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"Alexandru Ioan Cuza" University of Iași, Romania

ANCUȚA ELENA FRANȚ
ORCID: 0000-0001-8020-377X
ancuta.frant@uaic.ro

# The Effect of Artificial Intelligence on Forensic Science: Technical and Legal Aspects

Wpływ sztucznej inteligencji na kryminalistykę. Aspekty techniczne i prawne

## INTRODUCTION

One of the key features of forensic science is its ability to evolve alongside technological advances. This feature has enabled forensics to make significant progress and to contribute to the resolution of highly complex legal cases. Forensic science has progressed so much that, today, in some cases, only minimal traces, such as saliva on a cigarette butt or a barely visible fingerprint, are enough to identify the perpetrator of a crime. The accomplishments of forensics are so great that, for an uninitiated person, it might seem that it can no longer progress. However, this is an illusion. Forensic science inevitably advances with the discoveries, sometimes extraordinary, that occur in many fields[1].

The continuous interaction between forensic science and advances in various fields has revealed that some forensic methods, long considered scientifically reliable, were less accurate than previously believed. For example, the discovery that DNA analysis can be used to identify individuals with a high degree of accuracy has shown that some methods used in the past did not achieve the level of precision initially attributed to them. This applies to techniques such as hair analysis or bloodstain pattern analysis, which were frequently used to solve

[1] For further details, see S. Predescu, *Reconstrucția Tridimensională a Locului Faptei*, "Analele Universității de Vest din Timișoara – Seria Drept" 2025, vol. 1, pp. 41–46.

criminal cases in the 1960s and 1970s[2]. In some cases, after investigations were reopened, it was proven that the DNA found at the crime scene did not belong to the convicted individual[3]. Furthermore, studies indicate that for certain traditional forensic methods, such as voice analysis, it remains difficult to establish their actual level of accuracy[4].

Such cases demonstrate the importance of forensic science keeping pace with developments in various fields[5]. As a discipline at the intersection of multiple sciences, forensic science is inherently linked to these fields and, by extension, to their evolution. It is interesting to point out that many of the crucial forensic techniques were discovered by chance. For example, the use of DNA in forensic identification was discovered accidentally by Alec Jeffreys in 1984[6], as was the use of ninhydrin as a substance that can reveal fingerprints[7]. As the field of artificial intelligence (AI) is increasingly applied by humans, it is necessary to understand the benefits of applying AI in forensic science.

In this context, we aim to determine what improvements can be achieved in the field of forensics through the use of AI and how AI technologies should be integrated with the legislative framework. Therefore, this paper proposes an analysis of four major research questions: (1) How does AI actually contribute to improving specific areas of forensic science? (2) How can AI address the so-called "forensic science crisis", which is happening today? (3) What are the main regulatory directions, particularly at the international level? (4) How strong should the relationship between AI technologies and legal norms be?

In this paper, we present the results of a systematic literature review on the use of AI in forensics. We focus on the benefits which AI brings to various forensic domains, examining both traditional areas (such as fingerprint analysis) and emerging ones (such as deepfake detection). International legislation on AI is

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[2] FBI, *FBI Testimony on Microscopic Hair Analysis Contained Errors in at Least 90 Percent of Cases in Ongoing Review*, 20.4.2015, https://www.fbi.gov/news/press-releases/fbi-testimony-on-microscopic-hair-analysis-contained-errors-in-at-least-90-percent-of-cases-in-ongoing-review (access: 16.3.2026).

[3] I.E. Dror, *Bloodstain Pattern Analysis (BPA): Validity, Reliability, Cognitive Bias, and Error Rate*, "Science & Justice" 2025, vol. 65(3); J. Toobin, *The CSI Effect*, 30.4.2007, https://www.newyorker.com/magazine/2007/05/07/the-csi-effect (access: 2.3.2026).

[4] J. Kaplan, S. Ling, M. Cuellar, *Public Beliefs about the Accuracy and Importance of Forensic Evidence in the United States*, "Science & Justice" 2020, vol. 60(3), pp. 263–272.

[5] For further details, see B.A. Ureche, *Inteligența artificială în cercetarea locului faptei: Garantarea drepturilor omului în era tehnologiei*, [in:] *Protecția Drepturilor Omului în Dreptul Public și Dreptul Privat. Studii doctorale*, ed. G.L. Gîrleșteanu, vol. 7, Craiova 2025, pp. 251–258.

[6] A.J. Jeffreys, *The Man Behind the DNA Fingerprints: An Interview with Professor Sir Alec Jeffreys*, "Investigative Genetics" 2013, vol. 4.

[7] S. Odén, B. von Hofsten, *Detection of Fingerprints by the Ninhydrin Reaction*, "Nature" 1954, vol. 173, pp. 449–450; D.A. Crown, *The Development of Latent Fingerprints with Ninhydrin*, "Journal of Criminal Law, Criminology, & Police Science" 1969, vol. 60(2), pp. 258–264.

also reviewed, with an emphasis on current legal trends. Based on the systematic review, we analyze the findings and draw conclusions, aiming to provide a clear picture of AI's implications in forensic science and the directions for future actions. The study employs the inductive, deductive, comparative, historical, and prospective methods.

## OVERVIEW OF THE IMPACT OF AI IN FORENSICS

The advantages that AI brings to forensic science can be significant. Artificial intelligence can help address many of the challenges currently faced by the field, while also contributing to the emergence of new and previously unforeseen possibilities.

Essentially, AI enables rapid processing of large volumes of data and pattern recognition, which increases the speed and accuracy of analysis and allows for faster identification of suspects. It also increases the accuracy of predictive analysis, supporting crime prevention in a more effective way. As law enforcement involves managing vast amounts of data, AI can play a crucial role in helping judicial authorities process case information and achieve more effective investigation outcomes[8].

To better understand the role of AI in forensic science, it is important to first consider its main categories. Artificial intelligence can be classified according to several criteria. From the perspective of cognitive capability and task generality, it is divided into narrow AI (designed for specific tasks such as image recognition or language processing), general AI (a theoretical form capable of performing a wide range of intellectual tasks across different domains at a human-like level), and superintelligent AI (a hypothetical system that would surpass human intelligence across all domains of cognition). From a functional perspective, AI systems can be categorized into reactive machines (which operate without memory and respond only to current inputs), limited memory systems (which use past data to support decision-making), theory of mind systems (which remain at the research stage and aim to model human emotions and intentions), and self-aware systems (a hypothetical form of AI with consciousness and self-awareness). In terms of functionality, a further distinction can be made between generative AI systems, which are capable of producing new content such as text, images, or documents; discriminative (predictive) AI systems, which focus on classification and

[8] I. Ketsekioulafis, G. Filandrianos, K. Katsos, K. Thomas, C. Spiliopoulou, G. Stamou, E.I. Sakelliadis, *Artificial Intelligence in Forensic Sciences: A Systematic Review of Past and Current Applications and Future Perspectives*, "Cureus" 2024, vol. 16(9); T. Nayerifard, H. Amintoosi, A. Ghaemi Bafghi, A. Dehghantanha, *Machine Learning in Digital Forensics: A Systematic Literature Review*, "Computer Science" 2023.

decision-making tasks; and agentic AI systems, which are capable of autonomously planning and executing sequences of actions to achieve specific goals. From the perspective of interpretability, AI is classified into explainable AI, where decision--making processes are transparent, and black-box AI, where internal reasoning remains largely opaque. It can be observed that several of these AI categories are still in the stage of ongoing research[9]. In the context of forensic applications, the most relevant classification is the one based on interpretability, as the transparency of decision-making is essential for ensuring reliability, accountability, and legal admissibility of AI-generated results.

Overall, AI is ushering forensic science into a new era by enabling powerful techniques and approaches that enhance the accuracy of evidence interpretation. Moreover, AI can make a significant contribution to crime prevention, which remains one of the foremost goals of contemporary society.

In the sections below, we explore AI's contributions to several key forensic areas.

## 1. Applications of AI in fingerprint identification

The technique of identifying a person through fingerprint analysis is considered a classic method in forensic science. Moreover, if we ask people what the first thing that comes to mind is when they think of forensics, most would probably say "fingerprints". It is important to mention that fingerprint analysis has contributed to the correct resolution of a very large number of cases through traditional methods, without the use of AI. In this context, of course, we can legitimately ask ourselves whether we really need to change the way we analyze fingerprints. We consider the answer to be affirmative.

One reason is the overall need to enable forensic science to benefit from discoveries in other fields. We must not forget that forensic science has reached its high accuracy through continuous improvement, constantly borrowing new techniques from other fields (e.g., regarding DNA expertise, as we have previously shown). Another reason refers to the practical reality, which shows that, sometimes, fingerprint analysis has led to erroneous results. We believe that

[9] A.B. Arrieta, N. Díaz-Rodríguez, J. Del Ser, A. Bennetot, S. Tabik, A. Barbado, S. Garcia, S. Gil-Lopez, D. Molina, R. Benjamins, R. Chatila, F. Herrera, *Explainable Artificial Intelligence (XAI): Concepts, Taxonomies, Opportunities and Challenges Toward Responsible AI*, "Information Fusion" 2020, vol. 58, pp. 82–115; A. Kaur, *A Comprehensive Analysis of Types of Artificial Intelligence: Classification, Applications, and Future Directions*, "International Journal of Advanced Research in Computer and Communication Engineering" 2025, vol. 14(2).

it is essential to try to use discoveries in other fields, in order to reduce errors and to capitalize on the finest traces[10].

An advantage of using AI in fingerprint analysis is its speed. An AI-powered fingerprint verification system can analyze millions of fingerprints in seconds, far exceeding the speed of human analysis as well as traditional database verification systems, such as Automated Fingerprint Identification System (AFIS). AI systems use deep learning and can learn complex patterns directly from databases. Unlike traditional approaches, AI is not limited to papillary details known as "minutiae"; it can also recognize global texture, curvature, line density, angles, and other features. Additionally, AI can identify subtle patterns that may be difficult for human experts to detect[11].

Artificial intelligence can reconstruct partial fingerprints by filling in missing areas through database-based prediction. It can also improve the interpretation of poor-quality fingerprints, such as those degraded by external factors including rain, snow, drought, and similar conditions[12].

Furthermore, AI can provide substantial support in detecting staged events (e.g., when someone "plants" another person's fingerprint at a crime scene) by analyzing the texture and microscopic features of fingerprints. Thus, it can help determine whether a print was created using a silicone mold rather than a real finger[13].

If AI fingerprint analysis technology is used in combination with other identification methods (especially if they are also AI-based), the chances of correct identification increase greatly. For example, such results can be achieved if AI fingerprint identification technique is used together with AI facial recognition and DNA analysis technology.

A major advantage is that AI systems can get better over time, learning from each confirmed case and reducing the risk of error.

An important feature of AI is its ability to make discoveries previously considered impossible. For example, some researchers have used AI to highlight the fact that there are similarities between the fingerprint patterns of the same

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[10] B. Kumar Sharma, M. Walia, S. Chander Sharma, D. Dhillon, Ishant, N. Kumar Mishra, *Fingerprint Science: A Review on Historical and Contemporary Forensic Perspectives*, "Bulletin of Environment, Pharmacology and Life Sciences" 2002, no. 5 (Special Issue), pp. 57–61.

[11] K. Cao, A.K. Jain, *Automated Latent Fingerprint Recognition*, "IEEE Transactions on Pattern Analysis and Machine Intelligence" 2019, vol. 41(4), pp. 788–800; N. Singla, M. Kaur, S. Sofat, *Automated Latent Fingerprint Identification System: A Review*, "Forensic Science International" 2020, vol. 309.

[12] K. Cao, A.K. Jain, *op. cit.*, p. 789.

[13] E. Marasco, A. Ross, *A Survey on Antispoofing Schemes for Fingerprint Recognition Systems*, "ACM Computing Surveys (CSUR)" 2014, vol. 47(2), pp. 1–36; Y. Yu, Q. Niu, X. Li, J. Xue, W. Liu, D. Lin, *A Review of Fingerprint Sensors: Mechanism, Characteristics, and Applications*, "Micromachines" 2023, vol. 14(6).

person, a fact that was once believed to be impossible. This result has the potential to greatly expand the limits of the "classical" way of analyzing fingerprints. Specifically, this means that if a fingerprint of a perpetrator is found at the scene (e.g., the index finger of the right hand), but the database contains the fingerprint of another finger of the same perpetrator (e.g., the thumb of the left hand), we can include the perpetrator among the suspects, because the fingerprints share similar patterns. Basically, this opens the way for cross-finger matching, which would represent a major advance in forensics. Studies conducted to date have used machine learning systems and indicate an accuracy rate of 77%[14]. In forensic contexts, this percentage may be considered low, as accuracy should ideally exceed 99% to ensure reliable identification. However, such a percentage is not negligible, considering that it is significantly higher than the 50% accuracy expected by chance alone. Even if it cannot lead to certain identifications, such a method could contribute to narrowing the pool of suspects.

Another use of AI that can be very important in forensics is contactless fingerprint recognition, a procedure that can maximize the results, making certain steps, such as revealing with powders or chemicals, no longer necessary[15].

However, the use of AI in forensic fingerprint analysis faces key challenges, including algorithmic bias, limited explainability of decision-making, reduced accuracy when analyzing poor-quality or partial latent prints, the risk of false matches, and legal concerns regarding the validation and admissibility of AI-generated evidence in court[16].

## 2. Applications of AI in document and handwriting analysis

Forensic analysis of documents and handwriting is a field with a long tradition. Analyses in this forensic branch are usually performed through meticulous visual comparisons, carried out by an expert. Due to the overwhelming importance of the human factor, the risk of subjective conclusions is high. Artificial intelligence can significantly improve the way analyses are performed in this field, bringing high accuracy, speed, and objectivity.

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[14] G. Guo, A. Ray, M. Izydorczak, J. Goldfeder, H. Lipson, W. Xu, *Unveiling Intra-Person Fingerprint Similarity via Deep Contrastive Learning*, "Science Advances" 2024, vol. 10(2); B. Powers, *Do Prints from Two Different Fingers Belong to the Same Person? AI Can Tell*, 12.1.2024, https://www.science.org/content/article/do-prints-two-different-fingers-belong-same-person-ai-can-tell (access: 14.3.2026).

[15] A.M.M. Chowdhury, M.H. Imtiaz, *Contactless Fingerprint Recognition Using Deep Learning – A Systematic Review*, "Journal of Cybersecurity & Privacy" 2022, vol. 2(3), pp. 714–30.

[16] C. Herke, *Automated Fingerprint Identification: The Role of Artificial Intelligence in Crime Scene Investigation*, "Forensic Sciences" 2026, vol. 6(1).

Artificial intelligence can quickly compare two texts using algorithms that can determine the probability that they were written by the same person. To reach a conclusion, AI can recognize graphic patterns and identify subtle details that may be difficult for the human eye to detect. For example, AI can analyze writing pressure, curves, angles, and the natural or intentional shakiness of handwriting. It can also identify deletions and overlaps, which may indicate forgery[17]. AI algorithms can greatly contribute to stylistic analysis by grouping texts according to stylistic similarities[18].

In analyzing printed documents, AI provides information that is extremely difficult and even impossible for a human to observe, e.g., regarding pigment distribution, toner uniformity, or alignment anomalies[19].

Nevertheless, the use of AI in forensic document and handwriting analysis faces several challenges, including algorithmic bias, difficulties in interpreting the reasoning behind AI-generated results, difficulties in accurately interpreting degraded documents or highly variable handwriting styles, dependence on large and representative training datasets, and concerns regarding the reliability, validation, and legal admissibility of AI-generated conclusions[20].

## 3. Applications of AI in facial recognition

Facial recognition is an area where the help given to investigators by AI is essential. The main reason is the fact that, in this field, very large amounts of data have to be analyzed. It is enough to think about the difficulty that humans have in identifying people of a different race to understand the importance of AI in the field of facial recognition.

Essentially, facial recognition involves identifying or verifying the identity of a person based on the facial features. The operating principle consists of comparing the image of a person with information stored in a database. The method basically involves the following steps: image capture (taking a photo or a video of the person's face); face detection (locating the face and separating it from the

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[17] H. Zhao, H. Li, *Handwriting Identification and Verification Using Artificial Intelligence--Assisted Textural Features*, "Scientific Reports" 2023, vol. 13.

[18] R.T. Mani, V. Palimar, M.S. Pai, T.S. Shwetha, M. Nirmal Krishnan, *An Evolution of Forensic Linguistics: From Manual Analysis to Machine Learning – A Narrative Review*, "Forensic Science International: Reports" 2025, vol. 11.

[19] M.-J. Tsai, Y.-H. Tao, I. Yuadi, *Deep Learning for Printed Document Source Identification*, "Signal Processing: Image Communication" 2019, vol. 70, pp. 184–198.

[20] M. Can, C. Işık, M. Cengiz, *AI-Based Quantitative Handwriting and Signature Feature Analysis: Development and Validation of a Mobile Application for Forensic Document Examination – A Preliminary Study*, "Forensic Sciences" 2026, vol. 6(2).

background); facial feature extraction; comparison with the database to see if there is a match; and providing the result[21].

One of the main advantages of AI in this field lies in its ability to operate at high speed. Basically, AI technology compares the image of a person (e.g., a suspect) with thousands of images in a matter of seconds, which far exceeds human capabilities. In addition, AI-based facial recognition methods rely on facial recognition algorithms which use precise parameters, such as the distance between the eyes, the width of the jaw, the distance between the nose and mouth, the shape and size of the eyes, the ratio between facial width and height, facial symmetry, skin texture, and the presence of distinctive features. In newer generations of deep learning systems, actual images of individuals are no longer stored; instead, numerical vectors (which may contain hundreds of values) unique to each person are used. The high processing speed of AI enables the real-time identification of individuals in video feeds from surveillance cameras. Another application of AI in facial recognition is the reconstruction of partial or blurred images, e.g. when a person's face is partially obscured or captured from an angle that prevents the entire face from being visible. This capability is also very useful when images have been captured using low-resolution cameras[22].

Despite the extraordinary performance of AI in the field of facial recognition, AI-assisted methods should be used in conjunction with other types of evidence rather than as the sole basis for conclusions. This is because algorithms can sometimes generate false positives or false negatives, which makes human oversight essential.

## 4. Applications of AI in deepfake detection

One of the major problems in today's efforts to fight crime involves the use of deepfake technology to commit crimes. Deepfake technology creates false, but very realistic images, videos, or audio recordings that can easily mislead a person. Criminals can use deepfake to misinform and manipulate, to commit financial fraud, to blackmail or compromise a person's reputation, and even to commit acts that are threats to a country's security.

In the process of identifying deepfake, AI analyzes a series of elements that can provide clues in this regard. For example, in videos, AI examines eye movement and blinking, because deepfake often does not generate a natural appearance of these elements. It also analyzes skin texture and the appearance

[21] M. Yang, S. Li, J. Zeng, *The Effects of AI-Driven Face Restoration on Forensic Face Recognition*, "Applied Sciences" 2024, vol. 14(9).

[22] M. Jacquet, C. Champod, *Automated Face Recognition in Forensic Science: Review and Perspectives*, "Forensic Science International" 2020, vol. 307.

of pores, because deepfake often creates a perfect, unnatural appearance of the skin. It checks if there is a lack of synchronization of the voice and lip movement, if the body posture is unnatural, if there is an artificial appearance of lights and shadows, or if the speech has inconsistent content. In addition, AI can recognize the specific traces left by the technology that creates deepfake, e.g. the traces left by Generative Adversarial Networks (GANs). In its attempt to detect deepfake, AI uses dedicated deep learning models, e.g. Convolutional Neural Networks (CNNs) or Recurrent Neural Networks (RNNs)[23].

Despite its performance in detecting deepfakes, AI technology faces difficulties in this area, particularly because deepfake generation models are improving, creating results that are difficult to distinguish from reality. Some of the most important challenges AI faces in the effort to identify deepfakes are the lack of training on new types of deepfake, the variety of deepfake generation techniques (each leaving different traces), and the alteration of video and audio signals (which occurs, e.g., in the compression of files when they are shared on social platforms)[24].

## THE SO-CALLED "FORENSIC SCIENCE CRISIS"

A major problem in modern forensics is the so-called "forensic science crisis". There are multiple reasons for this crisis, which can mainly be divided into the following categories: scientific, technological, institutional, and ethical.

From a scientific perspective, the crisis refers to the growing recognition that some forensic methods previously considered highly reliable have increasingly been challenged by some specialists on the grounds that there are no uniform international standards and that existing databases are not sufficiently large to enable the validation of hypotheses. This applies, e.g., to fingerprint analysis, hair analysis, and voice recognition.

From a technological perspective, there is often a gap between the methods used by criminals, which can be very sophisticated, and those used by forensic experts, e.g., in the context of cybercrime.

Institutional aspects take into account the organizational and administrative difficulties that forensic experts often face. In countries such as Romania, the number of public forensic institutes and laboratories is insufficient to meet the

[23] R. Rafique, R. Gantassi, R. Amin, J. Frnda, A. Mustapha, A.H. Alshehri, *Deep Fake Detection and Classification Using Error-Level Analysis and Deep Learning*, "Scientific Reports" 2023, vol. 13; T.M. Abraham, T. Wen, T. Wu, Y. Chen, *Leveraging Data Analytics for Detection and Impact Evaluation of Fake News and Deepfakes in Social Networks*, "Humanities & Social Sciences Communications" 2025, vol. 12.

[24] Y. Lu, N. Yao, *A Fake News Detection Model Using the Integration of Multimodal Attention Mechanism and Residual Convolutional Network*, "Scientific Reports" 2025, vol. 15.

demand for forensic examinations. Sometimes, public forensic institutions are underfunded, which prevents them from having all the necessary technology, particularly advanced equipment, to carry out high-precision forensic procedures. Another issue specific to Romania is that, although the legislation allows private forensic experts to conduct forensic expertise, in reality it is difficult for them to establish their practice, because judicial bodies often prefer to turn to experts from public institutions, considered to offer greater credibility.

Ethical issues concern several aspects. Some relate to the credibility of judicial bodies, which is often affected by errors resulting from mistakes in forensic examination procedures. Others relate to the protection of personal data, since many forensic procedures use biometric information to identify individuals. In this context, a large part of the population fears potential abuses by authorities during forensic investigations[25].

The aspects discussed above illustrate that contemporary forensics indeed faces serious challenges. However, these challenges are not insurmountable and do not undermine the fundamental value of forensic science, which has demonstrated its remarkable ability to resolve complex legal cases through indisputable scientific methods.

## EMERGING DIRECTIONS IN AI REGULATION

As we have seen above, the discretionary use of AI can lead to serious violations of human rights and social norms. With AI becoming increasingly widespread, people have been able to see not only the beneficial potential, but also the negative sides of it. Furthermore, we can foresee an increase in the negative implications if the use of AI is not well regulated. Effective regulation is essential not only to address the risks but also to support the development of trustworthy AI technology. For this reason, in seeking the optimal form of AI regulation at both national and international levels, a balance must be struck between the protection of human rights and security, on the one hand, and the promotion of continued development of AI technology, on the other.

It should be emphasized that, generally speaking, there can be no separation between national and international legislation on AI, as AI technology has a pronounced transnational character. The two categories of legislation need to be harmonized, which explains the efforts made at the international level to reach an agreement. There is a broad international consensus that AI should be regulated to ensure transparency, the protection of human rights, security, and accountability. However, countries have different views on how AI should be regulated,

[25] C. Weyermann, C. Roux, *A Different Perspective on the Forensic Science Crisis*, "Forensic Science International" 2021, vol. 323.

particularly on how strict the laws should be. These differences primarily reflect the differing interests and strategies of countries.

Essentially, there are three broad approaches to AI regulation. The first emphasizes strict regulation with detailed provisions covering all aspects (e.g., the European Union's perspective). The second promotes a flexible approach, encouraging innovation and competition in the field of AI (e.g., in the United States of America). The third prioritizes rapid AI development under centralized state control (as in China)[26].

In this context of significant differences, we consider it encouraging that, at the international level, many discussions have taken place on that topic, and, moreover, that international treaties have been signed regarding AI regulation. On 5 September 2024, the Framework Convention on Artificial Intelligence and Human Rights, Democracy and the Rule of Law was adopted under the auspices of the Council of Europe. The Convention has been signed by more than 50 signatories, including the United States of America, the United Kingdom, Canada, Israel, Japan, and the EU Member States[27]. Its objective is to ensure that activities throughout the lifecycle of AI systems are fully consistent with human rights, democracy, and the rule of law[28].

At the European Union level, the use of AI is regulated by the Artificial Intelligence Act (AI Act), which came into force on 1 August 2024[29]. The AI Act classifies AI applications by their risk of causing harm in four categories: unacceptable (which are banned, e.g. social scoring), high (which must comply with security, transparency, and quality obligations), limited (which only have transparency obligations), and minimal (which are not regulated). In addition, there is also a category for general-purpose AI, which must respect transparency rules, with reduced requirements for open-source models[30].

There are interesting views on AI regulation. For example, some argue that prohibitions should not concern what AI technology can do, but rather what humans

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[26] R. Kaliisa, R.S. Baker, B. Wasson, P. Prinsloo, *The Coming but Uneven Storm: How AI Regulation Will Impact AI and Learning Analytics Research in Different Countries*, "Journal of Learning Analytics" 2025, vol. 12(2), pp. 140–157.

[27] Council of Europe, Chart of Signatures and Ratifications of Treaty 225, https://www.coe.int/en/web/conventions/full-list?module=signatures-by-treaty&treatynum=225 (access: 15.3.2026).

[28] Council of Europe Framework Convention on Artificial Intelligence and Human Rights, Democracy and the Rule of Law, adopted at Vilnius on 5 September 2024, CETS no. 225.

[29] Regulation (EU) 2024/1689 of the European Parliament and of the Council of 13 June 2024 laying down harmonised rules on artificial intelligence and amending Regulations (EC) No. 300/2008 (EU) No. 167/2013, (EU) No. 168/2013, (EU) 2018/858, (EU) 2018/1139 and (EU) 2019/2144 and Directives 2014/90/EU, (EU) 2016/797 and (EU) 2020/1828 (Artificial Intelligence Act) (OJ L 2024/1689, 12.7.2024).

[30] D. Lilkov, *Regulating Artificial Intelligence in the EU: A Risky Game*, "European View" 2022, vol. 20(2), pp. 166–174.

are permitted to do with it[31]. As far as we are concerned, we believe that ethical norms and laws that incorporate fundamental legal principles should be considered during the creation of AI applications. This approach is particularly important in areas with direct practical applicability, as it prevents post-development debates over prohibitions or limitations and reduces the risk of misuse that could violate ethical and legal standards. However, regarding fundamental AI research, we believe that limitations should be imposed only for core principles, such as the right to life, bodily integrity, dignity, and freedom of conscience. Imposing drastic restrictions on research could slow the development of AI technology, which would be undesirable given its potential benefits.

## RESULTS

Our research findings suggest that AI can bring dramatic improvements to forensic science, contributing to solving the so-called "forensic science crisis". At the same time, significant risks may arise from applying AI across the diverse areas of forensics. At the legislative level, countries hold different views on AI regulation, although some general directions are widely accepted. The integration of AI with legal frameworks must be strong, but it must not jeopardize the development of AI technology.

## CONCLUSIONS

Artificial intelligence can significantly transform forensic science, bringing new opportunities for the correct resolution of legal cases. One of the great advantages of AI is its ability to process large volumes of data accurately and rapidly, which is extremely useful when comparing traces found at the crime scene with database records or when organizing evidence in complex cases. It can also detect fine details that human examiners might overlook. The versatility of AI makes it applicable across virtually all areas of forensic science.

Moreover, AI can help address the so-called "forensic science crisis", which essentially stems from the lack of a solid scientific foundation for many methods, which undermines their credibility within the justice system and society. In this regard, AI contributes by reducing the subjectivity of human experts and by strengthening the scientific basis underlying case resolution.

However, AI can make errors, which is why its output should not serve as the sole basis for resolving a case, and an expert should always validate its conclusions. AI errors can arise from multiple factors, such as insufficient or

[31] Ž. Turk, *Regulating Artificial Intelligence: A Technology-Independent Approach*, "European View" 2024, vol. 23(1), pp. 87–93.

unbalanced training data, or attempts to mislead the system. Nevertheless, the benefits of AI in forensics are so significant that it is worth seeking solutions to mitigate the risks.

To fully leverage the advantages that AI brings to forensics, it is necessary to harmonize national legislation concerning this technology. This objective is justified, among others, by the cross-border nature of AI systems, which, e.g., may be developed in one country, trained on data from another, and applied elsewhere. In this regard, there is international consensus that AI-related legislation should ensure transparency, the protection of human rights, security, and accountability. However, countries differ in their views on how stringent these laws should be, depending on their respective interests.

Overall, this paper highlights the idea that discussions on AI applications in general, and in forensic science in particular, must always consider legal and ethical aspects alongside technical ones. It is advisable to assess legal implications from the early stages of AI system development to ensure that the final outcome respects general principles of law and therefore can be applied in forensic practice. However, we argue that in fundamental AI research, restrictions should be limited to a core set of individual rights; otherwise, progress in the field may be hampered, potentially depriving human society of some of the most significant discoveries in AI.

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## ABSTRACT

Artificial intelligence (AI) is transforming forensic science by increasing the speed and accuracy of investigations. This paper aims to examine how AI contributes to improving certain areas of forensic science, what regulatory approaches are emerging, and how strong the relationship between AI and legal frameworks should be. Research findings show that forensic science can be significantly enhanced by AI; however, there are high risks of error if specific rules are not followed. One of the most important principles is that decisions in legal proceedings should not be based

solely on AI, and that it is always necessary that an expert validates the conclusions. Regarding AI regulation, there is an international consensus that AI-related legislation should ensure transparency, the protection of human rights, security, and accountability. However, countries differ in their approaches to the level of regulatory strictness, depending on their respective interests. Overall, our research demonstrates that, despite the associated risks, the use of AI in forensic science is highly important. Therefore, all necessary measures should be taken to ensure that AI is applied under appropriate conditions, enabling its further development.

**Keywords:** artificial intelligence; AI; deep learning; forensic science; AI regulations; AI risks; forensic technology

## ABSTRAKT

Sztuczna inteligencja (AI) przekształca kryminalistykę, zwiększając szybkość i dokładność prowadzonych badań. Celem artykułu jest zbadanie, w jaki sposób AI przyczynia się do ulepszania wybranych dziedzin kryminalistyki, jakie są kierunki regulacji oraz jak silna powinna być symbioza między AI a normami prawnymi. Wyniki badań wskazują, że kryminalistyka ulega znaczącej poprawie dzięki zastosowaniu AI, ale istnieje wysokie ryzyko błędów, jeśli nie są przestrzegane określone zasady. Jedną z najważniejszych zasad jest to, że decyzje w sprawach prawnych nie powinny opierać się wyłącznie na AI i zawsze konieczna jest weryfikacja wniosków przez eksperta. W zakresie regulacji AI istnieje międzynarodowy konsensus, że przepisy dotyczące AI powinny zapewniać przejrzystość, ochronę praw człowieka, bezpieczeństwo oraz odpowiedzialność. Państwa jednak różnią się w podejściu do stopnia rygorystyczności tych regulacji w zależności od swoich interesów. Ogólnie rzecz biorąc, przeprowadzone badania dowodzą, że pomimo istniejących zagrożeń wykorzystanie AI w kryminalistyce jest bardzo istotne, dlatego należy podjąć wszelkie niezbędne działania, aby zapewnić jej stosowanie w jak najlepszych warunkach, umożliwiając jednocześnie dalszy rozwój AI.

**Słowa kluczowe:** sztuczna inteligencja; AI; głębokie uczenie; kryminalistyka; regulacje dotyczące AI; ryzyka związane z AI; technologie kryminalistyczne