

Digital Investigative Model in IoT: Forensic View

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Abstract

The multidisciplinary branch of science that is forensic science almost implicates all different disciplines of science to deal with various cases scientifically. The approach nowadays is very much efficient than it was used to be. Now, in the digital era where the use of various technologies is getting more popularized, forensic sciences got its own branches such as digital forensics, mobile forensics, and cyber forensics. Now, the application of artificial intelligence, machine learning, etc., is also engaged in this branch. The scope of this article suggests the use of artificial intelligence in forensic science in various cases as of now. This involves the application in blood spatter analysis, crime scene reconstruction, image examination, audio/video analysis, satellite monitoring, etc. We can observe a high potential of precession during the crime scene investigation till the verdict in court of law when implicating artificial intelligence. However, the article also pointed out the challenges and threats to the forensic domain as well as human being.

Keywords: Artificial intelligence, machine learning, forensic science, AI in forensic science, ANN

5.1 Introduction

When it comes to criminal justice delivery, forensic science puts forwarded numerous cases as example of its efficiency and the importance in a criminal case investigation [1]. To elaborate forensic sciences in simple terms, we can say that it is a multidisciplinary branch of science which efficiently uses various scientific principles to handle criminal cases and help to deliver justice in the court of law. The extensive use of artificial intelligence or AI can be observed nowadays which is efficient enough. Further discussion will illustrate various application of AI in forensic science [2]. AI can be defined as the ability of machines or computer to show case intelligence which can be compared to the intelligence of human or any other animal. Hence, it can be considered as “Machine Intelligence” [3]. The major aim to develop AI is to develop a machine to collect information from the environment as an input and act accordingly to reach the desirable results. This system can be compared to the ability of humans to learn and implementing. As the enhancement of AI is impactfully contributing various sectors, we can encounter various application of AI in crime scene reconstruction, blood spatter analysis, cyber forensics, data management and processing, data acquisition, pattern recognition, puzzle solving, questioned document analysis, ballistics

(analysis of various firearms and projectiles), forensic medicine, forensic toxicology, pharmacological analysis, record maintenance, improving contact between individuals during an investigation, etc. [4]. Apart from all this, in forensic medicine, “virtual autopsy” is introduced. Virtual autopsy is the process in which the examination of dead body will be done without performing incision in the body. This is having various advantages over the traditional autopsy. However, this technology still needs special attention for the enhancement. Further discussion figured out the challenges that need to be eliminated for future enhancement of such technology. But sticking to the AI, the virtual autopsy uses AI technology to perform accordingly.

5.1.1 Artificial Neural Network

Artificial Neural Network or ANN is also implicated in the forensic investigations. ANN can be compared to human brain and the nervous system [5]. This technology basically runs independently after certain data are processed in terms of example, such as image recognition or object recognition in an image. To elaborate this, the system is given samples of dog images [6]. The system now will get various features that a dog possesses. Here upon the analysis when even the system will be deployed for any such task where a dog needs to be located, it will give the results from past learnings. Here, one complication can create hindrance that is the similarity of objects. For example, another such image having the similar features of dog is given to be analyzed. The system may give wrong answer or results. But in order to overcome this, the analysis can take place in pixel level [7]. The image that has been shown to the system will be processed initially in the pixel level. Further the results will be given after analyzing pixels of given image [8]. This really makes the error precise in results. The most advantageous thing in such technology is the less coding procedure. Unlike traditional systems which need various coding in order to take input and give output, it works with less coding and programming [9].

Considering forensic sciences, we do have seven laws in this branch. The following are the seven laws:

- a) Law of Individuality
- b) Locard’s principle of Exchange
- c) Principle of Comparison
- d) Principle of Analysis
- e) Principle of Probability
- f) Principle of Progressive Change
- g) Principle of Circumstantial Facts

Using any technology and following these principles can be helpful in crime scene and in the court of law as well. We can consider the Law of Exchange, which is also known as Locard’s principle of exchange that is a very basic principle. AI can analyze a fingerprint or bloody impression to connect with the suspect and to explain scientifically in the court room as well.

Using AI and ANN properly can be efficient even more. As of now various applications of AI already have been introduced and are explained as follows.

5.2 Application of AI for Different Purposes in Forensic Science

5.2.1 Artificial Intelligence for Drug Toxicity and Safety

Basile, Yah, and Tatonetti explained about the preclinical drug safety and post-marketing surveillance of ADRs with an advanced technique that will be focused on machine and Deep Learning. There are two methods to monitor, detect and prevent the future toxicity and drug safety challenges [10]. Those are AI and traditional methods. The main approach of traditional methods has assessing for preclinical safety like “Quantitative Structure Activity Relationships” (QSAR), which is largely moving toward group of machine learning and deep learning. Post-marketing pharmacovigilance (PV) relies on a variety of data source such as molecular, chemoinformatic, and clinical database as well as social media and biometrics literature [11]. DL-powered natural language processing (NLP) technique was embedding in attention mechanism including word to extract drug’s advance effect (AE) relationship in text data [5]. The main approach at predicting ADES has been using annotated datasets that have exclusive use of supervised model limit and predicts novel and unknown drugs effect that cannot rely on labeled data. The down of AI ensemble the numerous questions in supervised modeling task like how incorporate unsupervised approaches in PV studies and how techniques such as GANS will be addressing these concerns. The main motive of this review is to promote the development of safe medical device, using AL algorithm in drug assessment an essential and pressing for development and safety in the future [12]. We need to establish data centres to control the risk of false positive. In the PV, implication of AI is having low risk assessment and also having high beneficial impact on healthcare in various aspects [13].

5.2.2 Crime Scene Reconstruction

In forensic investigation to maintain record, various methods have to be considered which further helps in crime scene reconstruction and to maintain the chain of custody as well. Methods including sketching of crime scene, photography, and other documentation are followed. But AI in the similar situation can help analyzing multiple videos, which must be captured before the collection evidence process. Analyzing multiple videos captured from different angles and giving a result as an animated crime scene video can be helpful in various aspects. Human mind cannot remember all the minute details simultaneously, but computer can do the same. Animated graphics can put forward much more detailed information in a crime scene with a 3-D representation [14].

5.2.3 Sequence or Pattern Recognition

After an initial investigation, the collection of data needs to be analyzed. Analysis can be done for various purposes such as data validation, shortlisting, and, in some case, identifying a desired object from the collection. One common aspect that all the information follows is the sequence or pattern. In some puzzles or riddles, we need to recognize the specific pattern in order to solve that. So, what AI's contribution in such cases is, it can use certain algorithms to solve or just to recognize the pattern followed. It helps in saving time and increases the accuracy as well. So, the basic mechanism that a system can follow is- at the initial stage it provided with various test patterns with given results [15]. AI analyzes the provided information at the initial stages and various test patterns are introduced thereafter. After this, during the training of the system, it is expected to recognize some other related patterns and the performance is examined. This programmed algorithm now can help solving and recognising various patterns in real time.

5.2.4 Repositories Building

The collection of crime records to maintain file and analyze past cases whenever needed is one of the important tasks that forensic experts or forensic scientist do. In such case using a compact disc, memory card, HDD, or any other such storage device can create hindrance. The size as we know cannot be expanded in such devices. But using AI, we can expand the space automatically when the memory needed to be expanded. The data interpretation can also be done simultaneously using such advantageous technology [16].

5.2.5 Establishment of Connection Among the Investigating Team

We can observe multiple involvements of various individuals from different organizations while investigating a crime, such as the investigating officers, medical officers, scientific team, police, and other persons whose involvement is needed. In such cases, the misunderstanding due to lack of communication or incomplete data sharing can easily happen. This situation can be minimized using various application of AI. Using various software that can help assist and build direct connection between all the individuals or responding officers, the direct virtual connection can be established. This will reduce the chances of error and mishandling of cases [17].

5.2.6 Artificial Intelligence and Expert System in Mass Spectrometry

Advance technologies of AI and expert system (ES) are operated by some of the aspects of mass spectrometry as reviewed by Li and Wang (2019). Nowadays, with an evaluation of hardware competencies and computer software, both of these fields are growing quickly. Modern mass spectrometers have grown into essential parts of life with a particular attention to reward its importance on depending on AI and ESs. This article covers history of computer, data system, factor analysis, principal component analysis (biological applications), and techniques of optimization in MS and ANNs. Basically, AI and ESs are applied in MS techniques. ESs are method or program to fixed data or rule that will be control the method, data analysis and cause a result [18]. AI is connected with advanced scholarly practices like the ability to reason, generalize, discover, and learn are all connected

with AI. Now, digital computers have become a crucial component of analytical instruments like MS, and their ability to perform tasks without variation is vital to produce reproducible and defensible in the results of experiments [17]. But they properly maximize instruments and efficiency of laboratory in giving fast end to user results, great sample throughput, and higher profitability. In early work, the data analysis made by conducting simultaneous linear equation results in raw peak conversion into mole fractions of normalized analyte. Seventeen-component sample needed 0.5- to 3-min computer processing time [19]. Today's mixture order of magnitudes more analyte with a reduced amount of time, offering considerably extra information rather than simple quantification of peak. AI to macrospectral interpretation applications worked in DENDRAL that is a list processing language-based code, eight-peak index are most familiar version for Mass Spectrometrists. MS compares or highly analyzes the dimensional multivariate data that have been used for chemometrics and that may give qualitative information from natural system. The application ANNs used in qualitative or quantitative analysis are becoming more acceptable in the MS because neural computational methods have portrayed themselves as an exceedingly effective and valuable tool for the complex data analysis [20]. MALDI/TOF simple calibrations for optimization in mass spectroscopy are easily executable and robust [21]. These results are comparable with polynomial curve fitting for routine applications and the main motive of this article to excel resulting in more hard and tough conditions for instance when sample and calibrants are different fundamentally, when calibrant peaks are correctly assigned or when the range of mass interest is extended past that of the calibration and can be used in a wide variety of application to analyze an accurate result in the complex data [22].

5.2.7 AI in GPS Navigation

In various situations in a forensic investigation and even in other cases, the GPS was found to be an efficient option to carry out various tasks. It helps in shortlisting different routes to a particular location. It also suggests the best route to choose according to the vehicle, weather condition, traffic, and other factors [23]. GPS implicates AI to collect information in real time to provide the best it can ([Figure 5.1](#)). The results can vary according to the weather condition, traffics, stop signs, holidays, etc. The given image below ([Figure 5.2](#)) is collected from Google Map. Time 5.30 PM IST and the date recorded as 2nd February 2021. It covers the Khordha district and the Puri District located in Odisha state, India. The information as per the image is the result derived when the direction was asked from Biju Pattnayak International Airport, Bhubaneswar to Puri Beach. Two routes can be located as highlighted by Google Map. The Blue one (via Badshahi Rd/Bhubaneswar-Puri Highway/cuttack-Puri bypass road) suggests the fastest route which is having toll gates and around 60 km, wherein the other light-colored route (via Delang Rd) is the other possible route which is 76.6 km and no toll gates are there. The map also suggests the time, which can vary accordingly depending on the above mentioned factors [24].

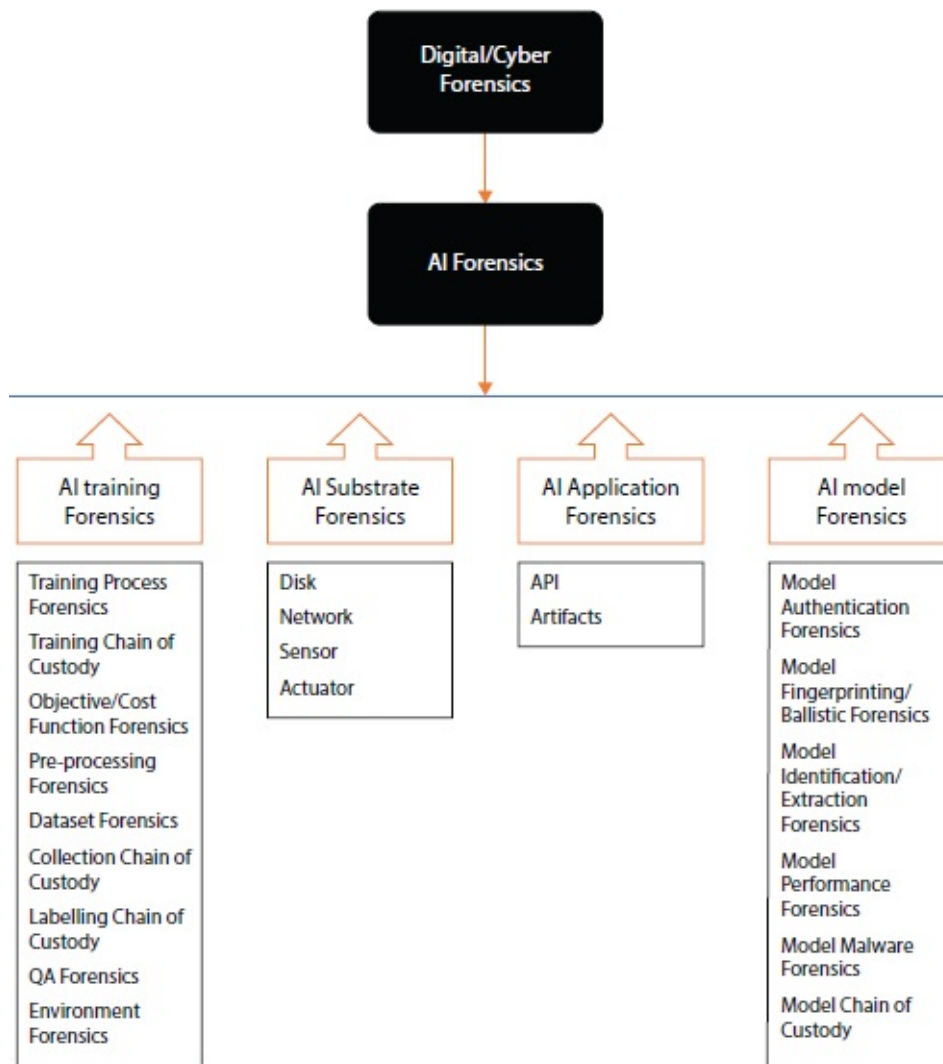


Figure 5.1 Describes the subdomains of AI forensics [S].

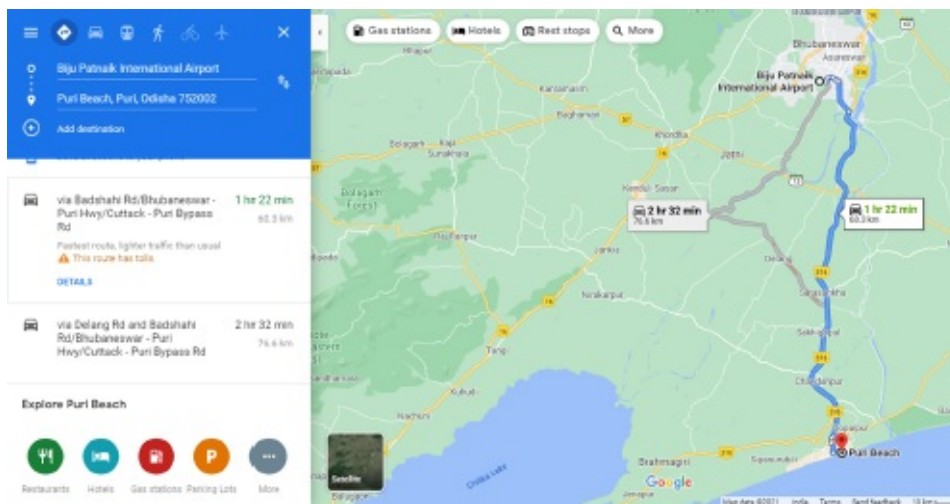


Figure 5.2 AI in GPS navigation.

5.3 Future of AI

Although it has various useful features while implicating AI, it also fails in some situations.

The GPS in our mobile phones helps Google Map to gather information about the traffic. It can be manipulated intentionally or unintentionally by deploying multiple GPS devices to misguide Google satellites which are collecting information about the traffic. Hackers can also mislead the connection by manipulating the server, etc., with criminal intension.

Numerous applications can be found well evolved and some under developing condition as well. Such as voice analyzing software which uses AI, face recognition feature, and detection of manipulated facial features. Although we consider AI as an advancing and emerging technology, it has lots of aspects to be worked upon for the betterment so as to get flawless results upon demand. The following discussion regarding the challenges can give the idea that we can encounter while using AI in forensics.

5.4 Challenges While Implementing AI

5.4.1 Unexplainability of AI

Sound and evident root origin investigation of failing in AI may desire translucent and definite clarification of the decision-making practice which appears in inadmissible behavior [25]. Though, the study on the explainability of complicated AI systems is still at its initial stages, and it is quite difficult to solving the problem of explainability. Additionally, some recent information disagreed that as the AI technology and proficiency progress over time; it can be tougher or even impossible for AI systems to be understandable [26]. In this condition, simpler abstractions of the decision-making process can intensify the forensic inquiry of such failing. For example, recommend a psychopathological abstraction for complicated AI security problems. Same abstractions can be desired to facilitate scientific forensic investigation of advances AI [27].

5.4.2 AI Anti-Forensics

In the sphere of digital forensics, culprits continually modify to the state of the technology and promote techniques such as decoys, false evidence, or forensic cleaning to retard the forensic analysis [28]. It is feasible that such anti-forensic techniques can be assumed and modified by culprits to employ AI forensic analysis. Proactive description of such techniques and advancement of alleviate solutions will become a progressively necessary area of research in this sphere. A new anti-forensics general taxonomy was formulated by the researchers. So far, anti-forensics was not included in the taxonomy [29].

5.4.3 Connection Interruption Between the Cyber Forensics and AI Communities

One of the tremendous challenges faced is the disconnection between the AI safety and cyber forensics communities ([Figure 5.3](#)). Researchers from those spheres are not working together. Though, the sphere of AI forensics has not been accepted and is prepared for future research. This disconnection was supposed in a new survey study, where the maximum number of

digital forensic practitioners was agreed or neutral on their proficiency in data science [29, 30].

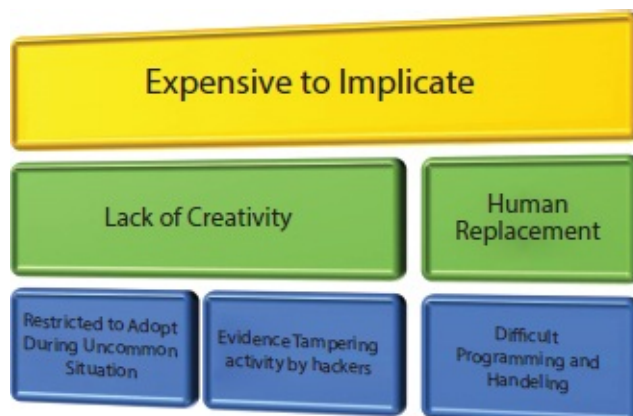


Figure 5.3 Challenges on implication of AI.

5.4.4 Data Analysis and Security

Implementing various technologies, it has been easy to increase storage capacity in various ways upon needed with no time. Storage over cloud and physical devices such as HDD can be easily upgraded. But the main concern is to analyze the huge size of data and to provide security. It is very challenging to analyze this source of data without more manpower and advanced technology. Apart from this, cyber-crimes can be a threat. Keeping the fact in front that the number of cyber hacking activities was found to be increasing at a high rate, hackers can steal data in a single run when we keep our data saved in a single storage space. Also, hackers tend to evolve frequently according to the frequent development and enhancement in the security. The advancement in technology needs further advancement for the safeguarding of information [6].

5.4.5 Creativity

It can be easily noted that the creativity and critical thinking considering the situation to be dealt can create a huge difference when we compare human and the AI technology. Humans can train to be more creative and can adopt to deal with numerous situations [31].

5.5 Conclusion

From the above discussion, it is clear that we are using AI and ANN in different techniques combinedly to get better accuracy and reliability in our results. However, it can also be observed that we have a lot of challenges to face and overcome while using such advanced technology as well. The current studies on the same area are trying to overcome such challenges either by minimizing them or by enhancing the AI technology. Various new technologies based on AI are still under development and in some case under continuous controversy. But it is clear that the future of AI in forensic science is well enlightened with the contribution of various researchers. Already we are able to implicate AI in most of the

cases in forensic techniques as mentioned above and many more. The continuous effort will be a grate breakthrough in overcoming and enhancing the technology.

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