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Forensic Trial Investigation Using AI and Blockchain

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Abstract:- **Forensic science is a science of how evidences are collected, which is a very important step in criminal investigation process and plays a vital role in preparing a hypothesis. Collaboration of technology and an inter-disciplinary approach can work wonders in this field. AI and Blockchain have a great potential in revolutionizing the way evidences are collected and analyzed and comes under the part of IoT (Internet of things). The AI can analyze very complex and vast amount of data by Artificial Neural Network (ANN) or Convolutional Neural Network (CNN) and generate a logical output which one can use to arrive at a certain conclusion. The blockchain technology on the other hand protects the integrity and security of the database and make it tamper-proof. AI and Blockchain can go hand in hand and make this process of forensic trial investigation an efficient and more accurate process. This technology, does however also comes with number of difficulties and ethical issues that needed to be addressed. This paper focuses on the applicability of AI and Blockchain in field of forensic science and also highlights various limitation to the use of this technology in this field. Present article aims to analyze the ever-expanding role of AI and blockchain in the criminal investigative techniques and its ethical implication in its usage. The papers also intend to highlight the various ways in which AI has been contributing towards the Criminal Administration of Justice.**

Keywords:- *Artificial Neural Network (ANN), Blockchain, Convolutional Neural Network (CNN), IoT (Internet of Things), Forensic Science.*

I. INTRODUCTION

Forensic science is multi-disciplinary in nature and serves as a solution to one of the key aspects of legal trial, that is, the accountability of the evidences and finding out the most relevant evidence and the link of that evidence to the criminal activity. The science becomes forensic if it is related to the judicial procedure. The accuracy of the forensic science is directly proportional to the efficiency in identifying the most relevant suspects and provides the answer to 4W's that are who, what, where and when, related to a crime. There are various steps in forensic trial investigation crime scene investigation, crime detection, analyzing the evidences, collecting trace evidences etc. these steps can be performed in much more effective manner by the use of artificial intelligence, machine learning, deep learning and blockchain. The goal adopted by UN namely 17 sustainable development goal (SDG) which is aimed to be achieved by 2030[1] does not specifically mention AI but goal number16 which talks about peace, justice and strong intuitions can be achieved by the use of AI and Blockchain in the field of forensic science. The; SDG's aim is to provide sustainable development in various field which also include advancement in science and technology, the improvement in the overall life of people and improvement in judicial system through various innovation in science which will surely improve the transparency, accountability and accuracy of the judicial system and help to maintain rule of law in the nation. The use of AI can contribute towards this goal of the UN SDG's by improving the accuracy and efficacy of the trials and investigation and by providing fair and just legal proceeding [2]. Therefore, the use of AI and Blockchain can be seen as promoting multiple goals including goal 9: industry, innovation and infrastructure of the UN SDG's. According to the most recent UN report on the SDGs, which was released in 2022, the 4G network coverage area doubled between the years 2015 and 2022, encompassing 88 percent of the global population. Due to the massive transition from the 2G network to the 3G and finally the 4G networks and the numerous fraud and mobile crimes that followed, AI has become indispensable in forensic science and trial investigation [3].

Artificial intelligence and the blockchain technology have the potential to change the latest trends and scenario in the forensic trial investigation by providing faster, more precise and accurate analyses of the evidence whereas blockchain have proved to play a significant role in forensic trial by providing the security, integrity and transparency of the evidence gathered in a database. AI can be used for pattern recognition, facial recognition, speech and audio analysis, predictive modeling, sentiment analyses, document analyses etc. similarly block chain plays a vital role in chain of custody, smart contracts, digital forensic, data management, verification etc. When these technologies are used together, they can significantly aid in upholding and defending the victim's dignity as well as in assessing the evidence more precisely, accelerating the legal process, and upholding the rule of law.

There are various forms of AI used in forensic trial investigation such as symbolism, Bayesian inference, nearest neighbor, artificial neural network, machine learning and deep learning. This study deals with aid of artificial neural network in forensic science as well as aid of blockchain in ensuring the

integrity and dignity of the victim and securing the evidence confidentiality. This study will also highlight the advantages and disadvantages with the use of AI and Blockchain in forensic science.

II. ENABLING TECHNOLOGY

Artificial intelligence in forensic science refers to the use of advance computational techniques, using machine learning algorithm, computer vision, and natural language processing, to analyze and interpret forensic evidence, automate forensic processes, and aid forensic investigations [4]. Artificial intelligence basically involves taking an input and processing it according to predetermined algorithms. These algorithms may be based on logic, image processing, statistics, operation research, psychology, linguistic philosophy, or neurobiology, among others. The result is a large amount of output, and this is where human intelligence comes into play. Now the database of the evidences and various other outputs generated by AI which can easily be tampered are stored online and this issue is solved by blockchain. Blockchain, also known as distributed ledger technology refers to a decentralized and transparent digital ledger that is used to record and verify transactions across a network of computers. It uses cryptography to secure data and ensure its integrity, make it tamper proof and immutable. Now this technology if combined together can help and aid a lot in forensic trial investigation.

III. AI & BLOCKCHAIN IN FORENSIC TRIAL INVESTIGATION

Artificial intelligence uses various approaches to enable machine learning and process data. Symbolism, which utilizes symbols to represent knowledge and reasoning is used in knowledge-based system. Bayesian inference a probabilistic approach is prevalent in AI application such as Spam detection and medical diagnosis for statistical reasoning and decision making. For example, if there are three suspects of a crime and maximum number of evidence are related to A then according to probability A becomes the most potential suspect. This approach is also known as forensic statistic. In this, the outcome is based on the statistics provided by the input. Nearest neighbor (considering all the possibility), it is a form of instance-based learning [5], that is utilized in pattern recognition. Artificial neural network (ANN). They are extensively employed in various application such as image recognition, natural language processing and speech recognition [6]. Artificial neural network is a web of neurons just like our mind which are called perceptron these neurons work together and forms a neural network which can function according to the algorithm predetermined by the authorized person and generate an output.

❖ *Uses of Artificial Intelligence*

A. Crime Scene Investigation with AI:

Crime scene investigation is the most crucial part of forensic trial as there are many crimes in which circumstantial evidences plays a major role such as dowry death and abetment to suicide under section 306 and 498A of IPC. This makes crime scene investigation the most important part of crime investigation and aided by AI can revolutionize the way how evidences are collected. The police officer's photograph from the crime scene is stored in the database, and the AI then marks and remembers the objects in the photograph. If the AI discovers that the object is connected to another crime as well, it can be inferred from the output that the crimes are connected in some way.

AI based image and video analysis techniques can be used to analyze C.C.T.V footage to draw the important information about the suspect and for facial recognition, license plate recognition and object detection. This technique can help identify the criminal and suspects related to crime and produce and create leads for further investigation.

Spanish National Cyber Security institute is also working on developing evidence recognizing tool which will use AI to recognize objects uses in crime.

It is crucial to determine the victim's age and sex if the body was discovered much later than the crime was committed. The femur, patella, mandible, and calcaneus bones are frequently used in predicting sex [7]. There are many crimes in which age becomes a deciding factor, and the court considers age very crucially. As a result, it is crucial to identify the victim's age and sex. Now that AI has advanced to the point where it is possible to identify the age and sex of the victim by Artificial Neural Network (ANN) and deep learning network [8].

B. AI in Pre- Detection of Crime

In smart cities, a method of criminal detection known as shot spotter is quite innovative. The shot spotter applies artificial neural networks to the data gathered by sensors and C.C.T.V cameras in order to locate the location of the gunshot and identify it. Chinese business Hikvision also created artificial intelligence (AI) specifically for C.C.T.V cameras that can recognize faces and detect any potential illegal activity.

There is deep neural network system that uses voice activity detection with hybrid speech feature for deceptive speech detection and detect any suspicious and spam calls that can potentially commit fraud [9].

C. Prevention of Child Abuse, Pornography, Human Trafficking and Others Crime Related to Women.

➢ *Content Monitoring*

Pornographic and content related to child abuse is continuously monitored over the internet and the suspicious data can easily be analyzed and removed from the internet. AI algorithm can also track the user IP address so that in near future if such person again posts such content the content can easily be taken down from the internet.

➢ *Natural Language Processing*

The methods can identify the suspicious language in chat logs, messages and social media post and if it finds anything that can promote child abuse and pornography, the content is automatically taken down from the internet. All the chats, messages and post are analyzed and remembered by the AI and crime can be prevented. For example- boys locker room incident on Instagram [10].

➢ *Pattern Identification*

AI can analyze the ups and downs of the internet and any abrupt changes in a person's activities. From there, they can follow that individual and any suspicious sudden changes, and they may be able to stop them from engaging in unlawful behavior.

D. Empower Mobile Forensic with AI driven tool

Mobile forensic is the branch of digital forensics which aims at investigating the digital evidence recovered from a cell phone that can provide a wealth of information in a forensically sound manner. There are lot of operating system in the market which make it difficult for latest techniques and trick to gain full insight of the data of the device and collect the relevant evidences needed for criminal investigation. Latest advancement in AI has helped and revolutionized the mobile forensic tool thus making it more convenient and an effective way to collect relevant evidences from the mobile devices. One such technology is THE CELLIBRITE (digital intelligence platform for a safer world). This AI mobile forensic tool used by law enforcement agency and digital forensic investigators to extract and analyze the data collected from various technological devices such as mobile phones, GPS, laptop, tablet etc. the software tool such as Cellebrite physical analyzer is used to analyze and interpret the extracted data [11].

E. Leveraging AI for Criminal Intelligence Analysis:

This involves gathering and analyzing data on criminal behavior in order to develop an algorithm that will detect and correlate offenders. VALCRI (visual analytics for sense making in criminal intelligence analysis) is one such advancement. This system uses a complex database and analyze the data to co-relate various suspects with the crime and creates a hypothesis that can potentially lead the law enforcement agency to a probable suspect and ultimately justice is delivered effectively and efficiently.

F. AI in Trace Evidences and DNA Separation:

The AI evidence database is packed with pictures and images of numerous crime scenes and trace evidences. AI is utilized in a variety of approaches such as fiber and hair analysis, gunshot analysis, glass analysis, paint analysis, chemical and drug material analysis, and it may even aid in the diagnosis of minute particles. All of these evidences and trails are examined, and the algorithm generates a logical output from the vast database on its own. AI-powered next-generation sequencing in DNA samples is being developed [12]. In the event of mass devastation or other occurrences when forensic specimens and samples are difficult to get and analyze, this technique can quickly separate the numerous DNA samples at the same time and generate a logical output.

Blockchain offers a better solution to the security and confidentiality of the database accumulated, as all the databases and complex windows of AI generated outputs are very crucial to the legal proceeding and their tampering can cause unfair judgement and it will directly impact the credibility of the criminal judicial system.

Table 1 Use of Ai and Blockchain in Various Steps of Forensic Trial Investigation

Stages of trial investigations	Use of AI	Use of blockchain
Crime scene investigation	Identifying Objects and Evidences	Maintaining a Database
Evidence Analyses	Analyzing Fingerprints, Facial Recognition, Voice Recognition, DNA sampling	Encrypting the Database to avoid any tampering with the evidences
Creating Hypothesis	Checking all the probability	No Information Leakage
Data Management	Analyzing the Complex data	Securing the integrity of data and producing it to the person who is authorized to access it

In blockchain all the communication in the internet or the IoT (internet of things) are stored in the blockchain as transaction, and this creates the existing chain of custody process pretty handy [13].

A blockchain that consists of four chains of custody or a series of transactions can be used to store all circumstantial evidence. However, altering the blockchain necessitates the creation of new blocks or transactions, which will eventually have an impact on the current series of blocks and alert the authorized person of any tampering with the evidence and database [14].

❖ *Principals to be followed to design secure distributed ledger of blockchain:*

➢ *Flexibility in the structure of ledger:*

The need of the clients is changing because of the dynamic nature of the society, the ledger should be design in such a way that it can be modified according to the need and increase the adaptability of the ledger.

➢ *Easy fault detection:*

The ledger must be incorporated with smart AI that can easily identify and detect any fault in the ledger the moment it arises. This will not cause any misappropriation in the result of the output created by the system.

➢ *Linear performance:*

This is a very big challenge for an AI and Blockchain driven system that it must handle the complex large scale distributed ledgers and integrate them to work in a linear progression. This defines the performance of the system generated.

➢ *Reliability:*

This is one of the most important principals and ranked at the top priority in the system generated for forensic trial investigation. The outcomes generated should be reliable as they will be used in the court of law as evidence before the judges. So, there must be a sense of reliability on the output created by the system so that there can exist proper and fair delivery of justice.

➢ *Security in the ledger:*

The ledger must be secure and the data must be tamper-proof. Security should be everywhere in the blockchain mechanism. The sole purpose of using an advance technology of blockchain is to have the sense of security that the data will be secured and there will be no manipulation.

➢ *Expandable:*

The ledger designed should be in a way that it can incorporate new services and new tools. This will make the ledger a system that will be future-proof. This will reduce the cost in the future and the survival rate of the system in advancement of technology will be higher.

The following principles must be present in a blockchain that deals with large-scale distributed ledgers. This will guarantee the blockchain system's effectiveness and efficiency. Making it an even more cutting-edge technology. Forensic trial investigation is a process which require a system that can generate logical output and at the same time stores it in a place which is secure and tamper-proof. The blockchain technology fulfills all the requirements of the process.

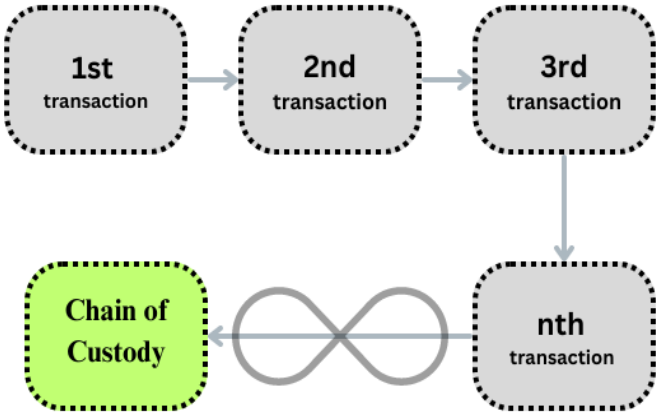

Fig. 1. Chain of Custody

There are various steps involve in collection of evidences:

- Samples received
- Case is assigned to the investigator
- Finalizing of report
- Dispatched (sec 173 of Indian Evidence Act) to the magistrate

Because of 4 chain of custody records cannot be altered at any stage and if there is any alteration then authorized person will get to know immediately. Blockchain protect the security and integrity of the victim as well as the accused and it also ensures the better enforceability of the section 165 of the Indian Evidence Act, which prohibits tampering and alteration of the evidences. The blockchain system uses hash encryption for the security and provide a unique access to only the authorized person so as to avoid tampering. The admissibility of the document in the court requires chronological documentation so as to achieve this a broader chain of custody is needed to facilitate modern forensic and incident response.

Now there are various stages of how blockchain technology helps in the efficient and effective functionality of forensic trial investigation process. These stages are: Preparation, media acquirement, gathering evidences, transportation of evidences, analysis and report.

Now in the preparation stage all the preliminary work is done and the crime scene investigation is done with collecting all the relevant evidences. After the preparation stage there comes the response stage in which all the relevant media of crime scene is acquired and the crime scene is safeguarded and preserved.

After this the stage of evidence acquisition stage comes in this stage evidence medium and storage medium is checked and the evidence is sealed. After all the necessary proceedings the evidences which are gathered are carried to the investigating agency. The gathered data arrives at the investigating agency then the agency confirms the data and this stage is called the confirmation stage. Then the copy is generated and the original report of evidence is preserved. Then at the very last stage the

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analysed report is testified in the court and this stage is known as report [15]

At every stage of the investigation through blockchain new chain of command is used which is authorized and any sort of tampering is checked at the affirmation stage.

There are various types of blockchain technology on a very root level, the technologies are public blockchain, private, blockchain and the consortium blockchain.[16]

Now, if everyone has access to the ledger, everyone can monitor the ledger, everyone can verify the chain of blockchains, and everyone has control over the chain, then that blockchain is a public blockchain. Members of the public domain can share and record the ledger [17]. Private ledgers are those that can only be supervised by the participants and are only accessible to them. Only one central authority has the power to monitor the blockchain. Only if the central authority permits the addition of the participant to the ledger can it be done. The main difference between the public and private ledgers is that the private ledger has an exclusive supervisor, making it effective and relatively simple to change and amend the ledger, whereas the public ledger does not have a central authority overseeing it. The public and private ledgers are combined to create the consortium blockchain, which is used for transactions between parties who have previously been granted authorization. These kinds of blockchains can be utilized for a wide range of tasks and can be employed in accordance with the requirements of the tasks.

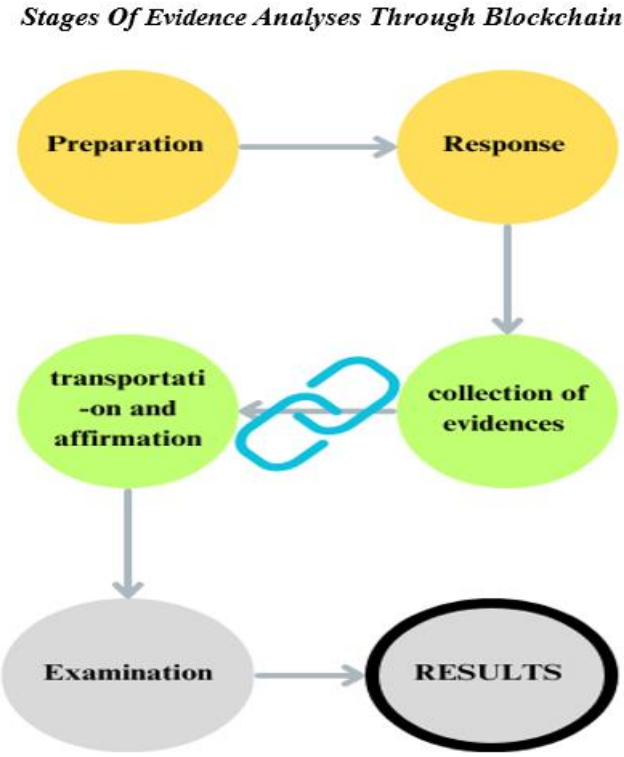

Fig. 2. Stages of Evidence analyses through Blockchain

IV. LIMITATION OF AI AND SUGGESTIONS:

- Even if AI is very capable of producing logical output from a complicated database, selecting the most advantageous output from the most likely ones still need the human mind and intellect. For this reason, a human-in-the-loop method that will support the researcher rather than replace them must be used.
- AI is built on algorithms that are applied to data, and if the data input has any bias, the outcome will also have bias, which will affect how fair the AI result is. To prevent this, AI must be updated frequently, and the new algorithm must be regularly validated.
- Because large neural network AI models perform several operations simultaneously, it is highly difficult to understand how the AI system arrived at a given result and what strategy it employed, which reduces its explainability and justification for usage. To solve this Explainable AI should be used which will allow the investigator on how the AI reached to that conclusion. For ex: XAI by IBM
- The accuracy and dependability of AI output depends on the correctness and clarity of the data, yet the data acquired at crime scenes is frequently ambiguous, compromising the AI's accuracy.
- As technology has developed, several more issues with AI have arisen, including hacking, a lack of privacy, and scalability, which renders AI less trustworthy in ethical and legal concerns. In order to resolve this, a more secure encryption method—such as the Rabin cryptosystem, Merkle tree, Blake2 algorithm, etc.—must be employed to encrypt the database.
- The cost of integrating AI in forensic science is quite high, and smaller forensic organizations are unable to integrate AI into their forensic trial system, which has an impact on the usability and cost-effectiveness of AI.
- In DNA sampling if there is a very complex data and sample to analyse then the interpretability may be compromised so the deep learning can help in getting more accurate result.
- Technology and tools that are accessible to the common population are extremely far apart. Because of this mismatch between tools and technology, fraudsters benefit, and regular people who are unaware of the technology risk being conned and becoming a target of scammers.
- When processing data, an AI-driven forensic tool moves quite slowly. This could reduce the trail's effectiveness because time is such an important consideration.

V. CONCLUSION

Blockchain and AI integration have the potential to completely transform the way that legal evidence is gathered today. Investigating and solving crimes may be made easier and more effective by integrating AI into the forensic system. In the legal industry, this technology can provide excellent accuracy and efficiency. The enormous and complicated database can be handled and analyzed quickly by AI, while blockchain ensures

the data's security and integrity. The blockchain technology guarantees the data's secrecy and makes it tamper-proof.

The technology does, however, also present a number of difficulties and ethical issues that need to be addressed, such as hacking into the system database that puts privacy at risk and bias in the AI algorithm that can significantly alter the output of AI and lead to unfair results. The development of the AI system must make it more interactive and explicable as to how the system arrived at that conclusion as technology may assist human labour but cannot totally replace human intelligence. With further updation, research, and development, the technology can be improved to a much higher level of accuracy so as to get a more just outcome and one can ensure that justice is served more accurately and efficiently, benefiting both the victim and the accused. The integration of AI and blockchain is an exciting and cutting-edge technology that offers immense benefits.

REFERENCES

[1]. H. S. Sætra, "AI in context and the Sustainable Development Goals: Factoring in the unsustainability of the sociotechnical system" in *Sustainability*, vol. 13, no. 4, p. 1738, 2021 [doi:10.3390/su13041738].
[2]. "The Sustainable Development Goals (sdgs) and Global Health," ISGlobal. [Online]. Available: https://www.isglobal.org/en/-/global-health-inequities. (Accessed: May 11, 2023).
[3]. "Sustainable development goals: United Nations Development Programme," UNDP. [Online]. Available: https://www.undp.org/sustainable-development-goals. (Accessed: April 08, 2023).
[4]. C. Watson, Q. Shen, and C.M. Bowers (Eds.), "Forensic Applications of Artificial Intelligence and Computer Vision," Springer, 2020.
[5]. N. S. Altman, "An introduction to kernel and nearest-neighbor nonparametric regression," in *The American Statistician*, vol. 46, no. 3, pp. 175, Aug. 1992, doi: 10.2307/2685209.
[6]. J. Heaton, "Ian Goodfellow, Yoshua Bengio, and Aaron Courville: Deep learning," in *Genetic Programming and Evolvable Machines*, vol. 19, no. 1–2, pp. 305–307, 2017, doi: 10.1007/s10710-017-9314-z.
[7]. M. K. Turan, Z. Oner, Y. Secgin, and S. Oner, "A trial on artificial neural networks in predicting sex through bone length measurements on the first and fifth phalanges and metatarsals," *Computers in Biology and Medicine*, vol. 115, pp. 103490, Dec. 2019. doi:10.1016/j.compbiomed.2019.103490.
[8]. N. Vila-Blanco, M. J. Carreira, P. Varas-Quintana, C. Balsa-Castro, and I. Tomas, "Deep Neural Networks for chronological age estimation from OPG Images," in IEEE Transactions on Medical Imaging, [Online]. Available: https://pubmed.ncbi.nlm.nih.gov/32012002/ (accessed April 08, 2023).
[9]. S. Mihalache and D. Burileanu, "Using voice activity detection and deep neural networks with hybrid speech feature extraction for deceptive speech detection," *Sensors*, vol. 22, no. 3, pp. 1228-1239, Feb. 2022. doi:10.3390/s22031228.
[10]. "Bois locker room: Indian teens' lewd Instagram group causes outrage," BBC News, Apr. 8, 2023. [Online]. Available: https://www.bbc.com/news/world-asia-india-52541298. (Accessed Apr. 8, 2023).
[11]. O. Afonin and Vladimir Katalov, "Mobile Forensics – Advanced Investigative Strategies," in Google Books, [Online]. Available: https://books.google.com/books/about/Mobile_Forensics_Advanced_Investigative.html?id=9oVcDgAAQBAJ. (Accessed Apr. 9, 2023).
[12]. M. J. Alvarez-Cubero et al., "Next generation sequencing: An application in forensic sciences?," Annals of Human Biology, vol. 44, no. 7, pp. 581-592, Nov. 2017.
[13]. J. H. Ryu, P. K. Sharma, J. H. Jo, and J. H. Park, "A blockchain-based decentralized efficient investigation framework for IOT Digital Forensics," *The Journal of Supercomputing*, vol. 75, no. 8, pp. 4372–4387, 2019. doi:10.1007/s11227-019-02779-9.
[14]. H. Al-Khateeb, G. Epiphaniou, and H. Daly, "Blockchain for Modern Digital Forensics: The chain-of-custody as a distributed ledger," in *Blockchain and Clinical Trial*, pp. 149–168, 2019. doi:10.1007/978-3-030-11289-9_7.
[15]. M. Harbawi and A. Varol, "An improved digital evidence acquisition model for the Internet of Things forensic I: A theoretical framework," in 2017 5th International Symposium on Digital Forensic and Security (ISDFS), Tirgu Mures, Romania, 2017, pp. 1-6, doi: 10.1109/ISDFS.2017.7916508.
[16]. P. K. Sharma, S. Singh, Y. -S. Jeong, and J. H. Park, "DistBlockNet: A Distributed Blockchains-Based Secure SDN Architecture for IoT Networks," IEEE Communications Magazine, vol. 55, no. 9, pp. 78-85, Sep. 2017, doi: 10.1109/MCOM.2017.1700041.
[17]. M. Harbawi and A. Varol, "The role of digital forensics in combating cybercrimes," in 2016 4th International Symposium on Digital Forensic and Security (ISDFS), April 2016, pp. 138-142.