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Unmasking The Digital Trail: Integrating Cyber Forensics In Serial Homicide Investigations

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ABSTRACT

Serial homicide investigations require complex investigative procedures. In digital age, the trace to the offenders is equally available in the digital records as is available at the crime scenes. With this as the context, the research paper aims to elucidate on the intersection of cyber forensics in the realm of serial homicide investigations, shedding light on how digital evidence is becoming an indispensable tool for law enforcement agencies and how it can play an important role in decoding the chain linkages, *modus operandi,* etc., in serial homicides.

Through a synthesis of case studies and empirical analysis, the paper expounds the pivotal impact of cyber forensics in unmasking perpetrators and establishing evidentiary links in serial homicide scenarios. It highlights the evolving nature of criminal activities in the digital age and underscores the need for law enforcement to adapt with the developing cyber forensics investigative methodologies accordingly.

Furthermore, the paper explores various challenges and ethical considerations inherent in leveraging cyber forensics, addressing issues such as privacy concerns and potential legal constraints. It provides insights into the development of protocols and best practices for law enforcement agencies to effectively utilize digital evidence while respecting individual rights.

The findings underscore the significance of a multidisciplinary approach, emphasizing collaboration between cyber forensic experts and traditional investigative units. Ultimately, this research contributes to the ongoing discourse on enhancing investigative methodologies, thus, ensuring that justice is served in the face of evolving criminal landscapes.

Keywords: Culpable homicide, Cyber Forensics, Serial Homicide, Digital Evidence, Novel Investigative Methodologies

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Homicide, a deliberate termination of another individual's existence, has persisted throughout the history of humanity. Motivation for such an action includes the preservation of one's dwelling or sustenance, the acquisition of authority, or the manifestation of intense animosity. Presently, throughout the global legal frameworks, homicide is universally considered as a criminal offense, underscoring the paramount importance afforded to the sanctity of life.

Murder, a material crime, comprises in its effect the taking of another person's life.[3] Under the Indian legal framework murder has been defined as an act which is done with the intention of causing death, or causing such bodily injury which is likely to cause the death, or causing bodily injury which is sufficient in the ordinary course of nature to cause death, or lastly, an act that it is so imminently dangerous that it must, in all probability, cause death.[4]

In this regard, the term 'serial homicide' does not receive explicit mention within the statutory provisions of our criminal justice system as the term 'serial homicide,' is relatively new, despite the incidence of such crime as an act per se existing throughout the history of mankind.

Serial Homicide can be defined as an act when *"a serial murderer kills at least three victims in various locations and within such time intervals that each murder constitutes an independent act making up part of a series,"*[5] and that it can take place over the space of several days, weeks, or even years. However, in order to enhance the operational efficacy of law enforcement agencies, there was a need to adopt a more encompassing definition of this phenomenon, one that transcended the confines of explicit statutory delineations. Hence, the National Centre for the Analysis of Violent Crime defined serial murder as the unlawful killing of two or more victims by the same perpetrator(s), in separate incidents comprising a series.[6]

Furthermore, as the prevalence of serial homicides continues to escalate over time, there arises a pressing imperative to transcend conventional legal paradigms in apprehending perpetrators. Therefore, arises a need for novel solutions that not only address the commission of such offenses but also proactively endeavour to forestall their occurrences. This necessitates a departure from traditional law enforcement methodologies towards the development and implementation of contemporary strategies tailored to the distinctive characteristics of serial criminality.

Criminal Profiling is one such technique which studies the interrelationship between physical evidence and psychological evidence left at crime scenes.[7] Profiling is now called Criminal Investigative Analysis and

[3] A. Urbanek, *The Experience of Tenson in relation to the Victim, based on Interviews with Murderers* 11 (ATUT Oficyna Wydawnicza, Wrocław, 2010).
[4] The Indian Penal Code, 1860 (Act 45 of 1860), s. 300.
[5] J.A. Fox, J. Levin, *et. al.*, *Extreme Killing: Understanding Serial and Mass Murder* 90 (SAGE Publications, New Delhi, 5th edn., 2023).
[6] Federal Bureau of Investigation, Serial Murders: Multi-Disciplinary Perspectives for Investigators, 8-9 (U.S. Department of Justice, 2005).
[7] ST. Holmes and R.M. Holmes, *Profiling Violent Crimes: An Investigative Tool* (SAGE Publications, Thousand Oaks, 3rd edn., 2002).

involves the examination of each behavioural aspect and detail of an unsolved violent crime in which evidence of psychopathology has been left at the crime scene.[8] Criminal profiling endeavours to accomplish four primary objectives: firstly, to furnish the investigative team with a comprehensive psychological delineation of the perpetrator, coupled with, whenever feasible, a prognostic assessment of their conduct; secondly, to refine the pool of potential suspects; thirdly, to maintain persistent surveillance of the prospective offender; and fourthly, to establish an interconnected framework grounded in the analysis of the *modus operandi*, in conjunction with other pertinent factual considerations, thereby, facilitating the discernment of relevant implications.[9]

Stages of Criminal Profiling

The process of Criminal Profiling can be delineated into six distinct stages:

- Profiling Inputs

  The initial stage of Criminal Profiling, known as Profiling Inputs, encompasses the systematic collection of evidentiary data and materials. These include information gleaned from the crime scene such as physical evidence, details regarding the positioning of the body, and specifics regarding the utilized weaponry. Additionally, pertinent data concerning the victim, encompassing their personality traits, social standing, habitual behaviours, and comprehensive descriptions of their personal and professional circumstances, are acquired. Moreover, criminalistic data pertaining to the manner of death, toxicological analysis, and related forensic assessments are incorporated. The preliminary police report and photographic documentation, inclusive of aerial imagery delineating the crime scene area, constitute integral components of this phase.[10]

- Decision Process Models

  During the second stage, known as the Decision Process Models, the amalgamated data collected in the preceding phase is systematically organized to elucidate distinct models for subsequent decision-making processes. This phase involves the differentiation of various typologies of perpetrators, ranging from solitary homicides to mass killings, serial murders, or murder sprees characterized by the absence of a cooling-off period and the dispersion of incidents across temporal and spatial dimensions.

- Assessment of Crime

  The third stage, denoted as the Assessment of the Crime, entails a meticulous reconstruction of the sequence of events, wherein criminal profiling specialists endeavour to delineate the most plausible behaviours exhibited by both the perpetrator and the victim.[11] This process entails not only an examination of the temporal progression of events but also an evaluation of the extent of premeditation and coordination

[8] M.E. O'Toole, "Criminal profiling: the FBI uses Criminal Investigative Analysis to solve Crimes" 61(1) *CJ* 44-46 (1999).
[9] J.E. Douglas and M. Burgess, "Criminal Profiling - A Viable Investigative Tool Against Violent Crime" 55(12) *FBILEB* 9-13 (1986).
[10] K. Gradoń, *Multiple Killing: Criminal Profiling* 165 (Wolters Kluwer, Warsaw, 2010).
[11] *Id.* at 170.

involved in the commission of the crime. Consequently, this stage facilitates the determination of whether the perpetrator demonstrates characteristics indicative of an organized or disorganized nature, achieved through an analysis of victim selection, the perpetrator's exertion of control, and the unfolding dynamics throughout the criminal act.

- Refinement of Perpetrator Profile

The fourth stage entails a refined synthesis of the data pertaining to the perpetrator, wherein an intricate profile of the unidentified offender is meticulously constructed. This profile encompasses comprehensive details regarding the perpetrator's background, including their intellectual aptitude, occupational status, educational background, and an evaluation of their interpersonal interactions. Additionally, it incorporates information pertaining to the perpetrator's external attributes, behavioural tendencies, appearance, and anticipated conduct preceding, during, and subsequent to the commission of the offense. The primary objective of this stage is to furnish both indicative clues and strategic recommendations concerning the approach that investigative authorities should adopt in relation to the individual under scrutiny.[12]

- Digital Evidence and Forensic Analysis

The subsequent stages in the profiling procedure, namely the fifth and sixth phases, entail forensic analysis and apprehension of the suspect. In the event that fresh evidence or information surfaces during the investigative process, it necessitates a comprehensive reassessment and adjustment of the entirety of previously gathered data and deductions, in alignment with the newly acquired evidential material.[13]

This stage of forensic analysis has led to an emerging trend in the contemporary law enforcement, involving the utilization of computer models for crime prediction, facilitated by algorithms capable of self-learning, notably the Machine Learning techniques. This approach, known as predictive policing, leverages mathematical analytics and Machine Learning algorithms to anticipate potential criminal activities. Within the framework of predictive policing, distinct methodologies are employed for forecasting crime occurrences, anticipating the identities of potential perpetrators, and predicting prospective victims.[14] It is essential to clarify that predictive methods do not possess the capability to forecast future events per se; rather, they serve to identify individuals and locations exhibiting heightened susceptibility to criminal activities. Consequently, these predictive methodologies are intended to be integrated as integral components of broader proactive strategies aimed at addressing issues pertaining to criminality.[15]

One such strategic approach is Forensic Modelling, which entails a perceptual and processing procedure of source data predicated upon conditional probabilistic syllogisms, namely the 'if, then, probably' framework.

[12] K. Bonda and B. Lach, *An Imperfect Crime: The greatest Criminal Mysteries of recent years solved by a Polish Profiler* 37 (Videograf, Chorzów, 2012).
[13] Wayne Petherick (ed.), *Serial Crime: Theoretical and Practical Issues in Behavioural Profiling* (Elsevier, San Diego, 2nd edn., 2009).
[14] Yakimov, I.N., (1924). A practical guide to the investigation of crimes.
[15] Jonathan Caulkins, Jacqueline Cohen, *et. al*. "Predicting Criminal Recidivism: A comparison of neural network models with statistical methods" 24(3) *JCJ* 227-240 (1996).

This method endeavours to establish and leverage inherent connections and relationships within immersive and prognostic models of criminal activity mechanisms and investigative protocols.[16] The overarching aim is to construct a comprehensive evidentiary framework within a criminal case. Forensic modelling facilitates the acquisition of novel insights into the origin of criminal phenomena and employs them to address a spectrum of investigative challenges, including search, cognition, recognition, identification, and others.[17]

Computer models utilized for crime prediction are categorized into two distinct groups:

- Type one programs are designed to ascertain individuals most predisposed to perpetrating or falling victim to criminal activities. These programs analyse various aspects of individuals' profiles, encompassing age, criminal history, employment records, and social interactions, often gleaned from online platforms such as social media. The specific types of data employed in these models vary according to the discretion of developers, with details sometimes remaining undisclosed.
- Whereas the models belonging to the second type prioritize temporal and spatial considerations, focusing on the when and where of potential criminal incidents. Algorithms employed in these models partition urban areas into smaller zones, typically spanning several tens of meters, such as specific neighbourhoods or intersections. It is by utilizing incoming data, these algorithms compute probabilities associated with the likelihood of criminal events occurring within these delineated zones.[18]

The way these models work can be divided into three categories:[19]

1. **Boolean:** This means the answer is either 'Yes' or 'No', represented by 1 or 0. For example, the question 'Is there a connection between the criminal and the victim?' would have a yes or no answer.

2. **Categorical:** Herein, the answer falls into a specific category. There are usually more than two options to choose from. For instance, if we're considering the age of the criminal, there could be different categories like 'teenager,' 'young adult,' or, 'middle-aged.'

3. **Quantitative:** This type of model gives responses as numbers that represent a certain measurement. For example, if we're looking at the distance from where objects were thrown by the criminal, the answer would be a number indicating how far they were thrown.

One of the prevailing trends in contemporary law enforcement involves the utilization of computer models founded on algorithms endowed with self-learning capabilities, namely Artificial Intelligence ("**AI**") and Machine Learning, aimed at the investigation, prediction, and prevention of criminal activities. Among these technologies, Digital Twin stands out as a prominent tool, constituting a synchronized virtual representation of various entities, encompassing objects, systems, individuals, processes, and environments. This model simulates internal dynamics, technical attributes, and behavioural patterns of the corresponding real-world entities under the influence of external stimuli and environmental factors.

[16] Luzgin, I.M., (1980). On the issue of forensic modelling. Topical problems of Soviet criminalistics.
[17] Volchetskaya, T.S., (1997). Modern modelling problems in forensic science and investigative practice: a textbook.
[18] Aaron Shapiro, "Reform Predictive Policing" 541 *NP* 458-460 (2017).
[19] *Supra* note 14.

The Digital Twin framework facilitates retrospective analysis and prospective forecasting, functioning as a dynamic learning system, comprising a comprehensive array of mathematical models spanning different levels of complexity. These models are refined through empirical data obtained from field experiments, thus, constituting an evolving digital profile encapsulating historical and pertinent data pertaining to the physical entity or process under scrutiny. Leveraging Machine Learning algorithms in conjunction with Digital Twins enables the creation of robust predictive models capable of forecasting the future behaviour of the subject entity, predicated upon the analysis of extensive and semi-structured datasets.[20]

With respect to serial homicides the challenge lies in the isolated recording of individual criminal incidents, impeding the timely detection of patterns indicative of serial killings. Consequently, serial killers are afforded the opportunity to perpetuate their criminal endeavours unabated. A potential solution to this predicament involves the conception and implementation of a digital counterpart of such a serial killer. This innovative approach entails the integration of two distinct categories of computational models within a crime prediction framework. Leveraging this technology would facilitate the identification of prospective perpetrators and enable the prediction of both the temporal and spatial dimensions associated with impending criminal acts. By amalgamating these predictive capabilities, law enforcement agencies stand to enhance their proactive intervention strategies, thereby, mitigating the recurrent perpetration of criminal offenses by serial killers.[21]

Thus, one of the benefits of using an AI program is its ability to analyse vast amounts of data. This includes not only information about crimes but also data about various aspects of the world, like natural phenomenon, news stories, and global politics. As a result, AI can uncover connections between crimes and other events that may not be immediately apparent. An illustrative instance, demonstrating the existence of non-obvious connections was provided in 1980 by Phillips. In his study, Phillips revealed a peculiar correlation: following a surge in media coverage pertaining to suicides, there was a remarkable 1,000% increase in fatalities resulting from plane crashes. Intriguingly, this escalation in fatal incidents extended beyond aviation mishaps, manifesting in a notable rise in road accidents as well. This observation underscores the potential of utilizing comprehensive datasets within AI programs to unveil latent patterns that have hitherto eluded detection within the realm of scientific inquiry.[22] In the process of developing a digital twin, multiple concurrent research domains can be delineated, all underpinned by the fundamental tenets of Machine Learning, specifically focusing on data, features, and algorithms. The initial domain, which serves as an indispensable precursor to the creation of software tools, pertains to the establishment of an extensive dataset comprising real-world cases that have been effectively concluded. This foundational step is essential for providing the requisite empirical basis upon which subsequent analytical endeavours are predicated within the digital twin framework.[23]

[20] A.F. Lubin, "Forensic Science: Features of Didactics Versioned Thinking" 17(3) *JSP* 84-93 (2021).
[21] L.V. Bertovsky, "High-tech Law: Concept, Genesis and Prospects" 25(4) *RUDNJL* 739 (2021).
[22] Robert B. Cialdini, *Influence: The Psychology of Persuasion* 135-136 (Harper Business, India, 2006).
[23] *Supra* note 19.

Challenges in developing AI digital Models for Crime detection

When constructing a model, it is crucial to understand the types of questions the algorithm can handle. A computer program learns from experience as it tackles specific tasks and objectives. As it gains more experience, its ability to solve these tasks improves relative to the set objective. Therefore, the focus of the learning process is not solely on the data, but rather on the objective function and how results are evaluated. The choice of objective function dictates all subsequent work, and even tasks that seem similar can lead to entirely different models depending on the chosen objective function.[24]

However, building a digital twin model is challenging due to various factors such as significant diversity in data, limited structuring, small datasets in terms of Machine Learning methods, high dimensionality of feature space, and the absence of a clear hypothesis regarding the distribution of source data. Furthermore, another challenge lies in analysing the natural language texts to automatically differentiate information from different sources, such as incident scene inspection reports, victim interrogation protocols, forensic medical examination conclusions, and indictments.[25]

Key Factors in Developing AI Models for the Prevention of Serial Homicides

Detecting serial crimes involves a process where specific cases are classified into established crime series. This classification task is typically carried out by seasoned investigators who rely on pre-marked data or indictment outcomes. To enhance effectiveness, ensemble Machine Learning methods, which involve training multiple models to address the same problem and combining their outputs, are often employed. The underlying hypothesis is that by utilizing a combination of weaker models, more accurate and reliable crime classification results can be achieved.[26]

In the context of predictive policing, clustering is utilized to group similar crime incidents together. Unlike classification, where the number of classes is known beforehand, clustering involves grouping data points into clusters without prior knowledge of the number of clusters. The dataset consists of feature vectors representing various aspects of each incident, and the objective is to develop a model that can assign new incidents to existing clusters or create new clusters when necessary.[27]

There exist various neural network architectures, such as Cohonen networks, graph neural networks, or adaptive resonance networks, which can effectively address this clustering task. These networks take input variables, which can be binary or analog, and produce output values representing the distance to existing

[24] Adderley, R. and Musgrove, P.B., (2001). Data mining case study: modelling the behaviour of offenders who commit serious sexual assaults. In: Proceedings of the Seventh ACM SIGKDD International Conference on Knowledge Discovery and Data Mining, 26 August 2001, New York: ACM. Pp. 215–220.

[25] Gromov, V.I., (2003). Inquiry and preliminary investigation. Methods of investigation of crimes. Examination of the crime scene (Collection of scientific works): To the 200th anniversary of the founding of the Lomonosov Moscow State University.

[26] Gross, H., (2002). A guide for forensic investigators as a system of criminology. Moscow: LekEst. P. 1088.

[27] Irina Kotlyarova, "Method of Modelling in Pedagogical Researches: History of Development and Current State" 11(1) *SUSU* 7 (2019).

clusters. Throughout the model's life cycle, adjustments are made to its training parameters to ensure accurate identification of trends and connections between unsolved murders and related crimes.[28]

Conclusion

The relentless march of technological advancement continues unabated, with predictive policing emerging as a prominent tool deployed worldwide, showcasing its effectiveness in enhancing law enforcement efforts. However, despite the widespread adoption of predictive policing techniques, the detection rate of serial murders remains alarmingly low. To address this critical gap, the development of a groundbreaking initiative: the 'digital twin serial killers' program can be initiated. This innovative endeavour aims to harness cutting-edge technology to gather crucial data on potential offenders, crime scenes, victims, and weaponry, thereby, revolutionizing investigative methodologies.

In the immediate future, the primary focus should lie on addressing key challenges, both operational and legislative in nature. A paramount task entails the establishment of a comprehensive dataset comprising completed cases and ongoing investigations. This dataset must be meticulously curated, ensuring its adequacy in volume and timeliness in updates to facilitate its seamless utilization. Additionally, the selection and optimization of Machine Learning algorithms represent a critical endeavour. By carefully evaluating and choosing the most suitable algorithms, we can develop a robust digital twin model tailored specifically for analysing crimes with serial characteristics.

The envisaged program holds immense potential in augmenting the solvability of serial murders while simultaneously alleviating the burden on law enforcement agencies. Thus, by leveraging sophisticated analytical tools and advanced data processing techniques, we can unravel intricate patterns and associations inherent in serial criminal activities. Moreover, the utilization of predictive analytics enables law enforcement agencies to adopt a proactive stance, pre-emptively identifying and thwarting potential threats before they materialize into criminal acts.

Undeniably, the success of the program hinges on concerted efforts to foster collaboration across various stakeholders in the criminal justice ecosystem. A collaboration between technology developers, law enforcement agencies, and policymakers is essential for ensuring the seamless integration and deployment of the program's capabilities. Furthermore, ongoing refinement and optimization of the digital twin model are imperative to enhance its effectiveness and adaptability to evolving crime trends and patterns.

In conclusion, the advent of such progressive initiatives represents a pivotal milestone in the evolution of law enforcement methodologies. By harnessing the power of technology and data-driven insights, we can usher in a new era of proactive crime prevention and detection. Hence, the authors of the paper do believe that through sustained collaboration and innovation, we can realize the full potential of predictive policing, ultimately contributing to a safer and more secure society for all.

[28] *Ibid.*