiritual beliefs, weaving particular patterns into cloth and so on (Kurin, 2004).

ICH has undeniable importance for uniqueness of the culture and it also provides the guarantee for the sustainable growth in the globalisation (Lupo, 2007). That is why the new trend is not to register and protect the dying heritage rather it is about now to conserve the heritage and to nurture the tradition through creating favourable circumstances so that the culture can be propagated. There is a need to preserve the culture in a way that more emphasize on the protection of the present social values and ensure that these values can be reclaimed by the forthcoming generations in its original forms (most possibly). Although, the heritage variants are not recognised as they are supposed to be globally (Simpson, 2009) but improvements in new-media can play a major role in ensuring the recognition of the cultural heritage (Brown, 2005).

1.4.1 Emerging Intangible Cultural Heritage Representation

Cultural heritage, both tangible and intangible, and evolving multimedia technologies, with dedicated journals, conferences and educational programs, are today regarded as developed academic domains, along with more recent and still emerging related sub-realms such as DIH. The goal of this study is not only to summarise the literature on ICH, but also to speculate on how new technologies may aid in the implementation, sustainability and transmission of ICH to future generations.

When there is social interaction, knowledge is gained. DIH is a depiction of ICH through the digital realm, and it is a recent phenomenon. The domain is new and currently is rapidly evolving because of the emerging interactive technologies and new ways of looking at human interaction with these technologies. The notion of its dissemination, engagement and preservation will be more apparent with time. Museums' articles and their visitors' behaviours have been evolving. AR/VR and emerging sensor-based user interaction will also wholly change human interaction with the past's nonmaterial culture. Moreover, there will be a need to document and archive these emerging interactions for future generations. The methods, procedures and framework to archive and preserve these new interactions will be based on AI and unique data mining strategies. Hence, the traditional preservation strategies will no longer be applicable in AR/VR and emerging sensor-based non-physical installations/exhibits.

It is believed that creating an immersive and engaging experience for the representation of the cultural heritage is very critical (Adams et al., 2004). The experiences get meanings when the ideas and the concepts are controlled and explored appropriately by the users. Experience is acquired when there is clarity of purpose, social engagement, design factors and learning. This is the reason for the change or shift in the asset's representation related to heritage from tangible to intangible or from visible to invisible.

In the current times, the experiences of the visitors include the linear interactions which can be defined as the interactions where the information is received and the visitor is unable to skip, start or stop the information. The non-linear interactions on contrast are based on the interactions where the visitors have full autonomy in terms of selection, running and retrieving the information. The linear displays influence the users or the visitors with the extravagance of the visuals or multimedia. On the other hand, the non-linear interaction is based on the touch screens as well as the interactive displays in order to challenge the mental capabilities of the visitors and for retrieving the information. The basic goal is actually about allowing the users to create deep understanding of the application of the content in an easier and natural way (Ganotto, Mainetti, & Paolini, 2008).

The Amsterdam Historical Museum and the exhibition accompanied by it known as 'East' exemplifies the non-linear interaction through the collection of the stories (Alivizatou, 2004). Similarly, the collection of the first virtual elements is exhibited by the oral histories with the same goal of preserving ICH. The theatrical events are sufficiently portrayed as well as recorded by the museums as the elements of the heritage collection (Alivizatou, 2004). As mentioned earlier, the displays and the content exhibited by the museums are now relatively more interactive and non-linear as compared to the past when these were non-interactive and linear (Leinhardt & Crowley, 2002). It has become the need for the museums to adopt the interactive mean for providing the information by using interactive information retrieval system because of the increased trend of the online information. For instance, the "Pockets Full of Memories", exhibited on the main floor of the Centre Pompidou National Museum of Modern Art in Paris (Legrady, 2002) is a good and most suitable example of the interactive installation that motivates the visitors to make contributions in terms of generating the visual but descriptive information to the digital archive related to a certain object, they possess. "Pockets Full of Memories" was an attempt to embody the information within an interactive kiosk but the actual information becomes accessible online once the visitors visit the site.

Pockets Full of Memories, conceived as an installation on the theme of archive and memory, was exhibited from 10 April to 3 September 2001 on the main floor of the Centre

Pompidou National Museum of Modern Art, Paris. Approximately 20,000 visitors came to see the installation during this period and led to their possession of over 3,300 objects, which were digitally scanned and identified. This information was stored in a database and arranged by the algorithm Kohonen Self-Organizing Map, which placed objects in a two-dimensional map with identical descriptions close to each other. In the gallery room, the object map was projected and was also available online where people in the gallery and at home could study the objects and add comments and stories to each of them. Somehow, the website is no longer available, but the Kohonen Self-Organizing Map algorithm is available here: http://users.ics.aalto.fi/teuvo/teuvo/teuvo/teuvo/teuvo/teuvo.

This is only an existing instance of an immersive exhibit like this. In the future, more engaging and astonishing user engagement will be omnipresent with interesting and mind-engaging content created on AR/VR platforms. Figure 38 in the thesis shows the proposed intervention and framework for DIH content selection, altered creation, users' feedback and additions, and content archiving as a digital repository. This proposed framework is presented for the preservation of future AR/VR interactive engagements. The idea is to document the interaction as a repertoire and guidance for future generations. It is also essential to know that the discussion in the thesis is not about comparing the old and new methods of archiving. There are diagrams and explanations for speculating on future interactive technologies in the context of emerging technologies related to AR/VR and DIH.

Even after being so considerate about the preservation of the cultural heritage the preservationists still face the challenges in terms of diminished indigenous songs and languages of all the cultures. The emerging technologies are however very effective in terms of providing entertaining, meaningful and endless learning opportunities. It is necessary to learn the languages because there are more than 6700 languages are spoken worldwide among which the top ten languages are preferred and used by 40% of total population of the world whereas if top twenty languages are considered so they are spoken by half of the world's population but the misfortune is that after every fifteen days a language die (Dalby, 2002).

Considering this fact Marett and Barwick (2003) discussed about the diminishing indigenous Australian songs and languages. Therefore, the preservationists of the Australia felt the need of making collaborations among the performers, experts, the concerned authorities and the relevant communities for revitalising the music awareness being an important element of Australian cultural heritage. They further mentioned the present localised existence of indigenous musical culture in Australia. This musical culture is needed to be protected urgently because the oral history seems to be incapable of passing it to the next generation. Since the society has been getting modernized but the traditional culture is being neglected as now only fewer festivals are arranged or the events promoting the folk songs/lore are just held once in a year. Even though ICH is registered in Australia (in Australian National Intangible Cultural Heritage List) but it is not ensuring the preservations of the context, details and the nuances for the forth coming generations.

The role of emerging technologies is significant in preserving the cultural heritage as well as in ensuring the oral past as evident by the today's kinaesthetic, interactive computer games on the motion-sensitive Xbox Kinect, Nintendo Wii and PlayStation Move greatly helps to record, preserve and provide the virtual game-based learning activities related to the contemporary hip-hop and break-dancing scene. Similarly, these technologies can help (if used strategically) to conserve the traditional customs, languages, musical culture, dance culture that can be felt through bodily experience only otherwise.

As mentioned above, cultural heritage, both physical and intangible, and evolving multimedia technology, with dedicated journals, conferences and educational programmes, together with more recent and still developing related sub-realms such as DIH, are now considered to be developed academic domains. The aim is not just to summarise the ICH literature, but also to speculate about how new technologies will promote ICH's implementation, sustainability and transition for future generations. It is very important to create an immersive and engaging environment for the portrayal of cultural heritage (Adams et al., 2004).

Immersive experiences with Head Mounted Display (HMD) systems, for instance, can give a mechanism for revitalising ICH. Until now there has been no sufficient research presented and published that has examined the necessity of the purposeful use of new media particularly in heritage-related premises. However, the advantages of AR in relation to learning and teaching justifies their application to ICH (Jayfus, 2008). Moreover, mobile AR systems are very effective as they are capable of enabling the visualisations of the intangible unseen content (either 3D or not) as well as adding "edutainment" value in today's cultural heritage sites (Papagiannakis, Singh, & Magnenat-Thalmann, 2008).

1.5 Digital Intangible Heritage: A New Multidisciplinary Domain

Heritage is a verb rather than a noun (Harvey, 2001), and research shows that heritage study is now an interdisciplinary field (Smith & Akagawa, 2009). It is a verb that implies heritage as a mechanism and as an instrument of human action and organisation. Heritage may be a contemporary type of a substance created by historical events and the transformation presented, manifested and enforced by the later generation of those changes in the past. In the context of this thesis, physical heritage is the by-products of intangible heritage. In other words, material culture is a manifestation of people's individual or collective thought processes. Cultural heritage is something very significant for the communities (Asante, 2003) because it defines the past and present identities of the individuals as well as for itself (M.Zhang, 2010). Due to its significance, the cultural heritage is needed to be conserved and preserved which is about keeping the cultural heritage from present for the forthcoming generations (Smith, 2020), and when the arts, science and technology in the heritage get combined with the perceptual immersion, it enters into the digital preservation sphere. DIH can portray the embodiment of the senses and conscious-level enactment of the past—feelings, actions, memories and interaction through the digital realm.

Moreover, when extra measures are required to reconstruct cultural heritage, it is known as restoration and digital restoration (in time and space). It is argued that the role of media advancements in spreading the awareness for cultural heritage is very prominent and significant that is why the media around the world should contribute in this regard. The collected assessment from this study will serve as a resource for those interested in merging VR/AR and sensor-based technologies with heritage content for archiving and transmission of cultural data. The cultural heritage keeps developing and is not static as discussed by Noriko Aikawa Faure (2009). The basis of the main idea of the concept of heritage relies on ICH which must be safeguarded. Therefore, it is believed that the practitioner or community-cantered approach should be adopted for ensuring the validity and continuity of the cultural heritage. The ubiquitous presence of these emerging systems in the near future may create several challenging situations; therefore, a critical assessment of community involvement can ensure the authenticity of heritage (Byrne, 2009).

Heritage can be defined as a set of cultural processes and practises that people use to connect with modern society and negotiate its future, such as in terms of continuity or change (Holtorf, 2020). Heritage is a cultural and social process that involves remembering actions to produce new ways of understanding and engaging with the present. It is commonly acknowledged that cultural heritage values and uses are not fundamental and eternal but rather change with time in response to their social and cultural context. As a result, cultural heritage can be beneficial (or even harmful) to the many valuable practices and processes it is tied to.

The preservation of visible cultural heritage is only a tiny part of the many ways in which the past is invoked and given meaning in modern cultures (Holtorf, & Fairclough, 2013). There are a variety of strategies and approaches that can be used in relation to the past and cultural heritage in society, including storytelling, carrying out shared traditions, celebrating religious services, staging site-specific performances and other art projects, creating digital reconstructions and augmented realities, realising physical recreation, practising role-play and living history, and designing. All of these approaches and many more offer choices for restoring cultural heritage even in the face of severe physical destruction.

Heritage has been used to promote discrimination, social exclusion, racism and divisive political ideas that are unjustified. It can unite people, engage them with one another and their values, improve well-being and provide meaning, inspire global collaboration and strengthen cultural resilience. Cultural legacy can help society foster social integration, promote lifelong learning, provide jobs and contribute to long-term sustainability. On the other hand, cultural heritage has dangers and can have negative consequences, such as dividing communities, promoting hate and prejudice, discouraging innovation and impeding growth. Some historical interpretations, such as those made by state authorities and elites based on cultural legacy, are problematic because they contradict or marginalise the values and identities of marginalised groups in society. The impact of cultural legacy, whether positive or negative, is closely tied not only to what it represents in connection to the past and who we are as descendants of previous generations, but also to what it does in the present and who we want ourselves and our descendants to become.

We must examine the projected benefits and potential hazards for future generations of any current actions, including the physical reconstruction of cultural heritage. However, few heritage industries are systematically concerned with the future (Högberg et al., 2017). The desire to pass on cultural heritage to future generations as a human legacy is frequently portrayed as completely unproblematic, absolutely good and universally praised. Even while the future motivates conservation in the first place, there is a general lack of concern for advances and changes over time and the ramifications of expected human requirements in future societies.

Global cultural heritage is a valuable commodity (Otero, 2021). It is a significant industry that generates millions of jobs and billions of dollars in income each year. However, despite the enormous economic and socio-cultural benefits, conservation and the development of creative big-picture tactics to update its professional field receive little attention. This viewpoint tries to assemble some of the most pressing global demands to consider various approaches to developing the United Nations' 2030 Agenda for Sustainable Development's future steps. From this vantage point, it is envisioned how rising AI and digital technologies can represent an alternative transformative solution by overcoming the heritage conservation community's current global communication and technical restrictions.

As mentioned earlier, when cultural artifacts are digitised, a new form of heritage is born; this is known as "digital cultural heritage", sometimes also called "heritage information resources" (Lor & Britz, 2012). It has moved beyond the mere representation of artifact, user interaction and even user immersion. It is heading towards a phenomenal handshake with big data, AI and the crowdsourced environment. In this way, heritage representation is expecting to create another form for its existence and ontological discussion. This is the time when this domain needs to extend its discussion, moving beyond methodological naturalism, and embarking on the subjective representation of the past. This unique way of representing events from the past could foster cultural autonomy, not heavily reliant on synoptic and synthetic manifestations, instead originating a new form of classical *technê, logos* and *ethos.*

There are several scholarly descriptions about technology and its friendship with the past. A prominent publication that theorises on the subject is "The Wired Museum: Emerging Technology and Changing Paradigms" by Jones-Garmil (1997). More recently, "Theorizing Digital Cultural Heritage: A Critical Discourse" by Cameron and Kenderdine (2007) also discusses the subject. The articles in this publication illustrate and theorise the practical aspects of digital heritage. Researchers discuss the ontological aspects of the heritage and its manifestations through the digital realm. Since this collaboration is in its early stage, more branches and sub-categories are emerging from this interesting phenomenon—and DIH is one of them.

Within "Theorizing Digital Cultural Heritage: A Critical Discourse" edited by Cameron and Kenderdine, is a collection of 22 essays by a diverse group of authors from around the world who critically evaluate and theorise on museum and heritage subjects. The editors wanted to move away from a simple descriptive and introspective language, focusing on projects and their technical issues instead of the deployment of digital technologies themselves. Rather, the focus was on the relationships formed within philosophical, historical, social, artistic, biological, geographic and linguistic-cultural complexes. On the other hand, the completely theoretical was to be avoided in favour of a mix of theory and practice.

DIH is a transdisciplinary approach to inquire about the intangible past with the support of emerging tools. The inquiry reinforces the cyclic process of representation, reinterpretation, archiving and perpetuating folklore or living heritage, as shown in Figure 7. Not necessary in every attempt, the process gives life to the masterpiece and the master in a digitally intriguing manner. The resultant and accumulated deliverables of this enquiry foster awareness about the intangible heritage and may sometimes evaluate, archive, preserve, reinterpret and perpetuate heritage-related activity in either a traditional or contemporary manner. Intangible heritage is a living activity, and its lively character also homogenises communal contribution and cultivates an attractive invitation to everyone inside and outside the norm. Hence, “through a process of collective recreation”, the enquiry and related activities correlate with the definition of ICH by UNESCO (Kirshenblatt-Gimblett, 2004).

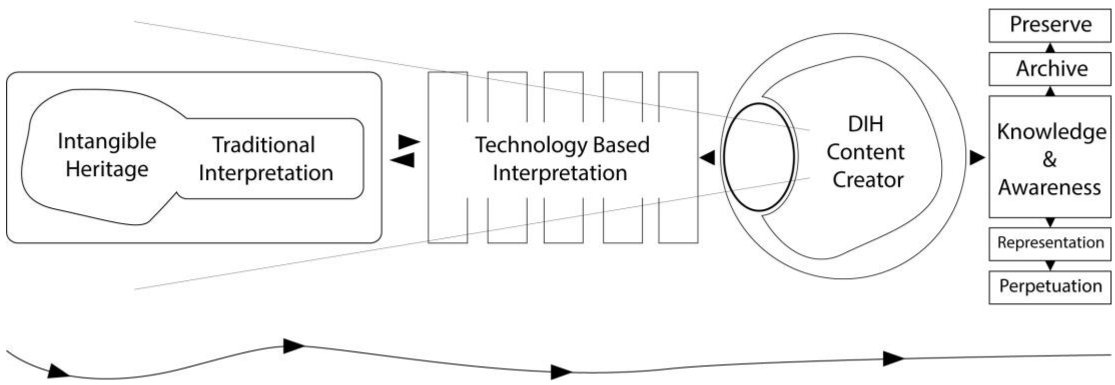

Figure 7. The system of inquiry related to the Digital Intangible Heritage and its flow from traditional to technology-based interpretation.

It is hard to define the word "culture" (Crang, 2013)—and technology is a cultural construct. The meaning of culture is concurrent to the cultural values and imagination of a people (Hayles, 1999). People no longer experience the past simply by making the effort to go to a museum, festival or historical site. Now, they can interact with one of the three screens—television, cinema, computer and handheld devices—to experience previous civilisations and their livelihoods. The impact of this is powerful and these technological interventions could permeate every aspect of human life. Museums, in their current form, are also affected by this technologically driven tsunami, but its impact is overall a positive one. These new technologies and devices not only display artifacts from the past, but also engage audiences in a novel manner. Sarah Kenderdine and Jeffrey Shaw, in *A Cultural Heritage Panorama: Trajectories in Embodied Museography* (Pok, & Wei-hsin, 2014), discuss the ontology of heritage representation with emerging technologies:

> When dealing with the representation of cultural heritage in these installations, we do not intend to overtly assert translation of real-world phenomena in the implementation of the digital or virtual. Nor do we assume that a mapping of phenomenological attributes of material forms in the virtual are possible or even desirable. We do not equate historical forms of representation (for example, rock art)with the potential of the digital transcription. However, we do believe that a wide cross-referencing to preceding strategies of representation and interpretation better enables us to articulate new forms of engagement and embodiment to produce new experiential interfaces for cultural heritage that must, if we are to do our work well, have their own intrinsic aura. (p. 198)

The six installations discussed in this chapter contribute to the reformulation of somatic, kinaesthetic and embodied experiences in immersive digital spaces and the reframing of cultural heritage interpretation. These installations are intended for significant public exhibitions and were developed through a series of transdisciplinary experiments in large-scale, interactive cinematic projection systems. The immersive display systems and their accompanying visual, audio and algorithmic methodologies are based on world heritage from India, Hong Kong and China, and provide compelling ways for mapping and remediating cultural heritage landscapes.

Furthermore, David Thorburn, Edward Barret and Henry Jenkins, in a book edited by Cameron and Kenderdine (2007), write about the digital realm and state that new media will be historical, comparative and accessible. While new technologies are transforming, archiving and preserving cultural artifacts, they will also have an impact on the control and proliferation of archival data as assets. This is a new form of digital asset that results from: (1) digitised old artifacts; (2) thoughtfully integrated digital methodology; and (3) their careful deployment to heritage-related environments such as museums.

The characteristics of the digital medium present the conventional preservation techniques with various challenges, ranging from exhibition to selection and preservation. Museums, galleries and creative industries in general have been largely "object oriented" for the longest time and have designed their system and infrastructure to support the static art object's presentation and preservation. The features of so-called new media art have initiated a shift from object to process and will change conventional notions of preservation and preservation strategies. Because of social media and crowdsourcing techniques in the future, the data will be massive and scattered worldwide. And that will create even more challenges for museums' management to document and archive their artifacts.

1.6 Types of Intangible Cultural Heritage/Digital Intangible Heritage

The linkage between cultural heritage and cultural diversity has been studied by Arizpe (2004) where he also argued that ICH is the major source of development of human society. As in human societies or communities the linguistics, cognitive as well as the normative values act as the premises or context under which the society functions. These values have an ultimate effect on the decision-making process and their capacity of creating culture. Then the culture gets transformed with the passage of time. Over the centuries the new norms and style get built even sometimes two cultures assimilate and give new meanings to the culture. Khutiyattam in Indian culture, Kunqu Opera in China and Nogaku theatre in Japan exemplify the evolvement of the new styles in the culture. Even the important creative ideas and masterpieces are the outcome of the merged cultures. The communication among various cultures enhance through the organic flow of ICH and its embedded elements. As stated, that the culture is something that keeps on developing so it is vital to document and archive the ever-evolving character of ICH content so that the culture can be cross-pollinated and celebrated by the future generations.

To deploy, choreograph and perpetuate the ICH manifestations such as memories (Gandhi & Gandhi, 2009), oral tradition (Arizpe, 2004), music (Fitch, 2005), traditional craftsmanship (Conan, 2009) and the cultural practices (Simpson, 2009) the Kinaesthetic-learning based exhibit is effective because can uniquely deploy them within the museum by providing the challenging scenarios and entertaining feedbacks embedded in the ICH-related content.

ICH and DIH have various forms of representation from the individual, community and nation. Since digital technologies are now part of our lives and everyday encounters, we tend to use them without acknowledging their existence. When the electric motor first came out, it was prominent, and its physical presence was noticed in our daily lives. Now we are not even aware of its presence in our mobile phones, watches, etc. Similarly, the acknowledgement of new technologies and their presence is becoming invisible in our lives. We interact with these technologies in a very similar way to the physical objects in our past and present. Together with them, we will create a new form of heritage, a new paradigm of cultural representation.

In the following section, I illustrate examples of ICH and DIH and talk about their various manifestations in the context of performing arts and dance. The examples given are closely connected to my interests and experiences. For instance, I play the *tabla* (a subcontinental percussion instrument). I have also worked with my father in his clinic and still practise the "Unani" medicinal system; this enables me to speak about Unani practices and methodologies. I have worked on several apps related to dance and body postures, so I can also discuss cultural dances and the martial arts.

1.6.1 Performing Arts

The definition of performance is contested among researchers (Conquergood, 1995). Conquergood quotes Victor Turner, who says that "performance is making not faking" (p. 138). Performance is a shift from poiesis to kinesis; new activity related to movement and dynamics. For some, it is a reinvention of nature (Haraway, 2013); for others it is a creative and continuous process. When performativity materialises as a performance, its cultural meanings and critical evolutions begin (Diamond, 2013). Schechner (2004) refers to Erving Goffman's book, "The Presentation of Self in Everyday Life", and argues that performance coexists with different human conditions. He further clarifies that people, with or without deliberation, are always involved in role-playing and constructing multiple identities. He further categorises performance as an inclusive term. It is the illusion of an illusion, therefore considered more truthful than ordinary experiences. He also affirms Aristotle's point of view, reinforcing the realness of performance as it vitalises reality.

According to Phelan (1993), recorded and physical performances are different in nature. The recorded manifestations of living performance cannot be categorised as performance. A live performance, if recorded, turns into something else, and it should no longer be considered a performance. However, Auslander (2006) categorises documented performances as another form of performance. According to Auslander, the documented performance is also a performance in itself and forms its own identity. Interestingly, Taylor (2003) contributes to this discussion by arguing that repertoire and archive are essential sources of information and can create embodied memories. She argues that archived data from a tangible and durable media can recreate and transmit only through repeating bodily patterns and codes—a type of mediation. UNESCO's website also states that documented data can raise awareness about ICH (Bortolotto, 2015). Hence, the compression of live performances and their documentation is important in heritage (Pietrobruno, 2014).

There are two different kinds of performances: one includes the display of skills and the other just display (Carlson, 2013). Sometime, when addressing the performance of a child at school, for example, it is not the display of skills, rather a recognised and culturally coded pattern of behaviours. The emphasis is not so much on display, rather it is the assessment or standard of achievement, which may not correctly articulate the actual display of skills. Performance is also different in the case of theatre. Carlson, (2013) refers to Richard Bauman from the International Encyclopedia of Communication and further explains that all performances involve a consciousness of "doubleness". The idea suggests that the genuine execution of an action lies in the complete immersion of one's self in a given role, i.e., the original model of the action, the one you are trying to emulate. Most of the time, audiences, theatre attendees, evaluators or scientists make this distinction. However, this does not always happen as it should in every performance. Consciousness of doubleness is not always an internal process; a sportsperson continually evaluates his/her performance (external process) and improves on skills by comparing performance with internal standards. Carlson (2013) further explains that:

> …practitioners, almost by definition do not base their work upon characters previously created by other artists, but upon their own bodies, their own autobiographies, their own specific experiences in a culture or in the world, made performative by their consciousness of them and the process of displaying them for audiences... (p. 5)

Carlson mentions Milton Singer's work on "cultural performance", and says that cultural content can be transmitted by media as well as by people of a culture. It conveys certain concept similar to theatrical performances, such as limited time, beginning and end, an organised program of activity, and so on. In addition, Hansen (1996) defines cultural performance as “a way of persuading through the production of pleasure” (p. 53). Play is also related to performance. A recent study related to play was conducted by historian, Johan Huizinga, and according to him, the activity of play is a free and meaningful activity, carried out for its own sake. Spatial and temporal requirements are not present in this activity. Play as an activity is bound by its own rules and detached from practical life. According to Huizinga, play is not a serious activity. However, some researchers argue against this, particularly in the context of a serious game environment. Miura, (2000) also narrates the concept of doubleness from the paradigm of theatre:

> …I must insist on this idea of an active culture, a kind of second wind growing within us like a new organ, civilization as applied culture, governing even our subtlest acts, the spirit alive in things. The distinction between civilization and culture is artificial, for these two words apply to one and the same act… (p. 23)

Albert Einstein addresses this internal conscious-related discussion when he talks about consciousness (Hathaway, 2017):

> A human being is part of a whole, called by us the ‘Universe,’ a part limited in time and space. He experiences himself, his thoughts and feelings, as something separated from the rest—a kind of optical delusion of his consciousness. This delusion is a kind of prison for us, restricting us to our personal desires and to affection for a few persons nearest us. Our task must be to free ourselves from this prison by widening our circles of compassion to embrace all living creatures and the whole of nature in its beauty... (p. 185)

1.6.2 Dance

There are numerous challenges in the process of learning to dance from the perspective of an instructor or choreographer. For instance, a dance instructor spends a considerable amount of time with one or more students when choreographing and composing a movement. Sometimes this tedious process can take weeks or months and requires a teacher–disciple relationship. A large space is also sometimes essential in which to move around freely and work on dance notations—an expensive feature in teaching and learning dance.

The complex and interdisciplinary knowledge of dance has been a part of the UK-based university curriculum for nearly 35 years (Bannon, 2010). With its multifaceted interface between themes and ideas, dance is continuously absorbing knowledge from other disciplines. Dance, from choreography to performance, combines the body, brain and other senses intelligently. Video used to be the main means of documentation and presentation of dance for choreographers and teachers. However, computer assisted technologies have gained considerable attention (Birringer, 2002). Researchers are also curious about dancers' movements and graphical representations. Various methods have been used to understand human movements as a collection of fixed points. The human body has been studied in various fields and disciplines, and related theories are constantly changing. As a dance teacher and dance historian, Brooks (1993) illustrates the complexity of this investigation by the involvement of various languages, cultures and nationalities.

It is imperative to distinguish between analytical and intuitive forms of movement (Sutil, 2012). Movement analysis is a theoretical approach in which the frozen frame of the movement is analysed and investigated and then presented graphically. Various methods are deployed to evaluate body movements during dance performances, and the most prominent methods are Labanotation (Laban, 1950, 1980; Laban & Ullmann, 1971) and Benesh Movement Notation (Benesh & Benesh, 1969). In 1878, Eadweard Muybridge used a photographic technique called "chronophotography" to study movement (Muybridge, 1957). As for the standardisation of human movement, the Laban/Bartenieff Institute of Movement Studies in New York offers a unique program. It is a non-profit institution and educational entity, which concentrates on networking, scholarly research and cultural arts. According to the institute, movement is the first and foundational language. The institute teaches subjective and educational aspects of movements and their multicultural nature. The program and its outcomes have been studied by several researchers, such as Sutil (2012), Madden and Gantz (1990), and Billingham (2009).

Laban Movement Analysis (LMA) is a prominent methodology developed by Rodolf Laban and improved over a period of time. The methodology and related language have been developed to visualise, describe, interpret and document body movement. The approach is multidisciplinary and incorporates knowledge such as human anatomy, psychology and physics. The system is designed to incorporate inner motivation for movement of the body to its outer functionality. With the help of LMA, the value and meaning of a particular body movement can be established by the help of notations language. The system is helpful in eliciting the audiences' emotions through carefully choreographed body movements and by a dancer's intention and expression. In 1980, Irmgard Bartenieff extended the methodology and injected Bartenieff Fundamentals (BF)

(Hackney, 2003). This system categorises movement into six further divisions: body, effort, shape, space, relationship and phrasing. These subdivisions can be isolated and evaluated in relationship to one another.

The method can be deployed in any form of human body movement. The system is famous for its four studies: LMA, Anatomy and kinesiology, BF, and Labanotation. LMA illustrates the in-depth analysis of the body action. It monitors the four categories of movement: Body, Effort, Shape and Space (BESS). Researchers have used the system to assess the behaviours of autistic children (Durand et al., 1996), rats (Foroud & Pellis, 2003) and the Japanese macaque (Vasey, Foroud, Duckworth, & Kovacovsky, 2006). Furthermore, there have been several attempts to incorporate LMA/BF into the digital realm, such as in handheld devices ("Moving Space: The Laban Scales on the App Store on iTunes," n.d.), for animators ("CGTalk - Workshop: Laban for Animators," n.d.), and in the field of robotics (Lourens, van Berkel, & Barakova, 2010).

The Benesh Movement Notation (BMN) records human body movements and has been used successfully for many genres of dance (Singh, Beatty, & Ryman, 1983). The system is reliable, practical and has been frequently used in clinical studies such as physiotherapy (Harrison, Atkinson, & De Weerdt, 2009). Research shows that Labanotation is more comprehensive when it comes to complex body movements (Shukla & Choi, 2013).

An interface was also designed to merge LabanWriter, a word-processing-like software for dance notation, and Life Forms, an animation program created for choreographers to plan and visualise a dance (Fox, 1999). The National Initiative funded the software for Preserving American Dance and the National Endowment for the Arts. The program allows dancers to practise dance without being present on stage. Dancers can see the notation in an animated visualisation. New interdisciplinary research in technology and dance began in the mid-1990s, when sensors, computers and emerging technologies started to make interventions into the realm of dance and performance. The notion of performance went beyond a single domain and came to be considered a collaborative activity.

To document dances in the digital realm, two-dimensional methods such as video capture were quite common until recently (James et al., 2006). However, over the past 20 years, motion-detection technologies have opened up many new exciting possibilities. The data captured through these systems can be easily incorporated into real-time graphics and sound design software and, furthermore, provide tremendous opportunities for a dancer to express harmonious movement. A number of dance-related installations and digital interventions in the field of dance have given way to new areas of investigation and exploration for scholars to study this new form of digital culture and its various impacts (Calvert et al., 2005). With the help of digital technologies, several dancers have also developed ways to incorporate digital tools into their dance practices and performances. Images, sound and other related sensor-based technologies have played a role in enhancing the impact of dance notations on audiences. Michael Noll mentioned examples of digital intervention in *Dance Magazine* in 1967. New York choreographer Merce Cunningham also talked about dance and digital technologies around the same time (Copeland, 2004).

Moreover, there have been several notable attempts to incorporate digital technologies into dance installations, such as the interactive installations Trajets (Calvert et al., 2005), and Whispers (Nunez-Pacheco et al., 2014). In the Trajets installation, motorised screens respond to visitors and their movements with the help of computer vision. Whispers uses head-mounted sensors with wearable wireless handheld computing devices that allow participants to interact with computer displays. Various venues, such as the Monaco Dance Forum (Monaco Dance Forum - Les Ballets de Monte-Carlo, n.d.) and the Digital Performance Archive (Smith, & Dixon, 2007) present a similar amalgamation of art, dance and emerging technologies.

In addition, some systems also manipulate the auditory senses based on the performer's actions on the dance floor. In these movement-based interactive dance systems, such as Lucidity (James et al., 2006), the choreographer and dancer, with the help of their movement, can easily change the music and onscreen graphics. In this way, every performance has a unique feel and look. Markers on the dancers' bodies convey spatial and temporal data to the screens with real-time audio and graphics—an interesting method to integrate improvisation into the performance.

In addition, spaces for dance are evolving into new forms with high-tech gadgets. With Very Nervous System (VNS), developed by sound artist David Rokeby, body movements are transformed into sound, music and video projections in real-time (Winkler, 1997). Systems like EysWeb (Camurri et al., 2000), Music via Motion (Ng, 2004) and BigEye or Eyecon (Birringer, 2002) are using camera and motion-sensing technologies that trigger responses and feedback in real-time as well as explore interesting interactions between dancers and their invisible partners. A similar concept has been created by Escape Velocity, where two remote dancers can interact with each other (Tait, 2000).

There are some online archival repositories such as Siobhan Davies Dance Archive in the UK ("Archive ← Siobhan Davies Dance," n.d.), Digital Dance Archives – University of Surrey, Guildford (Digital Dance Archives, n.d.), Dance Collection Dance (Bowring, 2011) and numerous online incentives to record and archive dance (Whately, 2008).

Cross-institutional collaboration with multidisciplinary methods is also generating some interesting results. Ohio State University's Advanced Computing Centre for the Arts and Design and the Department of Dance collaborated with William Forsythe in 2009 and launched an Internet-based project, Synchronous Objects (Shaw et al., 2009). This is an interesting attempt to quantify choreography and its visual presentation. This cross-disciplinary project tries to understand the intricacies of choreography with the use of 3D animation, annotation and interactive graphics.

The Synchronous Objects project is built around explorations of one dance work, One Flat Thing, reproduced in 2000. Besides the digitisation of the dance, the project aims to analyse and visualise choreographic elements such as patterns and cues. The floating objects manifest the choreographer's organisational intention and decisions. The added or complementary objects have the freedom of timelessness, and they maintain a 3D and sequential relationship.

Communities are now also aware of the preservation and presentation of ICH-related content such as indigenous or cultural dances. The MotionBank project is one of several attempts to preserve body movements in the context of cultural dances (Kahn, Keil, Muller, Bockholt, & Fellner, 2013). The project examines the complete workflow of a dance, and generates the representation of dance in a visual manner. Hand and body movements of the dancers are captured with the use of Microsoft Kinect camera and Software Development Kit (SDK). MotionBack is a low-cost, modular and scalable approach that tries to achieve scalability, adaptability and affordability with a marker-less capturing technique. The proposed workflow is based on 3D head tracking and motion reconstruction. In the future, researchers are hoping to track more dancers with the system and improve the performance of the capturing method.

Besides enabling learning new steps, movements and various dance combinations, emerging technologies are influencing and changing the tradition of dance and performances. Computer vision and motion-sensing technologies have forced users to interact with machines physically and kinaesthetically (Jähne & Haussecker, 1999). Moreover, technology has developed rapidly, and there is always the promise of future adaptations with greater intricacies and complexities in the realm of performance and dance learning. The hybrid juggling of technological tools with traditional art forms also demands an expansion of our understanding of complementary thought processes. These processes drive new interdisciplinary studies and theoretical models. Moreover, this multidimensional combination of the performing arts and emerging technology requires careful attention and multifaceted curiosity as well as transdisciplinary inquiry. Astonishing digital technologies are constantly improving ways to visualise and choreograph movement as well as enhance performance. However, the available digital strategies for teaching dance are challenging in terms of their inability to synthesise the complete aspects of the dance, and are not yet entirely user-friendly. They must incorporate better AI-based motion analysis engines to provide interactivity that is more meaningful.

In addition, the ontological nature of dance and digital presence is generating another form of living heritage, and facilitating sustainable methods. Emerging technologies are shortening the gap between art and science by producing a revolutionary authoring environment (Schulz & Velho, 2011). Esling (2013) characterises the documentation of dance and notes that it is adopting a new “wrapper” because of emerging tools and online presence.

With sensors and thoughtful choreographing, performances are now becoming like a magician’s performance on stage. Dancers’ moving bodies are successfully sending and acknowledging hidden cues. With intricate body movements and spatial awareness on stage, modern dances are now providing a wow factor to spectators. The focus is shifting from a mere performance to the quality of performance led by intelligent computer systems. Delahunta and Zuniga Shaw (2006) discuss the ontological nature of memory:

> ...memory isn’t necessarily fixed at the time of an experience. It is a creative and dynamic process in which the recollection of past events is a condition of present circumstances; where you are and what you are doing when you remember… (p. 62)

This above argument is somewhat similar to and coincides with the statement about ICH being a living expression and constantly evolving in form and characteristics. New technologies are ready to represent movements and dynamics of indigenous dances in a playful and engaging manner. Sometimes, technological intervention is used to create new memories and interpretations, as seen in the Pure Land project (Kenderdine, 2013).

The moving imagery and dancing clips in the project are designed to enhance the content of the painting, hence creating new experiences and embodiments.

The Pure Land projects, consisting of two visualisation systems and their associated applications – Pure Land: Inside the Mogao Grottoes at Dunhuang (2012) and Pure Land Augmented Reality Edition (2012) – are described in this article. Each installation allows visitors to interact in various ways with a full-scale augmented digital recreation of Cave 220 from the Mogao Grottoes, a UNESCO World Heritage site in Gansu Province, northwest China. The Applied Laboratory for Interactive Visualization and Embodiment (ALiVE), City University of Hong Kong, and the Dunhuang Academy, collaborated. At the site, comprehensive digitalisation has become the principal method of preservation. The digital facsimiles of this cultural exemplar have been changed in the Pure Land initiatives, providing formative personal experiences for museum visitors. These projects combine high-resolution digital archaeological resources (photos and 3D architectural models) with immersive, interactive presentation systems. Because the treasuries of paintings and sculptures at Dunhuang are particularly sensitive to human presence and, in the instance of Cave 220, are forever closed to public visits, this effort is extremely important. Both installations have received critical acclaim after being displayed to the public in several museums and galleries across the world. The projects contribute to new approaches to rendering cultural information and historic landscapes and a vision for embodied museography's future. Each project is discussed in depth here, including technological interface application and user experience advances.

The Pure Land projects not only set standards for integrating archaeological data with interactive and immersive technologies, but they also guide us in new directions for the future of museum interpretation. Pure Land and Pure Land AR encourage the mobilisation of the viewer to combine in virtual and real space, which is a substantial departure from the previous exhibition practices and modern cinematic viewing. Other VR forms, such as commercial AR devices, are frequently utilised for digital heritage, but these interfaces limit social contact between real people. Using social dynamics to create museum experiences is a critical mission. A typical CAVE has a strict limit on the number of people it can hold, making it unsuitable for museums with large crowds. Pure Land and Pure Land AR revive the history of the immersive view in museums by establishing solutions for the embodiment of many visitors at once. They also breathe new life into archaeology with the fully embodied interface, extending the role of digital facsimiles to provide new degrees of aesthetic and interpretative experience.

In the context of archaeology and digital heritage, Pure Land and Pure Land AR reawakened the history of the immersive view in museums by establishing solutions for the embodiment of a large number of visitors at once. They also breathed new life into archaeology with the fully embodied interface, extending the role of digital facsimiles to provide new degrees of aesthetic and interpretative experience. With the original under threat from rising tourism and climate change, the Pure Land initiatives and their successors may be the only way to keep the Mogao Grottoes' creative and spiritual brilliance alive for this and future generations through new digital techniques.

On the basis of significance of ICH in Australian current context, a simpler prototype has been developed which can be referred as ‘Indigenous Australian Dance for Kids’. This prototype will exhibit sound, dance movements and the body paints. This app will be a source of encouragement for the children regarding the promotion of indigenous dance in a heritage–related site. This app has been designed on the basis of infrared camera immersed in a Microsoft Kinect device and many patches on a Quartz Composer as well as it includes a visual programming language based on node-based visuals added as an element of the Xcode development environment on Mac OS X to process and render the graphical data. In my developed app when a person moves in front of the camera, an Indigenous Australian puppet appears on the screen and moves as the person moves because the animated images based on QC patch has been inserted instead of live footage behind the background plate. In other words, the puppet on the camera and the skeleton of the person calibrates after which the movement of the puppet can be controlled. Even this app allows Indigenous Australian song during the calibrated period of the app.

Before further discussing the app, it is critical to define and clarify the term "Aboriginal" in this context. "Native" was formerly a common term, but it is now considered to be uncivil and is seldom used in respectful conversations (Joseph, 2016). “Aboriginal peoples” moved into popularity as the correct collective noun for First Nations, Inuit and Métis and was widely adopted by government and many national groups. This distinction became legal in 1982 when the Constitution Act was passed in Canada. The terms "Australian Indigenous people" or “Indigenous Australian” are used throughout the thesis to refer to “Australian Aboriginal”.

According to Bruce Pascoe's book Dark Emu, evidence suggests that indigenous Australian people employed cultivated plants for sowing, harvesting, irrigating, and storing across the continent (Pascoe, 2014). The author contends in his book that indigenous Australian societies should be referred to as "farmers" rather than "hunter-gatherers." They were not mere hunter-gatherers in 1788, but rather farmers. According to some experts, however, Aboriginal people were hunter-gatherers. Others have claimed that indigenous Australians were hunters, gatherers, and fishermen during the time of the British colonisation of Australia, and that at least some groups were farming (Keen, 2021). Another study found that for most of the last 100,000 years, Australia, Tasmania and New Guinea formed a single continent called Sahul, which was separated from Sunda (the continental landmass that includes mainland and western island Southeast Asia) by a series of deep oceanic troughs that were never exposed by sea-level changes (Mathieson et al., 2018). The demographic history of Indigenous Australian is mostly unknown. According to research, Papuan and Indigenous Australian ancestors diverged 25,000–40,000 years ago. Indigenous Australian spoke approximately 250 different languages at the time of European contact.

In the “Indigenous Australian Dance for Kids” app, the puppets' movement could not be properly controlled. After testing, it was discovered that the puppet only moves in general directions i.e., left/right, up/down (only) which makes the children frustrated and disappointed because they want puppet to rotate freely (M. Khan & de Byl, 2011). Therefore, in future there will be a need to integrate a 3D avatar for ensuring the full range of human motion. The following diagram represents the interest and engagement of the selected children (30 children from 6 to 12 years range) which was 83.3% whereas rest of them showed no engagement while trialling the app. However, this graphical representation shows the content enjoyable to the majority of the children.

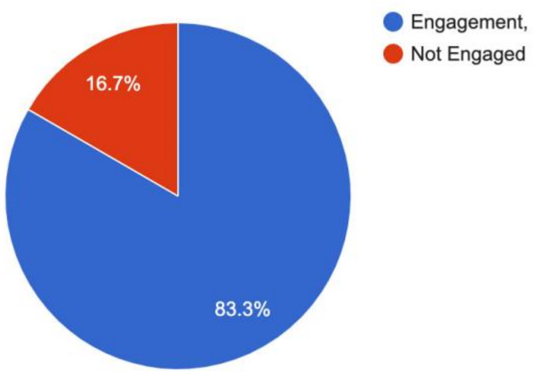

Figure 8. Scoping study with children for the preliminary prototype of the “Indigenous Australian Dance for Kids” application.

The app supporting indigenous dance exhibited favourable and promising results at initials levels as the findings show that the young children were highly motivated achieving the primary objective. The primary goals were to identify the overall effectiveness of the prototype in the premises of ICH with the children as well as the objective was also about to determine the important perceptual and technical additions important for the recommended 3D version of the prototype. Following diagram demonstrates this prototype;

Figure 9. "Indigenous Australian Dance for Kids" application prototype.

1.6.3 MUSE: Understanding Traditional Dances

In new ways, cultural institutions face the future and tackle the task of maintaining heritage content, while keeping relevance and rising attendance. It is now generally recognised that cultural institutions ought to combine their shows with engagement and involvement, and in a fashion that appeals to technology-savvy tourists. The "Mimicry Understanding and Safeguarding Environment" (MUSE) app for museums was proposed and created in this thesis for the recording and transmission of indigenous dances as ICH material. The idea is not only to preserve cultural dances or movements of indigenous human body movements, but also to record and archive new and contemporary postures and styles of the body that develop when imitating indigenous movements. This alternative thinking will create new preservation ways and push cultural organisations to draw new clients into their facilities. There will always be difficulties when running an application to manage software-specific content. People will use technology, however, to continue to find ways to handle this situation. To replicate and conserve artwork, physical articles and even cultural sights, modern methods have emerged.

Similarly, the study also discusses different tools and frameworks implemented across the globe in the case of ICH. Often, there is no harm in using old and conventional methods such as audio/video recording to document patented or special applications based on software. Collaborative and crowd-based techniques also play a key role in coping with this situation, as in the case of Apple's abandonment of Quartz Composer (QC). Even before Apple stopped supporting QC, users and recipients formed their own community and started their own software patch, node and routine to support their previous compositions created by QC. It is now called Vuo: https://vuo.org/qc. A variety of other related examples exist. But in the case of running this software inside heritage institutions, more sustainable methods can be deployed such as open-source digital library software and proprietary software for museums: https://oedb.org/ilibrarian/5-free-and-open-source-tools-for-creating-digital-exhibitions/

In several research fields, including human-machine interaction, robotics, biomedical engineering and even reverse engineering applications, low-cost RGB-D cameras are increasingly being used. Microsoft Kinect is an old bulky depth camera technology. These days, handheld devices have the same and even more advanced cameras inside them. That does not mean, however, that Microsoft's MS Kinect system cannot be used inside museums.

It is vital at this point to review the terminology for cultural asset conservation, preservation and documentation. Conservation and preservation are closely related and may appear to be synonymous. Conservation refers to preserving natural resources, whereas preservation refers to the preservation of buildings, items and landscapes. Both phrases imply some level of protection, but the key distinction is how that protection is implemented. Documentation of a heritage item, on the other hand, is a continual process that allows for the monitoring, maintenance and knowledge required for conservation or preservation by providing relevant and timely information. Documentation is both a product and a process for addressing heritage management's information demands.

DIH content needs to be preserved for its reuse and documentation. DIH content is the digital assets, programs and internal computer routines that have been updated, amended, altered or transformed from their initial form by visitors and users of future exhibits. The users and visitors are the next generations of young people who will develop and improve the entertaining digital activities while playing and interacting with the exhibits. I am also speculating that, as technology evolves and expands its capabilities every day, it will be possible to automate the documentation and preservation of future DIH information by the technology itself.

For the documentation and transmission of Indigenous Australian dances as ICH content, I designed the “Mimicry Understanding and Safeguarding Environment” (MUSE) app for museums. Microsoft Kinect device was used in the system to capture human body movements and joint positions. This is explained further in my published paper reproduced below.

Khan, M. (2014, March). MUSE: Understanding traditional dances. In *2014 IEEE Virtual Reality (VR)* (pp. 173-174). IEEE.

ABSTRACT

This demo encapsulates the possible manifestation of Middle Eastern indigenous dance, *Al Ardha*, in the form of a serious gaming environment. The presentation also illustrates the interconnection and possible transformation of Intangible Cultural Heritage (ICH) content, such as traditional dances, into a digital kinesthetic learning system. The system is called Mimicry Understanding and Safeguarding Environment (MUSE). It is designed to help museum visitors learn traditional or indigenous dances with the help of motion-sensing technologies. MUSE is a multidisciplinary research project and is expected to analyze the intricacies of various indigenous dances, particularly the Arabic sword dance. MUSE interface is expected to facilitate museum visitors' awareness, learning, and practice of the *Al Ardha* dance of the Middle Eastern region. Through its easy-to-learn and user-friendly interface, MUSE can facilitate and foster playfulness and user engagement to enhance the experience of museum visitors.

Keywords: Virtual Reality, Motion Sensing, Heritage, Culture, Augmented Reality, Digital Humanities, Virtual Museums, Intangible Cultural Heritage, Cultural Dances, Cultural Studies.

INTRODUCTION

These days, novel interactivity can be seen among individual, social, and communal spaces with the use of new gadgets and the latest sensors. Computer vision- and motion-sensing technologies have enabled users to interact physically and kinesthetically with the digital environment in many more ways. However, museums around the world are just beginning to adopt these new forms of interactive exhibits. A number of digital interventions inside museums have already opened up new boundaries for investigation and exploration in which a scholar can address new forms of digital culture and their various impacts on socio-economic and socio-cultural situations. The hybrid combination of these new tools with traditional art forms have also required that researchers investigate inter-disciplinary issues that can drive new theoretical models. MUSE will examine unconventional ways in which Intangible Cultural Heritage (ICH) content can be presented and perpetuated in a heritage-related environment [1]. This simple and intriguing set-up inside the museum can easily stimulate multifaceted and multidimensional curiosities among museum visitors. Hence, they not only see the heritage content, but also interact with it kinesthetically [2].

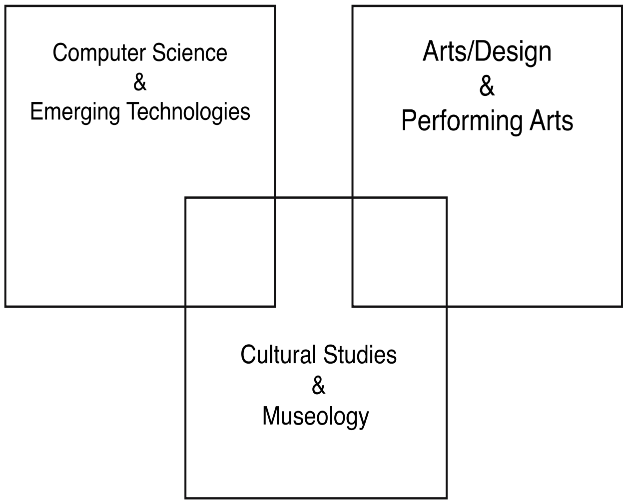

Figure 1: Inter-disciplinary study for museum professionals.

OBJECTIVES

- There are three objectives related to this proposed investigation:
- Is it possible to generate added value through the use of motion-detecting technology in fabricating emerging exhibits for cultural spaces?
- How do motion-detecting technologies enhance visitor engagement inside museums?
- What are the ways in which motion-detecting technology-based ICH content can be made re-usable and transferable?

DISCUSSION

- *Al Ardha* is a famous traditional dance in the Arabian Peninsula, shown in figure 2. This study will examine the process and methods whereby the *Al Ardha* dance can be transferred from the traditional to the digital domain. This museum installation will inaugurate a new form of heritage representation with a non-linear and interactive user interface that can go beyond conventional screen-based cultural representations. The initial prototype is intended to embed an artificial intelligence-based dance instructor in a virtual environment. This dance instructor will be the key visual cue for visitors to interact with the prototype and learn the *Al Ardha* dance. This prototype will be assessed in a controlled museum environment to evaluate the efficacy of motion-sensing technology inside museums, the interaction of museum visitors with the exhibit, and visitors' learning outcomes.

Figure 2: An anticipated inter-disciplinary study for museum professionals.

Various technology-based installations have been introduced into museums of late. However, they do not promote ICH content as much as they can. Moreover, there are displays and screens for visitors to watch, but there is not much scope for visitors to interact with the exhibits in a playful manner. These exhibits do not fully exploit a serious gaming environment and, therefore, users do not learn indigenous practices, dances, and so forth. These conventional installations rely heavily on simple visuals, which present some ICH-related content in a linear fashion. For that reason, complex ways of learning about the past and opportunities to acquire and perpetuate cultural heritage are not common in museum settings. On the other hand, museums around the world are increasingly exploring intangible aspects of culture besides tangible ones; moving attention from the visible to the invisible. This new shift can be easily extended with the help of emerging technologies such as motion-capturing technology.

The author has been exploring various forms of ICH content, such as calligraphy, indigenous practices, and traditional dances, with available and emerging motion-sensing technologies. He has also presented some of his work at the TED@Doha conference in 2012. Videos of this TED talk can be found at:
http://talentsearch.ted.com/video/Muqeem-Khan-Playful-technology;TEDDoha

The conception of a virtual *Al Ardha* tutorial is also an extension of some preliminary studies related to Australian aboriginal dance, videos of which can be found at:
http://www.youtube.com/watch?v=r32o50nTIG0

Initially, a two-dimensional application, “Aboriginal Dance for Kids” has been fabricated and evaluated as a scoping study with 30 children, aged 6-12 (23 female, 27 male) [3]. It was noted that they were predominantly pleased with the application and found the content enjoyable. Since the avatar was a two-dimensional interactive puppet and the user could not see the avatar in a three-dimensional format, the range of movements were very limited and they felt frustrated while turning right or left. They could not rotate the puppet, as shown in Figure 3. For that reason, a 3D game engine was required, together with an appropriate avatar and virtual environment.

For this 2D application, the object-orientated programming language Quartz Composer (QC) was used with some Java and Objective-C patches. While using QC, limitations related to the true 3D environment were noted and the Unity 3D gaming environment was deployed to perceive the full three-dimensional experience. Moreover, Apple has stopped developing QC in their new operating systems, so it was important to migrate to an available 3D gaming environment such as Unity 3D that offers multi-platform tools for user interactivity with better file transfer protocols with applications such as Autodesk Maya, Studio Max and Blender.

With current and available skeleton-joint limitations, such as neck and ankle joints, in Microsoft Kinect, the application is still limited in its ability to respond fully with users’ actions and positions. However, it is anticipated that the new Kinect device from Microsoft will resolve many of these challenges [4].

METHODS

In this application, participants will first calibrate with the avatar and then look at the six basic steps related to the *Al Ardha* dance on the screen. These dance steps would help the participant to perform and interact with the avatar. Participants can also see an *Al Ardha* dance video in a small window on the screen.

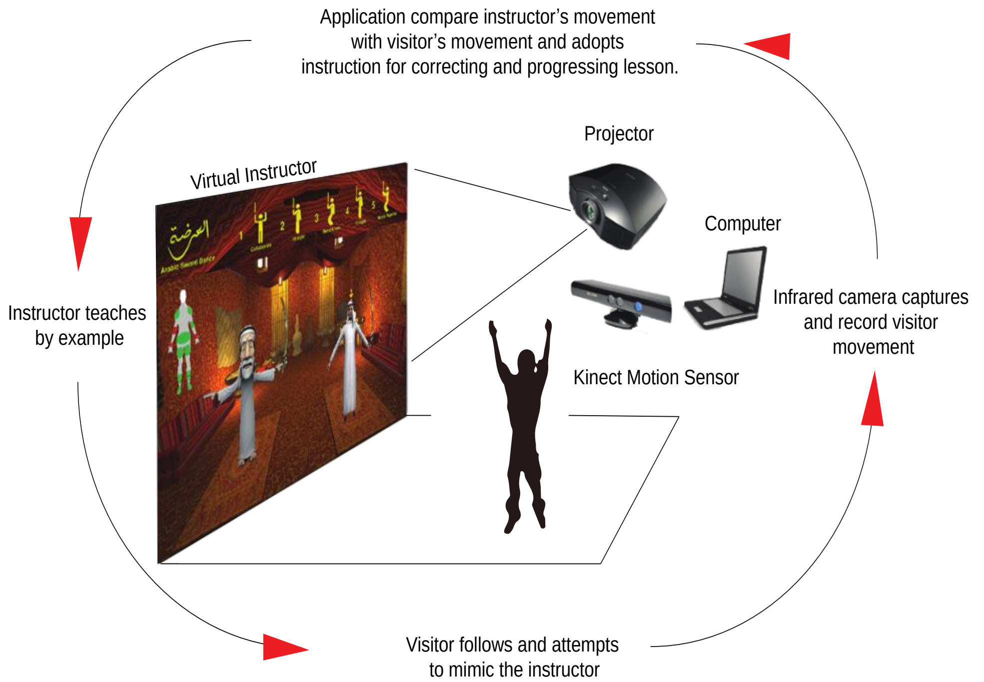

Figure 3: Projector/Computer Screen and area for the user in front of the screen represents the MUSE environment.

Conclusion

The motion-sensing technology-based exhibit, MUSE, has been developing gradually and initial studies are in progress. Cultural artefacts, costumes, gadgets, and various digital environments are in the testing and evaluation phase. New Microsoft Kinect and other sensors will be tested for the future prototype to enhance the application and user interaction. New instructions inside the game engine are also being tested and various cultural graphics are incorporated based on user interaction. Problems and possible solutions related to user interaction, latency, and perceptions are being documented during this ideation phase of the project. Important data will be collected from further user studies and technology efficacy, impact, and various sustainability issues will be evaluated in the context of ICH.

Acknowledgement

This Research Demo was made possible by NPRP grant # 6-364-5-030 from the Qatar National Research Fund (a member of Qatar Foundation). The statements made herein are solely the responsibility of the author.

1.6.4 Transmitting Al Ardha: Traditional Arab Sword Dance

Al Ardha is a famous sword dance from the Middle Eastern region. To create a motion-detection-based kinaesthetic learning system, I analysed the body postures/dance movements of dancers and attempted to use motion-sensing technologies to document and transmit the inside of this dance. The article below, published in the *International Journal of Heritage in the Digital Era*, outlines my project about Arabic traditional dance.

Khan, M. (2015). Transmitting Al Ardha: Traditional Arab Sword Dance. *International Journal of Heritage in the Digital Era*, *4*(1), 71-85.

Abstract

There is a knowledge deficit about Al Ardha dance movements in Gulf Arab culture, and the dance form is not yet analytically documented. This paper is the first attempt to explain and isolate some of the thought processes related to this indigenous festive activity in the Arabian Peninsula, particularly in the State of Qatar. The study conceptualizes the dance in a manner conducive to its transfer to a digital learning environment designed for user interaction. Aimed at developing a motion detection-based kinesthetic learning system, this study also tries to identify the motor and cognitive skills related to the Al Ardha dance. The anticipated system can provide tremendous opportunities for users to learn the dance-related harmonious movements without the help of a live instructor. The study can also help identify and isolate some of the predominant movements of this dance to investigate its analytical paradigm.

Dance

Prehistoric rock art in India and Africa provide some evidence of human dance forms, as shown in Figure 1 (Chakravarty & Bednarik, 1997). When a human body is engaged in organized movements, the body enacts a dance. It is a creative process whereby dancers use their body shape, gestures, movements and group dynamics to express an idea to their audience with ambiguous and unambiguous messages. Knowledge of the human body is very important in choreography and dance training. The mediated environment and its mandatory conventions have secondary importance in this process. Among all the genres of the arts, dance is the form that takes the longest to learn (Calvert, Wilke, Ryman, & Fox, 2005). While it is an art form and its functionality is not quite vivid among humans, honeybees signal to each other and recruit other bees to collect honey by performing a waggle dance, one of the most remarkable discoveries in the study of animal behavior or behavioral biology in the twentieth century (Dyer, 2002). The waggle dance is a navigational tool for honeybees and an important source of information for the community (Grüter & Farina, 2009).

Figure 1. Rock art in India and Southern Africa, 10,000 to 15,000 BC

Dance and Technology

Until recently, two-dimensional methods, such as video capture, were quite common to document and analyze human motion (J. James et al., 2006). Over the past twenty years, motion detection technologies have opened up many new exciting possibilities. The data captured through these systems can be easily incorporated into real-time graphics and sound design software and provide tremendous opportunities for a dancer to express harmonious movements. A number of dance-related installations and digital interventions in the field of dance have opened up new areas of investigation and exploration for scholars to study this new form of digital culture and its various impacts (Calvert et al., 2005). With the ease of digital technologies, several dancers have also developed ways to incorporate digital tools into their dance practices and performances. Images, sound and other related sensors have played a role in enhancing the impact of dance notations on audiences. Michael Noll mentioned the traces of digital intervention in *Dance Magazine* in 1967. New York choreographer Merce Cunningham also talked about dance and digital technologies around the same time (Copeland, 2004).

There are several notable attempts to incorporate digital technologies into dance installations such as the interactive installations *Trajets* (Schiller, n.d.) and *Whispers* (Schiphorst, 2011). In the *Trajets* installation, motorized screens respond to visitors and their movements with the help of computer vision. *Whispers* uses head-mounted sensors with wearable wireless handheld computing devices that allow participants to interact with computer displays. Various venues, such as the Monaco Dance Forum (Monaco Dance Forum - Les Ballets de Monte-Carlo, n.d.) and the Digital Performance Archive (Digital Dance Archives, n.d.), present a similar amalgamation of art, dance, and emerging technologies.

Besides interactive installations and various visual experiments, some systems also manipulate the auditory senses based on the performer's actions on the dance floor. In these movement-based interactive dance systems, such as Lucidity (J. James et al., 2006), the choreographer and dancer, with the help of their movement, can easily change the music and on-screen graphics. In this way, every performance has a unique feel and look. Markers on the dancers' bodies convey the spatial and temporal data to the screens with real-time audio and graphics; an interesting method to integrate improvisation into the performance, as shown in Figure 2.

Figure 2. Motion capture performance by Aura (Motion Lab, 2008), Interactive 3D Stereoscopic Projection

The hybrid juggling of technological tools with traditional art forms has also demanded an expansion of our understanding of complementary thought processes, which can drive new interdisciplinary studies and theoretical models. Moreover, this multidimensional combination of the performing arts and emerging technology requires careful attention and multifaceted curiosity as well as trans-disciplinary inquiry.

Computer vision and motion sensing technologies have forced the user to interact with machines physically and kinesthetically (Jähne & Haussecker, 1999). Technology has developed rapidly and there is always the promise of future adaptations with greater intricacies and complexities in the realm of performance and dance learning, as shown in Figure 3.

Figure 3. A real-world image is recognized by infrared camera-based Microsoft Kinect

Besides the availability of traditional interactivity among individual, social, and communal spaces, there are numerous challenges in the process of learning a dance from an instructor or choreographer. A dance instructor spends a considerable amount of time with one or more students when choreographing and composing a movement. Sometime this tedious process could take weeks or months and still requires a teacher-disciple relationship. Sometimes a large space is mandatory in which to move around and work on dance notations; an expensive feature in teaching and learning dance.

Astonishing digital technologies are constantly improving ways to visualize and choreograph a movement as well as enhance performance. However, the available digital strategies for teaching dance are ambiguous and not yet user-friendly. They must incorporate better artificial intelligence-based motion analysis engines to provide more meaningful interactivity.

Al Ardha: Consciousness and Motor Skills

Al Ardha, the traditional Gulf Arab sword dance, is a form associated with male Arabs of all ages, as shown in Figure 4. Its exceptional feature is its focus on slow, wavy, and rhythmic movements of shiny swords while the body moves up and down with unique neck and head movements. An *Al Ardha* dancer shows his expertise by demonstrating a sword movement synchronized with the auditory senses. Other than a few newspaper articles, there is not much written about the *Al Ardha* dance form. It is also disappointing that not much scholarly work has been done on the subject. Furthermore, it is hard to find experts or skilled *Al Ardha* dancers in the Arabian Peninsula in general and in Qatar in particular. Most of the time these expert dancers are adult or elderly men, working within families. Moreover, a conceptual framework for describing the dance form is also missing, even among the skilled performers, which can define correct or adequate movements on the level of consciousness.

Figure 4. *Al Ardha* dancers in the Arabian Peninsula

Besides other learning theories, cognitive psychology and motor learning address the importance of movement based on consciousness (Hatch & Gardner, 1993). Cognitive learning is the most basic and dominant form of knowledge that humans develop through observation (Ferrari, 1996). Motor learning also shows that human learning is closely linked to motor control processes (Willingham, 1998). Sometimes, dancers' conscious attention or forceful performance of movements turns into habits (W. James, 1890). In other words, a consistent practice of conscious behaviors or movements can be transformed into unconscious acts. When a person mimics others' body postures, movement consciousness is acting independently of movement control (Georgieff & Jeannerod, 1998); two different levels of information. According to Koriat (2000), these two levels of information act during this process; knowledge about the motion and also being aware of this particular or related knowledge. Hence, a conscious inner feedback or evaluation is involved in executing the effective replica of a motion (Flavell, 1981).

Humans attain motor skills in three distinctive phases (Fitts & Posner, n.d.). The first phase is the cognitive phase, in which humans learn the basic skill with verbal aids. The second phase of acquiring a motor skill is an associative period—a transitional period in which conscious performance turns into automation by an additive and subtractive process. In the last phase, an unconscious acquisition of motor skills occurs; here, the movements can be performed fast, with other ideas and distractions in mind (Adams, 1971).

A young *Al Ardha* performer uses cognitive structures, such as cognitive diagrams, strategies, models, and shapes. As time goes by, these young dancers progress by building constantly on the old structure. By the selection of critical characteristics and symbols, as explained in the process of self modeling (Dowrick, 1999), new motor patterns build upon old ones. The young dancers' body movements are independent of the information on movement control.

To assess the current state of the *Al Ardha* dance form in Qatar, the author conducted several interviews with *Al Ardha* experts. One of them is Rashid Al-Hajri from the Qatar Museum Authority (QMA) (Al-Hajri R., personal communication, January 30, 2014). According to Al-Hajri, the dance form is quite poplar at weddings and National Day celebrations. He does not remember when he first began to dance. He became adept at the intricacies of the dance form at the age of sixteen. He then realized that one has to submerge completely into the melody, rhythm, and lyrics in order to become a good dancer. Al-Hajri also mentioned that he did not receive any formal training in the dance form. He just learned it with the help of his father, uncles, and other elderly men. He also identified some of the basic steps of the *Al Ardha* dance form, as shown in Figure 5.

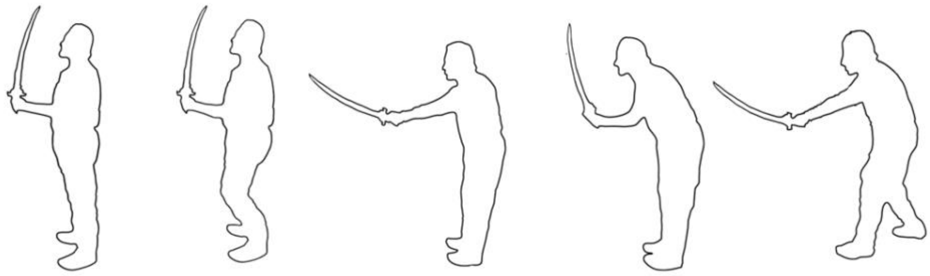

Figure 5. Preliminary studies related to *Al Ardha* dance positions

When a young *Al Ardha* dancer is learning a step demonstrated by his elderly master, a cognitive representation controls his efforts. His ability to compare right and wrong movements and other concepts allows him to transform the information into actions. The process occurs beyond the attention and memory processes, which define the acquisition of cognitive representation. His visual observation of the movements, as presented by his master or elderly family member, allows him to constantly adjust his repeated patterns to improve his dance steps. The process continues and ends sometime after the young learner achieves the desirable cognitive representation or associated dance step. Consequently, a repeated sequence and sets of improved representations of the *Al Ardha* dance form are produced from the young dancer's memory, which are very similar to the dance steps and walking cycles presented simultaneously by his elders around him.

It is quite common for older learned individuals to teach the *Al Ardha* dance steps to young ones. The process of learning happens in quite an informal manner, most of the time by the young performance observing the skilled older individuals. This is very similar to other indigenous teaching methodologies; however, sometimes these methodologies have some established and intricate teaching procedures to transfer knowledge; for example, the classical music traditions of the Indian subcontinent. Many cultures have well-articulated and analytical music theories and verbalizations which help to transfer auditory knowledge. Research on musical cognition has become popular in the last decade (Baily, 1988).

Conclusion

To summarize, the concept of a motion sensing-based interactive dance system is challenging, while holding great potential. More learning paradigms should be studied in the context of indigenous dance forms. Future work must also incorporate the assessment of physiological and other learning theories. It is also important to isolate various dance steps, which are common in all *Al Ardha* dance versions. The verbalization of these dance steps will also create an awareness of the variations of this dance form in different regions of the Arabian Gulf. Young novices in the Arabian Peninsula have traditionally learned their dance steps through observation, imitation, and performance, rather than through formal training. The transfer of dance steps and related knowledge of the *Al Ardha* dance form is an unexploited area of research. Such research requires critical evaluation, regulation, and in-depth explanation of existing aspects of the performance and practices of the *Al Ardha* dance form.

Acknowledgement

This Research Demo was made possible by NPRP grant # 6-364-5-030 from the Qatar National Research Fund (a member of Qatar Foundation). The statements made herein are solely the responsibility of the author.

1.7 Indigenous Cognition

The existence of shadows always carries some major perceptual and interpretive conflicts in the human environment. The first acknowledgement of the concept of shadows can be seen in classical philosophy, with Plato's famous allegory of the cave (Bailey, 1984. The idea of the cave, imprisonment, shadows and an unknown light source from behind, all denote the layering of knowledge or an object of knowledge with various challenges of acceptance. Moreover, Plato's imagination also reveals the character or innate desire of humans to apprehend intelligence when acquiring new and uncomfortable knowledge. The shadows cast on the wall, for example, depict and reveal incomplete perceptions, and the viewer's curiosity allows them to experience the real source of light as the epicentre of knowledge.

Stoichita (1997) refers to Pliny the Elder in the introduction of his book "Short History of the Shadow" and mentions that the first sign of the sketch of a shadow would originate when someone drew the human shadow. He further discusses the dichotomy of light and darkness, and says that light is another side of darkness or darkened light. On the other hand, lightness can be categorised as illuminated darkness. According to Stoichita, the first image was produced in a single colour and called a “monochrome”. He argues that this process is a transformation of nothing into something. Therefore, a shadow has momentous value compared to the full detail of a person; a shadow is more emotional and memorable. The metaphysical aspect of the shadowy perception, which forces us to relate the missing person or obscureness of something to the present time, helps in creating the ritualistic glue between the present and the past.

Representation of shadow also conveys the feeling that the related personality is alive or present in the current time. Research shows that shadows’ theatrical presences are practised all over the world in different cultures and communities (Chen, 2003). Shadows alone were important in the theatrical narrative, and traditionally lantern light was used to cast shadows. Light and shadows were the main ingredients in the earliest form of moving imagery or animated pictures. In 1646, Kircher discussed knowledge about shadows and illumination, in a book titled “The Art of Light and Shadow” (Clee, 2005).

Shadows have been experimented with perspective-based artwork (Kaufmann, 1975). They were incorporated to make the light more prominent. Shadows worked well in those early drawings to create an immersive quality. Their depiction was either realistic or sometimes non-realistic, as in the case of Masaccio’s fresco “Tribute Money” in Santa Maria del Carmine, Florence (Clark, 1951).

Moreover, shadow puppetry is the oldest performing art form, which started somewhere in Asia (Schechner, 2013). It is a medium of storytelling where flattened puppets are moved behind a brightened screen to tell a narrative. Shadow puppetry became a well-accepted form of entertainment, similar to animation and films. The puppeteer sometimes also produces a sound and moves these flattened puppets and other objects to achieve different effects on the screen. Shadow puppetry also influenced the understanding of cross-cultural environments. Coleman (1996) shows the correlation between learning a language and shadow puppetry in his research. He refers to the link between learning the English language with a Javanese puppetry performance and an informal discussion after the show. Similar to the historic use of shadows, researchers have also transformed puppet performances with the use of the Kinect depth camera (Zhang, Song, Chen, Cai, & Lu, 2012). In this research, shadow puppets are controlled by body gestures using the Kinect camera. This is an interesting example of the use of depth cameras in the context of ICH and its awareness. Shadows, in some tangible manner, also connote the idea of doubleness and could elicit emotions in a virtual environment. Jacquemin, Gagneré and Lahoz (2011) refer to the use of shadows as a device:

> Digital shadowing is a source of interest in immersive and interactive artworks because it enhances the feeling of presence, and because it is a very intuitive and engaging interaction 'device'… (p. 173)

The depth camera research uses both physical and projected light to generate shadows. The process emphasises the doubleness of a person with projected shadows. Shadows are generated combining the use of a video projector, camera and light source, together with the developed app.

Deliverables of performing arts often involve various other disciplines, such as cognitive psychology. The ontological aspect of performing arts in the context of universality and broader audiences requires investigation into its relation to other social sciences. Besides other learning theories, cognitive psychology and motor learning address the importance of movement based on consciousness (Hatch & Gardner, 1993). Motor learning also shows that human learning is closely linked to motor control processes (Willingham, 1998). In other words, a consistent practice of conscious behaviours or movements can be transformed into unconscious acts. When a person mimics others' body postures, for example, movement consciousness is acting independently of movement control (Georgieff & Jeannerod, 1998). According to Koriat (2000), these two levels of information come into play during this mimicking process: knowledge about the motion and awareness of this particular or related knowledge. Hence, a conscious inner feedback or evaluation is involved in executing the effective replica of a motion (Flavell, 1981).

Humans attain motor skills in three distinctive phases (Hwa, 2019, December 1). First is the cognitive phase, in which humans learn basic skills through verbal aids; the second phase of acquiring a motor skill is an associative period—a transitional period in which conscious performance turns into automation by an additive and subtractive process; and in the last phase, an unconscious acquisition of motor skills occurs—here movements can be performed fast, even if people are consumed by other thoughts and distractions (Adams, 1971).

To build an immersive dance experience, the cognitive sub-process can be used (de Byl, Birt, & Khan, 2012). For this purpose, the app is being constantly scanned by the focused and peripheral visions in order to learn the cues and the feedbacks. According to various researches human's intellect is not sufficient for coding or their capability is limited for storing and retrieving the information from the screen as well (Lang, 2006). For example, the television viewers fall under the category of information processors but in limited capacity model. The information is processed by the viewers through parallel cognitive sub-process related the coding, storing and retrieving the messages being exposed to them. The cognitive sub-process might also be effective in motion-sensing interaction though it makes easier to allocate the resources according to the choice of user. The viewers may have control over sub-processes because they have some authority of allocating resources while using better user interface that allows the visual, emotional and novel interaction. This enables the viewers to retain the interesting things in the mind due to the attention-grabbing feedback provided by the screen while discarding or forgetting the rest. This system allows the use to process the information which only lasts for few minutes while sustaining their engagement with the exhibit that in result ensures the interaction between past and presently stored information.

1.8 Agents of Intangible Cultural Heritage Transfer

Individuals and communities transfer information through testimony (J. E. Adler, 1996). However, not all communal data can be categorised as transferable due to their forms and individual or group preferences. Transferring ICH-related content past-to-present, present-to-present and present-to-future is always a challenging task for individuals and communities. Institutionalisation and rapid industrialisation are external forces that have heavily affected ICH. Intricate teaching methods, such as the master–disciple relationship in Indian classical music traditions, delicate formulations in traditional medicinal systems, and indigenous practices and artisans' information, are all in danger of extinction and need attention to ensure their effective transmission. If attention is not paid to these forms of ICH, most of them are either going to die out or lose their authenticity or formal integrity.

There are certain key agents that facilitate the transfer of ICH content. Some cultures and groups are adamant about these preconditions/agents while some are flexible. Some cultures are comfortable and welcome external influence and change, while others resent them and adopt a protective attitude towards their indigenous forms of ICH. Some cultures perpetuate ICH-related content forcefully while others disregard it. Following are some of the preconditions that serve as vehicles and/or initiators of ICH content in communities. The term "ICH transmitter" refers to the person, group, community or event that promotes and initiates the transformation of ICH content. The term "ICH receiver" in this context is the person, group and/or community which receives ICH content in order to follow, perpetuate or transform it to the next level within a cultural context.

1.8.1 Master–Disciple Relationship

In many cultures, the master–disciple relationship plays an important role in transferring ICH-related content and in constructing the mindset of the knowledge-seeker. For many communities, this relationship helps in preparing learners for the next level of information acquisition. In Japanese culture, teachers help shy students elevate their confidence levels by assigning them repetitive and rigorous tasks (Namai, n.d.). This "do-as-master-says" approach is quite common in Eastern cultures. Some communities think that through this approach, students not only gain considerable confidence, but they also grow in ability to speak their mind. Classical Sufism practises the same method of self-fashioning by cultivating a close relationship between the Sufi master (*shaykh* or *murshid*) and the disciple (*murid*) (Malamud, 1996). Similar practices can be seen among other cultures and faiths (Puttick, 1995). This master–disciple relationship is also evident in other domains, such as music (A. Alter, 2000; Cott, 1974; Neuman, 1990; Slawek, 2000), medicine (Kang, 1990; Qiu, 1988; Y. Wu, 1994) and craftsmanship (Buntrock, 2001; Illich, 1971; Parker, 1987).

The oldest form of learning and knowledge transfer is the master-disciple relationship. The relationship (in which both males were involved) was connected with a reciprocal desire for learning and wisdom in ancient times, such as during the time of the sophists (Kosiewicz, 2018). The master-disciple relationship was significant in the social, cultural and scientific sense, connected with knowledge about the world and the gods, society and ethical norms. Until the time of Aristotle, those notions were synonymous. Sophists were not only teachers – that is, providers of objectified intuitive knowledge about the foundations of the world and the meaning of its existence – but also, like Socrates and Protagoras, they were practising philosophers and educators of the young people who were attracted to them. This reinforced their authority and status among their disciples, who were thirsty for their wisdom and guidelines. Such a connection is contingent on the presence of two individuals: a master and a disciple. When they both agree that such a link will exist, it can be said with certainty that such a relationship exists or will begin to exist. However, it is not proper when one party claims a master-disciple relationship between them without the other party's consent, just as it is not proper when one party argues that no master-disciple relationship existed between them.

The ancient teacher-disciple tradition is also recognised as one of the most celebrated traditions within the Chinese medical system (Solos, Liang, & Yue, 2014). Confucianism's theories are profoundly founded in such traditions of secrecy, private wisdom and honour. Scholars in ancient China were frequently well-versed and educated in medical philosophy, even if they did not practise professionally. The gravity of this tradition in "ancient China" meant that all outstanding teachers were always unusually harsh and used reasonable discrimination against those they deemed worthy of inheriting their knowledge. Geographic isolation, difficulty obtaining books, specialised material produced using local raw materials, various family traditions, the teacher-disciple system and various cultural bonds all contributed to the emergence of many smaller healing modes or methodologies within the greater complementary medicine (CM) system in ancient China. As a result, numerous secrets and healing practices are not documented in the literature and have instead been passed down from generation to generation.

This instructional system was also passed down in Chinese shadow puppetry for generations until the early 1900s (Rollins, 2015). The sonless master would occasionally hire male apprentices from outside their family clan. Typically, the young boy began around 10, or even younger if a family member worked as an apprentice. In both shadow puppeteering and puppet creation, a typical apprenticeship lasted upwards of 10 years. It could then take another 10 years of hard work for an apprentice to be recognised as a master.

In Hinduism, the master-disciple relationship is known as the Guru Chela relationship. In the West, the term “guru” is usually used mockingly, e.g., a media-guru, a political-guru or a spin-guru (Shridhar, 2021). The term "guru" is derived from Sanskrit. “Gu” means darkness or ignorance, and “Ru” means dispeller or remover. Therefore, the guru removes or dispels the disciple's ignorance.

The concept of the master-disciple connection is relatively similar but also different in nature in the context of DIH and the case studies presented in the thesis. The exhibits are expected to simultaneously depict heritage manifestations while also recording new data created by visitors. The process is illustrated through the schematic diagrams presented in both case studies. It is also anticipated that the new updated DIH content will be a heritage asset and should be used for continued application execution. The user of the exhibits will be able to learn about the displays and their functions through augmented learning with more helpful graphics. Hence, the master-disciple relationship is prevalent in these complicated processes and frameworks. The master or knowledge provider, in this scenario, is the exhibit's technology-oriented instructions on the screen and auditory senses, which will guide the user to interact with it. Furthermore, the disciple or knowledge seeker is the user who will get the instructions. I think that these two entities can have the traditional relationship that was mentioned earlier.

1.8.2 Archive to Repertoire: Motion Capture & Motion Sensing Data for Digital Intangible Heritage

It is important to consider the existing record of cultural data and use it for some kind of cultural production. I have long been thinking about how we can transform and use existing archived data to build formulate/construct a possible repertoire? This way, the recorded data in the form of repertoire could behave as a master. A master–disciple relationship can be somehow depicted if this repertoire gives instruction to the visitor about what to do. My following published article highlights this idea and presents a museum installation to transfer archive data to a new form of repertoire.

Khan, M. (2015). Archive to repertoire: Motion capture & motion sensing data for digital intangible heritage (DIH). In *2015 Digital Heritage* (Vol. 2, pp. 197-198). IEEE.

Abstract— This study investigates the transformation of digital documentation of Kung Fu into an interactive performative space for public engagement. The study creates an interface for learning the repertoire of forms from significant lineages from the south Chinese traditions— contributing to the perpetuation of this art form. The investigation will contribute to the theoretical understandings of the relationships between archive and repertoire, specifically in relation to performance and intangible heritage. The intricate user interaction in this study enforces the visitor's perception that the Kung Fu instructor is present behind the screen, which simulates physical intimacy.

Keywords— Digital Intangible Heritage, Serious Games, Virtual Reality, Traditional Knowledge

I. Introduction

The project's philosophical point of departure is grounded in performance theory through orientations such as Carlson's [1] "Consciousness of Doubleness," which posits that the genuine execution of an action lies in the mental compression with the original model of that action. Moreover, the study examines the possibilities to transform archival data to a form of a repertoire for the visitors' performance inside a museum as discussed by Taylor [2]. Taylor argues that recorded information about the performance is another form of performance. Research in performance also explains the notion of intimacy and says that it develops due to the closeness, trust and familiarity [3]. Feelings of intimacy arise because of the physical comfort.

This study is a unique attempt to develop a virtual instructor from the Motion Capture (mocap) data of Kung Fu masters, which will allow users to learn through interactive engagements. The mocap data will represent the Master as a "contoured shadow". This shadowy representation brings the receiver and the transmitter of the heritage content close to each other, as discussed and justified by the research in Shadow Theatre by Kent [4]. Shadows can be regarded as a surrogate for the physical master at the moment of performance. Acknowledging the human-scaled mocap data in the form of a shadowy representation on a human-scaled screen establishes a connection between the data and the visitor through augmented learning based visual feedback on the screen. The proposed scenario will invite the development of a unique and intimate relationship, helping to establish a "master-disciple" bond.

The rationale for carrying out this study lies in two facts: (1) there is a deficit in the research related to motion-capturing and motion-detecting technologies in DIH; and (2) a lack of relevant research in which a mocap performer interacts with

visitors in public spaces to create learning experiences. The use of mocap in DIH and the performing arts is limited and requires further investigation in maintaining the continuity of "production", "survival" and "access" in the realm of digital heritage [5]. The proposed case studies will also fill the gap in the literature by investigating new possibilities where archival data is transformed to repertoire. Hence, the study would benefit both theorists and practitioners in the context of DIH by stimulating the intellectual encounters and cultural interchanges. Additionally, it will contribute to the UNESCO's stated ambition of safeguarding the cultural diversity and creativity of humanity through "the process of collective recreation" and "formal or non-formal education" [6].

II. Scenario

The proposed prototype application uses archival data from the Hong Kong Martial Arts Living Archive. Visitors first calibrate with the avatar and then look at the six basic steps on top of the transparent rear projection screen.

This transparent screen is placed in front of the Chinese wooden partition. One of the sections of the wooden partition represents the shadowy mocap data from the master. The data is monochromatic and shadowy with some three-dimensional details. Visitor or visitor's avatar tries to match or overlap the shadowy representation from the master on the foreground transparent screen. The visitors, one after another, try to mimic

each shadowy body positions and complete the six steps. Since shadowy data is a mocap data, the rotational and translational parameters can be matched with the visitor's avatar through the conditional statements within the unity-scripting environment. Color-coded augmented learning cues help the visitor to match with the shadowy mocap data. A reward is offered to the visitor if all the steps are completed within a specific time. This is a unique technology-based intervention where Kung Fu motion captured archival data will transform into a working prototype as a repertoire. Based on various feedback and other limitations, it is intended that the prototype will be adjusted and modified during the fabrication period.

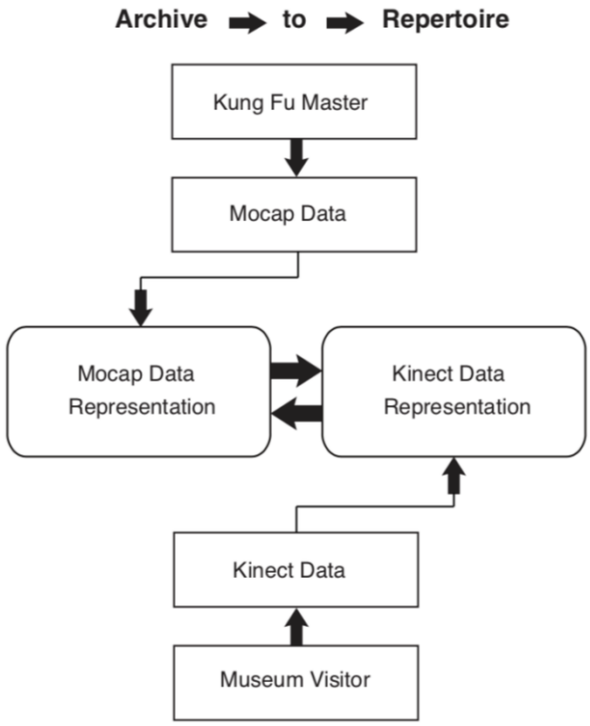

Fig. 2. Schematic diagram showing the transformation of archival data to a repertoire for the learning of Intangible Cultural Heritage (ICH)

III. Evaluation

The study proposes three practitioner-based case studies in distinct geographical regions: Hong Kong, the People's Republic of China and Dubai, United Arab Emirates. The research will undertake extensive evaluation of the application through triangulated data gathering tools such as direct/indirect observation, questionnaire, and interviews to discuss the visitors' responsiveness.

1.8.3 Spatial Configuration and Performing Spaces

Constructing a particular physical setup and spatial configuration may also be a factor in transmitting ICH content. If the appropriate space is not available, many cultural activities cannot be perpetuated. Consider the example of *sumo* (McAdams, 1997), *malkhra* (Black, 2002), *kushti* (J. S. Alter, 1994), and other forms of traditional sport where the right configuration of space is essential for the accurate performance of the traditional sporting activity. Sustainability and perpetuation of ICH content such as dances (Beckwith, 1916; D. Green, 1996; O'Shea, 1998; Ryan & Huyton, 2002), ceremonies, rituals and other festive events are all, by default, dependent on the provision of certain space requirements (Fitton, 1973; Lawler, 1954).

1.8.4 Time Duration, Age and Gender

Gender, caste and family background can also affect the transmission of traditional Indian musical knowledge (Weidman, 2006), and the process of transferring ICH content is sometimes contingent on the age and gender of the particular receiver. For example, the music gurus in Indian classical music traditions must spend a considerable amount of time establishing a close relationship with their potential student before they begin their first lesson (Schippers, 2007). This form of ICH is heavily dependent on the oral tradition, and very little written instructional material is available. However, recent generations are now trying to adopt a faster rather than traditional approach in music instruction.

1.8.5 Qualifications

Formal education/training is not necessary to acquire ICH-related content. In many instances, no formal training opportunities even exist. For example, in the case of the Arab indigenous dance, Al Ardha, children begin learning the dance while they are very young and the transmitters of this ICH content is only their older family members (Deady, 2005). Indigenous music is a cultural artifact and a communicative device among individuals and groups (Rose, 1995), and its learning takes place both formally and informally. When a society collectively elevates its intellectual level, a certain economic pattern emerges; researchers have already related economic growth to unwelcome changes in a society (Inglehart & Baker, 2000).

1.8.6 Cultural Privacy

Transferring ICH-related content is also heavily dependent on the acceptance and rejection of external interventions. Political conflict, modernisation and power struggle among different ethnic groups sometime create acceptance and resentment of outside social norms. Because of these interventions, emotions play a pivotal role and shape culture over time through bodily experiences, asserts Sara Ahmed (2004). While emerging economies have generated industrialised growth, this change has also nurtured cultural commodification and provoked clashes among civilisations. For some, this development is a welcome manifestation of modernisation; for others it is an invasion of their cultural privacy. Hence, ICH-related content sometimes becomes extremely important and turns into an issue of national identity and pride, as in the case of the Arabic sword dance, Al Ardha. The transfer of this ICH content to young Arabs is deemed very important and is much celebrated, particularly during National Day ceremonies.

In the context of indigenous communities, libraries, archives and museums, there are numerous projects to handle indigenous cultural heritage management and related demands. Mukurtu CMS is one of the most well-known, having been used by communities and organisations all around the world (Mukurtu CMS, n.d.). It is designed to be an online access point for digital collections and is managed by Washington State University's Centre for Digital Scholarship and Curation. Another online platform, FORM, exists for cultural arts, learning, social connection and associated activities (FORM, n.d.). It is a non-profit organisation based in Perth, Sydney. These projects have demonstrated how creativity can help individuals and places to thrive, build confidence and influence governments and corporations via their work.

1.8.7 Faith, Beliefs and Myths

Faith, beliefs and communal myths also influence the culture and traditions of societies, and are not only factors in the transmission of ICH-related content, but also sources of cultural activity. Faith plays an important and pivotal role in creating, promoting and transmitting ICH content within a society (Raj & Morpeth, 2007). Poetry and song have played powerful roles in Christianity (Hatcher, 2001), as well as the Judaic tradition, where people gather and listen to *Yadish* folk singers (Metzger, 1984). A new form of art/design and architectural motifs has emerged because of the limitations and boundaries placed upon artistic expression by the interpretation of some of the strictures of the Islamic belief system (Al-Faruqi, 1973).

Above are some descriptions of the agents that influence the transmission and sustainability of ICH-related content in human societies. Some similar sub-agents within the family structure also help in transferring ICH content, for example, gatherings on the occasions of marriage, childbirth and death. Communities repeat and practise their traditional activities in these gatherings, and this ensures the sustainability of ICH content. These family and social gatherings also provide a setting in which ICH undergoes significant changes in form and content. Changes in world politics, conflict among nations or groups, human migration and various forms of colonisation also play a role in creating, altering and eliminating ICH content.

1.9 Digital Heritage and Digital Archiving

It was not that long ago when Onsite Digital Archaeology (OSDA) started, in 1999 to be precise, and with it came a new form of archiving physical artifacts in heritage preservation (Champion, 2005; Levy & Smith, 2007; Levy et al., 2001). However, the digital archiving of ICH content is not that simple. ICH content deals with both memories and methodologies of the past, and hence, can be labelled "intangible policy"—actual or old practices of arts and ceremonies (Champion, 2005). When represented, however, there are some concerns about digital restoration artifacts (Tsiafaki et al., 2015). On the other hand, culture can only be perpetuated if everybody enjoys and recreates it, perhaps in different forms (Liritzis et al., 2015). Roussou and Drettakis (2003) argue that it may not be necessary to have photographic imagery of the past. A credible and convincing representation may be more relevant. With digital cultural heritage, one can use modern techniques to represent the past (Roussou & Drettakis, 2003).

Both approaches, such as emulation and simulation, will be used to store ICH material from the past. Emulation duplicates, while simulation replicates device or environment. In a simulated world, emulation imitates actions closely. Simulation mimics behaviour of a real system. While not currently efficient, in the future, however, the internet will be able to serve as an archiving tool. Indeed, the Web is the largest document ever published, with more than 4 billion public pages and an additional 550 billion linked documents (Lyman, 2002). It is written in 220 languages; 78 per cent of it is in English by writers from every country. Ninety-five per cent of Web pages are publicly available, a collection 50 times greater than the texts stored in the Library of Congress (LC), making the Web the information source of first resort for millions of readers.

Because this study is concerned with the future form of DIH content, it is also necessary to consider its long-term preservation. Long-term digital preservation is defined with the emphasis on dynamic activity within a specific timeframe and is introduced by contrasting it to the notions of digitisation and archiving (Macevičiūtė, 2014). The existing digital preservation framework and approaches may be able to bridge the gap in terms of DIH preservation. I believe that similar solutions will be used to preserve DIH content. The structure of digital preservation is presented in terms of activity elements as defined by activity theory.

Human interaction with technology has always been relevant to activity theory, which is unsurprising given the theory's concentration on mediation and tools (Kaptelinin & Nardi, 2018). This theory's key concepts and principles contain numerous references to various sorts of technology, ranging from the stone axe and potter's wheel to the most powerful computing systems of the time. Activity theory significantly influenced the formation of ergonomics and human factors as a separate field in Russia. In the late 1980s and early 1990s, activity theory began to be used internationally to address new difficulties related to computers and information systems, which was a significant breakthrough in applying the theory in studies of human uses of technology. Several scholars, particularly in Scandinavia and the United States, have pointed out that the idea allows for a deeper understanding of technology and its significance for humans by putting human–technology interaction within a larger context of purposeful human activities. It has become the theoretical framework for research into human-computer interaction and information systems.

In this thesis, I describe a difficult scenario that I predict will develop in the future when ICH-related content is transferred to the digital realm and subsequently shown in a memory institution or GLAM (galleries, libraries, archives and museums). This topic is a major theme in the thesis as a design problem, and it is examined in the context of cultural heritage documentation, preservation and transmission. The digital data generated by the proposed exhibits are depicted through schematic diagrams for long-term digital preservation of future exhibits and for future generations in each of the presented case studies describing the needs for digital preservation. The proposed plan aims to overcome long-term digital preservation to safeguard DIH content for future generations to use. I believe that the government-owned GLAM institutions' longevity will play a vital role in long-term digital preservation compared to private firms' far shorter lifespans.

In terms of online data preservation, it is still hard to predict what will happen next. In future DIH displays, while they will be able to capture and use DIH data for the next generation, I believe that they will address this issue through innovative data archiving methods. The underlying issue with digital data on the internet is not just data (Devendran & Arunkumar, 2020). It actually combines data and metadata, and then metadata about metadata. It is a complicated topic, and research is underway. Another group of people believe in the internet's eternal existence and use internet technology to archive all data. They contend that browsers or browser-like technologies can comprehend HTML, JavaScript and CSS and will continue to exist in the future to access all archived data.

As all of the artifacts in digital-only format are vulnerable to loss due to medium deterioration and storage, I do not think that regularly moving digital data to newer media will fix the problem. Serious problems will result when digital material is unavailable or unreadable. This occurs when the software used to interpret the data becomes obsolete. The data is lost in this scenario because a bitstream is meaningless unless we can interpret it. In future, I believe this issue will be addressed, either through a combination of analogue and digital storage or through other data archiving methods. Digital data preservation has a long history and is still in progress. Numerous methodologies and strategies for digital data preservation have been used in the past. I assume that emerging technologies will provide a framework that combines migration and emulation for digital preservation with fewer technological dependencies in the future.

New technologies have given way to imagination and thinking beyond our typical perceptions. A new cultural revolution is waiting for us to tap into and experiment with. But this time, it will use our senses by eliminating the rectilinear screens (mobiles, TV, computer screens) and incorporating the unimaginable synthetic real world. Many new terminologies have been generated and defended because of the nature of emerging content coming out of this new wave, such as digital/virtual museums, cultural artifacts in cyber-space, and so forth.

Heritage is a process of engagement (L. Smith, 2006), and according to the UNESCO definition, VR-related content that has been transformed from any analogue source is also a heritage (Roussou, 2002). (De Lusenet, 2007) also recognises that "Digital Heritage" is a unique source of human knowledge and expression. Digital heritage includes any digital representation of culture in the form of text, images, motion picture, navigation, virtual environment and/or 3D objects. Digital heritage has three domains: documentation, representation and dissemination (Addison, 2000).

Archiving digital heritage ensures the transmission of cultural knowledge to the general public (Sabharwal, 2015; Tost & Champion, 2007). When a digital environment is created to resemble the reality of the world, it is called a Virtual Environment (VE). By the same token, when this environment offers a sense of presence, it is called a Virtual Reality (VR) based environment. Research shows that VR offers an exceptional tool for heritage representation as well as a means for experiencing immersive feeling (Liritzis et al., 2015). On the other hand, when digital content is mixed with the real-world environment, it is known as an Augmented Reality (AR) based environment. In these virtual environments, sound, video, graphics or GPS data play a pivotal role in mimicking realism and playfulness.

The capacity to overlay computer graphics onto the real world is known as augmented reality (AR) (Billinghurst, 2002). Researchers have tested and looked at AR displays in a broader sense that also encompasses a wide range of mixed reality (MR) displays (Milgram, Takemura, Utsumi, & Kishino, 1995). AR has been tested and employed in computer-assisted learning, manufacturing and medical visualisation. These applications have demonstrated how AR interfaces can allow people to engage with the real environment in new ways. The user can wander around the three-dimensional virtual environment and examine it from different angles, much like a real object, while interacting with real and digital objects.

According to another research article, what was once exclusively available in research labs is now accessible to hundreds of millions of people in their cell (mobile) phones, homes and offices (Billinghurst, Clark, & Lee 2015). Content and applications for AR-enabled devices are now easier to produce than ever before, allowing even non-programmers to build rich AR experiences. With the emergence of low-cost wearable computers (e.g., Google Glass) and head-mounted displays (e.g., Oculus Rift), and the growing number of AR applications accessible, adoption is only anticipated to grow.

Azuma (2016) believes that AR will succeed when it can mimic the power of traditional media like books and films to transform people's perspectives, actions and beliefs. He further argues that many people's lives have been changed as a result of books, films and other conventional media. We will know we have succeeded if an AR experience is powerful enough to give a viewer a different perspective on something, whether that perspective is historical, cultural, social, political or anything else, and it is compelling enough to cause the viewer to change his or her beliefs and behaviours. Today's AR is analogous to VR's early years. Many research systems have been exhibited, but only a few have progressed beyond prototypes in the lab (Azuma et al., 2001). Several hurdles face the field, including technology limits, user interface difficulties and societal acceptance concerns.

Various other terms are also used in digital heritage and preservation such as Immersive Archaeology (Hollins, & Robbins, 2008); Structure from Motion (SfM) (Furukawa & Ponce, 2007; Hartley & Zisserman, 2003; Lowe, 2004; Wu 2007); Gamification (Zichermann & Linder, 2013); Serious Games (Anderson et al., 2009; Forte, 2010;

Liritzis et al., 2015; O'Neil & Perez, 2006); and so forth. These feelings of immersion offer a unique experience and feeling of presence for the user (O'Neil & Perez, 2006). The first digital reconstruction was known as "Virtual Archaeology", a term coined in 1990 (Reilly, 1990). It is visual, static, graphic and oriented to photorealism (Reilly, 1990). Furthermore, when the past is simulated with data and content representation, it is known as cyber-archaeology (CA) (Levy et al., 2012). It is dynamic, interactive and complex, and not just a photorealistic representation of the past (Maturana & Varela, 1980). This process of representing physical archaeological sites has become a challenge as it involves management and re-structuring of archaeometry processes in relation to material culture (Liritzis et al., 2014).

Flickr now provides spaces for the public to interact and engage with World Heritage sites (Garduño Freeman, 2010). Furthermore, YouTube is also attracting the world community to archive DIH in an intriguing fashion. Archiving in the traditional manner is normally controlled by a specific authority, which defines its access and preservation (Bastian, 2003). This older method of archiving is constantly being replaced and challenged by the digital realm (Hartley, 2012). Multiple users are now utilising the data, which results in diminishing centralised control of the digital archive.

People are using YouTube for several heritage-related tasks such as crowdsourcing (Oomen & Aroyo, 2011), heritage-related archiving (Ongena, Huizer, & van de Wijngaert, 2012) and the provision of shared spaces for cultural and heritage data (Oomen et al., 2010). Pietrobruno (2013) categorises YouTube as another archival form, where the listing of content and the content itself is continuously evolving due to the use of algorithms, codes and user choices. Similarly, the Internet is also an archive that allows users to retrieve intangible heritage-related information. These databases on the Internet are helpful in gaining access to multimedia ethnographical archives (Artese & Gagliardi, 2013).

As research emphasises that documentation and achieving heritage content ensures the transmission of cultural knowledge to the general public, the following section describes my attempt to visualise a museum installation for recording human body postures and style. In this way, I foresee new ways of archiving human movements for future generations. In summary, traditional modes of preserving and presenting cultural heritage will go nowhere in the future; instead, technology will complement and enhance these methods for heritage institutions. With the emergence of big data, new data recording devices and methods, AI and retrieving tools like web crawlers will change the paradigm of digital archiving methodologies. These new methods, hardware and tools will be crucial in accomplishing the task to archive Web content to ensure it is not lost for good.

1.9.1 Digital Documentation

Documents related to intangible heritage are also transforming the digital domain. These documents are now being made available to their original owners (Hennessy, 2012). The UNESCO convention in 2003 also talks about guidelines for protecting ICH for the next generation:

> …Measures aimed at ensuring the viability of intangible cultural heritage, including the identification, documentation, research, preservation, protection, promotion, enhancement, transmission, particularly through formal and non-formal education, as well as the revitalisation of various aspects of such heritage. (p. 348)

While documentation of ICH is strictly to preserve the artifacts, the circulation of digital files and content have elicited arguments over ownership. This situation has prompted negotiations and dialogues; hence, local property rights are also in discussion. These discussions occur in multiple layers: (1) the nature of recording or documentation; (2) access and control of documentation; and (3) the technical/visual aspects of archival systems, together with their scope. It portrays the diversity of members of relevant communities when they undergo negotiation for documentation. Because of the cultural sensitivities and sacred material involved in ICH, this is even more important when the documentation is put together for social media such as Facebook. However, these interesting characteristics related to DIH content also raise global challenges in terms of documentation, archiving and retrieval.

1.9.2 Reformulating the Repository: Digital Intangible Heritage, Empathic Design and Greek/Unani Medicinal Practices

Social media, websites and online resources exist for us to present traditional knowledge (TK) and knowledge providers. Careful user-centric design for the interface and online information will help the users around the world tremendously. My following published article provides an example of this type of online resource where a traditional knowledge related to a master of a particular profession can be documented. Empathic and co-design tools may help to design this type of interactive information retrieval site where users can retrieve metadata-based information more easily.

The United Nations emphasises intangible heritage, and calls for the identification, recording, research, retention, protection, promotion, enhancement, dissemination (especially through formal and non-formal education) and revitalisation of various aspects of such heritage. The following published paper is included in the context of digital documentation of intangible heritage so that heritage content can be discriminant and perpetuated.

Through the creation of a digital documentation of Greek/Unani medicinal practices and an experimental web-based interface, the study establishes a new structure for the classification, representation and dissemination of these practices. While some of the material is rephrased in the paper, especially the information about ICH, the approach presented is novel. More precisely, the study explores the analytic recording of Greek/Unani medicinal information and proposes an experimental web-based application in the context of DIH to explore how these traditions can be documented, identified, interpreted and transmitted. Digital recording is a very important feature of ICH; therefore, this paper is included to provide further explanation.

Khan, M. (2015). Reformulating the repository, Digital Intangible Heritage, empathic design and Greek/Unani medicinal practices. In *2015 Digital Heritage* (Vol. 2, pp. 487-488). IEEE.

Abstract— Within the emerging domain of Digital Intangible Heritage, my research focuses on the continuity of cultural knowledge by proposing a new model for access to indigenous methodologies. Through the creation of a digital repository of Greek/Unani medicinal practices and an experimental web-based interface to this archive, the research defines a new framework for the description, representation and transmission of these practices. The Unani medicinal system is entrenched in the Middle Eastern and South Asian regions. Through analytic documentation of these practices, I intend to reveal the intricate relationships between a traditional Unani physician's life experience and clinical practices. For example, I will examine the lifestyle practices of a physician in relation to his diagnostic understanding of lifestyle diseases. Following analytic documentation using a range of digital capture tools and the classification of this material using an extended metadata schema (Dublin Core)— the research challenge here is to create a sympathetic interactive information architecture for the repository. Drawing on 'empathic design', 'design probes' and 'experiencing prototyping' the experimental web-based application

intends to provide users with an intuitive interface through which to retrieve knowledge and experiences related to accomplished Unani physicians.

Keywords— Digital Intangible Heritage, Intangible Cultural Heritage, cultural/indigenous knowledge, user-centric design, empathic design

Problem

As Seong Park [1] has argued documenting intangible heritage is problematic in the countries that do not have maintain heritage inventories. Greek or Unani medicinal knowledge is a traditional knowledge in the Indian subcontinent and plays an active role in Intangible Cultural Heritage (ICH) of the region. Most records related to this system of diagnosis and prescription exists only in the form of scholarly texts, rather than documenting the comprehensive knowledge and practices of physicians themselves. It is essential, as David Arnold [2] has emphasized, that new ways to document intangible heritage be found using digital tools.

Research Question

This research undertakes analytic documentation of Greek/Unani medicinal knowledge and creates an experimental web-based application in Digital Intangible Heritage (DIH) to explore how these practices may be recorded, described, represented and transmitted?

Background

ICH of a community is not about buildings, monuments, and works of art or a landscape. It includes cultural expression

such as dance, cultural knowledge, performing arts, poetry, language and music [3] [4]. Moreover, the term DIH refers to the transmission of ICH in the realm of Information and Communications Technology (ICT). Various digital methods are already deployed to record, archive and transmit the intangible heritage related data for example Hong Kong Martial Arts Living Archive [5] [6] [7] as shown in Figure 1.

Besides Flicker and YouTube integration with the World Heritage sites [8], there are some metadata management and retrieval sites or tools such as Dublin Core [9], Creative Commons [10], CIDOC [11], Schema [12], Open Graph [13] and Twitter Card [14].

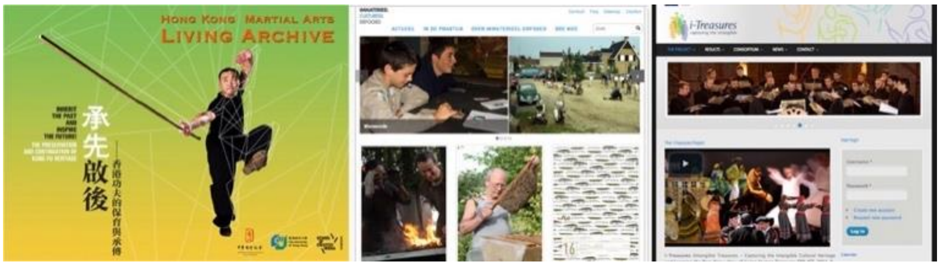

Figure 1. Transform ICH into DIH through Internet and emerging technologies.

Moreover, Unani medicinal practice is a cultural knowledge and it is one of the branches of ICH. Research shows that 'Unani' or Greek refers to the system, which incorporated the ancient Hippocrates philosophies [15] [16] [17] [18]. According to Maarten Bode [19], the Unani medicinal market worth US $800 million in the year 2000, and it is growing fast. Unani universities, research and dedicated hospitals are continuously establishing in the region.

Objective & Theoretical Foundation

Within the emerging domain of Digital Intangible Heritage, this research focuses on the continuity of cultural knowledge by proposing a new model for access to indigenous methodologies. Through the creation of a digital repository of Greek/Unani medicinal practices and an experimental web- based interface to this archive, this research defines a new framework for the description, representation and transmission of these practices as shown in Figure 2. Through analytic documentation of these practices, this research intends to reveal the intricate relationships between a traditional Unani physician's life experience and clinical practices. For example, it is intended to examine the lifestyle practices of a physician in relation to his diagnostic understanding of lifestyle diseases. Following analytic documentation using a range of digital capture tools and the classification of this material using an extended metadata schema such as Dublin Core, the research challenge here is to create an interactive information architecture for the repository. Drawing on 'empathic design'

[20] [21] [22] [23] [24] and associated techniques such as 'design probes' [25] and 'experiencing prototyping' [26], the experimental web-based application intends to provide users with an intuitive interface through which to retrieve knowledge and experiences related to accomplished Unani physicians.

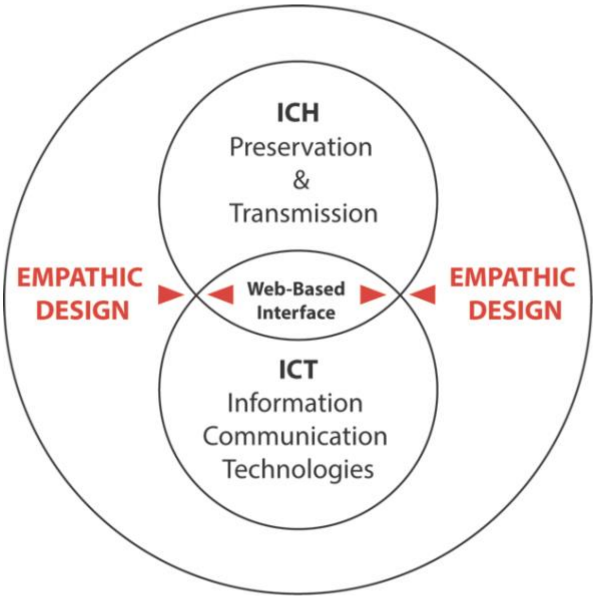

Figure 2. Web-based representation of DIH through 'empathic design' methodologies.

1.9.3 Other Tools and Console Games

Research argues that learning through observation, where the user tries to mimic body movements, has been found to advance learning more than mere verbal description has. Some researchers have collaborated and established online resources for ICH, such as online participatory media visibility for the Sydney Opera House (Garduño Freeman, 2013) and ICHIPEDIA (Park, 2014). The main idea behind ICHIPEDIA is to create an archival system for ICH content with collective intelligence and emerging tools. This project had some prominent ambitions, such as: (1) a digital inventory system for ICH making use of current multimedia tools; (2) ease of information between information provider and information receiver; and (3) easily heard participant voices.

Documentation of sound and auditory senses is another interesting aspect of DIH. Sound recording has been standard practice for a long time; however, new methods and tools have been deployed in this domain (Bendrups, 2013). Researchers are also arguing that the Internet is justifying its role as an information provider, and creating a new role for itself as a memory institution in order to be a key player in the future (Solanilla, 2008). Besides the presence of ICH over the Internet, some Geographic Information Systems (GIS)-based tools have also been created to manage special data for archiving content (Karavia & Georgopoulos, 2013). Besides numerous challenges, digital tools are now intervening to transform ICH, making it more interactive, accessible and didactic.

I am presenting two case studies in the following section. These studies are there to examine and speculate on future technologies in heritage representation. In the first case study is about human pulse reading knowledge and its various practices around the world. I also propose, in the end, an idea/concept for heritage-related installation. A literature search and museum installation idea for the field of martial arts is presented in the second case study. I search the literature and analyse the human body, body movements, and various technologies involved in the assessments of sports and martial arts. Moreover, I also tried to imagine an installation application I created for the documentation and transmission of martial arts.

Section 2: Case Studies A and B

As well as presenting and discussing my published papers in Section 1, in Section 2 I utilise two case studies in my research into using emerging technologies to protect Intangible Cultural Heritage (ICH). Researchers assert that case studies provide detailed description of a single topic (Flyvbjerg, 2006). However, they also allow us to gain authentic information about broader concepts, as it is possible to generate hypotheses about research at the ground level. The case study is not only a technique that can be used in the initial stages of research though (such as preparing to conduct a survey, testing hypotheses and creating theory); hence, in this thesis I am combining my memories, experiences, already published articles and knowledge about emerging technologies along with two case studies in order to more fully address my research questions. As an artist/designer, I needed to think about research paradigms and ontological/epistemological assumptions. Both case studies fall under the category of speculative design, in which I relied on wild guesses and techno-centric dreams. Because it seeks to study abstract forms of cultural interpretation, the speculative design paradigm was ideally suited to my research in this context.

As previously stated, the design we see daily is primarily constrained by practicality. Its primary purpose is to fix current problems or, at the very least, make the world a little brighter. In a period of rapid technological advancement, this approach is a type of denial of the difficulties and challenges that the future holds for us. Speculative design is a fascinating topic of design that seeks to simulate future events. In the context of this thesis, it analyses what may happen if museums were distributed and accessible from everywhere on the planet. What if artificial intelligence, big data, and edge computing become commonplace at museums, and we are entirely unaware of it? Or, perhaps, our youth will interact with our cultural artefacts and create a new type of cultural artefact for future generations?

In the early 1990s, the speculative design emerged as a hybrid discursive or critical design method. It became a large-scale venue for exploring ethical, cultural, social, and political issues while being a relatively new phenomenon. In their book " Speculative Everything, " the pioneers of speculative design, Anthony Dunne and Fiona Raby, claim their book "Speculative Everything" that it flourished due to imagination. Designers working on such projects have a full creative licence. They are always looking for new ways to solve problems, as speculative design creates goods and services for many "What if..."

scenarios. The practice demonstrates that creatives tend to speculate on the worst-case scenarios that society may face in the future.

These are just a few of the exciting projects that have been created under the umbrella of speculative design. Facestate, a research project by the Amsterdam design studio Metahaven that criticises contemporary liberalism (Hyde, 2020), and I Wanna Deliver a Shark(), which talks about an alternative technology that will appear in our future to become pregnant with a shark (Hasegawa, 2020), The Natural History of Enigma; aims to make biotechnology more poetic and philosophical (Kac, 2008), and Belief Systems (Hopfengranter, 2018); makes fun of the universal desire for freedom of choice, as with the help of technology we are trying to make our lives as easy as possible.

In general, these initiatives foresee the worst-case circumstances. Designers ponder questions not only for themselves but also for society and the surrounding community. Speculative designers attempt to imagine our future or the world of tomorrow, which may alter gradually or all at once. Perhaps these novel notions, ideas, and technologies will not seem so alien in the not-too-distant future. We have no idea.

Before I go into detail regarding the first case study, I would like to address some common misconceptions about their case study's usage in research. Five common misunderstandings are outlined by Bent Flyvbjerg (2006):

Misunderstanding #1

There are theoretical and practical contexts for a researcher. Most of the time, in a case study, a researcher apply practical context. And hence, a misconception is there that the context of the case study is not essential in research.

Misunderstanding #2

The second misconception about case study research is that a researcher cannot address their desired goals from a single case study. For this reason, people can have the misconception that case studies cannot play any part in scientific development.

Misunderstanding #3

Another misconception is that the case study is most helpful only in the initial stages of the research process (such as when creating hypotheses). On the other hand, other techniques are believed to be more useful for theory building along with the testing of hypotheses, for example.

Misunderstanding #4

It is also a misconception that it is not possible to verify the researcher's point of view using the practical experiences mentioned in case studies.

Misunderstanding #5

The fifth misunderstanding is that it is not possible, by keeping in view limited case studies related to specific topics, that researchers can generate general theories and propositions.

Thus, the five misunderstandings presented above lead to the notion that a case study approach cannot be helpful in scientific development, reliability, theory and validity.

In summary, people can hold the misconception that the lengthy process of conducting a case study should only be during the very first research step of generating hypotheses. In contrast, they may believe all other steps such as theory building and hypothesis testing should be done by different methods than through a case study. Moreover, there is a misunderstanding that there are biases in the context of case study verification. People may have the mindset that one cannot verify the thoughts and experiences of participants quoted in the case study, thus it is not considered reliable for scientific development.

In terms of case study methodology, they can be used to assist researchers by providing various tools with which to study multiple complicated phenomena (Baxter & Jack, 2008). It all depends on the researchers apply this methodology. Applied correctly, case studies can provide valuable findings, assist in the development of various theories and interventions, and they can be used to evaluate multiple programs.

Research shows that the case study is a method used only to learn more about a specific individual, to find out more about the details of a particular event, or as an example to understand a particular concept Baxter & Jack, 2008). This is beneficial in clearing misconceptions and providing researchers with another option to utilise when describing a phenomenon. Moreover, a qualitative case study gives researchers a chance to explore various people or businesses through multiple communities, programs or relationships. Furthermore, researchers can present various new descriptions of phenomena or amend existing ones.

According to Stake (1995) and Yin (2003), case studies are based on the constructivist paradigm. These researchers believe that truth is not independent; rather, it depends on the individual's perspective. Through the constructivist paradigm, an individual becomes familiar with the value of subjective human creation and, at the same time, does not consider the belief of objectivity wrong. Yin (2003) recommends that the case study technique should be applied when:

1) we need to answer questions starting with "why" and "how";
2) there is a situation where we cannot control the individuals who are participating in the study;
3) the contextual conditions are suitable for the phenomenon on which the research is conducted; and
4) the boundaries between the phenomenon and context are blurry.

There are different kinds of case studies. A *descriptive* case study is utilised when participants are required to answer questions in detail (Joia, 2002), and where a detailed description of the phenomenon is required through a real-life context (Yin, 2003). Sometimes research questions are so complex that they cannot be understood fully through various experimental strategies or surveys. An *exploratory* case study is utilised in situations where it seems that the evaluation of interventions will not provide any specific result and will not clear the confusion (Lotzkar & Bottorff, 2001). The *multiple* case study approach utilises various cases in order to draw a comparison. In this type of research, it is imperative to choose the cases very carefully for a reasonable comparison (Campbell & Ahrens, 1998).

Stake coined the term "intrinsic case study", and according to him, a keen interest should exist in order to utilise this approach for an in-depth analysis of a situation (Hellström, Nolan, & Lundh 2005). The *intrinsic* case study is the study of a case that is related to a specific person, group, business or organisation. This approach allows the researcher to explore new opportunities. In an instrumental case study, the purpose is not to understand a particular situation, but through the help of that situation, to attempt to clear another theory. The case plays a supporting role in this type of case study, while a *collective* case study is similar to the multiple case study approach (Scheib, 2003).

In my research, I utilise the intrinsic case study approach, with exploratory and explanatory case study types also playing a role. In-depth historical, contextual and technological knowledge is retrieved and deployed to manifest something new and viable. The exploratory aspects of these approaches should also contribute to addressing my three arguments, as presented in the Introduction. Through this approach, I assume that future DIH content creators will not only deal with simple but also complex situations. An in-depth study of the subject matter is crucial when a content creator selects a specific heritage topic and prepares to fabricate the heritage embodiment in the digital realm. This approach is also an effective way to answer the various questions which start with "how" or "why". In this context, comprehensive knowledge of the subject matter, in-depth study of the community and viability of the anticipated emerging interaction can be revealed using this case study approach.

Moreover, creating heritage embodiments with emerging digital tools is a diverse field of study. For a content creator working in this vibrant paradigm, there is a need to acquire and utilise a powerful qualitative research tool. A detailed literature search on the subject matter is imperative to create a good grasp on the topic. In summary, for my research study, the case study approach is essential for the justification of my research design, instrumentation, theoretical paradigm and analysis of the material collected. Utilising this approach, I also employ my previous experiences and a comprehensive literature search, as a constructivist approach, as illustrated in the constructivism philosophical paradigm (Adom, Yeboah, & Ankrah, 2016).

Below I present two case studies designed to illustrate how Intangible Cultural Heritage (ICH) can be protected using emerging technologies. Case Study A presents a comprehensive overview of pulse diagnosis in traditional medicine and my proposed Virtual Immersion with Pulsation (VIP) installation, while Case Study B examines martial arts and traditional knowledge (TK), followed by my proposed Mimicry Understanding and Safeguarding Environment (MUSE) installation.

In reference to the preservation of ICH material, it is very clear that the ICH content from the past cannot be duplicated or fully repeated in its true nature. Moreover, the important properties of the culture will simply be diminished or turn into something else – either intentionally or unintentionally. However, as stated in the thesis, new and altered types of ICH material can and should be considered as another layer or variation of an artifact for the benefit of future generations. The two case studies and their resulting by-products presented in the thesis may be considered another type of ICH element. Nonetheless, there are many existing cultural examples or artifacts that have evolved and changed their shapes and related characters. It is expected that the notion of preservation will be updated over time and that existing preservation methods will evolve as a result of big data and AI.

One clear example can be seen when Indigenous Australian dance style met with contemporary dance in 1989 in Australia (Stock, 2008). Bangarra Dance Theatre's aim is to maintain the interaction between Australia's traditional indigenous cultures and new forms of contemporary creative expression with respect and integrity, while also giving voice to social and political issues that touch everyone (Rimmer, 2000). It has created a unique and inventive blend of traditional and contemporary dance, music and storytelling.

Bangarra Dance Theatre has toured Australia and internationally with original performances such as “Fish and Ochres”, as well as collaborations like “Rites”. Its performances have also been adapted for television, film and multimedia. The dance company has also been invited to perform at huge national and international meetings to showcase its distinctive dance technique, for example, in the 2000 Sydney Olympic Games Opening Ceremony and accompanying cultural event. Bangarra Dance Theatre is contemplating using film as a means to archive its performances and to increase the distribution of its work. “Urbatq Clan”, a documentary about the Page brothers who founded the dance company, was produced in 1997.

Document preservation is indeed an ancient practice. In 2015, Michel Cloonan published a collection of texts on preservation from various contexts and time periods, beginning as early as 700–600 BC. She refers to the Book of Jeremiah, which mentioned the need to preserve a deed of purchase in earthenware jars, which was a standard preservation method at the time. Nonetheless, preservation was only established in the eighteenth and nineteenth centuries, and it has been mostly the responsibility of archives and libraries since then. These institutions established theories and procedures for collecting, preserving and managing records, as did their underlying academic disciplines. They were also instrumental in creating UNESCO's Memory of the World (MoW) Programme in 1992.

The process of technology obsolescence has introduced a new layer of danger to document preservation, and "memory institutions" worldwide have devised solutions to address digital records and their preservation and access needs (Prodan, 2020). For example, the Memory of the World Programme has responded with several initiatives, including the Charter on the Preservation of Digital Heritage (in 2003), the UNESCO Platform to Enhance the Sustainability of the Information Society Transglobally (PERSIST) project (in 2013), and the Recommendation concerning the preservation and access to documentary heritage, including in digital form (in 2015). Digital documents, like non-machine-readable texts, have artifactual worth, but are a little more challenging to grasp because their carriers are different.

Friedrich Kittler (1995), a medium theorist, claimed that digital texts live exclusively in the transistor cells of computer memory. In the end, all code operations boil down to voltage difference signifiers. Reading and writing to the hard disk is a sort of digital to analogue or analogue to digital signal processing. This property of digital records has influenced preservation thought. Keeping an electronic record empirically entails preserving the ability to recreate it. This also indicates that digital documents do not have a physical manifestation and only exist due to the interplay of numerous hardware and software pieces.

When it comes to comprehending the value of digital documents, their unusual nature presents some difficulties with their various layers (Prodan, 2020). According to research, there are several exciting disputes about digital documents and the tools or applications that create them. This was acknowledged by people who began treating digital documents as artifacts or objects with intrinsic value independent of their information content. The most challenging questions, they claimed, were about identifying the "digital artifact": What data or value is contained in the carrier medium? Is the equipment initially used to display the digital artifact now a component of the digital artifact? Is the software that displays and actualises the data a component element of the artifact? While some wondered if the software was a part of the digital document, others wondered if software might constitute a document itself. E-mail and a word processor-generated technical report are digital documents, but the definition of a “document” becomes less apparent beyond these simple instances. Is a computer program considered to be a document? There are lines of text that look like they belong in a language. Is a computer operating system considered to be a document? It is unclear where the line should be drawn between documents and non-documents.

The thesis explores a future scenario in which intangible heritage becomes digitised and is subsequently displayed at a heritage institution or GLAM (galleries, libraries, archives, and museums). This topic is a major theme in the thesis as a design problem, and it is examined in the context of cultural heritage documentation, preservation, and transmission. I further contend that visitors' and online users' DIH material will be a source of new and altered DIH content and that archived DIH data will be a part of our heritage that should be documented and maintained somehow. This is the main argument, and I took it as a wicked design problem. Two in-depth case studies in the thesis discuss these difficult scenarios and speculate on a framework for archiving DIH data using future technologies and new tactics. Of course, the debates over digital documentation, traditional cultural heritage preservation, and the challenges of new technologies in comparison to other digital and non-digital techniques, will continue.

2.1 Case Study A: Pulse Diagnosis for Health and Perceptual Pleasure

"Pulse diagnosis" is an essential component of traditional medical systems. It provides a clear view of the pulsating waves on the pulsating waves of the human body, which is important because different stimuli can affect the health of the organs. In Chinese traditional medicine, "pulse collection" has been used as the most important diagnostic tool for over 2,000 years. It is considered to be one of the most valuable tools available to Chinese physicians. Pulse diagnosis is subtle and complex. It provides information on kinaesthetic, visual and control channels. This information is then evaluated based on physiological conditions (H. K. Wu et al., 2017).

To analyse the pulse, a Chinese doctor asks their patient about their health and examines their tongue. The patient stretches out their wrist or places it on a small rectangular pad on a table. The physician registers the patient's heart rate by holding three fingers in three positions on each wrist at a time; they evaluate the heart rate by using 28 parameters. First, the doctor puts slight pressure on the patient's wrist and then increases weight. Mild stress permits the doctor to examine a particular organ and a larger strain to examine another organ. The condition of each organ can be checked according to the quality of the pulse. Doctors may find out, among other things, that organs lack energy or, when energy is at rest, they may notice lack of "blood" or if pathogenic factors have invaded organs (Chu et al., 2018). Research shows that the human pulse reveals how body fluids or body systems contribute to maintaining good health. Chronic diseases have a significant effect on the heart rate and can prevent normal acute pulse changes (Luo et al., 2016).

It is best to examine the pulse at least 30 minutes after a meal or exercise (D. Zhang, Zuo, & Wang, 2018). Experts and patients need to be relaxed in order to find the right pulse. The radial artery is often used in the body as an adjustment point. To do this, a practitioner's fingers are used to analyse the pulse of a patient. The practitioner's right hand is placed at the far end of the artery, on the patient's left wrist. The "fire" and "gas" fingers are placed in parallel, and the "water" and "fire" fingers are placed next to each other. Similarly, the practitioner's left hand is on the patient's right hand. The "air" finger is always in the middle, and the "water" finger is always almost extended away from the hand (Tsai et al., 2018). Each complete pulse diagnostic system has its own unique way of reading pulses (Zhou, Ogihara, Nishimura, Leng, & Jin, 2019). When practitioners first use the pulse as an analyser, it is best to look at the big picture, the dominant pattern (Cheifetz et al., 2017).

Pulse diagnosis is a dominant procedure in some of the alternative medicinal systems around the world. It is essential to examine these systems to understand their philosophy and underpinning methods. The following sections examine alternative medicines and therapies from around the world, then pulse reading is discussed in more detail. Finally, I introduce the concept I developed—the Virtual Immersion with Pulsation (VIP) installation—to document this form of traditional knowledge (TK) using emerging technologies.

2.1.1 Alternative Medicines and Therapies from Around the World

"Whole medical systems" are based on theoretical and practical systems from around the world. These systems are often far removed from conventional medical practice in developed countries. Examples include Ayurveda, Homeopathy, Unani (also known as "Unani Tibb") and other medicinal systems. The purpose of natural remedies is to support the body's healing ability through diet and lifestyle changes as well as through treatments (such as herbal remedies, massage and joint therapy). The most common system was homeopathy by western culture. Homeopathy aims to stimulate the body's self-healing ability by providing very small amounts of highly diluted substances that cause disease or symptoms (the so-called "cure"), as well as including natural remedies that make up the whole drug (D. Zhang et al., 2018). An example of a whole medical system developed in a culture other than the West is traditional Chinese medicine (TCM), which is a medical system which is practised all over China (Luo et al., 2016). Moreover, "alternative medicine" (or "integrated medicine" or "dietary supplement") is a term used to describe drugs that replace traditional treatments. There are various medicinal systems around the world, and they each have specific treatments, philosophy and history. The following sub-sections illustrate some examples of these medicinal systems, including acupuncture, chiropractic medicine, magnetic field treatment, homeopathy and yoga.

2.1.1.1 Acupuncture

Acupuncture is a TCM system that uses needles to stimulate specific points in the body (Farooqui et al., 2016). The person performing the acupuncture procedure inserts a thin, strong sterile metal needle, that can be manually or electrically stimulated, into the patient's skin. The goal is to help the body heal naturally. Research studies have shown that acupuncture can effectively treat a variety of conditions such as neck and back pain, nausea, anxiety, depression, insomnia and infertility.

Acupuncture is designed to restore and maintain health by stimulating certain points in the body using multilayer technology (Beedie et al., 2018). According to Chinese traditional medicine, acupuncture can release air in certain parts of the body associated with the "meridians"; a hypothetical channel for the flow of energies in Chinese medicines. According to research, some patients say acupuncture can help treat disease, while others say it has no effect (Ernst, 2006). People who want to improve acupuncture say that a patient has to undergo a lot of treatments for acupuncture to be effective. In addition, little is known about the side effects of acupuncture. According to the Chinese National Health Organization, acupuncture is an acceptable method of treating many forms of pain. For example, studies have shown that acupuncture can relieve pain in osteoarthritis and also alleviate pain caused by psoriatic arthritis (Ezzo et al., 2001).

2.1.1.2 Chiropractic medicine

Chiropractic medicine focuses on the structure of the human body—mainly the spine—and its function. Trained "rubbers" use a variety of methods to modify (manipulate) the spine or other body parts to move them into the right position (Beedie et al., 2018). Chiropractic medicine is designed to relieve pain, improve physical activity and improve the natural healing of the body. Much of the research around it has focused on lower back pain. However, research shows that chiropractic treatment can also cure many other illnesses, such as headaches, neck pain, upper and lower joint problems, and whiplash-related illnesses (Wang et al., 2019).

2.1.1.3 Magnetic field treatment

This system of treating illnesses uses magnetic or electric fields to treat many types of musculoskeletal problems (Brooks, George, & Kumar, 2017). Studies have shown that it may be suitable for osteoarthritis and other painful diseases. Some studies have even shown that it can help heal fractures more quickly. If a patient is pregnant, has a heart transplant, or uses an insulin pump or patch, magnetic field treatment may not be safe.

2.1.1.4 Homeopathy

Homeopathy is another healing system. There are different approaches to diagnosing, classifying and treating medical problems in traditional medicine: the purpose of homeopathic medicines is to stimulate the body's defences and processes to prevent or treat disease (Cheifetz et al., 2017). Treatment involves the administration of very low doses (so-called "therapeutic" treatment). According to homeopathy, higher doses cause the same or similar symptoms in healthy people (Zhou et al., 2019). Homeopathic treatment suitable for everyone. Homeopathic physicians choose a treatment based on the patient's general condition, which includes, in addition to symptoms, lifestyle, mood and state of mind, and other factors (Tsai et al., 2018).

In the United States, most homeopathy is practised along with other recognised health services, such as traditional medicine, herbal medicine, chiropractic, dentistry and acupuncture. People have reported effective homeopathic remedies for psoriasis, including sulphur and nickel. Homeopathy is usually mild to the point where it does not cause significant side effects. Consulting a person trained in this practice will help guide the treatment.

2.1.1.5 Yoga

In addition to other traditional medical systems from around the world, yoga can help in elevating the wellness of the human body (Cheifetz et al., 2017). Yoga is used in TCM and is considered a physical and mental healing technology. It consists of an Ayurvedic combination of medicines for breathing, body posture and meditation. Its purpose is to calm the nervous system and balance body, mind and spirit. People use a variety of yoga practices for their health; they usually combine posture, breathing and meditation or relaxation. Hatha yoga is the most common yoga practice in the United States and Europe: it focuses on posture and breathing. People use yoga for a variety of conditions, and for training and relaxation. There are many yoga schools to guide practitioners.

2.1.2 History of Arterial Pulse Reading

The diagnosis methods presented above are embedded in many alternative medical systems around the world. In particular, human pulse knowledge and analysis has been for thousands of years to diagnose health conditions; it is not known precisely when it originally started. This section provides an explanation of these medicinal systems with their associated pulse diagnostic methodologies and historical perspectives. Chinese, Greek and Indian civilisations, in particular, have been using this type of knowledge; the most elaborated methodology related to pulse reading is found in Chinese history. The following sub-sections will examine the history of pulse reading in Chinese, Egyptian, Greek, medieval, Arabian and modern medicine.

2.1.2.1 Pulse reading in Chinese medicine

In China, analysis is mainly carried out on pulse samples. This is called "pulse analysis" and it has become an art form, as shown in Figure 10. Information comes from the *Yellow Emperor's Inner Cannon*—an ancient document on health and disease, probably written by the famous Chinese emperor "Huangdi in 2600 BC" (Hajar, 2018a). According to historians, "Huangdi's side" was a mythical figure. It is thought that the book may even be dated later, for example around 300 BC, and may be a collection of works by several authors. The book was in the form of a discussion between Huangdi and her doctor; Huangdi asked questions about the nature of health, illness and treatment. Its meaning is a reference to Chinese practitioners, and it is still in use today. The book deals with health and disease caused by the imbalance of the two main "yin and yang" and the effects of five factors (water, fire, metal, wood and soil) on human organs.

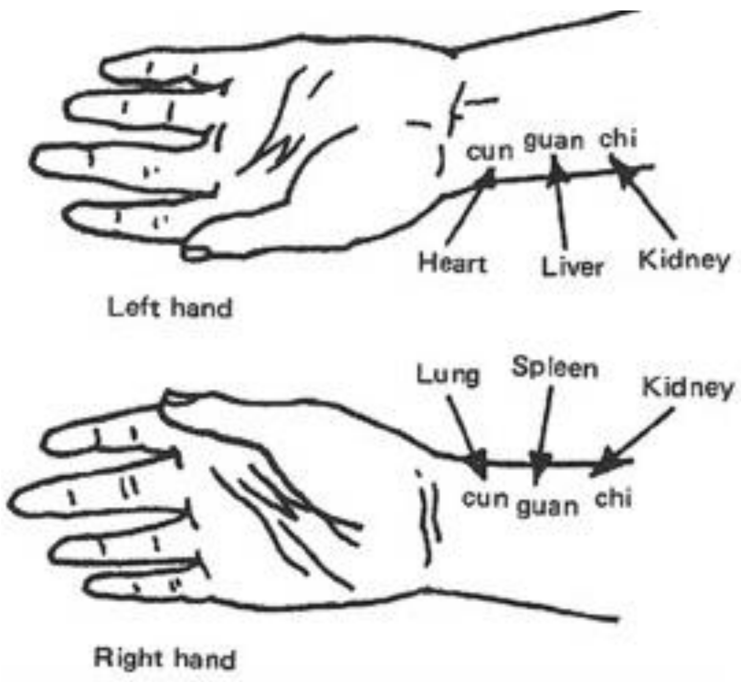

Figure 10. The Chinese pulse reading pressure points.

Davies (2019) states that the arterial pulse was studied in China from about 2,000 years ago. For the first time, Huangdi was called the Canon classic, the inner classic. In this approach, the main diagnostic method used in the inner meridian of the body is examination of the arterial pulse. Pulse theory is based on different levels of interaction between yin (disease) and yang (health). Ancient Chinese doctors must develop the ability and skills to penetrate through four major variants (shallow; deep; deep; deep; short; deep; deep; slow; and fast). The test is performed on both of the patients' wrists. The best time to conduct the assessment is early morning when yin and yang are in balance. In ancient China, the artery pulse was divided into three parts: the thumb (the next hand), the elbow (upper arm) and the central part. The position of each pulse in each arm represents the state of two corresponding organs in the body.

Formerly Chinese doctors considered heart rate testing to be an important part of Traditional Chinese Medicine (TCM) practice. TCM experts use pulse analysis as a tool to assess the health of all major organ systems in the human body. In addition, the pulse and the techniques for interpreting it are essential for detecting, conducting and forecasting epidemics, for example. There are 26 types of pulses in Chinese medicine that can be confusing to understand. Each type represents a specific disease or syndrome or another organ disease. A number of factors need to be considered when taking a pulse, such as time of day, time of year and gender of the patient. Treatments include medication, diet, acupuncture and guidance about healthier lifestyle.

Pulse detection is one of four primary methods in the Chinese medicinal system of analysis, and it has been described as an essential part of TCM practice (Kabigting et al., 2017). The other three methods of analysis are:

- **Inspecting**: a general examination of the patient, including facial features; skin colour and texture; overall appearance, shape, distinctive colour; and odours (further examine unusual odours in the body, mouth or urine);

- **Listening**: listening, as what patient is saying and disease sounds such as cough or bowel sounds; and

- **Inquiring**: obtain information about the patient's medical history and symptoms such as cold, fever, sweat, appetite and eating disorders, elimination, sleep and pain; ask about menstruation, pregnancy and other postpartum female and gynaecological disorders.

All of these diagnostic approaches provide information to help identify the syndrome and physique being treated (Ni et al., 2019). Although pulse and Chinese diagnostic methods have received considerable attention due to frequent commentary and the unique qualities of these traditional medical systems, other aspects of analysis cannot be overlooked or underestimated. The feeling of the pulse is called "contraction" and is part of the general method of detection to sense or feel the body. Emphasis is placed on an incomplete and inaccurate analysis, especially when pressure is the primary method of detection (leaving or disconnecting other methods) and there is failure to obtain full (front and back) stimulation. It is a theme that runs through Chinese medical history and also applies to modern medical analysis. An unreasonable expectation that may never be fully realised is that all physicians must achieve the highest standards and mastery of diagnostic techniques by carefully examining and constantly monitoring details (Solos & Liang, 2018).

As with other diagnostic methods, pulse detection is always intended to provide useful information about the causes of disease in the body, possible measures to solve any problems found, and the likelihood of success. In Chinese terms, a pulse can indicate whether a syndrome is "hot" or "cold", if it shows fatigue or lack thereof, what mood (e.g., Qi, moisture, blood) is affected, and which organs are malfunctioning (Solos & Liang, 2018). To make these decisions, the physician must assess under appropriate conditions (according to standard procedures) and then convert the individual assessments into one or more classes of pulse forms (Solos & Liang, 2018). TCM literature does not describe what practitioners experience (or should do) with pulse analysis. It is left to students to learn from experienced practitioners. Instead, Western scholars Li et al. (2018) sought to contact Western participants in writing to obtain more information on analytical methods. Knowledge of pulse classes must first be acquired, which seems to be supported in Chinese literature by the universal practice of presenting pulse analysis by recording and describing the main categories of the pulse (D. Zhang et al., 2018).

Many places of worship have been mentioned in traditional Chinese literature. For example, Neijing Suwen notes that veins are felt in the artery, and blood vessels can be found in the artery (above the wrist). Under healthy conditions, these should be the same, but they will be different when disease is present. In addition, detecting the pulse at multiple locations improves the analysis (de Moura, Cordovil, & de Sá Ferreira, 2016). Although pulse rate can be collected at many sites, TCM analysis is usually limited to the pulse of the wrist. This involves placing three fingers on the artery and checking both wrists at the same time (Chauhan et al., 2016). The traditional Chinese method of stimulus collection is touching the wrist under three different levels of stress. For example, as a person's mood changes from less stress to more significant stress and then from more to less stress, changes in pulse perception can also provide information about pulse elasticity (Ni et al., 2019).

In terms of modern Western medicine, the traditional style of pulse analysis was practised until the 19th century, in slightly different forms and replacing many other tests. Use of a stethoscope and taking pulse pressure are generally considered to be pulse diagnostic techniques. Stethoscopes show pulse rates, irregularities in cardiac structure, and function that requires further evaluation. If necessary, several tests can be performed using many different types of cardiac monitors, such as an electrocardiogram (ECG) (Ato & Sawayama, 2017). Abnormal ultrasound and invasive tests (such as inserting a monitor into the body) allow today's doctors to examine the arteries and heart. It is common for the information in these tests to reflect only the cardiovascular condition (cardiovascular system); they are not considered as a way to explore other aspects of health.

There are many other types of modern medical examinations, including blood and urine tests, and various scans and biopsies. These tests can reveal a lot of information about what is going on in the body, which can lead to a diagnosis. These tests also show a great deal of visceral function. For example, a simple blood test can detect liver inflammation or failure of the kidney filtration system. Most of these testing methods have only been used in recent decades and have added a new dimension to Chinese medical practice (Ato & Sawayama, 2017).

Many physicians have performed pulse analysis not described in traditional Chinese literature. Although the original Chinese heart rate collection method can be used for analysis and prognosis, many practitioners use allopathic knowledge to determine if they inserted the needle correctly (Ismail et al., 2017). Explaining the observations, he asserted that pulse diagnostics could use acupuncture to detect breathing and long-term dilation of blood vessels. Therefore, when acupuncture manages to dilate and relax the blood vessels, the pulse changes so that it does not look like a "chain" (or tension) (Kabigting et al., 2017). For those whose heart rate does not change during acupuncture, or for those who show an immediate change but recover quickly after treatment, symptoms usually cannot be relieved (Ato & Sawayama, 2017).

One of the serious objections to using heart rate analysis is that the heart rate pattern is highly subjective. For example, it depends on how the doctor puts his fingers on the patient’s wrist and how much pressure is used. Many doctors believe that the same patient’s pulse may show different results. In China, researchers are working to describe the value of wrist as an analytical method and hope to help standardise their measurements by designing a modern tool for obtaining objective pulse shapes (Ato & Sawayama, 2017). At the 1987 Convention on Traditional Medicine in Shanghai, several doctors recommended pulse measurement with pulse diagnosis. They further suggested that such a measure could help TCM students learn pulse analysis, where the accuracy of a student’s pulse measurement could be verified with a manometer; a device to measure pressures. Indeed, one author described the use of devices to reproduce a measured pulse that could then be sent to students. In this way, different recording pulses can be simulated and stored on a computer so that students can test them to help them learn each pulse class (D. Zhang et al., 2018).

In conclusion, pulse analysis in TCM is a method of determining a patient’s internal condition and is intended to determine the treatment regimen. To use this method of analysis, practitioners need to learn the correct way to take a pulse, the factors that affect it and the types of pulse patterns that are unique to each patient. Experts should carefully look for new factors that may affect the heart rate monitor to make sure the results of heart rate collection are significant. Most institutions now believe that practitioners need to be able to find a relatively small set of baselines to use this knowledge in treatment planning (e.g., acupuncture, herbal medicine). The scope of pulse analysis has recently been expanded. Pulse detection continues to be an important part of TCM and is still being further researched and developed.

2.1.2.2 Pulse reading in Indian medicine

Ayurveda, or “Life Knowledge”, is an ancient medical science that originated in the Indian subcontinent 3,000 years ago and was practised during the “Buddha period (500 BC)”; It is one of the oldest medicinal practices in the world. The name is from the two Sanskrit words Ayur = life and Veda = knowledge (Elahee, Mao, & Shen, 2019). In Indian mythology, medical knowledge is transmitted from the gods to the wise, then to human doctors. The theory is based on the belief that health and well-being depend on the delicate balance of mind and body. It deals with health, daily life and longevity, and has a lot in common with Chinese medicine. Both are now considered to be types of alternative or “other” medicine. Both focus on the patient, not the disease, and aim to promote health and quality of life and to treat people holistically. Ayurveda practitioners believe that life contains opposing forces that affect our health, and when these forces (or energy) are out of balance, then disease develops. It is a reminder of prehistoric healing and how the mind or spirit surrounds the disease. The mind or spirit is replaced by “power” or “energy”.

Pulse examination is an integral part of Ayurvedic medicine. According to Sage Canada (600 BC), each pulse has three points, and one abnormality reflects the three main physical diseases of the human body. Physical examinations of eight body parts are described, the first of which is the arterial pulse. The impulse test method can be described within three categories: examiner, candidate and test method. A special method is used to calculate the heart rate within Ayurvedic medicine, in which heart rate is recorded every 2.5 minutes. In addition, Ayurveda describes different pulses for people of different ages.

In Ayurvedic medicine, pulse rate is part of TCM analysis, but taking the pulse rate in Ayurveda is not as accurate as in TCM. The primary goal of both systems is to treat a healthy person through health promotion and quality of life, not just a comprehensive treatment plan for a specific disease or condition (Parasuraman & Perumal, 2020).

H. Singh and Singh (2016) explain that Ayurveda uses a three-dose balance (control system) to explain the dynamics of mechanics and health, while disease cannot support the consequences of dynamic mechanics and can be understood by “dosha imbalance”. In order to develop a specific treatment plan, an Ayurvedic physician must determine the exact nature of the dosha imbalance and the specific imbalance matrix. Careful diagnosis of clinical signs and symptoms can contribute to a broad understanding of dose imbalance. In ancient times, Ayurvedic doctors developed protocols for a detailed examination of the tongue, eyes, urine, stool, skin, etc., in order to measure dosha imbalance. Subsequently, sophisticated measurement methods were introduced, such as pulse analysis, which eventually was used to detect dose imbalances (Kadarmandalgi & Asaithambi, 2019).

2.1.2.3 Pulse reading in ancient Egyptian medicine

Ancient Egyptian medical art had a reputation in ancient times: some say that if you became ill, Egypt might have been the best place to be. Ancient writings tell us about the disease states of ancient Egypt. The oldest of the nine types of medical papers are from 1950 BC (Heydari, Dalfardi, Hashempur, & Kolouri, 2016). Documentation of ancient

Egyptian medicine is the oldest literature to date, and Egypt's medical concepts have not changed for thousands of years. Their medicines include simple non-invasive surgery, bone repair and comprehensive prescriptions. However, their medicine is often mixed with a mantra, and their prescriptions contain substances that trigger some diseases. The medical literature describes specialised procedures that are generally appropriate and suitable for examination, diagnosis, prognosis and treatment.

Other information we have about the pictures and translations of attached inscriptions, which often adorned the walls of Egyptian tombs. Egyptian medical thinking influenced later traditions, including those of the Greeks. Ancient Egyptian doctors knew that the body had impulses and was related to cardiac function. They also believed that the heart chose accessible blood vessels. According to them, the heart speaks of four civilisations. The proposal was adopted in Papyrus Ebers about 3,500 years ago (Elhabashy & Abdelgawad, 2019).

Van Meter et al. (2017) state that the heart has a canal (or vein) for each limb. The citations above show that the relationship between heart rate and environmental changes were understood in ancient Egyptian medicine. Arteries are believed to contain air, but the whole idea of the circuit is unclear. It is also believed that there are two vascular systems in the human body: the blood vessels that carry the digestive tract throughout the body, and the arteries that carry the lungs from the lungs to other organs. Under this system, the structure of the heart cannot be fully explained; however, the left side of the heart explains why air is extracted from the lungs and pumped into arteries in other parts of the body.

2.1.2.4 Pulse reading in Greek medicine

Plato, Socrates, Aristotle and Hippocrates are all famous Greek names from history. Greece has produced many philosophers and doctors whom we admire and who made important discoveries (even though we do not remember all their names)—and people see Greece as the cradle of modern science (W. Liu et al., 2019). There is no doubt that there are many modern medical practices that originated from ancient Greece.

Hippocrates (about 460–370 BC) is considered to be the father of a physician in "Greece or Kose". Doctors reported the writings of Hippocrates, or those that were attributed to him, and agreed that some practitioners wrote medical scripts. With the decline of Egyptian civilisation, ancient Greek medicine developed around 700 BC and, according to historians, remained popular until the end of antiquity around 600 BC. Initially, the ancient Greeks, such as the Babylonians and Egyptians before them, regarded disease as a divine punishment and treatment as a gift from the gods. Later, they tried to move from superstition to science to determine the real causes of disease. Greek physicians became more interested in the body, studying cause-and-effect relationships, the relationship between symptoms and illnesses, and the success or failure of various treatments.

Breathing is an essential aspect of ancient Greek medicine. In a religious context, breathing also means spirit or soul. They believed that breathing is full of vital arteries, and vital organs require circulating air to function. Their ideology and medicine are filled with this belief. Although Hippocrates allegedly described the symptoms of arterial pulse in many diseases, such as fever and somnolence, he did not understand its value as a sign of disease. Praxagoras de Cos saw the benefits of using the pulse as an indication of disease. First, he used harassment as a diagnostic tool. Based on his observations, he developed several theories about pulsation (Bodh, Yadav, & Goswami, 2017).

Furst (2020) deliberates that the word "artery" is derived from the Greek word "arter" which means air. Hippocrates (375 BC) characterised the arterial pulse in a variety of conditions, including fever and drowsiness, while Praxaglas Kos (340 BC) was the first to examine the famous pulse of a doctor. Herophilus Erasasistratus (304–250 BC) mentioned that he was very close to understanding the "circles". According to him, heart and arteries do not move at the same time—the arteries dilate as the heart expands and vice versa. He acknowledged that arterial motion occurs when the heart muscles contract. Erasistratus correctly explained that arterial dilation was a passive distribution of blood vessels, but wrongly believed that pulmonary oedema passed the arteries.

Moreover, Bhattacharya (2017) states that Herophilus believed that dilation of arteries will swallow the centre of the lungs, and contraction of the arteries causes an arterial pulse. Also, an arterial pulse is considered to be an intrinsic artery that is separate from the heart. Galen (129–200 AD) was the first to describe this theory that arteries contain blood and air, while Herophilus was the first to compare the pulmonary vein with musical rhythms, an approach that had a profound influence on medicine and music until the late Middle Ages and the Renaissance. Tempo was the unit used by Herophilus to create a conceptual match between musical rhythm and heart rate. Herophilus defined "apparent time" as the period during which neonatal arteries dilate. This detectable time is the base unit for measuring the length of each contraction and magnification, and thus the base unit for determining speed.

The most noteworthy part of Herophilus' clinical interest was his unique portable "water clocks" (or "boiler leaks"), which he used to control patients during health examinations. A water clock contained a certain volume of water to detect a natural heartbeat from people of all ages. Although Herophilus acknowledged the importance of heart rate measurement, his followers were unable to continue exploring the area until the 15th century, when heart rate was rarely mentioned.

Furthermore, H. Liu et al. (2018) explain that Galen estimated that the expansion of the arteries of the body should not be equal and that different stimuli may be detected depending on the extent of expansion on each side. For example, there may be perfect overheating with a lower lateral expansion resulting in high and narrow pulses. Similarly, full side expansion with a slight upward motion can result in low and wide pulses. Galen described several types of arterial pulses, such as sawdust, wave pulse and snake-like pulses. He described other types of arterial pulses at various temperatures or diseases, including hot and cold pulses, pain, inflammation, drowsiness, seizures, jaundice and even skin conditions. Unlike Erasistratus, Galen believed that enlargement and contraction of the heart and arteries occur simultaneously. As the ventricles contract, the arteries contract, and as they expand, the arteries dilate. Galen described the 27 symptoms of a single pulse in terms of size, speed and frequency.

Moreover, a more detailed description of all the different types of pulses reported by Galen goes beyond the scope of this thesis. The main task of pulse processing is explained in Galen's thesis published in four books entitled *De Pulsuum Differential*.

2.1.2.5 Pulse reading in medieval medicine

According to Furst (2020), the arterial pulse remains one of the most important diagnostic and prophetic indications in medieval medicine. For example, the arterial pulse was seen as valuable in the prospect for recovery from epilepsy. A medieval physician, if he thinks a patient has a specific type of epilepsy, would predict that the patient would develop seizures at the natural time of the disease. Like his predecessor, Avicenna (981–1037 AD) believed that health is based on the interaction of four different senses: blood, sputum, yellow bile and black bile. In his article on pulse, Avicenna described the quality of the combined effect of these four nuances. Like Erasistratus, Avicenna believed that the contraction and enlargement of the heart and arteries takes place at the same time. He also believed that there was blood and air in the arteries. Avicenna also believed that there were four different movements of the artery pulse: two movements and two pauses after each workout. Nevertheless, unlike Galen, Avicenna's theory is difficult to understand. It categorised impulses according to their different characteristics and described different impulse models in the following categories:

- Magnification size: strong, weak and medium;
- Duration of each activity: short, long and medium;
- Pulse length: pressure pulse, slow pulse or interval pulse;
- Pulse temperature: hot, cold or medium;
- Compression: simple compression, inconsistent and medium compression;
- Equal or unequal force in the event of a continuous impact; and
- Regularity: regular or irregular (irregular and regular irregular).

H. Liu et al. (2018) describe irregularities with random and continuous stimuli. In terms of the irregularity of individual pulses, they use shocks and premature falls as examples. Avicenna chose a general understanding of the various arrhythmias that are based on pulse symptoms. He described various stimuli similar to those seen in arteries and ventricles. He divided the artery pulse into categories more deeply than his ancestors. He further stated that three key factors were important in determining heart rate: buoyancy, endurance and elasticity. This was the first time that concepts such as immunity and elasticity were physiologically defined. In describing the different rhythms, Avicenna also compared the heart rhythms to musical ones. In the Middle Ages, this music was generally considered to be pulsating. He also described several types of "incentives" for different ages and types of people. Different stimuli were included under various physiological and pathological conditions. For example, the "rat pulse" described by Avicenna is similar to the so-called intermittent pulse following cardiac muscle weakness. He also described some examples of wave pulses, fatal pulses and peristaltic pulses.

Furst (2020) states that Avicenna understood pulses as wave-like, rather than a cylindrical tube shock. This is the basic concept of pulsed waves described in modern medical research. One of the most famous medieval physicists, Maimonides (AD 1135–1204), also believed that various arrhythmias came from the discovery of the pulse. In addition, this correlates the rhythm of the spine with the severity of disease (diseases that are more serious have an irregular heartbeat). In particular, Maimonides described the arterial pulse in patients with severe and weak accumulation.

Kala (2017) states that from Hippocratic times to the 13th century, doctors generally believed that the human heart consisted of four sections. The lower compartment, the ventricle, was thought to contain blood, while the upper compartment was thought to contain air. Due to the pores between the two ventricles, liver veins were thought to mix with air from the lungs, allowing significant asthma to pass through arteries throughout the body. Ibn al-Nafis (AD 1213–1288) discovered lung circulation. This ran counter to the theory of subversive antiquities, such as Galen and others, and introduced the pulmonary cycle to medicine. Ibn al-Nafis stated in *Canon's Anatomy Note* that blood flows from the right cavity of the heart to the lungs through the pulmonary arteries, then spreads through the lungs and blends with the air (forming left ventricular pneumonia), then the entire body.

2.1.2.6 Pulse reading in the Arabian region

Dating back to the 13th century, Unani practitioners—otherwise known as *Hakeems*—used pulse reading and its associated knowledge to diagnose patients with a variety of diseases by measuring the "kick" of a pulse at the wrist of an individual. In the face of rapid globalisation, however, information about these practices suffers from a lack of resources, archiving, and support.

Unani medicine is a system of medicine from South Asia that is rooted in diagnosis and treatment based on understanding the four senses of "humor" of the body: *dam* (blood), *balgham* (phlegm), *safra* (yellow bile), and *sawda* (black bile) (Rahman, Ali, Zulkifle, & Ahmad, 2014). In Unani, each individual retains a unique mixture of these humor and elements, which can then determine temperament. Through treatment and diagnosis, Hakeems can keep patients' temperaments internally balanced, which creates good health (Azmi, 1995).

The Unani medicinal system has been understood as a holistic system of medicine, as it incorporates mental, emotional, spiritual, physical and environmental causes of ill health (Ali, Islam, & Alam, 2007). Although Western medicine can link illnesses to particular bodily organs or systems, Unani treatments rely on understanding how different organs and systems of the body influence and impact each other. Thus, practitioners tend not to specialise in cardiology or abdomen health, for example, but rather focus on the body as a whole.

Pulse reading is a methodology employed by Hakeems to diagnose their patients. The history of pulse diagnosis is just as complex as the history and development of the Unani system itself; pulse reading was studied by Ibn Sina (980–1037 AD) from Chinese and Greek medical traditions, and was then incorporated into Unani (I. Khan, 2015). In this system, pulse reading knowledge often begins to be taught from a young age, as it takes years to master. The movement of the pulse consists of an expansion and then a contraction after some time. Pulse readings are conducted at the wrist of the patient, and Hakeems can use anywhere from two to four fingers, depending on the school of thought being followed.

Although Unani (also known as "Unani Tibb") is considered to be a form of alternative medicine in the West, it has been regarded as the primary form of treatment or in many parts of the global south. Unani, similar to Siddha and Ayurveda, is authenticated at the government level. Despite this authentication, Unani practices have been in steep decline and documentation on pulse reading is scarce. Since its rise in the global south during the Mughal era, to its decline and suppression in colonial India, the Unani medicinal system has undergone many transformations as well as continuities.

Ayurveda and Unani are both systems that are holistic and regarded as traditional. In the Ayurvedic medicinal system, the body is conceptualised via five basic elements: air, water, fire, earth and ether. It is believed that an imbalance in these five elements causes disease. Similarly, within Unani, the body is typically conceptualised via four elements: air, water, fire and earth. Furthermore, Unani employs four senses of humor: blood, yellow bile, black bile and phlegm. Pulse readings are paramount to Unani; while employed in Ayurvedic practices, they not central to diagnosis. An increasingly popular movement among Hakeems in Karachi is that of *mufeid-e-azaa* methodology. Followers of this methodology follow Sab-e-Multani, which is being regarded as an improved form of Unani. This belief system doesn't incorporate blood as one of the humors, instead only believing in three categories, which is consistent with Ayurvedic rather than Unani belief systems. Although not recognised by the Hakeems themselves as having been borrowed from Ayurvedic systems, this supposedly new methodology is a result of the cultural exchange between the two traditional medicinal systems in South Asia.

There was a strong congruence between indigenous medicine and nation building in the postcolonial era. Pre-colonial India lacked ideas of nationhood before the politicisation of the many ethnicities and languages in the nation state (Misra, 1998). In India, nationalists heavily contextualised Ayurveda within a Hindu context to reinforce nationalism. Post-partition, in a similar fashion, Unani came to be known as a sign of Pakistani national identity and culture (Sheehan & Hussain, 2002). It is perhaps for these reasons that people feel a binary when it comes to non-Western medicine because it becomes not about Unani itself, but also about notions of the strength and stability of the nation state.

According to historians, the renaissance in the Arabic region occurred in the 8th to 14th centuries. At that time, the Arabs began translating ancient editions, thus protecting the knowledge that the world had lost (Hajar, 2018a). The caliphate rules the Arabic region. Scientific, economic and cultural development is considered to be a major uprising. Islamic medicine systematically preserves and develops ancient medical knowledge, including from Hippocrates, Galen and Dioscorides. It contains concepts of ancient Ayurvedic traditions from Greece, Rome, Persia and India. When the Greater Empire died, Western European knowledge almost disappeared. However, Arabic translators have gained valuable experience since ancient times. In monasteries, this information has been translated from Arabic into Latin; this occurred during the Renaissance. As a result, doctors in Europe are now looking for old information. Of all the traditional methods of analysis, there is no greater myth and legend than pulse analysis. Arabs, Persians and central European physicians were known as specialists in pulse diagnosis. Avicenna (otherwise known as Ibn Sina) is known in the West. He wrote a manual called the *Medical Canon*, a medical encyclopaedia made up of medical departments operating in Greece, India and the Arabic region. His books were used in 18th-century Europe as standard medical books.

In addition to many other medical contributions, Hippocrates, Aristotle, Elast Stratus, Galen and Avicenna are considered to be giants in terms of pulse knowledge. However, they did not have advanced technology to prove or disprove the theory; they had arguments only. By analysing their patient's pulse and asking questions, practitioners could discover the patient's pain. Similarly, Ibn Nafis, who discovered lung circulation, described how the heart rate and its symptoms should be used to detect a specific disease. The theories explaining the physiology of love dominated Arabic medicine and were influenced by Greek thought.

Galen was the first to describe the pulse of health and illness, but his observations were not always accurate. Following Galena's perfect impulse theory, Avicenna gave the first correct impulse explanation. According to Avicenna, every heartbeat consists of two movements and two pauses: increase: pause: decrease: pause. In ancient times, Galician and Chinese doctors believed that every organ of the body and every disease had a unique form of stimulation (R. D. Lee, 2018).

2.1.2.7 Pulse reading knowledge and modern medicine

In their research, several physicians and scientists have also mentioned the importance of pulse reading. Hatala and Waldram (2017) mention few scientists who engaged in pulse reading knowledge. Lüscher, (2018) states that William Harvey (1578–1657AD) discovered an increase in blood circulation and made a little progress in understanding the arterial pulse and circulatory physiology. Harvey described the blood flow fully from the heart through the arteries.

Although the arterial pulse was an indispensable guide to ancient and medieval analysis, the emerging general terms were not well understood. The heart and arteries were thought to have their own heart rate and contractions at the same time. Harvey also monitored the contraction of the left ventricle of the arterial pulse and found the source of the pulse in the right corner of what part of the body. His findings conflicted with his ancestors, Galen and Vesalius, who believed that the generation of the artery pulse was due to the passive circulation of blood flow. This indirect, diffuse artery has been compared to the inflammatory process caused by blowing air into gloves. In addition, for the first time in medical history, Harvey stated that arteries and veins contained only blood.

Moodley and Shireen (2019) note that these significant discoveries were made through extensive experiments conducted on humans and animals. In *Anatomy of the Heart and Blood Movement*, researchers have detailed Harvey's analyses on various animals such as snakes, frogs, snails, crustaceans and fish. By engaging the upper limbs, his series of arterial pulse examinations clearly showed that Harvey believed the arterial pulse was a pulse rather than a shock. This experience-based conceptualisation and methodology opened the way to the study of today's pulse waves. For the first time in medical history, Harvey described quantitative hemodynamic operations such as stroke volume, cardiac output and fracture. His knowledge of these physiological methods yielded quantitative but qualitative research findings in medicine, leading to faster revolutionary discoveries. After a closer examination of Harvey's description of the circulatory system, it is clear that nothing about the capillaries was known at the time. These observations were made from examining capillaries, and were actually found by Marcello Malpighi, a professor of anatomy in the 17th century.

In terms of evaluating heart rate, Adji and O'Rourke (2019) state that the first doctor, Herophilus, calculated heart rate using a "drop jar". It is said that Bishop Nicholas (1401–1464 CE) first mentioned pulse rate in his work, although this method is not the current method doctors are currently using. Hundreds of shocks were counted in different subjects, and the weight of running water was compared to a threshold to determine health and disease. The discovery of the pendulum by Galileo in the early 17th century made Santorio Sanctorius (AD 1561–1636) think of the pulse. The scale of the pendulum device is a few inches, and a horizontal line indicates a flexible line with a lower weight. The doctor moves the pendulum and registers the pulse with his fingers. As the pendulum moves faster than the pulse, the physician extends the lines and vice versa until they meet, showing the pulse in inches.

A century after the pulse was first identified and named, John Floyer (AD 1649–1734) calculated the heart rate. He is known as the first physician to use a pulse meter, running for 60 seconds to count heart rate. After Floyer introduced modern pulse rate measurement, physicians began recording daily observations of pulses per minute. Moreover, de Moura et al. (2016) state that Irish physician Bryan Robinson (AD 1680–1754) examined people's heart rates at different hours and upward trends throughout the day. Jean Senac (1750–1770 AD) reported a 6-foot-tall soldier with an average pulse rate of 60 to 90 beats per minute. Other observations were made, such as that the heart rate increases with age. William Falconer (1744–1824 AD) made several charts in his excellent book *Pulse Observation*, which determined the rate of heat acceleration to normal pulse ratio. Chen, Shen, Liu and Yang (2017) state that the number of pulses per minute, and their symptoms, were the only way to evaluate patients until Jules Herisson invented circular scales in the 19th century. The circular scale apparatus consists of a graduated glass tube containing mercury and with a hemispherical steel sphere at one end. It was possible to calculate the effect of the veins and the strength of their stimuli by placing a hemispherical tip on the artery.

Hajar (2018a) specifies that the "crossover" was the first instrument that showed cardiovascular function. He described the measurement of blood pressure in various lung diseases, such as atherosclerosis and pulmonary obstruction. It was the first time that a physician had linked the objective results of the device to a physiologically active organism. Twelve years later, in 1847, the German physiologist Carl Ludwig invented the Kymograph device, which allowed the recording of haemodialysis variables, as shown in Figure 11. Ludwig introduced "Kymographer" in the mid-19th century, which had a significant impact on the speed of cardiovascular research over the next couple of decades.

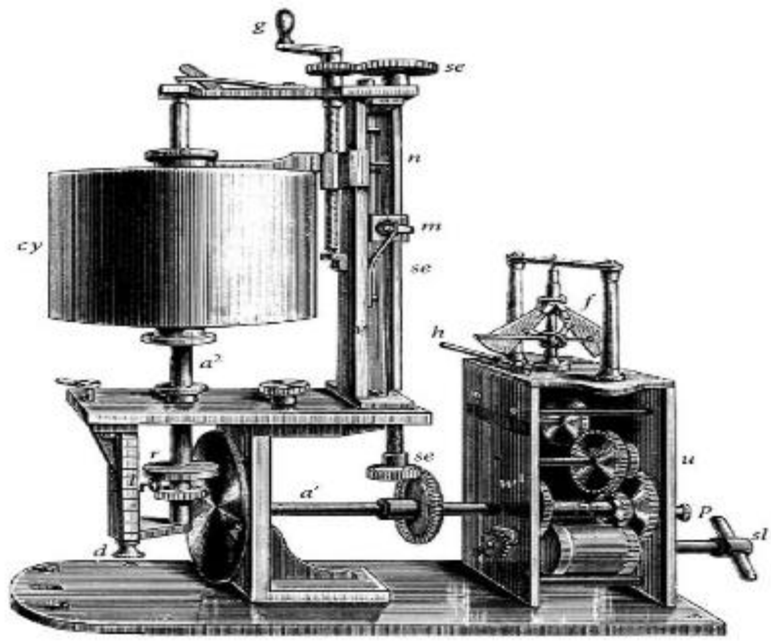

Figure 11. Carl Ludwig’s device, which could show the graphical representation of a pulse.

In 1860, the French physiologist Étienne-Jules Marey revised the previously invented “sphygmometer” and presented his “sphygmograph with graphical recording capabilities”, as shown in Figure 12.

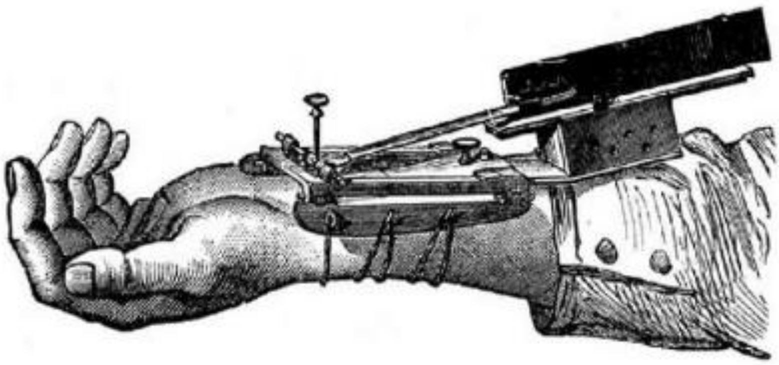

Figure 12. Marey’s graphical pulse recording device.

Moreover, Arozqueta (2018) states that Marey conducted the first official arterial pulse wave study using a breathing cycle, which described the difference in arterial pulse waves in the elderly and adolescents. Other examples of pulmonary artery wave studies include pulse reading and latency during examination, and methods for monitoring pulse, temperature and pressure gauges in long-term cancer. Mahomed used a modified cyclometer to study the pattern and strength of pulse waves in several different patients. He described hypertension with an odometer and was the first to describe primary hypertension and report glomerulonephritis hypertension.

H. Liu et al. (2018) state that, in the 19th and 20th centuries, graphical recording of stimuli made it possible to study the effects of shock waves. He believes that the blood pressure results from using these two devices seem contradictory. Based on the symptoms of 20th-century blood pressure, several types of arterial pulse are described, namely water hammer pulses, bipolar pulses and single pulses. “Mahomed’s Sphygmomanometer” had the capacity to measure pulse wave pressure quantitatively; as a result, a “circular masseter” was introduced in the late 19th century, and Postel-Vinay introduced the Inventory Pulse Meter in 1896. With the introduction of the “Riva Rocci heart rate monitor”, the peripheral blood pressure recording site was used to monitor the visual pulse wave lung. Bhattacharya (2017) states that pulse wave tracking is complex and time-consuming, and artifacts are often present on recordings.

In contrast, stem numbers represent only cardiac strength (systolic pressure) and arterial pressure (diastolic blood pressure), which facilitates interpretation. Numerous simultaneous studies have been conducted on the three main characteristics of peripheral arterial pulses, as well as their speed, weight and volume. This has resulted in clinical pharmacological studies of the use of some drugs at these physiological parameters today.

Modern heart rate studies and arterial haemodialysis are the results of an early revolutionary study. Van Meter et al. (2017) state that Stephen Hales (AD 1677–1746) introduced his Royal Society’s contribution to arterial disease in a series of articles entitled *Static Papers: Include Homeostasis*. The following excerpts from Hales’s article point to his first research into cycling mechanics. However, ventricular contraction, which increases blood levels during this period, should be completed within one-third of the interval between each pulse, so that blood supply at each contraction is three times 5,211 feet, or 0.98 miles per hour, or 86.85 feet.

Moreover, Furst (2020) states that Hales's research has attracted the attention of other researchers, such as Leonhard Euler, who developed quantitative methods for measuring arterial formation. However, it did not provide a simple formula that could indicate the relationship between mechanical power and the pulse wave of mercury. The idea of a series of waves in the treatment of arterial stimuli is related to the study of Fourier thermocouple transfer operations. Similarly, the method for detecting and interpreting the pulse activation time zone is characterised by the features of a single heartbeat device from Leonhard Euler's earlier works (AD 1707–1783). However, the Euler artery method failed to use a non-linear preservation equalisation form to explain a larger cycle organisation. A few years later, Riemann applied this to the pulse wave time zone theory.

Arozqueta (2018) also states that in the early 20th century, Bramwell, a Brighton scientist, first introduced the term pulse wave speed (PWV). Bramwell noted that velocity varies in proportion to arterial wall tension and blood pressure and is an indirect measure of arterial wall elasticity. Bramwell and his colleague Hill proposed a simple formula for calculating arterial elasticity from PWV. Using this formula, Bramwell found a positive correlation between PWV and age and a negative correlation between wall elasticity and PWV. Bramwell's formula is:

$$\sqrt{} \text{ Speed (m/sec)} = 3.57 \text{ \% mmHg pressure increase}$$

Van Meter et al. (2017) state that in the mid-20th century, Womersley and Nichols completed an excellent study into "haemodialysis" of arterial pulse waves. In addition, with the advent of digital computers, Fourier frequency analysis is becoming increasingly popular among researchers. Computers can calculate a variety of functions to measure heart rate faster and more easily. Over time, however, time zone theory has returned to study the dynamics of shock waves. Modern pulse analysis has been proven to support its historical perspective. Despite all these studies, best practice in clinical use is still under discussion.

Furst (2020) notes that since Schmitt invented "typography" in the mid-20th century, research on impulse waves has progressed rapidly. Over the past 50 years, several methods have been used in Venous Occlusion Plethysmography VOP studies, such as hot wire sphygmomanometers, resistance plethysmography, application tonometer and pulse wave recordings with crystal microphones. Plethysmography and pulse wave plethysmography can be used to monitor pulse waves and their regularity. In contrast, plethysmography can be used for technical applications, including peripheral blood oxygen measurements, blood pressure monitoring and Allen sensor-based blood tests. In the 1960s, Simmons and colleagues fingerprinted and used a powerful ECG to record changes in resistance as a result of blood entering the fingers. In this study, pulse waves in 80 normal subjects, and patients with different blood vessels, were recorded and compared. They asserted that technology can be important in assessing changes in peripheral arterial disease and peripheral arterial atherosclerosis. Microphones are mainly used for determining Pulse Wave Velocity (PWV): a crystal microphone is inserted into the groove above the femoral artery, which converts the pulse wave creation into an electrical signal. PWV is calculated using the difference between the tip of the ECG "R-wave" and the heartbeat, and the formula includes the distance between the two anatomical points of the patient's body.

2.1.3 The Unani Medicinal System: An Intangible Cultural Heritage

According to UNESCO's definition of Intangible Cultural Heritage (ICH), Unani physicians are TK holders and embody South Asian ICH (WIPO, 2016). Unani (also known as Unani Tibb) knowledge has been collected and described in 13 authoritative books, which detail the processes of diagnosis, treatment and prescription, using plant-based recipes and medicines (Gilani, 2005). Although the knowledge has been protected through intellectual property (IP)-related legislation, the text-based documentation of Unani does not capture the comprehensive knowledge and practices of physicians themselves. This non-codified or informal TK includes everything from clinical observation, expertise in herbalism/pharmacopeia and daily actions in people's personal lives.

Folk/traditional/indigenous medicinal systems around the world also constitute ICH. Unani Tibb is prevalent in the Indian subcontinent as a traditional medicinal system. These traditional systems are currently practised in the Indian subcontinent and are considered "codified" or explicit TK of South Asia (Organisation mondiale de la propriété intellectuelle, 2001; Toukam & Wamba, 2012). It has been emphasised to document and preserve Unani medicinal system (Ajazuddin, 2010):

> "Under the parasol of traditional medicine systems, the Unani system of medicine is also gaining global acceptance due to the amazing clinical efficiency of the formulations. Although Unani medicines have long been used, there is negligible documented evidence regarding their safety and effectiveness." (p. 318)

In Perso-Indian expressions, Unani means Greek/Ionian. In the context of this study, Unani refers to the system of medicine which incorporates the ancient Greek humoral pathology. As shown in Figure 13, the concept of "physis" and the transformation of theocratic medicine into rational medicine was first introduced by Hippocrates (Orfanos, 2007). Hippocrates was also responsible for transferring the very first standards and ethical rules to the medical profession. Although massive urbanisation, industrialisation and modernisation have altered the Hippocratic medicinal system, the ideology and core principles are still practised and recognised in the Eastern region today, particularly in the Indo-Pak subcontinent and Middle Eastern regions (Yesilada, 2005). Some Arab scholars have also translated the Graeco-Roman into the Graeco-Arab medicinal system. It is important to note that medical practices in contemporary Asia—Ayurveda, Unani and Chinese—follow the same underlying wisdom, logic and intellectuality of Greek philosophers (Leslie & Young, 1992).

The "Allopathic" or modern medicinal system is rooted in the ancient practices of Greek physicians and scientists (Porter, 2001), as shown in Figure 12. When molecular technology and germs theory disease penetrated modern society, the qualitative or holistic manner of treating the human mind, body and diseases was no longer practised as before. Characteristics of the Hippocratic approach, such as compassionate sympathy for patients, individualised management, humoral pathology and the individual temperamental approach, shifted severely because of the rapid growth of a scientific assessment of the human body rather than a qualitative one.

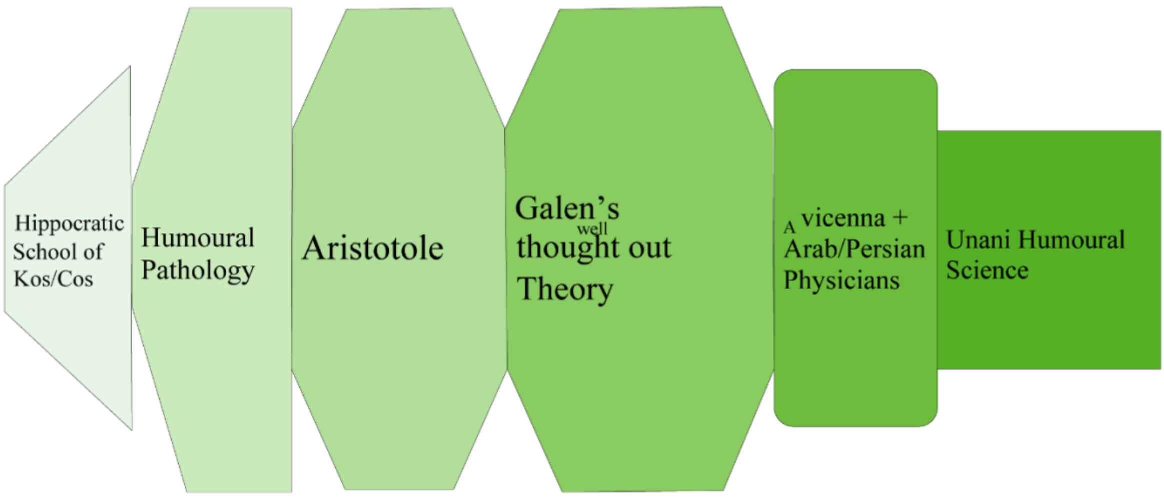

Figure 13. Humoral science and its impact: From the Hippocratic School of Kos to Galen (famous Greek physician, 130–201 AD) and Ibn Sina -Avicenna (Asian physician, 980–1037 AD).

Similar to the Chinese, Ayurveda and other alternative medicinal systems, the knowledge of human pulse reading is essential to diagnosis in Unani medicine (Chakrabarti, Ghosh, & Sahana, 1972). Galen (130-200AD) and Avicenna (980–1037 AD) documented the effect of the pulse on human emotion. Galen used humoral pathology and pulse to assess his patients (Jackson, 1969). Hajar (2000) mentions Avicenna in his article *History of Medicine – Body, Mind, And Medicine* and describes the types of pulse and related human feelings. In the Unani medicinal system, practitioners believe that the spirit ("Ar. Ruh") circulates in the human body through the blood, and the heart is the primary source of pumping blood to the various organs. According to the pulse diagnostic system, any kind of discomfort or disease can be traced by the character of the heartbeat. The Unani physician (the *hakeem*) senses the spirit of the body by holding the right and left hands of the patient. The fundamental life force is called "Nafas" in Unani.

The Unani system of medicine is considered to be legitimate and is regulated by a government agency in Pakistan (World Health Organization, 2001). Herbal treatments and herbal remedies have a long history in the region (Shaikh & Hatcher, 2005). Indeed, the herbal character of Pakistan has been a frequent subject of research (Parvaiz, 2014), and there are around 40,000 government registered Unani physicians in the country (Hamayun, Khan, Kim, Na, & Lee, 2006).

There are several universities and libraries in Pakistan that are involved in Unani research. For example, Hamdard University in Karachi offers higher education in the Unani medicinal system. The central library of the university holds a vast selection of valuable historical books, articles and digital archives related to Unani knowledge. It is also the centre of Unani research in the region (Zaidi, Yamada, Kadowaki, Usmanghani, & Sugiyama, 2009), with connections to regional Unani publications and academic resources. The Faculty of Eastern Medicine at Hamdard University offers bachelor, master and doctoral education in the Unani medicinal system. Another well-known university contributing to Unani knowledge in the region is Qarshi University, which has recently become known for promoting this ancient science.

Because of the introduction and success of English/Western medicinal approaches, the knowledge and practice of Unani has greatly declined, particularly after germ theory was introduced MicroDok. (n.d.). Since the loss of this great science is imminent, it is essential to find new ways of documenting these forms of ICH (Arnold, 2008). This work is especially important in countries such as India and Pakistan that do not have a history of maintaining heritage inventories (Park, 2013). Digital tools offer an opportunity for not only innovative documentation protocols but also interpretation and knowledge exchange.

2.1.3.1 Pulse reading knowledge as a cultural production and heritage

Cultural heritage is considered to be a valuable asset of humanity and reflects its success over the centuries (Chianese, Marulli, & Piccialli, 2016a). The need to identify and protect cultural heritage is well known, and various experts have made important efforts to reach this goal. Many published documents also underline the importance of cultural heritage (Da Costa & Da Costa, 2019). However, with the advent of human development and the discovery of new tools and technologies, the concept of cultural heritage protection has changed dramatically. New technologies, such as computers and digital devices, have opened new ways of protecting cultural heritage. In this context, it is important to review the different technologies to make the best use of these cultural heritage assets.

In addition, cultural heritage is threatened by various factors, such as natural disasters, vandalism, urban development and aging. Therefore, we need to make sure that cultural heritage is properly documented before it is lost, and save it for future generations or to use for reconstruction if needed. As such, it is essential to use digital technology to collect data and share file status. Digital technology can simplify and speed up archiving while ensuring accurate results and output during the protection stage. The recording stage is consistent with the other stages of any preservation project (Chianese et al., 2016).

Indeed, documentation is necessary at all stages of the cultural heritage protection process, and in each case, digital technologies can assist by providing relevant data according to the needs of the project (Pozo-Antonio, Rivas, López, Fiorucci, & Ramil, 2016). Many scientists and experts have researched, tested and reported on the use of digital technology to protect cultural heritage. However, there is a knowledge gap between cultural heritage experts or heritage agencies, technology and technology experts, especially in developing countries. In addition, the rapid development of electronic methods has further complicated this process, as cultural heritage experts need to continually update their knowledge in order to develop effective conservation strategies and policies. A variety of literature has been published to solve this problem, primarily through research. However, issues remain and many cultural heritage experts are unaware of the rapidly evolving technology, which can help them document and preserve the heritage (Chianese et al., 2016).

In some cases, large sums of money have been invested without first considering the purpose of the project. As a result, documents can eventually be stored and forgotten in archives. Thus, this problem must be addressed by researching and highlighting recently discovered technology. This can help project administrators more effectively communicate with scientists and technology experts on technical issues, allowing them to prioritise project needs more effectively and to improve the results of their protective measures (Bastidas & Coleman, 2018).

2.1.4 Pulse Reading Diagnostic Machines and Methods

A number of methods and technologies have been developed recently to capture pulse data. This section presents and describes various machines and their functions.

2.1.4.1 Nadi Tarangini

Kamble and Akant (2019) state that developing training in this competitive age requires the latest advances in technology and science. Building and maintaining patient confidence has never been so difficult. “Nadi Tarangini”, as shown in Figure 14, is an innovative development that addresses these issues and helps in the recommendation of proven treatments that increase patient confidence. It is a new and practical way of performing “Nadi Pariksha” (pulse reading). Ayurveda is a traditional medicinal and herbal system in India; “Nadi-Nidan” (pulse analysis) is an important method in Ayurveda and it is well known for determining all-important features of the human body (Kumar, Deshpande, & Nagendra, 2019). In their article, Kumar et al. provide detailed information on the process of obtaining Nadi’s full impulse in chronological order. The Nadi Tarangini system includes a diaphragm for a manometer, transmitter and amplifier component, and it is digital for measuring analogue signals. The system delivers data with 16-bit accuracy, without external electronics or interference. Compared to systems such as ECGs, other current technologies are rarely used in obtaining the pulse. The waveforms obtained by the Nadi Tarangini system have been compared with similar devices that were previously developed, and the screen provides data. It has also been shown that the pulse waveform shows a variation in patient age and pressure applied to the sensory portion. Ayurvedic doctors regard the system as a computer-based diagnostic tool (Patil, 2017).

Figure 14. Nadi Tarangini device for Ayurvedic pulse reading diagnostics.

According to the manufacturer, the portable Nadi Tarangini device provides accurate results and fully customised software. Kumar et al. (2018) note that in this fast-changing world, diagnostic tools must be extremely effective, and Nadi Tarangini provides unprecedented insights into managing personal health care. Use of the Nadi Tarangini device resulted in subtle changes being made to general health criteria, based on the analysis of “Vatta, Pitta, Kapha (Tridosha)”. These are the three fundamental forces or principles which dictate the function of our bodies on the physical and emotional conditions (Patil, 2017). A report by Nadi Tarangin (Nadi Tarangini, 2020), examined current and potential diseases and recommended changes in diet and lifestyle. By using unique sensory technology, Ayurvedic wisdom can interpret personal health metrics and complex data, making Nadi Tarangini an ideal tool for personal analysis (Patil, 2017).

Patil (2017) states that Nadi Tarangini is ideally suited to Ayurvedic, homeopathic, herbal, acupuncture and conventional medicine practitioners as it provides beneficial information about patients’ internal health. It also benefits health centres, health teachers, yoga teachers, health educators and nutritionists by helping them to more fully understand their patients and to develop personalised health plans for them (Kamble & Akant, 2019).

Custom reports generated from the Nadi Tarangini device are based on “Nadi’s reading (pulses), taking into account geographical location and climate change. The report contains explanations for the individuals’ ‘Prakrit’ (Tridosha balance)”. The Nadi Tarangini device provides data that graphically represents the human pulse analysis and its categories (Tridosha balance). In addition, it is recommended that patients change their diet and lifestyle based on their current “Prakruti and Vikrut (Tridosha imbalance)”. Analysis of the data can also predict potential disease and provide early detection, making Nadi Tarangini a health-focused diagnostic technology. Custom reports are based on user settings (Kumar et al., 2018). There are two types of reports generated—a summary of the patient’s health and a 10-page report with complex Ayurvedic variables—and all reports are available in English and Hindi (Kamble & Akant, 2019), as shown in Figure 15.

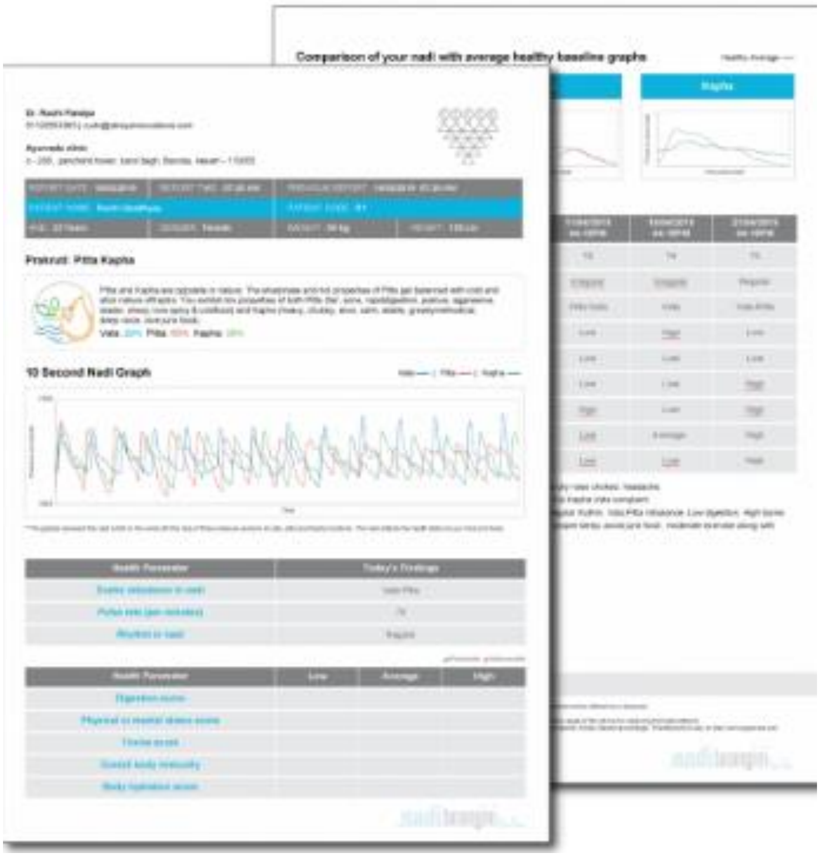

Figure 15. Reports generated by the Nadi Tarangini device.

According to the manufacturer, use of the Nadi Tarangin device can extend to, and change, patient care. For example, the device can detect small changes in a patient’s pulse.

It can then be used to provide preventive care and pave the way for personal health care development (Patil, 2017). Moreover, the data generated has great research potential. Nadi Tarangini has been used successfully in diabetes, heart and fertility studies (Kumar et al., 2018). It also shows great potential in studies of hypertension, mental disorders and arthritis. According to the manufacture of Nadi Tarangin device, they have worked hard to be a part of research and collaboration to obtain improved medical diagnoses (Kamble & Akant, 2019).

2.1.4.2 VedaPulse

Nambiar and Chacko (2018) describe "VedaPulse" technology (as shown in Figure 16), a health diagnostic solution based on emerging sensor technology for traditional and non-traditional medical professionals. VedaPulse is an innovative hardware and software system that helps Indian herbalists to analys the balance of "Doshas" and "Subdoshas" (Neeraj, Prasad, & Swayamprabha, 2018). In digital pulse analysis, VedaPulse examines pulse changes with ease of use. The device evaluates pulses in milliseconds. Repeated changes in heart rate length lead to a complex heartbeat detected by a computer program. The program's user-friendly interface allows beginners to master the basic technology in a matter of hours (Nambiar & Chacko, 2018).

Figure 16. The VedaPulse device and sensors.

The purpose of pulse analysis (traditional and digital) is to determine how blood circulation meets the needs of internal organs and physical systems (Neeraj et al., 2018). The basic version of VedaPulse Professional software has the following settings:

- Theoretical unit of analysis—Record pulse and pulse analysis (spectroscopy, indices and Baevsky);
- Meditation (Biofeedback) —Suitable for individuals who visualise and appreciate a variety of techniques: breathing (mountain breathing, qigong), car training, roaming, yoga, etc.;
- Fitness—Assessment of patients' personal fitness (based on "Ayurvedic Balance, Doshas Vata-Pitta-Kapha");
- Web synchronisation with the VedaPulse hardware and software model—Remote control of patient function status; and
- VedaPulse provides a home-based hardware and software model.

Neeraj et al. (2018) notes that VedaPulse also provides information about remedies. It provides a variety of software for conducting comprehensive health assessment and advice on health promotion and improvement (Nambiar & Chacko, 2018). The method for detecting heart rate variability is the basis of the VedaPulse system algorithm.

2.1.4.3 Bi-Sensing Pulse Diagnosis Instrument (BSPDI)

In the Chinese medicinal system, some devices have already been used to determine the nature of the pulse. One of them is the Bi-Sensing Pulse Diagnosis Instrument (BSPDI), as shown in Figure 17. The device can easily quantify finger-reading skills and sensations when measuring pulse. The Department of Electrical Engineering at the National Cheng Kung University in Tainan, Taiwan, has conducted research to evaluate the device when used on a healthy individual (Chung et al., 2012). The goal of the study was to compare the diagnostic methods in Western and Chinese medicinal systems. The device uses three positions and nine indicators through its sensors and mechanical placements. The device can detect the three sequential appearances of a pulse in the wrist artery, similar to the physician's fingertip displacement which moves from superficial to deep sensations.

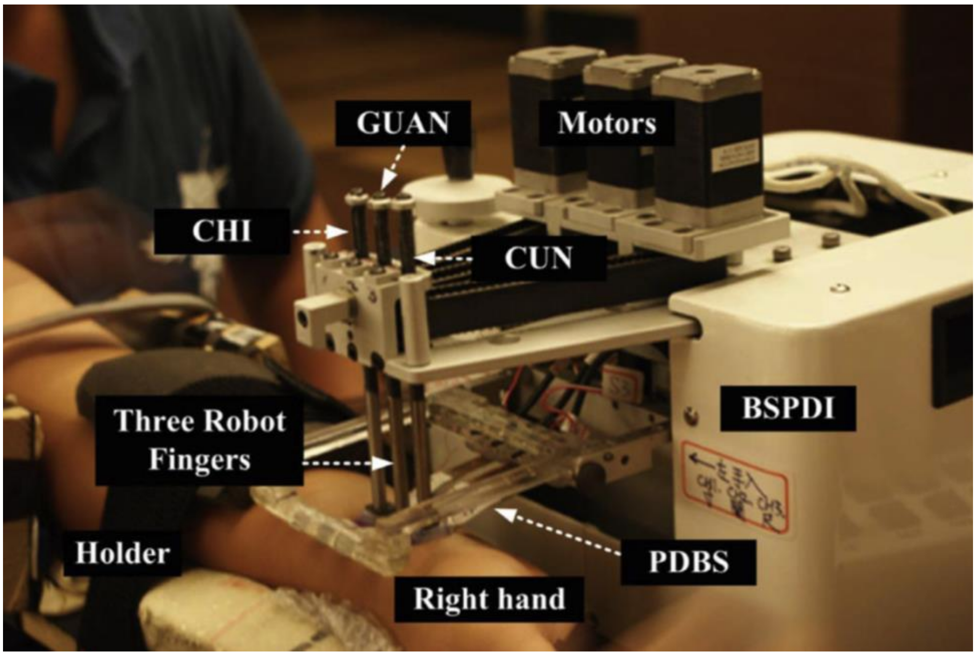

Figure 17. A patient’s hand and the BSPDI device used in traditional Chinese medicine diagnostic methodology.

The Chinese medicinal system is based on “yin-yang” balance. In order to balance these energies, physicians provide natural remedies and acupuncture treatments. The BSPDI instrument can mimic a TCM physician’s finger-reading skills according to TCM guidelines. Similar to the Nadi Tarangini and VedaPulse devices, the BSPDI can also categorise the pulse and detect the five elements necessary to evaluate human health and condition.

2.1.5 The Human Pulse and its Artistic Representations

An exhibit, Pulse Tank, by Rafael Lozano-Hemmer (a Mexican artist), was shown at the Hirshhorn Sculpture Museum and Garden (Caiafa & Neculaes, 2019), as shown in Figure 18. As people interacted with the exhibit, large light bulbs would blink (and a corresponding sound heard) based on their heart rate. Moreover, hundreds of light bulbs would strike the same pattern throughout the room. The recorded pulse is represented by a number of small bulbs (Menon & Shukla, 2018). The idea was to increase the amount of electricity until it is closest to the size of a person’s body (Brill, Park, & Kashyap, 2019). In addition, the “pulse chamber” was a composition of the three main structures of the museum’s second installation; the floor gallery contained pulses. These three works represented the largest display of interactive technology to date in Hirshhorn.

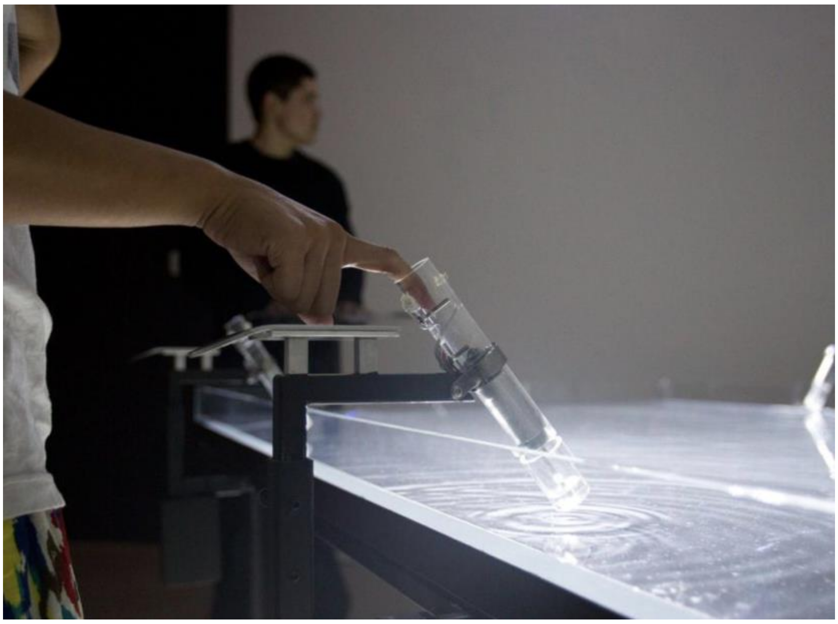

Figure 18. The Pulse Tank exhibit by Rafael Lozano-Hemmer.

The Pulse Tank exhibition began with fingerprint recognition. Using the 2010 heart rate index, visitors placed their index fingers on a device that could detect heart rate and display fingerprints on the wall using large projection. The viewer's heartbeat is also displayed, as the projection shows the heartbeat behind the fingerprint. As new visitors registered their fingerprint impressions, they were systematically displayed along with previous impressions on ever-smaller networks. Because of the ample space, 10,000 fingerprints could appear at a time (Pivina, Semenova, Doşa, Dauletyarova, & Bjørklund, 2019).

The exhibit's authenticity and privacy have been criticised by some researchers (Vikhnan et al., 2018). For example, when a new giant fingerprint was projected onto the wall, the last fingerprint was repelled and destroyed. "In other words, it's not just their fingerprint storage or archive, it's a process. We call it a reminder because it reminds us that we only have a short time here", Lozano-Hemmer explained (Pivina et al., 2019).

The New York Heart Bot exhibit also used human pulses transformed into an artwork, as shown in Figure 19. This exhibit produced drawings based on the beating hearts of people in the room. The Heart Bot tractor device consists of two-stepping motors 12 feet apart and connected by a long strap. It is secured by a pair of mechanical arms that hold the pen for drawing. As each exhibit visitor stepped onto the podium and placed his or her fingers on the heart rate sensor, the device moved across the wall and added to an artwork that displayed all the heart rates that had been input (Varadan et al., 2017). This occurred as pulse data from the sensor was transmitted to computer software, which then transmitted the information (with well-organised movements) to the motor and hand. The result was not an incredible composition but an interesting interactive application (Song & Vega, 2018).

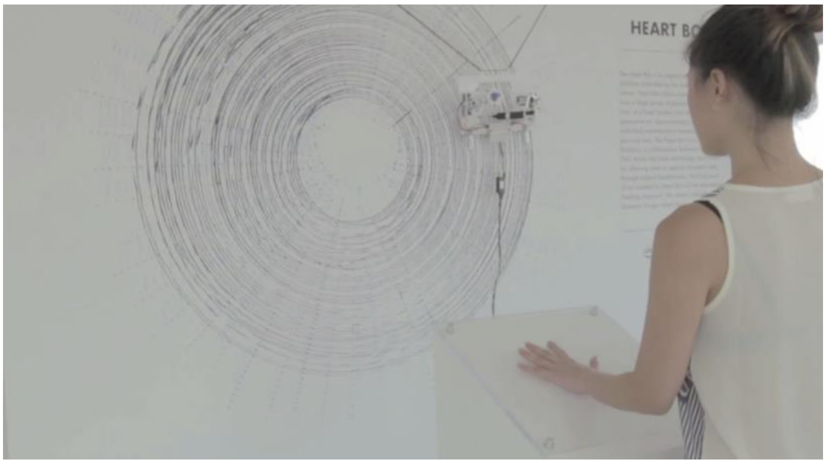

Figure 19. The New York Heart Bot exhibition.

The Heart Bot project was designed by the North American Interactive Agency in collaboration with Sid Lee’s NYC trademark firm, and it also introduced indigenous innovations. It attempted to engage visitors and invite them to spend time together and to visualise their heart rate (Yu & Arents, 2019). Nevertheless, like many similar projects, the system itself is often more creative than any of the traditional art forms it creates. Its practicality challenges the heart of art: the creative expression of human thought.

American technology companies are renowned for their innovative efforts. For example, the North American Interactive Agency also launched a biometric project called “Conductor”, which was a musical experiment and VR-driven virtual wave (Yu & Arents, 2019). The company also provided technical expertise for a partnership between James Murphy and the US Open, which enabled electronic music producers to convert tennis data into music tracks. The *Harvey Moon* exhibit used similar equipment and photo processing to turn photos into intricate murals (Varadan, Rai, Kumar, Mathur, & Agarwal, 2017). The exhibit creates and extends these concepts to work with biological statistics instead of machines taking commands directly from a computer. After being used by dozens of people, Director of Device This is probably true, however Heart Bot’s paintings resemble cardio rather than visual art. Therefore, the resulting creativity is less inspiring than the idea behind it (Song & Vega, 2018).

2.1.6 The Pulse as Intangible Cultural Heritage

Intangible Cultural Heritage (ICH) is defined as cultural expressions or practices as endorsed by UNESCO (Kurin, 2004b), concentrating mainly on intangible aspects of culture such as language, music, dance, poetry, memories and indigenous methodologies. Moreover, Virtual Reality (VR) is a digital technology that duplicates a situation, imaginary or real, and mimics real-world environments for user interaction. Importantly, VR and other three-dimensional (3D) display technologies can be used in the representation and transmission of pulse reading knowledge as a way of preserving ICH.

The Virtual Immersion with Pulsation (VIP) installation described in this section aims to explore the interpretation of non-codified TK such as pulse reading, and transform it to artistic expression. More specifically, this proposed installation is my attempt to perpetuate ICH, such as relaying conventional clinical practices through a VR-based Head Mounted Display (HMD) or stereoscopic perception. The aim of the installation is to collect and present the ancient science of pulse reading embedded in current clinical practices and to elicit the emotions of users in a heritage-related environment within museums and over the Internet. Hence, this part of Case Study A is an attempt to: (1) collect pulse reading TK through available sensors or commercial devices such as Nadi Tarangini and VedaPulse (as described in Section 2.1.4); (2) transform this incoming pulse data into auditory and dynamic stereoscopic visuals; (3) make the data available for HMD systems or 3D screens for entertainment, playfulness and user interaction; (4) archive the user experience, interaction and output; and (5) use the achieved data for further heritage-related purposes for the wider community.

2.1.6.1 Need and significance

ICH includes the manifestations such as memories, performances, identities and moving imageries related to the past (L. Smith, 2006). These manifestations are quite common but least focused because of their intangible nature and thus, heritage is often specified to only tangible objects. ICH in the museums and other heritage-related sites is not appropriately exhibited even social media is not effective to enable he visitors to understand the contexts of the intangible heritage. On the contrary, the tangible heritage can easily be represented though photographs, artworks as well as the items from the archaeological excavations usually included in the museums’ exhibits. ICH is however still limited or specified to only 2D art depiction, videos or animations. ICH can be exhibited by the live performances but it might be relatively expensive for the museum management to organise. Therefore, the interactive technologies are needed to be deployed to ensure the great linkage of the user interaction with the ICH content for transferring the knowledge, disseminating future and passing the historical information to the next generations (Shi, Hao, & Sun, 2008). These opportunities if not availed, may result as the disappearance of the traditions and customs which is evident by the lost civilisations (about intangible heritage) such as Greek Music (West, 1994) and the Chinese indigenous musical performance “kunqu” (Wong, 2009).

The heritage is often displayed by the artifacts, objects, traditions or customs among which the tangible representation in museums or historical spaces is very easy but to display ICH museums has to change their designs and ways of protecting and enhancing ICH so that the visitors can get incredible experiences (Shi et al., 2008). Emerging technologies, media advancements and the interactive technologies are some ways of moving the preservation and conservation of the cultural heritage beyond the static displays. These are effective to capture narrative form which an revitalise the intangible aspects of heritage (Kalay, 2008). The emerging technologies and the media advancements can greatly help in transforming the main activities regarding the recreation and understanding about the past. These activities include recording and analysing the scientific data digitally and communicating the past-related information covering maximum audience with the help of online/offline interactive applications (Silberman, 2004).

Moreover, it gives credence to the notion that visual representations are fundamental when it comes to tangible representations of artifacts (Milekic, 2010). In the case of creating virtual environments, a sense of presence is established, and if the user has the opportunity to interact with and navigate within the environment, a sense of engagement emerges. This scenario will also be true in representing ICH. Hence, it can be argued that, when pulse reading and physicians’ imaginations are transformed into visual perception, a sense of consciousness is established; intangibility is transformed into tangible visuals for users and a conscious interaction emerges. This also facilitates the de-codification of abstract information into a tangible experience. Milekic (2010) argues that when content is presented in a virtual manner, sensory experiences create new layers of knowledge and action spaces, whereby delivering a natural and conducive mechanism for the transfer of knowledge. Within the realm of ICH representation through VR, there is a deficit in representing the quality and quantity of TK with playfulness and fun, which is the gap this attempt aims to fill. Similar to the tangible representation of the past through digital technology, this case study will help to revitalise the intangible artifact—Traditional Knowledge through Virtual Reality.

2.1.6.2 Development of Virtual Immersion with Pulsation (VIP)

The term "Virtual Reality" (VR) was coined by Jaron Lanier in 1992 (Lanier, 1992) and VR and augmented reality have attracted people from every aspect of life, mainly after Mark Zuckerberg acquired Oculus for two billion dollars (Castelvecchi, D. (2016). The term was adopted by the media and, according to Ivan E. Sutherland (1996), it allows people to look at another place through a glass screen using VR. For example, his HMD prototype "Sword of Damocles" could track the movement of the user. Although there were several attempts to demonstrate HMD technology, such as Virtuality HMD in 1991, Cybermaxx VR in 1994 and Nintendo's Virtual Boy in 1995, users were not completely satisfied.

VR technology has been around for many years but it is now ready for adoption for multiple uses. It provides users with a feeling of presence inside an artificial space. The first HMD was built for watching television by Morton Heilig in 1960 (Heilig, 1960). It has stereoscopic vision and stereo sound. For a remote immersive experience of presence, the Philco Corporation created a headset called "Headsight" to track remote movements. Remote movement tracking or telepresence is a feeling of being present somewhere other than one's actual location (Telepresence, 1980). "Sensorama" was also an attempt to develop stereoscopic film, stereo sound, smell, vibration and wind (Heilig, 1960).

I have been thinking for a long time about how to revitalise the human pulse and its subjective manifestations based on the Unani/Ayurvedic and Traditional Chinese Medicine (TCM) pulse reading knowledge. Virtual Immersion with Pulsation (VIP) is a technology proposed for online and physical museums, as shown in Figure 20. It allows the non-codified knowledge of pulse reading to be transformed into a tangible manifestation with another kind of materiality for cultural production. It is intended that when coming generations use these installations (or the online version), they will feel an attachment to the heritage content and will also create another form of heritage within their specific communities. Ayurvedic, Unani and Chinese physicians regularly use analogies and cognitive abilities to visualise the pulse while they hold a patient's hands.

This device could subjectively produce those cognitions and imaginations using visual and auditory senses.

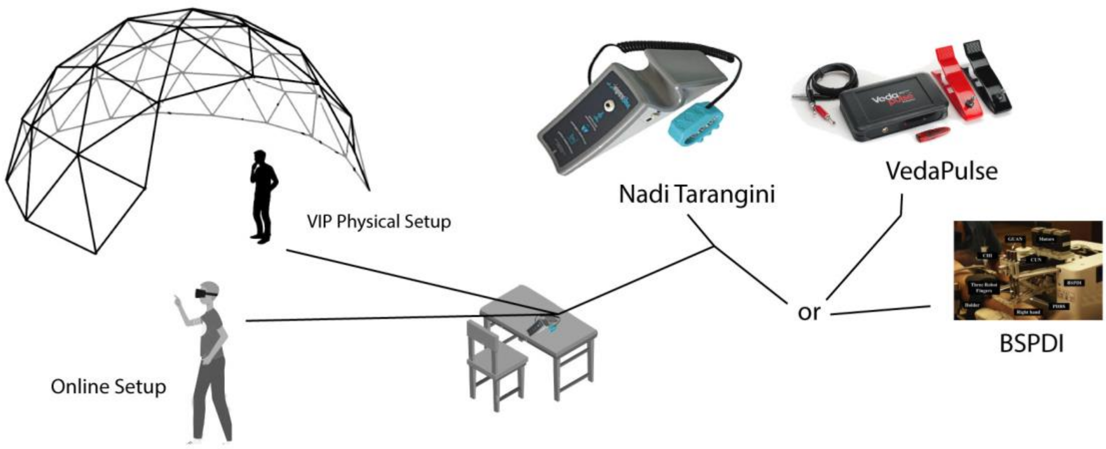

Figure 20. The Virtual Immersion with Pulsation installation setup (physical and online) with Ayurvedic and Traditional Chinese Medicine pulse reading devices.

VIP virtual and physical setup can transform incoming Unani, Ayurvedic and TCM pulse data and transform them into non-linear interactive user experiences, as shown in the schematic diagram in Figure 21. The three different values of Vata, Pitta and Kapha in Ayurvedic philosophy, or the nine different values of pulse in TCM, will be evaluated in this installation. Moreover, in Unani medicinal system, there are three out of four major elements: Sanguine (dum), Choleric (sufra), melancholic (soda), phlegmatic (bulgham). These various values from pulse reading devices will be synthesised in computer software such as Mad Rapper, Jitter, Quartz Composer, etc. The data could also be pipelined through various 3D game engines such as Unity 3D or Unreal and then represented either onscreen or in HMD devices.

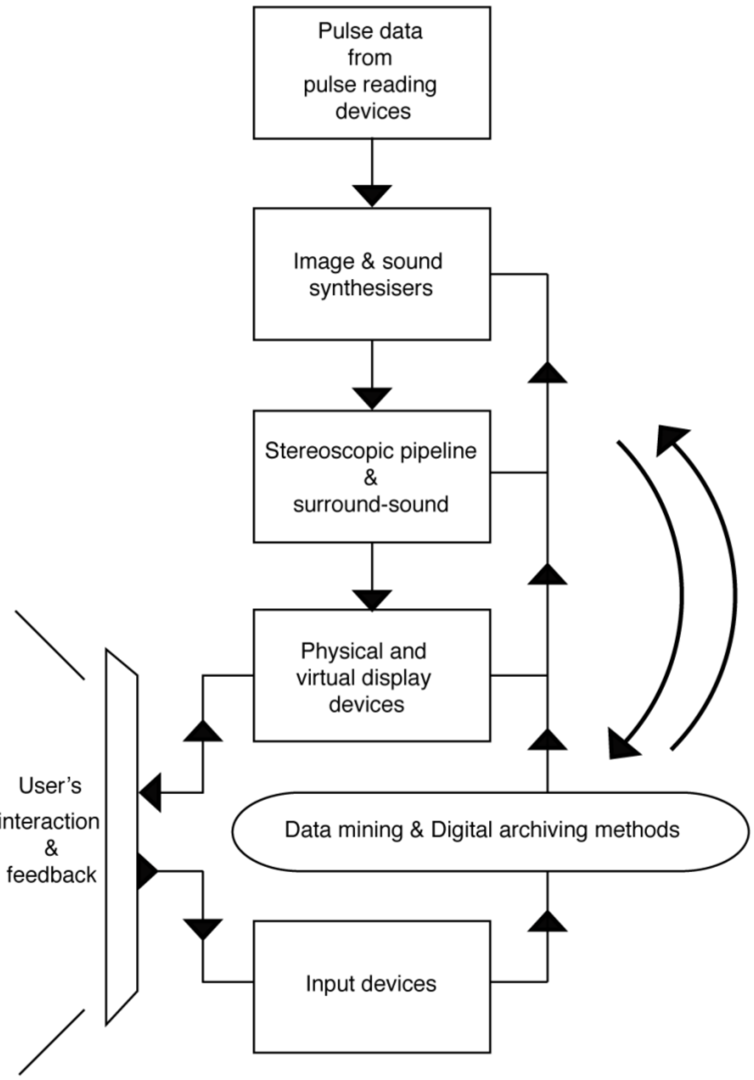

Figure 21. A schematic diagram of the workflow of the Virtual Immersion with Pulsation installation.

At the entrance to the installation, users will complete a digital consent form agreeing on the use of the installation and to provide their pulse reading data for processing. This allows for ethical recording of the pulse data. The machine will detect the dominant element of the pulse, such as in TCM, and calibrate the installation based on the Five Elements Theory in the Chinese medicinal system, as shown in Figure 22. Users will then will be given either a stereoscopic HMD system or may enter into a dome-like structure where LCD displays are arranged in a tiled manner. The data will then be presented along with some user feedback and particular choices. These choices will be presented based on the age and particular interests of the user.

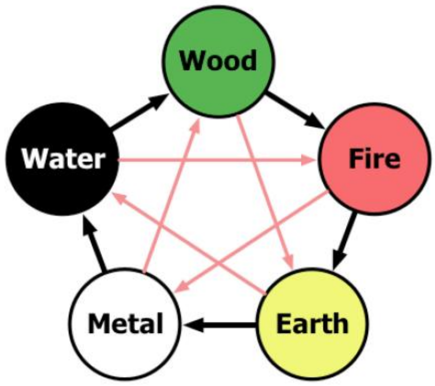

Figure 22. The Five Elements Theory as in the Chinese medicinal system.

User interaction and feedback will be critical in this museum installation. The installation, and the content of the installation, will be designed to depict some Chinese cultural motifs and physical objects. This installation will not only represent ICH but also manifest the tangible artifacts of Chinese cultural objects. The ancient Chinese clinical environment and other paraphernalia will be placed around the installation to create relevant ambiance.

The five elements—fire, earth, metal, water and wood—form the basis for evaluating how the diagnosis system will work. These five elements establish the following imbalances or balances in the body and also create the physiological perception of a person:

1. Fire—Heart: joy, laughing, communication;
2. Earth—Spleen—Thought: mental and emotional condition;
3. Metal—Lungs—Soul: immune system;
4. Water—Kidney—Willpower: bones, willpower and sexual power; and
5. Wood—Liver—Ethereal Soul: emotions of depression, frustration and anger.

In the case of the dominant elements such as fire, which is associated with a person's consciousness, joy and compassion, the virtual interaction, gamification and challenges within the interaction will be designed according to this particular element. Users will enjoy icons, indexes, symbols and categories of signs in the visuals of this interaction. The interaction and challenges will also be based on a user's particular temperament/element, and auditory impulses will enhance that dominant element too.

Users will see their avatars virtually (as shown in Figure 23) and interact with each other based on their specific dominant factors.

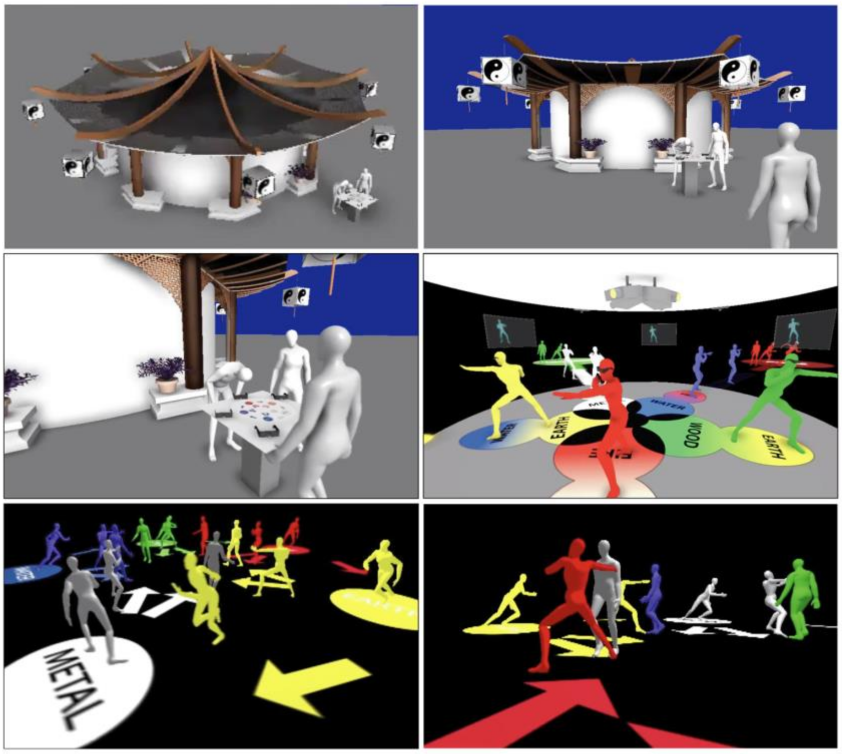

Figure 23. The use of imagination in the Virtual Immersion with Pulsation installation and various users' interaction outside and inside of the installation.

Based on humoral pathology and various balances/imbalances, the user will know what the dominant and sub-dominant elements (fire/water/earth/metal/wood) acting in his or her body are. In addition, for the purpose of entertainment and gamification, the user will also experience immersive reality and associated interaction. The interaction will be either on a touchscreen or virtually interactive with motion-sensing technology, as shown in Figure 24.

Figure 24. Me (Muqeem Khan) as a user of the Virtual Immersion with Pulsation installation, selecting and interacting with the content based on my particular choices and playfulness.

When interacting with the installation, a large field-of-view will engage the user with the content, and a room-scale tracking system will allow sufficient user interaction. The content will need to be interesting so that it can elicit the user's emotional condition and maintain a continuous level of engagement. Content should be developed according to the position and orientation tracking of the user, which is aligned with their temperament as declared by the pulse reader at the entrance to the installation.

While designing the content of the installation, I need to be particularly careful in several aspects. For example, the installation should provide a unique experience for individuals and families so that they can enjoy and learn at the same time. The entertainment value and unique interaction should help to make this installation successful. It should be clearly explained that this installation is designed for the particular age group; in this case, it should be targeted at various age brackets such as primary, high school, college and university students. There should be particular application for each specific group, so they receive the information accordingly. Moreover, the immersion of users into the museum installation is the most important aspect; in this installation, VR technologies with full-body immersion should help to make this happen. Then, after technology-based immersion, the content should drag users into the story—as well as into stories within the story.

Although most of the time, linear storytelling operates within museums, because of the VR technologies and various sensors in this installation, the content should offer non-linear storytelling and interaction. This is particularly necessary to both learn and be able to explain the challenging content. Several other elements should be included to enhance the experience, such as exhibit graphics, labels, signage, sounds and emerging display technologies. These cues will help users to immerse themselves completely with the content.

I intend to utilise the latest technologies from the gaming industry and emerging display technologies to achieve playful and interactive experiences in the installation. This will attract and provide familiar experiences for young children, together with their older family members. Gamification should be incorporated carefully to attract user interactivity and motivation. This should make the “boring” ancient content easier for users to absorb and digest. Hidden items and interesting animated visuals should also be included for an entire family to explore and interact together.

Again, it is important to examine the substance of the content before designing it for a particular audience. The content need not be an exact representation of pulse reading knowledge and its various intricacies. The user interactivity and its various embedded challenges may vary in its depiction. The elements of the content might be extremely subjective in its manifestations, particular embodiment or distorted restoration. Nevertheless, the content should culminate in entertaining, emotional user interaction.

2.1.7 Concluding Remarks About Case Study A

Virtual reality and stereoscopic perception are used around the world for heritage presentation, and these technologies can motivate users to learn and interact with the content. The proposed Virtual Immersion with Pulsation (VIP) heritage installation described in this section is one example of using existing emerging technologies for heritage production, as shown in Figure 25. Future digital technologists within the domain of Digital Emerging Communication (DEC) will generate these types of installations for entertainment and information. Researchers agree that emerging technologies act as a bond between advanced scientific visualisation and heritage representation (Kenderdine, 2007). It is one of the ways that cultural heritage or ICH knowledge can be collected and represented (Sparacino, 2002; C. Yang, Sun, & Xu, 1999). Simulated games manifest real-life circumstances and offer a profound perception of the subject matter (Boocock & Schild, 1968; Huang, Rauch, & Liaw, 2010; Pan, Cheok, Yang, Zhu, & Shi, 2006). The use of these technologies, in the context of ICH, provides not only tremendous showcasing opportunities but also guarantees spontaneous and undirected learning experiences for people of all ages (Tanenbaum & Bizzocchi, 2009). It is important to note that wearable sensors are expected to be ubiquitous in the future, and users will utilise them when visiting cultural sites. This will reduce the exhibit's physical presence, as well as the costs of installation and human resources (Can et al., 2019).

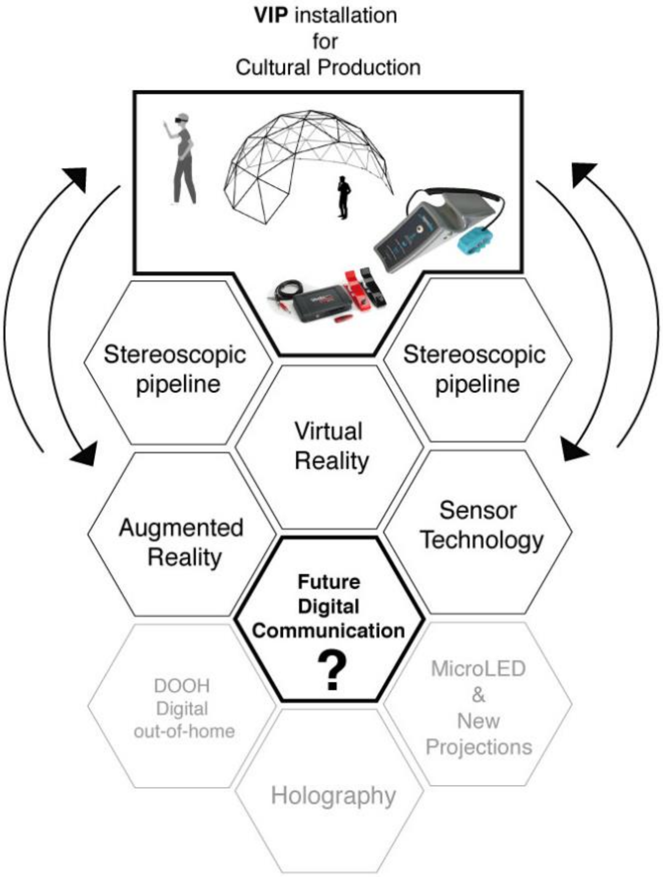

Figure 25. A schematic diagram of the Virtual Immersion with Pulsation installation workflow.

2.2 Case Study B: Applying emerging technologies to martial arts

This second case study examines human body movement from a historical perspective, in the context of applying emerging technologies to sports, dances and martial arts. The case study also explores and investigates the human body under the paradigm of the interactive performative space for public engagement and heritage representation. In this research, human body movements, particularly in martial arts, have been selected for the transmission of cultural production and documentation in a heritage-related environment. Indeed, other research reveals that the master–disciple relationship is essential in traditional knowledge (TK) transfer. This case study proposes and explores an Artificial Intelligence (AI)-based interface/museum installation (Mimicry Understanding and Safeguarding Environment [MUSE]) for learning about cultural body movements—thus contributing to the perpetuation of cultural heritage. The proposed technology-based concept will add to the intricate relationships between the knowledge provider (such as a master of TK) and knowledge seeker and transform that connectivity into a form of AI-based visual cues and directions for knowledge seekers such as museum visitors. The master–disciple tradition is a well-known institutional method for TK transfer in many communities around the world. The proposed museum installation described in this case study is expected to direct and enhance users' perception that the master or instructor is present behind the screen, which mimics the master–disciple relationship.

2.2.1 Introduction

The biomechanics of human mechanism and movement is a gripping field. Human movements have been examined to understand and cure pathological diseases. For example, analysis is frequently undertaken by physicians to help children undergoing cerebral surgery. Also, gait analysis can be used to track the progress and effectiveness of the treatment of disease.

In recent years, science in this field has advanced and important and interesting discoveries have been made. One example is the area of body language, both in the form of writing and scientific study that is commonly known as "kinesics". Body language or kinesics depends mostly on patterns of communication behaviour that are non-verbal; however, kinesics is new to science.

It is important to understand how the human body is designed so that it allows movements, as described in previous sections of this thesis. Humans make use of their forces to move. Most human body weight, at least 43% of total body weight, is in the trunk, while the head and neck represent 7% and the upper limbs 13%. The feet, lower legs and thighs represent the remaining 37% of total body weight. Branched bones make up the skeleton of the human body, and they are connected within joints by ligaments. The human body contains 206 bones. Bones facilitate movement and protect the soft tissues in the body. According to Tözeren (1999), unlike human-made structures (such as bridges and skyscrapers), the skeleton is degraded by gravity. About 700 muscles pull on different skeletal joints. These muscles are attached to the bones through structures similar to cables (such as tendons), or other muscles that contain flat supporting tissues, called "aponeuroses". The musculoskeletal system of humans has been studied for centuries, and experimental analysis of human gait and posture has been carried out with almost the same level of focus. In the animal kingdom, there are some artiodactyls, non-human primates and other mammals who move in a bipedal manner; according to Lovejoy (2005), human ancestors adopted this approach and posture as their pattern of locomotion. They altered their post cranium so that every transport event, whether just a few feet of walking or a desperate flight to prevent a predator from attacking, became limited to using it bipedality.

2.2.2 The Upright Posture

Keith (1923) suggests four later stages of human transformation: from the first ancestor that looked like a monkey ("pronograde catarrhine") to the last being the human phase ("hominoid") having a plantigrade progression that is upright. Large anthropogenic monkeys frequently practised "brachialism" or use of brachialis muscles; a major flexor of the elbow (Mahakkanukrauh, & Somsarp, 2002), and this vertical position probably yielded bipedalism in primal hominoids. Morton (1926) concludes that an arboreal (living tree) that stands in a vertical posture reflects the permanent, irregular state of the world. This is widely accepted and seems to be the only explanation of tree life after it adapted to the long life of the soil. The "brachiationist" theory later declined, with Keith (1940) subsequently rejecting his interpretation. A myth that spread for centuries in ancient times was that bipedalism existed in early people living in savannas. Shreeve (1996) asserts that the upright position of these early humans would have allowed them to detect tall grass, escape from predators, or walk for longer distances. According to the article, recent discoveries of fossilised hominoids from Africa have discovered new trends: in this case, a bi-directional, decentralised forest environment. According to Prost (1980), studies of kinematics found similarities between vertical climbing and human bipedalism, even though both had different musculature in hip arrangement.

According to Fleagle et al. (1981), nowadays vertical frontal contraction is the most accurate indicator of the development of the "straight body"—a term increasingly referred to as the biomechanical link between bipedalism. Lovejoy (2005) explains that the discovery in 1974 of the fossil material "Lucy" (*Australopithecus afarensis*) in Ethiopia, Africa, was important because it gathered enough information to investigate early locomotion and hominoid posture. Lucy walked straight and upright, and she had a straight spine; this characteristic was later seen in the species *Homo erectus*.

An interesting fact about Lucy was her long arms and curved fingers. Gebo (1996) debates that climbing represent only in primitive hominoid, while Wolpoff (1996) asserts that these modifications led to later adaptations for arm hanging and brachiation. However, Tobias (1965, 1982) states that normal straight body posture and bipedal walking are not a prerequisite for proper use or activation of tools. He explained that most of the work early people were carrying out was done sitting down. Sitting provides more trunk stability, which is one of the most important factors, both functional and structural, in developing practical skills. Tobias (1965, 1982) concludes that the straightness of the trunk may have occurred long before the full orthogonal position, even 50 to 60 million years ago, and in many respects, students of human nature were prone to take trunk erectness for granted. However, this was a fundamental and often primitive step in the development of bipedalism.

Based on the above discussions, it is clear that humans have a rich heritage of both functions and structures, that finally achieved expression in our current abilities and physical characteristics. These modifications mean that humans have established and specific body functions and purpose —including legal, physical and emotional. No wonder, therefore, that modern, stable humans are reliant on their valuable and important history, and the fact that their overall health depends tremendously upon understanding it.

2.2.2.1 The human body as communication

The term "body language" is widely defined in the context of all aspects of human interaction and communication. When talking about body language, individuals tend to look for the exact symbols that are being sent to and received from each other non-verbally. While the key to the success of personal and professional relationships depends on the ability to communicate effectively, it's a person's body language that "speaks" louder than their words. Whether one is aware of it or not, when talking to others, people convey noticeable signals. All of their non-verbal behaviours send compelling silent messages. They can rejuvenate people, build confidence and attract others, or break down, derail and weaken what is trying to be conveyed.

Furthermore, research into body language has shone new light on the dynamics of family relationships. Communication between humans, both verbal and non-verbal, depends largely upon the development of earlier and lower primates and widely learned cultural behaviours. The study of "kinaesthetics" can reveal behaviours that promote and influence all social categories—including personal, family, economic and governmental. Communication habits control and restrict human freedom, particularly as they apply to all types of institutions and policies.

Dynamic presentations of the entire body of emotions, including those involved in everyday activities and in a context of reality, were examined in a study by Van den Stock, Grèzes, & de Gelder (2008). Contrary to previous studies, the non-verbal listening skills of human and animal sounds were used, two conditions that meet the normal conditions of observing the physical aspects of the body from a comparatively proportionate distance. Using these two types of audio information, the study focused on whether ambient sounds (i.e., audio source to visual source stimulation) have a similar effect on identifying human expressions as is expected from voices. The researchers also used non-verbal auditory materials to minimise verbal or semantic processing that automatically begins when verbal information is presented.

Independent of human–animal communication, McColl and Nejat (2014) have conducted a study to expand on the important role that body language can play in conveying and documenting information about the transformation of the human mind from person to person during human–robot communication (HRI). In the research presented in their paper, the authors investigated the physical properties and the emotional intelligence of the human-like robot named "Brian 2.0". They improved the robot's body language and emotional intelligence with a variety of physical attributes, movements and posture identified during the research of human emotion.

2.2.2.2 Human body movements

As mentioned previously in the article (McColl & Nejat 2014), exploring how individuals can make use of their body for communication indicates how important human body movements are. Human beings have a specific physical structure allowing them to stand against gravity's pull. Animals and humans use forces of contact to move. Tözeren (1999) states in his book on human body dynamics that anatomists have also compiled a common terminology for classifying motion patterns in various parts of the human body. Most of the modes of motion in the body revolve around an axis passing through a joint; called "angular calls".

2.2.3 Historical Perspective

The following section discusses martial arts and dance, in the context of preserving their important cultural heritage. In terms of human body movement, martial arts and dance are two types of activity where individuals are most likely to feel a complete sense of rhythm. In a study by Schaab-Hanke (2007), the researchers noted that the primal connection between ritual, play and drama in the ancient communities they examined was frequently evident, especially in terms of dance performances and techniques of fighting, both of which were often inspired by perception and observation of nature.

Collectively performed manifestations of movement can also be a way of representing a community's history through the representational ability of the dancing bodies, which can be showcased as metaphors and forms of both war and love, for instance. A clear example is the well-known practice of the "haka", a war dance which is traditionally carried out within the New Zealand Maori ethnic group. The All Blacks (the legendary New Zealand national rugby team), perform the Ka Mate Haka as a united team, to intimidate their opponents before the beginning of every game; traditionally, however, the dance serves to express emotions of pain and joy. Another example is the "dragon" dance, frequently performed at Vietnamese and Chinese martial arts exhibitions; it initially served as a community force exhibition that made neighbourhood slaves to unwanted military action. This dance was widespread in the old Sung dynasty (960–1279) and was performed during certain celebrations, such as New Year, as an induction for luck, prosperity and peace; typically, some martial arts meetings focus on the traditional meaning of martial arts that is about "encouraging fighters".

Moreover, Theeboom and Knop (1999) describe how Asian martial arts have spread in the West over the last three decades. In recent years, there has been growing interest in integrating martial arts into dance and the curriculum of physical education. While Asian martial arts practice identifies three distinct approaches, western martial arts training is often limited to only one approach connected to a particular discipline. In a recent study, Lykesas (2018) notes that the "first existence of dance" was the first experimental way to learn dance and transfer it from one generation to the next. In a modern society that is urbanised, sedentary and often overloaded with, both martial arts and dance comprise all the required components to enhance the personality of individuals through an exercise that soothes the body and strengthens the mind. During rehearsals and trials, practitioners build a stronger character that results from a mixture of physical efficiency, emotion control and mental relaxation. When taking this background into account, it is not surprising that in recent decades there has been an increasing collision developing between Eastern martial arts and Western contemporary dance. Ancient martial arts have left more room for the exploration of psychophysical balance, aesthetic gesture and expressiveness than the effectiveness of combat. In contrast, modern dance has absorbed the effects of both traditional Asian theatre and dance—especially Balinese dance, Indian theatre and dance, Japanese theatre, and Asian martial arts.

According to Hewes (1955), a study of 481 cultural groups has shown that these groups generally held one-legged positions, especially in Nigeria, Australia, South Sudan, India, South America, Melanesia and Southwestern North America. Hewes also includes variations and drawings of the one-legged or single-sided "Nitolic stance", which he describes as a stork-like pose that involves standing on one leg, with the heel and sole of the other foot placed against the leg in an area close to the knee. He found that this stance was traditionally common to the tall tribesmen living in the southern Sudan area on the Upper Nile, and it was also popular in Africa, in South America among the Indian tribes, in Australia among the Aborigines, and in India among the hill folk. It was considered to be a very common position for people to hold when resting herds of animals; these people also typically travelled naked and barefoot and hence had no issues in assuming the posture.

Furthermore, Mallik, Chaudhury and Ghosh (2011) mention in their study that to preserve cultural heritage that is intangible, for example, dance and music, it is necessary to have access to background knowledge that is encoded together with performances being recorded and digitised in the documentation. In addition, Koutsabasis and Vosinakis (2018) explore how kinaesthetic interaction builds knowledge of mutual understanding. Furthermore, research has examined how people interact with their environments, keeping the focus on perception and awareness of the body, it's mobility and how it moves, as mediated by interactive technologies, as explored by Koutsabasis and Vosinakis (2018).

As mentioned previously, in terms of how body movements can be part of both martial arts and dance, this section further examines how the two co-relate. If not impossible, it is not straightforward to discover the specific place and date when martial arts and modern dance first came into contact with each other. Nevertheless, Novack (1990), Pallant (2006), and Tufnell and Crickmay (1999), agree that the cradle for this phenomenon was New York City in the 1970s. There was no doubt that modern American dance, which began in the early 20th century, was in stark opposition to classical ballet, which was considered extremely stringent in terms of clothing, roles, content and bodybuilding.

French pioneer François Alexander Nicolas (1811–1871) influenced other pioneers: Isadora Duncan (Dora Angela Duncan, 1877–1927), Ruth St. Denis (1879–1968) and Ted Shawn (1891–1972). The musician Nicolas developed a style of acting by observing the social relationships of humans, creating a code of expressions and gestures focused on helping singers and actors to communicate their feelings and emotions effectively. It is likely that, as described by some European and American artists and confirmed by some of the scant literature, Western dancers were involved in martial arts during the 19th century, although this combination more often reflected the individual's technical background rather than being representation to the public.

In this sense, the history of Muradoff, the Iranian Armenian quoted by Herand Murad Daviud Khan (1910–1985), provides detailed information, although it has not yet been analysed completely. Muradoff was a unique character, given that he was first a well-known ballet dancer in New York and Paris who later became a choreographer, teacher and, eventually, a master of Taijiquan (a Chinese martial art and deadly combat system, with unusual survival and fitness techniques and a simultaneous production tool for expressing feelings side by side). He began practising yoga in Paris in 1935 and continued it until the final stages of his life. He also became interested in Tajikhan under the direction of Jia Fu Feng (1919–1985) in New York in 1944. Muradoff also published the first books about Taijuana that were translated in Italian (1977–1985), which established an branch that has grown over the years. Henceforth, this made him a pioneer of Taijikhan in Italy, and he had a great influence on the representation and concepts of the particular discipline in public opinion.

According to Wilson (2009), Muradoff removed the component of combat since he probably learned Taijiquan without this element from his master Jia Fu Feng, who is known to be one of the most important individuals in the Western world to spread Taoism. Jia Fu Feng was a colleague of Alan Watts, friend of the author Jack Kerouac and other

Beat Generation writers; he was also friends with the psychologist Abraham Harold Maslow, who developed the Theory of Self-actualisation. Jia Fu Feng was also thought to be one of the key supporters in the hippie culture of the 1960s and California in the 1970s. Taking this background into account, peacekeepers could perhaps have easily ignored Taijiquan's military presence and element, especially if Feng transferred his experiences and information to professional ballet dancers. Thus, it is not surprising that there still exist schools where Taijiquan is taught in Italy even today, some led by students of Muradoff, who teach this discipline without the fighting component; instead, they stress the element of artistic expressiveness as it is in dance.

2.2.3 Martial Arts and Traditional Knowledge

According to Christensen and Calvo-Merino (2013), the body is a dancing device. The structure that ultimately controls the artist's communication message is the structure that controls movement. Downing, Jian, Shuman and Kanwisher (2001) describe a region of the brain located in the cortex, called the extrastriata body area (EBA), which responds to the appearance of the human body. Interestingly, the physiology of the body and movement are not independent of one another. There are obvious overlaps. Hence, most brain regions are always related to motion therapy, such as the visual field, as suggested by Kourtzi and Kanwisher (2000), and the regions of motor that Urgesi, Candidi, Fabbro, Romani and Aglioti (2006) describe as also being sensitive to static body postures. Because it is difficult to study how the brain regulates the human adaptation of these stimuli, these stimuli have been successfully used to learn more about cognitive intelligence and mechanisms of nerves adjacent to representing movement.

2.2.3.1 Internal martial arts posture and components

Internal master Kuo Feng-Chih was clear in his recommendation to his pupil Robert W. Smith: he clarified that preparing for all required three arts - unwinding, gradualness and equality, in life and breathing. R. W. Smith (2003) explains that the psyche is fundamental to learn the art form. In contrast, it is important to feel the "chi" (life force energy) penetrate the whole body with the goal that one is gradually revitalised and transformed into something natural. As Rottmann (2001) indicates, three types of martial arts stress an internal "spiralling" or "winding", which unobtrusively include the whole body. Indeed, "cross-connecting" between all parts of the body guarantees that any movement happens with the entire body moving as one integrated unit. Camilleri (2018) explains that the spine is adaptable and solid, with no inclining; however, it should be kept erect with the head held up as though supported using a string. He also asserts that the nose should be used for regular and abdominal breathing, whereas the knees should be bent continuously to differing degrees while keeping the cervical curves. Finally, the chin should be down and in a relaxed position.

Martial arts are coded systems and combat cultures that are used for various purposes, such as military and police campaigns, self-defence, competition, playing or for preserving the heritage that varies from country to country. Although the East Asian art of fighting has been associated with martial arts, it also refers to European combat since the early 1550s. Clements (2006) explains that the term “martial arts” comes from Latin and means “arts of Mars”, the Roman god of war. A few writers—including F. Draeger Donn and P’ng Chye Khim (1979)—have debated that “fighting systems” or “fighting arts” would be considered more acceptable and appropriate, based on the fact that most of the martial arts were not ever “martial” in terms of being created by professional warriors. Hamblin (2006) states that human wars began from the Epipalaeolithic to early Neolithic era. Nash (2005) and Hamblin (2006) reveal that ancient works dating from 10,000 to 6,000 BC, depicted battle situations in cave paintings in eastern Spain showing organised teams fighting with bows and arrows. Hamblin (2006) further confirms that similar proofs of wars were found during the Epipalaeolithic period up to the early Neolithic mass burial era, which was revealed in Germany and northern Sudan at Jebel Sahaba.

2.2.4 Types of Martial Arts

When the definition of martial arts is taken into account, wrestling is considered to be the oldest type of martial art, with its origins in hand-to-hand fighting. Belt wrestling is described in Mesopotamia and ancient Egyptian works dating back to 3,000 BC and the Sumerian Epic of Gilgamesh. The oldest known description of boxing is found to be from a Sumerian relief, BC III Millennium in Mesopotamia (modern Iraq). It is believed that the Yellow Emperor Huangdi (the legend of peace in 2698 BC) gave China the earliest combat systems. The Yellow Emperor has been described as a famous general who had written long “contracts” in medicine, astronomy and martial arts before becoming the leader of China. The creator of “jiao di” (an ancient form of wrestling), Chi You was considered as a precursor for contemporary China’s permutation art.

The basis of modern Asian martial arts is a mixture of early martial arts from India and China. Reid and Croucher (1991) state that during the Warring States of Chinese History

(480–221 BC), there was a massive advancement in the emergence of strategy and martial philosophy, as stated in *The Art of War* by Sun (Tzu Tzu, 2012). Legendary reports link the origin of “Shaolinquana” with the figure of Bodhidharma in China at the beginning of the fifth century AD, with the increasing level of Buddhism from ancient India. According to Zarilli (1994), documented proofs of martial arts in southern India refer to Sangam literature from the second century BC to the second century AD. The techniques of fighting from the Sangam era were the first pioneers of “Kalaripayattu”. Moreover, the oldest sources of martial arts in Europe belong to ancient Greece. Representations of pankration, boxing (pygmy, pyx), and wrestling (pale) were made in the ancient Olympic Games. The Romans designed the gladiatorial battle as a public performance.

Furthermore, numerous historical war guides date back to the European Middle Ages. This includes serval types, except for sword and shield, two-handed fencing and unarmed combat. These include long-standing translations of Johannes Liechtenauer’s mnemonic poem dating back to the late 14th century. Similarly, Japanese martial arts began with the formation of the samurai nobility in the 12th century. Modern sports such as fencing began to flourish in the 19th century when French and Italian military academies began coding instructions. The Olympic Games were established in 1913 by the Féderation Internationale d’Escrime, leading to Standard International Rules. Modern-day boxing is based on the rules of Jack Broughton in the 18th century and is now addressable under the Marquess of Queensberry rules of 1867.

There are many traditional fighting styles and martial arts practised around the world, with their roots existing in folklore and local culture. The most well-known fighting styles are those of folk wrestling—a few of these have been continually practised since ancient times and can be found in the remote outer regions. Other examples include boxing and stick fighting. Although these arts are supported by and from folklore’s historical traditions, they are still not considered to be “historical” in the sense that they preserve or reconstruct historical systems in a particular period. Instead, it is contemporary regional sports that coexist with modern martial arts forms that have evolved since the 19th century and that often involve cross-fertilisation between sports and popular styles. In this way, the traditional Thai art Muay Boran has evolved into a contemporary Muay Thai national sport, which in turn is played all over the world and contributes significantly to contemporary hybrid styles such as kickboxing and mixed martial arts. British martial arts linguistics are often seen in Morris dances. Many European dances share martial arts elements, including Hopak Ukraine, Polish Zbójnicki (with Ciupaga), Czech Odzemek and Norwegian Halling.

2.2.4.1 Martial arts in history and today

Martial arts are considered to be a popular sport and form of exercise around the globe. Judo is the most-practised sport in the world after soccer (football). Hundreds of unique styles of martial arts exist today, each of which is diverse culturally, mechanically, geographically and philosophically. Considering the United States as an example, it is estimated that there are around eight million individuals who participate in martial arts, with karate and tae kwon do considered to be most popular.

When people hear the term "martial arts", some assume it means tae kwon do, others think of karate, and others still look at it as Kung Fu. The most common element of all martial arts is that they are all fighting styles, however each is unique. Martial arts are defined as any different form of combat or fighting arts; they can be unarmed, armed or self-defended. According to research, martial arts first appeared in the Middle East in 3,000 BC (Porta). Currently, the countries where martial arts are most popularly practised are Korea, Japan and China.

Martial arts are a multi-functional fighting style that is practised and influenced by individuals all around the world. Many different types of martial arts exist. There are varieties such as tai-chi-chuan, judo, taekwondo, karate, Muay Thai, kendo, jujitsu, Shorinji Kempo, washu and aikido, for example. There are also styles within all types of martial art; for example, kendo requires the use of weapons. Kendo, which means "path of the sword", begins with fighters wearing the type of clothing worn by the ancient samurai, and holding bamboo swords. This fighting style can be dangerous because the shots (blows) are concentrated on the area around the neck and head. An individual with strong shoulders, large arms and speed would be able to adapt their body to that of a good kendo fighter. Over time, samurai swords are used after an individual has already practised with wooden and bamboo swords. Taekwondo, a kind of combat, which originated in Korea. Tai Kwon means "way of the foot and hand" and it is popular for its hard and high kicks. The target of these kicks is the head. Students learn how to break stacks of concrete and wooden planks, as part of their training routine.

The first known examples of martial arts come from artifacts, literature and arts. As stated by Iwona and Walery (2011), the oldest existing artifact related to martial arts is an ancient Egyptian painting showing a struggle that dates back to 3400 BC. This painting signifies military training in an ancient Egyptian site: the cemetery, Beni Hassan. It mainly depicts duelling with sticks and wrestling and shows the kinds of martial arts practised in this area. In addition, soldiers have also been found to have fought with poleaxes, spears, flails, shields, bows, axes, slings, clubs, and a variety of swords.

Nevertheless, individuals have been using spears for almost 3.3 million years, since the time of the lower Paleolithic era, and they are still considered to be a vital piece of weaponry. About 50,000 years ago, around the Upper Paleolithic era, the bow was introduced, later followed by the crossbow. In the stone Age, around 12, 000 years ago in the Neolithic era, bladed weapons came into existence and were diversified and defined later in the Bronze Age with a variety of different blades, swords and daggers (Thieme, 1997). It is evident that the ancient Babylonians created literature based on a war conflict in approximately 3000 BC (Slatyer, 2012). Also, in Vietnam at around 2879 BC, sketches and drawings were made depicting fights using swords, bows, sticks and spears (ALI, 2019). However, not much is known about the works of art presented. China is seen to be one of the leading continents of arts, including the development of martial arts Biswas, Chatterjee, & Shaikh, n.d.). The Yellow Emperor was recognised in 2698 BC as a person who had written extensively on martial arts before becoming a Chinese ruler. As stated on the website ChinaCulture.org: “According to tradition, the yellow emperor (Huangdi, traditional throne dates back to 2698 BC) introduced the earliest forms of martial arts to China. He reportedly developed horn-butting practice and used it in war” (History of Chinese Martial Arts. n.d.). However, the historicity of practices and events, despite their long treaties, cannot be fully confirmed.

Iwona and Walery (2011) explain that the next generation of martial arts history is the “Epic of Gilgamesh”. This is a poem written about 2100 BC in ancient Mesopotamia and sometimes considered an early work of literature. Based on online history, the “Epic of Gilgamesh” includes many important topics relevant to understanding the Kings of Mesopotamia. The details of the king’s role, death, eternity, rivalry, reconciliation, the relationship between man and woman, urban life versus distant life, urbanity, forest civilisation, and the relationship between man and God, all influence the poem. Gilgamesh’s intense poetry contributes to making of the poem feel and be a good king of his people (Sandars, 1972). These long poems describe many adventures and personalities that have their place in real history. As far as epics are concerned, it is difficult to find comparisons in Greek mythology. The Olympics began in 776 BC, and early events included competition and industry (Grause, 2018). An idea similar to modern Olympic sports was retained in its original form when war zones abandoned their struggles when participating in the Games.

Many other facts and stories could be added, but those described above are considered to be important in the history of martial arts. The earliest manifestation or theme of battle comes from Egypt, in around 3400 BC, with fine arts and military training. Knives, spears and other weapons. Martial arts soon moved from Asia to Babylon in Africa, starting with Vietnam and eventually Greece in Europe with the Olympics.

2.2.4.2 Forms of martial arts worldwide

In real and historical martial arts practice, many litres of sweat are released into the martial arts environment, including litres of blood. Bugei (the "fighting methods" skills used to fight the battle) itself is often divided into various eminences, which, for example, lead to kenjutsu (sword, technique or art); whatever the type, it is given a name, in this case, the kendo (sword method). This version of martial art is the result of Japanese history, inspired by Pax Tokugawa (Shogun Tokugawa Revolutionary War, 1600–1868) and widely accepted by Japanese in the late 19th century.

Furthermore, European tradition involves wrestling and struggling with the "sword"; use of knives in capoeira for "unarmed kick"; Spear and Sword (and Blowing) Chinese "Boxing" (Wushu); and skins (or weapons). In this context, even the concept of "art" has its problems. First, the term can simply be used as a way of expressing excellence based on the relative quality of the features. However, a more serious issue concerns the distinction between art and life, aesthetics and comfort, work and sport, and art and science in Western European culture.

Jodia George (1989) describes the lack of knowledge of modern sports lessons and the physical culture of indigenous people as:

> To kill a lion with a spear needs a different technique and different training than to throw a standardised javelin as far as possible. Spearing a lion was a duty to the young [Masai warrior], and different from a throw for leisure, enjoyment or an abstract result in terms of meters, a championship, or a certificate. (p. 268)

T. A. Green (2001) states that combat education is a structure that combines warfare with a particular teaching, theory, common meaning or personality that distinguishes it from non-existent responses of physical inactivity (i.e., new, installed, used, unused or separately).

2.2.4.3 Emerging technologies in martial arts

Integrating technology into settings of competitive sports and training has common ground. For example, one of the techniques being used to monitor performance is the use of “inertial sensors”. There is a growing trend in using this kind of technology in combat sports (including martial arts); nevertheless, the selection and use of technology has not yet been reviewed for combat sports. A systematic literature review has been conducted to analyse combat sports’ athlete performance to address this gap. According to Worsey, Espinosa, Shepherd and Thiel (2019), 36 athletic records were examined and selected for the review, predominantly by using inertial measurements. This assessment provides a summary of best practice frameworks for implementing and selecting inertial sensor technology, i.e., techniques for evaluating martial arts performance. Worsey et al. (2008) suggest that their evaluation is expected to be a guide for forthcoming research on the application of technology in martial arts sports.

2.2.5 Sensors and Ubiquitous Computing Technologies in Sport

The development of sport has historically played a crucial and significant role in human health and builds physical, mental and spiritual strength. Sport not only improves our body, mind and spirit but also helps us connect with our community via social activity. It fosters the spirit of the Olympic Games, strengthens the links between people from various cultures, and promotes peace. Chi (2005) states that the interests and values of sport should not be overestimated.

The use of sensors and advanced information technologies in sport have been used to improve martial arts. The field of information technology has developed substantial knowledge regarding the use of sensors in sport, including how they can be implanted in daily use objects. Devices such as gyroscopes, accelerometers, cameras and microphones, for example, are used for many applications and purposes within sport. Accelerometers, for instance, can be used to detect activities that produce unique motions, whereas variations in orientation can be measured with the use of gyroscopes. Advanced vision algorithms in computers allow researchers to study not only the movements of an individual player but also to examine the structure and states of groups of players simultaneously. For instance, the purpose of contextual information was investigated by Stephen Intille of the Massachusetts Institute of Technology (MIT) to track footballers using video footage of them playing. Knowing the rules of football allows players to eliminate confusion in a collision.

Chi (2008) hopes that the use of technology in sport will allow it to be more enjoyable for players and will encourage people to exercise more than they currently do. For example, the video game “Dance Revolution” should result in players burning an increased measure of calories, even though the game is also a fairly sedentary activity. If infrequent exercisers can be encouraged to get up and exercise by playing video games, then it exemplifies how new research is being discovered to help solve problems of obesity globally. The most recent research findings, together with advancement in the demand and interest for better sport-supporting technology, have led to a wide range of new fields for research. The UbiComp 2005 conference, for instance, hosted by Intel researchers Sunny Consolvo, Brooke Foucault and Elizabeth Goodman, launched a ground-breaking workshop focusing on issues regarding the application of technology to sport. Further, Chi (2005) states that, first of all, some of the emerging implications and trends need to be outlined and reviewed. The aim of his study was to highlight and encourage advancing research in this growing area, and also to enhance and project individual interest in learning how sports and technology can be linked.

The history of sports performance sensors is full of stories of success in the recent past, as stated by Akins (1994). Golf clubs have been successfully used, for example, in providing one-sided computer analysis. Runners also commonly use fitness screens to monitor the progress of exercise. At Philips Research in the Netherlands, Wijnalda, Pauws, Vignoli and Stuckenschmidt (2005) presented a product developed from a study that allows people to customise their music choices using heart rate monitors and MP3 players. The concept proved to be elegant and simple. By tracking the heart rate of runners before, during and after training, an automated personalised training program can be successfully created. The IM4Sports system does not just dynamically change music playback to guide the runner, but also assists them in choosing songs that best fit their training program. The tempo of the songs can also be modified during training to match the pace of the runner. This product had a huge and quick breakthrough in the market by introducing training programs that are not only effective but also more entertaining. Researchers in the field continue to initiate advanced methods to understand human sports performance. For instance, at the University of Calgary, Dr Joan Vickers examined mental health to understand how athletes perceive their sports skills using an eye-tracker device that is helmet-mounted. Research into the wearing of sensor devices to increase training and output performance also exists. Michahelles and Schiele (2005) propose analysing the application of wearable sensors during downhill skiing, for instance. Furthermore, by incorporating various sensors on skateboard apparel and shoes, the system can locate information about athletes' movements, such as strength, acceleration and rotation. This ensures a significant improvement in data quality, which was formerly only able to be partially obtained using video analysis. Working with coaches and former trainers for the World Cup, a data visualisation program by the technicians is being developed that provides sensor data that is measured along with the reference videos.

Sports technology not only improves performance but can also help in recovery and injury prevention. For instance, as mentioned by Hood (2005) in a recent IEEE Spectrum article, Oscar Pistorius, a double-leg amputee, ran almost as fast as able-bodied athletes using high-tech prosthesis limbs. This raises the question of whether the Olympics will allow prosthesis athletes to compete in future. It can be easily imagined that the measurements provided by novel technology, equipment enhancements and performance analysis of athletes can prove to be beneficial to any sport. Whether it is a popular sport such as basketball, golf and baseball, or an extreme sport like rock climbing, motocross racing and snowboarding, use of technology allows athletes to have a better understanding of their response in terms of heart rate, muscle movement or orientation and are likely to benefit from it. The purpose of the study by Chi (2008) was to understand what sensors are the most appropriate and how they should be utilised, rather than instrumenting the human body as a whole. The term "appropriate" used here refers to how the players should be encouraged, causing them to utilise the sensors for their training, modifying unnoticeable arrangements. This way, trainers can use the best available data to analyse and collaborate with judges, referees and umpires.

2.2.6 The Use of Sensors (and SensorHogu) in Martial Art Competitions

Recently, research has explored how to integrate sensors into wearable chest shields for martial arts matches, as shown in Figure 26. Technical challenges exist in understanding how this affects match management and in the design of the prototype, as shown by Chi (2005). The wearable chest shield system utilised sensor technology called "SensorHogu". According to Chi, Song and Corbin (2004), it uses sensors of piezoelectric force on body guards to help taekwondo referees and judges evaluate and mark real league matches. The goal is to ensure judge accuracy in scoring, while allowing them to remain in the background of the action. Based on the product testing, there were four main problems and obstacles encountered when SensorHogu was introduced to referees and players during tournaments. First, it was a challenge to make the system function technically without significantly affecting the operation of the match. Second, player acceptance depended on their perception of justice and the inconspicuousness of the technology. Third, the judges needed to be supportive of the transition to the new scoring system. Lastly, for the electronic scoring equipment to be adopted, changes in rules were needed. To address these issues, working with the United States Taekwondo Union (USTU) and the World Taekwondo Federation (WTF) will help secure and validate the necessary equipment to host tournaments. The experience of the study will be shared and then compared with the adoption problems that have arisen in other sports.

Figure 26. Taekwondo is an extreme full-contact sport.

Admitted as an official Olympic sport in the 2000 Sydney Games, taekwondo has become enormously popular in the last couple of decades. Due to this popularity, there has been an increasing focus on ensuring fair judgement and making the sport friendlier for spectators. This pressure has caused an immense number of changes in the ruleset and the call to use gadgets and electronics to ameliorate some issues in judging matches. The most problematic issue in ensuring accurate scoring is personal judgement of what qualifies as a valid scoring kick to the abdomen. In the 2003 WTF Competition Rules (Chi, 2005) and Interpretation, a kick must hit to the right part of the body. A further obstacle to the progression of the sport it is the effect on results by favoured judges preferring players from specific countries.

Taekwondo is conducted using both sides of a 12-metre-wide course on a square padded mat. The opponents—one in blue guard and the other in red—are located in a controlled position in relation to the other. The judging panel includes three people and an arbiter (referee). The referee is in charge of deciding a competition when judges contest the scoring index. Current systems of scoring use wired "handphones" for judges to view all the match details so that the points can be totalled. Following the existing rules for electronic scoring, one point is allocated when two judges allow it at one second of the timeframe. The system includes a laptop connected to a single base station, three scoring handsets for the judges, and two TrueHorse™ SensorHogu wireless sensors that ensure power is connected to the processor (wearable computer) through a physical protection device. The device wirelessly transmits signals to the computer, which encodes and displays the relevant period. The researchers hope that using the technology will help judges avoid conflict and reach decisions. The use of voltage sensors (accelerometers) was not considered in the study because the researchers wanted to measure the positive energy directly affecting the situation, and the most well-known dynamic detector is the piezoelectric sensor. The strength and rigidity of piezoelectric sensors make them particularly suited to a protective rigid suit.

The application procedure involves using plastic backing to help mount a piezoelectric sensor piece, which is then inserted into a body that is approved by the WTF. The head and facial areas are not instrumented as having a facial mask would hinder the vision of the player. Moreover, attacks that are concentrated on the face are easier for judges to score. A manual system was also developed for SensorHogu so that all the sensors work wirelessly on the same access point. Each referee uses two hands in scoring, one hand to show a win for the red player on the left, and the other for the blue player on the right. The handset used by judges has two buttons: the trigger button allocates a point to the body, and the side key gives two points for a head hit. The shield events must be coordinated with the grading handsets, which demonstrates the complexity of system design. At least two judges are required and they must press the same button on their equipment in a second window for the score to be awarded.

The SensorHogu device needs to measure the amount of force applied and not just to send the contact wirelessly. Second, the device needs to function properly. Various signals from each body guard are sent simultaneously, and these signals have to be interpreted by the system following the rules. Third, several sustainability criteria are taken into account to design the entire system. The product can resist excessive aggressive use. It is safe and small and can withstand possible radio interference and physical abuse.

2.2.6.1 Evaluating SensorHogu technology using the ubiquitous computing evaluation framework

The QuesTec Umpire Information System has been used for the analysis of video of balls and strikes in baseball (Chi, 2005). the use of the system was in constant debate in the Major League Baseball and its umpires in the United States. Both players and empires are not happy with the system and despite a fair and accurate analysis, most stadiums did not install the system for its inconsistent support. A similar technology is planned to be introduced in taekwondo that will set the threshold standard that players will have to perform in order to earn points. Based on the match and personal interpretation of the rules, the judges and players adjusted. The game had involved continuous inconsistencies. Belief in the fairness and accuracy of the QuesTec system was a must. Furthermore, it was crucial to make sure that the system forced no unwanted changes of behaviour on the part of the judges or the players.

SensorHogu, was introduced after realising what had happened to the QuesTec system. Scholtz, & Consolvo, (2004) introduced a ubiquitous computing evaluation framework for ubiquitous computing applications in sprots. The framework suggests 9 factors for evaluation for the examining and understanding of the ubiquitous computing. These factors are attention, adoption, trust, conceptual models, interaction, invisibility, impact, appeal, and application robustness. It is unknown what the adoption rate will be as a result of the introduction of SensorHugu technology to the sport of taekwondo. The system is highly predictable and consistent for players and judges, and that fair play can be achieved using sensors because they are reliable. Furthermore, the capability of the system can be easily understood both by the judges and the players. During the test matches, the players acted as if the system did not exist. Moreover, they did not change their strategy or behaviour while wearing the system while competing. By using SensorHugu, judges and players simply enjoy using the technology and understand the value that is added to the sport.

A lot of these early

The thesis shows how future digital heritage data will be used in the creation of futuristic heritage installations. It is like working on a speculative design project when we think about this issue. Every speculative design project is one-of-a-kind, and the wide range of possible issues, contexts, technologies, perspectives and audiences adds to the project's intrigue and wickedness. The fact that new approaches are constantly being invented and old methods are becoming more complex as the practice evolves further complicates the matter. As a result, the two case studies in this thesis are meant to give a more general approach to the subject of speculation, specifically how it must be designed to link to a particular audience's view of the temporal environment around them. These perceptions can be stretched or modified carefully and informed once developed. These are believable, tangible and approachable proposals or hypothetical translations of disruptive technical advancements into future products. The methodologies used in the case studies can motivate DIH content authors to consider what they want and do not want for their future selves.

A lot of these early assumptions were founded on inherent reliability and system reputation, but this is likely to fluctuate if a high-profile system failure was to occur. It is interesting to consider the fact that the third party in this context is the audience, who have an indirect stake. An assumption is that it is valuable to display the force with which an individual’s body guard/shield was hit; thus, the system’s entertainment value could be increased by revealing this information. The culture of apprehension about the transparency of threshold scoring could become clearer and more easily verified. An additional issue to clarify is how the system might change the distribution of player kicks without the system knowing what kick type was being used; this is still unknown. It has also not yet been confirmed whether kicks are being scored by judges with a high enough level of difficulty, even though they may not have generated much power.

2.2.6.2 Biomechanical methods and martial arts

In the context of martial arts, many biomechanical methods have been considered in research studies related to physics. Rodrigues and Rodrigues (1984) conducted a study about karate, measuring the reaction and movement time of kicks that were frontal (“maegeri”) and (“mawashi-geri”), known as circular kicks, upon which the correlation between both the variables was checked. Fernandes et al. (2011) used videos to examine the movements of five people who participated as volunteers. These participants either had no experience of martial arts, or they were new to learning the sport. The participants were video-recorded, and these showed that their way of moving their body, their hand stiffness, and the movement and stance of their feet and hands, changed gradually and demonstrated impressive improvements. The participants adjusted their posture in order to be better and more powerful at kicking; this was due to the right kind of body angles being used, as well as science also being in play. The researchers found a negative correlation between both of the researched variables; the frontal kicks (mae-geri) and circular (mawashi-geri).

In 2000, Sforza examined karate-kicking in a three-dimensional experimental analysis. The “mae-geri-keage” kick was tested using an electrical optical instrument. Thirteen different markers of reflex were anatomically placed. The ankle joints showed higher variability. According to the article Fernandes et al. (2011), a research, attempted to find the similarities and differences in stimulation of the bicep muscles. Twenty trained black-belt taekwondo athletes participated in the study. Electromyography was used to measure their activity, which was electrically recorded in regard to the movement of muscle and its stimuli. Video was also recorded to capture the kicking and divide it into five phases. The researchers found higher activation of muscles during “dolha chagui” striking in contrast to the “tuit chagui” kick that it was compared with.

The vertical and horizontal forces of reaction of the body were compared and analysed in a study by Pucsok, Nelson and Ng (2001). They measured the reaction forces of the vertical support leg and the sweeping leg’s vertical and horizontal speed in the throwing technique used by both advanced and amateur judo wrestlers (“harai-goshi”) with the use of video cameras and a force plate. They concluded that the sweeping leg’s horizontal speed, and its horizontal reaction force, had a positive relationship and showed a visible difference in the support leg’s horizontal reaction force among advanced and beginner competitors. In addition, Fernandes (2009) performed biomechanical analysis of the “ap bal ap Dolio tchagu” taekwondo kick with 13 elite athletes. His study identified the electrical activation pattern of four lower limb and two-chord muscles. He also measured the vertical and horizontal acceleration of the lower limb that was used to perform the strike as well as the electrogoniometry of the knee. Based on the results, it was concluded that all the examined muscles were activated before the knee motion, excluding the vastus medialis muscle. It was also observed that the lateral gastrocnemius and the biceps femoris were positioned in phase, with the right and left vertical erector spinae pre-activated, and with maximal knee joint elongation accounting for approximately 10 per cent of the movement in front of the foot/sandbag.

In a study by Gorgy, Vercher and Goyle (2008), a force plate was used to investigate the effect of practising the Chinese martial arts “shing-hi-chuan”, “tai-chi-chuan” and “pa-koua”, to examine postural control with the use of external interference while practitioners were in an orthostatic state; a reduction in systolic blood pressure. Halfway through the experiment, the force plate was moved middle-laterally. This operation was performed by volunteers either keeping their eyes closed or having them open. The study sample consisted of martial arts and non-sports practitioners. It was concluded that practising martial arts affects equilibrium, reducing the movement of the centre of gravity and canter of pressure, as well as increasing the use of strategies that related to the ankle to treat disturbances caused in the experiment. Nevertheless, no change was noticed in the temporal structures of the electromyographic signals of the muscles that were examined.

Santos, et al. (2005) examined the measurements of the forces of the ground reaction of the judo athletes of judo when they apply the two surfaces of different kinds. In another study by Oliveira, et al., (2008), identified the strength of palm pressure with the help of a hydraulic dynamometer. He concluded that raised values of palm pressure strength were not shown by the athletes of jiu-jitsu in comparison to athletes of other modalities and martial arts. A study by Borges Junior et al. (2009) compared the maximum isometric pressure strength of the palm among practitioners of jiu-jitsu, aikido, rowing, judo and other non-practitioners. The results showed that maximal strength values were higher in jiu-jitsu, followed by judo, rowing, and aikido. The ability to unbalance an opponent using direct and reversal punches was studied by Gulledge and Dapena (2008). The researchers used Earth's reaction forces, strong transducers coupled to the opposite object and digital cameras (to measure kinematic parameters). The results showed that the reverse punch is twice as strong as the direct punch; nevertheless, direct punching was more effective when aiming to disturb the balance of the opponent. This is a good model of a complex biomechanical setup, which answers a question related to martial arts.

2.2.7 The Necessity of Engaging Youth in Dance and Martial Arts via Museums

According to Pruitt (2008), in recent decades the music industry has grown significantly and become globalised. There is now more music available to more people than ever before. However, although researchers such as Christenson and Roberts (1998) suggest that music plays a central role in the social system of adolescence, the academic literature includes little research into the specific impact of this trend on young people, who are significant consumers of music. Analysis of the relationship between youth, music and politics is also limited.

Eyerman and Jamison (1998) discuss the role of music in new social movements, but beyond this there has been little research into ways that could prevent groups, including young people, from using music to challenge or strengthen existing power systems.

Moreover, contemporary music, according to Michel Foucault (Foucault, Boulez, & Rahn, 1985), provides hearing only the outer layer of its composition. Therefore, something is challenging there, and listeners have to accept it as it is. In comparison to the classical or more traditional music, this is a problematic mode where there are no cues or logical pattern in contemporary music. He further talks about the uniqueness of contemporary music for young listeners and says:

> "Things are more serious. Contemporary music owes this unique situation to its very composition. In this sense, it is willed. It is not a music that tries to be familiar; it is fashioned to preserve its cutting edge. One may repeat it, but it does not repeat itself. In this sense, one cannot come back to it as to an object. It always pops on frontiers." (p. 11)

According to Baxter Tresise, Higgs and Vize (2019), no matter where they live in the world, young people face significant risks and challenges. They are particularly defenceless to poverty, exploitation, exclusion and violence, especially young people from vulnerable or marginalised groups or those in crisis or conflict. Young women and girls also face other risks. In many countries, programs and services for the healthy development of young people are inadequate, and the systems supporting their implementation are fragile and inconsistent. Nearly half of the world's current population is aged under 25, making it the largest generation of young people and children in history. With the right support and opportunities, young people can play an essential role in bringing the world closer to meeting the ambitious United Nations 2030 Sustainable Development Goals (SDGs). However, most young people live in developing countries, where the quality of life varies greatly, and poverty and crises can affect their lives. The use of sport to achieve national and international development goals has traditionally been linked to the development of elite sport to raise the international profile of a particular country, to promote a particular sport or to promote the health and well-being of its citizens. Interest in sport as a vehicle for positive social change is relatively new (since the 1990s). Although still a developing field, "Sport for Development" has attracted the interest of development practitioners who are looking for cost-effective, creative and effective development challenges, especially in terms of health and well-being.

Community programs play an important role because they are often located close to the problems they seek to address. Many of these programs do not trust donors or development partners but instead use their own resources to operate independently. Sports organisations are among the hosts of community programs that can take action to organize programs. Grassroots sports development programs have both advantages and disadvantages. Almost all of these programs are delivered locally by local “masters” who respond to immediate problems in their communities. This is an important foundation for their success. However, programs developed using this bottom-up approach are generally scarce and operate independently of government or established institutions. Without a detailed understanding of their technical issues and design, providing grassroots sport for development programs is often unpredictable and rare.

In contrast, in situations where these programs are unrelated to the broader national development goals of their governments, or when governments are planning local activities that are not based on the needs of the community, they are unlikely to succeed. Although there are currently many grassroots youth-focused martial arts programs, for example, they are often led by martial arts fans, development practitioners or professionals trained in youth development education rather than professionals in a club or gym environment. This approach raises questions about the quality of the programs, the qualifications of the teachers, and ultimately the effectiveness and safety of the young people involved. Considering the safety of children and young people involved in sport is a growing concern for decision-makers and developers. All kinds of abuse by coaches, teachers and teammates at sporting events are reported on a fairly regular basis. Despite some initiatives to develop protective measures for sports professionals, there is an international interest in developing evidence-based policies and standards to protect children and young people involved in sport. An example is Kazakhstan’s Action Plan, which includes explicitly recognised detention systems in all sports programs to ensure a positive sporting experience. It is important to note that martial arts, by their very nature, increase the chances of injury, and therefore strict adherence to security measures is essential. This factor can also attract young people to martial arts. Finally, programs of martial arts teach respect and self-control, both in martial arts heritage and modern practice.

2.2.8 Martial Arts and Positive Youth Development

Martial arts can affect young people’s development in many ways. They can attract young people (especially those looking for strong role models and street credibility) to participate in sporting programs. Moreover, the power of sport is widely known, and martial arts can expand in recognition by reaching out to some of the most vulnerable, at-risk individuals through its unique features, such as controlled use of power, meditative elements and rich cultural history. When integrated into a well-designed program, young people have the opportunity to network with other young people and adults, to be exposed to positive role models, and to improve their lives through education and community building. Performing arts can build flexibility for young people. Baxter Tresise et al. (2019) state that young people are more likely to achieve healthy, favourable results and to succeed if they are supported.

Furthermore, endurance is defined as a process that works well to manage stress, even in adversity or trauma. For such positive change to occur, participants must first have the confidence and ability to apply their new skills to solving daily problems. Martial arts can be an effective way to teach or change behaviour, values and attitudes. Performing arts are another tool that can be used to teach young people. Exercises and physical activities can be configured to achieve certain desired results. Appropriate teaching and learning strategies are essential. Proper planning is also critical to the success of sports-based youth development programs and will be considered separately.

2.2.9 Body Movements and Health Benefits

There are a number of health benefits for the body when people engage in a kinaesthetic learning activity. Seven of these benefits are presented below.

1. Warm-up: In American dance, like other exercises, students should be warmed up to minimise injury, increase blood pressure and prepare the body for movement. Franklin (2013) mentions that by performing traditional African dances, participants are provided with warmth and long-term physical activity. The whole body is used in African dance. The movement is usually aerobic and it provides cardiovascular fitness.

2. Awareness of the Body: Students learn basic dance routines and maintain the body.

3. Time, Energy and Space: These are important aspects of dance and these elements are the theme of African dance for young people. Timing is an important part of West African dance, which encourages students to practice the dances.

4. Repetition: The African dance movement is repeated and complemented by drumming. Repetition improves the learning process by giving students time to perfect the body movements.

5. Start at the Beginning: According to Franklin (2013), West African dance allows students, regardless of their background and age. Some students will have

experience in dance education in other ways, and this knowledge is useful. However, with African-based dance, students must be prepared to start from scratch and approach a learning process that is beyond their expectations. Each student starts from the beginning and has their own learning curve.

6. Incorporation/Association: African dance is comprehensive and based on a long and rich history. All ages participate in American dance, and people come together to form communities. Students include boys and girls from different cultures and backgrounds. This premise is extremely important as it also provides access to homeless students, for example, who are given the opportunity to learn and grow. In addition, since the program is supported by public school enrolment, all students are free to attend the classroom or training.

7. Gender Equality: Creating a safe environment and community must address the issues of both men and women. As for sexuality, African dance seems to appeal to both boys and girls, given its complexity and attractiveness. American dance also has many physical characteristics.

Learning inside heritage environments, such as museums is essential for young minds, and there are various concepts/forms of learning. These concepts are more fully explored in the next section.

2.2.10 Museum Learning

In defining a museum, D. Adler (2004), as a museum researcher, agrees with the International Museum, along with many others. Established by the 1984 ICOM Resolution, it was clear that museums were non-profit, permanent institutions at the service of the people. According to Ahmad, Abbas, Yusof and Taib (2013), the theme of museums has changed along with community development. ICOM adapts this definition to the reality of the “global museum”. Besides, as ICOM has evolved and opened to the public, it has clarified the role of the museum as an institution capable of receiving, maintaining, researching and integrating the language of instruction in teaching, educating, entertaining and informing people in their 21st-century environment.

At the 2007 ICOM General Meeting in Vienna, Austria, they added to their definition that exhibitions contained in a museum are a medium. The interpretation of these terms is widely used throughout the world. In Malaysia, the museum is also an organisation dedicated to the awareness of history, culture and nature (Tambi, 2011). The role of the museum, according to Kamaruddin, (2019), museums play an important role in “lifelong learning” and educational fun. A museum is a place that combines learning experiences and advancement through curiosity, observation and play. According to Falk and Dierking (2000), this is why museums have a unique context for non-vocational education, often referred to as “free education for Choice”, as many people visit the environment.

2.2.11 Kinaesthetic Learning

There is a variety of information available in regard to how students can effectively learn new concepts. Although visual, auditory and kinaesthetic education are common features of curricula, less attention has been paid to physical education. This is especially true in colleges and universities. In this section, I discuss the value of incorporating scholarly activities into the discipline of physical education as a content guide. First, according to Tranquillo (2008), the term “active learning” is integral to the learning community--it can include teacher lectures, feedback, reflections and positive texts. Physical education is a form of active learning in which students learn in practical ways. Second, the term “regular education” is often used in some scientific fields. In this context, the focus is usually on skills such as learning to handwrite or improving coordination. For example, engineers need to learn how to build body structures and often use their hands to perform tasks. Active learning in science is used in wire and radio welding, and pipe sealing. Tranquillo (2008) states that these skills can be practised in a classroom environment; in addition, principles of physical education are used to inform and stimulate ideas by including practical strategies. In the following sections, the terms “activity” and “active” are used to refer to any practice that the learner wants to deepen.

2.2.12 Active and Observational Learning

In the 1960s and 1970s, Albert Pandora and his colleagues were renowned for their philosophical research in education. Fryling, Johnston and Hayes (2011) declare that much of the experience gained in this field is now well known and considered to be a different discipline in terms of thought and behaviour. There are several reasons why we can build on these studies—partly to influence the degree of association with psychoanalysis according to Bandura and Huston (1961) and Bandura, Ross and Ross (1963), and the development of theories by Bandura and McDonald (1963), along with the role of observation as a central determinant of behaviour change. More importantly, this point of view is often seen as going beyond the concept of behaviour; indeed, the study of behaviour alone can help to reach a fuller understanding of learning. Given the importance of these studies, I now provide a brief overview of some of the general findings from a number of clinical trials. It is important to note that my analysis is not comprehensive, as my main aim was to explain some parallels to the literature.

2.2.13 Onscreen Learning

Over recent years, the use of videos for training and learning has gained considerable attention in the developing world, as it has been proven to improve outcomes in certain situations (Ertelt, 2007). For example, video recordings to demonstrate steps in using a computer have been shown to be effective in program operation, due to the fact that videos help students to receive, process, collect and store information. However, empirical research on the effectiveness of digital video general education is still lacking. This is probably partly due to the design of faulty video equipment and because developers do not always consider the limitations of human understanding. When developing digital video content, educators should set limits on the student's ability to understand; they need to develop their vision of the learner in order to interact with the design, interest and promotion of educational films. Human memory is divided into three working groups, namely short-term memory (SM), and long-term memory (LTM). Each of these types of memory has a limited ability and duration; they are also linked due to the transfer of information from one memory type to another. There are two methods of limiting access to information: videos that use visual information and oral presentations that convey information such as text and narratives.

2.2.14 Technologies Inside Museums

According to Travel Leisure (2020), Google's Arts & Culture collection includes the Van Gogh Museum in Amsterdam, the British Museum in London and the Guggenheim in New York, as well as hundreds of other places where people can experience art, history and science. These experiences are particularly useful for students to find ways to stay active in their learning when school closes.

Exhibitions around the world have always been a vital source for propagating indigenous knowledge about martial art forms. For example, a full report was compiled on the Hakka Kungfu Exhibition in Hong Kong, as shown in Figure 27. According to research conducted by Lo and others (2009), the exhibit was popular with people of all ages. It was seen as fun and informative (with an unpredictable and welcoming guest room), and it helped guests engage with interest on the topics and material presented. The results of this study also indicated that the exhibit was successful in attracting female visitors and those who have no previous knowledge about martial arts.

Figure 27. Various body movements depicted in the Hakka Kungfu Exhibition.

In 2017 martial arts experts across China gathered at a forum to discuss measures to promote Chinese culture among children, as shown in Figure 28. According to Ecns.ec., (2011), a martial arts exhibition was organised that involved one million children across 100 cities to celebrate Children’s Day on 1 June 2018, following the presentation of the Martial Arts Development Plan 2018–2020 at a workshop held in Beijing during the forum. China has also decided to launch a new “battlefield” science and education program, to host martial arts competitions and to provide fighting classes for children across the country. The plan is to organise international exchanges to promote martial arts among the youth population in China.

Figure 28. Students conduct a variety of collaborative activities at the School of Shaqu Experimental.

Moving to another part of the world, Muay Thai is a cultural heritage activity that originates from Thailand. It is fascinating to explore ways in which educational development can be related to Thai fighting and self-defence as activities that provide both learning and enjoyment. According to Phunsa and others (2009), there are 30 types (double postures) of techniques used in Muay Thai Boxing. The researchers designed an intervention program to help students enjoy the sport using 3D, characters, sounds, actions, emotions, interactions, movement, reality and nature. In their study, exercise footage was captured by both professional and Muay Thai photographers using nine audio-visuals to gather information on real practices. The findings suggested that recreational education has helped students become more interested in Thai culture, as well as improving their levels of physical activity, fitness, self-defence and enjoyment.

In addition, Yehoshua Sofer is known as a “grandmaster” of Abir, a lethal fighting technique developed by ancient Hebrews. In a video recorded by Museum Secrets by Kensington TV (2013), Yehoshua Sofer explains that there are many elements to mastering Abir; one element relates fighting moves to letter shapes from the 22-letter Hebrew alphabet. Every letter contains seven categories (initiative, responsive, choke, takedown, lock, throw and combination). Abir was used for centuries in ancient Israel by Jewish revolutionaries. Thousands of Roman soldiers died at the hands of grandmasters.

In considering the preservation of digital cultural heritage in the field of martial arts, It is important also to examine various different games and digital interaction that represent the different forms of martial arts and its various types and. These emerging games and their gamification techniques are essential to examine for any successful interactive cultural installation. One example is the Mortal Kombat game series (Mortal Kombat, 1992), as shown in Figure 29. This series is notorious for its insurmountable and “deadly” attacks, which have been consistent in the game since 1992. Each of its characters plays a distinctive role in terms of movement and realism.

Figure 29. Image from the Mortal Combat game (Mortal Kombat, 1992).

The Bruce Lee game (Bruce Lee 1984), as shown in Figure 30, was a great success when it was released in 1983. It was an Atari 8-bit game, with the martial artist and actor Bruce Lee himself being featured, and it sold more than a million copies and was well accepted even by the critics. It is still known as one of the first few games which featured martial arts as the main theme.

Figure 30. Image from the Bruce Lee game (Bruce Lee, 1984).

On the other hand, the Kung Fu Master game (Kung-Fu Master, 1984), was originally a Japanese arcade game connected to the stuntman and actor Jackie Chan, although he was not part of the game's storyline. The game was only exported after the characters were changed, as shown in Figure 31. Despite its general title, game players engage in a tough battle to progress through five levels, with a brilliant combat game system that allows for different moves.

Figure 31. Image from the Kung Fu Master game (Kung-Fu Master, 1984).

Museums add to the social and cultural benefits of society, and the use of exhibition technologies play a vital role in this regard. At museums, information and knowledge are presented alongside other elements, including art, history, science and technology, and music. According to Samir (n.d.), this - the martial arts, theme is presented to visitors through a series of stories. The illustrations used in the exhibitions continually value the visual aspect of storytelling, as a way of guiding guests through the stories. Visitors also interact with and contact objects in the museum along the way.

How museums and exhibitions plan to interact with their visitors will also determine how visitors interact with the exhibitions. Kaynar (2005) states that this is why regulating museum trade is a central issue. Museums showcase their collections in interesting and appealing ways in order to attract the public. According to Ch'ng, et al., (2019), emerging digital technologies is essential for the sustainable preservation and transmission of cultural heritage for people and in developing value in activities for the creative economy.

User interaction is also an important subject when dealing with emerging technologies inside museums. There are two contradictory themes when considering VR concepts, which create 3D models of artificial intelligence (AI) and virtual exhibitions based on samples. Wojciechowski, Walczak, White and Cellary (2004) state that a critical finding has recently been made in the field of 3D modelling: the technology is becoming bigger, faster and cheaper. Within a few years, museums will be easily able to purchase high-quality 3D printing equipment. This is a prerequisite for 3D capability, but it is also only a first step. To use advanced technology, museums need a cost-effective, simple and direct way to create virtual images and 3D models and add them to their collections. According to Wojciechowski et al. (2004), museum staff should be able to arrange virtually interactive meetings. At the same time, the system must provide museum visitors with an unprecedented view of human computers through digital technology. Users need to be able to interact with digital content easily and naturally, and in the real world. Not everything that meets these criteria will be understandable and unacceptable in the context of museums.

Younger generations have started to use VR glasses and other devices in order to participate in an immersive, playful environment and emotional engagement. According to Holdgaard (2011), “virtual museums” are not clearly defined: digital museums, electronic museums, online museums, hyper museums, web museums and cyber museums, among others, are other names used to describe them. As stated by Geser and Niccolucci (2012) and Holdgaard (2011), while there are varying labels, consistent elements include being digitally available online and falling into three main categories—focusing on content, communication, and collaboration. An example of this is the Museum of Music in Paris. The museum’s website not only includes information about the museum but also guest-generated content, including photos and videos, wikis and forums, blogs, microblogs, group translation, logos, tags and syndication. The museum shares the information on social media sites such as Facebook, Twitter, Instagram, Pinterest, and others (Geser & Niccolucci, 2012; Johnson et al., 2015). Carvalho and Raposo (2014) note that users prefer interactive rather than negative relationships. Thus, users are influenced by the museum experience and, as a result, they developed new models for the museum–visitor relationship. The Museum of Music, which is currently accessible on the Internet, states that the lack of personal contact can be of service to many visitors. The collapse of websites linked to museums and social media sites over the past two years has raised the question of whether virtual spaces will one day replace physical museums. However, it is believed that a virtual museum does not remove our passion for viewing and interacting with real physical objects.

On the contrary, VR can pose a challenge to the realisation of preserving cultural heritage and is therefore of greater importance for broader knowledge. According to Veiga (2013), ultimately, virtualisation can serve as a bridge to or focus on reality. The Louvre is an example of this type of bridge. The tools available on the museum's website include the ability to:

- download a map from the museum;
- conduct interactive conversations throughout the museum;
- take a guided tour of the museum with 360-degree and 3D views;
- enter into the mini art gallery where, in particular, viewers can watch quick documentaries;
- access relevant work-related information; and
- schedule visits to research particular areas, such as collecting art (Louvre, 2016).

In addition, recent studies have found that the Louvre site is increasingly aware of storage and location articles, which improves visits through real-time bookkeeping and planning of visits.

Further examples include the Google Art Project, where online visitors can find real-life experiences through virtual tours of many artworks in museums around the world. The Cultural Institute (2013) has designed a tool that allows for detailed control, which can only be obtained by direct observation of museum work. The VanGo Your Own project combines VR, content creation, interaction and presentation. The idea was to recreate the experience of visiting public art with friends. Visitors can choose from a variety of jobs, such as photographer or specialty museum curator. Users take a photograph and upload it to the site, where it is then shared on social media (VanGo Yourself, 2016). The Art Detective Portal is a free online tool that helps people in the public art community work together to create design documents, find pictures and solve puzzles. Participants pose or answer questions about various aspects of a project—for example, artist, content, date, technology, promotion, description, etc. According to Art UK (2016), over 100 interviews have been published, resulting in about 40 new discoveries about publicly owned art in the UK. In summary, it is widely recognised that a strong and successful museum is not only a repository of works of art and collections of artifacts, but the most important challenge is to create a unique space, interaction and commitment, and dissemination of knowledge. In the future, museums around the world will review and discuss digital installations and local techniques as part of their approach.

Similar to VR, AR also places users into a virtual environment. According to Freeman et al. (2016), and Johnson, Adams and Witchey (2011), the majority of portable devices (e.g., cell/mobile phones, tablets and smartphones) have webcams and potential issues besides enabling network and real connections, some of which may facilitate new types of interactions with visitor groups and museums. Most people bring along their portable devices when they visit a museum. These institutions can profit from this reality by making relevant applications (apps) available (Freeman et al., 2016). McMulla (2015) argues that successful museums are a dialogue with elements and language, and they invite their audience to learn in an enjoyable way while also monitoring what's going on around the world. For example, the San Francisco Museum of Modern Art has created the SFMOMA app, which encourages museum visitors to look at physical objects and art and to go to their phone screen to listen to special descriptions (SFMOMA, 2016). Both Chun (2016) and SFMOMA (2016) also mention a virtual computer app that has been developed by Apple for the museum. The purpose of the app is to use the visitor's technological knowledge to visualise and integrate stories in audio/video formats. Visitors can edit their content—such as point of view, reflection, artwork response and website tagging—while taking a walk around the museum.

On the other hand, the Second Canvas – a application, created for the Museo del Prado in Spain allows visitors to learn more about the 14 owners of the permanent collection, in Gigapixel images, with the main detail being almost invisible. According to Mad Pixel Factory (2014) and Williams (2014), further details about the collection can be seen with ultraviolet, Infrared and X-ray vision. This was previously tested by museum curators and insurance agents, as the app allows users to share the cut-out photographs directly on Facebook and Twitter. Museum director Gabriel Vinaldi said in an interview with Williams (2014), that the purpose of the app was to give users a more in-depth understanding when using their smartphones and tablets. The app allows individuals to discover artwork at any time on their device, providing a deeper understanding of its elements and how it was created by the artist.

A few museums, such as the Royal Ontario Museum in Canada, use AR to permit visitors to experience the past in real life. The app SopifyROM allows users to add skin to dinosaur fossils, revitalise extinct animals, restore objects to their original form, decode original words and decipher antique languages (Czikk, 2013). The app allows individuals to view X-rays of objects and to examine Quick Response (QR) codes throughout the museum, giving the public more information about the objects that the exhibition holds in the form of interactive graphics, text, audio and video (Oliveira, 2013).

According to Browne (2014), to reduce the distance between visitors and museum staff, the Brooklyn Museum in New York is designing an ASK app that allows visitors to ask questions, meet real-time professionals, get answers to questions and take pictures. Users can send their queries directly to the museum where content provision helps answer the questions. After evaluating the impact of ASK, Shelley Bernstein, managing director of the Digital Initiatives and CEO of Barnes, concluded that the negotiations were successful in achieving cooperation and understanding of the process. On the other hand, according to Bernstein (2015), the result was by no means significant when compared to earlier ideas implemented by the Brooklyn Museum, such as the exhibition booth, cell/mobile phone applications, and QR numbers. In 2015 the app was used to ask questions and share visitors' thoughts about art (ASK Brooklyn Museum, 2015). In 2017, The museum administration also tried to incorporate the app into its information kiosk (Farhat, n.d). They tested the app - a free digital tool, for iPad too. The app has been used successfully via android and mobile texting and has held over 15000 conversations (Devine, 2019).

As a solution to these issues, the National Museum of Scotland implemented the Museum app, the first physical activity group app created for the museum. Visitors in a group can be mobile, and watch museum-based presentations for scientific and clinical research using a camera. With a 30-minute time limit, the game app can accommodate up to 50 players and is a real-time map showing the winning team linked to multiple museums. Building an app can be daunting because the public doesn't necessarily expect to find this type of technology in a heritage, environment to get more about past. It is anticipated that this digital application will draw new visitors to the environment (National Museums Scotland, 2013).

With the advanced sensors in the market these days, sensor-based user interaction also fascinates museum visitors and can enhance their interaction with heritage content. Vaz, Fernandes and Veiga (2018) refer to the Complex World exhibition that uses sensor-based technology to track the vital signals of visitors to installations by using breathing exercises and manipulating biometrics. Visitors to the exhibition wear smart glasses that contain sensors to measure heart rate, respiration and brain function; the data is processed and allows interaction with the digital art presented. According to Charara (2016), an example of the technology can be seen in an exhibit containing a green box which covers an image of a rose. The visitor's breathing is measured, and in a video, there is a corresponding pull on both ends of a rope, which becomes more or less taut as vital signs are measured.

2.2.15 The Mimicry Understanding and Safeguarding Environment (MUSE) Installation

It is essential to revitalise the master–disciple relationship and help in preserving its ICH-related content, particularly in the modern era, when cultural heritage seems fragile and venerable because of the globalised nature of the world. I propose a Mimicry Understanding and Safeguarding Environment (MUSE) installation, which is designed to address this challenge. It will include a virtual instructor, either an expert dancer or an expert martial art specialist, to teach cultural body movements to learners. A life-size image of the instructor will be projected on a rear projection film. There are various manufacturers of this type of film (W. H. Lee, 2008). Technology has improved a lot, and now this translucent screen can have a wide-angle for broader viewing, as seen in Figure 33. These films can also be used with projectors at a very short distance. An ultra-short rear projection screen will be used in this case, requiring a minimum of museum space even though it has a large magnification projection.

Figure 33. A life-size 3D instructor projected from the back of the MUSE installation screen.

An exciting application of this particular type of projection screen has already been implemented at Burberry’s holographic runway show in Beijing (Phan, Thomas, & Heine, 2011). Burberry is a luxury fashion house with more than seven million fans followers from all over the world. The company was the first to broadcast a life-size 3D fashion show from London to five cities internationally, as shown in Figure 34. Their novel use of this technology in the fashion industry has attracted lots of younger customers (Stevo, 2011).

Figure 34. Burberry hosts a holographic fashion show in Beijing.

In this museum installation, I present the workflow of an artificially intelligent learning environment. Besides being useful for dance and other cultural body movements, MUSE can also provide instruction in a specific martial arts style. It is intended to teach martial art body postures through placing a virtual master alongside the museum visitor. The virtual instructor senses the visitor’s movement in the real world via a motion-sensing unit such as Microsoft Kinect or a more sophisticated available sensor. As the visitor attempts to mimic the body posture of the master, the system will extract skeleton data and joint rotations to assess the martial art performance, as shown in Figure 35. An analysis of the visitor’s movements will be supplied into the system’s AI, which will give real-time feedback and specific targeted direction to assist in improving the visitor’s performance. This technology has promising applications for indigenous martial art performances in terms of both conservation and propagation of ICH.

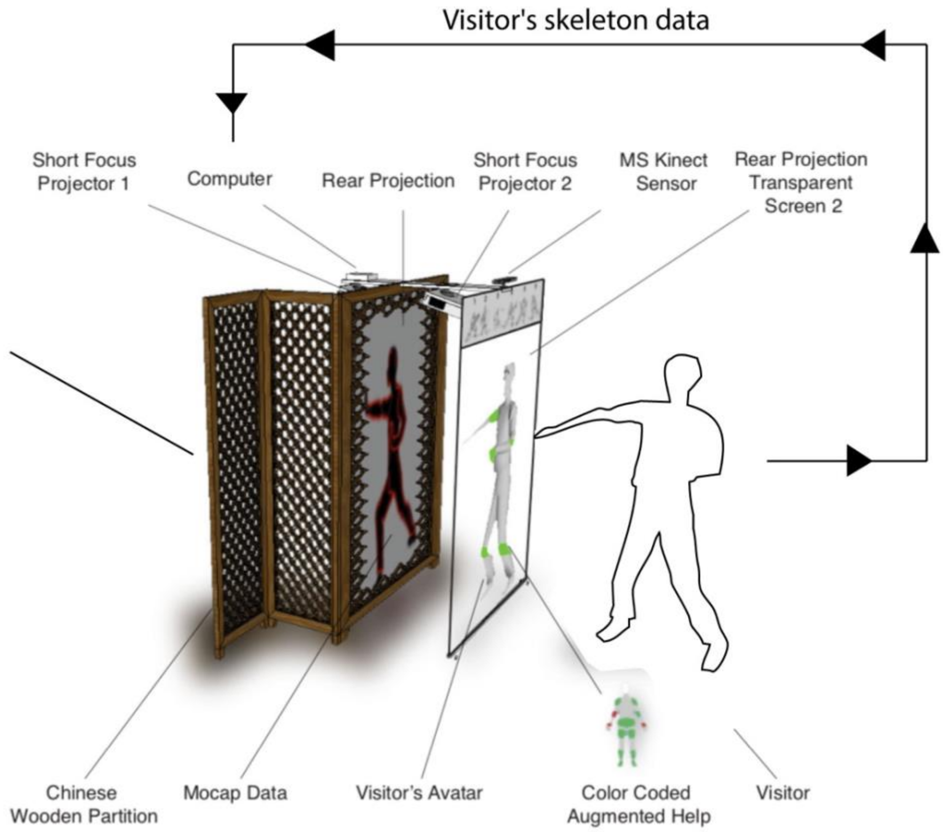

Figure 35. The virtual instructor is learning from the visitor's skeleton data captured by the motion sensor in the MUSE installation.

MUSE will involve the back projection of a virtual martial arts instructor character, compiled using authentic and traditional body posture routines recorded from expert martial artists; it will also include a specific area for a visitor. Visitors entering the space will receive instructions from the life-size, realistic 3D martial art character projected on a translucent screen. The motion-sensing devices will track the visitor's movements, and the virtual instructor will provide feedback on their performance.

Martial arts body postures can be learned from verbal information, spatial examples or tutor imitation. Verbal description works well if the body posture is not too complex; however, as movements become more complicated or active, information is too leisurely, broad and narrow to represent the complexity of precise body posture. In MUSE, the AI-based coordinated instruction can provide a kinaesthetic learning experience, better than verbal description alone.

In observational learning, motor skills are more rapidly and accurately acquired when an instructor is placed alongside the learner (Gray, Neisser, Shapiro, & Kouns, 1991). AI is set up in MUSE in such a way that the virtual instructor can also adapt the lesson to the visitor's strengths and weaknesses. This type of learning situation is beneficial in various serious gaming environments, such as in healthcare and dancing, for example.

Intelligent MUSE setup can provide a significant impact on the intangible cultural learning environment—in particular, cultural body movement—in museum exhibits. MUSE is equipped with a virtual instructor, who can understand the learner's body movements in real-time. It is not only important to preserve ICH through the capture of traditional martial arts styles, but it is also necessary to accommodate the challenging circumstances and engaging feedback that attracts visitors to ICH-related content. Furthermore, it is intended that MUSE, once stationed remotely at two geographically distant places, will offer collaborative martial art instructions and observational learning for multiple users. Research reveals that remotely connected and immersive settings can promote enhanced choreography, higher levels of synchronisation and a better learning experience (Z. Yang, Yu, Wu, Diankov, & Bajscy, 2006).

In this case study, I developed the proposed MUSE system for a heritage-related environment such as physical or virtual museums. Motion-sensing technologies and advance projection screens are already in use for commercial, marketing and promotional domains around the world. These emerging technologies not only help engage the audience but also emotionally attach users if an interactive environment is present. The MUSE heritage installation is one of the few examples that use motion-sensing technologies together with AI, microLED and new projections for heritage production, as shown in Figure 36. I anticipate that when these technologies are mixed with interesting heritage content, an appealing user experience will evolve. I am also positive that in the future, Digital Emerging Communication (DEC) content creators will mix various tools and gadgets to produce an Extended Reality (XR) experience for young people (Fast-Berglund, Gong, & Li, 2018). This is likely to increase "time–room" flexibility, which refers to the need to not be present at the same time and in the same place. With XR, the user's involvement in both 2D and 3D environmental controls will be enhanced, and the brain-computer interface (BCI) system could easily be accomplished (Jantz, Molnar, & Alcaide, 2017). This amalgamation of emerging technologies will showcase exciting new experiences for learning and entertaining with heritage content.

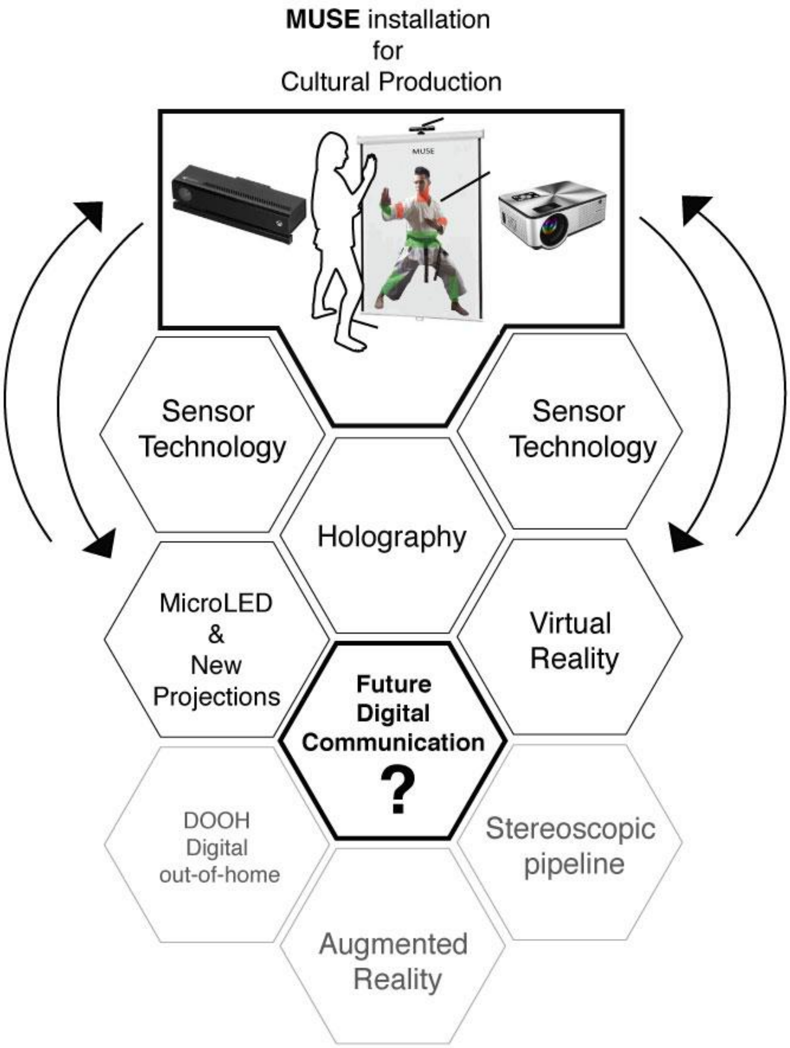

Figure 36. A schematic diagram of the MUSE installation's workflow.

Through the intelligent kinaesthetic learning space design of the MUSE installation, emerging technologies can be evaluated. The MUSE project aims to:

a) create a proof-of-concept for a smart kinaesthetic learning space;

b) assess and examine information transfer opportunities afforded by kinaesthetic peripheral games technology; and

c) combine TK of martial arts forms and the notion of the serious gaming environment in the realm of kinaesthetic learning space.

Through the MUSE installation, cognitive sub-processes play the leading role through visual and kinaesthetic activities. The visitor's peripheral and focused gaze regularly scans the application on the screen for learning cues and feedback. This communication interacts simultaneously with the user's short-term memories, based on their choices and immediate emotional or structural shifts, from digital elements presented by the MUSE screen. It has been said that humans have a limited capacity for coding, storage and retrieval of information from screens (Lang, 2006). The limited capacity model classifies screen viewers as information processors. In the case of MUSE, visitors process the information on the screen with identical cognitive sub-processes of coding, storage and retrieval of information that they have presented. MUSE's desired feedback is based on qualitative assessments driven from the visitors' embodiments and recorded instructions from the virtual instructor.

Through MUSE, these cognitive sub-processes of coding, storage and retrieval will enhance learning, and the novel interaction of MUSE will help the visitors to choose their preferred choices more comfortably. Therefore, visitors can have some self-assurance over the cognitive sub-processes involved. They can deal with various intended interactions about what to see and how careful to be. The MUSE kinaesthetic experience contains more learning possibilities for visitors. The attention-grabbing feedback from the MUSE screen allows visitors, for a particular portion of content, to remember or not to remember. This autonomy for accessing information can last for several minutes and supports visitors' engagement with the exhibit, hence initiating the interaction with new and previously stored data.

Besides various layering of user interactions, MUSE contains linear instruction from the virtual teacher, which may include TK instructions. These direct instructional messages guide visitors to pay more careful attention to the instructional information. Visitors can then accurately use this information to synchronise and copy the virtual instructor. In this manner, visitors see, learn and follow the instructor's gestures and prepare for the next task in order to master a specific martial arts step. From a visitor's point of view, this part of the interaction confirms the computerised allocation of processing resources through the elicitation of orienting responses (OR) (Lang, Bolls, Potter, & Kawahara, 1999). The short-term linear guidance from the virtual instructor under the MUSE's interactive paradigm may be viewed as basic features and support invoking both programmed and guided allocation of processing resources for the visitor.

The principal distinction in my approach to creating MUSE, with respect to existing systems, is in defining the optimal configuration between the AI techniques used to provide visitor feedback and the efficiency with which motion is apprehended and examined. In short, I attempt to define a point in the design at which training effectiveness does not improve with more complex processing and feedback.

Although extremely reliable and precise feedback could be developed in the MUSE museum installation, it is apparent from existing Xbox Kinect dance games that very little data gathering and precision of movement analysis are required to engage users adequately. While these types of interactions do not boast of teaching martial art forms efficiently, there is also no research on whether these interaction techniques do indeed teach the art forms or body movements.

2.2.17 Concluding Remarks About Case Study B

The proposed Mimicry Understanding and Safeguarding Environment (MUSE) installation suggests a unique kinaesthetic learning space with a playfulness that can easily foster dynamic, helpful and engaging user interaction with observational learning possibilities. In the current marketplace, entry of these types of emerging technologies are now available to everyone. While there are plenty of motion-sensing applications being examined, there has been little inquiry into their effectiveness concerning teaching martial art forms under the umbrella of ICH and TK. MUSE represents a necessary examination of motion-sensing technologies and their potential for kinaesthetic experience transfer to a broader worldwide community (in the case of online setup). While the design of this installation will explore the parameters for a genuinely useful virtual martial arts tutor, the installation can easily foster and promote various martial art lineages around the world. The preservation and teaching of cultural body movement is an essential focal area in ICH research. The emerging technologies can facilitate not only engaging showcasing platforms but also help in creating playful cultural production.

In the following section, I am suggesting some recommendations and propositions. This section talks about a crowdsourced archiving portal, “FolkAir”. Moreover, the section proposes a new domain that I foresee for future content creators in the digital domain: Digital Emerging Communication (DEC). Limitation to the study and recommendations are also discussed in the following section.

2.2.18 Limitations and Challenges

Exhibiting the cultural heritage through these kinds of museums is quite challenging even the emerging technologies have contributed in installing and representing the past but still the heritage-related artifacts and the objects are not properly showcased in terms of their processes and the contexts (Kalay, 2008). Although the emerging technologies are being used ubiquitously around the world to enable the visitors to understand the culture but these technologies are more effective to present the objects or artifacts but in terms of examining such artifacts in their historical context these technologies are not effective to use (O. Y. Lee, 2004). This challenge however can be met through emerging interactive technologies that exhibits new displays and that are based on the highly engaged technology-mediated narrative (Dunleavy, Dede, & Mitchell, 2008). Due to this, the concepts of ICH based on virtual reality and interactive technology to represent the heritage has taken the central position to design and evaluate the future of cultural heritage representations.

Video games have increasingly found their way into museums and exhibitions over the last decade, emphasising the growing cultural significance of games and the institutionalisation of game culture. While games research has demonstrated that they are deeply rooted in a grassroots participatory culture, these perspectives are curiously absent from heritage exhibitions (Nylund, Prax, & Sotamaa, 2021). To begin incorporating the diverse practices of communities into the game heritage, museum professionals' crucial expertise is required. While games come in various shapes and sizes and have spawned a plethora of subcultures, communities, and interactive networks, digital game heritage work does not always represent this diversity.

Instead, it frequently leans significantly on the dominating perspective offered by one particular group, notably young and middle-aged white male gamers. Nylund, Prax, and Sotamaa use pertinent examples from recent game museums and exhibitions and their own experiences working at the Finnish Museum of Games and the National Swedish Museum of Science and Technology to describe museum working practises in their paper. To provide a critical view on the cultural heritage process of digital games, the writers blend theoretical ideas from cultural heritage research and game studies. According to them, the intangible and critical concepts of heritage suggest that involving players and game communities in creating gaming heritage could result in more diversified heritage discourse. Games are in a unique position here since hobbyists, enthusiasts, and other types of player participants have already driven the preservation of game culture. Their behaviour in and of itself documents and preserves the activity of play.

It is important to note that these exhibits do not fully exploit a serious gaming environment. According to research, most amateur heritage work overlooks "play" as a kind of intangible heritage, resulting in 'fetishistic' collections of game rarities and other collector artefacts, rather than collections that are distinguished by their openness to dialogue and context information. As a result, interactive methods at collector-run game museums tend to develop a version of game history that implicitly promotes the same kind of one-sided understanding of games that has been extensively criticised in recent game studies. Instead of establishing a sense of gaming heritage based on fetishistic collections of brands, the paper argues that museums and other professional heritage institutions should work toward the systematic long-term preservation of game heritage in their collections. Critical expertise from various museum professionals is also required to move beyond an authorised discourse and begin incorporating the many practices of actual play and play communities into a knowledge of gaming heritage.

Media industries are an evolving mix of sectors such as print media film, digital content creation, interactive applications, video games, emerging display technologies, architectural and scientific visualization, and online entertainment. Within the media industry and research domain, arts, science and emerging technologies could easily let us see and examining new visual and interactive experiences of our surrounding. This particular interaction and collaboration may quickly foster a learning situation and perpetuate imagination. Emerging interactive technologies can easily duplicate a condition and generate unique user interaction with collaborative synergies between arts and science. MicroLEDs (Virey & Baron, 2018) and new projection/display technologies (Leopardi, Ceccacci, & Mengoni, 2019) will have answers to engage visitors to see a new form of reality, ideas and imaginations (Gates-Stuart, 2013 & Gates-Stuart et al., 2016).

Section 3: Recommendations

I have been exploring and experimenting with heritage-related content for a long time. I did not know that this type of content was going to become such an essential part of my life during my doctoral studies. I feel happiness when observing beautiful buildings and other forms of past-built structures—and research in neuroscience shows that beauty in arts and design can give us pleasant feelings (Starr, 2013). In various cities, I have wandered and visited historic buildings, and immersed myself in elderly culture and customs, which always reminded me of who we are and how our ancestors dealt with their thought processes. I have reflected on people who have similar backgrounds and mindsets but who live on the other side of geographical borders. What is that unity and belonging that binds them together and makes them a community? What is my family genealogy and historical lineage? These types of questions have fascinated me constantly. I did not know that heritage manifestation is not just essential in showcasing a culture; it is also a wealth of knowledge and skills which have been passed down through generations.

In this research study, I utilised the UNESCO sub-categories that define intangible heritage topics such as indigenous arts and music, folklore medicines, cultural dances and Unani knowledge. My six published research papers (included in Section 1) manifest, document and transmit these sub-topics through emerging Virtual Reality/Augmented Reality (VR/AR) and motion-sensing technologies. My two case studies (in Section 2) explored areas of intangible cultural heritage and presented installations I have designed that use emerging technologies to help protect intangible cultural heritage.

While I engaged in this transformational research activity, I realised that for young people, it is more enjoyable and playful if the heritage content is comprised of both objective and subjective representations of the reality of the original Intangible Cultural Heritage (ICH) content. I also realised that content creators should be extremely empathetic to the content and the content owner’s personality and environment. Respect should also be given to the owner of the ICH content. This way, content creators can best comprehend the subject matter for the emerging technology-based ICH—in this case, DIH. Retrieving cultural knowledge from practitioners, such as a master of a particular skill or from an indigenous community, could be cumbersome if the content creator does not show considerable empathy. Since individuals and communities transfer information through testimony (J. E. Adler, 1996), the empathy approach to learning the content is crucial for content creators.

During the selection of a specific heritage element of ICH, content creators should also practise intuition, as depicted in the centre box of Figure 38. As the use of intuition is becoming more popular (Dane, Rockmann, & Pratt, 2012), content creators should use it to help select the right cultural elements for playfulness and enjoyment. Sometimes a well-known or repetitive cultural element from heritage content may not actually be a point of interest for young museum visitors. For that reason, making courageous decisions can play an important role in content creators' selection of specific content (Collins, Collins, & Carson, 2016).

An intuitive and empathetic approach to selecting heritage content, together with the use of emerging technology-based knowledge, can facilitate in designing DIH content. Furthermore, in every DIH-related exhibition—whether physical or online—a digital repository will play an important role. A digital repository or archive can help in generating future DIH content. The archived data can also feed into manipulating real-time user activity while learning and enjoying the content. In the proposed intervention in Figure 38, I also emphasised the recording and future/real-time usage of visitors' feedback/interaction. Given that Artificial Intelligence (AI) will be increasingly sophisticated in future, I assume that visitors' data gathering and its nexus to the exhibition/installation will be immensely appealing. The gathered data could easily be archived and implemented in future online retrieval systems/strategies, such as in the Dublin Core Metadata Initiative (DCMI) (Dublin Core Metadata Initiative. n.d.).

As mentioned above, UNESCO categorises two main groups of heritage: physical and intangible (ICH). When we use digital emerging technologies to document and present ICH, we call this domain DIH. The next section discusses the transmission, sustainability and future of DIH. I also look ahead to future DIH content creators, and consider their approach towards ICH and emerging technologies.

3.1 Digital Intangible Heritage: Transmission

The master-disciple connection is vital in the transmission of traditional knowledge. The case study, Mimicry Understanding and Safeguarding Environment (MUSE) installation, addresses this type of connection. The proposed virtual instructor in the case study could build a valuable master-disciple relationship, a good example of employing technology in learning. With the novelty of these technologies, deploying new technologies to use learning paradigms remains a difficulty. The proposed installation will contain a virtual instructor who will teach cultural body motions, perhaps instructions from an experienced dancer or a martial arts professional, on a rear projection film. Technology has advanced to the point where this translucent screen can now provide a wide-angle perspective for a better viewing experience. These films can also be projected at a very short distance. An ultra-short rear projection screen will be employed in this situation, needing the least amount of museum area yet having a significant magnification projection.

According to research, when consumers are exposed to and interact with unique and immersive user interfaces, their engagement time increases; this is known as Active Prolonged Engagement (APE) (Zhao & Horn, 2021). As an evolutionary finding, the ability for inquiry, discovery, sharing and understanding using skilled tools, will result in learning, and knowledge transmission will be faster (Anderson, 2016). It is most closely related to the social constructivist learning theories of Dewey, Mead and Piaget. Like many other popular ideologies, constructivism has been characterised and defined in a variety of ways. This viewpoint holds that active participation by learners is critical and that effective learning necessitates a diversity of ideas and a long-term debate. Teaching traditional sports in any communal setting can be difficult at times, especially in the context of traditional sports learning. It needs a lot of concentration on the side of the knowledge seeker and a great educational approach on the part of the knowledge provider. In the transmission of traditional knowledge, the master-disciple relationship is critical. This form of link is addressed in the MUSE installation. It is an initiative to improve informal cultural learning and increase visitor involvement and collaboration.

There are several initiatives already underway by educational institutions and private sector enterprises for raising awareness about DIH. These initiatives are evident all over the world, such as in Europe, DIHE – Digital Intangible Heritage of Europe (Krawczyk-Wasilewska, 2016); in Singapore (Economou, 2015), in Korea (Kim et al., 2019). and by UNESCO's online intangible heritage lists including its representative (Pietrobruno, 2014). In different pockets all over the world, communities are becoming increasingly conscious of ICH and its digital documentation. For example, the website www.immaterieelerfgoed.be was launched by the Flemish government in 2012 (Janssens et al., 2013). This tool provides services to the Flanders community to collaborative with ICH-related content on the Internet. This online tool promotes cultural knowledge and expertise among individuals and communities, giving way to identification and safeguarding of ICH. The aim is to strengthen the community and provide an opportunity for members to learn from one another. A similar project, i-Treasures (Cozzani et al., 2017), was also launched in 2013 for 48 months. The aim of this online project was to capture rare ICH-related knowledge. ICT and similar technologies are also deployed in the case of "Cantu a Tenore", a typical artistic expression from Sardinia, Italy (Pozzi, Antonaci, Dagnino, Ott, & Tavella, 2014). In order to reduce anxiety and promote the visibility of indigenous peoples, some web-based tools were also introduced so that the community is able to share their knowledge and wisdom (Mendoza, 2009).

Similar to online systems on the Internet, researchers are constantly investigating and experimenting with information retrieval strategies for DIH. One example is a management information system developed by researchers at the School of Xiamen University (Chen, Wang, & Chen, 2009). The aim is to archive ICH-related information normatively to fulfil the desire of a specific heritage-related investigator. The system works as a centre point for Internet users, but also creates links with the administrative staff of museums. The system proposes adoption of three main modules: 1) retrieval and navigation; 2) registration and log; and 3) management and system settings. The idea is to use VR and motion capture ("mocap") technologies embedded in archiving methodology.

In order to represent intangible heritage, motion capture technology and VR are also important (C. Yang et al., 2006). Relics and other media characters can be embedded in the system for cross-referencing purposes. The idea is to provide a visually appealing environment in which users can retrieve and play with intangible content. Researchers acknowledge the fusion of intangible heritage and digital technology, its humanistic approach and visual pleasure by injecting knowledge from other sciences (Shi et al., 2008; C. Yang et al., 2006).

In the console gaming industry, the Kung Fu Superstar game idea can also represent greater kinaesthetic learning and understanding than spoken or written instructions or a leaner pictorial description (Kung-Fu Master, 1984). The game concept attempts to place the gamer's body and mind inside the fighter's body and mind. It may be the most ambitious fighting game idea ever developed in the console gaming industry. It represents the next level of motion-sensing-based fighting games, where the gamer emulates the fighter and develops skills at the same time. This is due to the fight choreography engine created by the developers. The engine helps to create memorable cinematic fight sequences. The gamer's avatar learns while progressing to various levels. The game has incorporated motion control peripherals, a touch screen, traditional thumb stick controllers and future support for VR devices. It is intended that the game engine not only supports the most important martial art techniques, but also allows the user to add body movements. The dynamic and efficient movements of the fighter may not be an authentic manifestation of the actual martial art, but the idea has the potential to become popular in kinaesthetic learning situations. It is designed around real combat art techniques rather than instruction in the traditional art form. The traditional instructional technique is absent in some game ideas such as Kung Fu. The full-body movements and accurate data from both the knowledge provider and the knowledge seeker, are absent. Hence, it is impossible to create an impactful learning scenario.

Some other attempts have been made to capture cultural body movements using motion capture technologies such as Hong Kong Martial Arts Living Archive (HKMALA) (Chao et al., 2018). The system is developed by School of Creative Media, City University Hong Kong and the International Guoshu Association. The precise digital data will help in teaching and learning the South Chinese Kung Fu lineages. According to Master Lam Chun Fai, author of the book *Kung Fu Hung Kuen Fundamentals* (Lam, 2013), technology helps in preserving and promoting the ancient martial art form.

Some applications even offer customisable avatar experiences to satisfy users, such as Maple Story (MapleStory, 2003), World of Warcraft (World of Warcraft, 2004), and Second Life (Second Life, 2003). These visual and kinaesthetic experiences seem to interact with the player's visuomotor skills (Visuomotor skills. n.d.). An internal interaction between visual input and required motor command is necessary to learn and adopt a correct visually guided movement (Paz, Boraud, Natan, Bergman, & Vaadia, 2003). Visuomotor skill is one of the factors contributing to kinaesthetic learning. There are other internal mechanisms that influence the learning process, such as contrast sensitivity, spatial resolution, attentional visual field, enumeration, multiple object tracking, and so on (Spence & Feng, 2010).

VR/AR technologies are not only advantageous to younger people but they have also been applied in a number of circumstances to benefit the older population. For older folks, VR offers a world of possibilities in a variety of therapy fields (Benoit, et al., 2015). According to studies, the elderly accept technology well and it might even help them remember things. For example, traditional balance assessments for older persons can benefit from the use of visual stimulus technologies. In another study, VR technology was utilised to help the elderly cope with their fear of falling (Fabio et al., 2016). Another VR tool, Optic Flow, helps older persons increase their step width and length while also performing a dual task (Leeder et al., 2019). The study looked into gait and cognitive losses in older persons by putting them in an environment where a scene flows by them as they walk on a treadmill, simulating real-life locomotion.

With a full-body avatar, Immersive Virtual Reality (IVR)-related applications have tremendous impact on users' perception, attitudes and behaviours. Research proves that when a full-body immersion occurs, together with VR, the user exhibits an implicit attitude and behaviour (Slater & Sanchez-Vives, 2014). With IVR, people can transcend themselves into a virtual, synthetic environment. Researchers also argue that the embodied person's behaviour changes when a complete immersion with unexpected self-representation occurs by virtual embodiment. Similar to the self-perception theory, this phenomenon is called the Proteus Effect (Yee & Bailenson, 2007). The illusion of body ownership easily affects motor behaviours and thus influences embodied perception, attitude and behaviour, called "body semantics" by some researchers (van Elk & Blanke, 2011). VR, IVR and kinaesthetic spaces with motion-sensing technologies apparently place users into a virtual world. However, thoughtfully designed content provides a transformation of perception, while also altering users' behavioural responses.

Museum exhibitions will, more than ever, use rapidly emerging technologies that are integral to progress across all sectors and disciplines as we move forward. After travelling from the dawn of computing and digital communication, we have arrived at the present, where all media has gone digital. We take a deep breath as we enter uncharted areas where digital technology and computation can replicate human expression and behaviour. New digital devices communicate with us in human-sounding voices, and robots resemble humans in appearance and behaviour. As it takes on human affordances, digital has grown more real, deepening our interaction with virtual existence. As we experience art via a digital lens, we are increasingly living in changed states of being. We employ AI, machine learning, and augmented and virtual reality to create art with our digital instruments while our sense of self changes and imitates digital reality. In the future, exhibitions will increasingly include digital art that may transform digital material into real-life immersive experiences, making digital beings more real.

Technology is present everywhere and is changing the way things are done, making it disruptive. In the form of AI, networks and robotics, disruptive technology has also had an impact on human resource management (HRM) practices (Stanley & Aggarwal, 2019).

Recruitment, legal work, employee monitoring, coaching and performance management are all areas where AI is used in HRM. Heritage management is not a stand-alone field; instead, it is influenced by new technology and methodologies. While visitors enjoy new technology in exhibits, museum staff need to deal with the new framework provided by numerous technical tools.

The relational, organisational, technical and experiential components of modern museum settings are becoming increasingly important, and various factors influence visitors' experiences. Modernisation of museum space based on strategic planning, new technological decisions, advanced technology and modern administration will prompt response to public needs (Vasylenko, Butko, Maslak, & Domitrak, 2020). 3D printing, for example, is becoming more simple, affordable and ubiquitous. It is a rapidly evolving technology that has been regarded as a game-changing tool for museums and historical organisations (Cooper, 2019). 3D printers now enable novel and compelling haptic encounters with artifacts in collections that cannot be handled.

Similarly, many museums have used interactive walls to improve the tourist experience. These were typically huge and expensive, and their primary purpose was to display general information about the museum. As a result, they were difficult to set up in many locations across a museum and were only used to tell narratives about specific exhibits. New low-cost techniques, such as i-Wall, are emerging. The i-Wall is a low-cost interactive wall system made with off-the-shelf parts and technology. It was created for the Syros Industrial Museum in Greece and tells a story of a specific exhibit. It is an interactive wall that gives visitors information on the exhibit's concept, design, difficulties, creators and socio-political backdrop. It also uses AR technology to allow visitors to enjoy the artifacts. Interactive storytelling, animations, projection mapping, conductive paint, touch boards and AR are all part of the i-Wall design.

In the future, museums will employ fewer people and have more efficient management. The Architecture, Engineering and Construction (AEC) industry is moving to the digital era, improving the collaboration among its partners using information and communications technology (ICT) tools. In this context, Building Information Modeling (BIM) provides to smart buildings novel mechanisms to embed Internet of Things (IoT) architectures and perform end-to-end communication, data exchange and information sharing between project actors (Siountri, Skondras, & Vergados, 2019). However, this openness and high decentralisation of BIM and IoT services can lead to several security issues. New technologies also present several other challenges, including the management and protection of exhibition areas and the objects on display, the security and convenience of visitors, the financial management of tickets and profits from museum shops, and the management and protection of workshops, laboratories and storage areas, which typically house numerous valuable artefacts.

Museums will become more efficient and viable in the future thanks to smart management infrastructure. Furthermore, involving local government might make this activity more cost-effective and profitable. To handle museums and their management, some countries are merging local governments into the system (Taniguchi, 2021). In Japan, for example, the designated manager system (DMS) was implemented in museums. The DMS is a new type of public management that allows private companies to manage public assets. HRM will be considerably easier and more affordable. As a result, it is correct to state that the use of new technologies has had a significant impact on innovation orientation, visitor experience investment, and running and funding performance in museums (Camarero, Garrido, & Vicente, 2019). When it comes to attracting people, using new technology and adapting to the audience has proven to be beneficial.

A new paradigm or framework will be deployed with cloud and edge computing, big data and AI. Few expert individuals will be handling, controlling and upgrading future museum systems. The gadgets and technologies of the past will be simpler and more integrated into our daily lives. These gadgets will be modified through edge computing or even change themselves, either remotely or with AI. Human behaviour, or more specifically, visitor behaviour within museums, will be critical. Future preservation systems will properly gather and archive these behaviours while also changing the exhibits on a regular basis. These changes will not require the hiring of additional museum workers. These changes will take place in a transparent and timely manner in order to attract more visitors, as playfulness inside exhibitions will take on a new shape.

Furthermore, VR has evolved and is now included in mixed reality (MR) situations. MR devices are used by many public services and entertainment industries to create highly immersive and interactive applications (Hammady, Strathern, & Mohamad, 2020). Recent advances in MR processing, on the other hand, have led the tourism and events industry to invest in and develop commercial applications. The mixing of real and virtual worlds to create new environments and visualisations in which physical and digital objects co-exist and interact in real-time is known as MR. Mixed reality is a combination of reality and virtual reality that does not take place exclusively in either the physical or virtual worlds. Individuals' involvement, spatial mobility and perceptual awareness are all enhanced by this method in MR environments.

Moreover, VR hardware has been expensive in the past, but the price is now consistently dropping. As a result of the competition, more affordable gadgets are now available, and users may even purchase accessories for their existing smartphones. These add-ons transform standard mobile phones into VR headsets. In the case of MR experiences, the inclusion of actual walking is hampered and impractical because it frequently necessitates enormous amounts of physical space. Using new technology, multiple users immersed in separate VR experiences can now be jammed into the same physical location. I am confident that museums will not bear the cost of gadget upgrades when visitors are responsible for their own mobile phone upgrades. As a result, visitors will have upgraded gadgets and will either carry their own VR headsets, or museums may supply these headsets for them. Edge and cloud computing will also be used to improve the embattled technology. I believe that shortly, these technologies will be so transparent that we may not even need bulky Head-Mounted Displays (HMDs). They will first evolve from their current state to become more like conventional eyeglasses and even more like contact lenses. It will only be a matter of years until we begin to observe the virtual and physical worlds coexisting everywhere and at all times. Such approaches can be seen in several systems being developed, such as Google Cardboard (Yeolekar, Shinde, & Qadri, 2019). However, I am speculating that there will be even more inexpensive systems available soon.

For example, VirtualSpace is one of the systems where several users can be in a single virtual space (Marwecki, et al., 2018). VirtualSpace does this by keeping each user in a subset of the physical space at all times (called "tiles"), and then rearranging tiles and users across the full physical environment using app-invoked manoeuvres. This allows apps to relocate users to where their narratives require them to be while keeping the fact that they are constrained to a tile concealed from the user. The application demonstrates how VirtualSpace can squeeze four users into a small space. Participants were able to use more space and feel less confined in this fashion than in a control condition with static, pre-allocated space.

Finally, objects inside museums are are now being made accessible to visitors in the digital realm. Intangible artifacts of a culture, ICH, are also being changed in the name of safeguarding. Emerging technologies and their unforeseen linkages can have tremendous impact on socio-economic and socio-political aspects of daily life. The amalgamation of these new gadgets and tools with the artifacts of the past has generated meaningful additions for museums. These unique interventions facilitate the phenomenological nature of perception, and place the mind within uncertain boundaries of imagination.

The above practices are unique, not in the way they are utilising technologies, but in the way they create linkages and relevancies to the technologies. This unique merging of technology and art creates particular content, form, ethics, aesthetics and phenomenology. Chatzichristodoulou and Zerihan (2012) discuss technology and performances and state that media arts are not just arts that incorporate media into their practice, but that media art is a by-product of ever-developing technology.

3.2 Digital Intangible Heritage: Sustainability

Traditional or digital documentation of a heritage piece is a continuous process that provides for the monitoring, maintenance and understanding required for conservation or preservation through the provision of relevant and timely information. Documentation is both a product and a process for meeting the information needs of heritage management. According to a study, a document, or a digital document, is an object consisting of analogue or digital content (Edmondson, 2020). It is defined as signals or codes (such as text), images (still or moving) and sounds (transferred or moved). The carrier's aesthetic, cultural and technological aspects may be significant. The content-carrier connection can range from insignificant to vital. The contrast between carrier and content is significant from the standpoint of preservation. For some researchers, distinguishing between a document as an artifact and an information carrier is critical. A document is a device for storing and sending information as an information carrier. A document, in any format, is a physical thing whose interest is based in part on its information content.

Hence, in the case of this research, I assume that DIH content generated by an exhibit is itself a heritage document. The challenges will remain to sustain and preserve digital installations and data related to DIH exhibits. I further speculate that there will be several organisations and online groups (such as working groups and participatory heritage groups) who would help develop DIH content in the future. Working groups and participatory heritage can easily help future museums. A venue where people participate in cultural activities outside official institutions to share knowledge and co-create with others could be termed participatory heritage (Roued-Cunliffe, & Copeland, 2017). As mentioned earlier, various groups exist as a result of social media, user-generated content and crowdsourcing, such as Wikipedia, Old Copenhagen, the Sydney Opera House Flickr community, Ravelrynetwork of Eruption Museum OnlineOganization, and Ancestry. These groups explore museums' ability to engage and collaborate with various creative industry stakeholders. They encourage collaboration between museums and the creative industry by sharing creative applications of museum resources for new goods and services. Some organisations are dedicated to promoting socially engaged museums and diverse staff. They work ethically and sustainably, collaborating with partners who share their goals and values. These working groups promote and support museums and everyone who works in and with them in realising the value and significance of their collections.

Research also highlights the importance of digital sustainability and utilisation of its benefits for the user, particularly the sharing of the tacit knowledge structure for long-term availability (Stuermer & Abu-Tayeh 2016). Therefore, a number of collaborative approaches have commenced for: a) visibility, b) sustainability and c) preservation (Ras, 2016). To support these three paradigms and real-time heritage transmission, several working groups have been established (Blewer & Rice, 2016; Di Iorio & Caron, 2016). Moreover, digital artworks/installations need to be archived, and for that purpose, various methods have been created, such as the Emulation as a Service framework (Espenschied et al., 2016). As a holistic approach, the benefits of digital resources are maximised by the concept of digital sustainability (Stuermer & Abu-Tayeh 2016). Similar to the concept of sustainability in software design (Becker, 2014), the notion of sustainable digital heritage is important for its resilience, adaptability and durability. In addition, digital heritage content should adopt similar concepts of open-source software, open content, open data and open access (Hillenius, 2009; Miller et al., 2008).

In addition, there are a number of challenges identified for long-term preservation of heritage-related data (Lorie, 2001). As mentioned in the previous paragraph, these collaborative approaches are being used to ensure that the produced information is available in the storage media, devices and data formats. An Open Archival Information System (OAIS) is an organisation of people and systems responsible for the preservation of heritage information and to make it available to the public (Lee, 2010). For long-term preservation, it is intended that the proposed framework will help formulate archival content ready for OAIS organisation.

The acutely precise or analytical nature of heritage representation adds a layer of dullness to the heritage project, and user interpretation is entirely missing from it (Affleck & Kvan, 2008). Too much emphasis is placed on the technicality of representation and authentication of data transformation rather than the end-user receiving aspects (Tan & Rahaman, 2009). Hence, we see numerous ICH data interpretation with a linear depiction of the past (Thornton, 2007). Therefore, it is important to create interesting ICH digital representation (Kaptelinin & Nardi, 2006) and to incorporate non-linear interpretations and subjectiveness to heritage-related content.

Museums are the key connection between the past, the present and the future (Sharif-Askari & Abu-Hijleh, 2018) and are typically non-profit institutions/organisations dedicated to the fulfilment of their social purpose of collection, restoration and public education (Hebda, 2007). As with every organisation, museums have to be concerned with social and environmental points of view in order to meet sustainability targets. Some scholars suggest that museums could return to being learning centres, not only destination attractions. Only then they can be viable (Di Pietro at al. 2014).

Most museums have been built to accommodate artifacts in an indoor climate. Several aspects play a significant role when contemplating the sustainable indoor environment, such as temperature, relative humidity, illumination, air quality and ventilation. The energy conservation component of museums is also considered an essential factor for sustainability. Furthermore, it is important to decide the various issues involved when we look at the protection of a physical item in relation to preserving the details. This distinction has long been a part of cultural heritage practices and has only become more important in this era of digitisation and shrinking budgets.

To conserve all kind of museums artifacts, including digital and analogue, standard principles are essential (Harvey, & Mahard, 2020). For others, digital is seen as different and digital preservation can be done differently - a widespread concept within cultural institutions. Some also doubt whether there is a requirement for digital preservation in the first place. Acquisition, ensuring entry, retention and holding items in good condition are some other considerations. Moreover, as far as digital artifacts are concerned, inventory management, restoration, storage, information science and connectivity are the most common subjects in museum disciplines (Katre, 2011). When museums continue to digitise their artifacts, gather new technologies-based objects and store born digital records, all of them became part of digital preservation.

It is also important to know that digital materials are particularly vulnerable to failure and destruction because they are placed on delicate magnetic and optical media that deteriorate rapidly and that may malfunction unexpectedly from exposure to sun, humidity, airborne pollutants, or defective reading and writing equipment. Even if the media are kept unchanged, digital materials become unreadable if the playback systems required to extract content become outdated or if the software that converts digital information from computer- to human-readable form is no longer available. Moreover, cultural institutions are now facing technological, regulatory and operational difficulties in adapting to the current demands of digital preservation. Cultural institutions often face regulatory challenges in meeting their mandates to protect valuable content where copyright or licence arrangements forbid reproduction or local preservation of digital information. Hence, digital preservation is a multi-faceted challenge that is perceived differently by different institutions and practitioners.

Museums and other cultural institutions are sometimes hesitant to use new technologies in exhibits, not because they dislike them, are philosophically opposed to them or do not see their potential, but because they are concerned about their own institution's ability to maximise and sustain these technologies' potential. This trend, however, will be reversed when more reliable and standardised instruments become available on the market. A variety of initiatives, including Khronos Group's OpenXR standards project, are being investigated for standardisation. Microsoft has already joined the list of firms that support this project (Brennesholtz, 2018). Naturally, Microsoft is a huge addition to the group. The firm is in charge of both the Windows operating system, which is used by many other VR/AR-related headsets and programs, and its own line of MR headsets. According to Road to VR, Google has joined a working group that aims to build a multiplatform, royalty-free standard for VR and AR platforms and devices, which includes Google, Oculus, Unity, Valve, and numerous other companies. In an ideal world, such a project would streamline the development process by allowing developers to design apps and games that can operate on any VR device, rather than having to adapt projects for each platform separately. As a result, the standardising difficulty has been recognised, and additional work will be done in the future to overcome it.

Another initiative is to use web technology for the aim of standardisation. The open-source ATON framework is the outcome of national and international research and development programs over the last five years. It has been built on current and robust web standards, open specifications and massive open-source ecosystems ((Fanini, et al., 2021). The web and recent improvements offer a great chance to create ubiquitous, rich, multi-user and immersive Web3D/WebXR applications for the cultural heritage field, such as 3D presenters, inspection tools, applicable VR games and collaborative education tools, among other things. The emerging application should be able to reach every device, adapting its interface, rendering and interaction models automatically. This will result in a single, liquid product that can be consumed on mobile devices, PCs, museum kiosks and immersive AR/VR devices without the need for final users to install anything. ATON provides institutions, researchers and professionals with a scalable, flexible and modular solution for creating and deploying liquid web applications with novel and advanced features in terms of 3D presentation, annotation, immersive interaction and real-time collaboration targeting the cultural heritage field.

We live in an era characterised by globalisation, remote social networking and hyper-connectivity. We have figured out how to exist in a world of isolation and separation, and we are seeing the results in our lives, identities, relationships and liberties. Performing arts - from theatres, museums, galleries and the public square - have already closed due to social alienation and work-from-home demands due to the worldwide COVID-19 pandemic. This scenario, or opportunity, has prompted a rush to go online and immerse oneself in cyberspace, the new way of life.

We have been experiencing a tsunami of technological advancements in computing and digital devices. Mobile and tablet devices are getting not just smaller, cheaper and more powerful than previous PCs, but they are also now including cameras to create high-quality and 3D images, as well as a variety of sensors to indicate location, orientation, radio waves and humidity. Tiny sensors can be found or, rather, go unnoticed in various places, including in toys, furniture, ordinary clothing and jewellery. People and "things" may communicate and exchange information via these sensors and gadgets due to internet access available 24 hours a day, seven days a week.

There is concern that developing technologies and visitor-induced activities could turn museums into a place where novelty and playfulness dominate. Furthermore, contemporary museum installations may turn a heritage visit into an interactive experience, which is a concern. The museum's entire identity is jeopardised: visitors are drawn in by games, gadgets and light and sound shows, not by the exhibits and the messages they represent. Visitors may potentially influence the indigenous heritage content, as their opinions compete with scientifically sound facts. The communal audience puts the actual learning of the original objects in jeopardy. Some people wonder if digital gadgets send any messages or have any sound effects aside from the fun of playing.

The availability of gadgets and information, both technically and financially, has opened up new terrains for culturally relevant applications that appeal to a wide range of people. The museum is one of these environments. It is a challenge for the traditional form of heritage institutions to redefine themselves in light of the changing context in which they operate. The digital natives, its new, potential consumers, have significantly different learning and communication patterns than their parents, and a vast array of digital media competes for their attention and time. The rise of new digital technologies, on the other hand, enables new tools for interpretation and outreach for cultural heritage institutions (otherwise known as galleries, libraries, archives and museums [GLAM], a recently developed term for these institutions) (Candela et al., 2020). Finding the correct place for digital technologies in these institutions, on the other hand, is not always obvious. The debate has taken place in both newly developed professional forums and the general media.

The museum's daily operations are both aesthetic and scientific at the same time (Berra, & Kaplan, 2001). Things that are required and things that are flexible both have to be completed. The art and science of museum management necessitates some level of command or influence. There are some things that human resource manuals demand. And then there is everything else that comes up along the way. There are directives about communication methods (such as memoranda, e-mails, meetings, phone use and IT restrictions) when it comes to managerial activities. In regard to budgeting and dealing with money, management as a science is very visible. Management is about getting things done, staying on pace with daily tasks, preventing regression and deflecting inappropriate operations.

Museums are no longer distinct entities, and they will operate in a similar manner within the new and emerging system. They will be linked to other entities within an economic framework in a similar way. After the digital revolution, tourism and other revenue-generating units in any country will undergo huge changes, which have already begun. Operating museums will take on a new shape, with considerably more remote management and a more interconnected audience, necessitating the utilisation of specialised technology and human resources. Finally, with ever-smaller, cheaper and more widely available products and services, digital technology provides ample opportunity to meet these goals (Ruttkay & Bényei, 2018).

In the framework of speculative/critical design thinking, DIH, and evolving interactive technologies, which are the major topics in this thesis, the traditional concept of recording and preserving intangible digital heritage, will take on a new form. I am not claiming that for tangible and intangible cultural heritage (ICH), traditional conceptions of documentation and preservation will be updated or transformed; rather, I believe that DIH-related documentation and preservation will take on a new shape. This will occur because machine continuous recording of digital exhibits will be used to implement future modifications. In both of the case studies mentioned in the thesis, examples have been given. The case studies show that the automated recorded data will be transformed into a repertory for the next generation of exhibitions or installations. As a result, it is important to stress that I am not suggesting that current or traditional documentation and preservation processes and frameworks will be altered.

In summary, the archiving of digital heritage is important, and several research strategies have been devised to tackle this challenge. To preserve an intricate digital artifact in museums, researchers have been using several strategies; however, most of these strategies are linear in nature. This kind of linear interaction is most common in digital heritage but research shows that it has frustrated users who would like to see more excitement and engagement with the content (Champion, 2003). User interaction is finding its place in heritage-related representations, and a number of new tools are being used to enhance end-user interaction (Benko et al., 2004; Guven & Feiner 2006; Miyashita et al., 2008). It is also important to "connect" the new content with end users so they feel an affinity with it and are not affected by "heritage dissonance" (Tunbridge & Ashworth, 1996).

3.2.1 The Dublin Core Metadata Initiative

With the spread of the World Wide Web in 1990, sharing information over the Internet was a challenge, and new tools for the documentation and retrieval of information were explored (Arakaki, da Costa, & Alves, 2015). However, there were concerns as to how to best represent and recover these new digital archival resources. Many researchers devised various strategies to tackle this problem. One of these strategies, formed in 1995, was called the Dublin Core Metadata Initiative (DCMI): its broad aim was to locate and identify any online information.

VR/AR and sensor-based DIH representations are certainly likely to be recognised for their educational and entertainment potential. However, when archiving information as metadata for future retrieval, this medium can differ substantially from other media representations. It may be safe to say that these technologies, in the future, will involve the use of our senses, cognition and engaging sensory experiences. As new generations—such as “Generation Z”—increasingly turn to future technologies to convey and communicate their ideas, protecting, perpetuating and transforming heritage is becoming vital. These young minds will also be the future creators and presenters of their ancestral heritage. Doing so requires the development of the capability to document, record and dispatch that new cultural content so it can be reused and transformed as required.

Moreover, the standardisation of metadata schema determines that systems can work together and use data with interoperability. Nevertheless, current standards for defining cultural/technology content cannot directly be utilised to explain these future emerging cultural contents as a standard set of heritage content. It will be challenging to include future heritage representation in ICH storehouses, and to describe them coherently in the various online repositories. This study introduces a metadata schema for describing future DIH content as archival resources, based on existing standards, so that emerging heritage representations by new content creators can be described within online repositories.

Soon, immersive and sensor-based installations will be replete in museums and on the Internet. This content will be a means to carry forward our heritage and past artifacts—either modified, or in their original form. These installations or objects will also transfer the digital intangible aspects of culture, particularly using emerging technologies. These installations/artifacts will be ubiquitous and will provide even higher levels of engagement with multiple adjectives, characters or elements. They will have, but not be limited to, the following prominent elements:

1) Category—of ICH content/sub-content as defined by the UNESCO convention;

2) Engagement—with the indigenous community/individual/agency;

3) Nature—level of subjectivism or realism;

4) Emotions—emotional level from tragic to playful; and

5) Representation—focused, or unfocused/organic representation.

The importance of heritage has been well established and, certainly, some standard metadata schemas have been developed to explain digital preservation accurately. Standardisation means that the information can be used and reused in various digital platforms. Still, these standard schemas are not designed to encompass all DIH-related content and they overlook certain aspects, such as information about the indigenous community, type of installation and content creators. The most crucial element is their association with the providing community or individual, particularly essentials concerning the intangible heritage domain. While schemas exist for heritage documentation, a representation of DIH-related metadata schemas is missing, which can describe DIH heterogeneously. Developing ICH in a digital format with future technologies will be a costly and complex task; it needs new technologies and an online community or other source might be producing this content. In the case of future DIH, since the content might be produced based on crowdsourced initiatives or an unknown producer, it is also important to identify the producer of the content. Hence, it is crucial to acquire interoperability among the various heritage resources and metadata standards.

3.2.2 FolkAir: A Crowdsourcing Archiving System for Digital Intangible Heritage

"Crowdsourcing" is an emerging concept—originally developed and defined by the business community (Owens, 2012b)—to collect ideas, information or content. It can also be understood as the continued use of available communication networks (Schreibman, Siemens, & Unsworth, 2015). The "crowd", in the notion of crowdsourcing, refers to a group of people (different in knowledge, number and heterogeneity) who are willing to undertake tasks originated and controlled by source institutions (Carletti, Giannachi, Price, McAuley, & Benford, 2013). In research articles published between 2006 to 2011, around 40 definitions of crowdsourcing were published, but there was no common agreement on a definition (Estelles-Arolas & Gonzalez-Ladron-de-Guevara, 2012).

The idea of crowdsourcing and its associated initiatives have become prevalent worldwide in the domain of cultural heritage (Noordegraaf, Bartholomew, & Eveleigh, n.d.). Scholars play a significant role in researching, scoping and theorising crowdsourcing activities throughout the wider cultural heritage sector. Researchers have been examining the pros and cons of the associated initiatives (Carletti et al., 2013). Indeed, the term "crowdsourcing" was invented in 2006, around 182,000 websites started using it in some way. For instance, it became the term to describe various online activities such as Wikipedia, Flickr and Project Gutenberg (Schreibman et al., 2015). Furthermore, the Old Weather project, which was one of the most renowned and successful combinations of historical crowdsourcing, motivated the general public to observe and contribute local weather observations to help improve weather pattern projections and information about former environmental conditions (Schreibman et al., 2015).

From 2010 to 2011, several other notable projects were launched using crowdsourcing, reflecting the scope and breadth of online effort to preserve cultural heritage—for example, Finland's DigitalKoot project (http://www.digitalkoot.fi/index_en.html). The site aimed to make it possible for users to enjoy games, which at the same time supported them to refresh the metadata of their Historical Newspaper Library (Schreibman et al., 2015). Another example is the Modeling Crowdsourcing for heritage project (http://cdh.uva.nl/projects-2013- 2014/m.o.c.c.a.html), which was initiated as the result of collaborative efforts of the Centre for Digital Humanities and the Creative Research Industries Amsterdam. The project aimed to identify a comprehensive model to determine the types and techniques of crowdsourcing which are significant and have relevance for specific purposes (Schreibman et al., 2015). More complex tasks, which were traditionally fulfilled by academic scholars in digital humanities, can also be crowdsourced, for instance, the transcription of manuscript material.

In the past few years, cultural heritage institutions and museums have conducted many practical experiments to explore the efficiency of crowdsourcing. This unique approach to promoting maximum public participation and voluntary contribution to core activities (such as collecting, describing, categorising and curating heritage collections) has resulted in many initiatives. Utilising the concept of crowdsourcing in this way has been controversial for some commentators (Brabham, 2008; Owens, 2013; Eveleigh, 2014); however, there is clear organisational appeal towards involving the general public in creating and/or improving the information held within collections. Crowdsourcing is also considered to be an effective way to increase the engagement of audiences with their cultural heritage. In turn, this enables greater accessibility to cultural collections, where people can share, recommend, remix, embed and cite information. This concept is underpinned by postmodernist theories and has drawn on cultural and societal trends towards collaborative creativity. It endorses the democratisation of experts through promoting multiple public expositions covering cultural heritage content (Noordegraaf et al., 2014).

Crowdsourcing employs social engagement techniques to aid in the achievement of a specific, common and significant goal that would be impossible to attain without a group effort. It enables organisations to attain goals that would otherwise be impossible to fulfill due to time, financial and resource restrictions (Ridge, 2016). Research shows varied (successful and unsuccessful) results emerging from crowdsourced projects. For instance, the study recommends that the number of scaffoldings evolved into a design that uses "pull-down menus", (graphical control element, similar to a list box), might be important to both excite and support project participation (Causer et al., 2012). The complexity of the original task, the level of necessary specific information, imprecise way, or a lack of feedback when the job is completed, are all important determinants (Ridge, 2013). Furthermore, simplicity and clarity in direction are essential when building a crowdsourced heritage portal. With fewer and more direct instructions, participants tend to find the task more enjoyable, and barriers to participation are minimised, leading to a higher project yield (Holley, 2010; Ridge, 2013). Finally, "crowdfunding" can also be a method used to generate funding for projects.

I hope that "FolkAir"; my own designed crowdsourcing system/portal, will be an ionic project, a way to preserve intangible cultural heritage in the digital realm and thereby be important for future generations. It is needed because, in future, DIH will be a common form of cultural remembrance. The aim of FolkAir is to build a web presence to demonstrate cultural embodiments with a "wow factor". To achieve this goal, people all over the world will be asked to involve and contribute. To assist in determining the most symbolic and iconic DIH projects, an online survey will be conducted, which will help in defining the magnitude of the uploaded project. A detailed and comprehensive list of descriptions will also be added to the website, as well as information regarding locations, time period, audience reaction, and so forth.

FolkAir's home page (the URL of this portal will be www.FolkAir.com) will be similar to the existing crowdsourced site for indigenous music, "FolkCloud" (Jastram, 2018); FolkCloud, 2020). The idea for FolkAir came from the FolkCloud website, in which users from around the world can register and upload cultural music. Moreover, users can easily select the region on an interactive globe, similar to the Google Earth website. They can also listen to music from all over the world. The FolkAir project will invite people, to contribute in the same way to organise and add value to ICH. The interface should work in a meaningful way in which individuals can interact with, explore and understand the historical record, as well as being able to add DIH-related projects to the portal. It is not about attracting anonymous masses of people; rather, it is about inviting participation from those who are interested and engaged. After registering, content creators will be given the following initial parameters to fill in:

- project name in English;
- project name in local language;

- content creator name in English;
- content creator name in local language;
- genres/tags/keywords;
- upload a file; and
- country.

There appears to be a deficit in archiving of, and an online presence for, DIH-related content. The idea of a crowdsource-based web portal is designed to address this gap. The FolkAir website will be accessible to DIH content creators from all over the world so they can personally upload content and connect with other content creators around the world. Crowdsourcing helps in improving, extending and sharing text, audio and video fragments automatically to users (Snoek, Freiburg, Oomen, & Ordelman, 2010). FolkAir will be an online repository with unique metadata tags for easy retrieval of text, images and video, or perhaps even emerging web tools, that could be embedded within the portal. Multimedia retrieval continues to be underappreciated because of the shortcomings of being applied in the real world, despite years of vibrant research. For instance, if one wants to search for a video on the web, the only method has been to search by using (user-provided) text. However, some advanced multimedia retrieval tools have now been developed, which allow easy retrieval of video fragments from previously recorded videos. Such video fragments and footage, which were previously only able to be accessed through the offline archive of digitisation, can now be accessed because of the newly developed search engine (Snoek et al., 2010). In the case of speech, automated speech recognition (ASR) is a technology that can also be used in the FolkAir portal to recognise speech in the interview fragments within the collection.

When I examined two projects, one from Finland .and the other from the Netherlands; the FolkAir project idea came into my mind. These two projects are already mentioned in the thesis. The FolkAir project is merely a proposed technique for documenting, transmitting and archiving DIH information worldwide. The project's goal was to develop a comprehensive online emerging technology-based consolidated model for determining the sorts of DIH materials that are significant globally and relevant for specific heritage goals. Moreover, I coined the term "FolkAir" after experiencing the existing crowdsourcing platform for indigenous music called FolkCloud (Jastram, 2018). I included "Air" after "Folk" since we cannot touch air but can sense and perceive its quality and intensity, which I believe is quite comparable to DIH content.

In summary, crowdsourcing projects can be seen as the best way for audiences and institutions to collaborate, especially in digital humanities (Carletti et al., 2013). Thus, the proposed FolkAir portal can be understood as the continued use of available communication networks and platforms for distributing DIH content to a broader range of interested people who voluntarily work towards a common objective. The system can be considered a step towards converging and consolidating the DIH content around the globe. It can be extremely realistic if endorsed and approved by the relevant legislative and cultural agencies. FolkAir will also act as an agile mechanism for those who work in digital humanities to respond immediately to significant contemporary events, as well as to preserve and collate evidence and archiving material, both for future scholarship and community use. It is anticipated that FolkAir will be accessible in every community. Research shows that the use of crowdsourcing is effective in universities and school classrooms for promotional purposes (Schreibman et al., 2015).

GLAM organisations are increasingly using interactive technology to aid in understanding cultural heritage. There are numerous options for researchers to creat DIH content. In one study, a qualitative evaluation of data based on interviews, workshops and fieldwork focused on possible transcultural audiences and Chinese/non-Chinese puppetry stakeholders (Zhao et al., 2019). The study offered various design solutions for overcoming transcultural hurdles while preserving culture. Moreover, it aimed to see how digital technologies might help cross-cultural audiences connect with intangible Chinese history. This research proposed ways in which the digital domain might promote cross-cultural audiences' knowledge of puppetry gestures and numerous performance aspects, thereby assisting audiences from many cultures in interpreting puppets' gestures more accurately. Furthermore, this research found that interactive digital technology better assists in the basic and symbolic understanding of intangible cultural assets. Rather than being used in conjunction with traditional performance, it is used on its own.

Another study in China looked at the role of “edutainment” - the combination of educational and entertainment activities – in preserving intangible heritage (Luo, 2021). The study examined the benefits and drawbacks of incorporating interactive and experiential components into the dynamic safeguarding of intangible heritage in creative urban settings. The article focuses on a cultural park in Guizhou Province, southwest China, that bundles traditional ethnic practices into cultural products and leisure experiences for public participation and presentation. The site is an example of a new type of hybrid cultural venue that resembles older models of theme parks and museums while also differing significantly. The research proposed that while edutainment provides new learning opportunities for the general public and younger generations, it also necessitates transforming old cultural forms and practices. In this framework, edutainment becomes a strategic instrument for preserving traditional knowledge and skills while promoting local cultures.

The current status of serious game technology is identical to the current state of entertainment game technology. As a result, recent advances in computer games, real-time computer graphics, virtual and augmented reality, and AI are all addressed in the field of serious heritage games. On the other hand, serious gaming applications provide major advantages in the areas of communication, visual expression of information, cooperation mechanisms, interactivity and entertainment. With the rapid advancement of technology and the widespread use of social media, numerous opportunities for the design and implementation of interconnected systems have arisen, allowing for a paradigm change in how we interact with cultural material (Nisiotis, Alboul, & Beer, 2020).

Museums are responsible for cultural heritage preservation, education, exhibition and historical artifacts' conservation (Barbieri, Bruno, & Muzzupappa, 2018). They use exhibits and multimedia interactions to assist visitors to grasp information and context about a topic or event in history. However, presenting antiques in glass cabinets and offering audio guides, brochures or written guidebooks that describe the artifact or location, are insufficient to engage and excite tourists. As a result, to compete with the entertainment business, the necessity to update exhibit presenting methods is emphasised, overcoming the obsolete concepts of traditional museology. Museum visitors today are exposed to a wide range of entertainment technologies, including social networking, computer and console games, films, and Internet of Things devices like wearables, connected smartphones, sensors and so on. The old museum paradigm of "featuring displays" and "museum visitors" is giving way to the "museum experience" and the visitor as a "museum consumer" paradigm.

This thesis has focused on VR/AR and emerging sensor-based technologies. In museums, VR is widely used to display, reconstruct and/or virtually repair artifacts, settings and archaeological sites that have been damaged or vanished over time. Due to the technology's affordances of immersion and presence, VR enables highly immersive and engaging experiences to support visitors in retrieving and adapting information about artifacts and exhibits when compared to instruments utilised in traditional museology display practices. Immersion is the result of a technology that replaces real-world sensory input with digitally created input. Presence is related to immersion, but is different in that it is the user's brain's reaction to the virtual environment, in the same manner it would have reacted to the real world after immersion. The benefits of presence and immersion and VR's potential to create situations that are difficult or impossible to experience in the actual world are all factors that boost technological adoption goals. Despite initial scepticism, VR is rapidly being used in museums to enhance and support visitors' interactions with cultural heritage. Until recently, VR was thought to be an expensive and resource-intensive technology plagued by technological challenges and needs. As a result, several attempts to develop cultural heritage experiences in 3D virtual worlds - employing desktop virtual worlds such as Second Life and OpenSim – have been made throughout the last decade.

Visitors have engaged with the virtual world through their computer screen, keyboard and mouse in these environments. During a period when these settings were trending as the next big thing in social virtual world experiences, this enabled a much more efficient and cost-effective access to immersive cultural heritage experiences than VR. However, due to product commercialisation and virtual world designers moving on to private and individualised solutions, these environments never quite realised the high expectations that many virtual world enthusiasts had hoped for. As a result, users lost interest in the technology, and it finally became obsolete. Nonetheless, recent technological breakthroughs have permitted tremendous technological leaps, and VR is now a cost-effective and mature customer-ready technology. It has progressed to the point where it can be adapted to any smartphone, minimising the reliance on expensive hardware and the difficulty/inconvenience associated with Head-Mounted Displays (HMD). As a result, utilising the power of smartphones that visitors carry in their pockets could become commonplace in the museum experience, especially with low-cost HMDs like Google Cardboard, which allow visitors to immerse themselves in virtual settings using their smartphone device.

Like VR, AR has evolved rapidly in the consumer market and is now available ubiquitously in every mobile device. AR technology projects computer-generated digital content onto the actual world, such as 3D objects, video and photos. Initially, experimental work employed a pair of smart glasses to superimpose digital material in a real-world context; but, as smartphone technology advanced, mobile AR became a simple, affordable and widely adopted tool, particularly in cultural heritage. In recent years, the advancement of AR has seen a return to the development of a new sort of headset that resembles a pair of spectacles. The first example was a Google Glass project, but there are already a few headsets on the market (for example, Microsoft's Hololens 2 (HoloLens, n.d.) and Magic Leap One (Magic-leap, n.d.). These project 3D computer-generated pictures onto the lenses using modern optics technology. Like mobile AR, AR headsets superimpose 3D computer-generated visuals onto the actual environment. AR glasses, unlike VR headsets, do not generate a simulated environment, allowing the user to see the real world.

Because the hands are not engaged, the chance and potential for full-body connection is greater while using an AR headset than when using a mobile device (Vainstein, Tsvi & Joel, 2016). Looking via a headset while keeping eyes on the physical environment and having hands free is a more immersive experience than using the phone (Mason, 2016). Furthermore, the experience design can use a range of sensory input, such as eye-tracking and voice, to enable more natural interaction mechanisms for visitors of all ages. The majority of AR headset research has concentrated on aspects of science and ergonomics, such as navigation to a target place, situational awareness and augmented imagery visibility (Mason, 2016; Mokatren, 2018, Vainstein, 2016; Kerr et al., 2011). Even though there have been more than 20 years of research on AR in cultural assets, the literature focuses primarily on technological factors with little attention paid to its employed context. A few projects have addressed the importance of using stories (Spierling & Kampa, 2014), but they have all approached storytelling as a linear, didactic experience with object-centric stories or by using simple game mechanics in such a way that the experience is primarily a game with a learning component.

Despite their enormous potential for engaging tourists, the few heritage applications that use AR headsets rely on the novelty of the technology and do not apply any story. A few examples include the TouristicAR system, an AR application that provided context-aware content for tourists visiting UNESCO World Heritage sites in Malaysia (Obeidy, Arshad & Huang, 2018); an MR Museum in Kyoto. (n.d.), a 10-minute AR experience that combines The Folding Screen of Fujin and Raijin with 3D graphics; and “HoloMuse”, which allows user interaction with archaeological artifacts from the Anonymous Mummy (Pollalis et al., 2017). These works miss the possibility of connecting into the site's stories, touching on the intangible heritage and the physical surroundings, and bringing them together in a unified narrative that generates an effectual experience due to a lack of attention to the dramatic potential of the headsets. Aspects of the experience, such as utilising multisensory modalities, interaction points, playful encounters, and emotional and moral involvement, have been shown to drive audiences and give a meaningful discourse that helps them learn and be delighted (Vagnone et al., 2015). AR headsets create a unique experience and, as a result, provide a wealth of new ways to connect to the past.

2.2.3 Current Technologies in Heritage

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3.2.4 Emerging Technologies: Advantages and Disadvantages

Archaeology has a long history of using information and digital technology in novel ways. Research, preservation, education, outreach, publication, and scholarly communication are all influenced by digital technologies in archaeology and heritage. In general, these initiatives have taken place along several distinct tracks: electronic and digital data, storage, retrieval, analysis, and so on, GIS, and computer-assisted drafting, to name a few (Watrall et al., 2016). As mentioned in an article, one of the key researchers in digital heritage study is Ross Parry (Myrczik et al., 2019). He wrote a book titled Museums in a digital age (Parry, 2013). He also described a case study of the use of chatbots in museum communication at four historic house museums in Milan, addressing one of the most widely debated emergent technologies in the field of cultural institutions.

Museums and Digital Culture encapsulate current practice and research on how technology and digital culture are changing present and future museum and creative work (Giannini, & Bowen, 2019). Various issues, trends, and theories that shape cultural institutions now and in the future are discussed in this book. According to the book, many individuals worked in the underlying theoretical assumptions and trends that define scholarly and practice-based museums and digital culture approaches. Prof. Tula Giannini is an American academician with musicology, digital culture, and digital heritage expertise. She founded the New York Pratt School of Information and created a Master's degree, also played a crucial role in investigating and guiding developments in museums and digitalism. Bowen represents the computer science perspective as an Emeritus Professor at the London School of Engineering. Giannini and Bowen seek to imagine the museum's digital future despite some reservations. One way to approach the issue is to look at the problems museums may encounter in dealing with audience views of the past and the future (Bowen, & Giannini, 2021). In general, they have a positive attitude toward technology, perceiving and explaining the potentials of the "digital ecosystem" while placing the obstacles in the context of museums. Their approach focuses on the impact of technology and digital culture on museums and visitors. They claim to have entered the next phase of the digital revolution. The layout shows the numerous angles and perspectives from which this shift might be understood from this standpoint of fundamental change.

Another chapter by influential practitioners Seb Chan (ACMI Australia) and Courtney Johnston (Te Papa New Zealand) appears in Museums and Digital Culture: New Perspectives and Research. They talked about the current digital practice at museums. They both have primary responsibilities for audience experience and development, but much of that responsibility appears to be heavily influenced by digital techniques. The discussion in their article is thought-provoking, as it examines outstanding career trajectories for digital museum executives who began their careers in technology outside of the museum field and have changed roles and positions as museums and technology have evolved.

Herbert Bruderer is a retired lecturer at the ETH Zurich Department of Computer Science and a technology historian. In his article Preserving the Technical Heritage, he discussed the use of technology and its shortcomings (Bruderer, 2020). According to him, rapid technological advancements have resulted in a loss of material and immaterial cultural heritage. Gadgets and devices have long been discarded due to a lack of space, the fact that they were no longer functional, and no one wanted them, or their value was not acknowledged. The tools and technologies commonly used in the past are now obsolete. International Business Machines (IBM) and Remington Rand are two of the few original manufacturers that have survived. Furthermore, human resources might be a concern because equipment can end up in private hands, such as former employees.

The article "Preserving the Technical Heritage" discusses the shortcomings of technological use and cites other articles (Schärlig, 2001) to indicate that regular copying of electronic documents to current high-quality storage media is essential for reliable long-term archiving. The required programmes or multimedia applications must be available when texts, tables, drawings, and diagrams are handled later. These must be installed regularly and matched to the environment's platform, operating system, or device. Electronic storage media, such as magnetic, optical, and semiconductor storage, are inappropriate for long-term archiving. Migration, which involves moving to new file formats, storage mediums, operating systems, or programming languages, is one of the fundamental approaches for long-term preservation. Emulation, a device and software simulation, is the other method.

Another article contributes to the concept by looking at how digital technologies transform the museum value chain in the Internet world. In this information environment, the lines between the offline and online worlds are fast blurring (Simone, Cerquetti & La Sala, 2021). The article's detailed literature review depicts the current situation of museums' usage of digital technologies. The current evolving environment discusses the impact of Information and Communication Technologies (ICT) on museums' fundamental production processes. Lastly, the article addresses four approaches to digital transformation: a back-office approach to improving cultural heritage preservation, an onsite approach to enhance museum experience quality, an online approach to extend museum experience beyond museum doors, and an onlife approach based on multisensorial and interactive technologies. The ultimate goal is to make museums more accessible and create a hybrid museum experience.

Another essay discusses the essential – and sometimes overlooked – aspects of what it means to be "digital" in the cultural context and findings on strategic planning for the growth of digital museums (Kamariotou, Kamariotou & Kitsios, 2021). Another article also acknowledges that museums undergo substantial changes in their content and operations due to the ever-changing world (Chepurda & Tomiuk, 2020). The function of museums in preserving and interpreting cultural heritage, in complicated processes of social adaptation and cultural identity, in educational settings, for example, and in organising leisure is clear.

The Routledge International Handbook of New Digital Practices in Galleries, Libraries, Archives, Museums, and Heritage Sites paints a fascinating picture of how today's cultural institutions are changing due to creative digital technology applications (Lewi, Smith, Vom Lehn, & Cooke, 2020). The Australian Research Council Discovery Grant and a University of Melbourne Cultural Engagement Grant supported the Routledge International Handbook of New Digital Practices in Galleries, Libraries, Archives, Museums, and Heritage Sites, as well as the DigitalGLAM symposium. Several professors and practitioners in heritage and technology are featured in the book. The book brings together a diverse group of academics and practitioners who contribute to developing new digital practices in galleries, libraries, archives, museums, and cultural sites worldwide. The Handbook offers a breath of fresh air in terms of new ideas and directions for the upcoming digital problems and opportunities. As a result, reading should be required for scholars, students, designers, and professionals interested in post-digital culture production.

Fiona Cameron's chapter in the book, 'Theorising heritage collection digitisations in global computational infrastructures,' lays the groundwork for re-thinking fundamental theoretical notions that run across the entire handbook collection. Andrew Dewdney similarly rejects binary classifications favouring a significantly more complex depiction of the post-digital state.

He proposes that culture is becoming increasingly technological and technologised and that, as a result, technology can no longer be differentiated from the culture. Ed Rodley's chapter 'The distributed museum is already here: it's just not very equally distributed' expands on the idea of the post-digital museum in the twenty-first century. Rodley examines a museum structure that is more rhizomatic in view and thus lacks clear definitions of cultural delivery from the centre to the periphery and from the museum custodians to the visitor, based on Nancy Proctor's formative thought on the distributed museum.

Even though it had nothing to do with museums, the handbook includes an edited version of Bethany Nowviskie's keynote speech on 'Speculative collections and the emancipatory library,' which she gave at Harvard University in 2016. Furthermore, Andrew White and Eugene Ch'ng examine the acceptance of digital technology in China's museums and cultural heritage institutions, questioning its value-add to the current museum-going experience in China through a close examination of technical currency and adoption. In his chapter 'From planned oblivion to digital exposition: the digital museum of Afro-Brazilian heritage,' Livio Sansone from Brazil gives a fascinating account of how a digital cultural museum came to be. Sara Perry and colleagues tackle a fresh set of obstacles in another collaborative initiative that transcended digital and physical international borders. They remark on the importance of shared story-telling while visiting heritage sites in their chapter 'Shared digital experiences promoting collaborative meaning-making at heritage sites.'

The book also discusses the digital's challenges and prospects for archives and archival practice, including creative reuse, digitalisation, and ethical engagement with users and other stakeholders. The practical and ethical shift that feminist ethics of care brings to the process of digital archiving is discussed by Michelle Caswell and Marika Cifor. Ola Uduku writes on the Alan Vaughan Richards Archive digitisation project in Lagos, Nigeria. Richards was a well-known architect in Lagos until he died in 1989, and his assignments included homes, universities, and industrial structures. Furthermore, Thomas Kvan, Peter Neish, and Naomi Mullumby discuss the more practical aspects of digitising the William J. Mitchell collection's "hybrid archives" at the University of Melbourne. Tin-Kai Chen's chapter highlights the work he and others have done at Taiwan's Kaohsiung Museum of Shadow Puppet to preserve and bring back to life an archive of videotapes and other documents from the dying art of shadow puppetry. Gregory Markus, Maarten Brinkerink, and Brigitte Jansen's work explore the idea of repurposing or remixing heritage artefacts in an aesthetic approach to generate new methods of cultural knowledge.

John Hindmarch, Melissa Terras, and Stuart Robson investigate if digitised items may have the same aura as real objects when creating compelling experiences. Based on their research at the Science Museum in London's Shipping Gallery, they believe that 3D-scanned artefacts can effectively impact if presented in the right way and contextualised by the information that comes with them. The chapter 'Configuring slow technology through social and embodied interaction' by Areti Galani and Rachel Clarke explores the findings of a research-through-design study of people's engagement with a digital interactive display. The chapter 'Exhibition design and professional theories' by Kate Sang, Richard Glassborow, and Louise King take a distinct exhibit design approach. From conception to implementation in an observatory, the authors examine the evolution of an interactive exhibit. Jeffrey Levin, Robert Checchi, Lori Wong, Garson Yu, and Edwin Baker use the Buddhist cave temple at China's Mogao Grottoes to demonstrate how immersive technology may enable the experience of an immoveable site in their paper 'Meeting the challenge of the immoveable.' In a completely different global setting, Adam Muller's chapter addresses the Embodying Empathy project, which was carried out in Canada and looked into the history of Indigenous Indian residential schools. Moreover, Sarah Kenderdine describes the DomeLab, a hemispheric projection that generates immersive visualisation through digital media, as a remarkable endeavour to build a fruitful relationship between numerous international research and GLAM organisations.

The book describes exhibition design initiatives from the designers' perspective. Indigo Hanley discusses the work of Sydney-based studio Lightwell in 'Human-centred design in digital media,' which analyses the relationship between exhibition design, technology, and the visitor experience. In 'Unlocking the glass case,' Peter Higgins continues his study of the possibilities presented by digital technologies. Paul Gurrumuruwuy and Jennifer

Deger explain an approach to exhibition design that incorporates technology to generate 'dhäkayanawuy from,' a social aesthetics that strives to transform visitors' interactions with the museum and each other; in 'The law of feeling: experiments in a Yolngu museology.' The exhibition Henry VR, displayed at the Art Gallery of New South Wales, is examined by Andrew Yip, Paula Dredge, Anne Gerard-Austin, and Simon Ives. Gurrumuruwuy and Deger also conclude their chapter by encouraging museum professionals to employ this technique in the design of their shows, so enriching all of our lives.

Tim Jones and David Simpson explore how the Christchurch Art Gallery Te Puna o Waiwhet in New Zealand expanded the scope of their online offering in the aftermath of the terrible earthquakes in 2010. Jones and Simpson discuss the website's remarkable transition into a magazine-style publication that pulls together the wide range of textual and visual content generated by museum personnel every month. Julia S. Kuehn’s talks about how the open-source digital publishing platform. 'Interpreting the future,' Tony Holzner's last discussion piece, examines the opportunity that emerging technology provides GLAM organisations to produce value for people.

Digital technology and our relationship with place are also discussed in the book. This book contains several authors who elaborate on this topic. Anthea Gunn outlines how the Australian War Memorial created Art of Nation, an online exhibition of WWI paintings. Mitchell Whitelaw presents Succession,' a project in the northeast of England that exploits digitally created unpredictability. Whitelaw's account demonstrates the generative techniques by mixing images from several internet sources to create new collages that offer further readings and responses to location. Hannah Lewi and Andrew Murray also adopt a historical approach to tracing the roots of rephotographing, a method that juxtaposes historical and current photos of the same viewpoint.

Finally, Cristina Garduno Freeman explores how Google Maps has become the primary medium through which we experience sites of heritage and significance. Wally Smith, Dirk von Lehn, Hannah Lewi, Katie Best, and Dora Constantinidis look at how people use digital walking tours to learn about cities' histories, using examples from GLAM and historical organisations in Melbourne and London. Sara Huws, Alison John, and Jenny Kidd talk about creating a unique audio guide for Cardiff's St Fagans National Museum of History. Steven Cooke and Dora Constantinidis explain an examination of a web program called PastPort, which provides an online platform for citizen-generated heritage when discussing the potential of digital heritage as a resource for communities to grow.

Diego Merizalde and Jon Voss describe how the National Library of Colombia and the worldwide digital history platform collaborated on a project to help Colombians recover after decades of internal violence. Alicia Marchant also tells the narrative of how she designed and built a website to capture people's emotional attachment to the Derbal and Djarlgarro river systems in Perth, Western Australia.

While these great technologies help our lives in various ways, including DIH, we must equally consider their disadvantages, mainly digital and physical waste. Hence, before moving on to further difficulties, we must first grasp the concept of waste. In the 17th century, an "improver" was someone who made land valuable and profitable by reclaiming waste (unimproved land) and consolidating and enclosing new kinds of property (Chow, 2020). Waste is a symbol of societal inefficiency and resource misallocation, and we must normalise conflict to comprehend it better (Zaman, 2013). Carl Zimring, director of the Pratt Institute's Center for Sustainable Design Strategies and a professor of sustainable studies, talks about historical information on the process of upcycling aluminium rather than downcycling it. In his book Aluminum Upcycled: Sustainable Design in Historical Perspective, he said that garbage is a design product that may be salvaged through design. Upcycling, or the ability to increase the value of recycled materials through design, is an essential topic in his research.

Aluminium’s many uses can help us meet our moral imperative to reduce waste. Metal guitars, for example, sustain notes better than wood guitars due to the lack of warp. Moreover, one of the reasons Apple selected aluminium to encase its computers in current times is the fuel efficiency of recycling versus the expense of extracting raw material and the versatility and durability of both primary and secondary aluminium. McDonough is an architect from the United States, while Braungart is a scientist from Germany. The writers criticise manufacturers' attempts to decrease poisons in products while keeping the problematic modern linear production method in place. According to them, good design should be a cyclical redesign of corporate strategies modelled after nature's closed-loop system, not just less terrible for the environment. Systemic difficulties include essential items not created with human or environmental health in mind and products with unwanted add-ons like dangerous chemicals. Researchers urge to reshape humans and Earth to enact more robust policies, forming ecological citizenship with greater governance over information, regulation, and industrial policies, which other progressive policies have overshadowed.

According to Chow (2020), after WWII, the notion of waste was redesigned and spread through commercials to speed up the slow development rate caused by consumer resource conservation. As a result of these new boundaries, "trash" is enclosed in intricate networks separated from mental and physical locations beyond our capabilities, and it becomes unmanageable. When Apple's developer team understood that users needed to remove data permanently, they created the first virtual "wastebasket" in the 1980s. Apple sued Microsoft and Hewlett-Packard over the "Maclike" ness of their trash icon designs five years later, forcing Norton Desktop to use a "shredder" and "smart eraser" and forcing Unix to use a "dumpster." Waste classification is influenced by cultural and personal preferences, socioeconomic status, geography, education, age, and new industrial processes (Strasser, 1999). During the Industrial Revolution, newly processed materials changed the meaning of waste. After the Information/New Media Age, data were discarded individually and collectively, and our notion of waste shifted yet more.

Waste classification is influenced by cultural and personal preferences, socioeconomic status, geography, education, age, and new industrial processes (Strasser, 1999). During the Industrial Revolution, newly processed materials changed the meaning of waste. Our perception of waste has shifted even more with the arrival of digital trash following the Information/New Media Age, data discarded on both an individual and corporate scale. Waste creation is inaccurately and inconsistently quantified on local and global dimensions due to the fluidity of waste perceptions, making it difficult to formulate and implement international rules on our digital and physical legacies. Waste represents society inefficiency and resource misallocation, and we need to normalise conflict to understand it better (Zaman, 2013). The less we are conscious of and control over what we choose to own or disown, the worse our grasp of ownership rights and property enclosure clarity becomes, and the less we can govern our privacy.

Other publications, such as "Cultivated Building Materials: Industrialized Natural Resources for Architecture and Construction," also discuss plastic and digital waste (Hebel & Heisel, 2017). The issues, tactics, and future of plastic and construction waste are discussed in this book. The authors discuss the future generation of building materials and the construction industry's forthcoming significant transformations. A shift toward cultivating, breeding, raising, farming, or growing future resources is also discussed in the book. The article studies artworks that highlight and critique networks of electronic waste and digital waste in digital media. Global signal traffic demands labour that depends on coloured bodies, which bear the brunt of toxic pollution from e-waste disposal and post-traumatic stress due to durational exposure to graphic violence. Digital garbage refers to pornographic, abusive, or violent photos "cleaned" by content moderators on platforms like YouTube and Facebook (Wan, 2021). Pornographic, offensive, or violent photographs that are "cleaned" by content moderators on platforms like YouTube and Facebook are referred to as "digital rubbish" (Wan, 2021).

Is putting digital content into a heritage exhibit causing digital and plastic waste? Are we also aware that, when the show is no longer in use or discarded, we may or may not own the non-usable and non-physical content, such as digital data and so on? These and similar problems should be considered while designing future DIH exhibitions. We must be aware of handling and thinking about nonusable content/items and how to transform waste into a useable thing. Before beginning the knowledge acquisition phase, the DIH content creator should be well informed of these challenges. Knowing these critical challenges will aid the designer in managing the whole journey of designing the DIH project.

3.3 Digital Intangible Heritage: Future and Opportunities

The addition of 14 video games to the Museum of Modern Art (MoMA) collection in New York in 2012 sparked outrage in the media (Brown, 2017). At the same time, the Smithsonian Institution launched The Art of Video Games, a travelling exhibition comprising 80 games and 20 gaming consoles that ran until September 2015. In April 2016, the National Videogame Museum in Frisco, Texas, opened its doors. All of the children who grew up playing Nintendo in the 1980s and 1990s are now adults, ready to redefine visual and material culture in an increasingly technologically advanced world.

For collection managers, directors and curators, preserving complicated digital tools and gadgets inside a museum is a challenge that necessitates creative solutions. Although video games are becoming more common in museum collections, little research has been done in the discipline of museology to explore how games are cared for, displayed and digitised by museums (Brown, 2017). Because each museum is different in terms of content, size, budget, age, activities, and how their game or digital interaction collections are used, one strategy may not be appropriate for all. They do, however, take similar care of their collections.

With little or no unified tools or rules, museums with extensive collections of video games must figure out how to keep and organise them. Museums that want to display their games have the challenge of allowing people to play them without causing undue wear or irreversible damage to the ageing magnetic media and the hardware that runs them. Museums that want to preserve their games for future generations must consider whether they have the resources or the means to embark on long-term digital preservation of their collections. Furthermore, they need to figure out how they will navigate the plethora of practical, legal and ethical issues that accompany game digitisation. With video games appearing in museum collections and exhibits, it is time to start talking about what these institutions are doing and what other museums may learn.

It is worth noting that game preservation is difficult due to the nature of video games and how they exist as tangible objects in their cultural contexts. The scope of preservation for a typical museum object, such as a renaissance painting or a hand-woven basket, is understood both in terms of what needs to be preserved, namely, the object itself and the information about it, and in terms of how best to preserve the object based on material needs and susceptibilities. However, in the case of video games, keeping the cartridge or optical disk on which the game is stored, is merely the first step. The object includes code that must be preserved, and this code must be executed on the console that corresponds to it, which is connected to a compatible television or monitor for output and a controller or joystick for input. Finally, a human being must play a game in order for it to exist in its entirety. Game preservationists refer to these needs as the "gameplay experience", and this ideal is being pursued in both physical and digital video game preservation.

Hence, researchers have been considering a number of issues surrounding exhibit preservation, including why and what to save, if creativity should be kept or applied methods should be maintained, and how to retain digital preservation approaches, practices and tools utilised in an exhibit. Digital preservation, according to UNESCO, is the process of ensuring the continuous accessibility of digital materials. Finding ways to re-present what was originally provided to consumers via a combination of software and hardware tools operating on data is one approach. Some scholars have produced digital humanities (DH) tools like “Juxta”. which may be tailored to meet unique demands and make manuscripts more readily available and retrievable among its users by presenting them in sophisticated digital media. Researchers have also identified and investigated the issues of conserving complex digital items such as simulations, visualisations, digital art, and video games and recording exhibitions (Kushwaha & Singh 2020).

In the light of this research, I believe that the improvement in technology, which contributes to or will contribute to the human environment, will never stop. Its source and form will shift. It will sometimes be forced to improve or transition into another digital system, or another vendor will take its main engine to another area of the world with a facelift. QC users, for example, developed a community even before Apple discontinued supporting Quartz Composer, as mentioned in the thesis. They constructed their own QC software patch, node and procedure to support their earlier QC digital compositions. The same reasoning may be applied to Microsoft's Kinect, a depth camera. Many 3D cameras on the market today, like the Microsoft Kinect, use RGB-depth (RGB-D) sensors. This is a continuous process, and many technical solutions for 3D scanning, motion capture and other digital tools are being developed. Microsoft launched Kinect, but Intel has now released the Intel RealSense D4, a new generation of RGB-D cameras. These cameras are accessible to adapt to diverse technical infrastructures, depending on the area of application (Celakil & zcan, 2021). They combine passive stereo processing and active infrared scanning technology to gather high-resolution picture depth information and colour data.

Using modern technologies for museum exhibits has both advantages and disadvantages. For instance, the novelty aspect has enhanced user interfaces over its predecessors and the ease of use of information retrieval. It has also improved learning capabilities for visitor interaction by engagement time and possible collaborative interaction among visitors. However, despite their many advantages, modern technologies have certain disadvantages for museum administration and the GLAM sector (galleries, libraries, archives and museums). By deploying new technologies inside museums in the context of physical interaction with the exhibit, one may be concerned about the display's long-term documentation and sustainability and archiving difficulties. I believe that addressing these difficulties through research is needed, which will undoubtedly have positive consequences. However, due to the flaws described above, the lack of new ways of documenting the new technologies for museum displays will negatively impact our next generation and future museum environment.

Museums, and heritage and memory institutions, will heavily shift their forms from physical visitors to online and remote users, or a combination of both. They are evolving from elite showcasing entities to general access in cities to virtual users worldwide. Some museums will be famous and respected in the future, even if they do not have a physical presence. I also believe that a museum's sole organisational control will be altered, resulting in an unpredictable form. It might instead be managed by a group of licence holders, either individuals or businesses, who will share the burden of representing a community's heritage. They will commodify it and profit from unknown virtual entities as well, such as remote visitors; however, it is difficult to imagine who they would be at this point.

Emerging technologies will find ways to absorb their fragile existence in our future for heritage enactment, documentation and preservation in one way or another. Furthermore, the GLAM sector's experts will work hard to shake hands with these new technologies and eventually establish their comfort zone. It will be very similar to the upgrade in the film industry after computer graphics imagery was introduced. I think museums will also adopt the new concepts, blurring the lines between authoritarian and democratic control. There will always be those who try to undermine the handshake between new technologies and museums. It will, however, democratise the development of heritage content, making GLAM services a profitable entity for a country at the forefront of future globalisation. It is the reality that we will face in the future, and it is the evolutionary law that we have seen in many sectors of human endeavour.

As described earlier, there are many challenges in perpetuating and creating cultural production for future generations. The current representation is based on either process or product (Rahaman & Tan, 2011), and we need more engaging content for future minds. Heritage content creators, most of the time, rarely consider end users' perceptions. This ocular centric tendency in the enactment of cultural artifacts has often resulted in an unentertaining experience for users. It is also important to have participatory interaction from users, as descriptive and linear interaction may lose their sense of engaging participation.

There are new paradigms waiting where we can more easily engage new generations and equip them to become familiar with past heritage. In future, VR/AR and sensor-based heritage representations will have new disciplines and even sub-disciplines, with various new terminologies. Virtual cyber-archaeology and cultural heritage have already started emerging and are in use in digital and serious gaming environments (Liritzis et al., 2015). However, the emergence of these new entities—VR/AR and sensor-based technologies—has created several hermeneutical questions with synoptic and synthetic discussions about technê, logos and ethos for the nexus of art and science. For instance, physical activity has been measured using "sense wear" armbands and wearable devices (Kemmer et al., 2020). These gadgets were also employed to see how sleep quality affected academic achievement (Topal, 2019). Sense wear technologies are also being employed to improve smartphone capabilities (Xu et al., 2021) and the physical health of autistic youngsters

(Bricout el a., 2018). Hence, it is easy to predict that sense AR/VR and wear design will flourish based on this progress and the continued and consistent use of these gadgets.

The goal of this current study is to show how pleasurable heritage experiences can be when used in the collection, representation and transmission of ICH or traditional knowledge through VR/AR and sensor-based emerging technologies. We know that VR/AR refers to digital technology that duplicates a situation, imaginary or real, and mimics a user's physical presence and environment to allow user interaction. We also know that ICH refers to the cultural expressions or practices as endorsed by UNESCO. And finally, traditional knowledge means knowledge, skills and practices that are established, continued and spread from generation to generation among people and within communities, repeatedly developing part of its cultural identity. Hence, this study is an attempt to: 1) propose various possible transformations of intangible heritage-related data into digital representation; 2) consolidate my scholarly experiences and discuss various challenges related to knowledge transfer; 3) synthesise and frame the data for the new future domain that I am proposing, which is Digital Emerging Communication (DEC), as shown in Figure 39; 4) disseminate relevant instructional resources within different categories for the wider digital preservation community through the Dublin Core Metadata Initiative (DCMI) for interoperability; and 5) suggest policies and guidelines for the future DEC content creator and controlling agencies such as government authorities.

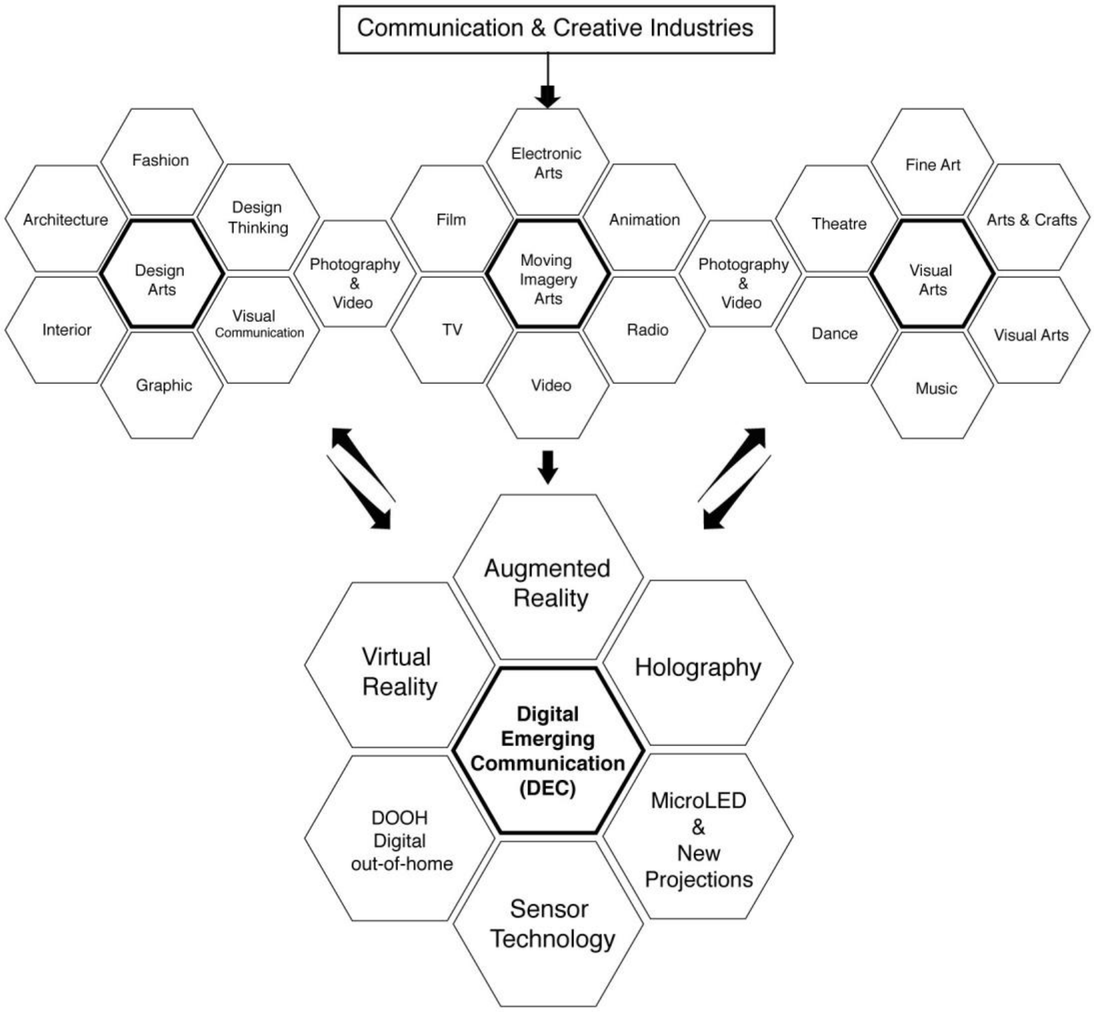

Figure 39. The proposed Digital Emerging Communication domain will be compiled from various creative disciplines.

There are still various gaps that needed to be addressed in detail, such as:

- What abilities and capabilities does the DEC content creator need to possess for the creation and transmission of DIH?
- How do we archive DIH?
- What are the guidelines and suggestions for DEC when dealing with DIH-related content and how might they help to promote the cultural edification of a nation or country for the contribution of developing human culture?

I am assuming that the VR/AR and sensor-based activities will be comprehensive, collaborative and highly transdisciplinary experiences for future content creators. Therefore, I coined the term "Digital Emerging Communication" (DEC) has been coined for the content creator who would like to use AR/VR and emerging sensor-based technologies as vehicles for communication, expression and representation of the past. To further elaborate on my assumptions, I describe DEC domain and DEC content creator as:

> Digital Emerging Communication (DEC):
>
> Digital Emerging Communication (DEC) is a systematic, creative and pleasurable activity, which uses AR, VR, XR and sensor-based emerging technologies together with a radicalised multidisciplinary approach to plan for possible and exciting user experience.
>
> DEC Content Creators:
>
> DEC content creators search, isolate, define, manage and manipulate the methodologies of multiple pieces of knowledge to communicate, express, and represent their ideas for emerging technology-based digital fabrications.

I further believe that dealing with heritage content, the masters of heritage and indigenous communities, using emerging technologies, will be an exciting task for DEC content creators. They should be sensitive to the subject matter and careful to its interpretation. They should not just start transforming content without a cautious assessment of the associated communities.

To address this challenge of how DEC content creators should deal with ICH content, I propose some “probes”—I call them “Intangible Probes” or “iProbes”—for DEC content creators. I came up with this idea after reading about the first mention of “cultural probes” by Gaver, Dunne and Pacenti (1999). The concept of cultural probes has recently become popular among interaction designers when creating design spaces outside of their workspaces, drafting tables and digital environment. When designing for the elderly, for example, designers should explore other notions besides production and efficiency. This way, designers will be more focused on and develop support for “ludic pursuits”, as mentioned by Gaver et al. (1999). It is important to note that the word, term or adjective "Ludic" has been around since Greek time, and it means a certain playful spirit (Netz, 2009). In this thesis the term is introduced as "ludic pursuits", which was coined by Gaver et al. (1999). Ludic interaction for the computer is a type of user interfaces that are inherently "playful". Research shows that there are many types of terms used by the researchers such as ludic activities, ludic design, ludic engagement, ludic pursuits, ludic values, ludic practices, ludic experiences and so forth (Gaver et al., 2004). This fascinating and somewhat postmodernist concept can draw attention to the “playful” character of human life. This strategy could be the ideal framework for DEC content creators when dealing with ICH content. In the context of young minds and playful activities, this concept fosters and facilitates the environment, without restricting it to whatever currently passes as entertainment. Instead, it is a far more subtle and comprehensive approach for young people to explore and generate new ways of seeing a single idea. As a result, young museum visitors can more easily direct their attention to more personal and diverse situations. They can also have autonomy in generating the new, subjective and fictitious form of cultural production.

Another study casts doubt on the term's origin and according to it, the term "ludic" is derived from the Latin noun “Ludus”, which refers to a wide range of enjoyable activities, including stage plays, games, sports and even jokes. According to Merriam-Webster, it means "fun", and psychologists invented it in the 1940s (Merriam-Webster, 2011). They needed a phrase to explain what children do, and "ludic activity" was born. That may appear absurd - why not simply name it "playing"? - but the term "ludic" caught on, and it is no longer just for kids. It can refer to light-hearted architecture, amusing and even satirical narrative, and light-hearted literature. The word “ludicrous”, which is more commonly used, comes from the same source.

The term ludic has also been employed in the context of a “ludic marker” (Alavesa et al., 2018). The purpose is to provide more precise descriptions of the indirect and direct cues that players utilise for player-player observation, often known as ludic markers (Montola et al., 2009). Because existing location-based mobile games are not meant to disclose intricacies in player behaviour, it might be challenging to capture the subtleties of social behaviour during gameplay using them as a research probe. When playing a digital location-based mobile game that permits location faking in addition to automated location, designers investigate if players spontaneously look for unknown fellow players and detect ludic markers in player-player observation. Physical ludic markers, digital ludic markers and hybrid ludic markers are among the several ludic markers used in digital gaming environments.

Our natural instinct is to make the environment around us a better place to learn from and play with. We interact, experiment and are curious, and we see the world as a place where we may have fun. This is similar to a ludic interaction or approach when designing a user interface for digital interaction. For example, ChemCraft is one of the applications that take a ludic approach to design (Han, 2021). The project is a chemistry-themed adventure computer game. It focuses on a ludic approach to educational game creation, converting real-world chemistry rules into digital ones. ChemCraft is a game that investigates how well chemistry systems may be transferred into game systems in the niche field of games for higher education, notably International Baccalaureate (IB) Higher Level Organic Chemistry. The gameplay mechanisms in the programme are based on chemical reactions, game objects are chemical compounds, and game object attributes are based on real chemistry data values. Instead of asking, "What does a chemistry game look like?" the initiative asks, "How can chemistry be a game?".

Hence, I assume that ludic drives are extremely important for DEC content creators. Because of this character and working style for DEC content creators, the content is more likely to be engaging for young minds. The proposed iProbe concept also helps content creators connect mentally with the master/s of the heritage entity. Therefore, to extend this concept further, I propose three separate iProbe elements in the following hierarchy: search and isolation of ICH (iProbe A), definition and analysis of ICH (iProbe B), and reference and association of ICH (iProbe C).

iProbe A—Search and Isolation of ICH

- Your interpretation and known facts about the heritage, master or the indigenous community;
- How you define the related or current challenge that is faced by the community and its significance;
- What the relevancies and impacts on the society/community/individual are;
- The past and current states of existence—what they would be if not rectified, resolved, documented, transmitted and archived; and
- Similar problems and situations around the world with various communities and individuals.

iProbe B—Definition and Analysis of ICH

- How you define the problem in words;
- How you analyse the problem, images, schematic diagrams, flowcharts;

- How you see its various components and hidden variables;
- Whether you have researched similar situations around the world and various possible attempts to solve the situation;
- Your process/methods/strategy to solve the situation;
- Whether you have discussed, consulted and searched for the relevant individual/ community who owns the content indigenously;
- Whether you have involved the relevant individual/community; and
- The causes and effects of your solution.

iProbe C—Reference and Association of ICH

- Whether you have addressed, analysed and scrutinised the subjectiveness or fictitious nature of ICH embodiment;
- Whether you have explored the desirability, viability, feasibility and sustainability of the heritage installation/application;
- Whether you are sure about your articulated, informed and ethical decisions to transform and transmit the heritage content with emerging technologies;
- Whether you are certain that your method, final output and the impact will not harm or disturb the indigenous community or owner of the heritage content; and
- Whether you have followed the UNESCO guidelines and have a clear, comprehensive and genuine idea.

For an engaging user interface for future young minds, a playful interaction design such as a ludic interface is important (Fuchs, Russegger, & Carbonell, 2013). By using iProbes, future DEC content creators could develop desired museum installations, as shown in Figure 40.

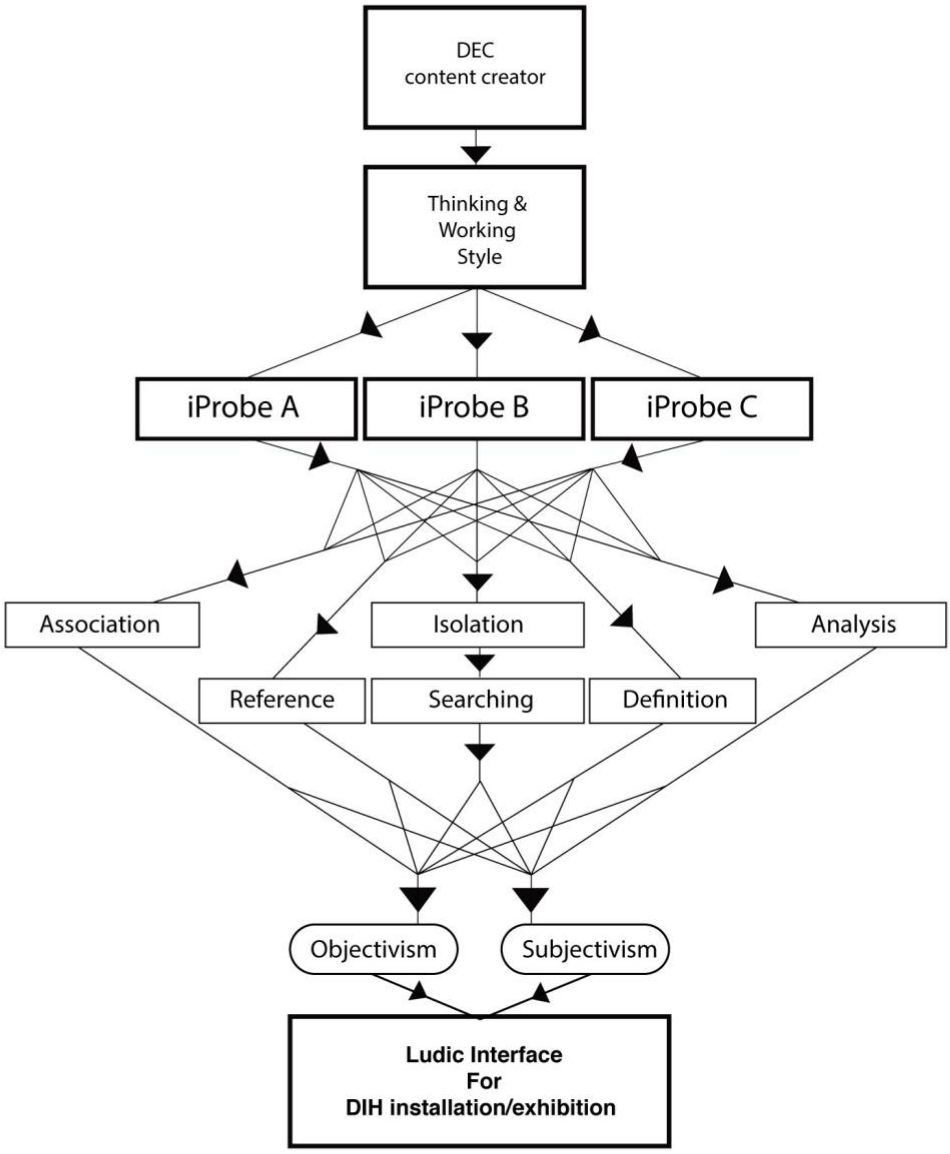

Figure 40. Digital Emerging Communication content creator working and thinking style to achieve a ludic interface-based Digital Intangible Heritage installation/exhibition.

I believe that it is important for DEC content creators to adopt and practise all three types of iProbes when dealing with ICH content. iProbes A and B allow them to search and select the right ICH content and clearly define the significance of the heritage element. In addition, iProbe C encourages them to deeply engage with the repercussions, authentication and viability of the produced emerging technology-based outcomes. Using iProbe C, DEC content creators could easily delve into the imagination and subjectiveness of the subject matter and design interesting, appealing and engaging content for a DIH installation/exhibition. It is important to note that Intangible Probes” or “iProbes" is just a toolbox for collecting and disseminating the DIH material for DEC technicians and staff. Certainly, the tool can be expanded and stretch deeper to accommodate uniform requirements.

According to Laura Fish and Scott Kiekbusch, design is a vital corporate capability, and designers must play a role (Fish & Kiekbusch, 2020). The development of designers into strategic designers is required. Designers can grasp a game-changing method for transforming unique product and service visions into high-value market offerings. Defining an effective product vision necessitates a high level of discipline and a diverse set of talents. Designers should assist in the organisation of strategy, the planning of innovation, and telling a compelling story for future experiences. Designers should put their strategy-driven product vision into action once they have defined it.

The discipline of design collaborates with other human and social sciences (HSS) and engineering science disciplines (Catoir-Brisson, 2019). It is interdisciplinary since it connects the humanities, social sciences and design sciences. As previously stated in the thesis, I have used speculative design to examine the convergence of new technologies in the context of ICH, and the future amalgamation's dilemma as a design problem. In the neutral environment of any issue where a viable solution is tricky, speculative design thinking may provide some safe locations for difficult ideas to be explored (Woodcock, 2016).

My proposed DIH ideas are positioned as speculative designs in the thesis. It is, however, open to a variety of interpretations, including subjective interpretations of heritage and fictional manifestations of heritage entities. In my two case studies, I examined these issues in-depth and suggested that, while interacting with DIH exhibits, visitors and new technologies produce three types of heritage dimensions: fictitious, realistic and audience-generated. The thesis serves several purposes: first, it considers the DIH discipline's future, challenges, and the nature of prospective content creators. The major goal is to introduce upcoming interactive technology to future generations. I realised that both true and imaginary DIH content would symbolise our future intangible heritage. This freshly created DIH content should be preserved and archived for future generations as a repetiteur. This is the fundamental point of my thesis, and it is illustrated in both case studies with schematic diagrams.

The design discipline is on the verge of becoming free of any particular discipline or activity (Gentes et al., 2017). This concept serves as the epistemological foundation for what researchers have called "the indiscipline of design". Its purpose is to identify how disciplines collaborate and combine many types of creativity, ranging from design and art to social science, humanities and engineering sciences. The goal is to demonstrate how disciplines under-determine each other through design, allowing for a radical unknown to emerge. This idea of indiscipline emphasises the deconstruction/reconstruction processes of disciplines and the intense dynamic that permits them to renew themselves through mutual contributions.

The Digital Emerging Communication (DEC) discipline for DIH content, the DEC content creator's criterion, the FolkAir potential effort, and the proposed framework for DIH content selection and creation - "Intangible Probes" or "iProbes" - are all by-products of the concept of "the indiscipline of design" and a speculative design approach. It is a wicked challenge to imagine future possibilities relating to developing technology and intangible heritage generated by exhibits/users. Society is increasingly expecting specialists to bridge boundaries in order to cope with wicked situations and discover answers. Little is known about how multidisciplinary approaches encourage learning through boundary-crossing when dealing with wicked situations. It is speculated in the thesis that objective and subjective representations of ICH through emerging technologies will be an effective means of perpetuating the culture for future generations. The goal is to generate ideas for a future DIH discipline that I believe will help future generations to enact, sustain and transform cultural heritage.

The iProbes idea is used in this thesis to encourage DIH content creators' knowledge authentication. This hypothesis posits that future DIH content providers will justify their abilities, gathered data and qualifications, allowing them to access indigenous societies for knowledge collection and processing. On the one hand, iProbes will act as a filter for the content creators themselves. Regulatory agencies, such as the government and GLAM institutions, will, on the other hand, have certified parameters for engaging such individuals. Moreover, academic institutions are also expected to consider or improve these probes for their newly planned curriculum, mission and vision.

In an area where materiality has been highly emphasised, the acknowledgement of intangible heritage is an important step (Pocock, Collett, & Baulch, 2015). The junction of the tangible and intangible, on the other hand, is crucial for good management. While it is widely recognised that material heritage protection must take into account intangible values, it is also true that "intangible" heritage is frequently dependent on access to material resources and spaces. Despite this, many policies and procedures for identifying and managing heritage have remained constant, failing to integrate these two objectives successfully. Attempts to correct this imbalance have resulted in a clear distinction between intangible and “tangible” parts of heritage.

Furthermore, while intangible heritage is an important part of tangible heritage's significance, and intangible values are intertwined with material resources and spaces, many procedures for identifying and managing heritage sites have remained unchanged, failing to integrate these two sets of values. Identifying a material site and then identifying the underlying qualities that compose its significance continues to dominate heritage site conservation. Some researchers believe that rather than identifying physical aspects of heritage as the starting point for heritage assessment, stories (or intangible values) from a region's or country's past can be the primary method for locating physical heritage sites. The Australian National Heritage List, for example, intends to build a list of outstanding natural and cultural places that contribute to Australia's national identity through public nominations.

The impact of digital technology on the cultural heritage domain has enhanced the speed and automation of procedures and practices that entail digital heritage data processing and presentation (Udeaja et al., 2021). Virtual Reality (VR) and Heritage Building Information Modelling (HBIM) can help conserve, preserve and manage architectural heritage. At numerous levels, this encompasses preserving both tangible and intangible cultural heritage. Incorporating qualitative and quantitative information about a heritage-built asset has value in the (re)interpretation, documentation and protection of cultural heritage. The development of HBIM and VR can bring together heterogeneous data, which could serve as a paradigm for future heritage conservation and digital technology initiatives. Indeed, for essential stakeholders such as local government, heritage conservation experts, urban planners and local communities, this holistic integration can increase awareness of urban cultural heritage and promote local urban heritage conservation processes.

An unpredictable future is waiting for us where the four screens—television, computer, mobile phone and cinema—may one day be completely gone from our daily lives, to be replaced by technologies that use our senses. Future technologies are likely to involve our minds, senses and feelings; indeed, they have already started penetrating and interacting with our brain waves. We will also use our perception to engage with technology. Perception is not just the process of seeing—it is the process of using all our senses and interacting with our environment.

With all these new developments in our future, I anticipate that there will be another utterly separate domain dealing with emerging technologies and their communicative capabilities. I call this domain “Digital Emerging Communication” (DEC). I assume that it might be a sub-domain of creative industries, or it may be a completely new domain. The individuals involved, either technically or creatively, will be known as DEC content creators, as shown in Figure 41. These individuals will define heritage content and content carriers. These content carriers could be single or multiple emerging technologies that can create three types of heritage dimensions: fictitious, realistic and audience-generated. These dimensions will comprise associated characters or adjectives of the generated content. Moreover, DEC content creators will face professional, ethical, communicative, pedagogical and archival challenges.

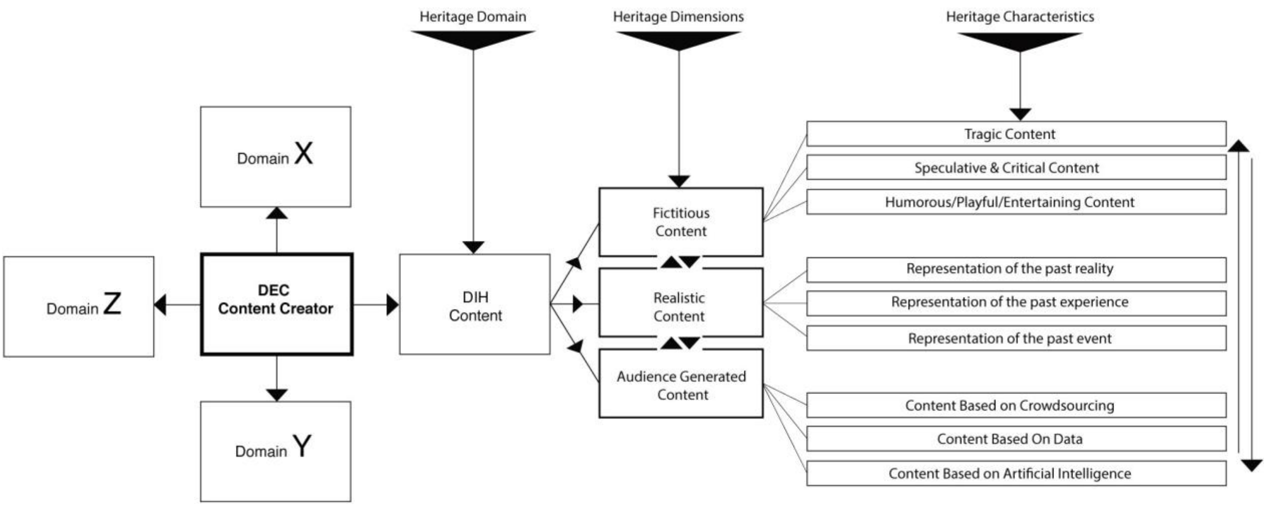

Figure 41. The proposed Digital Emerging Communication domain dealing with Digital Intangible Heritage content.

My second proposition is related to the nature of future heritage content, particularly intangible content represented by this new domain of DEC. What I am trying to argue is that future generations will be creating more appealing and radicalised heritage content than we can even perceive at this moment. This will be a new form of heritage and a new representation of the past. We will no longer have control over heritage as we know it; instead, heritage will be a mere association with an event or something related to past civilisation, as can be seen in the context of my published papers related to Al Ardha and Indigenous Australian dances. I believe that we should allow this to be and to flourish under the authentication of heritage representation. We should not attempt to prevent it by describing it as not being heritage nor a realistic depiction of heritage content. Whatever form it takes—be it entirely subjective, distorted or fictional—it must be considered a cultural production, and we will have to accept it as a means to perpetuating our ancestral livelihood. We should not create boundaries or hurdles or dismiss it as non-cultural content.

Finally, to further articulate my argument, I need to provide some insight into art and its representation. In contemporary philosophy, there are multiple definitions of art (Davies, 2015). The ancient definition of art was to make things according to rules (Tatarkiewicz, 1971). This definition is clear, concise and unambiguous in nature as a description of art or artistic representation. However, the contemporary form of art, while retaining the same terminology, renders the old perception of art no longer applicable. When music, poetry and so forth, were subsequently included, the meaning and interpretation of art changed drastically. The representation of art also has different meanings across different communities, cultures and nations. I argue that along with interpretation of the past, we should also consider transforming ICH content into subjective and pleasurable experiences, which would be extremely helpful for future generations.

What I have found in my experience working on DIH content with young people is that imaginative and distorted representation of the past is a vital aspect of material culture in heritage embodiment. By using VR/AR and sensor-based technologies, heritage representation can produce great interest among young people. It is not just a representation of the past; it is important as to what it does and how the end-user receives the experience of the past. This way, users can better engage cognitively with the content, and their experience will help transform the content from short-term to long-term memory. Importantly, it is beneficial for young people to be connected with their ancestral heritage.

Freeman (1977) states in his book, *Interpreting Our Heritage*, that "The chief aim of interpretation is not instruction but provocation" (p. 60). He further talks about artistic representation and suggests that artistic depth and the level of people's perception cannot be evaluated. He emphasises the presence of subjectivity, arts and storytelling when representing heritage. He is not saying that interpretation in its totality should be an artistic representation, but that subjective or playful interpretation can give the content a new form and life. Hence, the materiality is pleasurable and playful. According to him, telling a story is different from reciting the story. He further talks about pleasurable experiences and explains that dull performances result in dull audiences. Indeed, the main feature that attracts people to content is the content's entertainment character. The audience primarily seeks enjoyment, and in this way, they are not influenced by certain directives which force them to get instructions.

Each person indeed receives particular cultural, analytical and cognitive knowledge that is different from others. Making meaning is a complex process, relying on individual characteristics such as visual perception, attention, memory, learning and mental model (Preece et al., 1993). It is, therefore, important to understand users' requirements for heritage-related digital content; in this case, young people interacting with DEC content. In addition, the symbolic representation of the environment through art is another language. This language clarifies and stimulates other ideas (Cohen & Gainer, 1995). We enjoy art, not only for its symbolic value but also for the aesthetic stimuli we receive through the use of material. Kalay et al. (2008) point out that emerging technologies can do more than just represent the past. Presently, we know that visitors are encountering new interactive installations in museums around the world. However, making the content relevant to its historical context is still a challenge (Hafstein, 2009; O. Y. Lee, 2004).

As mentioned earlier, the central idea, or the "golden thread", in my publications, is DIH. Therefore, I consider myself as a DEC content creator, intending to create, document, transmit and archive DIH content, as represented in Figure 42.

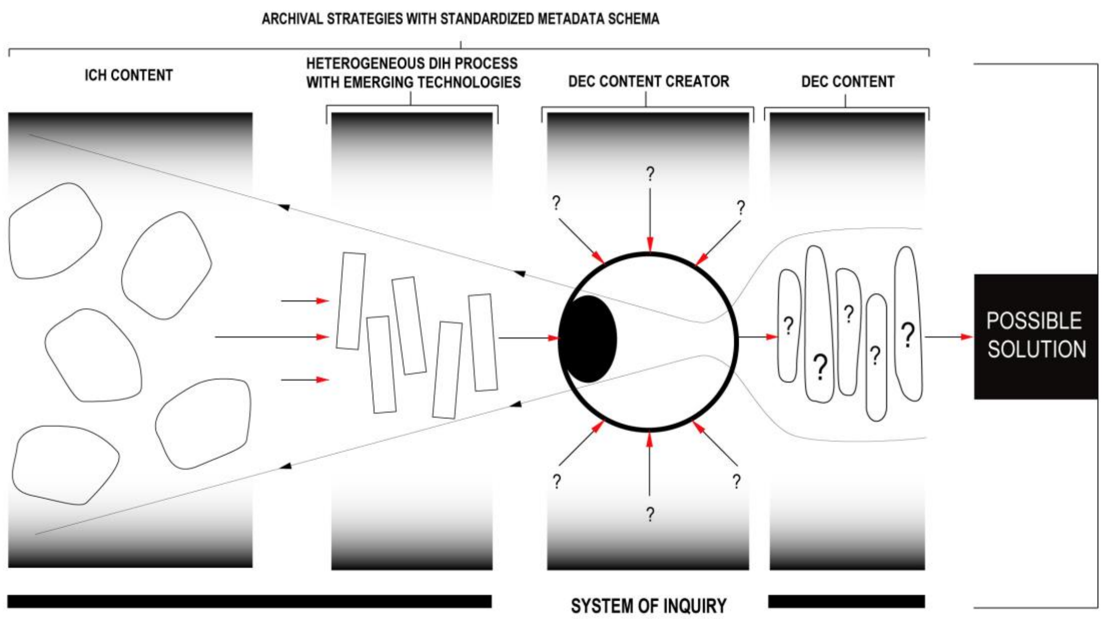

Fig 42. Digital Intangible Heritage challenges in the Digital Emerging Communication domain.

My journey exploring the notion of heritage started in my childhood while learning calligraphy. I realised that past communities were hinting at us to follow their trial-and error-based methodologies. The method and process of creating intricate bends, folds and rhythms in calligraphy were made simpler because of the thoughtful work of masters from the past. These processes were designed, illustrated and explained so well that I could easily follow their path. That is when I realised the importance of the nexus between the past and the present. It is also when I acknowledged the benefits of recreating and following the past.

Conclusion

Meaningful experiences of Digital Intangible Heritage (DIH) are increasingly seen as essential for the understanding and engagement of cultural embodiments; however, little is known about the future impact of this when emerging technologies will have more control over our living environments. While information about DIH-related content is ubiquitous, few have attempted to establish its need, importance and tremendous impact on cultural heritage, particularly for future generations.

It is important to explain the form and function of DIH for the broader community, particularly as new phases of development approach. Establishing a theoretical framework for DIH content, particularly in terms of Virtual Reality and Augmented Reality (VR/AR) and sensor-based content, can assist in the creation of engaging content. It is important to fulfil both the heritage learner's needs and the heritage content creator's objectives. Indeed, beyond this, a greater understanding of meaningful/engaging DIH content may also provide new insight into how individuals and communities can perpetuate heritage content. It is intended that the concept of DIH, as a motivation for cultural reproduction, supports the use of artistic/enjoyable experiences as play, and learning through play to enhance future research into Intangible Cultural Heritage (ICH).

My curiosity about this topic, which I presented in the form of a research question in the Introduction led me to examine, explore and discuss the methodology for this thesis. In the research question, the challenge was to combine two distant "dots"; the intangible past and future emerging technologies for our next generation. The reasons for connecting these two dots were critical to me after I connected cultural embodiments through the digital realm, my experiences travelling the world, and through the literature search and case studies I conducted during this study.

When I first started the study, as a designer/artist, it was critical for me to think about research paradigms and ontological/epistemological assumptions to help me understand all of the phases and components of a research study. My inquiry would be questionable if the selected philosophies and goals were not correctly interconnected due to a lack of appropriate reason and rationality, as I understood them. I chose the speculative design approach to qualitative research because my study involved interpreting my own thinking and experiences. The speculative design paradigm was ideally suited to my research in this context since it strives to investigate abstract forms of interpretation.

In this study, I made the philosophical assumption that VR/AR and sensor-based technologies could aid in the interpretation of ICH content. As a result, in this study, the premise is that reality exists inwardly, in my thinking as a researcher. As a result, the research's ontological position was subjective. Due to the subjectivism of the ontological assumption, a qualitative methodology or speculative design or fiction design approach was chosen, which included my observations, technical expertise and experiences. In order to achieve the polarity of the research objectives, available literature searches, my juried published articles and presentations, and two case studies were evaluated in this study. Consequently, the approach of the current study was speculative, reflecting my passion and enquiry into knowledge, and suitable to the interpretation of cultural knowledge with emerging technologies.

In this thesis, after deciding on a speculative design approach to combine cultural heritage with upcoming interactive technologies such as AR/VR, I needed to investigate some of the issues with this terminology, as it is not ideal. Many of the classic visions of the future, such as jet packs and flying automobiles, are wild guesses, playing to spectacle and techno-centric dreams rather than being based on logical trajectories or controlled by the rules of real reality, thanks to their etymological baggage. It is possible to craft the speculation into something more poetic, based on logical iterations of emerging technology and tailored to an identified audience's complex and subtle requirements, by acknowledging these rules, collaborating with scientists, and not straying too far into the future. The second issue with the word speculative has to do with the strong tie that exists between conjecture and the future. It is vital to note that speculative design can serve as a framework for analysing, criticising and rethinking present technology and encouraging contemplation of the technological future.

Existing paradigms can inform future technological breakthroughs, and speculative futures anticipate near-future products and services by extending current systems and product lines. These are meant to serve as assessment tools, allowing proposed products and services to be tested in the broader public and within the industry before they are released. Furthermore, alternative ways of thinking about the future are design concepts that use current technology but employ different ideals or configurations than those currently guiding product developments.

The appropriate management of the speculation is one of the most critical components in the success of a speculative design project (Auger, 2013). Let us say, for example, that it goes too far into the future and shows impossible concepts or alien technological dwellings. The audience will then be unable to connect with the proposal, resulting in a lack of engagement. In effect, design speculation necessitates the creation of a link between the audience's view of their environment and the concept's fantastical element. The insights they offer into the complex workings of the human mind and how it can be carefully manipulated to elicit a reaction, inspiration and influence for this "perceptual bridge" can come from various fields, such as observational comedy, psychology, ecology, horror films and illusion.

In the context of this thesis, the speculative tag makes sense. As previously stated, the term "speculation" might take someone too far away from the present time, making the proposed concepts, such as the future nature of DIH, appear unreal or implausible. The issue is the range of possibilities for fiction, ranging from the implausible to the verge of reality. The concept, best described as "design factions" - a type of realism in which realities are blurred and suspension of disbelief is permitted, particularly in the context of futuristic documentation, representation and archiving of cultural exhibit data - should be taken seriously in the domains where these fictions sell their commodities and interact with their viewers.

This research aims to show how DIH data can be used to design futuristic heritage installations. I approached it from the standpoint of speculative design and wicked problems in design. Every speculative design project is unique, and the variety of concerns, contexts, technologies, views and audiences contributes to the project. New ways are continuously being developed, and older methods are becoming more sophisticated as the field progresses, further complicating the situation. As a result, the two case studies in this thesis are intended to provide a more general approach to the topic of speculation, specifically how it must be developed to link to a certain audience's perception of the temporal world around them. I tried to extend or modify these perceptions or proposals carefully in the thesis. These are ideas or hypothetical translations of disruptive technological developments into future products that are credible, tangible, and approachable. Moreover, the case study approaches can inspire future DIH content creators to think about what they want and don't want for their future selves.

I have always been curious in considering how we live together, how we form cultural communities, and how we interact with and retrieve traditional knowledge and memories from heritage agencies. Furthermore, I've been interested to find out if there is an effective way to transform this intangible heritage into a form of digital tangible heritage, for younger generation. The population of the world is large and there are many different customs practised. Of course, we have many differences, but we also share many similarities. I have always seen the cultures of the world in a similar way to how I see human faces. Even though we all have different facial features, our faces are all identifiable as human and have distinguishing features. I see communities in a very similar way.

Furthermore, our cultures are as diverse as our traditional sports, games and dances. These indigenous dances, sports and traditional games, however, are under danger as a result of globalisation and require special attention. Although enormous and rapid progress has been made in the fields of motion tracking, sensitive wearable sensors and other wearable technology, capturing the true sensation and thinking processes required by the indigenous communities of these traditional dances and sports remains a difficult issue. Preserving these cultural entities reveals various obstacles, and further research is needed to produce effective and viable low-cost platforms that efficiently utilise these existing approaches.

Traditional sports and dances are all based on the movements and postures of the human body. Life has always included movement and will continue to do so. It can be utilitarian, purposeful, an art form, a form of play; it is embedded in various indigenous communities and is thus an outgoing manifestation of communal identities. Cultural sports and dances, indigenous methodologies and festive events, as our ICH, all hold components of our cultural identities and heritage to pass down from generation to generation in our folk tradition.

Throughout this current study, I found that ICH is of crucial importance—and our physical, cultural spaces are the by-products of our ICH. Heritage is a verb rather than a noun. I developed the idea to protect, document and transmit our ICH through the digital realm. The main research question challenged me as to how I could:

- retrieve and combine emerging technologies and ICH in the form of DIH;
- culminate and manifest an acceptable approach relevant to young people; and
- implement steps to make DIH sustainable and playful for future generations.

The fundamental argument in the thesis is that intangible forms of cultural embodiments—with their intriguing objective and subjective mix of representations—will assist future generations to engage and familiarise themselves with the heritage content. Furthermore, this research looked at how emerging technologies can be used to demonstrate fictitious, subjective and playful enactment of a community's intangible cultural aspects as an effective way to perpetuate the heritage for future generations. While the serious gaming environment provides functions and analyses for targeted content (Sermet, Demir, & Muste, 2020), I propose a playful strategy for representing and enacting cultural components for future young generations using emerging technologies. Children's cognitive growth is emphasised in Piaget's Theory of Cognitive Development (Plass, Mayer, & Homer, 2020). According to the theory, play is essential for cognitive development, and it gets more abstract, symbolic and social as children advance through different stages of development. According to Piaget, play helps children’s learning and development by activating schemas (fundamental units for organising information and behaviour) in ways that go beyond the present reality. Play, according to Piaget, was essentially about assimilation, or the interpretation of environmental stimuli so that they can be assimilated into the existing schemas.

Throughout the study I discovered that both actual and fictitious DIH content will represent our intangible heritage. This newly generated content should also be documented and archived as a repetiteur for future generations. I also found that the content should be pleasurable and playful in order to best engage young minds, which will lengthen the time they interact with the content. Therefore, a particular new domain should be acknowledged for future content creators: Digital Emerging Communication (DEC) (see Section 3.3). When DEC content creators are engaged to fabricate DIH content, they should follow some guidelines and recommendations, as discussed in this thesis, and utilise some proposed tools (such as iProbes) to acquire comprehensive knowledge about the subject matter. Hence, I introduced an interventional strategy and framework for DEC and, for sustainability, some related concepts such as an online repository for DIH.

One of the key ideas for consolidating DIH-related material from around the world is to ask all DIH content creators to submit their work and make it available for documentation, comparison and future transmission as cultural embodiment. For this purpose, a crowdsourced archiving portal— “FolkAir”—was introduced and conceptualised (see Section 3.2.2). This online DIH representation will be a kind of repetiteur for future DIH content creators, and will assist them to address the challenges and outcomes related to the creation of content.

DEC content creators need to search, isolate, define, manage and manipulate the methodologies of multiple pieces of knowledge in order to create a ludic (characterised by play) interface-based installation/exhibition of cultural heritage. In my research I act as a DEC content creator, and work with multiple sets of knowledges, to attempt to represent and perpetuate intangible heritage content. This approach helps to communicate, express and represent cultural heritage ideas via carefully designed systematic and engaging activities for future generations to engage with. Besides other heritage-related installations, I have also created various digital applications for the documentation, preservation and perpetuation of ICH, as shown in Figure 43. As the figure shows, some ICH digital representations have been designed to investigate the "inside" of the content, and some to elicit emotional responses. Some are just for entertainment, while others aim to create awareness about indigenous methodologies and cognitions. (My proposed Virtual Immersion with Pulsation (VIP) heritage installation was presented in Section 2.1.6.2, and the proposed "Mimicry Understanding and Safeguarding Environment" (MUSE) application was presented in Section 2.2.15.)

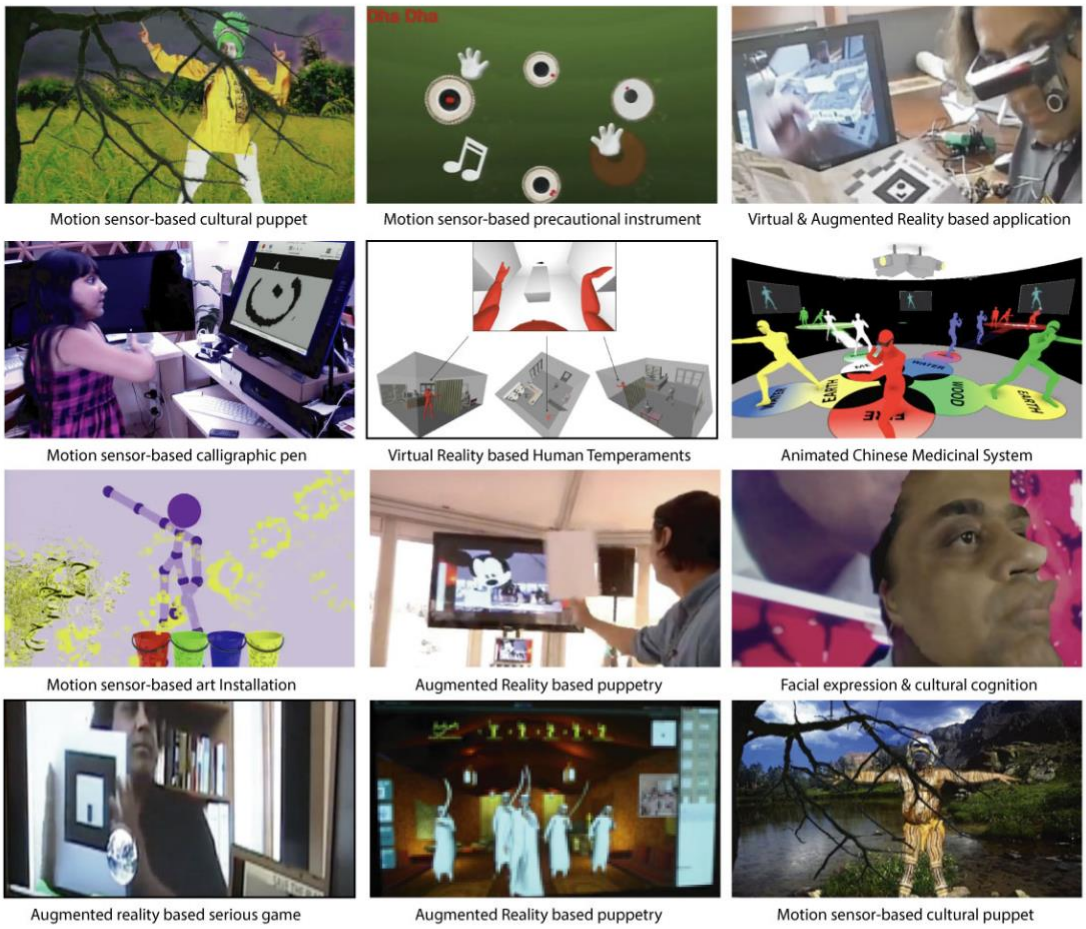

Figure 43. Various Virtual Reality/Augmented Reality and sensor-based applications and installations designed by Muqeem Khan.

The thesis incorporated published articles and case studies that used the infrared camera for body tracking. In cultural dances or sports such as martial arts and so on, there should be two phases in preserving the human body movements so that the content attracts audiences. The first phase is to get accurate information on the movement, and the second is to put that information to good use by manipulating it with inventiveness, creativity and enjoyment. The first phase is quite technical and necessitates the use of cutting-edge technology and software. However, in the second phase, where numerous sensors, AI and selected cultural information might translate this data into a serious gaming experience, there is a lot of space for creativity. Furthermore, an interactive scenario can be created in the second phase using a platform that incorporates a multi-modal capture system, motion comparison and analysis, and a semantic-based feedback system. I propose that future DEC content creators need to be aware of these two phases and the sensitivity issues surrounding DIH, indigenous communities and local/international regulations.

To describe DIH content in a comprehensive, interoperable manner, we need to have standardised online content. Content creators should also know the agency of the heritage content they are working with, besides understanding the relevant emerging technologies. However, this type of standardisation for online content does not exist. To help fulfil this need, I propose a metadata schema for the description of VR/AR and sensor-based DIH content. It would be based on the existing metadata standard and a five-layered framework for the assessment of content. I am well equipped to do this as demonstrated by my published articles, invited conference talks, and my ongoing efforts to embody ICH through emerging technologies. In my research, I have been using three-dimensional digital tools, motion sensors and various VR/AR devices to represent the intangibility of cultural content (see Appendix A). Moreover, I have been extensively engaged in various ICH-related learning and production activities, such as indigenous music, indigenous methodologies and several master–disciple relationships. According to Moore's law, I expect that the pace of technology will accelerate in the near future. Moore's law states that the component density and performance of integrated circuits increases every year (Thompson & Parthasarathy, 2006). Furthermore, these devices will enter our lives more quickly than Moore's law suggests (Shalf, 2020). My passion for acquiring these technologies and my thirst for ancient knowledge has put me in a position where I can recommend some critical considerations for future DIH content and its preservation.

While thinking about my research question, I also thought about my five assumptions/hypotheses, which I presented on page 4 of this thesis. In summary, I wanted to see young participants, either online or when they visit museums or heritage-related environment s, enjoying the ICH content. While these young minds enjoy and interact with emerging interactive technologies, particularly VR/AR and sensor-based technologies, they could also interact with their heritage, ancestral lifestyle and the heritage of the world. I also wanted to see the heritage embodiments aligned with emerging trends such as playful ludic interfaces and kinaesthetic installation/exhibition of cultural heritage. The fabrication of these installations will be more likely to be impactful if there is a novelty factor, and if the content is entertaining. I further acknowledged that the amount of time spent at the exhibit is essential (Roberts et al., 2018). This can facilitate participation, motivation and informal learning experiences - valuable components of an exhibition (Ahmad et al., 2015).

If we do not save user input, user experiences and interactive exhibit performances for future generations and the show itself, they will be gone. Technology-driven exhibits will be too technologically complex to be collected or stored by libraries or current archiving technologies. On the other hand, future DIH research is contingent on the availability of archives and records. Therefore, memory institutions will have to address this issue for sustainability. Thus, I presented a "Digital Repository" concept based on AI, as shown in Figure 38. Furthermore, I inserted the idea of the transection of information and possibly real-time guidance for users while interacting with an exhibit. I reasoned that future generations would be more likely to engage in play and be interested in using the exhibit by taking this method.

Moreover, my proposed iProbes intervention can help content creators define and explore the ICH content and indigenous community The iProbes framework can assist DIH content creators to be more sensitive and considerate of the community, and more careful of the content. The compartmentalisation of content creators to a proposed domain, Digital Emerging Communication (DEC), is also an attempt to provide conducive disciplines for these individuals to focus and enhance their abilities in the realm of VR/AR and sensor-based technologies.

While some digital archives, such as those sponsored by libraries, museums and other institutions, maintain the conservationist impulse behind traditional analogue archives (reworking the model only to provide greater access to the materials), in the hands of others, especially youths, archives no longer preserve the past for the future, but serve as generative repositories (Bench, 2016). Bench further claims that, in the context of dances and body movements, digital archives have the ability to produce, that is, to create the performances that they are also used to chronicle and save, and that this is linked to how digitality redirects or reconceives dance pedagogies. Digital technologies, he claims, have diverted the archive's social, political and historical purposes and accomplishments, putting circulation ahead of preservation.

When networked digital media began to replace earlier forms of transmission (television, radio, cinema and print) as "the cultural dominant" (Auslander, 2008) in areas with widespread internet access, the ties binding public memory to the state began to loosen, and memory began to forge links with many other masters - people who had never received training in library and information sciences (LIS) (De Kosnik, 2016). While formal memory institutions are becoming more interested in digital archiving, amateurs, admirers, hackers, pirates and volunteers—in other words, "rogue" memory workers—have embraced it most passionately.

The internet is populated with digital archives of cultural information that are not associated with any physical museum, library or archive, to the point where many people refer to the internet as a huge archive. According to Manovich, the Internet can be viewed as a massive, globally dispersed media database (Manovich, 2002). Indeed, AI, neural networking and learning consumers' behavior through their interactions and preferred choices are already being used by YouTube, Google and other huge data repositories (Tufekci, 2018; Covington et al., 2016; Kauffman et al., 2021). As a result, it is evident that the data has been and will be used in a variety of fields.

It is anticipated that the FolkAir project will be useful for creating and protecting DIH discourse as identified and elaborated in this thesis. More generally, the overall explanations and assertions from the literature appear to back up the idea that not only factual representations of cultural embodiments, but also fictitious and exciting cultural productions with playfulness, are imperative to engage future generations. Moreover, with emerging interactive technologies, artificial intelligence and various data management frameworks, it is now easily possible to transform any archive into a cultural repertoire for our future generations.

I had no clue where this study would lead me when I started it, drawing on my experiences working on technologies and my published papers, and that, in many ways, is the fundamental feature of my curiosity - the assessment of speculative design thinking. While it may appear contradictory, I am still unable to clearly see where it ends; the lines are muddled and the limits are hazy. This is done on purpose. The case studies in the thesis began as a probe of the methodology I employ to combine intangible heritage with emerging technologies. It grew into a more in-depth investigation of the meaning of exhibition design as it relates to the portrayal of history for us and future generations. I should continue to be curious and pursue my curiosity to its logical and rational conclusion. The boundaries or limitations that I encounter in a variety of disciplines will pave the way for the next step, which is a reflective examination and critique of my own imagination, as well as a broader explanation of my steps into other disciplines, methods, problem-solving paradigms and unknown territories.

Heritage representation, in my opinion, is just the recreation of historical "events" or "objects", In this thesis, I was able to look into many things, including how I think and what I have been thinking about, and how various fields have borders surrounding them. The journey has taught me that heritage representation could be found inside the constraints we choose for ourselves or within culturally established parameters. The personal recognition of my "method of portraying heritage", more especially intangible heritage gained through this thesis, allowed me to explore exhibition design for people now and for our future generations. I attempted to represent heritage through subjectivism and a blurry reality, but I relied on near-possibilities. The traditional means of representing the past could not translate my way of thinking about future exhibits. This investigation has allowed me to engage in a speculative enactment of heritage outside of reality and time, which has allowed me to ask more questions, delve deeper, and seek a better understanding of whatever situation I faced as an artist/designer or as an individual. As I tried to play with my imagination's organic but possible tentacles for the next generation while describing my case studies, I noticed that I was more enthused about our past, the intangible past, and more motivated.

In this thesis, I attempted to push the boundaries and intersections of several disciplines. I realised how my own constraints were built through rough sketches, schematic designs, analyses, research, meetings, discussions, tiredness and uncomfortable mornings. This process allowed me to redefine my perspective by moving beyond self-imposed or culturally/communally established constraints. The acknowledgement also suggests that heritage representation has built its boundaries. In their current status, heritage representations have selected their borders to obtain identity and validity, even though they appear to be imposed by outside and inside regimental forces.

The haziness is fading, and I am seeing what happens when we examine the different constraints that confine and restrain us and push through them: we discover moments of creativity that exist outside the box. It is apparent to me that creativity can re-imagine the world in new and diverse ways, allowing aspirations of a new paradigm for exhibition design. When the world is faced with uncountable wicked challenges, it appears that speculative thinking may hold the key to developing previously unimaginable answers. In my opinion, speculative methods can push heritage content creators and GLAM services managers to a new level of problem solving and solution making, making them invaluable in creating our desirable future worlds.

I will keep following the avenues of research that I have established in this thesis. I need to keep going as I learn and grow. The goal remains to open the door to a broader expression of heritage enactment for future generations, the creation of multiple and possible disciplines such as Digital Intangible Heritage (DIH) or Digital Emerging Communication (DEC), and the use of VR/AR gadgets to play with speculative design thinking. Despite the enormity and potential consequences, I am devoted to following in the footsteps of my thinking.

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Appendix A

Here are the juried (peer-reviewed) publications (six of these publications are included in Section 1 of this thesis). These publications discuss emerging technologies, particularly VR/AR and sensor-based tools and heritage representations:

#	Juried Paper/Presentation	Peer-reviewed/ Scholarly Publication/ Presentation	Thematic Statement
1	MUSE: Understanding Traditional Dance	Publication	This paper encapsulates the manifestation of Middle Eastern indigenous dance, Al Ardha, in the form of a serious gaming environment. The purpose of this paper is to illustrate the interconnection and possible transformation of Intangible Cultural Heritage (ICH) content, such as traditional dances, into a digital kinaesthetic learning system. • Digital Intangible Heritage (DIH) • Dances & Digital Technologies • Traditional Knowledge • Indigenous Methodology • Emerging Content Creation
2	Preserving our Past with Toys of the Future	Publication	This is a scoping study undertaken to explore the role of augmented reality and motion-detecting technologies in the context of Intangible Cultural Heritage (ICH) for museum-related environments. • Digital Intangible Heritage (DIH) • Dances & Digital Technologies • Traditional Knowledge • Indigenous Methodology • Emerging Content Creation
3	GLIDE: Towards an Intelligent Kinaesthetic Learning Space for Teaching Dance	Publication	This paper represents indigenous dances with artificial intelligence and motion-sensing technologies. • Digital Intangible Heritage (DIH) • Dances & Digital Technologies • Traditional Knowledge • Indigenous Methodology • Emerging Content Creation • Artificial Intelligence
4	Technology Embedded Imagination for Arab Women	Publication	This paper explains how current technological tools and pedagogical explanations foster learning for a specific gender and initiate their imagination. • Digital Intangible Heritage (DIH) • Master–Disciple Relationship • Pedagogy • Emerging Content Creation • Indigenous Cognition • Dances & Digital Technologies • Indigenous Cognition
5	Playful Technology to Keep Cultural Heritage Alive (TED Talk)	Scholarly Presentation	This TED talk presents the role of emerging motion-detecting technologies and augmented reality in the context of Intangible Cultural Heritage (ICH) for younger generations. • Digital Intangible Heritage (DIH) • Dances • Calligraphy • Arts • Traditional Knowledge • Indigenous Methodology • Emerging Content Creation • Indigenous Cognition
6	Archive to Repertoire: Motion Capture & Motion Sensing Data for Digital Intangible Heritage (DIH)	Publication	This paper investigates the transformation of digital documentation of Kung Fu into an interactive performative space for public engagement. The study creates an interface for learning the repertoire from significant lineages from South Chinese traditions, contributing to the perpetuation of this art form. • Digital Intangible Heritage (DIH) • Traditional Knowledge • Indigenous Methodology • Virtual Reality • Serious Gaming • Emerging Content Creation • Indigenous Cognition
7	A Radicalized Phenomenological Transformation of Greek/Unani Humoral Theory into a Virtual Reality-based Game Engine	Publication	This paper discusses the continuity of production, survival and access related to indigenous methodologies through the use of virtual reality, serious gaming technologies and affordances. • Digital Intangible Heritage (DIH) • Traditional Knowledge • Indigenous Methodology • Virtual Reality • Serious Gaming • Emerging Content Creation
8	Exploration of Cultural Paradigm: A Web-based Methodology	Publication	This paper proposes a web-based methodology to investigate and collect cultural cognitive/perceptual data from all over the world and to examine its various transformations and mutations.

#	Juried Paper/Presentation	Peer-reviewed/ Scholarly Publication/ Presentation	Thematic Statement
			• Digital Intangible Heritage (DIH) • Emerging Content Creation • Indigenous Cognition • Emerging Content Creation
9	Fostering Intellectual Transactions: A Pedagogical Approach in Delivering Technology Based Instructions for Qatari Women	Publication & Presentation	This presentation/paper shows how current technological tools embrace contextual adjectives and storytelling in a classroom setting with cultural context and emerging technology-based instructions. • Digital Intangible Heritage (DIH) • Master–Disciple Relationship • Pedagogy • Emerging Content Creation • Digital Storytelling • Emerging Content Creation • Indigenous Cognition
10	Transdisciplinary Designerly Attitude	Scholarly Presentation	This invited talk is about the working and thinking styles of future content creators and their attitude towards knowledge acquisition in the context of emerging technologies. • Digital Intangible Heritage (DIH) • Master–Disciple Relationship • Pedagogy • Emerging Technologies • Emerging Content Creation • Indigenous Cognition
11	Creating Tangible Cultural Learning Opportunities for Indigenous Dance with Motion Detecting Technologies	Publication	This paper represents the transfer of knowledge from the knowledge provider to knowledge seekers in the context of Intangible Cultural Heritage (ICH). • Digital Intangible Heritage (DIH) • Dances • Traditional Knowledge • Indigenous Methodology • Emerging Content Creation
12	Pulse Reading Knowledge & its Practitioners in South Asia	Unpublished Paper	This paper explores the transformations of herbal medicinal systems and examines how Unani Tibb is embedded within social networks in the context of pulse reading knowledge. • Intangible Cultural Heritage (DIH) • Traditional Knowledge • Indigenous Methodology • Pulse Reading Knowledge
13	Transmitting Al Ardha: Traditional Arab Sword Dance	Publication	This paper represents Arabic sword dance with motion-sensing technologies, indigenous methodology and cognition. • Digital Intangible Heritage (DIH) • Dances & Digital Technologies • Traditional Knowledge • Indigenous Methodology • Emerging Content Creation • Indigenous Cognition

1. Khan, M. (2014, March). *MUSE: Understanding traditional dances*. Minneapolis, MN: IEEE VR.

2. Khan, M., & de Byl, P. (2012). *Preserving our past with toys of the future* [From IEEE Xplore, a scholarly research database, Sep, pp. 1-3, ISSN: 2166-6741].

3. Khan, M., de Byl, P., & Birt, J. (2012, December). *GLIDE: Towards an intelligent kinesthetic learning space for teaching dance*. Oral presentation and in the proceedings of the 3rd Annual Pan-Arabic Simulation and AI in Computer Games Conference (GAMEON-ARABIA), Muscat, Oman.

4. Khan, K. (2012, November). Technology embedded imagination for Arab women. Virtual presentation and in the proceedings of the Arab-US Association of Communication Educators (AUSACE), Atlanta, GA.

5. Khan, K. (2012, April). *Muqeem Khan: Playful technology to keep cultural heritage alive*. TED@Doha Summit, Doha, Qatar.

6. Khan, M. (2015). Archive to repertoire: Motion capture & motion sensing data for digital intangible heritage (DIH). *2015 Digital Heritage* (Vol. 2, pp. 197-198). New York, United State: IEEE.

7. Khan, M. (2015). A radicalized phenomenological transformation of Greek/Unani humoral theory into a virtual reality based game engine. *2015 Digital Heritage* (Vol. 1, pp. 397-400). New York, United State: IEEE.

8. Khan, M. (2008, March). *Exploration of cultural paradigm: A web-based methodology*. Oral presentation and in the proceedings of the IASTED International Conference on Internet and Multimedia Systems and Application, Innsbruck, Austria.

9. Khan, M. (2008, April). *Fostering intellectual transactions: A pedagogical approach in delivering technology based instructions for Qatari women*. Oral presentation and in the proceedings of the 6th Learning and Technology Symposium, Jeddah, Kingdom of Saudi Arabia.

10. Khan, M. (2019, October). *Transdisciplinary designerly attitude*. Oral presentation and in the proceedings of the National Digital Design Conference (ND2C), Islamabad, Pakistan.

11. Khan, M., & de Byl, P. (2012, September). *Creating tangible cultural learning opportunities for indigenous dance with motion detecting technologies*. In 2012 IEEE International Games Innovation Conference (pp. 1-3). New York, United State: IEEE.

12. Khan, M. (2019). *Pulse reading knowledge and its practitioners in South Asia* (Unpublished Paper).

13. Khan, M. (2015). Transmitting Al Ardha: Traditional Arab sword dance. *International Journal of Heritage in the Digital Era*, *4*(1), 71-85. New York, United States: SAGE

Appendix B

Muqeem Khan. (2012, April). *Muqeem Khan: Playful technology to keep cultural heritage alive* [transcript]. TED@Doha Summit, Doha, Qatar.

Transcription

Hi,

For the next five minutes, I would like to draw your attention to a future scenario and future challenges that we will be facing soon in our future. Just look at these faces. These are amazing minds who have contributed tremendously to the industrial and scientific world that we live in today. And these faces have changed the socio-economic, socio-cultural and socio-political landscape that we are carrying at this moment. Just by looking at the age difference, I can easily predict that these young minds will be controlling the new wave of our development, the future lifestyle. But the problem is, they forget about cultural heritage, as well as intangible cultural heritage, because of the massive traveling, available social networking options and of course wacky ideas that they will have. My focus is to create awareness about intangible cultural heritage such as music, sound language, and cultural dances with the help of playfulness and available emerging technologies. Trust me, intangible cultural heritage is everything, who we are, what and how we think. We have to find ways where learning about ingenious music could be fun. Research says that learning a percussion or melody could increase the IQ of a growing child. But that could only be possible if the music is attached to your heart, attached to your culture. Amazing possibilities are out there in our future where our young minds who are forgetting about their cultural heritage can play with their indigenous or their ancestral language, the preferred choice of colors, and their arts and design motifs.

Calligraphy is a dying art for a particular language. Awareness about calligraphy is even more important. Why? Because of available lots of typefaces from computer graphics [which] are killing this beautiful art form. For me, it is a beautiful artform where beautiful bands and folds can create amazing visuals. You know, in this world right after when you touch a paper, a pen becomes so heavy but not in an innovative way. Cultural dance is an expression, social interaction, and sometimes a spiritual representation of a past narrative. A cultural dance can contain a feeling of livelihood of a culture. It also contains a livelihood of people living in a certain area. I hope an amazing future is waiting for us where we have the leverage to connect intangibles of our culture to our consciousness, especially the young mind who will be controlling our future. Amazing gadgets and technologies are going to be there, but the most important thing is that you have to have very meaningful cultural content creation so they can feel attachment. As Benjamin Franklin said, “Tell me I will forget, teach me I will remember and involve me, I will learn.” Thank you.