



The Research Frontline - Journal

A Peer-Reviewed Quarterly Journal of Interdisciplinary
Inquiry and Research

Journal homepage: <https://trfjournal.cdfaindia.org/index.php/trfjournal/en/index>

AI and Digital Evidence in Indian Sexual Assault Cases: A Legal-Ethical Analysis

Hamda Akhtarul Arfeen

To cite this article: Arfeen, H.A. (2026): AI and Digital Evidence in Indian Sexual Assault Cases: A Legal-Ethical Analysis, The Research Frontline - Journal (Vol 1, Issue 2, January - March 2026)

DOI:<https://doi.org/10.66871/trf-j.v1i2.047>

To link to this article: <https://doi.org/10.66871/trf-j.v1i2.047>




© 2026 The Author(s). Published by
Allahabad Academic Press,



Published online: 05 May 2026.



Submit your article to this journal 



Vol. 1, Issue 2, January - March 2026



AI and Digital Evidence in Indian Sexual Assault Cases: A Legal-Ethical Analysis

Hamda Akhtarul Arfeen¹

¹PhD Scholar, Symbiosis International University, Pune (India)

ABSTRACT

This research explores the use of artificial intelligence in India's digital forensic system, particularly in sexual assault investigations. As cybercrime grows, agencies are adopting AI tools like facial recognition, automated analysis, and rapid DNA matching to handle complex digital evidence more efficiently. The study highlights how these technologies can reduce delays caused by backlogs and manual processes, enabling faster chargesheet filing.

It also considers integration with platforms like the National Cyber Crime Reporting Portal and the Indian Cyber Crime Coordination Centre (I4C). Further, it examines legal and ethical concerns under the Bharatiya Sakshya Adhinyam, 2023, the Digital Personal Data Protection Act, and the IT Act. The research concludes by proposing an ethical framework to balance efficiency with transparency and data protection, ensuring timely justice delivery.

ARTICLE HISTORY

Received: 10 February 2026
Accepted: 30 March 2026

KEYWORDS

AI forensic tools, Sexual assault investigations, Ethical considerations, Fundamental Rights, DPDP Act, Bharatiya Sakshya Adhinyam, 2023

I. Introduction

The notion of AI is not new or recent; it is rather embedded into our lives far more than we have admitted. The upcoming generations are dependent on these AI tools for their normal day-to-day life activities. Though the idea of AI doesn't revolve around only science fiction, but has soon become a reality through the use of AI support personal attendants like SIRI or Google Talk, the use of maps or motorized driving vehicles, or phones suggesting websites, songs, or videos reflecting our inclination.^[1] Globally, the world is witnessing the fourth industrial revolution, with artificial intelligence becoming a foundation for all technological transformation initiatives.^[2] AI is seen as a detachment of computer science and how machines can impersonate human intelligence (being human-like rather than becoming human beings). The "English Oxford Living Dictionary" noted: "The theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages".^[3] Kaplan and Haenlein define AI as "the ability of a system to correctly interpret external data, learn from such data, and use it to achieve specific goals and tasks through flexible adaptation."^[4]

[1] Christopher Kuner, Fred H. Cate, et.al., "Expanding the Artificial Intelligence-Data Protection Debate, 8(4) International Data Privacy Law 289 (2018).

[2] Adib Bin Rashid and MD Ashfakul Karim Kausik, "AI Revolutionizing Industries Worldwide: A Comprehensive Overview of Its Diverse Applications" (2024) 7 Hybrid Advances 100277.

[3] Oxford Learner's Dictionaries 2022.

[4] Michael Haenlein and others, "Artificial Intelligence (AI) and Management Analytics" (2019) 6 Journal of Management Analytics 341.

CONTACT: Hamda A. Arfeen  hamda.arfeen@gmail.com

© 2026 the author(s). Published by Allahabad Academic Press, India. This is an Open access article distributed under the terms of the Creative Commons attribution license (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. The terms on which this article has been published allow the posting of the accepted Manuscript in a repository by the author(s) or with their consent.

The wave of technology in the face of AI and Generative AI has permeated diverse aspects of our lives, knowingly or unknowingly, and has raised the aspect of multidisciplinary research. Artificial Intelligence is a system's capability to analyse external data, comprehend it, and apply and adapt to distinct tasks. Even after so much deliberation around the term 'Artificial Intelligence, there is no infallible definition of the said term. However, the term has an umbrella effect to it and includes all of the computerized techniques and methods used for eclectic human work like pattern forming, calculations, computer vision, language processing, etc. In general, the work done by the tools of Artificial Intelligence, which was to be done by the human mind, is being done by the use of machines, and then it is 'Artificial Intelligence'.

The use of scientific concepts, procedures, and methodologies for the sake of justice is known as forensic science. In order to investigate the crime and provide justice to the people concerned, it entails the application of efficient scientific tools and methodologies. When someone was accused of a crime, they were required to present their case before a group of people in the forensic, or forum, era, which is where the term "forensic science" originated in ancient Rome. Recent trends in AI have brought drastic transformations in forensic science and pathology. Technology introduced us to new terminologies as 'datasets', 'algorithms', 'data analysis', 'pattern recognition', 'anomaly identification', which are building these big data-driven decision-making systems. In forensic medicine, AI/ML aids in crime scene analysis, DNA analysis, ballistic identifications, analysis of traumatic injuries, toxicology reports, and many more. More quickly and accurately than traditional human-centric methods alone, these sophisticated algorithms can evaluate enormous amounts of data, identify complex patterns, and glean insightful information from the evidence.^[5]

AI has emerged as a disruptive force in the field of digital forensics, altering traditional investigative techniques. From ballistics comparisons to facial recognition and fingerprint analysis, AI systems have shown a great deal of promise in improving forensic procedures. It may speed up the evidence collection techniques, storing evidence, and even facial recognition technologies and biometrics, which can help solve crimes faster, speeding up the dispensation of justice. The increasing usage of digital devices is accompanied by an increase in the sophistication of cybercrimes.^[6] However, extremely successful machine learning techniques that use the insights gained from huge data analysis, artificial intelligence have advanced.^[7] Digital forensics (DF) faces growing challenges in terms of precision and timeliness in the analysis of a rising amount of data from increasingly diverse sources.^[8]

To assist law enforcement, a variety of intelligence techniques were available. For instance, in crime analysis, the following techniques emerged: geographic analysis, crime pattern analysis, investigative techniques like network analysis, telephone record analysis, and bank record analysis, and in strategic analysis, threat assessments, target profiles, and strategic targeting. These technologies are excellent in quickly processing enormous datasets, finding subtle patterns that human analysts would miss, and possibly minimizing procedural errors. But integrating them into forensic operations necessitates carefully weighing their advantages and disadvantages.^[9] Nevertheless, the challenges that come with the deployment of AI in sectors are still being discussed globally, and the risks of privacy, bias, and data security need to be addressed to ensure responsible and ethical use of AI to its fullest potential in various sectors.^[10]

[5] Shai Farber, "AI as a Decision Support Tool in Forensic Image Analysis: A Pilot Study on Integrating Large Language Models into Crime Scene Investigation Workflows" (2025) 70 *Journal of Forensic Sciences* 932.

[6] Shai Farber, "AI as a Decision Support Tool in Forensic Image Analysis: A Pilot Study on Integrating Large Language Models into Crime Scene Investigation Workflows" (2025) 70 *Journal of Forensic Sciences* 932.

[7] Russell, S., Norvig, P., *Artificial Intelligence: A Modern Approach*, Prentice Hall Press, 2009, 3rd edition.

[8] https://cris.unibo.it/bitstream/11585/799009/1/2020.Brighi_etal_Legal_issues_in_AI_forensics.pdf.

[9] Shai Farber, "AI as a Decision Support Tool in Forensic Image Analysis: A Pilot Study on Integrating Large Language Models into Crime Scene Investigation Workflows" (2025) 70 *Journal of Forensic Sciences* 932.

[10] D. H. Pethkar, "Artificial Intelligence in Forensic Science: Bridging Systematic Challenges with Next-Generation Applications" (2025) 12 *International Journal of Scientific Research in Science and Technology* 536.

These technologies are excellent in quickly processing enormous datasets, finding subtle patterns that human analysts would miss, and possibly minimizing procedural errors. But integrating them into forensic operations necessitates carefully weighing their advantages and disadvantages.^[11]

Nevertheless, an extensive examination of AI's definition would exceed the scope of this study. Throughout AI's development, various methodologies have been explored that have alternatively focused on cognitive processes and human logic or behavioral patterns, seeking to create systems that replicate human task performance and develop either optimally intelligent systems or systems that utilize logical decision-making processes to function effectively. For the context of this research, AI can be understood as a tool that can perform and support human activities. This functional perspective allows us to examine AI's applications without delving into the broader theoretical debates about artificial intelligence itself. This approach enables a more focused analysis of how AI technologies can be practically implemented and utilized, rather than getting absorbed in the complex philosophical and technical discussions surrounding the nature of artificial intelligence.^[12]

The integration of AI in gathering and analysing digital evidence forensically represents a potential game-changing advancement that could enable the judicial system to optimize processes, especially by reducing investigation duration. In today's environment, AI has infiltrated multiple domains of forensic examination, transforming conventional approaches. The analysis of images and videos has undergone a particularly significant transformation, with AI systems now demonstrating capabilities in identifying faces, detecting objects, and improving the quality of poor visual evidence obtained from crime scenes. These technological advances offer the possibility of processing evidence more efficiently and extracting valuable information that might otherwise be difficult to obtain through traditional methods. This technological evolution in forensic analysis represents a shift toward more automated and potentially more accurate evidence processing, which could substantially impact how criminal investigations are conducted and how quickly cases can be resolved.^[13]

FORENSIC EVIDENCE

Edmond Locard, a pioneer in forensic science, opined that a criminal will always leave an aspect of his in the crime and to explain this gave the concept of exchange, which asserts that "when two entities come in contact with each other, they leave a trace on each other," is one of the fundamental tenets of forensic science. In the sense that even a pattern will be sufficient to identify the suspect and assist us in carrying out our procedures from crime scenes to courtrooms, this principle is essentially in charge of the foundation of forensic science and investigation, as well as artificial intelligence.^[14]

AI^[15] can be a helpful tool in many ways, including:

- i. Data analysis and availability to support the inquiry.
- ii. Dealing with issues that have a clear scope and case technique.
- iii. Identification of patterns.
- iv. Giving a thorough explanation of the thinking process.
- v. In forensic science, lowering the number of false-positive or false-negative results during analysis is a standard practice.

[11] Shai Farber, "AI as a Decision Support Tool in Forensic Image Analysis: A Pilot Study on Integrating Large Language Models into Crime Scene Investigation Workflows" (2025) 70 Journal of Forensic Sciences 932.

[12] Raffaella Brighi, Michele Ferrazzano and Leonardo Summa, "Legal Issues in AI Forensics: Understanding the Importance of Humanware" [2020] Journal of Legal Sciences, Cognitive Sciences and Artificial Intelligence.

[13] Shai Farber, "AI as a Decision Support Tool in Forensic Image Analysis: A Pilot Study on Integrating Large Language Models into Crime Scene Investigation Workflows" (2025) 70 Journal of Forensic Sciences 932.

[14] Siddhant Gupta, Vinny Sharma and Prashant Johri, "Artificial Intelligence in Forensic Science" (2020) 7 International Research Journal of Engineering and Technology (IRJET) 7181.

[15] Swapnil R. Kamdar and Astha Pandey, "The Scope of Artificial Intelligence in Forensic Science" 58 The Indian Police Journal 48.

- vi. The legal community will also benefit from formalizing the representation of knowledge to provide prompt and precise solutions.
- vii. Knowledge discovery and data mining.
- viii. Constructing statistical proof.
- ix. Connecting with existing applications, tools, and architecture.

Pattern recognition plays a vital role in the criminal justice system. Humans possess a natural ability to identify patterns and have developed skills to differentiate between various elements, including objects, individuals, information, complex emotional states, and situations. AI technology seeks to replicate this human capability through computer hardware and software systems. AI utilizes datasets to develop the ability to identify individuals from photographs, execute sophisticated robotic and computational operations, analyse online consumer behavior and purchasing trends, diagnose medical conditions from complex imaging studies, and forecast financial market trends. These self-improving algorithms demonstrate AI's potential to mirror human pattern recognition abilities across diverse applications. This technological capacity to identify and interpret patterns has significant implications for criminal justice applications, where the ability to recognize connections and anomalies can be crucial for investigative success.^[16]

APPLICATION FOR AI TOOLS

Although forensic science provides information from the crime scene to help clear the air and convict those responsible, the majority of the work is still done by humans, who take their time and make mistakes. Therefore, using artificial intelligence will make things much faster, more efficient, and error-free. By providing such analyses on object-based data analysis, AI removes this. For instance, by using AI-based technologies that provide rapid analysis of large digital evidence or DNA samples, the backlog of cases awaiting forensic scientists' analysis can be reduced.^[17] Artificial algorithms are being used in treatment to infer radiological images that could play a major role in the administration of and collection of evidence, which can expedite the justice delivery system, which could have important implications for the criminal justice and medical examiner communities when establishing cause and manner of death.^[18]

Facial Recognition Technology

In order to help criminal investigations, the criminal justice and law enforcement communities use video and image analysis to gather information about individuals, items, and activities. Conventional human-assistance software algorithms are restricted to preset features like eye color, shape, and distance between eyes for facial recognition or demographic data for pattern analysis. Beyond what humans could think, AI video and image algorithms can learn and do difficult jobs by developing and determining their own unique complex facial recognition features and parameters. These algorithms can detect complicated events like accidents and crimes in progress or after the fact, match faces, and recognize guns and other things. With National Institute of Justice(USA) funding and in collaboration with the FBI and the National Institute of Standards and Technology, researchers at the University of Texas at Dallas are evaluating human facial recognition and exploring ways to compare AI algorithms and skilled visual examiners. According to preliminary findings, AI-based facial recognition algorithms created in 2017 perform similarly to human face examiners when the researchers set a recognition time constraint of 30 seconds. A team of researchers at the University of Central Florida is working with the Orlando Police Department to create algorithms that can recognize things in videos, including people, vehicles, weapons, and buildings, without the need for human assistance. Additionally, they are creating algorithms to recognize behaviors like violent crimes and traffic accidents.^[19]

[16] <https://nij.ojp.gov/topics/articles/using-artificial-intelligence-address-criminal-justice-needs>

[17] Muhammad Arjamand and others, "The Role of Artificial Intelligence in Forensic Science: Transforming Investigations through Technology" 7 International Journal of Multidisciplinary Research and Publications (IJMRAP) 67.

[18] Christopher Rigano, "Using Artificial Intelligence to Address Criminal Justice Needs" (National Institute of Justice, October 8, 2018) <<https://nij.ojp.gov/topics/articles/using-artificial-intelligence-address-criminal-justice-needs>> accessed July 6, 2025.

[19] Christopher Rigano, "Using Artificial Intelligence to Address Criminal Justice Needs" (National Institute of Justice, October 8, 2018) <<https://nij.ojp.gov/topics/articles/using-artificial-intelligence-address-criminal-justice-needs>> accessed July 6, 2025.

DNA Analysis

The majority of the cells in our bodies contain DNA, which is specific to each person and leaves a trace of ourselves wherever we go. Forensic investigators who utilize DNA to identify victims and suspects at crime scenes now have an advantage because of this.^[20] To perform a forensic DNA analysis, DNA is first extracted from a sample. Just one nanogram of DNA is usually a sufficient quantity to provide good data.^[21] According to delicate processes developed in recent years, police would now be able to detect even the smallest traces of DNA and "touch DNA" on evidence or at the scene of a crime. During the conduct of a crime, contact with persons and items can spread biological material, including blood, saliva, semen, and skin cells. The sensitivity of DNA analysis has increased along with DNA technology, enabling forensic investigators to find and handle low-level, deteriorated, or otherwise unusable DNA evidence that was previously unusable. Large volumes of complicated data are produced in electronic format by DNA analysis; these data contain patterns that may be beyond the scope of human interpretation but could be helpful when system sensitivity rises.^[22] The implementation of hybrid analytical systems has demonstrated significant improvements in DNA sample processing capabilities, enabling forensic laboratories to handle increased caseloads while maintaining rigorous quality standards.

STRmix, GEDmatch, and Parabon NanoLabs are examples of tools that employ AI to evaluate DNA evidence and identify suspects.^[23] The Golden State Killer case (2018)^[24] in the United States was a significant forensic genealogy case in which detectives matched DNA from murder scenes with genetic profiles found in public databases using GEDmatch. However, these procedures have brought up moral concerns around consent and genetic privacy.

In *Ranjitsing Brahmajeetsing Sharma v. State of Maharashtra*^[25], the Apex Court recognized the relevance of DNA evidence in criminal trials. An important step toward the official acceptance of DNA testing in the Indian court system was taken with the passage of the DNA Technology (Use and Application) Regulation Bill, 2019^[26]. In order to set guidelines for the use and preservation of DNA profiles, this law was filed to control the use of DNA technology for establishing people's identities in criminal and civil proceedings.^[27] The *Nirbhaya* case (2012) in India, in which forensic specialists employed DNA profiling to identify and convict the offenders, was a significant case for DNA analysis.^[28]

AI-Powered Crime Scene Analysis and Data Integration

Machine learning algorithms possess the capability to analyse and identify connections within this information that might escape human investigators' attention. Additionally, AI can synthesise various types of accessible data to create comprehensive crime scene reconstructions, offering investigators a more complete understanding of events. DNA evidence analysis represents a cornerstone of modern investigative techniques. AI has the potential to significantly enhance this process by automating the analysis of complex DNA mixtures, which traditionally present considerable challenges for human analysts to interpret accurately. Through automated systems, AI can handle these intricate biological -

[20] Jaya Lakshmi Bukyya and others, "DNA Profiling in Forensic Science: A Review" (2021) 08 Global Medical Genetics 135.

[21] Norrgard, K. (2008) Forensics, DNA fingerprinting, and CODIS. *Nature Education* 1(1):35.

[22] Eman Ahmed Alaa El-Din, "Artificial Intelligence in Forensic Science: Invasion or Revolution?" (2022) 10 Egyptian Society of Clinical Toxicology Journal 20.

[23] Abhishek Sharma Padmanabhan and S Sapna, "Forensic Investigation Approaches of DNA Analysis and Criminal Investigation" (2023) 13 International Journal of Safety and Security Engineering 129.

[24] Ray A Wickenheiser, "Forensic Genealogy, Bioethics and the Golden State Killer Case" (2019) 1 Forensic Science International: Synergy 114.

[25] (2005) 5 SCC 294 : 2005 SCC (Cri) 1057 : 2005 SCC OnLine SC 696 at page 329.

[26] The DNA Technology (Use and Application) Regulation Bill, 2019 was introduced in Lok Sabha by the Minister for Science and Technology, Mr. Harsh Vardhan, on July 8, 2019. The Bill provides for the regulation of use of DNA technology for establishing the identity of certain persons.

[27] Aditya Nuna and Tejas Gupta, "The Role of Forensic Evidence, DNA Tests, and Narco-Analysis in the Indian Legal System" (Elsevier BV 2025) <<https://doi.org/10.2139/ssrn.5069346>> accessed July 7, 2025.

[28] Muhammad Arjamand and others, "The Role of Artificial Intelligence in Forensic Science: Transforming Investigations through Technology" 7 International Journal of Multidisciplinary Research and Publications (IJMRAP) 67.

samples more efficiently and potentially with greater precision than conventional manual methods. This technological advancement allows forensic teams to process evidence more rapidly while potentially uncovering insights that might otherwise remain undetected through traditional investigative approaches.

AI algorithms are constantly getting better at recognizing contributors to a mixture and combining each in one profile, improving the accuracy and speed of DNA profiling.^[29] Traditional forensic examination methodologies, including visual inspection, microscopic analysis, infrared spectroscopy, and conventional chemical testing protocols, are characterized by inherent temporal and accuracy limitations. These conventional approaches often require extensive processing time and may yield inconclusive or erroneous analytical results, particularly when confronted with insufficient sample quantities or degraded evidence materials.^[30]

In contrast, artificial intelligence-driven analytical systems demonstrate superior precision and efficiency in trace evidence detection and characterization. Machine learning algorithms can identify and analyse microscopic evidence with enhanced accuracy while significantly reducing processing timeframes. This technological advancement is particularly valuable in forensic cases involving sexual offenses, where the detection of biological evidence such as spermatozoa may be compromised by minimal sample volumes or challenging preservation conditions.^[31]

Pattern Recognition

Among the various artificial intelligence architectures employed in forensic applications, convolutional neural networks (CNNs) represent one of the most promising and effective computational frameworks. In forensic odontology, CNN architectures have proven particularly effective in automated dental identification procedures, demonstrating superior performance in tooth detection and systematic numbering on periapical radiographic images. Furthermore, convolutional neural networks have shown significant promise in sex determination analyses based on dental morphological characteristics.^[32] These AI systems can systematically analyze dental features and morphometric measurements to provide reliable sex estimation, contributing valuable information to forensic identification processes in cases involving skeletal remains or incomplete biological evidence. The National Institute of Justice (NIJ), has demonstrated sufficient efficacy to warrant integration into the Chicago Police Department's comprehensive Violence Reduction Strategy.

The incorporation of predictive analytics into operational law enforcement protocols represents a significant advancement in proactive crime prevention methodologies. A notable implementation of predictive analytics in law enforcement was developed through collaborative efforts between the Chicago Police Department and the Illinois Institute of Technology. This partnership resulted in the creation of advanced algorithmic frameworks designed to systematically collect and analyse comprehensive datasets, enabling the formation of strategic analytical groupings for enhanced crime prevention initiatives. Moreover, these digital technologies can help in analysing the fingerprints, handwritten notes, including other types of biometric data, once the database is created, matching gets easier, faster, and accurate; in turn reducing human error.^[33]

[29] Muhammad Arjmand and others, "The Role of Artificial Intelligence in Forensic Science: Transforming Investigations through Technology" 7 *International Journal of Multidisciplinary Research and Publications (IJMRAP)* 67.

[30] Suresh Kumar and others, "Use of Artificial Intelligence in the Field of Forensic Medicine & Criminal Investigation: A Way Forward - IJFMTS" (2024) 9 *IP International Journal of Forensic Medicine and Toxicological Sciences* 73.

[31] Ray A Wickenheiser, "Forensic Genealogy, Bioethics and the Golden State Killer Case" (2019) 1 *Forensic Science International: Synergy* 114.

[32] Madzida Hundur Hiyari, Mirza Pasic and Selma Zukic, "Application of Convolutional Neural Networks for Determining Gender and Age in Forensic Dentistry" [2024] *Cureus*.

[33] Christopher Rigano, "Using Artificial Intelligence to Address Criminal Justice Needs" (National Institute of Justice, October 8, 2018) <<https://nij.ojp.gov/topics/articles/using-artificial-intelligence-address-criminal-justice-needs>> accessed July 6, 2025.

3D Crime Scene Modeling and Virtual Reconstruction

The investigative value of AI-powered 3D reconstruction extends beyond courtroom presentation to include critical analytical capabilities that have contributed to significant breakthroughs in complex criminal investigations. These sophisticated three-dimensional visualizations serve as powerful demonstrative evidence, enabling courtroom audiences to develop a comprehensive understanding of crime scene dynamics and the sequence of events that transpired during criminal incidents. These systems excel in trajectory analysis, particularly in cases involving projectile evidence, enabling forensic investigators to accurately determine bullet paths, impact angles, and points of origin with remarkable precision.

Additionally, the technology facilitates detailed positional analysis, allowing investigators to reconstruct the spatial relationships between suspects, victims, and physical evidence at critical moments during criminal events, thereby providing crucial insights into the mechanics and chronology of criminal activities.[34] In *State v. Peterson* (2003)[35] forensic rebuilding played a crucial role in determining whether Kathleen Peterson's death was a coincidence or homicide. AI-driven 3D reconstructions can offer courts more precise visual representations of crime scenes, refining judicial decision-making.

A particularly significant development in this domain is the emergence of virtopsy, also referred to as virtual autopsy, which represents a revolutionary non-invasive approach to postmortem examination. This advanced technological framework employs sophisticated imaging modalities, including computed tomography (CT) scanning, magnetic resonance imaging (MRI), and three-dimensional surface scanning techniques, to conduct comprehensive examinations of deceased individuals without requiring traditional invasive dissection procedures.[36]

Artificial intelligence technologies have assumed a pivotal role in the advancement of bloodstain pattern analysis (BPA), representing a substantial enhancement in forensic blood evidence interpretation capabilities. The implementation of AI-driven BPA technologies has proven particularly valuable in determining the precise spatial positioning of victims and perpetrators during the commission of violent crimes. Through systematic analysis of bloodstain distribution patterns, impact angles, and spatter characteristics, these intelligent systems can generate highly accurate reconstructions of the physical dynamics present at crime scenes.[37]

The implementation of AI-enhanced forensic reporting systems provides substantial analytical support to judicial officers, enabling more comprehensive evaluation of complex forensic evidence and facilitating more informed judicial determinations. These intelligent systems ensure that judges have access to thorough analytical frameworks and comprehensive evidentiary assessments that support equitable and scientifically sound legal judgments.

LIMITATIONS AND CHALLENGES

We must make sure to pursue the strategy that maximises the benefits of artificial intelligence's profits while minimising its risks, since, on the whole, its advantages outweigh its threats. A person-centric approach to AI is desired in order to keep us on the right track. This means that we must remember that the development and application of AI should not be viewed as a path in and of itself, but rather as

[34] Saurav Yadav and others, "Artificial Intelligence: An Advanced Evolution In Forensic and Criminal Investigation" (2022) 1 Current Forensic Science.

[35] 634 S.E.2d 594

[36] Saurav Yadav and others, "Artificial Intelligence: An Advanced Evolution In Forensic and Criminal Investigation" (2022) 1 Current Forensic Science.

[37] Niketha Ravivarma, "Development of an Artificial Intelligence Method for the Analysis of Bloodstain Patterns" <<https://hdl.handle.net/11244/330997>> accessed July 7, 2025.

a means to increase personal security. Since people can only assertively and fully reap the benefits of AI if they can trust the technology, trustworthy AI will serve as our compass. Evaluating the legal and human rights ramifications of excessive use of ICT or artificial intelligence tools is no longer about the future; rather, it is about the present. Concerns about jurisdiction, data leaks, privacy, copyright, and other human rights issues are emerging as a result of the battle for human and fundamental rights in this age of overuse of AI-driven tools.^[38]

The interpretation of information, also known as the interpretation of information in Artificial Intelligence and ontologies, is the most important principle in the majority of AI programs. This refers to how we interpret the facts that we wish to debate and how we methodically organise the knowledge representation so that we can debate it. It is crucial to keep in mind that our understanding of knowledge may involve the characteristics of AI and how we process the data, and how it is implemented.

The ethical framework governing AI applications in forensic science encompasses four fundamental challenge categories that demand rigorous attention from practitioners and policymakers.

(1) Informed consent to use

The primary ethical concern relates to informed consent protocols, which require establishing comprehensive procedures for obtaining appropriate authorization before implementing AI analytical tools on individual cases or personal data. The use of artificial intelligence in criminal investigations, particularly facial recognition technology and widespread surveillance systems, has sparked significant privacy issues. India's Supreme Court established privacy as a constitutional right under Article 21 in the landmark *K.S. Puttaswamy v. Union of India*^[39] case from 2017. Despite this ruling, government agencies continue implementing AI-driven monitoring systems without adequate data protection legislation in place. The UK provides a relevant precedent through the *R (on the application of Bridges) v. South Wales Police* case from 2020, where the Court of Appeal ruled that law enforcement's deployment of real-time facial recognition technology breached privacy rights. This decision represents a significant legal milestone in limiting AI surveillance overreach.

(2) Safety and transparency

Safety and transparency considerations represent the second critical ethical dimension, necessitating the development of robust protocols that ensure AI systems operate with appropriate levels of reliability while maintaining transparency in their analytical processes and decision-making algorithms. This transparency requirement is essential for maintaining public trust and ensuring that forensic AI applications remain accountable to judicial and scientific scrutiny.

(3) Algorithmic fairness and biases

The third major ethical challenge concerns algorithmic fairness and bias mitigation, which requires systematic evaluation and correction of potential discriminatory patterns that may emerge in AI analytical systems. These concerns are particularly significant in forensic applications where biased algorithms could disproportionately impact certain demographic groups or communities. These AI-driven predictive systems have been documented to systematically direct increased law enforcement attention toward certain neighbourhoods and populations, often reflecting historical patterns of -

[38] Karen Yeung, Council of Europe, "A study of the implications of advanced digital technologies (including AI systems) for the concept of responsibility within a human rights framework" DGI(2019)05.

[39] WP (C) 494/2012.

discriminatory policing practices rather than objective risk assessment. A particularly well-documented manifestation of AI bias in criminal justice applications involves the Correctional Offender Management Profiling for Alternative Sanctions (COMPAS) system, which has been extensively analysed for its discriminatory impact on racial and ethnic minorities. A comprehensive analysis of COMPAS algorithms revealed systematic disparities in risk assessment outcomes, with the system demonstrating a pronounced tendency to classify Black defendants as high-risk offenders at significantly higher rates compared to white defendants with similar criminal histories and circumstances.[40] In *State v. Loomis* (2016)[41] the Wisconsin SC ruled that the defendant's sentencing could not be solely based on AI predictions due to concerns about bias and lack of transparency.[42]

(1)Data Privacy Protection

This constitutes the fourth fundamental ethical challenge, requiring the implementation of comprehensive safeguards to protect sensitive personal information processed by AI systems while ensuring compliance with privacy regulations and maintaining individual confidentiality rights. In the United States, forensic applications involving health information must comply with HIPAA regulations[43], which establish stringent requirements for protecting personally identifiable health information (PHI). The GDPR's[44] automated decision-making provisions create additional regulatory complexity for AI-enhanced forensic systems. The automated decision-making framework (Article 22 GDPR) serves as a form of indirect control over the use of AI systems, on the basis that AI systems are frequently used to take automated decisions that impact individuals. The “Digital Personal Data Protection Act (DPDPA) 2023” is India's first inclusive data privacy framework of India aiming to regulate private information and protect and process personal information of citizens.

(2)Privacy Issues and Surveillance

The deployment of AI technologies in criminal investigations across India raises significant privacy concerns regarding data collection and surveillance practices. While AI capabilities such as facial recognition systems, predictive policing algorithms, and social media monitoring can enhance law enforcement's ability to identify and prevent criminal activities, these same technologies pose risks of creating extensive surveillance networks that may infringe upon citizens' privacy rights. In India, individual liberties are fundamental principles, and the widespread implementation of AI surveillance systems creates potential for invasive monitoring of ordinary citizens. Facial recognition technology exemplifies this concern, as it can operate continuously in public areas, capturing and processing images of people without their awareness or permission. This capability enables real-time tracking of individual movements and activities. Although such surveillance tools may prove effective in criminal detection and crime prevention, they raise critical questions about the appropriate boundaries of government surveillance power and the protection of citizens' privacy rights. The challenge lies in balancing law enforcement effectiveness with the preservation of civil liberties in a democratic society. [45]

(3)Admissibility of AI-Generated Evidence

Since legal systems consider it difficult to establish specific regulations for AI-driven investigations, the admissibility of forensic evidence generated through AI remains a serious concern globally. In India,

[40] Tim Brennan and William Dieterich, “Correctional Offender Management Profiles for Alternative Sanctions (COMPAS)” [2017] Handbook of Recidivism Risk/Needs Assessment Tools 49.

[41] 881 N.W.2d 749 (Wis. 2016)

[42] Hlr, “State v. Loomis” (2017) 130 Harvard Law Review.

[43] Health Insurance Portability and Accountability Act,1996.

[44]The General Data Protection Regulation, 2016.

[45]Navin Kumar, “From Surveillance to Sentencing: Evaluating AI’s Role in Indian Criminal Justice” (2025) 30 Scientific Bulletin 68.

courts have been cautious in accepting AI-based evidence due to concerns about accuracy, bias, and dependability. In *Anvar P.V. v. P.K. Basheer*^[46] (2014) it was ruled that on the admissibility of electronic evidence, requiring compliance with Section 65B of the Indian Evidence Act, 1872, which outlines the conditions under which digital evidence can be considered valid.

The case of *United States v. D'Angelo* (2018) represents a significant international example of judicial scrutiny regarding AI-assisted digital evidence analysis. This case demonstrated the substantial evidentiary value of AI technologies in processing complex digital evidence while simultaneously highlighting critical concerns about the reliability and transparency of AI-generated analytical conclusions. However, the defense counsel in *D'Angelo* raised fundamental challenges to the admissibility of AI-generated evidence, arguing that the absence of adequate human oversight and the opaque nature of AI decision-making processes created substantial reliability concerns. The defense contended that AI-generated evidence should be excluded from judicial consideration due to the inherent "black box" characteristics of machine learning algorithms, which prevent meaningful examination of the reasoning processes underlying AI analytical conclusions.^[47]

FORENSIC EVIDENCE IN SEXUAL ASSAULT CASES

Sexual assault investigations conducted by forensic laboratories in India encompass a broad spectrum of criminal cases involving diverse biological and non-biological evidentiary materials. The effectiveness of these forensic investigations is influenced by several critical factors, including the nature of evidence being examined, the quantity and quality of available samples, and the analytical capabilities of the investigating laboratory. The probative value of physical evidence is inherently dependent on the specific circumstances surrounding each case, where evidence that may prove pivotal in one prosecution could hold minimal significance in another. For instance, fingerprint evidence, hair samples, and touch DNA may establish a suspect's presence at a crime scene, but such evidence could have been deposited under innocent circumstances hours or days before the actual crime occurred. However, when circumstances indicate that the suspect had no legitimate reason to be at the location, such scientific evidence assumes highly incriminating significance.

Under the Indian Evidence Act, 1872, expert opinion evidence is admissible under Section 45, which allows courts to consider scientific evidence presented by qualified forensic experts. The Indian Penal Code, originally under Sections 375-376 and now under Sections 63-64 of the *Bharatiya Nyaya Sanhita, 2023*, provides the legal framework for prosecuting sexual assault cases, while the Criminal Procedure Code mandates specific procedures for evidence collection, including medical examination of victims under Section 164A.

Unlike the extensive CODIS^[48] system in the United States, India's DNA database system is still developing but includes crime scene DNA profiles, convicted offender profiles, and missing persons databases. The Supreme Court of India, in *State of Punjab v. Gurmit Singh* (1996)^[49], established that DNA evidence is admissible under Section 45 of the Evidence Act, emphasizing the reliability of DNA profiling in sexual assault cases.

[46] (2014 10 SCC 473)

[47] Nasa Zata Dina, Sri Devi Ravana and Norisma Idris, "Legal Judgment Prediction Using Natural Language Processing and Machine Learning Methods: A Systematic Literature Review" (2025) 15 SAGE Open.

[48] The Combined DNA Index System, or CODIS, blends forensic science and computer technology into a tool that enables federal, state, and local forensic laboratories to exchange and compare DNA profiles electronically, thereby linking serial violent crimes to each other and to known offenders. Using the National DNA Index System of CODIS, the National Missing Persons DNA Database also helps identify missing and unidentified individuals.

[49] AIR 1393, 1996

The landmark Nirbhaya case, decided by the Supreme Court in *Mukesh & Anr v. State for NCT of Delhi* (2017)[50], highlighted the critical importance of comprehensive forensic evidence collection in sexual assault cases. This case led to significant legal reforms through the Criminal Law (Amendment) Act, 2013, which introduced mandatory medical examination protocols, standardized evidence collection procedures, and time-bound investigation requirements. The Protection of Children from Sexual Offences (POCSO) Act, 2012, further strengthened the legal framework by establishing special provisions for child victims, including mandatory reporting requirements and child-friendly evidence collection procedures.[51]

Forensic toxicological investigations play a crucial role in cases involving drug-facilitated sexual assault, providing corroborative evidence through the identification of substances such as benzodiazepines, ketamine, and other sedatives in blood, urine, and hair samples. The Narcotic Drugs and Psychotropic Substances Act, 1985, governs the investigation of cases involving date-rape drugs and provides the legal framework for toxicological analysis. These investigations are particularly time-critical, as the detection window for many substances is limited, although improved sensitivity of toxicological methods has extended detection periods for certain drugs.[52]

The Central Forensic Science Laboratory (CFSL) and state forensic science laboratories operate under standardized guidelines established by the Bureau of Police Research and Development (BPR&D), which outline standard operating procedures for DNA evidence collection, chain of custody requirements, quality assurance protocols, and laboratory accreditation standards. These laboratories must maintain accreditation from the National Accreditation Board for Testing and Calibration Laboratories (NABL) and comply with ISO/IEC 17025 standards to ensure reliability and admissibility of forensic evidence.[53]

Research and case studies consistently demonstrate that the most commonly collected and examined physical evidence in sexual assault cases includes fingerprints, bodily fluids, and hair samples. Sperm detection is a police investigation is very relevant aspect in rape or sexual assault cases. Sometimes, the samples are not sufficient for analysis and therefore require a lot of manual work to scan the sperm under an optimal microscope. “Convolutional Neural Networks[54] trained by the VGG19 network and a variation of VGG19 with 1942[55]” can achieve this tedious work, by reducing the sperm scanning time by hours, thus expediting the whole investigation process.

However, the Indian forensic landscape has expanded to include advanced DNA analysis techniques such as Low Copy Number (LCN) DNA, mitochondrial DNA analysis, Y-chromosome analysis, and rapid DNA testing. Digital forensics has also become increasingly important, encompassing mobile phone evidence, social media investigations, CCTV footage analysis, and GPS tracking data.[56]

[50] (2017) 6 SCC 1.

[51] Aditya Nuna and Tejas Gupta, “The Role of Forensic Evidence, DNA Tests, and Narco-Analysis in the Indian Legal System” (Elsevier BV 2025) <<https://doi.org/10.2139/ssrn.5069346>> accessed July 7, 2025.

[52] UNODC, “Guidelines for the Forensic Analysis of Drugs Facilitating Sexual Assault and Other Criminal Acts” [2011] United Nations.

[53] Donald Johnson and others, “Use of Forensic Science in Investigating Crimes of Sexual Violence” (2012) 18 Violence Against Women 193.

[54] A Convolutional Neural Network (CNN) is a type of artificial neural network (ANN) majorly used for image and video recognition to detect patterns and features.

[55] A deep convolutional neural network known for its 19 layers (16 convolutional and 3 fully connected) and its ability to classify images into 1000 different categories.

[56] Bruce Budowle, Arthur J Eisenberg and Angela van Daal, “Validity of Low Copy Number Typing and Applications to Forensic Science” (2009) 50 Croatian Medical Journal 207.

Articles 51A (h) and (j) of the Constitution of India prescribe fundamental duties of citizens to develop a scientific temper and the spirit of inquiry and reform and to strive towards excellence. In the landmark case of *Narayan Dutt Tiwari*^[57], the Delhi HC reiterated the same and explained that: “...What we wonder is that when modern tools of adjudication are at hand, must the courts refuse to step out of their dogmas and insist upon the long route to be followed at the cost of misery to the litigants. The answer obviously has to be no. The courts are for doing justice, by adjudicating rival claims and unearthing the truth and not for following age-old practices and procedures when new, better methods are available.”

The admissibility and probative value of forensic evidence in Indian courts depends on proper evidence collection, maintenance of chain of custody, and expert testimony that meets judicial standards. The Supreme Court's decision in *Arjun Panditrao Khotkar v. Kailash Kushanrao Gorantyal* (2020)^[58] clarified admissibility standards for DNA evidence and established comprehensive guidelines for DNA sample collection and analysis. Legal challenges often arise regarding contamination of samples, degraded DNA evidence, mixed DNA profiles, and statistical interpretation issues, requiring expert witnesses to meet stringent qualification standards and withstand rigorous cross-examination.^[59]

Maharashtra Police pioneered AI integration in crime prevention by acquiring "Predictive Policing Software" and Universal Forensic Extraction Devices (UFEDs) from international manufacturers.^[60] In December 2018, DGP Om Prakash Singh of Uttar Pradesh introduced "Trinetra," an AI-powered mobile application containing a database of 50,000 criminals with photographs, addresses, and criminal records. This system proved effective in capturing a notorious criminal in Lucknow, demonstrating its practical value in law enforcement operations.^[61] Delhi Police extensively utilized AI and forensic technologies to investigate 755 cases related to the 2020 North East Delhi violence. The investigation involved analyzing 945 CCTV recordings and smartphone videos using facial recognition and other AI tools, leading to successful arrests.^[62]

The recent enactment of the *Bharatiya Nyaya Sanhita, 2023*, and the *Bharatiya Nagarik Suraksha Sanhita, 2023*, has further strengthened the legal framework for sexual assault investigations by enhancing punishment provisions and streamlining investigation procedures. These legislative developments, combined with advancing forensic technologies and standardized protocols, ensure that forensic evidence continues to serve justice while maintaining the highest standards of scientific integrity and legal admissibility in Indian courts.

[57](2012) 12 SCC 554.

[58] (2020) 7 SCC 1.

[59] Varun Chhachhar and others, “Exploring the Role of DNA Technology in Administration of Justice in India: A Comparative Analysis with USA” (2023) 11 *Journal of Law and Sustainable Development* 1841.

[60] Ankita Deshkar, “To Fight Crime Using AI, Maharashtra Police Create MARVEL” *The Indian Express* (July 18, 2024) <<https://indianexpress.com/article/cities/mumbai/to-fight-crime-using-ai-maharashtra-police-create-marvel-9460472/>> accessed July 7, 2025.

[61] “AI Is Being Used by the UP Police to Catch Criminals” (IndiaAI) <<https://indiaai.gov.in/case-study/ai-is-being-used-by-the-up-police-to-catch-criminals>> accessed July 7, 2025.

[62] Rahul Jaywant Bhise, “Delhi Police Used AI Technology to Probe 755 Cases in February 2020” *Zee News* (March 12, 2021) <<https://zeenews.india.com/technology/delhi-police-used-ai-technology-to-probe-755-cases-in-february-2020-2347266.html>> accessed July 7, 2025.

CONCLUSION

The integration of artificial intelligence in forensic medicine, pathology, and justice systems represents a transformative advancement that promises enhanced societal safety and well-being. While countries like India are developing sector-specific regulatory frameworks rather than comprehensive AI legislation, the global challenge remains to create adaptive legal structures that can keep pace with rapidly evolving AI technologies. The key to successful AI implementation lies in recognizing that these technologies should augment, not replace, human expertise with AI serving as a powerful tool for accelerating evidence analysis and data interpretation while human judgment remains essential for contextual understanding and critical decision-making. Through this balanced collaboration between technological innovation and human knowledge, coupled with robust data quality standards and thoughtful regulatory oversight, we can harness AI's full potential to create more efficient, precise, and ethical justice systems that serve the greater good of society.

REFERENCES

Articles

1. Adib Bin Rashid and MD Ashfakul Karim Kausik, "AI Revolutionizing Industries Worldwide: A Comprehensive Overview of Its Diverse Applications" (2024) 7 Hybrid Advances 100277.
2. Abhishek Sharma Padmanabhan and S Sapna, "Forensic Investigation Approaches of DNA Analysis and Criminal Investigation" (2023) 13 International Journal of Safety and Security Engineering 129.
3. Aditya Nuna and Tejas Gupta, "The Role of Forensic Evidence, DNA Tests, and Narco-Analysis in the Indian Legal System" (Elsevier BV 2025) <<https://doi.org/10.2139/ssrn.5069346>> accessed July 7, 2025.
4. Ankita Deshkar, "To Fight Crime Using AI, Maharashtra Police Create MARVEL" The Indian Express (July 18, 2024) <<https://indianexpress.com/article/cities/mumbai/to-fight-crime-using-ai-maharashtra-police-create-marvel-9460472/>> accessed July 7, 2025.
5. Bruce Budowle, Arthur J Eisenberg and Angela van Daal, "Validity of Low Copy Number Typing and Applications to Forensic Science" (2009) 50 Croatian Medical Journal 207.
6. Christopher Kuner, Fred H. Cate, et.al., "Expanding the Artificial Intelligence-Data Protection Debate,8(4) International Data Privacy Law 289 (2018).
7. Christopher Rigano, "Using Artificial Intelligence to Address Criminal Justice Needs" (National Institute of Justice, October 8, 2018) <<https://nij.ojp.gov/topics/articles/using-artificial-intelligence-address-criminal-justice-needs>> accessed July 6, 2025.
8. Donald Johnson and others, "Use of Forensic Science in Investigating Crimes of Sexual Violence" (2012) 18 Violence Against Women 193.
9. D. H. Pethkar, "Artificial Intelligence in Forensic Science: Bridging Systematic Challenges with Next-Generation Applications" (2025) 12 International Journal of Scientific Research in Science and Technology 536.
10. Eman Ahmed Alaa El-Din, "Artificial Intelligence in Forensic Science: Invasion or Revolution?" (2022) 10 Egyptian Society of Clinical Toxicology Journal 20.
11. Jaya Lakshmi Bukyya and others, "DNA Profiling in Forensic Science: A Review" (2021) 08 Global Medical Genetics 135.
12. Karen Yeung, Council of Europe, "A study of the implications of advanced digital technologies (including AI systems) for the concept of responsibility within a human rights framework" DGI(2019)05.
13. Michael Haenlein and others, "Artificial Intelligence (AI) and Management Analytics" (2019) 6 Journal of Management Analytics 341.
14. Muhammad Arjamand and others, "The Role of Artificial Intelligence in Forensic Science: Transforming Investigations through Technology" 7 International Journal of Multidisciplinary Research and Publications (IJMRAP) 67.

16. ·Nasa Zata Dina, Sri Devi Ravana and Norisma Idris, “Legal Judgment Prediction Using Natural Language Processing and Machine Learning Methods: A Systematic Literature Review” (2025) 15 SAGE Open.
17. ·Navin Kumar, “From Surveillance to Sentencing: Evaluating AI’s Role in Indian Criminal Justice” (2025) 30 Scientific Bulletin 68.
18. ·Niketha Ravivarma, “Development of an Artificial Intelligence Method for the Analysis of Bloodstain Patterns” <<https://hdl.handle.net/11244/330997>> accessed July 7, 2025.
19. · Norrgard, K. (2008) Forensics, DNA fingerprinting, and CODIS. Nature Education 1(1):35.
20. ·Raffaella Brighi, Michele Ferrazzano and Leonardo Summa, “Legal Issues in AI Forensics: Understanding the Importance of Humanware” [2020] Journal of Legal Sciences, Cognitive Sciences and Artificial Intelligence.
21. ·Ray A Wickenheiser, “Forensic Genealogy, Bioethics and the Golden State Killer Case” (2019) 1 Forensic Science International: Synergy 114.
22. · Russell, S., Norvig, P., Artificial Intelligence: A Modern Approach, Prentice Hall Press, 2009, 3rd edition.
23. ·Saurav Yadav and others, “Artificial Intelligence: An Advanced Evolution In Forensic and Criminal Investigation” (2022) 1 Current Forensic Science.
24. · Siddhant Gupta, Vinny Sharma and Prashant Johri, “Artificial Intelligence in Forensic Science” (2020) 7 International Research Journal of Engineering and Technology (IRJET) 7181.
25. ·Shai Farber, “AI as a Decision Support Tool in Forensic Image Analysis: A Pilot Study on Integrating Large Language Models into Crime Scene Investigation Workflows” (2025) 70 Journal of Forensic Sciences 932.
26. · Swapnil R. Kamdar and Astha Pandey, “The Scope of Artificial Intelligence in Forensic Science” 58 The Indian Police Journal 48.
27. ·Tim Brennan and William Dieterich, “Correctional Offender Management Profiles for Alternative Sanctions (COMPAS)” [2017] Handbook of Recidivism Risk/Needs Assessment Tools 49.
28. ·UNODC, “Guidelines for the Forensic Analysis of Drugs Facilitating Sexual Assault and Other Criminal Acts” [2011] United Nations.
29. ·Varun Chhachhar and others, “Exploring the Role of DNA Technology in Administration of Justice in India: A Comparative Analysis with USA” (2023) 11 Journal of Law and Sustainable Development 1841.

Case Laws

1. · (2005) 5 SCC 294 : 2005 SCC (Cri) 1057 : 2005 SCC OnLine SC 696 at page 329.
2. · 634 S.E.2d 594
3. · AIR 1393, 1996
4. · (2017) 6 SCC 1.
5. · WP (C) 494/2012.
6. · 881 N.W.2d 749 (Wis. 2016)
7. ·(2014 10 SCC 473)
8. ·WP (C) 494/2012.
9. · 881 N.W.2d 749 (Wis. 2016)
10. ·(2012) 12 SCC 554
11. · (2020) 7 SCC 1.