



E-ISSN: 2707-4455
P-ISSN: 2707-4447
IJFM 2024; 6(2): 25-29
www.forensicpaper.com
Received: 26-06-2024
Accepted: 30-07-2024

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The application of artificial intelligence in the forensic medicine and toxicology: Need of the hour

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DOI: <https://doi.org/10.33545/27074447.2024.v6.i2a.91>

Abstract

Forensic medicine is the application of medical knowledge for the purpose of law and administration of justice. A branch of science called toxicology studies the detrimental effects of various substances, chemicals, and poison on humans, animals, and other living things. The primarily concerned of toxicology is examining the poisons and the harmful effects of chemical exposures. The process of testing, identifying and analysis can be improved or can be made more accurate by incorporating AI into the current techniques. Ultimately, artificial intelligence will be vital to the fields of toxicology and forensic medicine.

Keywords: Forensic medicine, toxicology and artificial intelligence (AI)

Introduction

Medical specialisation that involves applying medical knowledge to legal issues and the administration of justice is known as forensic medicine. Autopsy procedure, toxin analysis, obtaining medically important samples from bodily cavities, recognising pathological alterations in different organs, spotting bodily stains, identifying the weapon used in a crime, estimating the time since death and sex determination of the decomposed bodies are the various procedures involved in forensic medicine ^[1].

Researching the detrimental effects of substances on human health is known as toxicology. Toxicology's main goal is to examine how chemicals, both natural and manufactured, affect human health. It includes a broad variety of substances, such as alcohol, narcotics, illicit drugs, prescribed drugs and over-the-counter medications, environmental toxins, etc. ^[1]

Artificial intelligence (AI) is the umbrella term for a set of technologies that enable computers to do a wide range of sophisticated tasks, including data analysis, suggestion making, spoken and written language interpretation, and more. AI provides the groundwork for innovation in modern computing. The goal of the computer science discipline is to create machines that can mimic human intelligence and problem-solving skills. This is known as artificial intelligence ^[2]. In order to improve performance it involves analysing enormous volumes of data. Artificial intelligence (AI) systems can perform better and solve problems on their own without human assistance, which sets them apart from standard computer programs. Artificial intelligence was first conceptualized by Alan Turing, who defined it as a science that is applied to computers to create a variety of intelligent computer programs ^[3].

The idea of "artificial intelligence" originated in ancient times, when philosophers were delving into the secrets of life and death. In the past, people created "automatons," which were mechanical machines with independent motion. Derived from ancient Greek, the word "automaton" means "acting of one's own will" ^[4].

Artificial intelligence (AI) is the study of building computers and other devices that are capable of carrying out tasks that normally require human intelligence. Over the last ten years, practically every industry has seen advancements in artificial intelligence (AI) ^[5]. AI applications have become popular, especially in specialized fields like medicine, criminal justice, computer science, law, statistics, neuroscience, and philosophy ^[6]. It is anticipated that artificial intelligence (AI) will assist in diagnosis, prognosis, and decision-making ^[7].

Forensic medicine is among the most fascinating fields in which AI is having a significant influence. Artificial Intelligence is transforming forensic investigations by improving autopsy accuracy and predicting crime patterns.

Expert opinions in toxicology and forensic medicine will be profoundly impacted by AI. AI can enhance analysis, identification, research, and sample collection when combined with existing methods. Artificial intelligence will eventually play a major role in toxicology and forensic medicine. Artificial intelligence (AI) is becoming more and more popular in the field of forensic medicine. AI technologies, such as machine learning and data analytics, are now enhancing various aspects of forensic investigations [8].

The artificial intelligence, have enormous potential for growth in the fields of toxicology and forensic medicine.

History of Artificial intelligence [9-13]

1950-1960 Period

- The foundation for artificial intelligence was established in the early 1900s. However, the most significant developments in the field of artificial intelligence occurred in the 1950s.
- During this period, there was a surge of interest in AI.
- In order to assess computer intelligence, Alan Turing published his article "Computer Machinery and Intelligence," which introduced the idea of simulating intelligent behaviour and critical thinking with computers which later became known as The Turing Test, as a means of evaluating computer intelligence.
- After being coined, the term "artificial intelligence" became widely recognised.
- Considerable innovation was prevalent throughout the late 1950s and early 1960s. With the advent of computer languages, artificial intelligence became widely accepted quite rapidly.
- Since the creation of programming languages, AI has rapidly gained popularity.
- John McCarthy defined artificial intelligence (AI) as the scientific and technical process of creating computers with intelligence.

1960-1980 Period

- This rapid growth of AI occurred in the 1980s, this period also known as the "AI boom."
- The goal was to create machines that could draw conclusions or make decisions that were previously limited to humans.
- Research breakthroughs and more government support served as the driving forces for AI development.
- Expert systems and deep learning techniques became more widely used, allowing computers to learn from mistakes and make judgements on their own.
- The first industrial robot arm, known as Unimate. It carries out repetitive operations and handles heavy objects by following instructions.
- Shakey, sometimes known as "the first electronic person," was created in 1966 as the first moveable robot with the capacity to comprehend commands.

1980-2000 Period

- In this era, there are decreased funding and interest in AI and the consequent lack of substantial advancements, the majority of this time period is known as the "AI Winter."
- Expert Systems (ES) were created in the 1980s. It helps with medical decision-making by imitating human

specialists' knowledge and decision-making abilities.

- AI used to assist radiologists in finding anomalies in X-rays and MRIs.

2000-2020 Period

- During this phase three technologies were developed: clinical decision support (CDS), personalised medicine, and deep learning.
- The early 2000s saw the advent of machine learning (ML), which improved AI systems' capacity to examine massive datasets.
- During this time, AI was used into a number of healthcare applications, such as personalised medicine and predictive analytics.
- Electronic Health Records (EHRs) evolved as the mainstream health records management system, providing a rich source of data for AI.

2020-Present Period

- A new age of practical applications of AI in consumers and the healthcare system began with the development of generative AI (Gen AI) Ex-Chat GPT and DALL-E 2.
- The applications of Gen AI in health care settings are simulation and training, investigation, surgery, documentation, patient education and prognostic analysis.

AI-powered machines can do the following [2, 3]

1. **Acquire knowledge:** AI has the ability to acquire knowledge to identify speech, find patterns, and anticipate future circumstances.
2. **Rationalize:** AI has the capacity to rationalize, finding meaning, and make generalizations.
3. **Perform:** AI is capable of performing actions to resolve simple as well complicated problems.
4. **Self-adjustment and corrections:** This feature entails algorithms constantly learning and fine-tuning themselves to deliver the most precise results achievable.

AI is used in a wide range of applications [2]

- Chatboxes for customer support that help with website navigation
- Voice assistants such as Siri and Alexa.
- AI has applications in medical diagnosis as well.
- AI is used by computer search engines.
- AI is used in handwriting recognition for mail delivery.
- Spam screening is done with AI assistance.
- Linguistic interpretation
- Applied to Google and WhatsApp search engines.

Application of AI in forensic medicine

There are several ways to use AI in forensic medicine and toxicology field:

Digital Autopsies [14, 15]

- AI-powered imaging technologies i.e VIRTOPSY enable virtual autopsies enhanced the process and reducing error rates.
- It is crucial to identify victims quickly and accurately in situations like mass casualties, decomposed bodies, natural calamities, bomb blast or fire.

- An artificial intelligence (AI) algorithm helps in rapid identification of individuals from fragmented remains through dental matching, anthropological analysis, and facial recognition.
- In clinical forensic medicine, AI models are being developed and used in autopsy for the purpose of post-mortem identification, sex determination, determining cause of death, time of death and estimating post-mortem intervals.
- AI can also be utilized to recognize injury patterns and cause of death. 20
- AI-powered autopsy techniques include computer vision, machine learning algorithms, and many more techniques.
- The conventional autopsy method also has numerous drawbacks, including the need for specialized personnel in each case, the potential for human variation in the framing of opinions at certain points, and the inability to see minute details with the naked eye.
- By performing a medico-legal autopsy with accuracy and precision while avoiding human variation, AI helps to overcome this limitation.

Identification [8, 16]

- Identification is a crucial component of forensic medicine especially to identify deceased bodies, decomposed, and identify victims of mass disasters like earthquakes, bomb blasts, floods, etc.
- Traditional methods of identification are Genital examination, facial descriptions, tattoos, scars, body marks, and other methods.
- Fingerprinting and DNA analysis are recent advancement of identification process.
- AI development has made it possible for machines to verify identity.
- A computer will electronically store information that it obtains in the form of physiological characteristics like fingerprints, retinal patterns, and facial features.
- These parameters, which are already electronically stored in the system, can be used by the machine to use artificial intelligence (AI) to identify a specific person.

Age and sex estimation [14, 15]

- The main components of age assessment are medical history, physical examination, radiographs of the hand, panoramic photographs of the jaw, and, if necessary, thin-section computed tomography of the medial clavicular, femoral epiphysis.
- The age and sex estimation is the main steps in forensic identification especially during severely mutilated bodies, decomposed, burned body, genocide, natural calamities, is of great importance.
- The AI model is developed to evaluate age and determine the sex through proper training of AI.

Estimating the time since death [14, 18]

- Estimating the time since death can be predicted from a variety of blood markers.
- AI systems are able to process these blood markers and produce precise information regarding the time since death.
- Various blood markers are-Lactate dehydrogenase (LDH), blood pH, triglycerides, cholesterol, sodium,

potassium, and other biomarkers.

- The body starts to deteriorate after death, and biomarker levels vary with the amount of time that has passed.
- AI devices can interpret changes in biomarker levels in terms of time since death using available statistical data.

Facial recognition [14]

- Facial features can be recognized and compared to a database of known offenders through AI training.
- Advanced artificial intelligence algorithms improve the accuracy of facial recognition, helping to identify victims and suspects.
- On the other hand, AI technology can aid in improving the clarity of images and videos, and it also enables investigators to make use of object detection and facial recognition software.
- The accuracy and results of investigations can be increased by investigators by employing AI to improve image and video analysis.

DNA analysis [8, 19]

- The application of AI has improved the efficiency of DNA data investigation and DNA matching speed.
- AI algorithms are utilized to compare DNA samples from crime scenes with forensic DNA databases, which contain genetic profiles of well-known individuals.

Fingerprint analysis [20, 21]

- The process of fingerprint analysis and matching fingerprints to a database can be automated using AI.
- Artificial Intelligence (AI) is used in fingerprint analysis to find patterns in fingerprints from different fingers that belong to the same person.
- Consequently, improving fingerprint analysis precision and accuracy and overcoming the constraints of conventional fingerprint analysis.
- Thus, AI has the potential to improve the efficiency and accuracy of forensic investigations.

Producing animated videos [8]

Artificial intelligence can be used to recreate crime scenes.

Toxicology Analysis [8, 22, 23]

- Artificial intelligence (AI) algorithms can identify substances and their effects more effectively by analyzing toxicology reports with speed and accuracy.
- Identification of chemicals and drug metabolites in post-mortem samples is made possible by AI-based toxicological data analysis, which aids in determining the cause and pattern of death.
- Artificial Intelligence (AI) helps with complex analytical tasks.
- Determining an individual's identity, identifying and gathering samples of biological fluids, examining wounds, and externally examining different stains on clothing or the body, variety of fractures and small wounds that are often invisible to the unaided eye but could potentially result in a person's death, detection of pathological changes in various organs of the body, detection of a weapon used in a crime, time since death calculations, etc.

- Any areas of the body those are diseased or inflamed as a result of poisoning. Additionally, they must inspect a variety of evidence pieces, including blood samples, fingerprints, semen stains, etc.
- Samples can be analyzed more accurately and in a shorter period of time by AI compared to traditional methods.
- Artificial intelligence (AI) can be used in toxicology analysis and forensics to detect the presence of drugs and poisons in biological samples like blood, urine, hair, saliva, and skin.

Sexual assault ^[24]

- Artificial intelligence may play a significant role in the examination of stains or different color changes on the body due to assault.
- Analysis of seminal fluid stains could be seen.
- The identification of sperm is crucial in the sexual assault cases.
- By utilizing deep convolution neural networks, AI microscopy imaging can more precisely visualize sperm stains also be used to find blood spatter patterns or fingerprints on surfaces.

Limitation of Artificial Intelligence (AI) in forensic medicine and toxicology ^[2, 3, 8]

Artificial Intelligence (AI) is becoming a vital component of many different fields and benefits other fields in many ways, but it also has a number of limitations-

1. For accurate interpretation, AI machines need a large quantity of data to be fed to them.
2. AI machine training is a complex and time-consuming process that requires experts.
3. In order to interpret the findings of a post-mortem examination, forensic experts are needed to train and feed the data in several crucial areas of forensic medicine.
4. Applying AI will make it more difficult to use human judgment in some cases.
5. It presents with ethical issues.
6. Forensics experts handle the deceased person's body with humanity, but artificial intelligence lacks emotional intelligence.
7. Every piece of data that is input into the computer will need human supervision and expertise.
8. The computer's initial training takes a lot of time and effort, and continuous data updates are also necessary.
9. Privacy concerns resulting from AI's data feed.
10. The complexity of AI systems making them challenging to comprehend
11. Unfairness and bias issues with training data may lead to erroneous clue identification at crime scenes.
12. Artificial Intelligence is not well-suited to adjust to changing conditions.
13. Humans' over reliance on technology
14. The use of AI raises serious concerns about data privacy and ethical issues.
15. Artificial intelligence's capacity to make conclusions based on scant or inadequate data is one of its main drawbacks.
16. AI's limits in regard to empathy towards deceased caregivers.
17. AI opinion may not be regarded by the court as

definitive proof; it can serve as corroborated evidence because every machine is dependent on the data that it is given.

Conclusion

AI plays a pivotal role in molding the various perspectives of medicolegal importance. Artificial intelligence (AI) includes the development of intelligent machines with cognitive functions. In every field, artificial intelligence (AI) is the future of development. AI can be incorporated into the testing and analysis procedures of forensic medicine and toxicology. The application of AI to the analysis of biological samples has enormous potential in the field of toxicology.

In forensic medicine, artificial intelligence is crucial. It offers advantages as well as disadvantages. However, processing large amounts of data requires expertise and takes time, and there are legal considerations. The main barrier to applying AI in toxicology and forensic medicine is the requirement for high-quality data to be fed into the machine and the presence of expertise in this area. On the plus side, it helps with identification, age estimation, sex determination, death pattern, cause of death and post mortem interval.

The future of many fields lies in AI. It is something we should rely on and use carefully. The creative and intellectual abilities of humans are indispensable and cannot be replaced by a machine.

Conflict of Interest

Not available.

Financial Support

Not available.

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How to Cite This Article

Hussain A, Jyotishana. The application of artificial intelligence in the forensic medicine and toxicology: Need of the hour. *International Journal of Forensic Medicine*. 2024;6(2):25-29.

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