AG Publishing House

Investigative Frontiers Integration of Science Transforming Criminal Investigation

Year: 2026

Machines as Analysts: AI-Assisted Decision-Making and Evidence Interpretation in Forensic Science

Mrs. Pallavi A Rao[1]

[1]*Assistant Professor Department of Forensic Science Kristu Jayanti (Deemed to be University) Bengaluru, Karnataka*

Abstract

Forensic science now utilizes artificial intelligence (AI) as a decision support tool to improve the interpretation, analysis, and evaluation of increasingly complex evidence. This review focuses on pattern recognition, image and multimedia analysis, DNA interpretation, and medical forensics as major forensic applications that employ AI-assisted decision making. It explains the basics of artificial intelligence, machine learning and deep learning, as well as the process for AI support in forensic decision making. The review also takes into account the scientific reliability, explainability of AI, validation of the models, transparency of the algorithm, and the legal admissibility of AI generated evidences in Indian legal landscape in light of the Bharatiya Sakshya Adhiniyam, 2023. Finally, it highlights current challenges, future technological developments, and the importance of human–AI collaboration. The review recommends that AI is a scientifically developed decision support tool that is used alongside forensic analysis to provide accurate, transparent and legally defensible evidence interpretation.

Keywords; Artificial Intelligence (AI); Forensic Science; Evidence Interpretation; Explainable Artificial Intelligence (XAI); AI-Assisted Decision-Making.

[1] ISBN No. - 978-93-7640-081-2

1 Introduction

Machines as Analysts refers to the increasing use of Artificial Intelligence (AI) as a decision support system to help forensic scientists analyze, interpret and evaluate evidence. AI will not replace human experts, but rather complement their work, by analyzing large volumes of data and providing analytical insights, patterns and classification of complex data. The applications of AI have grown, in particular in fingerprint identification, facial recognition, DNA interpretation, forensic pathology, and digital forensics, all of which rely on advances in machine learning (ML), deep learning (DL), and computer vision, to ensure speed and uniformity of evidence analysis. Advancements in computing technology and the amount of data now available have made it easier than ever to incorporate AI into the work of contemporary forensic labs and investigations.[2]

AI assisted decision-making involves using intelligent algorithms to process evidence, identify relationships, and make probabilistic evaluations to support scientific interpretation by the forensic practitioner. However, AI-generated outputs are intended to complement rather than replace expert judgment. While automated analysis carries out a set of computational tasks based on patterns that it learned, forensic experts analyze the output of the AI before forming their opinion and do so in conjunction with case-specific information, scientific principles and legal requirements. Thus, human intervention and control are still necessary to ensure the reliability, transparency, and admissibility of forensic evidence.[3]

The expansion of AI is fueled by the rapid growth of forensic evidence collected from surveillance systems, mobile devices, social media platforms, cloud storage, genomic databases, and other digital sources, which are growing at exponential rates. Most of the conventional manual analysis is not adequate to handle such a variety of information in large quantities in short duration. By leveraging AI, the data can be processed quickly, analysis is consistent, examiner workload is reduced, and evidence-based decision making is enhanced, in increasingly complex investigations. However, there are considerable challenges in achieving the efficiency

[2] S. Farber, "AI as a decision support tool in forensic image analysis: A pilot study on integrating large language models into crime scene investigation workflows," J. Forensic Sci., pp. 932–943, 2025, doi: 10.1111/1556-4029.70035.

[3] M. F. F. Rasyid, "AI in Forensic Investigation: Digital Evidence Analysis and Authentication," Proceeding Int. Conf. Law Hum. Rights, doi: https://doi.org/10.62383/iclehr.v2i2.78.

of Artificial Intelligence, which require strict validation, explanation of algorithms, and constant human monitoring to ensure scientifically valid and legally defensible results.[4]

2 Foundations of AI-Assisted Decision-Making in Forensic Science

Artificial intelligence (AI) is a valuable technology in forensic science that has enabled fast and accurate analysis of complex evidence, and helped experts make sound decisions. AI systems learn from existing forensic datasets, patterns, classify evidence and aid in evidence interpretation, as opposed to computer programs that operate on a set of predefined instructions. The use of AI has also grown more common in forensic labs where it is used to analyse digital images, biometric data, biological evidence and multimedia files, helping investigators to process vast amounts of information more effectively. Forensics, however, is designed to be used in conjunction with AI, not instead of science, and human oversight is still crucial to the decision-making process.[5]

A. Artificial Intelligence, Machine Learning, and Deep Learning in Forensic Applications

Artificial intelligence (AI) is the capability of a computer system to perform actions that typically require human intelligence, such as pattern recognition, reasoning, prediction and decision support. In the field of forensic science, AI can help investigators analyse evidence, find patterns and relationships between data, and generate analytical outputs that are objective.

Machine learning (ML) is a branch of AI that entails training algorithms on past forensic evidence to learn and prepare for a wide range of situations. In applications such as fingerprint comparison, facial recognition, DNA profile interpretation, document examination, and categorizing digital evidence, the use of ML models has been common and has been shown to provide a greater degree of accuracy with continued learning from validated datasets.

Deep learning (DL), an advanced type of ML, is a technique that uses multilayer neural networks to interpret complex, unstructured forensic data. The ability of DL to automatically extract meaningful features from raw data, without requiring a lot of manual effort, has proven to be

[4] E. A. A. El-Din, "Artificial Intelligence In Forensic Science: Invasion Or Revolution?," Artif. Intell. Forensic Sci., vol. 10, no. 2, pp. 20–32, 2022, doi: 10.21608/esctj.2022.158178.1012.

[5] Y. Wang, Q. Ni, T. Wei, H. Xu, L. Liu, and L. He, "How AI-Assisted Decision-Making Paradigms and Explainability Shape Human-AI Collaboration," Sustainability, vol. 18, no. 3516, pp. 1–19, 2026, doi: https://doi.org/10.3390/su18073516.

very useful in image recognition, video analysis, latent fingerprint enhancement, and forensic facial identification.[6]

B. Workflow of AI-Assisted Forensic Decision-Making

The AI-assisted forensic decision-making process generally follows five sequential stages:

1. **Data acquisition:** Forensic evidence collection from crime scene photos, fingerprints, DNA profile, surveillance videos, mobile devices and digital storage media.
2. **Feature extraction:** AI can detect key attributes or measurable traits in the collected evidence, including minutiae from fingerprints, facial features, DNA patterns, or texture in images.
3. **Pattern recognition:** Machine learning models perform a comparison between extracted features and reference databases to identify similarities, relationships, and anomalies that are relevant to the investigation.
4. **Prediction and classification:** AI is able to categorize evidence, make potential matches, prioritize investigative leads, or make predictions based on statistical inference, all learned from patterns.
5. **Human verification:** AI-generated results are analyzed by qualified forensic experts who take into account the individual circumstances of the case, verify the scientific reliability, and make a forensic interpretation before presenting conclusions.

C. Human–AI Collaboration in Forensic Investigations

Forensic investigations depend on the cooperation of AI systems and forensics practitioners. AI can effectively carry out repetitive analytical duties, handle vast amounts of data quickly and precisely, and discover subtle patterns that might go unnoticed in manual analysis. Forensic experts bring scientific expertise, contextual analysis, ethical considerations, and legal liability, however. This partnership approach not only saves on mental effort but also benefits from the expertise and experience of the professionals, making the forensic conclusions both scientifically valid and legally sound. This means that AI is not a replacement for a forensic examiner but rather a tool that supports them in making decisions.

[6] I. Ketsekioulafis et al., "Artificial Intelligence in Forensic Sciences: A Systematic Review of Past and Current Applications and Future Perspectives," Cureus, vol. 16, no. 9, 2024, doi: 10.7759/cureus.70363.

D. Advantages over Conventional Manual Interpretation

AI-based forensic analysis has a number of key benefits over manual interpretation. AI can greatly cut down analysis time for complex and massive data sets and enhance consistency by reducing examiner subjectivity and variability. It helps to identify subtle evidence patterns, assist in the interpretation of objective evidence, and helps to improve the repeatability of forensic analysis. Moreover, AI can help investigators deal with the vast amount of digital evidence that is created in today's criminal investigations. However, for these benefits to be realised, the algorithms are subject to rigorous testing and validation, the datasets used are of high quality, the decision-making is explainable, and human oversight of the process is constant and is necessary to ensure trustworthy forensic results.[7]

3 AI Applications in Evidence Interpretation and Forensic Analysis

AI has also revolutionised the prowess of forensic laboratories, particularly in the interpretation of various types of evidence. AI can help forensic investigators identify intricate patterns, categorize evidence, and make informed decisions using machine learning (ML) and deep learning (DL) and computer vision techniques. AI is not about replacing traditional forensic techniques, but rather complementing them to improve analytical efficiency, consistency, and accuracy in various forensic disciplines. The following sections highlight key applications of AI in the interpretation of evidence and summarise the techniques used, the decisions which are supported, their advantages, and the limitations.[8]

A. Pattern Recognition and Image-Based Evidence

Convolutional neural networks (CNNs) and other deep learning models are effective techniques for image-based forensic evidence interpretation with AI. For fingerprint comparison, AI systems can automatically detect minutiae details, match fingerprint images with reference databases, and calculate similarity scores, aiding in the identification of fingerprints. This has the benefit of speeding up the examination of the fingerprints and saving the examiner time, but is not suitable for poor quality or partial prints, which may need to be interpreted by the expert.

In facial recognition, deep learning models identify facial features and landmarks from images captured by surveillance cameras or photographs to help identify unknown persons. In controlled

[7] L. T. P. Aya et al., “The Role of AI: from Conventional Methods to Digital Crime Analysis,” Int. J. Account. Econ. Stud., vol. 12, no. 5, pp. 1201–1206, 2025, doi: https://doi.org/10.14419/ap57rx96.

[8] T. Oikonomidi et al., “Applications of artificial intelligence for real- world evidence generation: a protocol for a living scoping review,” BMJ Open, vol. 16, pp. 1–6, 2026, doi: 10.1136/ bmjopen-2025-109725.

settings, AI technologies can enhance the recognition accuracy, and can quickly scan large databases, but has been found to have lower performance in the presence of low image quality, facial occlusion, ageing, and demographic bias.

In the field of footwear and toolmark pattern matching, AI-driven computer vision analysis helps identify unique footwear and tool markings from crime scene data. Although automated comparison enhances consistency and assists in prioritizing potential matches, the accuracy of the results will rely on image quality, the existence of standardized databases, and the careful screening of images prior to use in court.[9]

B. Digital and Multimedia Evidence

As digital evidence has become increasingly plentiful and quickly evolving, AI has become an indispensable aid in the field of multimedia forensics. Deep learning-based super-resolution and image restoration methods enhance the quality of surveillance videos and images, making them more visible and revealing more forensic details when they are blurry, noisy, or low-resolution. However, too much enhancement can create artifacts which need to be verified by experts.

Deepfake detection is another area where AI is being used: Convolutional neural networks and transformer-based models are used to detect inconsistencies in audio-visual synchronisation, lighting, textures and facial movements. These systems enable judgment of the authenticity of digital media, however, they need to continuously evolve to meet increasingly complex synthetic media.[10]

Machine learning algorithms classify files, emails, documents, and multimedia evidence automatically based on their relevance to the investigation in digital forensic data classification. This drastically saves man hours in manual review and allows vast amounts of digital information to be handled efficiently, yet it does not work for encrypted or data that has not been seen before for automated classification purposes.

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[9] P. Wu et al., "A Review on Research and Application of AI-Based Image Analysis in the Field of Computer Vision," IEEE Access, vol. PP, p. 1, Jan. 2025, doi: 10.1109/ACCESS.2025.3565300.

[10] M. A. Haider, U. I. Khan, M. O. Masood, and S. Mashhood, "AI-Based Deep fake Detection," J. Cogn. Artif. Intell., vol. 01, no. 1, pp. 13–17, 2025, doi: https://doi.org/10.66512/jcai.1.1.2025.6.

C. Biological and Medical Evidence

AI has also proven to be a significant asset in biological or medical forensic analysis. Forensic DNA mixture interpretation involves using machine learning models to analyse complex DNA profiles from multiple contributors and to make probabilistic assessments that support forensic identification. Final interpretation will need expert review though, as algorithmic outputs will be dependent on the data quality and validated statistical models.

AI analysed computed tomography (CT) scans and magnetic resonance imaging (MRI) scans to detect fractures, haemorrhage, foreign objects and other abnormalities, even before the conventional autopsy, when a person is deceased. This enhances the efficiency of the diagnostics and assists forensic pathologists, but cannot replace the full medico-legal examination.

In the same way, AI plays a role in injury and pathology assessment where it analyzes medical imagery to find characteristics of wounds, tissue damage, and pathological findings. The use of deep learning models can increase the level of consistency, and help record injuries, but interpretation still relies on the clinical context and the expertise of the forensics. In all its applications, across the biological and medical realm, AI is a dependable decision-making tool that becomes effective when it is backed up with high-quality datasets, validated rigorously, and is constantly supervised by human staff.[11]

4 Reliability, Explainability, and Legal Admissibility of AI-Based Evidence

AI's role in forensic science is becoming more prominent and interactive, enhancing evidence interpretation efficiency, but its forensic utility relies on scientific rigor, transparency, and legal acceptance. While AI-generated findings can support investigators and forensic experts, it is important for them to meet specific standards of accuracy, validation, and accountability to be accepted as trustworthy evidence. Within the Indian context, AI-driven forensic analysis must follow these principles of Bharatiya Sakshya Adhiniyam, 2023 (previously Indian Evidence Act, 1872), which dictate the admissibility of expert opinion based on the credibility and reliability of the scientific processes used.

[11] Y. A. Fahim, I. W. Hasani, S. Kabba, and W. M. Ragab, "Artificial intelligence in healthcare and medicine: clinical applications, therapeutic advances, and future perspectives," Eur. J. Med. Res., vol. 30, no. 848, 2025, doi: https://doi.org/10.1186/s40001-025-03196-w.

A. Scientific Reliability and Explainability of AI Models

While AI systems may be highly accurate in analysis, they cannot be considered reliable for forensics due to just the analytical results. Reliable forensic evidence requires that it performs well on all data sets in a consistent manner, that it yields the same results each time, and that the methodology is well documented. Explainable AI (XAI) increases reliability by offering human-readable explanations for AI-based decisions, as opposed to generating a 'black box' prediction. In the context of forensic investigations, explainability can help experts, investigators, and judges understand the reasoning behind the AI's decision, thus fostering trust in the scientific soundness of AI-generated forensic evidence.

B. Validation, Verification, and Algorithmic Transparency

AI models need to be carefully validated and verified before they are deployed in forensic labs to ensure they are accurate, robust and repeatable in real forensic settings. Validation measures the ability of the system to operate consistently for the intended purpose and verification confirms the technical requirements of the system have been fulfilled. Just as crucial is the transparency of the algorithms, enabling an independent assessment of the model's performance and limitations. Another point that researchers have noted is that an algorithm might be biased if the training data set is biased or unrepresentative, which could impact facial recognition, fingerprint matching and other forensic uses. Thus, transparency in development, representative datasets, and continuous performance monitoring are key in order to ensure scientific credibility.[12]

C. Human Oversight and Legal Admissibility in India

AI should be used as a decision support not as a stand-alone forensic examiner. The AI-generated outputs are still subject to the evaluation of qualified forensic experts, who take into account the case-specific situation and give independent scientific opinions. Such human supervision guarantees ethical responsibility and decreases the possibility of false inferences. The admissibility of AI-assisted forensic evidence in India will depend on the scientific validation, transparent documentation, and the ability to be presented in competent expert testimony as per the provisions of the Bharatiya Sakshya Adhiniyam, 2023. In the future, as AI technology advances, the development of uniform validation procedures and explainable AI standards will

[12] A. T. Lexi, "Ai-Driven Forensic Evidence Validation Empirical Framework And Ethical Dilemmas In Predictive Policing: Redefining Legal Accountability In Algorithmic Justice Systems For Regulating Machine Bias, Transparency, And Due Process In Next-Gen Criminal Investig," Int. J. Crim. LAW Crim. JUSTICE, vol. 3, no. 1, 2025, doi: https://doi.org/10.5281/zenodo.15720676.

play a crucial role in boosting judicial trust and promoting responsible AI use in forensic investigations.[13]

5 Challenges, Future Directions, and Human–AI Collaboration

Artificial intelligence (AI) is showing great promise in the field of forensic science, with its ability to enhance the interpretation of evidence and streamline investigative processes. Its implementation on a large scale in India, however, will need to solve various scientific, technical and legal issues and ensure its responsible use within the forensic setting. Future developments should focus on, among other things, trustworthy AI systems that enhance the skills of forensic professionals, and respect the national legal and data governance frameworks.

A. Challenges

However, there are a number of challenges to the effective implementation of AI in forensic science. Limited and biased forensic data is one of the main concerns that can impact the accuracy and generalizability of AI models, especially in diverse populations like India. Another important problem is black box decision making, where the complex deep learning models make predictions without giving explanation, so it is hard to verify independently. Furthermore, different forensic laboratories do not use the same protocols for validation, which impacts reproducibility and reliability of AI-based analyses. Privacy and data security are also crucial, as forensic investigations require sensitive biometric, medical, and digital data that should be safeguarded against unauthorized access and misuse.[14]

B. Future Directions

This study needs to be continued with the aim of developing Explainable Artificial Intelligence (XAI) models, which can offer transparent and interpretable reasoning behind the AI generated conclusion. Scientific reliability and judicial confidence will be enhanced through the use of standardized industrial standards and national representative forensic datasets, as well as the interoperability of AI systems. Additionally, generative AI and multimodal AI are poised to improve forensic processes by combining text, images, videos, biometric data, and digital evidence into a single data analysis platform. These technologies need to be adopted with

[13] G. AGANPAL, "Ai-Generated Evidence and Admissibility under the Indian Evidence Act," Indian J. Leg. Rev., vol. 6, no. 8, pp. 746–753, 2026.

[13 K]. S. Anand and D. S. Thakur, "Challenges and Limitations of AI in Forensic Science: A Critical Review," Int. J. ofResearch Publ. Rev., vol. 6, no. 1, pp. 5621–5632, 2025, doi: https://doi.org/10.55248/gengpi.6.0125.0672.

comprehensive regulatory frameworks and ongoing monitoring in India to facilitate ethical and legally sound applications.[15]

C. Human–AI Collaboration

The future of forensic science lies in effective collaboration between AI systems and forensic experts rather than autonomous decision-making. While AI can process vast amounts of data, uncover patterns, and prioritize leads in investigations, forensic experts offer context, legal context, and scientific reasoning, ensuring that there is no lack of accountability. Thus, the use of AI should be intended as a tool to support decision-making and not take the place of qualified experts in the final interpretation and presentation of forensic evidence. This partnership between human and AI will foster precise, transparent, and trustworthy forensic investigations and aid in the ongoing modernization of forensic science in India.

6 Conclusion

AI is transforming forensic science, enhancing the efficiency, uniformity, and accuracy of interpreting evidence in various areas of investigations. AI has proven to be a valuable assistant in scientific decision-making, as seen in applications like fingerprint comparison, facial recognition, digital forensics, DNA mixture interpretation, and postmortem imaging, among others, that help ease analytical burdens. However, the effectiveness of using AI to generate evidence relies on having proper algorithms, appropriate datasets, explainable decisions, and constant human oversight. AI-generated forensic evidence should be accepted in India in line with the scientific and legal standards laid out in the Bharatiya Sakshya Adhiniyam, 2023, to guarantee that the opinions of experts are transparent, reliable, and accountable. Going forward, focus should be done on ensuring standardized protocols for validation, providing explainable AI frameworks, managing data securely, and responsible integration of generative and multimodal AI technologies. In conclusion, AI can be seen as a smart decision support tool that can augment the skills of forensic scientists, making a forensic investigation or judicial process more credible, efficient, and fair.

7 Reference

[1] S. Farber, “AI as a decision support tool in forensic image analysis: A pilot study on integrating large language models into crime scene investigation workflows,” J. Forensic Sci., pp. 932–943, 2025, doi: 10.1111/1556-4029.70035.

[15] V.-A. Cărcăle, “The Future of Artificial Intelligence (AI) Applications in Forensics,” in RAIS Conference Proceedings, 2025, pp. 249–256. doi: 10.5281/zenodo.15481632.

[2] M. F. F. Rasyid, "AI in Forensic Investigation: Digital Evidence Analysis and Authentication," Proceeding Int. Conf. Law Hum. Rights, doi: https://doi.org/10.62383/iclehr.v2i2.78.

[3] A. A. El-Din, "Artificial Intelligence In Forensic Science: Invasion Or Revolution?," Artif. Intell. Forensic Sci., vol. 10, no. 2, pp. 20–32, 2022, doi: 10.21608/esctj.2022.158178.1012.

[4] Y. Wang, Q. Ni, T. Wei, H. Xu, L. Liu, and L. He, "How AI-Assisted Decision-Making Paradigms and Explainability Shape Human-AI Collaboration," Sustainability, vol. 18, no. 3516, pp. 1–19, 2026, doi: https://doi.org/10.3390/su18073516.

[5] Ketsekioulafis et al., "Artificial Intelligence in Forensic Sciences: A Systematic Review of Past and Current Applications and Future Perspectives," Cureus, vol. 16, no. 9, 2024, doi: 10.7759/cureus.70363.

[6] L. T. P. Aya et al., "The Role of AI: from Conventional Methods to Digital Crime Analysis," Int. J. Account. Econ. Stud., vol. 12, no. 5, pp. 1201–1206, 2025, doi: https://doi.org/10.14419/ap57rx96.

[7] T. Oikonomidi et al., "Applications of artificial intelligence for real- world evidence generation: a protocol for a living scoping review," BMJ Open, vol. 16, pp. 1–6, 2026, doi: 10.1136/ bmjopen-2025-109725.

[8] P. Wu et al., "A Review on Research and Application of AI-Based Image Analysis in the Field of Computer Vision," IEEE Access, vol. PP, p. 1, Jan. 2025, doi: 10.1109/ACCESS.2025.3565300.

[9] M. A. Haider, U. I. Khan, M. O. Masood, and S. Mashhood, "AI-Based Deep fake Detection," J. Cogn. Artif. Intell., vol. 01, no. 1, pp. 13–17, 2025, doi: https://doi.org/10.66512/jcai.1.1.2025.6.

[10] Y. A. Fahim, I. W. Hasani, S. Kabba, and W. M. Ragab, "Artificial intelligence in healthcare and medicine: clinical applications, therapeutic advances, and future perspectives," Eur. J. Med. Res., vol. 30, no. 848, 2025, doi: https://doi.org/10.1186/s40001-025-03196-w.

[11] T. Lexi, "Ai-Driven Forensic Evidence Validation Empirical Framework And Ethical Dilemmas In Predictive Policing: Redefining Legal Accountability In Algorithmic Justice Systems For Regulating Machine Bias, Transparency, And Due Process In Next-Gen Criminal Investig," Int. J. Crim. LAW Crim. JUSTICE, vol. 3, no. 1, 2025, doi: https://doi.org/10.5281/zenodo.15720676.

[12] AGANPAL, "Ai-Generated Evidence and Admissibility under the Indian Evidence Act," Indian J. Leg. Rev., vol. 6, no. 8, pp. 746–753, 2026.

[13] K. S. Anand and D. S. Thakur, "Challenges and Limitations of AI in Forensic Science: A Critical Review," Int. J. ofResearch Publ. Rev., vol. 6, no. 1, pp. 5621–5632, 2025, doi: https://doi.org/10.55248/gengpi.6.0125.0672.

[14] V.-A. Cărcăle, "The Future of Artificial Intelligence (AI) Applications in Forensics," in RAIS Conference Proceedings, 2025, pp. 249–256. doi: 10.5281/zenodo.15481632.