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Integrating body-worn cameras, drones, and AI: A framework for enhancing police readiness and response

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ABSTRACT

The combined use of body-worn cameras (BWCs), drones, and artificial intelligence (AI) within the context of policing represents a significant advancement in policing methodology. This article presents a comprehensive framework for (a) the integrated use of these technologies to promote real-time situational awareness, heightened evidence collection, enhanced officer and public safety, improved operational efficiency, cognizant of compliance with ethical and privacy standards; and (b) an evaluation approach to the combined technology application. Illustration of the framework application to historical high-profile events presents a unique lens to assess potential outcomes and advantages, fostering and informing on a comprehensive discussion on future policing policies. This examination aims to offer a practical approach for implementing a synergistic BWCs, drones, and AI framework to leverage policing initiatives.

INTRODUCTION

In the evolving landscape of law enforcement, the integration of body-worn cameras (BWCs), drones, and artificial intelligence (AI) marks a critical juncture in advancing policing strategies. This manuscript proposes a conceptual framework that seeks to harness the synergistic potential of these technologies, aiming to enhance the efficacy and responsiveness of police operations. The impetus for this integration is substantiated by the burgeoning adoption rates of these technologies, with most police departments in the USA now employing BWCs and a marked surge in the utilization of drones for surveillance purposes.

Historically, policing methods have undergone significant transformations with each technological innovation, from the telegraph to radio systems, each heralding a new era in law enforcement capabilities. Today, the convergence of BWCs, drones, and AI holds the promise of a similar transformative impact, potentially redefining the strategic and operational landscape of policing. The paper recognizes that the operationalization of such technologies in law enforcement is not a one-size-fits-all solution; it is subject to the legislative frameworks and societal expectations that vary significantly across international borders. What may be permissible and effective in the USA could encounter legal and cultural barriers in other countries, necessitating a nuanced approach to the global discourse on democratic policing and adopting these technologies.

Despite the individual benefits of each technology, there is a discernible gap in the literature concerning their collective employment. The absence of a comprehensive framework that amalgamates the capabilities of BWCs, drones, and AI significantly diminishes the full potential of these tools. This research endeavours to fill this void by proposing an integrative framework posited to enhance situational awareness, optimize evidence collection, and improve operational efficiency, all within the ambit of ethical and privacy considerations.

The rationale for this study is anchored in the imperative to address the fragmentation of these technologies in policing. The proposed framework serves as a theoretical construct and a practical guide for operationalizing an integrated technological approach. The significance of this research transcends the academic sphere, with the potential to inform policymaking, shape future law enforcement practices, and contribute to a more secure, transparent, and efficient policing paradigm.

The paper acknowledges the variability in implementing this integrated framework across jurisdictions, necessitating an adaptive approach responsive to local laws, community norms, and available resources. It also recognizes the importance of qualitative outcomes, such as community trust and public perception, alongside quantitative measures. This dual focus on the measurable and the intangible effects of technology integration in policing is crucial for a holistic understanding of the framework's effectiveness.

BACKGROUND

The combined use of BWCs, drones, and AI as an integrated framework in policing operations represents a transformative

approach to modern policing. The BWC offers a personal account of incidents and interactions, providing an intimate understanding of the unfolding situation, while the drone supplements this perspective with a bird's eye view of the scene. This synthesis of perspectives promises an enriched situational awareness, offering policing a comprehensive understanding of the incident. It is the synergistic function of these technologies that underpin the proposed framework. The BWC and drone operate in tandem, with the drone providing real-time aerial footage that complements the BWC's ground-level view, the intelligence of both extended through the addition of AI pre and post-incident insights for operational effectiveness. This paper presents and discusses a conceptual framework for the synergistic application of BWCs, drones, and AI as a reflective tool assessing operational effectiveness and a future-focussed approach for spiralling up effective operational response.

LITERATURE REVIEW

In order to better understand the integration of BWCs, drones, and AI in law enforcement, it is necessary to examine their current usage and potential effects. Appreciatively, there is a wealth of literature regarding these three technologies and their adoption not only for policing but also across a broad spectrum (this list is not conclusive) of business, crisis and emergency management, first responder agencies, private and public entities, for example. This literature review provides a high-level scan of the use and capabilities of BWCs, drones, and AI individually to consider their contribution to applying an integrated approach for police.

AI in policing

The utilization of AI within policing has yielded transformative applications, among which predictive policing stands prominent. This paradigm harnesses machine learning algorithms to scrutinize historical crime data, societal variables, and environmental factors, thereby forecasting the occurrence of crimes in specific locations and timeframes. This predictive approach aims to optimize the allocation of police resources, preventing criminal activities. However, the adoption of predictive algorithms has ignited ethical concerns, predominantly centred around the potential reinforcement of existing biases within the criminal justice system (Berk, 2021; Fussey, 2021).

Leveraging natural language processing

The utilization of natural language processing (NLP) algorithms within policing agencies enables the parsing of extensive textual data, including social media posts, emails, and recorded speech. The primary aim is identifying potential threats or criminal activities embedded within these sources. Furthermore, this technology facilitates the automation of transcription during interviews and interrogations, streamlining the investigative processes (Korhonen *et al.*, 2021). Watters and Phair (2012), in their work detecting illicit drugs on social media using automated social intelligence analysis (ASMIA), explore the use of AI and NLP for identifying illicit drug activities on social media. ASMIA, an AI-driven approach, incorporates expert systems for in-depth reasoning and ontologies for structured knowledge representation. By addressing NLP challenges such as term disambiguation and semantic processing, the authors aim to automate the detection of drug-related posts. NLP assists policing agencies in pinpointing potential threats and criminal activities via the online environment.

Unveiling crime patterns through AI-driven analytics

AI-powered crime analytics tools can process and analyse vast datasets, unveiling concealed patterns, correlations, and trends within criminal activities. The insights gleaned from such analyses furnish invaluable assets for ongoing investigations and formulating proactive policing strategies (Baveja and Redmond, 2002; Korhonen *et al.*, 2021).

Facial recognition technology

Another significant advancement is the escalating integration of facial recognition technology within global policing agencies. This technology's applications span diverse scenarios, encompassing suspect identification in crowded areas and locating missing persons. However, the technology is not without critique, primarily concerning its potential encroachment upon individual privacy rights and its varying levels of accuracy across distinct demographic groups (Anning and Goldberg, 2022; Raaijmakers, 2019).

Automated license plate recognition

Automated license plate readers, equipped with advanced AI algorithms, exhibit the remarkable capability to swiftly identify and log license plates on vehicles, whether in motion or stationary. This technology frequently applies in diverse scenarios, including recovering stolen vehicles, tracing suspects, and enforcing traffic statutes (Korhonen *et al.*, 2021). In a similar context, a notable advancement emerges from the recent study by Ramadan *et al.* (2022). Their work introduces an AI-driven system tailored explicitly to aid policing agencies in the dynamic tracking of fleeing vehicles. This system adeptly pinpoints and supervises selected vehicles across a designated county by synergising the potential of AI and automated license plate recognition technology. Notably, this AI-centric approach not only streamlines the tracking process but also effectively eliminates the requirement for manual scrutiny of archived video footage. In the face of escalating challenges in policing, particularly in cases involving vehicle thefts or elusive suspects, integrating AI into such systems heralds a transformative advancement.

Real-time decision support

Advanced AI systems extend real-time decision support during police operations, these systems furnish actionable insights to field officers by analysing multiple data streams, encompassing video feeds, biometric data, and geolocation information. Recent research delineates principal domains underpinning AI military staff technology enhancing commanders' decision-making capabilities (Lee *et al.*, 2021). Traditional policing methods might require officers to manually cross-reference information from different sources, which can be time-consuming and prone to errors. In contrast, AI systems can automatically pull data from various databases, sensors, and live feeds, ensuring officers have the most up-to-date information.

Cybercrime investigations and AI

AI algorithms offer indispensable aid in cybercrime investigations by scrutinizing network behaviours and identifying aberrant patterns indicative of illicit activities. The integration of modern information technologies, including AI, within the operations of the National Police of Ukraine, for example, has engendered legal predicaments concerning conformity with the rule of law during the deployment of such technologies, notably intelligent video surveillance systems and the aggregation and analysis of personal information (Striltsiv and Fedorenko, 2022).

Augmenting situational awareness

Apostolakis *et al.* (2021) discuss the DARLENE ecosystem, an amalgamation of augmented reality (AR) and AI technologies to enhance situational awareness among European law enforcement agents. This innovative system expedites on-site tactical decision-making, thereby minimizing errors. DARLENE is an innovative system that combines AR and AI to enhance the situational awareness of law enforcement officers. It provides officers with a hyper-virtual representation of their surroundings, aiding in efficient decision-making during high-risk situations. By integrating AI analysis results into AR displays, DARLENE enables officers to rapidly identify threats and illegal activities, leading to quicker crime prevention and response. This combination ensures that officers are better equipped and more informed during their operations.

AI and police information systems

A report on the analysis of the importance of AI in the information systems of police forces (Ramos *et al.*, 2020) suggests AI is emerging as a pivotal tool, enhancing both public service quality and internal procedural management. However, it is worth noting that the infusion of AI into policing endeavours is not devoid of challenges and controversies. A conundrum for police leaders revolves around the ongoing debates focussed on ethical concerns linked to data privacy, potential biases ingrained within AI algorithms, and the broader implications for civil liberties (Berk, 2021; Fussey, 2021).

BWCs and policing

A wealth of literature is associated with studies of the application of BWCs for policing. In particular, the impact of BWCs on police-community relations (Davies, 2022; Miethe *et al.*, 2019; Sousa *et al.*, 2018; White *et al.*, 2018); transparency of officer and citizen behaviour (Braga *et al.*, 2017; Davies, 2022; Demir, 2019; Sousa *et al.*, 2018); ethical and privacy concerns with the use of such surveillance and recording devices (Crow *et al.*, 2017; Jiang *et al.*, 2021; Meithe *et al.*, 2019), professionalism and accountability of police (Ariel *et al.*, 2015; Jennings *et al.*, 2015; Braga *et al.*, 2017; Sutherland *et al.*, 2017; Braga *et al.*, 2018; Wright and Headley, 2021; Davies, 2022), evidentiary material for criminal proceedings (Fan, 2017; McCulloch *et al.*, 2020; Rickman, 2023); occupational violence for police officers (Ariel *et al.*, 2019; Douglas 2020; Lum *et al.*, 2019; White *et al.*, 2017) and use of force against citizens (Ariel *et al.*, 2015). From the early pilot studies of BWC implementation (Ariel *et al.*, 2015), a key anticipated outcome for the implementation of BWCs centred on improved police-community/citizen relations, enhancing trust between the parties, including increased transparency (Medlock *et al.*, 2020) and a crime reduction. Such increased transparency (afforded through the use of BWCs) influences officer and citizen behaviour, police legitimacy and procedural justice. Demir *et al.* (2020) indicated in a review of the literature associated with police legitimacy and procedural justice that the behaviour of the police influences community views of police legitimacy. Procedural justice, as explained by Tyler (2003), is the perceived fairness of decision-making and respectful treatment of citizens. A US study in 2021 concludes that citizens think that BWC may improve transparency, accountability, and officer behaviour (Wright and Headley, 2021).

Braga *et al.* (2022) connect the potential influence of BWCs on improved behaviour by police by examining the influence of BWCs on complaints against the police. Studies associated with the influence of BWCs on the level of complaints against police (Davies and Krame, 2023; McCluskey *et al.*, 2019) indicate that BWCs have a positive influence in this domain. On the other side of the lens, studies indicate that improved behaviour by community members is influenced by police wearing BWCs (Abramovaite *et al.*, 2022; Ariel *et al.*, 2017; Chin-Quee, 2018; Martain *et al.*, 2021). Interrelated with consideration of the influence of BWCs on police and citizen behaviour is the level of acceptance by community members for the use of BWCs and the perception of ethical use of captured BWC footage.

As discussed by Davies (2022) and Todak and Gaub (2020), there are studies from across the globe, that indicate a general acceptance of the use of BWCs for police agencies on the expectation that their use will improve community safety, reduce crime, and improve evidentiary material for criminal prosecutions. Studies are emerging, indicating that these community and police agency expectations are gaining traction. BWC footage is influencing criminal justice proceedings, with a particular focus on early guilty pleas and the provision of visual footage versus text-based evidence (Davies and Krame, 2023; Gazelka, 2021; Pimley *et al.*, 2022; Todak *et al.*, 2018; Vakhitova *et al.*, 2022). There is an increasing body of literature focused on concerns associated with the use of BWCs and their impact on privacy and human rights concerns (Adams and Mastracci, 2019; Andreescu and Kim, 2022).

Studies examining the issues associated with concerns related to the invasion of privacy associated with using BWCs by police officers fall into two broad categories. First, citizens' concern about adhering to guidelines for ethical capture, storage, dissemination, and ultimately destruction of BWC recordings (Adams and Mastracci, 2019; Gramagila and Phillips, 2017). The second category concerns the use of BWC footage as an officer performance monitoring tool and the potential for invasion of privacy if the footage is misused (Boivin *et al.*, 2022). Whilst studies have indicated these privacy concerns, there are also studies indicating a level of disagreement that BWCs are an invasion of citizen and officer privacy (Crowe *et al.*, 2017; Jiang *et al.*, 2021). In respect of the model proposed in this article, the important element is the guidelines that underpin the application of the model and the importance of establishing ethical standards at the centre of the operational protocols.

Drones and policing

Capabilities and studies of drones in policing is less readily forthcoming in the literature compared with the body of work associated with BWCs. As an emerging tool for police and policing activities, it is anticipated that research in this field will increase over time. The application of drones in police and policing work is not new, as discussed by Smith (2017) and more recently Enemark (2021, p. 124):

> [g]overnments around the world are already making drones available to police for purposes including border control, criminal investigation, rescue missions, traffic management and the monitoring of public assemblies.

As recently as 2021, Wenguang and Zhiming (2021) in proffering an intelligent surveillance and reconnaissance mode of police unmanned aerial vehicles (UAV)/drone use based on a grid approach, discuss UAVs are actively deployed to support police and policing activities. The authors further proffer that applying police drones to complement the 'officer on the ground' has achieved all-around security management and technical investigation tasks in a more three-dimensional and multidimensional manner—offering real-time dynamic monitoring of public security. The application of drones, as discussed in the Wenguang and Zhiming (2021) study, did not extend to including the capabilities of BWC and AI technologies to scale up the support for police and policing activities. Oliver and Kugler (2022), in their comprehensive study of the use of surveillance technologies by US police agencies, indicate:

> [d]rones have become a feature of local policing, with police using drones to locate both suspects and missing persons, record video footage of an area, and for investigative purposes more generally. The many available functions of drones, including cameras, remote operation, and facial recognition, make these valuable tools from the perspective of police officers.

Whilst studies have indicated a general acceptance of drones, there remain areas of concern in some sectors of society. The work of Anania *et al.* (2019), studying the relationship between public support for police drone missions, political affiliation, and neighbourhood demographics, found that racial composition and political affiliation influenced perceptions of police use of UAVs. Sabino *et al.* (2022) identified in the systematic literature review on the main factors for public acceptance of drones there was widespread support by the surveyed public for the use of drones, especially for environment monitoring and rescue applications. The study further identified the populations perceived several risks in the use of drones, in particular, '… invasion of privacy, misuse, malfunction and damage, safety, noise and lack of legal liability' (Sabino *et al.*, 2022, para. 1).

In the USA, the most common policing use of drones, according to a 2020 survey by the Police Executive Research Forum (PERF), is for search and rescue operations, such as missing persons (Johnson *et al.*, 2023, p. 6). Johnson *et al.* (2023) further report that the critical rationale for using drones in policing is their ability to 'save enforcement time and money, faster than officers on the ground and significantly cheaper than helicopters' (p. 6). The Chula Vista Police Department in California was the first in the USA to pioneer a concept whereby drones are used proactively versus reactively. Through stationing drones across the 52 square mile jurisdiction, the first responder to an emergency is the drone to live stream visuals of the scene for analysis by officers to determine the officer response required (Steinert, 2021). As signalled by the Chief of Chula Vista Police, the application of drones for police and policing work can only expand as drones and other technologies advance, whilst also highlighting 'with technology you will always have to balance the rights of the community's privacy while protecting and keeping communities safe' (Steinert, 2021, p. 172). Concerning the conceptual BWC-drone integrated model, we are witnessing an example of 50% of the model already well established in the policing domain.

The rapid advances in technology are bringing tools to police and policing agencies that have the capacity to extend the reach of AI surveillance significantly. In discussing the integration of AI with drones and 'smart city' sensors, Hayward and Maas (2021) refer to current technologies, including

> [a]ccurate gigapixel cameras that can recognise faces and license plates in photos taken kilometres away such that a single drone overflight of a protest could in principle enable authorities to compile a list of all attendees (p. 220).

This is a stark reminder that approaches for utilizing BWC-drone integrated with AI require agencies to be cognizant of the development and application of ethical and privacy safeguards for community members and officers.

Robotics and drones

AI-equipped robotic units find application in diverse areas, including explosive detection, disposal operations, and surveillance within high-risk zones. Concurrently, drones offer aerial surveillance capabilities, particularly advantageous for monitoring large gatherings and inaccessible terrains. These technologies mitigate risks to officers and demonstrate enhanced efficacy in specific contexts (De Cubber *et al.*, 2017; Sheridan, 2016).

Theoretical framework

As indicated in the literature review, the BWC-drone-AI integrated approach has the potential to offer multiple prospective benefits including, but not limited to:

- Increasing the accumulation of evidence by capturing both the officer's interactions and comprehensive real-time intelligence, including potential escape routes and accomplices beyond the ground officer's field of vision;
- Increased safety for both policing and the community, the combined capabilities of the BWC-drone approach offering more strategic deployment of resources and tactical manoeuvres enhancing operational effectiveness;
- Potential reduction in violence through more adequately informed view of an evolving incident and an increase transparency of officer behaviour ensuring officer culpability for their own actions.

- Increasing officer levels of operational preparedness through employing the integrated model in training scenarios. Engaging an immersive and interactive platform such as a metaverse could simulate complex and high-stress scenarios for officers to practice using these technologies. Officers could learn how to deploy these technologies in various situations, understand the equipment's limitations and potential to apply, and understand the implications of strategic decision-making. Training in the metaverse could also include ethical and legal considerations, including respecting privacy rights and understanding how to manage and store data under the respective jurisdiction law (Dwivedi *et al.*, 2022).

Whilst the integrated approach benefits are evident, the associated ethical application is paramount for maintaining police legitimacy and procedural justice. This includes establishing clear guidelines for deployment that respect privacy and balance technological benefits against potential intrusions into personal privacy.

Integral to this ethical framework is the proactive addressing of biases in police data, which is crucial for preserving the objectivity of technology-driven insights. By embedding stringent data governance and bias auditing processes and by diversifying the data sources for AI training, the integrity of law enforcement practices and public trust can be safeguarded.

The focus on privacy also brings into contention the issue of the security of networks. From an operational standpoint, the BWC-drone-AI approach requires operating on a secure network to ensure real-time, uninterrupted communication. The data collection and storage, utilizing cloud technology or similar, must be encrypted for security and integrity to prevent unauthorized access and ensure that the data remains a reliable tool for justice and public safety.

Creating a theoretical framework to measure the benefits of the integrated use of a BWC-drone-AI approach in policing can be challenging in the absence of pre-existing data and metrics. However, an exploratory and adaptive approach provides opportunity to evaluate improvements in various aspects (Casula *et al.*, 2021; Stebbins, 2001; Swedberg, 2020). The exploratory and adaptive approach is appropriate for measuring the benefits of the integrated use of a BWC-drone-AI approach in policing for several reasons.

First, the integration of these technologies in policing is a novel concept. This lack of pre-existing data, established metrics, or best practices necessitates an exploratory approach to uncover new insights, generate hypotheses, and identify effective measures. Moreover, the impacts of the BWC-drone-AI framework are complex and multifaceted, encompassing areas such as situational awareness, evidence collection, safety, operational and tactical efficiency, and ethical and privacy concerns. A rigid evaluation methodology might not capture these diverse impacts adequately. Instead, an adaptive approach allows for continual learning and adjustment in these different areas as more data and insights become available. The technological landscape related to BWCs, drones, AI, and data analysis is also rapidly evolving. With an adaptive approach, the evaluation framework can keep pace with these advancements, ensuring that it remains relevant and effective.

Additionally, the implementation of this integrated three-technology framework can vary greatly between different jurisdictions and departments. Factors such as local laws, community norms, departmental resources, and officer training can influence how this model is applied. An adaptive approach can cater to this variability, allowing for tailored evaluation that takes into account the unique context of each implementation. The BWC-drone-AI approach effects extend beyond the strictly quantitative. Aspects including community trust, officer morale, and public perceptions also have a crucial role in the level of acceptance of these technologies, as has been experienced with BWCs and drones in their independent application for policing. An exploratory approach provides the premise for identifying the more nuanced impacts, fostering a more holistic understanding of the model's effectiveness (Jenkins, 2015; Manning, 2015; Schulenberg, 2007). Furthermore, an exploratory and adaptive approach can make the evaluation framework more responsive, comprehensive, and effective, helping to maximize the benefits of this innovative model whilst addressing weak points.

In instances where no existing data or metrics are available, creating a new theoretical framework to evaluate the benefits of an integrated BWC-drone-AI framework and approach would necessitate the formation of hypotheses about potential outcomes and ways of measuring them. The key here is to define what constitutes a successful outcome in each of the dimensions identified. The following evaluation framework has been developed to apply hypotheses to pilot or simulation studies, the results of which inform the continual refinement of the framework.

Conceptual evaluation framework

1. Situational Awareness: Hypothesise that the integrated BWC-drone-AI approach will provide a greater contextual understanding of policing incidents compared with any one of the technologies in isolation. This can be measured by analysing the completeness and clarity of the incident narrative when the technologies are used in combination versus when applied in isolation.
2. Evidence Collection: The hypothesis could be that the use of BWCs, drones, and AI together will increase the amount of actionable evidence collected during an incident. Measuring this to involve assessing the additional types of evidence collected, or the number of incidents where drone footage provided evidence that would have been missed by BWCs and vice versa.
3. Safety: Hypothesise that the combined use of these technologies will decrease the number of incidents that escalate to violence or harm to officers or the public. This can be measured by tracking the frequency and severity of violent escalations during incidents when the integrated model is used versus when it is not.
4. Operational Efficiency: The hypothesis that the use of BWCs, drones, and AI together will improve operational efficiency; for example, reduction in response and resolution of policing incidents can be established by comparing incident resolution times with and without the use of the integrated model.
5. Ethical and Privacy Compliance: Hypothesise that the integrated model can be used while complying with ethical

and privacy guidelines. This could be measured qualitatively, for example, through officer and public feedback, and measured quantitatively, by, for example, tracking the number of privacy concerns or complaints raised during the implementation of the BWC-drone-AI approach.

6. Training Effectiveness: Hypothesise that training officers in the metaverse will improve their understanding and ability to effectively use the integrated BWC-drone-AI approach. This could be measured by assessing officers' performance during simulated incidents in the metaverse before and after training.

The conceptual evaluation framework approach, producing both qualitative and quantitative data, would allow the framework to evolve as more data is collected and understanding of the effects of the integrated approach advances. The data analysis contributes to guiding future policies and procedures as an avenue to maximizing the benefits of the BWC-drone-AI framework. In the reality of application—looking back to look forward.

The matrix in Fig. 1 illustrates a structured approach to evaluate the impact of the BWC-drone-AI approach on policing effectiveness, with the assessment done both individually and in combination across six key performance indicators (KPIs). Each KPI is evaluated on a scale from low to very high impact. The BWCs and drones are evaluated separately to understand the unique contributions each brings to policing operations. For instance, BWCs provide a first-person perspective, enhancing situational awareness and ensuring safety through transparency, while drones offer an aerial view, aiding in evidence collection and situational awareness. Combining these two technologies potentially creates a synergistic effect, increasing their overall impact. The Combined Impact column reflects this synergy, showing how the combined use of BWCs and drones enhances the effectiveness across the range of KPIs.

The matrix also considers the impact of AI on each KPI. As the literature indicates, AI has the potential to significantly enhance the effectiveness of technologies by enabling real-time analytics, object recognition, predictive policing, evidence management, and training improvements. By quantifying the impact as low (1), moderate (2), high (3), and very high (4), the matrix (Fig. 2) provides a clear visual representation of the technologies' effectiveness. This simplifies the task of identifying areas where these technologies contribute significantly and where improvements may be of benefit.

Of note, the values assigned are relative and may vary based on specific contexts and the quality and use of the technology. Therefore, the matrix provides an overall perspective of the potential impact of these technologies when used in tandem with AI. It is not proposed that this process is a complete substitute for detailed situational analysis.

Case study application of the BWC-drone-AI approach

To place the BWC-drone-AI integrated conceptual approach and the associated evaluation framework into context, three case studies have been deconstructed, and the operational implications of a BWC-drone-AI approach and evaluation framework applied.

Case examination 1: Reimagining policing—An examination of BWCs, drones, and AI in counternarcotics operations

The United Nations Office on Drugs and Crime (UNODC) has used UAVs or drones in counternarcotics, illicit border trespassing, and unlawful drug crop harvesting operations. The UAVs are outfitted with a variety of technologies, including thermal, video, and photo cameras, as well as multispectral cameras, which allow for real-time surveillance and intelligence gathering. The UNODC Program Office in Kyrgyzstan performed combined tactical exercises with the Counter Narcotics Service of the Kyrgyz Ministry of Interior, demonstrating the effectiveness of UAVs and Unattended Ground Sensor (UGS) equipment in drug countering operations. UGS systems consist of a network of small, covert ground sensors such as seismic, infrared, and microwave sensors, in addition to unattended thermal, video,

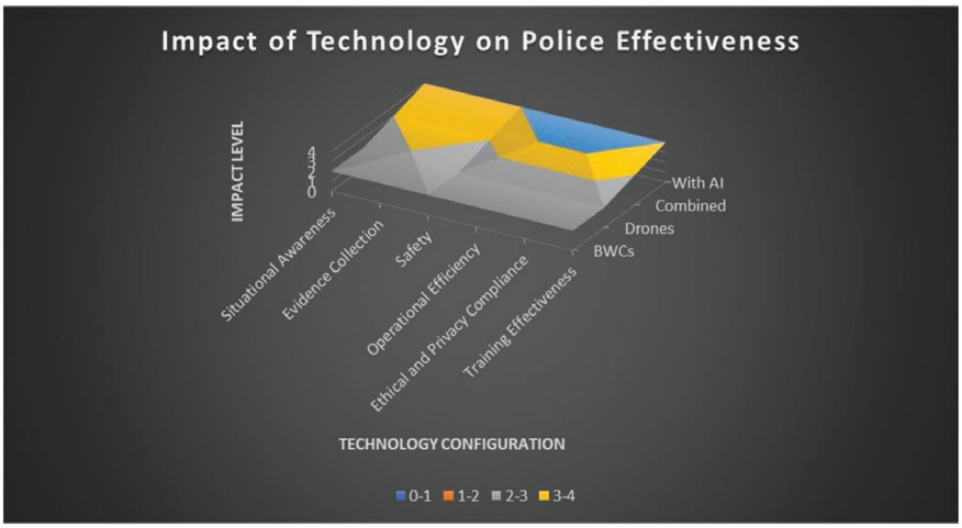

Figure 1: BWC-drone model impact matrix

KPI/Indicator	BWCs Impact	Drones Impact	Combined Impact	Impact with AI
Situational Awareness	Moderate	High	High	Very High
Evidence Collection	Moderate	High	High	Very High
Safety	High	Moderate	High	Very High
Operational Efficiency	High	Moderate	High	Very High
Ethical and Privacy Compliance	High	Moderate	High	Very High
Training Effectiveness	High	Low	Moderate	High

Very High Impact (assigned value of 4): The technological synergy of BWCs and drones, when paired with AI, has an exceptional contribution to the effectiveness of the police force in this area.

High Impact (assigned value of 3): The technological synergy of BWCs and drones greatly contributes to the effectiveness of the police force in this area.

Moderate Impact (assigned value of 2): The technological synergy of BWCs and drones significantly contributes to the effectiveness of the police force in this area.

Low Impact (assigned value of 1): The technological synergy of BWCs and drones somewhat contributes to the effectiveness of the police force in this area.

Figure 2: KPI indicator matrix

and photographic cameras (UNODC, n.d.). These sensors connect to a wireless ad hoc radio network and provide warning and service information to a command centre or field operator (UNODC, n.d.).

UAVs are used to map an area for prospective drug crop farms while a command centre watches the situation. Seismic sensors are installed on the field's approach routes, with each sensor having a circular detection zone of up to 300 m in diameter. Intruders detected within this detection zone generate an alarm at the command centre and can also activate an unattended camera for instant visual verification. The GPS coordinates of the sensor are utilized to create a drone travel plan, giving policing real-time intelligence.

Aligned to the proposed six indicators/KPIs in our evaluation framework, the benefits, and advances of using BWCs and drones in tandem could be as follows:

1. Situational Awareness: The use of BWCs, drones, and AI can provide an enhanced understanding of policing incidents. While drones offer an aerial perspective, BWCs give a crucial first-person viewpoint of the unfolding situation on the ground. This combination allows for better contextual understanding compared with using UGS systems, which might miss the human aspect of incidents. Furthermore, compared with UGS systems, BWCs are simpler to operate, requiring less technical training. AI algorithms can further improve this by processing real-time video feeds from both drones and BWCs, performing tasks such as automatic object and people recognition, behavioural analysis, and activity prediction. This allows for a more informed contextual understanding and a swift interpretation of vast amounts of data, thus enhancing decision-making.
2. Evidence Collection: Integrating BWCs with drones could boost the quality and quantity of actionable evidence collected. Drones can provide overarching aerial visuals, while BWCs document direct interactions and situations encountered by police officers. BWCs could provide more immediate, contextualized evidence than UGS systems. BWCs, used in conjunction with drones, can gather a diverse range of actionable evidence. Furthermore, BWCs are generally more cost-effective and less complex than UGS systems, making them a practical choice for evidence collection. AI can streamline this process by automatically tagging and categorizing data captured by drones and BWCs, highlighting key moments in the footage, detecting anomalies, and even cross-referencing evidence across multiple devices. This results in the collection of diverse and relevant actionable evidence, making BWCs a practical and cost-effective choice for evidence collection.
3. Safety: BWCs and drones, together, can enhance safety for both police officers and the public. BWCs offer transparency and accountability for officers' actions during encounters, which can discourage escalations. They are also simpler and more immediate in their operation compared with UGS systems, providing real-time documentation without the need for advanced technical setup. Unlike UGS systems, BWCs offer direct, officer-centred perspectives that can highlight areas of concern immediately. AI can enhance this further through predictive analytics, analysing body language and voice tones captured by BWCs to predict potential escalations and prompt preventive actions. This provides real-time documentation and can highlight areas of concern immediately, improving the safety of all involved.
4. Operational Efficiency: BWCs, coupled with drones, can improve operational efficiency. BWCs are simple to operate and provide direct, real-time footage, which can

accelerate decision-making and incident resolution. The economic benefit of BWCs over UGS systems lies in their relative affordability and simplicity, leading to equipment costs, and training time savings. The use of AI can automate certain tasks like real-time analysis of video footage, predictive patrolling, and streamlining evidence management, allowing officers to focus on critical decisions, thus reducing costs and training time.

5. Ethical and Privacy Compliance: BWCs, being more targeted in their surveillance, could potentially reduce privacy concerns compared with UGS systems. Guidelines for BWCs are often clearer and more established, ensuring ethical use and compliance. AI can be programmed to automatically redact sensitive information from the footage, maintaining privacy guidelines. However, ensuring that the AI itself is designed for ethical usage is important. In addition to being a crime deterrent and a useful tool for managing incidents, the presence of BWC footage has been linked to fewer complaints. According to a 2018 study, every dollar spent on BWCs saved $4 in litigation (Wexler, 2018).
6. Training Effectiveness: BWCs are technically simpler devices for police officers to operate compared with UGS systems. Training officers to use BWCs effectively can be quicker and less expensive. In combination with virtual platforms, for example, the metaverse for simulation, the effectiveness of training can be maximized. AI can play a pivotal role in virtual training environments, providing dynamic, and scenario-based training modules. It can assess officers' performance in real-time and provide feedback, enhancing training outcomes and maximizing effectiveness.

The combined use of BWCs, drones, and AI in counternarcotics operations could significantly enhance policing capabilities. This integrated approach, offering real-time evidence collection, enhanced situational awareness, and improved safety, would provide an effective and cost-efficient alternative to UGS systems. The role of AI in processing and analysing data, coupled with the accessibility of BWCs and the surveillance capabilities of drones, indicates a promising direction for future policing strategies. Despite potential challenges related to ethics and privacy, this preliminary exploration underlines the transformative potential of integrating these technologies for more effective policing operations.

Case Examination 2: The synergy of sky and ground—Evaluating the role of BWCs, drones, and AI in FBI operations

In 2013, the FBI stated that it utilized drones ten times over US soil, including the successful rescue of a 5-year-old child who was being held hostage in an underground bunker in Alabama during the nearly 7-day standoff (Underwood, 2013) where two bombs were found (Pearson, 2013). The FBI's revelation came in a letter to Kentucky US Senator Rand Paul, in which the agency claimed that drones are never armed and are exclusively employed for surveillance in the USA. According to the FBI, drones have been employed as help in fugitive tracing, narcotics investigations, kidnappings, and search and rescue missions in two national security cases and eight criminal cases (FBI Has Used Surveillance Drones on US Soil 10 Times, 2013). According to the National Conference of State Legislatures, data for 2021, at least 44 states have laws or resolutions addressing drones (Current Unmanned Aircraft State Law Landscape, 2023). However, each state has its regulations and protocols, which allow some police departments to have greater access to drones than others. For example, only 15 states mentioned the need for a warrant when police used drones in their jurisdictions through 2021. All 15 states have exceptions that permit police to operate drones without warrants in extreme or exceptional circumstances (Cahill, n.d.). On the other hand, since October 2020, the US Department of Justice has integrated BWCs on federal task forces, including ATF, DEA, FBI, and USMS, during pre-planned policing operations (Office of Public Affairs, 2020). A month later, in December 2020, the Department of Justice Office of Community Oriented Policing Services (COPS Office) published a Roadmap to Implementing an Effective Unmanned Aircraft System (UAS) Program, the first in a series of deliverables deemed essential to advancing the safe and appropriate use of Unmanned Arial Surveillance (UAS) technology.

In the context of this case examination, the benefits, and advances of using BWCs and drones in tandem, when augmented with AI, can be applied to the six KPIs in the following manner:

1. Situational Awareness: In the event the FBI utilized BWCs in 2013 during the Alabama crisis, it would have provided a ground-level perspective of the situation that drones alone could not offer. These cameras could have provided an immediate, first-person view of the situation, which is essential in fast-moving or tense scenarios. However, without AI to assist, the volume of data could have been overwhelming, reducing the timeliness of response. With AI, the video feeds from drones and BWCs could have been analysed simultaneously in real-time, enhancing overall situational awareness by predicting potential scenarios and aiding in devising effective strategies.
2. Evidence Collection: Using BWCs coupled with drones would have provided a larger, more detailed volume of evidence from different vantage points. However, without AI, the task of manually sorting through this data would have been labour-intensive and time-consuming. With AI, the process of tagging, categorizing, and cross-referencing evidence could have been significantly expedited and simplified, leading to a comprehensive, organized collection of actionable evidence.
3. Safety: BWCs would have given the officers the ability to document their interactions during the standoff, possibly acting as a deterrent to escalation and enhancing both officer and hostage safety. Without AI, though, the prediction of escalations would still rely heavily on human judgment. AI can provide added benefits through analysis of body language and voice tones to predict potential escalations and suggest appropriate actions, thus further enhancing safety.
4. Operational Efficiency: Drones and BWCs together would provide wider surveillance coverage, with the potential to

streamline operations by offering real-time footage from different perspectives. However, extracting useful insights from this large dataset would be challenging and time-consuming without AI. AI can enhance operational efficiency by automating certain tasks, such as analysing the footage, thus reducing the resources needed and resolution time.

5. Ethical and Privacy Compliance: Using BWCs in 2013 would have been instrumental in ensuring accountability and transparency during operations. Without AI, protecting privacy would still be a manual task with potential errors and omissions. With AI, however, algorithms could automatically redact sensitive information from the footage, ensuring compliance with privacy guidelines and ethical use of technology.
6. Training Effectiveness: In a world where BWCs were available in 2013, the video footage could have served as invaluable training material for future incidents. However, without AI, the effectiveness of this training would depend largely on manual analysis and feedback. With AI, dynamic, scenario-based training in virtual environments could be provided, with real-time performance assessment and feedback, thereby enhancing the overall training effectiveness and operational readiness.

The 2013 Alabama hostage crisis highlights the potential of a BWC-done-AI framework in policing. Despite the constraints of that time, drones provided crucial aerial surveillance. The addition of BWCs could have offered a detailed ground-level view, aiding evidence collection and enhancing safety. When these technologies are augmented with AI, their utility can be significantly amplified. AI can analyse real-time video feeds to guide strategic decisions, automate evidence processing, increase operational efficiency, and help ensure ethical and privacy compliance.

Case Examination 3: Analysis of drone and BWC use in Santa Monica police first respondents

In Santa Monica, California, USA, drones are being utilized as first responders prior to the arrival of police officers at a scene. This innovative approach, known as the "drones as first responder" initiative, originated in 2018 in the San Diego suburb of Chula Vista (Hodge, 2023). The city secured FAA approval to integrate drones into its airspace, expanding drone usage to other Californian cities like Beverly Hills and Redondo Beach. A key benefit of employing drones is their potential to defuse tense situations. For instance, consider a 911 call in Santa Monica reporting an armed individual in a drugstore parking lot. Swiftly deploying a drone initially appeared to corroborate the report (Dilanian, 2023). Nevertheless, upon closer examination of the drone footage, it became evident that the individual was actually using a lighter, not wielding a firearm (Barnes, 2023). This real-time insight enabled officers to adapt their approach, mitigating potential hazards.

1. Situational Awareness

For first responders, immediate and accurate information is crucial. Drones provide a rapid aerial assessment of a scene, allowing first responders to gauge the situation before they arrive. BWCs, once on the scene, offer a real-time, ground-level perspective, ensuring that first responders are constantly aware of their immediate surroundings and any potential threats.

2. Evidence Collection

From a first responder's viewpoint, the initial moments at a scene are often the most critical for evidence collection. Drones can capture the broader context of an incident, while BWCs document the officers' first-hand interactions and immediate findings, ensuring that no detail, however minute, is overlooked.

3. Safety

Safety is paramount for first responders. Drones can identify potential threats or hazards from a distance, allowing first responders to approach cautiously. BWCs, meanwhile, record interactions in real time, ensuring that any confrontations or challenges faced by officers are documented, which can deter aggressive behaviour and promote accountability.

4. Operational Efficiency

Efficiency is key in emergency situations. Drones can be quickly dispatched to provide an initial assessment, allowing first responders to strategize their approach. BWCs ensure that every action taken on the ground is recorded, minimizing the need for retrospective reports, and allowing for a more streamlined documentation process.

5. Ethical and Privacy Compliance

From a first responder's perspective, maintaining public trust is essential. Drones, while effective, must be used judiciously to respect privacy. BWCs ensure transparency in immediate interactions with the public, demonstrating that officers are held to ethical standards in their conduct. Together, they strike a balance between effective response and respect for individual rights.

6. Training Effectiveness

For first responders, continuous learning and improvement are vital. Drone and BWC footage offer invaluable insights into the challenges faced during initial interventions. While drone footage can highlight strategic and positional decisions, BWCs provide a detailed account of interpersonal interactions and decision-making under pressure. This combined footage can be instrumental in training sessions, refining the skills, and approaches of first responders.

In summary, from a first responder's perspective, the integrated use of BWCs, drones, and AI in the Santa Monica Police Department offers a comprehensive approach to initial interventions. This tandem use ensures that first responders have both a macro and micro perspective, optimizing their response while ensuring safety, efficiency, and ethical conduct.

Conclusions and recommendations

The impact of technology such as BWCs, drones, and AI on policing is complex and multifaceted. As indicated in the literature, individually, these technologies are impacting policing endeavours across a broad spectrum of activities (Braga *et al.*, 2022; Davies and Krame, 2023; Enemark, 2021). Combining these technologies and understanding how such a combined BWC-drone-AI framework influences policing falls to adopting a flexible exploratory approach to capture the wide array of outcomes and the nuanced elements that underpin the activities. The integrated use of BWCs, drones, and AI in policing is a relatively new field. Traditional methods, which often rely on historical data and established theories, might not provide the necessary depth of understanding for this novel context. In contrast, an exploratory approach allows for continuous learning and adaptation based on emergent findings, proving more effective in navigating such novelty. The effectiveness of BWCs, drones, and AI in policing can be influenced by a variety of contextual factors, from the specifics of the situation to the training of the officers involved. The exploratory approach provides an in-depth understanding of these contextual factors and their interplay with the technology, thereby offering a richer and more nuanced evaluation than traditional methods.

Harnessing the rapid advances of technology is evidenced in the conceptual BWC-drone-AI integrated approach; however, such concepts must be accompanied by the methodology to evaluate their benefits, advantages, and disadvantages to contribute to informed decision-making as to their deployment. This article has presented the rationale for adopting a BWC-drone-AI integrated framework to support the endeavours of police and policing agencies, importantly, accompanied by a conceptual evaluation tool underpinned by documented rationale.

Integrating BWCs, drones, and AI is revolutionizing policing in unprecedented ways. Each of these technologies has already shown significant impact across a range of policing activities, as evidenced by recent studies (Brager *et al.*, 2022; Davies and Krame, 2023; Enemark, 2021). However, the synergy arising from their combined use—what we term the BWC-drone-AI framework—opens up new vistas of opportunity and challenge.

While the BWC-drone-AI framework shows promise, it is imperative that its deployment is guided by a robust evaluation methodology. This article has laid the groundwork by presenting a conceptual evaluation tool that is both flexible and rigorous. This tool aims to assess the integrated framework's benefits, drawbacks, and overall impact, thereby contributing to informed decision-making, policy, and protocol development for its wider adoption.

Limitations and future directions

In pursuing enhancing law enforcement capabilities through technological integration, this investigation has established a conceptual framework that is at the forefront of evaluating the efficacy of an amalgamated approach involving BWCs, drones, and AI. The initial outcomes of this research suggest that such an integration has the potential to augment the operational effectiveness of policing agencies, bolster situational awareness, and contribute to the enhancement of transparency and accountability within law enforcement procedures.

Nevertheless, this study encounters a significant limitation in that the extant literature is deficient in examining the synergistic application of BWCs, drones, and AI. This lacuna in research highlights the imperative for empirical inquiries that can substantiate and refine the proposed framework, thereby ensuring its robustness and applicability within the contemporary policing landscape.

The KPIs delineated herein represent an innovative and exploratory step towards quantifying the benefits of technological synergy in law enforcement. While these KPIs are predicated on contemporary scholarly discourse and the projected advantages of the technologies, their capacity to encapsulate the comprehensive application of these technologies in law enforcement has yet to be fully realized. Consequently, developing these KPIs is an incipient endeavour, with the anticipation that future scholarly work will extend and enhance these indicators through empirical substantiation and interdisciplinary critique.

Future scholarly endeavours should be directed towards the empirical application of this integrated approach across diverse operational scenarios, including both simulated and authentic field conditions. Rigorous methodological designs should underpin such investigations and should leverage the proposed conceptual framework to critically evaluate the efficacy of technology integration. This is of paramount importance as law enforcement agencies globally navigate the intricate and evolving security challenges of the contemporary era.

The current absence of standardized benchmarks for the integrated application of BWCs, drones, and AI in policing presents a seminal opportunity for scholarly and practical advancement. Subsequent research is tasked with the development of universal benchmarks that will inform the deployment and evaluation of these technologies, fostering consistency and methodological rigour across varied policing contexts.

It is essential to recognize that this research constitutes the inaugural scholarly endeavour to methodologically assess the effectiveness of an integrated technological approach within the domain of policing. The absence of pre-existing models or KPIs accentuates the innovative essence of this work, necessitating provisional assumptions in the initial formulation of the evaluation framework. With the accumulation of empirical data and the progression of the field, it is anticipated that both the methodology and the KPIs will be subject to iterative refinement, thereby augmenting their validity and practical relevance.

Thus, this study should be perceived as an initial, yet pivotal, contribution that not only introduces a new evaluative framework but also catalyses ongoing research. The limitations delineated herein signify the emergent nature of this field and should act as a catalyst for future scholarly and operational pursuits aimed at advancing intelligent policing practices that are both efficacious and attuned to the societal ramifications of technological integration. This study's trajectory for future research is unequivocal: to empirically validate, refine, and standardize the integrated use of BWCs, drones, and AI in policing, propelling law enforcement into a new epoch characterized by innovation and underpinned by rigorous empirical scrutiny.

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