*Original Article*

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# Use of Artificial Intelligence in the field of Forensic Medicine & Crime Scene Investigation: A way forward

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**Abstract**

Forensic Medicine deals with applying medical knowledge in the administration of justice, bridging medical science with the law. The professions of forensic medicine and criminal investigation are increasingly utilizing the cutting-edge technology known as artificial intelligence (AI). It is used by forensic pathologists to establish the identity of an unknown person, estimate the age of injuries, primarily bruises, detect and analyze trace evidence, etc. It is very convenient to store, analyze, and transmit massive data within a very short time. This new technology is also helpful in conducting non-invasive autopsy by using various technologies such as Sonography, CT scans, MRIs, 3D surface scanning, etc. Detection and analysis of many trace evidence can be carried out by using AI. It is also very convenient to reconstruct the crime scene by creating video animation. However, as of now, its use is minimal and at a nascent stage. Moreover, it is not legally acceptable in a court of law.

**Keywords:** Artificial intelligence; Forensic Medicine; Identification; Autopsy; Technology; Criminal investigation.

## INTRODUCTION

In a broad sense, Artificial Intelligence (AI) may be defined as intelligent works done by man-made machines, particularly computer systems, as opposed to the natural intelligent work done by human beings. Alan Turing, the founding father of AI, first defined artificial intelligence as the science and engineering of making intelligent machines and brilliant computer programs.[1] During the mid-1950s, John McCarthy, an American computer scientist, also defined it as "the science and engineering of making intelligent machines''.[2] So, AI is a technology that enables machines to work efficiently, simulating human intelligence in problem-solving. This technology is widely used in many fields, such as industry, research, and health sectors. Very high-profile applications use AI, such as advanced web search engines, autonomous vehicles, generative and creative tools, video games, robotic surgeries, etc.

Gradually, AI has also been applied in the field of forensic medicine for the last decade.[3] AI technologies were used to estimate the biological age of migrants or human remains. It was used in the field of justice and criminal law.[4] An outline of the regular uses of AI in the realm of forensic medicine was provided by Tournois and Lefèvre.[5] Many complicated cases can be better analyzed and understood by using AI technologies.

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*Definitions of terms related to AI & Machine:*

**A. Machine Learning (ML):**

It is a statistical technique for fitting models to data and learning by training models using data.[6] It is a range of powerful computational algorithms capable of generating predictive models via intelligent autonomous analysis of relatively large and often unstructured data. This technology enables DNA analysis faster and more accurate.

**B. Deep Learning (DL):**

In order to perform tasks like computer vision and natural language processing (NPL), deep learning, a subcategory of machine learning, uses a deep neural network with a specific configuration in which neurons are organized in several successive layers. This network can also independently learn representations of the 5 data and gradually extract complex features. Deep learning is used in medicine to detect diseases from medical imaging.[7]

**C. Natural Language Processing (NPL):**

In order to achieve human-like language processing 1, a theoretically motivated range of computational techniques for analyzing and representing naturally occurring texts at one or more levels of linguistic analysis are employed for a variety of tasks or applications. In medicine, these techniques are used to organize information in healthcare systems and extract pertinent information from narrative texts to help with decision-making.[8]

**D. Robotics:**

The Robot Institute of America defined it as "a reprogrammable multifunctional manipulator designed to move material, parts, tools, or specialized devices through variable programmed motions for various tasks". Virtobot, a Robot System for Optical 3D Scanning in Forensic Medicine, is a new technique for non-invasive autopsy.[9]

**E. Artificial Neural Network (ANN):**

This new term, "Artificial Neural Network," is derived from biological neural networks that develop the structure of a human brain. Similar to the human brain, which has neurons interconnected to one another, artificial neural networks also have neurons that are interconnected to one another in various layers of the networks. It mimics the natural human neuron system. It is a new data processing pattern described as a mathematic simulation system of the structure and function of the human brain.[10]

**F. Convolutional Neural Networks (CNNs):**

It is a regularized type of feed-forward neural network that learns feature engineering by itself via filter optimization. Using regularized weights over fewer connections prevents vanishing gradients and exploding gradients seen during backpropagation in earlier neural networks. CNNs make the explicit assumption that inputs have specific structures like images. This allows for the encoding of this property into the architecture by sharing the weights for each location in the image and having neurons respond only locally.[11]

*Applications of AI:*

Many AI applications have been developed in the field of thanatology, especially for post-mortem identification,[12-14] the calculation of the post-mortem interval,[15,16] and the establishment of the cause of death.[17-20] In some clinical forensic medicine practices, AI applications are also helpful, such as age estimation,[21-24] gender determination,[25-27] and age estimation of bruises.[28] Bruises undergo color changes due to the breaking down of hemoglobin during the healing process. It is originally reddish, then violet-blue, then greenish on the third day because of biliverdin, brown on the fourth or fifth day because of bilirubin, and finally yellow because of the build-up of hemosterin pigment, which vanishes in ten to fourteen days, it turns brown due to bilirubin and later turns yellow due to the accumulation of hemosiderin pigment, disappearing in 10–14 days. These color changes were initially studied by naked eye examination, which is inaccurate. Now, the machines can detect such color changes more accurately, which is less time-consuming. It was also used in the assessment and management of violent behaviors among prisoners.[29]

Now, AI technologies are also applied in various fields of autopsies.[30] This is very important because autopsy examination plays a vital role in criminal investigation. Virtopsy, which is also known as Virtual Autopsy, is noteworthy to be cited here. This non-invasive technology uses various imaging techniques such as CT scans, MRI, and 3D surface scanning to examine the body.[31] These technologies enable thorough study of internal injury or pathological conditions without invasive dissection of the body.[32]

In cases of unknown or mutilated bodies, identification may be challenging. In the traditional methods for identification, we depend on different parameters like anthropology, facial descriptions,

tattoos, scars, body marks, etc. In the newer era, we use fingerprints, iris scans, DNA analysis, etc. However, in this modern era, different AI technologies are introduced. Super human-like computers can be utilized for identification. These machines can process and store data such as facial features, gait, voice, retinal patterns, fingerprint patterns, etc.[35,36]

In crime scene investigations too, AI is also very useful. Conventional methods, such as naked eye examination, microscopy, infrared examination, and various chemical tests, will take longer and sometimes may give erroneous reports, which may be due to inadequate samples. However, machines can detect such trace evidence more accurately within a shorter duration. In cases of sexual offenses, it may be challenging to detect the presence of sperm, especially when there is a very small sample. In such cases, the use of Convolutional neural networks trained by the VGG19 network and a variation of VGG19 with 1942 can fulfill this task. They can reduce the scanning time by locating the sperm on the microscope images.[37] Detection and analysis of many trace evidence can be carried out by using AI. It is also very convenient to reconstruct the crime scene by creating video animation.

In forensic ballistics, AI technologies are also now applied. When a bullet leaves a barrel, it carries microscopic evidence, which can be analyzed to establish the type of weapon used. It guides experts to the place where they need to look for gunpowder and cartridge tubes and compare the traces with a database through image processing without actual human involvement. Some algorithms allow for the highlighting of the residues resulting from firing with firearms, allowing for the detection of the explosion inside the barrel changes due to shock waves, as well as the provision of data that allow for the establishment of the class and calibre.[33]

AI has future prospects in identifying various poisonous drugs and substances in the field of Forensic Toxicology. Helma C. et al. revealed in a scientific paper that there can be human errors by using the spectrophotometer, neutron, and high-performance liquid chromatography (HPLC), and in this sense, AI can play an essential role by providing a data set as a sample which will increase the precision of the method, the efficiency, and even the reduction in the costs of investigations.[34]

AI technologies are also applied to evaluate medical malpractice cases. This may be useful to a certain extent in the future investigation of medical negligence cases.

## DISCUSSION

Since the last decade, there has been increased application of AI in the field of Forensic Medicine & Toxicology. The application of AI in this field may be considered from the following few perspectives:

1. To assist the forensic pathologist regarding the accuracy of both the anatomopathological diagnosis macroscopically, as well as all complementary examinations;
2. To reduce subjective judgment, all the factors that define human nature through its vulnerability;
3. To eliminate unnecessary investigation, saving both time & cost;
4. It is very convenient for storing & transporting files as it is created in digital form, very convenient in storing many huge files;
5. It gives a very fast and more solid opinion.

Previous studies showed that AI in the field of Forensic Medicine & Toxicology is mainly applied in Forensic Thanatology and clinical Forensic Medicine.[27,28,32] In thanatology, AI models were designed for post-mortem identification, determining the causes of death, and estimating the post-mortem interval. So far, in Clinical Forensic Medicine, AI has been used to estimate the age of living individuals, the risk of violent reoffending among prisoners, and bruises dating.

The use of AI permeates almost all spheres of life, and it is becoming more sophisticated day by day, too. It also brings with it a host of legal implications and challenges that demand careful consideration and regulation. It is challenging to keep pace with the rapidly proliferating application of AI and the existing legal system. The policymakers worldwide are having a tough time formulating a comprehensive law governing the use of AI. It is currently not admissible in a court of law. There aren't any three statutory laws or regulations that specifically govern the application of AI in India either. Nonetheless, particular frameworks for different industries have been recognized for the creation and application of AI.[31] In the financial industry, Stockbrokers, Depository Participants, Recognized Stock Exchanges, and Depositories received a circular from SEBI in January 2019 outlining reporting requirements for systems and applications that use and offer Artificial Intelligence (AI) and Machine Learning (ML). The National Digital Health Mission's (NDHM) plan

in the health sector notes the requirement for rules and guidelines to guarantee the dependability of AI systems in healthcare.

## CONCLUSION

Though we have heard of the increasing application of AI in many fields, including the health sector, the application of AI in the field of Forensic Medicine & Toxicology is in a nascent stage. There is a paucity of literature that shows that AI applications are used by forensic pathologists in daily practice to date. However, there has been an increase in interest in the application of AI in the field of Forensic Medicine and various crime investigations. It would not be wrong to say that in the near future, AI may be applied in routine forensic work.

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