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Contents

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Analysis of Red-Lipstick using Attenuated Total Reflectance Fourier -Transform Infrared Spectroscopy

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Abstract

In the context of criminal investigations, specifically those involving crimes against women, it is common to find cosmetics such as lipstick, eyeliner, eye shadow, nail polish, and vermilion as potential evidence. These cosmetic items are frequently used in everyday life and can be easily transferred onto clothing, drinking cups, handkerchiefs, tissue papers, cigarette butts, and various surfaces through contact during the commission of a crime.

This paper presents the application of Attenuated Total Reflectance Fourier-Transform Infrared Spectroscopy (ATR-FTIR) as a powerful technique for investigating the chemical composition of red lipstick. By employing ATR-FTIR spectroscopy, the researchers have analyzed the compounds present in the red lipstick. This spectral analysis provides valuable chemical information that can aid in criminal investigations and forensic analysis. The result demonstrates that ATR-FTIR spectroscopy is a highly effective tool for examining the chemical composition of cosmetics. The technique enables the identification of key compounds and functional groups present in the samples, allowing for differentiation and characterization of various cosmetic products. Overall, this paper highlights the significance of ATR-FTIR spectroscopy as a valuable tool in forensic analysis and criminal investigations involving cosmetic product (red lipstick). The chemical information obtained through this technique provides crucial evidence that can contribute to the understanding and resolution of cosmetic-related crimes.

Keywords: ATR-FTIR, spectroscopy, cosmetics, crimes against women, Lipstick

Introduction

Lipstick is frequently utilized as a part of daily routines, and as a result of its widespread usage, it may be discovered as trace transmitted evidence at a murder scene. Examinations of these displays can furnish supporting evidence to establish a connection between the perpetrator and the victim or the location of the crime. In the context of criminal investigations, specifically those involving crimes against women, it is common to find cosmetics such as lipstick, eyeliner, eye shadow, nail polish, and vermilion as potential evidence. These cosmetic items are frequently utilized in everyday life and can be easily transferred onto various surfaces, including clothing, drinking cups, handkerchiefs, tissue paper, and cigarette butts, due to contact during the commission of the crime [1]. The term "Cosmetic" is officially defined in Section 201 (i) of the 1938 FOOD, DRUG, AND COSMETIC

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ACT (FD&C Act). According to this definition, cosmetics are articles that are intended to be applied to the human body or any part of it through rubbing, pouring, sprinkling, or spraying. These articles are used for purposes such as cleansing, beautifying, promoting attractiveness, or altering appearance. Additionally, the term includes articles that are meant to be used as a component of such cosmetic products. However, it is important to note that soap is specifically excluded from this definition[2]. One category within the realm of cosmetics, sometimes referred to as "makeup," encompasses products that largely consist of color pigments and are designed to alter the visual appearance of individuals. Additional examples of commonly used cosmetics include body lotion, shampoo, skin cleanser, and conditioner, among others. The use of cosmetic goods has experienced a significant surge, with lipstick being a prevalent choice among ladies. According to the provisions outlined in the Cosmetic Act, a total of 420 drugs are deemed illegal, while an additional 67 substances are permitted but subject to limitations[3].

Red Lipstick, lip balm, lip liner, lip stain, lip conditioner, lip primer, lip boosters, and lip butters are common lip cosmetics. Lipsticks are intentional to add color and texture to the lips and are even come in a wide range of colors, as well as finishes such as matte, gloss or shine. Lipstick applied on lips with a dye which is temporary. It is waterproof. The product of lipstick may come with a brush in the form of roller ball, stick or even can apply with finger.

Lip prints have been employed, akin to fingerprints, in the resolution of criminal cases. Through the comparison of the makeup of a lipstick smear found at a crime scene with that of the victim, forensic scientists are able to provide an indirect demonstration of touch or a potential relationship between the victim and the suspect. Various analytical techniques are employed in the examination of lipstick and its constituent substances. These techniques encompass chromatographic methods such as liquid chromatography, gas chromatography, and thin layer chromatography, as well as calorimetric analysis, acid-base titration, UV-VIS spectrophotometry, refractometry, and mass spectrometry. The aforementioned procedures are commonly linked to a particular, frequently arduous,

process of preparing samples and employing many measuring instruments[4].

One of the most recent advancements in the realm of cosmetics is to the emergence of active cosmetics. Presently, cosmetics serve a dual purpose by not only enhancing the aesthetic appeal and fragrance for consumers, but also providing targeted benefits to various areas such as the skin, hair, mucous membrane, or teeth. Through the use of a functional approach, products have undergone diversification and have begun to assert a myriad of effects on the human body. Following this, the cosmetic industry experienced significant growth, leading to its widespread availability to millions of people throughout the globe.

Figure 1: Red lipstick collected for the examination

Fourier-Transform Infrared Spectroscopy(Ftir)

The Fourier-transform infrared spectroscopy (FTIR) technique is employed to acquire an infrared spectrum that captures the absorption and emission characteristics of a solid, liquid, or gas sample. The FTIR spectrometer is capable of acquiring data with excellent spectral resolution across a wide range of wavelengths. This provides a notable benefit compared to a dispersive spectrometer, which assesses intensity within a limited range of wavelengths sequentially.

The phrase Fourier-transform infrared spectroscopy denotes the necessity of employing a Fourier-transform algorithm to turn raw data into a discernible spectrum.

Fourier-transform infrared spectroscopy (FTIR) is a measurement technique that is utilized in conjunction with infrared spectra. An interferometer is utilized to transmit infra-red light through both an interferometer and a gas cuvette sample. The presence of a mobile mirror within the interferometer alters the light distribution throughout the system. The raw signal, known as an interferogram, is a representation of the intensity of light. The raw data is subsequently transformed into the spectrum using a mathematical process known as Fourier Transform. The spectral characteristics of the optical signal are contingent upon the composition of the gas components that are present. Subsequently, the quantification of the diverse gas constituents is established by analyzing the optical signal derived from the spectrum.

Non-destructive infrared spectroscopy has been employed for the examination of archaeological artifacts, encompassing the research of cosmetic materials utilized during prehistoric eras[5]. The composition of lipstick from previous centuries can be determined by the utilization of infrared spectroscopy. Nevertheless, the identification of minute quantities of the constituents in the sample proves to be exceedingly challenging, if not unattainable[6]. Consequently, it is recommended to employ supplementary techniques such as chromatography and Raman spectroscopy. Typically, the utilization of a dual approach including two methodologies, such as FT-IR and Raman spectroscopy, yields a more comprehensive and unambiguous understanding of the sample's composition. The presence of surfactants, emulsifiers, and alcohols can be determined using infrared spectroscopy.

Materials and Methodology

A selection of popular lipstick brands was procured from the North Western Indian market. Lipstick samples, weighing approximately 1.5 mg, were applied directly onto an ATR-FTIR crystal for subsequent analysis. The crystal and sample were effectively brought into contact by means of a securely fastened anvil, ensuring optimal surface interaction. Regarding the instrumental setup, the materials were analyzed using ATR-FTIR spectrophotometer that was equipped with a ZnSe crystal.

The instrument was employed to capture spectral data inside the mid-infrared region. The spectral range of interest lies between 4000 and 600 cm^{-1}. The optimization studies conducted determined that the ATR-FTIR spectrometer's scan duration and resolution should be set at 24 scans and 4 cm^{-1} respectively, as these parameters are considered significant. There is no significant evidence or findings to support the claim.

Observation Table

Table 1: Results from ATR-FTIR

Hit No.	Hit Quality	Compound Names
1	370	RUMITEN 250 CQ* LOW DENSITYPOLYETHYLENE,
2	369	PARVAN 3150, F.N. 3502* REFINED PARAFINWAX
3	369	RUMITEN HD 630 INJECTION MOLDING* HIGHDENSITY POLYETHYLENE
4	354	EPCAR 5875* ETHYLENE/ PROPYLENE/DIENE TERPOLYMER
5	312	POLY(ETHYLENE) LOW DENSITY

Result and Discussion

The technique of Attenuated Total Reflectance Fourier Transform Infrared Spectroscopy (ATR-FTIR) was employed to acquire spectra of lipstick samples in order to discern the changes in composition among different lipstick samples. Figure 1 displays a representative spectrum of lipstick.The spectral range spanning from 3700 cm^{-1} to 3100 cm^{-1} exhibited a wide spectrum, which can be attributed to the vibrations of O–H bonds in compounds such as water and alcohol. Within the spectral region of 3100 cm^{-1}–2800 cm^{-1}, there are observed peaks at. The wavenumbers 3007 cm^{-1}, 2917 cm^{-1}, and 2850 cm^{-1} have been assigned to the vibrational modes associated with the CH3 functional group. The stretching vibrations encompass the C–H asymmetric and C–H symmetric vibrations. In accordance with their respective positions or roles. The occurrence of peaks within the spectral ranges. The spectral regions centered around 1730–1740 cm^{-1}, 1370–1560

cm−1, and 850–1270 cm−1 have been assigned. The C–O stretching vibration with a wavenumber of 1742 cm−1 corresponds to the propyl ester of hexanoic acid. The presence of acid, aromatic compounds (at a wavenumber of 1375 cm^{-1}), and the existence of silicates were observed.

The ATR-FTIR spectra of Red Lipstick reveal the presence of various components, namely RUMITEN 250 CQ* LOW DENSITY POLYETHYLENE, PARVAN 3150, F.N. 3502* REFINED PARAFIN WAX, RUMITEN HD 630 INJECTION MOLDING* HIGH DENSITY POLYETHYLENE, EPCAR 5875* ETHYLENE/PROPYLENE/DIENE TERPOLYMER, and POLY(ETHYLENE) LOW DENSITY. These components exhibit Hit Qualities of 370, 369, 369, 354, and 312, respectively.

Parvaneh 3150, F.N. 3502* is often known as Paraffin wax. It exhibits melting points across a spectrum of low, intermediate, and high temperatures. The Parvan company's goods are sourced from petroleum sources. EPCAR 5875* is a polymer composed of hydrocarbon molecules that incorporates an ethylene/propylene/diene terpolymer. Polyethylene low density (LDPE) exhibits favorable chemical resistance properties and demonstrates low levels of water absorption. The cost is relatively inexpensive. This material finds extensive application in high-frequency insulation, toys, tote bags, as well as gas and water pipes.
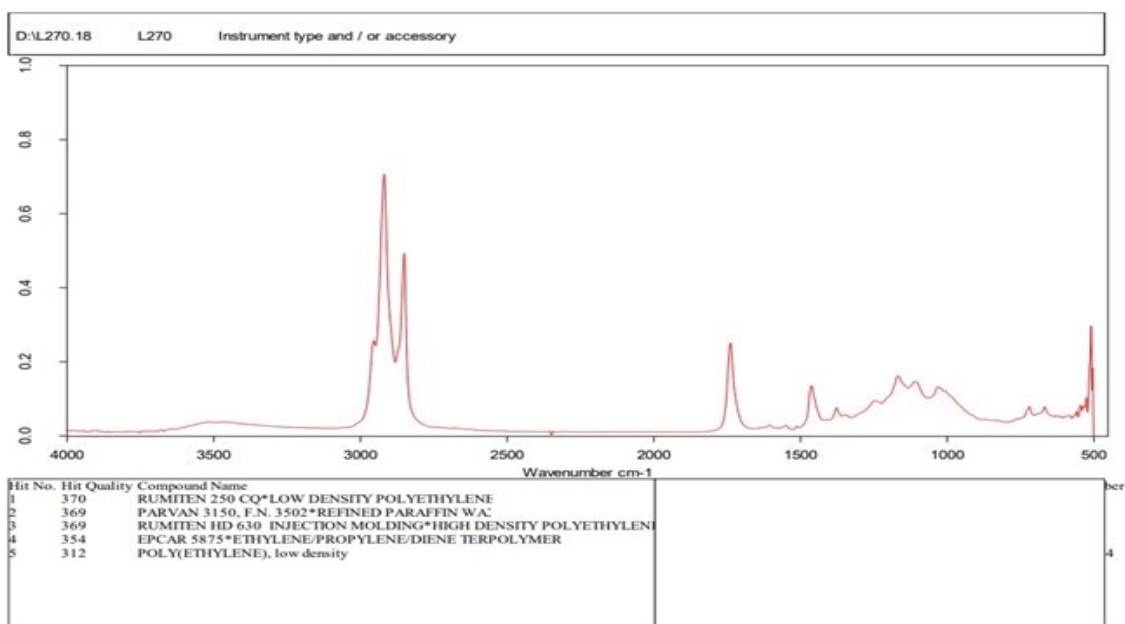
Figure 2: IR Spectra showing analysis of Lipsticks and related components

Conclusion

The comprehensive evaluation of Fourier-transform infrared spectroscopy (FTIR) in the context of cosmetics is challenging owing to the multitude of constituents included in these products. The ATR-FTIR spectroscopy technique is employed for the investigation of various substances. Cosmetic products, particularly lipstick, have the ability to serve as significant evidentiary material in crime investigations, offering vital insights into a suspect's actions or establishing a correlation with a specific crime scene. The examination of cosmetics can provide valuable insights by detecting minute traces of evidence, such as DNA or fingerprints, which can be essential in the process of identifying or establishing connections between individuals. Moreover, the existence of deleterious compounds or poisons in cosmetic products can play a significant role in instances related to assault, poisoning, or other illicit acts[7]. Thorough forensic analysis of beauty products can significantly contribute to the elucidation of factual evidence pertaining to a criminal investigation. The current investigation employed ATR-FTIR spectroscopy as an effective method for the analysis of lipstick samples. The samples were

subjected to non-destructive and expeditious analysis. The research approach employed in this study has the ability to facilitate a comparative analysis between questioned and known lipsticks by offering a statistical foundation upon which examiners can substantiate their results. Further investigation is necessary to validate the current research approach, and additional investigations should be conducted to establish a correlation between the lipsticks' smudges on substrates and their respective sources.

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Artificial Intelligence and Machine Learning

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Abstract

Artificial Intelligence (AI) and Machine Learning (ML) have rapidly gained prominence as transformative technologies with immense potential to revolutionize various industries and domains. This research paper presents a comprehensive review of AI and ML, encompassing their fundamental concepts, techniques, and applications. Additionally, it explores recent advancements in the field and offers valuable insights into the future prospects of AI and ML. The paper discusses the historical evolution of AI, the different approaches to AI development, and the components that constitute AI systems. Furthermore, it delves into the core concepts and algorithms of ML, including supervised, unsupervised, and reinforcement learning, as well as the advent of deep learning and neural networks. The applications of AI and ML across diverse domains such as natural language processing, computer vision, healthcare, and finance are also discussed. Recent advancements, such as transfer learning, generative adversarial networks, explainable AI, and federated learning, are highlighted, along with the challenges and limitations faced by these technologies, such as ethical concerns, data quality issues, and interpretability challenges. The paper concludes by presenting future perspectives, including the integration of AI with other technologies, advancements in human-computer interaction, and the impact of quantum computing on ML. This research emphasizes the importance of ongoing research and development in AI and ML and the need to address ethical, security, and interpretability considerations for responsible and beneficial implementation in society.

Keywords:AI, machine learning, technology, AIsecurity, technical challenges, computer.

Introduction

Artificial Intelligence (AI) and Machine Learning (ML) are powerful technologies that have revolutionized numerous industries. This research paper serves as an introduction to AI and ML, exploring their fundamental principles, techniques, and applications. AI involves the development of intelligent systems capable of perceiving, reasoning, learning, and making autonomous decisions. ML, a subset of AI, focuses on designing algorithms that enable computers to learn from data and improve performance without explicit programming[1].

The significance of AI and ML lies in their ability to process vast amounts of data, identify patterns, and make intelligent predictions or decisions. They find applications across various domains such as healthcare, finance, transportation, manufacturing, and entertainment. ML algorithms play a crucial role in enabling computers to learn from labeled or unlabeled data, while deep learning algorithms utilize neural networks with multiple layers to process complex information effectively[2].

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Recent advancements in AI and ML have further expanded their capabilities. Transfer learning allows models to leverage knowledge from one domain and apply it to another, leading to improved performance. Generative Adversarial Networks (GANs) generate realistic data, benefiting image synthesis and data augmentation. Explainable AI (XAI) provides transparency in the decision-making process, while federated learning enables collaborative model training with privacy preservation. Reinforcement learning algorithms have achieved groundbreaking results in complex environments. AI and ML also face challenges and considerations. Ethical concerns such as bias and accountability must be addressed for responsible deployment. Data quality and availability pose challenges, requiring representative and diverse datasets. Interpretability and explainability of AI systems are essential for gaining user trust. Security and privacy are crucial to protect sensitive data[3].

Fundamentals of Artificial Intelligence (AI):

Artificial Intelligence (AI) encompasses the development of intelligent systems that can mimic and perform tasks that typically require human intelligence. The field of AI aims to create machines capable of perceiving their environment, reasoning, learning, and making autonomous decisions. Understanding the fundamentals of AI is crucial to grasp its concepts, techniques, and potential applications.

➢ History and Evolution of AI: AI's roots trace back to mid-20th century pioneers like Alan Turing and John McCarthy. Early AI systems used rule-based symbolic reasoning, while modern AI has integrated statistical methods, machine learning, and advanced computing.

➢ Approaches to AI: Symbolic AI vs. Machine Learning: Symbolic AI relies on explicit rule-based programming, while Machine Learning (ML) enables systems to learn from data without explicit programming. ML algorithms allow computers to improve performance through experience and data exposure[4].

➢ Components of AI Systems: AI systems consist of Perception (interpreting data), Reasoning (logical thinking), and Action (decision-based responses). These components work together to enable intelligent behavior.

➢ Perception in AI: Perception allows AI to understand and interpret data from various sources. Computer vision analyzes visual data, while Natural Language Processing (NLP) deals with language understanding and generation.

➢ Reasoning in AI: Reasoning involves logical thinking and decision-making. Symbolic reasoning relies on explicit rules and knowledge representation, while ML employs statistical reasoning and probabilistic methods based on patterns in data.

Action in AI: AI systems act based on perceived data and reasoned decisions. This includes both physical actions (robots, autonomous vehicles) and virtual actions (software-generated responses, recommendations).

Understanding these AI fundamentals serves as a foundation for delving into AI techniques, algorithms, and applications. With the ability to perceive, reason, and take actions, AI systems have the potential to advance various domains significantly[5].

Machine Learning: Concepts and Algorithms

Machine Learning (ML) is a subset of Artificial Intelligence (AI) that involves developing algorithms enabling computers to learn from data and enhance their performance without explicit programming. It leverages data to find patterns and insights for tasks like prediction and classification. Key concepts include:

➢ Supervised Learning: ML models learn from labeled data to predict or classify new data. Algorithms like linear regression, decision trees, and support vector machines (SVM) map input features to target labels for accurate predictions.

➢ Unsupervised Learning: Models are trained on unlabeled data to discover patterns. Clustering algorithms group similar data points, while dimensionality reduction techniques reduce complex data while maintaining essential information.

➢ Reinforcement Learning: Agents learn by interacting with an environment, receiving

rewards or penalties for actions. Algorithms like Q-learning guide agents to make optimal sequential decisions, useful in robotics and games.

➢ Deep Learning: A subset of ML, it trains deep neural networks to extract complex data features. Convolutional Neural Networks (CNNs) are for images, Recurrent Neural Networks (RNNs) for sequential data. Deep Learning excels in image recognition, language processing, and more.

These concepts empower practitioners to apply ML effectively, choose suitable algorithms, and optimize model performance. Ensemble learning combines models for better predictions, anomaly detection finds outliers, and regularization prevents overfitting. Evaluation metrics like accuracy and precision assess model performance. ML continues to advance, expanding what machines can achieve[6].

Applications of AI and Machine Learning

Artificial Intelligence (AI) and Machine Learning (ML) have found a wide range of applications across various industries, revolutionizing the way tasks are performed, decisions are made, and insights are generated from data. The following are key domains where AI and ML have made significant impacts:

➢ NLP and Sentiment Analysis: AI understands human language, enabling chatbots and translations. Sentiment analysis gauges opinions for customer insights.

➢ Computer Vision and Image Recognition: ML interprets visual data for object detection, face recognition, and medical imaging, benefiting security and healthcare.

➢ Healthcare and Medical Diagnosis: AI aids diagnoses, predicts diseases, and enhances accuracy in medical imaging.

➢ Financial Analysis and Predictive Modeling: ML aids credit scoring, predicts markets, and detects fraud, bolstering risk management and investment strategies.

➢ Autonomous Systems and Robotics: ML powers self-driving cars, robots for manufacturing, and healthcare, improving safety and efficiency.

➢ Recommendation Systems: ML customizes product recommendations in e-commerce, streaming, and entertainment.

➢ Fraud Detection and Cybersecurity: ML identifies anomalies, preventing fraud and enhancing online security.

The applications of AI and ML are vast and continually expanding into new areas such as agriculture, energy, logistics, and environmental monitoring[7]. As these technologies continue to advance, the potential for innovation and impact across industries is significant. Leveraging AI and ML enables businesses and organizations to extract meaningful insights, automate processes, improve decision-making, and deliver enhanced user experiences[8].

Recent Advancements in AI and Machine Learning

Artificial Intelligence (AI) and Machine Learning (ML) have witnessed remarkable advancements in recent years, driven by continuous research, technological innovations, and increased computational power. These advancements have expanded the capabilities and applications of AI and ML, pushing the boundaries of what machines can achieve[9]. The following are some notable recent advancements in the field:

➢ Transfer Learning and Domain Adaptation: Transfer learning allows models to use knowledge from one domain to improve performance in another with limited data. Domain adaptation techniques make models adaptable across different domains.

➢ Generative Adversarial Networks (GANs): GANs are models that generate synthetic data and have transformed image synthesis, data augmentation, and style transfer.

➢ Explainable AI (XAI): XAI aims to make AI models transparent and interpretable by providing insights into their decision-making process, enhancing trust.

➢ Federated Learning and Privacy-preserving Techniques: Federated learning collaboratively trains models without centralized data, crucial for privacy-sensitive

industries. Techniques like differential privacy enhance data protection.

➢ <u>Reinforcement Learning (RL) in Complex Environments:</u> RL has advanced training agents in complex tasks like game playing and robotics. Techniques like DQN and PPO have achieved human-level performance[10].

These recent advancements in AI and ML have expanded the horizons of what is achievable and opened up new possibilities for innovation. They address challenges such as data scarcity, interpretability, privacy concerns, and complex decision-making. As AI and ML continue to evolve, ongoing research and development in areas like model compression, automated machine learning, and ethical AI will further enhance their capabilities and impact across diverse domains. These advancements pave the way for intelligent systems that can learn, adapt, and interact with humans more effectively, leading to advancements in healthcare, automation, personalized services, and societal well-being[11].

Challenges and Limitations of AI and Machine Learning

While Artificial Intelligence (AI) and Machine Learning (ML) offer tremendous potential and transformative capabilities, they also face several challenges and limitations that need to be addressed for their responsible and effective deployment[12]. The following are key challenges and limitations in the field:

➢ <u>Ethical Considerations and Biases:</u> AI's performance relies on training data, which can contain biases that lead to unfair outcomes. Addressing these biases is crucial to ensure fairness and prevent perpetuating inequalities. Additionally, ethical concerns about privacy, transparency, and accountability must be managed to ensure responsible AI use.

➢ <u>Data Quality and Availability:</u> ML models need accurate and diverse datasets for effective training, but obtaining such data can be difficult. Incomplete or biased data can result in poor model performance. Limited access to labeled data can hinder model development.

➢ <u>Interpretability and Explainability:</u> Complex ML models lack transparency, making it challenging to understand their decisions. In critical fields like healthcare and finance, the inability to explain decisions hampers trust and adoption.

➢ <u>Security and Privacy Concerns:</u> Protecting sensitive data used by AI systems is crucial. Adversarial attacks and data breaches are potential risks. Ensuring robust security and privacy measures is an ongoing challenge.

➢ <u>Skills Gap and Workforce Readiness:</u> The demand for AI professionals outpaces the supply. Bridging the skills gap is essential for responsible AI deployment across industries.

Addressing these challenges and limitations requires collaborative efforts from researchers, policymakers, and industry stakeholders. It involves developing robust frameworks and guidelines for ethical AI, investing in data quality and curation, advancing interpretability and explainability techniques, enhancing security and privacy measures, and fostering educational programs and initiatives to build a skilled AI workforce. By addressing these challenges, AI and ML can be harnessed effectively and responsibly to realize their potential in improving society and driving positive impact[13].

Future Perspectives of AI and Machine Learning

Artificial Intelligence (AI) and Machine Learning (ML) have already made significant advancements, but the field continues to evolve rapidly, presenting exciting future prospects and possibilities. The following are key future perspectives for AI and ML:

➢ <u>Integration with Other Technologies:</u> AI and ML are poised to integrate with emerging technologies like the Internet of Things (IoT), Blockchain, and edge computing. This integration will lead to enhanced automation, data analysis, and decision-making across various domains such as smart homes, cities, and industries. Blockchain can ensure the transparency and security of AI systems, especially in areas like supply chain management and data sharing.

➢ **AI in Edge Computing and Mobile Devices**: Edge computing, which processes data and AI functions closer to the data source, offers real-time decision-making, reduced latency, improved privacy, and efficient network resource utilization. This approach will enable AI-powered capabilities on mobile devices, enhancing user experiences, personalization, and on-device intelligent processing.

➢ **Enhanced Human-Computer Interaction**: Progress in natural language processing, gesture recognition, and computer vision will transform how humans interact with computers. Natural Language Understanding (NLU) and voice assistants will enable more natural conversations. Gesture recognition will enable intuitive interactions, particularly in gaming and augmented reality. Computer vision advancements will enhance facial recognition and object tracking for more immersive experiences.

➢ **Ethics and Regulations in AI**: As AI becomes more integrated into society, ethical considerations and regulations will play a crucial role. Ethical AI frameworks will address fairness, transparency, accountability, and bias. Regulations may be established to protect privacy, prevent misuse, and establish legal frameworks for AI-driven systems' liability and accountability.

➢ **Advances in Quantum Computing**: Quantum computing has the potential to revolutionize AI and ML. Quantum algorithms can solve complex problems exponentially faster, impacting optimization, pattern recognition, and data analysis. Quantum machine learning algorithms are being explored for enhanced performance. Quantum computing's evolution will significantly influence AI and ML capabilities[12].

These future perspectives highlight the continued growth and potential impact of AI and ML. Leveraging their integration with other technologies, enhancing human-computer interaction, addressing ethical considerations, and harnessing the power of quantum computing will shape the future of AI. It is crucial to ensure responsible and ethical development, foster collaboration between academia, industry, and policymakers, and invest in research and education to maximize the benefits and minimize the risks of AI and ML in our rapidly evolving world[13].

The forensic aspect of Artificial Intelligence (AI) and Machine Learning (ML):

The forensic aspect of Artificial Intelligence (AI) and Machine Learning (ML) involves investigating and analyzing AI/ML systems, algorithms, and data to understand their behavior, decisions, and biases. This is crucial in critical fields like criminal justice, healthcare, and finance to ensure ethical and accountable use of these technologies. Key points in this domain include:

➢ **Bias and Fairness**: Identifying and mitigating biases that could lead to unfair outcomes by examining and correcting algorithmic biases.

➢ **Transparency and Explainability**: Making AI/ML systems more understandable to verify their decisions and identify potential flaws.

➢ **Model Auditing**: Reviewing AI/ML models for vulnerabilities and potential malicious exploits.

➢ **Error and Failure Analysis**: Investigating and rectifying the sources of AI/ML system failures or incorrect decisions.

➢ **Data Provenance**: Tracing the origin and history of training data to address issues related to data quality and biases.

➢ **Fraud Detection**: Using AI/ML for detecting anomalies and patterns indicating fraud in various domains.

➢ **Legal and Ethical Considerations**: Assessing compliance with regulations and ethical standards.

➢ **Accountability and Responsibility**: Assigning responsibility for harmful or erroneous AI/ML decisions.

> ➤ <u>Litigation Support:</u> Providing technical analysis and testimony in legal cases involving AI/ML.

> ➤ <u>Continuous Monitoring:</u> Ongoing observation of AI/ML systems to detect and rectify changes in behavior.

To sum up, the forensic aspect of AI/ML ensures the responsible and transparent use of these technologies by examining their behavior, addressing biases, and identifying vulnerabilities. It is a multidisciplinary field that intersects with computer science, ethics, law, and data analysis[14].

Conclusion

This research paper has provided a comprehensive overview of Artificial Intelligence (AI) and Machine Learning (ML), covering their fundamental concepts, techniques, and applications. The historical evolution of AI and the different approaches to AI development were explored, highlighting the components that constitute AI systems. The core concepts and algorithms of ML, including supervised, unsupervised, and reinforcement learning, were discussed, along with the advancements in deep learning and neural networks.

The applications of AI and ML across diverse domains such as natural language processing, computer vision, healthcare, and finance were explored, showcasing the transformative impact of these technologies and The forensic aspect of Artificial Intelligence (AI) and Machine Learning (ML, this research paper contributes to the understanding of AI and ML, providing a comprehensive review of their concepts, techniques, applications, recent advancements, challenges, and future prospects. It highlights the significance of AI and ML as transformative technologies and calls for continued research and responsible implementation to unlock their full potential and drive positive impact across industries and society as a whole.

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Development of Latent Fingerprint Impressions using Ophthalmic Fiber Glass Powder

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Abstract

Fingerprints are a vital and unique identity of a person. These are impressions left by the friction ridges of a human finger on contact with any surface. The primary advantage of a fingerprint is that it does not change over time. Fingerprint identification is a method of identification using the impression formed by the minute ridges seen on the fingertips. Fingerprints have certain individual characteristics that are unique. Fingerprints are most generally recovered from crime scenes. Such prints are obtained when natural oils and perspiration (sweat) existing between the fingertip ridges are transferred to the surface by any contact. Fingerprints are invisible and are much harder to detect and preserve. These prints are obtained by physical and chemical methods. In this paper, my research focuses on detecting latent fingerprints or invisible fingerprints using ophthalmic fiber glass powder on different surfaces. Here I used the ophthalmic fiber glass and turned it into powder which is used for obtaining latent fingerprints.

Keywords: Latent, Fingerprint, White powder, Crime scene, Powder, Fiber, Glass, Ophthalmic.

Introduction

As Dr. Edmond Locard (1877-1966) had given a principle that "Every contact leaves a trace", the human's fingers also leaves a trace known as fingerprints. A Fingerprint is an impression left by the friction ridges of human fingers[1,2]. These are made from an association of ridges, known as friction ridges. Each ridge consists of pores that are connected to the sweat gland below the skin that are responsible to produce sweat in hands which. When we touch somewhere with our hands, due to sweat the ridge trace develops on the surface, which is a fingerprint impression[3]. All of the ridges of fingerprints have patterns referred to as loops, whorls, arches or composites. Fingerprints are one of the maximum treasured styles of proof because of their uniqueness and individuality[4]. They are discovered on items as evidence at scene of crime and are used to find the suspect or criminal and link them to the crime scene. "Latent fingerprint" is an impression of fingerprint formed by friction ridges on bulb of fingers, which is not apparent to the eye but can be made sufficiently visible through physical or chemical methods. Physical methods like powder method and chemical

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method like fuming method[5]. Latent prints may be discovered on a lot of surfaces; however, they're now no longer quite simply seen and detection frequently calls for using fingerprint powders, chemical reagent or exchange mild sources. Latent fingerprints do not show fluorescence on their own and so the various fluorescent powders are used. The powder approach for detecting latent fingerprints entails the utility of a finely divided formula to the finger-mark impression, normally with a glass-fiber or a makeup brush. The powder automatically adhered to the sweat residue defining ridge pattern[6].

Fingerprints can be printed anywhere, even on the human body. Based on the practicals, fingerprint impressions are classified into three classes consistent with the kind of surface on which they may be determined and whether or not they're seen, fingerprints on smooth surfaces (which includes soap, wax, moist paint, sparkling caulk, etc.) are probable to be 3 – dimensional which are plastic prints; the ones on tough surfaces are both patent (visible) or latent (invisible) prints. Visible prints are fashioned whilst blood, dirt, ink, paint, etc. is transferred from finger to any surface. Patent prints may be discovered on huge sorts of surfaces; smooth and rough, porous (along with paper material or wood) or non-porous (along with metal, glass or plastic). This research paper is mainly concerned with latent (invisible) prints, or we can say a method for development of latent fingerprint development[7,8].

Materials and Methodology

Latent or invisible prints can be found in various crime scenes, and it is considered as a piece of valuable evidence. There are different methods for developing latent prints. The powder method is one of the common methods used for development of latent fingerprints. In this research, a new method of latent fingerprint development is done, i.e., developing prints by the usage of ophthalmic fiber glass powder. This comes under the powder method of latent fingerprint development methods. Latent fingerprints were collected from various surfaces like plastic, mobile phone screens, etc. using the powder method. Here we use the ophthalmic fiber

glass powder to extract or develop latent prints. This ophthalmic fiber glass powder is generally found at the industries which make fiber glass or at the firms where the spectacles are made putting fiber glasses in them. The firms and industries throw them as a waste powder but it can be used as white powder for the development of latent prints. This powder can be commonly available and is cheap as it is just a waste of fiber glass to the optometrists or the firms making the spectacles. During cutting of fiber glasses the powder is formed which used for development of fingerprint on different surfaces. The powder was dusted on the surface where the latent print is to be extracted using a fingerprint dusting brush or clean and soft makeup brush. Using the brush, lightly apply the powder on the fingerprint and obtain a clear print. On applying the dusting method, the powder gets attached to the surface due to the perspiration, oil and other constituents from the finger which is shifted to the fingerprint. After the fingerprint was visible with all the ridges, we photographed the latent print and then we lifted it carefully with the help of cellophane tape and preserved it properly. Then from the obtained prints we identified type and pattern of fingerprint.

Result and Discussion

The result of the research on the latent (invisible) fingerprint exhibits the development of latent fingerprints from different surfaces like plastic, mobile phone screen, etc. as shown in Figures 1 to 9 using ophthalmic fiber glass powder.
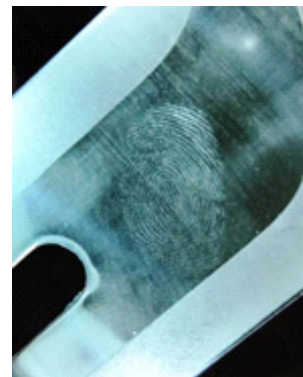
Figure 1: Development of Latent Fingerprint with the help of ophthalmic fiber glass powder on Metal handle surface.

Figure 2: Development of Latent Fingerprint with the help of ophthalmic fiber glass powder on Glass surface.

Figure 3: Development of Latent Fingerprint with the help of ophthalmic fiber glass powder on Oil-paint surface.

Figure 4 (a) and (b): Development of Latent Fingerprint with the help of ophthalmic fiber glass powder on Plastic surface.

Figure 5: Development of Latent Fingerprint with the help of ophthalmic fiber glass powder on Mirror surface.

Figure 6: Development of Latent Fingerprint with the help of ophthalmic fiber glass powder on Rough plastic surface.

Figure 7: Development of Latent Fingerprint with the help of ophthalmic fiber glass powder on Metallic surface.

Figure 8: Development of Latent Fingerprint with the help of ophthalmic fiber glass powder on Car key (hard rubber) surface.
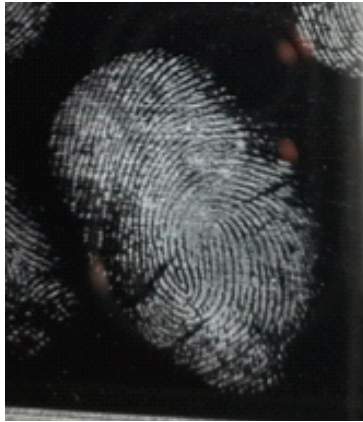
Figure 9: Development of Latent Fingerprint with the help of ophthalmic fiber glass powder on Mobile phone screen surface.

Powders are an excellent medium to develop latent or invisible prints. As ophthalmic fiber glass powder is white in color, so it gives excellent results on dark color surfaces. Thus, the results of the research revealed that the latent fingerprints present on the majority of the surface examined can be successfully developed using ophthalmic fiber glass powder for performing the powder method for the visualization of these invisible prints. The comparative evaluation of different surfaces with this powder manifested that it provides a final result on contrast surfaces than on the other surfaces examined.

The occurrence of latent fingerprints presents on the surface like plastic, mobile phone screen, etc. could be successfully done and their ridge features or ridge minutiae could be seen clearly. The present-day is just a preliminary investigation and can be explored further.

Conclusion

Ophthalmic fiber glass powder is generally found at the industries which make fiber glass or at the firms where the spectacles are made. This powder is commonly available and cheap as it is just a waste of fiber glass to the optometrists. This powder can be used successfully on various surfaces to develop prints in crime investigations. The print was successfully developed using the powder on all the surfaces (Metal, Glass, Oil Paint, Plastic, Rough Plastic, Mirror, Car key and Mobile Screen.) and has clear ridge characteristics present.

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Development of Latent Fingerprint using Carbon Powder

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Abstract

The uniqueness of human fingerprint plays the most prominent role in forensic investigation as a physical evidence Which is useful for criminal identification. With its unique features no two fingerprints have ever been found to be identical. In legal cases the identification of such print established the relationship between crime scene and the culprit. Generally , there are three types of fingerprint is to be found visible print, plastic print and latent print (invisible print) which has been taken in account for identification. There is no such crucial method is used for decipher the visible print and plastic print because they are easily visible to naked eye but in case of latent print the process for enhancement is necessary for the latent fingerprint to be observed by naked eye. The most encountered fingerprint is the latent fingerprint which is unconsciously left by perpetrators at any surface. For visualizing such prints Various method have been reported for the development of latent fingerprint on different surfaces. This present study introducing a new visualizing agent for the development of latent fingerprint by using Carbon Powder on various non-porous & porous surface through the powdering method. Here we use candle flame to collect black carbon mass and turn it into powder which is used for obtaining latent fingerprints. By the application of these powder it is observed that it gives a clear ridge on various surfaces.

Keywords: Latent, Fingerprint, Carbon, Powder, Crime, Scene

Introduction

A fingerprint is a unique individual characteristic that can't match with any two different human beings. The Palmer surface of the hand and feet are covered by a layer of folded skin. Which ensure a various activity[1]. The raised surface are known as papillary which also called as friction ridges. The reproduction of pattern of the friction ridges on the distal phalanges of the finger and thumb are called as fingerprint. This fingerprint begin to take form on the Palmer surface during the third or fourth month of fetal life and they remain unchanged through out the life of an individual and even no two fingerprints found to be identical[2]. With these permanence and unique characteristics of fingerprint. The fingerprint considered most valuable physical evidence to aid the criminal justice administration. Generally, the fingerprint are of three types visible print, Plastic print and latent print (invisible print)[3].

On the basis of Locard's exchange principle as "Every contact leaves a trace" the latent fingerprint is the most encountered print from the crime scene. Which is unconsciously left by the criminal at any surface in the crime scene. Which is trace of sweat, oil or other natural secretion of the skin and they are not typically visible[4]. It taken in account as trace evidence. The process of enhancement is necessary for the latent fingerprint to be observed by naked

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eye. For the decipherment of such finger impression the traditional fingerprinting detection techniques for treating latent print is powdering method Which has been used since old era. Which is based on powder adhesion[5,6]. Various types of fingerprint powder has reported previously for development of latent fingerprint, which may not always effective and having some limitation[7]. The present study introducing a new visualizing agent for development of latent fingerprint by using Candle carbon powder. This material is used by humans as their daily needs. The fine powder Particle of these material provide a good adhesion on both light and dark non-porous surface[8,9].

Candle

It is made up of the wax and when it burns they provide light and in some cases a fragrance. It can also provide heat and excrete blackish smokey substance which is non-other than carbon particles. Candle flame consist of three different zones each zones has different temperature. Every Zones has different colours and this will help us in understanding the temperature of each zones.

Materials and Methods

The carbon powder method is used to visualize the Latent fingerprint from various surface. We used unconventional powder that came from candles flame and collected on the steel glass material which is applied on the fingerprint surfaces. The method used for the development of latent or invisible fingerprint is powdering method. It is a physical method for enhancement of latent fingerprint. This method is mainly based on the adherence of fine fingerprint powder particle on the traces of sweat, oil and other natural secretion of skin which is released through ridge pores of skin and forms a mirror image of ridge pattern.

In order, to develop the latent fingerprint the commercially available candle (carbon powder) is used. The carbon powder is taken which is in the form of black colour. This powder is kept for a few minutes in room temperature. Whereas the fingerprint was collected by the subject on different non-porous surfaces such as Almirah, plywood of carrom board, gorilla glass of phone, book cover,

electric switch, sunmaica of wood, stainless steel, White Tiles, Surface of Vehicle the subject deposited heavily sweaty impression on the surface. The phenomenon is based on this while committing the crime the human perspiration secretion of human is abundant as compared to normal on criminals due to physiological response which cannot be controlled by criminals.

The above-mentioned candle (carbon powder) is sprinkled over the questioned surface as the fine powder particle of this material adheres on the traces of perspiration then with the help of camel hairbrush lightly brushing or tapping is done to remove excess powdered material. Hence, the heavily brushing is to be avoided because it may destroy the ridge characteristics. By following powdering method this fine non-conventional powder is used. Which provide good adhesion on traces of perspiration with clear visibility of ridges. Then, the developed images are photographed with the help of DSLR camera, and it transferred into laptop then the images are cropped.

Result and Discussion

The result of the current study showed the development of latent or invisible fingerprint on various non-porous surface by the application of candle (carbon powder) by using this powder or questioned surface it provides better result on both dark and light color nonporous surface due to the colour contrast of the powder. The visualization of latent finger impression on the surface of Almirah, plywood of cardboard, gorilla glass of phone, Book cover, electric switch, sunmaica of wood, stainless steel, surface of vehicle, and the surface of white tiles is successfully done which the pictorial result is shown from Fig 1 to Fig 5.

Thus, this result produce by following the oldest powder dusting method with fine particles of this powder provide good adherence on latent residue of latent impression that present in the form of natural human perspiration and deposited on to the questioned surface. Due to the adherence of particle it provide clear visibility of ridges. Which lead prominent factor in terms of fingerprint identification at a criminal offense . The developed result shows the clear visibility of ridges pattern. These result advice that This cardel (carbon powder) is to be successfully

employed as a new powder method on various porous and non-porous surface for the enhancement of the latent finger prints. This investigation is done with identification and examination of this powder on different surfaces which shows clear visualization of latent fingerprints . It is also observed that after development of latent finger impression on various surface it is clearly visible up to 3-4 days. Even it does not fade until and unless without any destruction onto the surface it provide a positive impact, in case of secondary collection of Finger impression through photography.

Figure 1: Development of latent fingerprint with the help of carbon powder on non- porous switch board

Figure 2: Development of latent fingerprint with the help of carbon powder on non- table.

Figure 3: Development of latent fingerprint with the help of carbon powder on non- porous metal surface

Figure 4: Development of latent fingerprint with the help of carbon powder on non- plastic sheet

Figure 5: Development of latent fingerprint with the help of carbon powder on porous wooden surface

Conclusion

The current study presents a new powdering method by using candle (carbon powder). For Decipherment of latent fingerprint on different various surfaces. This powder is a household product and used by the humans as their daily needs. So, basically it is easily commercially available and simple and cost effective. This newly introduced powder is also overcome with it. This product is formed by most of the natural ingredients which are mentioned above, so it does not lead any potential harm to health. From the present study it is concluded that this household powder is easy to use for the visualization of latent fingerprints on various surface at a crime scene. When other conventional fingerprint powder is not available. This investigation provides a beneficial fact to aid with criminal justice system for solving criminal offence.

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Digital Forensics for Ransomware-based Software

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Abstract

The rapid proliferation of ransomware attacks has posed significant challenges to individuals, organizations, and society. Ransomware attacks have become increasingly prevalent as information technologies continue to evolve and spread globally. Cybercriminals have increasingly used ransomware as a means of cyberattack, using various methods to penetrate target computers, encrypt system data, and demand payment for user access. Despite the development of security tools like firewalls, antivirus software, and automated analysis tools, they have limited effectiveness in safeguarding valuable assets stored in local or cloud storage resources. This research paper explores the field of digital forensics as a crucial tool in combating ransomware-based software. The research focuses on various aspects of digital forensics specific to ransomware, including malware artifacts, encryption algorithms, and communication channels employed by ransomware strains. By leveraging a comprehensive dataset of ransomware samples and real-world case studies, the study identifies key patterns, trends, and characteristics that aid in attribution and forensic analysis of ransomware incidents. The research proposes a framework for effective detection and mitigation strategies against ransomware attacks, enhancing organizations' ability to prevent and respond to ransomware incidents effectively. The findings contribute to the advancement of digital forensics in the context of ransomware-based software, providing valuable insights into the evolving tactics and techniques employed by cybercriminals. The proposed framework equips security practitioners and law enforcement agencies with a comprehensive set of tools and strategies to combat ransomware attacks effectively.

Keywords: digital forensics, ransomware, malware analysis, incident response, mitigation strategies.

Introduction

The alarming growth in attacks involving ransomware has become a major issue for individuals, organizations, and even entire countries throughout the world. Ransomware is a sort of malicious software that encrypts important data on infected devices and demands a fee to unlock it. Because of the huge financial losses, operational interruptions, and lost sensitive information generated by these assaults, ransomware has emerged as a critical cybersecurity concern of our day's work. The technique of gathering, analyzing, and preserving digital data, known as digital forensics, is crucial in detecting and countering ransomware-based malware[1]. Security practitioners and law enforcement agencies can use forensic techniques to learn more about the attack pathways, strategies, and perpetrators behind ransomware outbreaks. This information not only aids in the attribution of the attacks, but also in the creation of preventative steps to prevent future events. The goal of this study is to explore the subject of digital forensics with a focus on ransomware-based malware. This study efforts to uncover critical insights into the mode of operation of ransomware attacks by undertaking an in-depth investigation

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of numerous ransomware strains, their features, and accompanying forensic traces[2]. Furthermore, the study aims to provide effective methodology, tools, and a complete framework for identifying, mitigating, and investigating ransomware incidents. Understanding the changing ransomware attack situation is crucial for staying ahead of hackers. This study addresses an important void in literature by concentrating on digital forensics methodologies for ransomware, offering insight on the difficulties and problems associated in forensic examinations of these harmful software occurrences[3]. This study's findings will give vital knowledge and practical recommendations to security practitioners, forensic investigators, and policymakers fighting ransomware assaults. In short, the goal of this research project is to develop digital forensics in the context of ransomware-based software. It is feasible to increase the efficacy of incident response, improve attribution capabilities, and adopt preventative measures to defend against ransomware attacks by having a complete understanding of ransomware assaults and their forensic consequences.

Ransomware Attack Lifecycle: Ransomware attacks follow a typical lifecycle that involves several stages. The first stage is the delivery mechanism, which involves sending a phishing email or exploiting a vulnerability. Once the delivery mechanism has been executed, the ransomware will try to infect the system. This can be done through various infection vectors, such as malicious email attachments, infected websites, or drive-by downloads. Once the ransomware has infected the system, it will begin to encrypt files and data. Encryption techniques used by ransomware attackers are usually strong and will make it impossible to recover the data without the decryption key. The ransomware will then display a ransom note that demands payment in exchange for the decryption key. The payment process varies depending on the type of ransomware. Some attackers demand payment in cryptocurrency, while others may ask for payment via wire transfer or credit card[4]. The ransom amount may also vary, depending on the attacker's demands and the value of the encrypted data. The following is an example of a typical ransomware attack:

1. Delivery Mechanisms: Ransomware can be delivered through various mechanisms, including:

   ➤ Phishing Emails: Attackers send deceptive emails with malicious attachments or links. These emails often masquerade as legitimate organizations or individuals.

   ➤ Exploit Kits: Attackers exploit vulnerabilities in software or web browsers to deliver ransomware to vulnerable systems.

   ➤ Malvertising: Malicious advertisements on legitimate websites can redirect users to websites hosting ransomware.

2. Infection Vectors: Once the delivery mechanism is successful, ransomware enters the victim's system. Common infection vectors include:

   ➤ File-Based Ransomware: Malicious files, such as executable files or macro-enabled documents, are executed to initiate the infection.

   ➤ Drive-by Downloads: Visiting compromised websites can trigger automatic downloads of ransomware onto the victim's system.

   ➤ Remote Exploitation: Attackers exploit vulnerabilities in network services or remote management tools to gain unauthorized access and deploy ransomware.

3. Execution and Persistence: Once inside the system, ransomware typically performs the following actions:

   ➤ File Encryption: The ransomware scans the system for files and encrypts them using strong encryption algorithms, rendering them inaccessible.

   ➤ Privilege Escalation: Ransomware may attempt to elevate its privileges to gain control over critical system functions and bypass security measures.

4. Encryption Techniques: Ransomware employs various encryption techniques to lock files and demand a ransom:

   ➤ Symmetric Encryption: Ransomware uses a single encryption key to encrypt files. This key is typically generated locally and kept secret by the attackers.

   ➤ Asymmetric Encryption: Some advanced ransomware uses asymmetric encryption,

where a public key encrypts files, and a private key, held by the attackers, is required for decryption.

5. Ransom Note and Communication: After the target network has been successfully infected with ransomware, ransom demands are issued. Hackers notify the victim of the attack and provide information on the ransom needed to stop it. Computer displays may display ransom demands, or a letter may be placed in the directory containing the encrypted data. In addition to a promise to restore access to the encrypted data when the ransom has been paid, ransom demands frequently include information about the ransom amount, the necessary payment method, and the deadline for payment. If there has been data exfiltration, the hacker may also agree to refrain from disclosing more information and provide proof that the data has been deleted. Typically, cryptocurrency (like Bitcoin or Monero) is asked for as payment.

6. Ransom Payment: Attackers demand payment in exchange for decrypting the victim's files. The payment process usually involves:

   ➢ Cryptocurrency: Attackers prefer anonymous payment methods like Bitcoin or other cryptocurrencies to maintain their anonymity.

   ➢ Payment Portals: Attackers may provide a unique payment portal accessible via the Tor network, allowing victims to make the ransom payment securely.

It is important to note that paying the ransom does not guarantee file recovery, and victims are encouraged to report the incident to law enforcement agencies to aid in tracking and potentially disrupting ransomware operations[5,6].

Digital Forensics Fundamentals: Digital forensics is the investigation and reconstruction of digital occurrences such as cybercrimes or data breaches via the gathering, analysis, and preservation of electronic evidence. Several important concepts and strategies engage in this process:

1. Evidence Gathering:

   ➢ Disc Imaging: Using programmes such as dd, FTK Imager, or EnCase, create forensic copies (images) of storage devices.

   ➢ Live Forensics: Using tools like Volatility or Mandiant Redline, collect volatile data from a running system.

   ➢ Mobile Device Forensics: Using specialized tools such as Cellebrite or Oxygen Forensic Suite, extract data from mobile devices.

2. Protection of Evidence:

   ➢ Write-Blockers: Using write-blockers, either hardware or software, to prevent changes to the original evidence during acquisition.

   ➢ Hashing: The process of calculating and validating cryptographic hash values (MD5, SHA-1, SHA-256) to assure data integrity.

   ➢ Chain of Custody: Maintaining a detailed record of all individuals who have had custody of the evidence to establish its authenticity and admissibility in court.

3. Evidence Assessment:

   ➢ File System Analysis: Investigating the content, timestamps, and metadata of files to comprehend file-related operations.

   ➢ Searching for certain words or patterns inside documents or system artefacts to find pertinent data is known as keyword searching.

   ➢ Timeline analysis: The process of compiling an event timeline using system logs and file timestamps.

   ➢ Link analysis is the process of identifying connections and patterns of behavior between items.

4. Reporting:

   ➢ Grouping and Structure: systematically presenting facts together with a methodology, conclusions, and suggestions.

   ➢ A report must adhere to the correct processes to be acceptable in court and satisfy legal criteria.

All things considered, digital forensics is extremely important for locating and recording valuable information from electronic evidence, aiding investigations, and supporting legal procedures[7,8].

Digital Evidence Collection and Preservation: Collecting, preserving, and analyzing digital evidence is crucial in investigating ransomware attacks. Following best practices ensures the integrity and admissibility of the evidence. The key practices and their significance in the context of digital evidence collection and preservation are:

1. Chain of Custody: The chain of custody refers to the chronological documentation of the evidence's custody, including its collection, storage, transfer, and analysis. It is essential for maintaining the integrity and admissibility of the evidence in legal proceedings.

2. Volatile and Non-Volatile Data Collection: Ransomware attacks may leave traces in both volatile (temporary) and non-volatile (persistent) data. Collecting both types of data is crucial for a comprehensive investigation.

3. Use of Forensic Tools: Digital forensic tools aid in collecting, preserving, and analyzing evidence efficiently and effectively. Best practices include Disk Imaging, File Integrity Verification, Malware Analysis Tools.

4. Effective Techniques for Ransomware Attacks: Ransomware attacks present specific challenges that require tailored techniques.

   • Memory Forensics: Analyzing volatile memory (RAM) to identify running processes, injected code, encryption keys, and evidence of ransomware activity using tools like Volatility.

   • Network Forensics: Capturing network traffic during and after an attack to identify communication with malicious servers, analyze network-based indicators of compromise, and uncover exfiltration attempts.

   • Ransomware Decryption Tools: Leveraging publicly available decryption tools and resources, such as the No More Ransom project, to recover encrypted files without paying the ransom[9].

Ransomware Analysis Techniques: Ransomware analysis techniques play a crucial role in understanding the behavior, Functionality, and underlying mechanisms of ransomware samples. By employing a combination of static and dynamic analysis, reverse engineering, and malware sandboxing, analysts can gain valuable insights into the ransomware's operation.

1. Static Analysis: Static analysis involves examining the ransomware sample without executing it. Key techniques and tools used in static analysis include:

   ➤ File Metadata Analysis: Examining file properties, such as file type, size, creation/modification timestamps, and digital signatures, to gain initial insights into the sample.

   ➤ Code Disassembly: Using disassemblers, such as IDA Pro or Ghidra, to analyze the ransomware's assembly code, understanding its logic, control flow, and high-level functions.

   ➤ String Analysis: Extracting and analyzing strings within the ransomware binary to identify hardcoded URLs, encryption keys, command-and-control servers, or other indicators of the malware's behavior.

   ➤ API and Library Calls: Identifying API and library calls within the ransomware code to understand its interactions with the operating system and other software components.

2. Dynamic Analysis: Dynamic analysis involves running the ransomware sample in a controlled environment to observe its behavior and interactions with the system. Key techniques and tools used in dynamic analysis include:

   ➤ Malware Sandboxing: Executing the ransomware sample in a controlled and isolated environment, such as a virtual machine or an analysis sandbox, to monitor its activities without affecting the host system.

   ➤ System Monitoring: Observing system-level events, such as file system modifications, registry changes, network connections, and process execution, using tools like Process Monitor or Wireshark.

   ➤ Behavior Analysis: Studying the ransomware's actions, including file encryption, process injection, persistence mechanisms, and communication

with command-and-control servers, to understand its behavior and identify its unique characteristics.

3. Reverse Engineering: Reverse engineering involves dissecting the ransomware sample to understand its inner workings, algorithms, and anti-analysis techniques. Key techniques and tools used in reverse engineering include:

➢ Code Decompilation: Converting the ransomware's compiled code back to a higher-level programming language, such as C or C++, using tools like IDA Pro or Ghidra.

➢ Code Debugging: Analyzing the ransomware's execution flow, variable values, and memory modifications using debuggers, such as OllyDbg or x64dbg, to gain insights into its behavior and identify key functions.

➢ Malware Unpacking: Analyzing and unpacking any packed or obfuscated sections of the ransomware code to reveal its original structure and functionalities.

These techniques collectively aid in understanding the ransomware's infection methods, propagation mechanisms, encryption algorithms, anti-forensic techniques, and command-and-control communication. The analysis results can inform incident response efforts, help develop detection signatures, and guide the development of effective mitigation strategies.

Ransomware Detection and Prevention: Ransomware attacks have become increasingly sophisticated, necessitating robust detection and prevention mechanisms. Various approaches and tools are employed to detect and prevent ransomware attacks.

1. Anomaly Detection:

➢ Baseline Analysis: Establishing normal system behavior and identifying anomalies like unusual file access or high CPU usage.

➢ Statistical Analysis: Using statistical algorithms to detect outliers and unusual patterns in logs, network traffic, or user behavior.

➢ User and Entity Behavior Analytics (UEBA): Monitoring user and entity behavior for rapid file modifications or mass encryption.

2. Signature-Based Detection:

➢ Antivirus Software: Using databases of known ransomware signatures to detect and block known variants.

➢ Indicators of Compromise (IOCs): Using file hashes, names, or server addresses to identify and block known ransomware.

3. Behavior-Based Detection:

➢ Heuristics: Detecting ransomware based on predefined behavioral rules, such as rapid file encryption.

➢ Endpoint Detection and Response (EDR): Monitoring system-level activities to identify ransomware behaviors.

4. Machine Learning (ML) Algorithms:

➢ Supervised Learning: Training ML models on labeled datasets to identify ransomware characteristics.

➢ Unsupervised Learning: Applying clustering or anomaly detection to identify unusual patterns.

➢ Ensemble Methods: Combining multiple ML models for enhanced detection accuracy.

It is important to note that no single detection technique is foolproof, and a layered defense approach is recommended. This involves combining multiple detection methods and tools to increase the chances of detecting and preventing ransomware attacks effectively[10].

Ransomware Digital Forensics Challenges: Ransomware attacks have become a pervasive and sophisticated threat, targeting individuals, businesses, and even critical infrastructure. Digital forensic investigators face unique challenges when dealing with ransomware incidents due to the encryption algorithms used, anti-forensic techniques employed by ransomware authors, and the continuous evolution of ransomware variants.

1. Encryption Algorithms: Ransomware employs strong encryption algorithms to render victim files inaccessible until a ransom is paid. The use of robust encryption algorithms such as AES, RSA, or their variants poses significant challenges to investigators. Key points include:

    *   Encryption Strength: Modern encryption algorithms are impossible to break, making file recovery without the decryption key highly unlikely.

    *   Encryption Speed: Ransomware operates at high speeds, encrypting files rapidly and leaving minimal traces, limiting the time window for detection and response.

2. Anti-Forensic Techniques: Ransomware authors employ various anti-forensic techniques to hinder investigation efforts and increase the likelihood of successful attacks. Key challenges include:

    *   Data Destruction: Some ransomware variants delete shadow copies, event logs, and other system artifacts that could aid in the investigation.

    *   Code Obfuscation: Ransomware authors obfuscate their code to evade detection by antivirus software and make analysis more difficult.

    *   Tor and Onion Services: Ransomware operators often use the Tor network and onion services to remain anonymous and communicate with victims, complicating attribution, and tracing efforts.

3. Evolution of Ransomware Variants: Ransomware continues to evolve rapidly, posing challenges to investigators who need to keep pace with new techniques and tactics. Key considerations include:

    *   Polymorphic and Fileless Ransomware: Some ransomware variants change their code and behavior to evade signature-based detection, making them harder to identify and analyze.

    *   Ransomware-as-a-Service (RaaS): The rise of RaaS platforms allows less technically skilled individuals to launch ransomware attacks, leading to a broader range of ransomware variants and increased attack volume.

    *   Diversification of Targets: Ransomware attacks now target not only individual users but also critical infrastructure, healthcare organizations, and government entities, amplifying the potential impact and complexity of investigations.

4. Technical Aspects of Ransomware Digital Forensics: Investigative methodologies and technical approaches play a crucial role in ransomware incident response. Key considerations include:

    *   Isolation and Preservation: Isolating infected systems and preserving the state of the compromised environment to prevent further damage and ensure the integrity of evidence.

    *   Memory Analysis: Extracting volatile data from system memory to identify running processes, network connections, and cryptographic artifacts that can aid in analysis and attribution.

    *   Traffic Analysis: Examining network traffic for indications of command-and-control servers, communication protocols, and data exfiltration attempts, which can provide valuable insights into the ransomware operation.

The encryption algorithms used by ransomware, the anti-forensic techniques employed by ransomware authors, and the evolution of ransomware variants all present significant challenges. However, with the adoption of new techniques and tools, investigators are making progress in combating ransomware attacks and recovering encrypted data without paying the ransom[11].

Ransomware Research Landscape: This research provides an overview of critical research areas in combating ransomware threats. From advanced analysis techniques to emerging technology risks, the focus encompasses detection, prevention, attribution, and incident response best practices. Addressing legal concerns and promoting collaborative intelligence sharing aims to foster a resilient cybersecurity community prepared to counter evolving ransomware challenges.

*   Advanced Ransomware Analysis Techniques:

    o   Develop methods to dissect sophisticated ransomware strains and identify weaknesses.

- o Understand behavior and encryption algorithms of ransomware attackers.

- Automated Ransomware Detection and Classification:

  - o Design efficient machine learning and AI-based methods for automated detection and classification.

  - o Create robust models to analyze ransomware samples accurately.

- Ransomware Attribution and Tracking:

  - o Develop methodologies and tools to trace the origins of ransomware attacks.

  - o Improve attribution to hold perpetrators accountable and prevent future attacks.

Additionally, understanding ransomware attacker behavior, establishing incident response best practices, developing threat intelligence sharing platforms, and investing in training and capacity building are essential components in combating ransomware attacks effectively[11].

Conclusion

This review paper has provided a comprehensive overview of digital forensics for ransomware-based software, shedding light on the critical aspects of this evolving and complex domain. Ransomware continues to pose significant threats to individuals and organizations worldwide, making digital forensics an indispensable tool in understanding, mitigating, and responding to such attacks. Through the exploration of assorted topics, including ransomware attack lifecycles, digital forensics fundamentals, challenges faced by investigators, evidence collection techniques, and analysis methods, this paper underscores the importance of a robust and initiative-taking approach to ransomware incident response. Despite the advancements in digital forensics, ransomware authors constantly evolve their techniques, necessitating ongoing research and development to stay one step ahead. Addressing the legal and ethical considerations surrounding ransomware investigations is equally crucial, ensuring that investigations uphold principles of privacy and data protection. Moving forward, researchers and practitioners must collaboratively work to develop innovative detection, prevention, and response strategies. By continuously refining digital forensics methodologies and staying abreast of emerging trends, the field can better equip itself to combat the ever-changing landscape of ransomware-based software threats.

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Ear prints as Potential evidence in criminal investigation: A Review

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Abstract

When someone without permission does pre-intrusion activities like auditory surveillance close to a door or window and has oils and waxes on their auricles, the deposition of a latent ear print may take place. By using methods analogous to those used in fingerprint lifting processes, the visibility of this print can be increased. An earprint is a 2D representation of the auricle segments that have come into contact with a certain surface, similar to the impression left by a rubber stamp.

This study critically reviewed the efficacy of ear prints as a form of corroborative evidence and its significance in the realm of personal identification. Ear prints, in conjunction with other latent evidence, have the potential to be identified and gathered at the location of a criminal incident. The literature that has been examined exhibits promising advancements and a notable level of precision in the field of ear print development and identification, thereby emphasizing the necessity for further study.

Keywords: Latent ear print, trace evidence, powder method, Human ear

Introduction

An ear print refers to a bi-dimensional replication of the auricle segments that made contact with a specific surface, akin to the impression left by a rubber stamp. In contrast to the uniform print surfaces found on stamps, the auricle exhibits variations in elevation and flexibility due to its diverse morphological structures. Specific structures will therefore produce a noticeable indication, while others may not or only to a limited degree. The analysis of the relationship between morphological characteristics is dependent on their specific spatial coordinates and altitudes. Moreover, the variation in sebum production across various regions of the auricle may exert an impact.

Anatomical and Morphological Structure of Human Ear

The ear possesses a distinct anatomical arrangement akin to the facial region. As depicted in (Figure 1), the morphology of the ear is primarily influenced by the outer rim or helix, as well as the configuration of the lobe. Additionally, there exists an inner helix or antihelix that exhibits a general parallel alignment to the outer helix, but diverges into two separate branches at the uppermost point. The inner helix and the inferior branch of these two branches constitute the superior and lateral aspects of the concha, which is named after its resemblance to a shell. The inferior part of the concha anatomically

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connects with the highly recognizable intertragic notch. Additionally, it is important to observe the crus of helix, which refers to the point where the helix intersects with the lower branch of the antihelix. The anterior portion of the concha provides access to the external ear canal, also known as the acoustic or auditory meatus. The crux of the helix exhibits diverse morphologies and consistently produces an impression when an ear is pressed against a surface. The helix rim is the anatomical feature that determines the morphology of the external ear. The morphology of the rim exhibits significant variability. The initial or final point of unwinding varies among individuals.

The inside edges of the helix rim plays a crucial role in the identification process. The object may feature either notches or knobs and exhibit distinct angular characteristics..
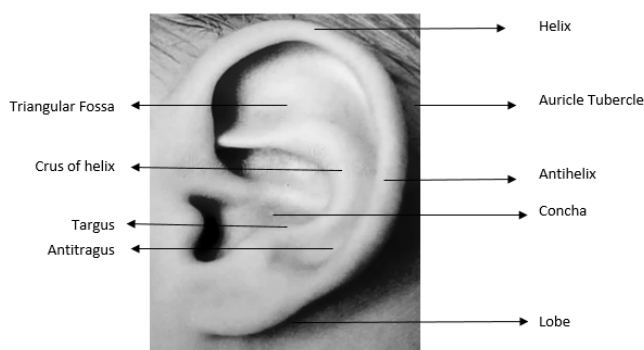
Figure 1: Parts of human ear

The ear prints commonly exhibit imprints of the helix, anthelix, tragus, and antitragus (figure 1). The latter two entities could potentially serve as an extension of the intertragic notch outline, or they may manifest as distinct patches. The anatomical structures known as the anthelix and antitragus frequently exhibit a connection, and occasionally a similar association can be observed between the anthelix and helix imprints. Moreover, the representation of a single morphological structure can be fragmented into one or multiple distinct patches. This is especially true for the impression of the helix.

Ear prints may contain features such as imprints of the earlobe, the crus helicis (part of it), and the crus superior anthelicis and/or crus inferior anthelicis. It is worth noting that a crus posterior anthelicis is not commonly found in the actual ear, and as a result,

its imprint is less frequently observed in earprints. A portion of the pre-auricular region is frequently depicted in a print, and appears to offer valuable insights as a result of distinctive skin folds in this region.

Ear prints in forensic investigations

Initially, a latent earprint discovered at a crime scene can be utilized to eliminate an individual as a potential suspect. It is necessary to ensure that the prints produced by a single ear do not exhibit significant variations that would prevent us from identifying them as originating from the same ear.

In the domain of forensic investigation, an alternative methodology can be employed to leverage earprints in scenarios where the presence of a suspect is absent. A latent print can undergo a comparative analysis against a database that contains prints collected from crime scenes. Each print in the database is linked to a particular case or potentially a suspect, determined by other evidence or a confession. A database can also incorporate control prints obtained from large groups of individuals, or a combination of both approaches. When utilizing earprints for the purpose of case linkage, it is crucial to acknowledge that the lack of substantial differences in prints created by a single ear, and the unlikely chance of two ears producing indistinguishable prints, are not acceptable circumstances. It should be noted that the auricle generally shows minimal alterations over a given period, allowing for the possibility of identifying a matching print from the same person at a different age in a database. The accurate processing of precise print dimensions is essential for determining the quantity of potential matches.

It is crucial to acknowledge that as time passes, a print stored in the database may become unidentifiable as a valid match due to a range of factors. However, it should be noted that the utilization of dimensions for initial categorization and limited association does not necessarily indicate that another individual is at risk of being implicated. The process of individualization is expected to depend on the identification and positioning of minute details, such as wrinkles, small raised areas on the skin, or other unique attributes, along with distinct irregularities or angles in the shape of imprinted features.
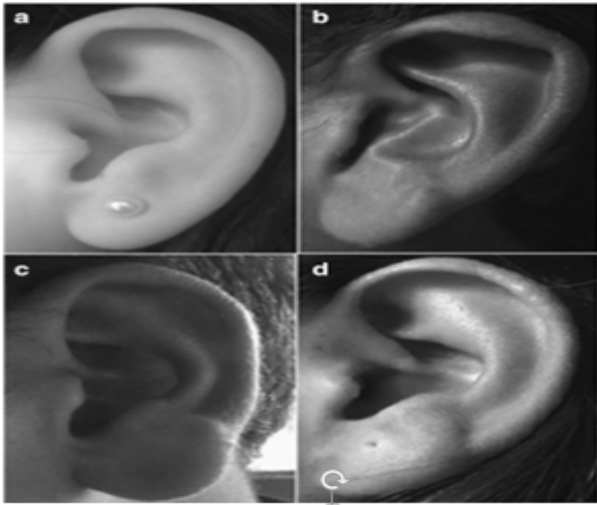
Figure 2: Different ear lobe structure: (a) Oval, (b) Triangular, (c) Rectangular, (d) Round

Courtsey: Krishan et al. Egyptian Journal of Forensic Sciences (2019) 9:6

Conclusion

Ear prints are commonly found as evidence in various crime scenes, particularly in cases involving burglaries. In contemporary forensic science, there is a growing emphasis on formerly regarded as unconventional traces, such as ear impressions[1]. However, the application of ear print evidence has not been widely utilized in comparison to other forms of body trace evidence[2]. The collection of biometric data from evidentiary material discovered at a crime scene is an essential element of the forensic process[3]. Previous studies have provided evidence supporting the practicality of employing ear biometrics due to the unique anatomical characteristics of the ear, which are expected to differ among individuals. Moreover, the measurements obtained from this anatomical analysis have demonstrated temporal consistency. Ear biometric identification is a viable and promising method, assuming its technical feasibility. This approach exhibits similarities to face recognition as it operates in a non-intrusive manner. Instead of relying on the complex process of extracting facial biometrics, ear biometrics can leverage more dependable and readily extractable biometric characteristics, similar to those present in fingerprints[4]. It is important to acknowledge that ear biometrics, although a recent addition to the growing field of biometrics, has already exhibited its efficacy and has the potential to become a prominent biometric tool[5].

Elevated features of the ear, such as helix, antihelix, antitragus, tragus, and inter-tragic notch; particularly the degree of antihelix curvature, are more easily impressed and identifiable on an ear print. The results support that ear prints may provide important clues to assist in establishing the identity of an individual if several morphological features are evaluated concurrently[6]. The distinctiveness of the human ear and its consequent usefulness for individual identification has been hypothesized. Currently, there is a lack of published data that definitively establishes the uniqueness and distinctiveness of each individual's ear, as well as the ability to conclusively identify an individual through ear comparison[7]. However, the work done by Chattopadhyay & Bhatia suggest that utilizing morphological examination to compare ears can serve as supportive evidence[8].

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Forensic Journalism in India

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Abstract

Criminalistics, another name for forensic science, is the application of science to criminal and civil legislation. Investigative journalism is the parent discipline of forensic journalism. A forensic journalist follows the "Ten Golden Rules" in order to ascertain the truth and spot errors by studying and researching it in any accessible medium. When forensics, which is thought of as combining science and law, is combined with journalism, a new phrase known as "forensic journalism" is created. Although not new in wealthy western nations, forensic journalism is a new field in our nation. It is challenging to pursue this as a career option since being a successful forensic journalist requires enthusiasm, tenacity, hard effort, patience, and my other attributes. Investigative journalism is a type of reporting where reporters delve closely into a specific subject of interest, such as significant crimes, government corruption, or corporate misconduct. Forensic journalism, which goes beyond what most journalists do, is described as being practised when journalists cross the boundaries between journalism and law in order to achieve something socially, and there is overlap in this action. This action frequently aids in revealing the truth and justice by gathering information that is admissible and withstands the scrutiny in court. Currently, journalism focuses on issues, whereas forensic journalism focuses on solutions to those problems. Broadcasting media, which is seen to be considerably more opinionated owing to organised discussion sessions, is a very close illustration of this discipline. In fact, forensic journalism compromises between the media organisation and the legal authorities. By structuring the reports so that they concentrate on the details of the entire crime under consent, the reports serve the interests of the media organisation, law enforcement agencies, as well as the general public and make the news much more interesting and informative. In other words, via forensic journalism, the media finally stands up for what it believes to be right.

Keywords: Forensic science, Forensic journalism, Ten golden rules, Career Opportunity

Introduction

Forensic journalism, also known as investigative journalism, is a specialized field within journalism that involves in-depth research, analysis, and reporting to uncover and expose wrongdoing, corruption, and abuses of power. It goes beyond traditional reporting by employing rigorous investigative techniques, including gathering and analysing evidence, conducting interviews, and verifying facts.

The term "forensic" in forensic journalism refers to the meticulous and systematic approach used to investigate complex issues and present evidence in a compelling and coherent manner. Forensic journalists act as watchdogs, seeking the truth and holding individuals, organizations, or governments accountable for their actions. The primary goal of forensic journalism is to serve the public interest by revealing hidden information, exposing corruption, and promoting transparency and accountability.

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It plays a crucial role in democracy by providing citizens with information they need to make informed decisions and fostering an open and accountable society[1].

Forensic journalists often tackle a wide range of topics, including political scandals, corporate malfeasance, environmental crimes, human rights violations, organized crime, and more. They delve deep into complex issues, often requiring extensive research, data analysis, and the piecing together of evidence from various sources. To carry out their work, forensic journalists employ various investigative techniques, such as conducting interviews with sources and whistle-blowers, analysing financial records, reviewing legal documents, conducting background checks, and collaborating with experts in relevant fields. They strive to provide accurate and well-documented reports, which may involve fact-checking, cross-referencing sources, and adhering to ethical standards Forensic journalists increasingly utilize data journalism techniques to analyse and present complex information. They use data visualization tools to create interactive charts, maps, and graphs that help convey patterns, trends, and relationships in a more accessible manner. Data-driven storytelling enhances the impact and clarity of forensic journalism investigations. Digital Verification and Fact-Checking: In the era of misinformation and fake news, digital verification and fact-checking tools have become indispensable for forensic journalists. They can use digital forensics techniques to authenticate images, videos, and online content, ensuring the accuracy and credibility of their reporting. Fact-checking organizations and tools also help journalists verify claims, debunk falsehoods, and maintain journalistic integrity.

In recent years, advancements in technology have had a significant impact on forensic journalism. Journalists now have access to vast amounts of digital data and tools to analyse it, allowing them to uncover hidden patterns, track digital footprints, and expose wrongdoing more effectively. Technological advancements have provided forensic journalists with powerful tools for data collection, analysis, and visualization. They can use advanced data mining techniques, social media analytics, and data visualization software to uncover patterns, connections, and anomalies in large datasets. These tools enable journalists to identify trends, track information sources, and present complex information in a more accessible manner. While forensic journalism can be a challenging and demanding field, it plays a critical role in ensuring transparency and accountability in society. By shedding light on hidden truths, it aims to bring about positive change, challenge the status quo, and empower the public to demand justice and accountability from those in power[2].

Forensic journalism has the power to inspire change at both individual and societal levels. By exposing social injustices, environmental degradation, and other pressing issues, it can create public awareness, empathy, and a sense of urgency. This can mobilize individuals, communities, and organizations to take action and drive positive change. Through in-depth investigations, journalists can bring attention to these issues, provide a voice to the victims, and advocate for justice. Their work can lead to legal action, policy changes, and societal reforms.

Forensic journalism continues to evolve and adapt to the changing media landscape and technological advancements. Here are some ways in which forensic journalism is evolving: Embracing Digital Platforms: Forensic journalists are increasingly leveraging digital platforms to reach wider audiences and engage with them in real-time. They use social media, podcasts, video streaming platforms, and interactive websites to disseminate their investigations and connect with the public. These platforms enable journalists to reach beyond traditional media outlets and have a direct impact on public discourse.

Data Journalism and Artificial Intelligence: With the growing availability of data and advancements in artificial intelligence (AI), forensic journalists are utilizing data journalism techniques and AI tools to analyse large datasets, uncover patterns, and draw insights. AI-powered algorithms can help identify trends, detect anomalies, and automate data analysis, allowing journalists to focus on investigative storytelling[3].

Role of Journalism in Criminal Justice System

The word "media" comes from the Latin "medium," which meaning "in the middle." The term "media" refers to conventional mass communication networks, content producers, and other technologies for mediated human speech. The phrases "media" and "mass media" are sometimes used interchangeably. With the invention of newspapers and magazines, the word "media" first entered the English language. A broad and diversified population may be reached with knowledge and pleasure thanks to the media. There are already several established online newspapers, journals, and publications. The acceptance of online publications is rising. The web versions of virtually all of the major newspapers are just as popular as their print counterparts. While giving individuals a practical means to live their lives, the media has also aided in bringing social consciousness to a greater level. In recent years, discovering crimes, allegations, and malpractice in the media has grown more and more crucial. Over time, the media has had an impact on how people think, act, and decide. Media impact is often described as the strengthening or weakening of particular groups' beliefs due to media messaging. The demographics and psychological health of the populace are only two of the many variables that determine how the media affects the populace. A damaging influence is regarded as such, whilst a beneficial impact is regarded as such. The judiciary may occasionally be impacted by the media. It is feasible to assert that public opinion affects judicial decisions because to the relationship between human psychology and opinions. Quantity varies depending on the person; the better the court outcome, the lower the influence.

The public's perception and understanding of the criminal justice system have always been greatly influenced by the media. The media heavily influences how the system functions. People want to know how crimes are found and handled by the system, in addition to the intense interest that the general public has in crime and offenders (Marsh and Melville, 2009). The media plays a crucial role since it serves as the public's "eyes" and "ears" most of the time. It may be a potent and effective tool for promoting corrective action in the conduct of public affairs.

The function of the media cannot be compared to that of the government, thus there should be restrictions just like there are in other aspect of society. As a result, the media helps to inform the public about the legal system. As few events generate more headlines for the TV news than, instance, a violent offender who has returned to the community, the media also plays a part in influencing public perceptions towards the criminal justice system (Clunies, 1999). Such reports occasionally, as is inescapably destined to occur, foster a hostile relationship between the media and the criminal justice system.

Many first-time jurors have admitted that their primary sources of knowledge regarding jury duty were newspapers and television. According to reports, the experience is very different from how it is portrayed in the media. Muncie & Wilson (2004) note that there hasn't been much study on how much the media affects the public's perception of the police. However, the little data appears to indicate that the early police-centric television programming may have had an impact on police officers' expectations of the force[4].

Career Oppurtunities in Forensic Journalism

It's important to note that career aspects in forensic journalism can vary depending on individual interests, specialization, geographic location, and the evolving nature of the field. Exploring opportunities for internships, mentorships, or networking with professionals in forensic journalism can provide valuable insights into specific career paths and further prospects in the field. Forensic journalism combines elements of investigative journalism and forensic science to uncover and report on criminal activities, corruption, and other wrongdoing. It involves in-depth research, evidence gathering, and analysis to present factual and compelling stories.

➢ Investigative Journalist

- They work as a journalist specializing in investigative reporting. They will dig deep into complex stories, conduct interviews, gather evidence, and collaborate with experts to expose crime, corruption, and injustice. The role of an investigative journalist is crucial in exposing hidden truths, uncovering

corruption, and holding individuals, organizations, and governments accountable for their actions. Investigative journalists go beyond surface-level reporting and engage in in-depth research, analysis, and verification to bring important stories to light. Investigative journalists prioritize accuracy and fact-checking. They rigorously verify information, cross-reference sources, and corroborate claims to ensure the reliability and integrity of their reporting. Investigative journalists conduct interviews with various sources, including whistleblowers, witnesses, experts, and officials. These interviews help provide firsthand accounts, insights, and perspectives that contribute to the investigative process. Investigative journalists often work with large datasets, analysing and interpreting data to identify patterns, trends, or anomalies. Data analysis techniques allow them to uncover significant findings and support their investigative reporting with concrete evidence.

Investigative journalism often requires collaboration with other journalists, researchers, experts, and even legal professionals. Collaborative efforts can strengthen investigations, pool resources, and provide diverse perspectives on complex issues. They delve into public records, interview sources, analyse data, and dig deep to uncover hidden information and connections. Investigative journalists aim to uncover the truth behind events, actions, and claims. They scrutinize official narratives, challenge conventional wisdom, and investigate leads to expose wrongdoing or reveal previously unknown facts[5].

➢ **Crime Reporter:** Crime reporters focus on covering crime-related events, such as major crimes, arrests, trials, and court proceedings. They gather information from various sources, including law enforcement agencies, court records, witnesses, and victims, to report on criminal activities accurately and promptly.

Crime reporters often engage in investigative journalism to uncover new information, expose wrongdoing, or highlight issues within the

criminal justice system. They may conduct their own research, interview sources, and analyze evidence to provide deeper insights into criminal cases. Crime reporters cultivate relationships with sources within law enforcement, legal professionals, and other relevant areas to gather information and gain insider perspectives on crime-related issues. Developing reliable sources is crucial for obtaining exclusive information and breaking news stories. They attend court hearings, trials, and other legal proceedings to provide comprehensive coverage of criminal cases. They report on key developments, legal arguments, witness testimonies, and verdicts to keep the public informed about the progress and outcomes of cases. Crime reporters conduct interviews with victims, witnesses, law enforcement officials, lawyers, and other individuals involved in criminal cases. These interviews provide firsthand accounts, insights, and perspectives that contribute to a more comprehensive understanding of the crime being reported. Crime reporters too analyse crime data, statistics, and trends to identify patterns, changes, or emerging issues in criminal activities. They use this information to report on the broader impact of crime on communities, identify potential root causes, and contribute to public discourse on crime prevention and criminal justice reform.

Crime reporters play a crucial role in informing the public about criminal activities, ensuring transparency in the justice system, and raising awareness of important issues related to crime and its impact on society[6].

➢ **Data Journalist**

The role of a data journalist in forensic journalism involves using data analysis and visualization techniques to uncover insights, patterns, and connections related to criminal activities, corruption, or other subjects of interest.

Data journalists collect relevant datasets from various sources, including government agencies, law enforcement organizations, court records, and other public databases. They may also obtain data through Freedom of Information Act (FOIA) requests or collaborate with other journalists or

researchers who have access to specific datasets. They clean and preprocess the collected data to ensure accuracy and consistency. They may remove duplicate entries, handle missing values, standardize formats, and perform other data cleaning tasks to ensure the data is ready for analysis.

Data journalists employ analytical techniques to uncover insights, trends, and patterns within the collected data. This can involve statistical analysis, data mining, and visualization methods to identify correlations, anomalies, or other significant findings related to criminal activities. Data journalists use data visualization tools and techniques to present complex information in a visually engaging and easily understandable manner. They create charts, graphs, maps, and interactive visualizations that help communicate the findings and tell compelling stories related to forensic journalism.

Data journalists collaborate with investigative journalists, crime reporters, and subject matter experts to integrate data-driven insights into broader investigative stories. They work together to identify relevant datasets, interpret findings, and present the data in a meaningful context within the investigative narrative. Data journalists ensure the accuracy and reliability of the data used in their analysis. They cross-reference and verify the data with multiple sources, fact-check claims and assertions, and adhere to rigorous journalistic standards to maintain the integrity of their work.

Data journalists contribute to the advancement of data journalism practices and promote the importance of data-driven storytelling within the field of forensic journalism. They share their methodologies, insights, and findings with the wider journalism community to encourage transparency, accountability, and evidence-based reporting[7].

Forensic Aspects of Journalism: Journalism holds forensic significance in several ways, contributing to forensic investigations and the legal system. Here are some key aspects of journalism's forensic significance:

- **Information Gathering**: Journalists are often among the first to arrive at crime scenes or incidents. Their observations and interactions can provide initial information crucial to forensic investigations. They document details such as the condition of the scene, potential evidence, and witness accounts. This information aids forensic experts in reconstructing events and analysing evidence.

- **Witness Identification**: Journalists may interview witnesses, victims, or individuals with relevant information. Their interviews can help identify potential witnesses or suspects, gather statements, and provide leads for investigators. Witness testimonies obtained by journalists can be valuable in corroborating evidence or identifying individuals involved in a crime.

- **Public Appeals and Tips:** Journalistic coverage of forensic investigations can generate public awareness and encourage individuals with relevant information to come forward. Journalists often appeal for tips, which can lead to the discovery of new evidence, identification of suspects, or location of missing persons. The information received through such public appeals can significantly advance forensic investigations.

- **Documentation of Evidence:** Journalists play a role in documenting evidence through various mediums such as photography, videography, and written records. Their documentation of crime scenes, injuries, or events can serve as visual or testimonial evidence during legal proceedings. Journalists are trained to maintain accuracy and objectivity, making their documentation reliable for forensic analysis.

- **Uncovering New Evidence:** Investigative journalism can uncover new evidence or revisit cold cases. Journalists may delve into overlooked aspects, conduct independent research, or interview relevant individuals. Their findings can bring attention to overlooked evidence, prompt further forensic examinations, or lead to the discovery of new leads that aid in solving crimes.

- **Accountability and Transparency:** Journalism plays a crucial role in holding authorities accountable for their actions and

ensuring transparency in the legal system. Journalists report on forensic investigations, court proceedings, and outcomes, allowing the public to understand the process, assess the fairness of investigations, and monitor the justice system's functioning.

- **Exposing Injustices and Wrongful Convictions:** Journalistic investigations have, at times, revealed flaws in forensic practices, biases, or miscarriages of justice. Journalists may expose wrongful convictions, highlight questionable forensic techniques, or shed light on cases of corruption or negligence. Such revelations can lead to re-examinations of evidence, reforms in forensic procedures, and the rectification of wrongful convictions.

- **Advocacy and Policy Impact:** Journalism with a forensic focus can create public awareness about the importance of sound forensic practices, advocate for reforms, or highlight the need for better training and resources. Journalists may investigate deficiencies in forensic systems, push for policy changes, or support the introduction of new legislation related to forensic investigations.

It is important to note that journalists are not forensic experts themselves, and their primary role is to gather and report information. Forensic investigations require the expertise of forensic scientists, law enforcement agencies, and legal professionals who conduct rigorous analysis and interpretations of evidence. However, journalism's forensic significance lies in its ability to contribute to the initial information gathering, public engagement, and accountability aspects of forensic investigations[8].

Conclusion

In conclusion, forensic journalism is essential for advancing justice, accountability, and openness in our society. Forensic journalists can assist in revealing the truth behind complicated issues and hold people and institutions accountable for their actions by using scientific methods and procedures to find and report on crimes, abuses, and other human rights violations. However, forensic journalism is not exempt from criticism, which might focus on biases and preconceptions, a lack of objectivity, moral and legal dilemmas, and potential effects on existing inquiries and legal proceedings. To ensure that their reporting is truthful, impartial, and transparent, forensic journalists must uphold the highest ethical and professional standards. But forensic journalism also has drawbacks, such as ethical and legal difficulties, dangers to the safety of journalists, and potential effects on media trustworthiness. Through legislative safeguards for journalists and sources, monetary support for independent media, and investments in digital technologies and data journalism, it is crucial to strike a balance between these effects and encourage forensic journalism. Promoting openness, responsibility, and social justice in our society requires sustained support for and development of forensic journalism. Since forensic journalism is a crucial part of a strong democracy, we must continue to acknowledge and encourage its significance.

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Juvenile Terrorism

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Abstract

Juvenile terrorism, also known as youth or adolescent terrorism. Youth populations have been found to be especially susceptible to recruitment by violent extremist organisations. The causes of juvenile's terrorism are multifaceted and complex, such as "Push factors" which can be defined as negative circumstances that the child tries to escape by joining the group, while the "pull factors" represent the positive incentives, attracting the children to join the groups. Factors contribute to the radicalization of young individuals, including marginalization, discrimination, and additionally ideological indoctrination, and also feeling lack of disenfranchised in society. Thus to examine and to know factors of Juvenile Terrorism and what are the preventative measure can be enabled in the society. The study is based on secondary data to find out the factors of terrorism. Juvenile terrorists who were brought to FSL Bangalore from different parts of India and examined to psychological behaviour through polygraph examination and showed that juveniles who were in the age group of 14- 17 years were unable to take proper decisions in life and to take proper organisation in their life and showed their susceptible to social influences of the organised group. Therefore providing guidance, counselling and improving communication pathways in family would reduce influences to radicalization.

Keywords - Juvenile Terrorism, Pull factors, Push factors, Ideological indoctrination, Polygraph examination.

Introduction

In several conflicts worldwide children are recruited as fighters in irregular forces and exploited by terrorist and violent extremist groups are victims of violence at multiple levels. They are often victims of extreme violence during their association with the group, which includes offensive recruitment methods, sexual exploitation, and enslavement, exposed to constant fear, indoctrination, and psychological behaviour[1]. They are often injured or killed in combat. At the same time, because of their young age and psychological malleability, children may become particularly dangerous instruments of the groups that recruited them. The nature and gravity of violence against the youth may vary from case to case. Children associated with the terrorist's group's entails stigmatization and a high risk of becoming victims of violence perpetrated by communities, law enforcement and military forces and others following the children's return demobilization or apprehension. Recruiting children by terrorists groups are complex and multifaceted, compared to adults, children are most recruited as they provide many advantages to the groups such as used in support roles or as combatants, children are usually paid less and require less food to survive. Not only is the trade in small arms poorly regulated, but the use of small arms is especially easy, making them more accessible to children. While power and control over

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weapons used to be in the hands of older members of society, children are no longer constrained by the age groupings that limited who could participate in warfare[2].

Children, particularly girls, are increasingly being used as spies, for delivering messages, carrying materials and undertaking suicide attacks. Children have less decipherment of the risk they face and therefore display less anxiety. They are also more likely to do as they are ordered, and they generally benefit from the advantage of arousing less suspicion, which can be a crucial asset, for instance in getting closer to targets. The transnational nature of terrorism and violent extremism has favoured the emergence of transnational recruitment and the involvement of children in the phenomenon of foreign terrorist fighters. Some youth cross borders to join a terrorist group on their own, some travel with their parents or guardian, while others are forcefully abducted, and subsequently cross borders as part of their engagement in violent extremist groups[3]. The use of online communication is a relatively new means of connecting terrorist and violent extremist propaganda. It expands the reach of the group's message and gets through to potential recruits throughout the world. As active Internet users, children are at particular risk. Specific websites advertise the existence of the groups and, in many instances, multiple sites in different languages include different messages tailored to specific audiences. Social media platforms such as email, chat rooms, e-groups, message boards, video recordings, and applications are especially popular recruitment tools, which facilitate tailored approaches. One of the methods, which can be defined as "grooming", is based on the perpetrator learning about the individual's interests in order to attend the approach and build up a relationship of trust. A second technique replicates "targeted advertising": by tracking the online behaviour of Internet users, a group can identify those vulnerable

to its propaganda and tailor the narrative to suit its target audience[4].

Prohibition of violence against children in the international legal framework guarantees children broad protection from serious forms of violence, including recruitment and exploitation of children by terrorist and violent extremist groups. The framework outlines relevant legal provisions that define violence against children and the duty of States to take all necessary measure to protect children from violence. Article 19 of the Convention on the Rights of the Child provides a broad definition of "violence against children", which, as underlined by the Committee on the Rights of the Child (the body of independent experts monitoring the implementation of the Convention by its States parties), includes both nonphysical and non-intentional forms of harm. Accordingly, judicial body are required to undertake all possible measures to prevent and prohibit violence against youth[5]. The exploitation of children is addressed in article 32 of the Convention, which calls on States parties to recognize the right of the child to be protected from economic exploitation and from performing any work that is likely to be perilous or to be harmful to the child's health or physical, mental, spiritual, moral, or social development. In article 34, States parties are called on to undertake to protect the child from all forms of sexual exploitation and sexual abuse and States parties are required to take all appropriate measures to prevent, among other things: (a) the inducement or coercion of a child to engage in any unlawful sexual activity; (b) the exploitative use of children in unlawful sexual practices; and (c) the exploitative use of children in pornographic materials. However, the term exploitation is considered to be broader, as article 36 requires States parties to protect the child against all other forms of exploitation prejudicial to any aspects of the child's welfare[6].

Table 1: Juvenile Terrorism Preventive Technique with reference understanding violence

LEVEL	RISK FACTORS	INTERVENTION
Social and Political Factors	Feeling of exclusion from community or lack of belonging	Creating community engagement including ambient environments that promote social integration and prevent alienation. Connecting at risk-youth with positive role models and mentors.

Continue

Family Factors	Exposure to family conflict, abuse, or neglect. Parents influencing extremist beliefs or promoting violent ideologies.	Providing information about the risks of radicalization and extremism. Addressing family dynamics and promoting healthier relationships.
Peer Influence	Encouragement from peers to join in extremists activities. Exposing their peers for online radicalization and recruitment efforts online	Positive peer relationships and support networks. Monitoring and removing extremists content from online platforms. Teaching young children to critically analyse online information.

Methodology

The study was on secondary data as well as based on theoretical aspects of Juvenile Terrorism. Designing a methodology and selection of analytical tools are an imperative for a meaningful analysis of any research problem. Juvenile terrorists who were brought to FSL Bangalore from different parts of India (Karnataka, Maharashtra, and Andhra Pradesh) examined to psychological behaviour through polygraph examination and through interview (such as age, family background , history of past illness) to know the causes and factors of Juvenile Terrorism.

Results and Discussion

Results show after polygraph examination and through interview that the suspected juveniles were found to be emotionally immature with reduction of judgemental capacity, lack of responsibility,

aggressiveness, manipulative. Through polygraph examination shows a positive relationship between low skin conductance to aggressiveness and anti-social behaviour which lead to develop the ability to lie easily and quickly, Low heart rates are further linked to higher rates of criminal activity through the response of being guilty. Children with single parents and orphans were reported to have inclined towards terrorism due to weaker family relationship, peer pressure, poverty, family rejection, and lack of supervision from the family. Juveniles want to continue the crime for their survival and creditability.

Table 2: Age group of juveniles who committed crime

SL NO	AGE	NO.OF SUSPECTS
1	14-15	9
2	16-17	11
3	18	10

Table 3: Education level obtained by the suspected juveniles.

EDUCATION	MAHARASTRA Juvenile	TAMILNADU Juvenile	KARNATAKA Juvenile
Less than 5th Grade	6	1	6
School drop out	3	2	4
More than 5th Grade	2	3	-
Never attended school	1	1	1
Total	12	7	11

Table 4: Family background of suspected juveniles.

MAHARASTRA			TAMIL NADU			KARNATAKA		
Single Parents	Parents with H/O Alcoholism	Orphans	Single Parents	Parents with H/O Alcoholism	Orphans	Single Parents	Parents with H/O Alcoholism	Orphans
4	5	3	5	2	-	3	6	2

Results and Discussion

Table 2 – shows the age group of juveniles who committed crime from 14 – 18 years old, table 3 – indicates the education level obtained by suspected juveniles. There are 12 juveniles who is obtained less than 5th grade, 9 juveniles who were school dropout, 5 juveniles who attended middle school and 3 juveniles who never attended school and table 4 indicates the family background of suspected juveniles. Interview was also conducted to know the status of history of past crimes, family background and any past illness. The study was attempted to explore the developmental factors of age that influenced to get involved in terrorism. In this study suspected juveniles who belong to rejected family or school dropouts or never been to school were found to be affiliated or inclined towards terrorist's organisation. The latter lowered the employment opportunities and criminal activity became more dominating. Due to low academic achievement, poor electro dermal response was noticed in reflecting poor behavioural inhibitions. Exposure to family conflict, poor performance in school, peer influence and peer pressure, feeling of exclusion from the society and lack of encouragement will eventually leads to the development of frustration, anger and ultimately delinquent behaviour which influences them to join the terrorist group.

Conclusion

From, the study of secondary data we can conclude that juvenile terrorists have various motivation and inclination for specific act thus leading to the process of radicalization. Juveniles having problem with societal engagement, family abuse, socio –economic status, low academic achievement etc. leads to under development of moral and ethical values.

There is urgent need to fight against juvenile terrorism. Juvenile are targeted both by recruitment and radicalization to violent extremist organizations and in terrorist attacks. They recognize prevention of violent extremism as a priority and many have already acted to reduce the impact of violent extremism, promote tolerance, and build resilience in their local communities and societies. The UN Security Council and the UN General Assembly implemented The Youth Engagement and Empowerment Programme

builds upon various texts submitted to the UN's principal organs for the mandate programme of Juvenile Terrorism. It aims to operationalize the provisions outlined under Mandate to empower and enable youth that actively prevent and counter violent extremism on all levels in partnership with the UN. The Programme takes a participatory approach to youth engagement and has two phases. Throughout the first phase participants focus on developing a data-driven, evidence-based, human rights compliant and youth-informed programme. It establishes formal mechanisms and an engagement platform for meaningful participation. The second phase emphasizes implementation of the Programme to prevent violent extremism in partnership with youth, including youth-led civil society organizations and private sector stakeholders.

- The main activities of the Programme include:
- Deliver 10 national and 5 regional consultative workshops programmes.
- Develop youth engagement tools and approaches for PCVE purposes.
- Establish a youth engagement platform for PCVE-efforts.
- Establish a youth advisory and consultation mechanism for PCVE-efforts.
- Build an infrastructure for intra-agency cooperation and coordination on youth-focused PCVE-efforts.
- Develop communication content and visibility material to promote the positive role of youth.

The Programme coordination rule of Youth Engagement and Empowerment are closely with UN entities at HQ level (e.g. UNDP, UNESCO, UNAOC, and ILO), UN Country Teams and the Resident Coordinator's Office, international youth-focused NGOs, the UN Major Group for Children and Youth, and national/regional civil society actors in beneficiary countries. This Programme aims at building and engaging with resilient, empowered and enabled young people to make meaningful contribution to the United Nation's efforts across global and regional activities to prevent and counter violent extremism and terrorism.

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Need of Blood Doping Test- From Sports to Recruitment

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Abstract

Doping is not a new trick to enhance endurance in sports. But now a days doping is not restricted in sports only. Many instances had been observed where the candidates were found doping during recruitment exam of Police and Defence services during physical test. Government   is trying to combat this situation. Gujarat became the first state who took initiative in this matter and conduct dope test in recruitment of Police Inspector The test was performed for six recreational drugs such as THC, amphetamine benzodiazepine, Barbiturates, cocaine and opiates.But as now the people are aware of these doping drugs and they know that these drugs can be detected in blood and urine sample .So they are now using another trick of doping i.e blood doping because it is easier way of cheating and its detection is very difficult .Blood doping is also not new in sports , its first case was observed in 1980 in Summer Olympic in Moscow .But it was not prohibited that time. Blood Doping is not only unfair mean of getting success however there are serious health hazards associated with this. Blood doping thickens the blood due to increased RBCs mass, which leads to several deadly diseases such as heart disease and stroke. So, there is need to prevent such kind of practices. Many sophisticated techniques are evolved nowadays to detect blood doping.

This article outlines the procedure of blood doping, and the brief review is made on the testing procedures. Emphasis is placed on the recent development and need of introduction of this blood doping test in recruitment process.

Key words: Blood, Doping, recruitment, sports

Introduction

In January 2023, many Agniveer applicants were found doping during Agneepath recruitment scheme and Police recruitment exam in Maharashtra. Similar incidence has been reported in in 2016 in Punjab Police recruitment where 294 aspirants were found positive for drugs. Due to increasing tendency of dope Punjab Chief Minister ordered a mandatory dope test for all Government employees. An investigation by India Today in 2016 reveal how candidates in Haryana Police recruitment drive used banned drugs to enhance performance. In Bareilly similar matter surfaced in army recruitment. So, initiative has been taken by the Government in many ways.

On recommendation of Gujarat Public Service Commission, National Forensic Science University conducted dope test in recruitment of police inspector. The tests were conducted for six recreational drugs such as Tetra Hydro Cannabinol, Benzodiazepine, Barbiturates, Cocaine Amphetamine.

But as the people are aware of these drugs and their testing and they know that theses drugs can be detected in blood or urine sample, so they are trying

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to find out some other way to enhance performance which is easy to commit but difficult to detect So Blood doping is the easier way for enhancing endurance.

Blood Doping

The World Anti-Doping Agency (WADA) defines blood doping as "the misuse of certain techniques and/or substances to increase one's red blood cell mass, which allows the body to transport more O_2 to muscles and therefore increase stamina and performance"[1].

Therefore, the more red blood cells that you have, the greater the oxygen capacity, and the greater the supply of oxygen available for muscles to generate energy without "burning out" during extreme physical activity[2].

Methods of Blood Doping

There are many ways of blood doping but few are very easy and common methods such as

1. **Blood Transfusions-** Blood transfusion is the process of transferring blood products into a person's circulation intravenously[3].

   Blood transfusions can be traditionally classified as

   (a) Autologous blood transfusion: It is collection and re-infusion of person's own blood or blood components Blood transfusion begins by the withdrawal of 1 to 4 units of blood (1 unit = 450 mL of blood) several weeks before competition. The blood is centrifuged, the plasma components are immediately reinfused, and the corpuscular elements, principally red blood cells (RBCs), are stored refrigerated at 4 °C or frozen at −80 °C[4].

   (b) Homologous blood transfusion: In this blood transfusion blood is transfused into someone other than the donor.

2. **Blood substitute** are the substance which have same functions of biological blood

   The main categories of blood substitutes are:

   (a) HBOC"oxygen-carrying" blood substitutes being pursued are hemoglobin-based oxygen carriers (HBOC). These are chemicals that have the ability to carry oxygen[5]. Haemoglobin is the main component of red blood cells, comprising about 33% of the cell mass.

   (b) PFCs -Perfluorocarbon-based blood substitutes are completely man-made; this provides advantages over blood substitutes that rely on modified haemoglobin, such as unlimited manufacturing capabilities, ability to be heat-sterilized, and PFCs' efficient oxygen delivery and carbon dioxide removal. PFCs in solution act as an intravascular oxygen carrier to temporarily augment oxygen delivery to tissues. PFC particles in solution can carry several times more oxygen per cubic centimeter (cc) than blood, while being 40 to 50 times smaller than haemoglobin[6].

3. **EPO injections.** Erythropoietin is a hormone produced by the kidney. It is a glycoprotein with attached sugar. It stimulates the bone marrow to produce more red blood cells. The resulting rise in red cells increases the oxygen-carrying capacity of the blood[10]. It regulates the body's production of red blood cells. In medical practice, EPO injections are given to stimulate the production of red blood cells. For example, a synthetic EPO can be used to treat patients with anaemia related to chronic or end-stage kidney disease.

   As the prime regulator of red cell production, erythropoietin's major functions are to:

   1. Promote the development of red blood cells.

   2. Initiate the synthesis of haemoglobin, the molecule within red blood cells that transports oxygen.

EPO injections are abused by the people to encourage their bodies to produce higher than normal amounts of red blood cells to enhance performance because of its easily availability and it is not a banned drug[8].

Detection of Blood Doping

Earlier it was very difficult to detect blood doping, but now novel techniques are available which are used to detect blood doping.

Detection for homologous blood doping

In 2004, a test for detection allogeneic/homologous blood transfusion doping was implemented. Flow cytometry is the method of choice. By examining markers on the surface of blood cells, the method can determine whether blood from more than one person is present in an athlete›s circulation. The test utilizes 12 antisera directed against the blood group antigens, obtained from donor plasma. The antigens are labeled with secondary antibodies, which are conjugated with phycoerythrin to label IgG or IgM-coated RBCs and enhance the detection by flow cytometry. The flow cytometry is able to detect minor variance in blood group antigens. The assessment was able to distinguish the blood of subjects who had earlier received at least one unit of allogeneic blood[7].

Modern flow cytometers are able to analyse many thousands of particles per second, in "real time" and, if configured as cell sorters, can actively separate and isolate particles with specified optical properties at similar rates. A flow cytometer is similar to a microscope, except that, instead of producing an image of the cell, flow cytometry offers high-throughput, automated quantification of specified optical parameters on a cell-by-cell basis[9].

A flow cytometer has five main components: a flow cell, a measuring system, a detector, an amplification system, and a computer for analysis of the signals. The flow cell has a liquid stream (sheath fluid), which carries and aligns the cells so that they pass single file through the light beam for sensing. The measuring system commonly uses measurement of impedance (or conductivity) and optical systems - lamps (mercury, xenon); high-power water-cooled lasers (argon, krypton, dye laser); low-power air-cooled lasers (argon (488 nm), red-HeNe (633 nm), green-HeNe, HeCd (UV)); diode lasers (blue, green, red, violet) resulting in light signals. The detector and analog-to-digital conversion (ADC) system converts analog measurements of forward-scattered light (FSC) and side-scattered light (SSC) as well as dye-specific fluorescence signals into digital signals that can be processed by a computer.

Detection for autologous blood doping

Currently, no test exists to directly detect autologous transfusions. Instead, indirect methods are used. One method is based upon a transfusion-induced immune-response resulting in specific changes in gene expression related to leukocytes such as T lymphocytes. Another method relies on detecting increased plasticizer metabolite levels in the urine caused by the leakage of plasticizers from the blood bags used during the blood storage. These methods need further development and validation across different types of transfusion regimes before they can be implemented[8].

Detection method for haemoglobin-based oxygen carriers:

It is done in four separate steps. Step one involves the elimination of abundance proteins in the blood samples by immunodepletion (i.e. Proteo Prep 20 plasma immunodepleting kit). This process ensures that other proteins (i.e. albumin and immunoglobulin) do not interfere with capillary electrophoresis (CE) separation by changing the ionization. Second step, CE separation is done under certain condition, in this case background electrolyte consisting of ammonium formate (75mM at pH 9.5) in order to provide sufficient resolution between HBOC and Hb. Third step, UV/Vis detection was performed at 415 nm to selectively detect HBOC and HB. Fourth step, time-of-flight or mass spectrometer allowed increased accuracy in selectivity between haemoproteins and other proteins and definite determination of HBOC uptake[12].

EPO injections

Blood and urine tests can detect the presence of synthetic EPO. ESAs is prohibited according to the World Anti-Doping Code and its prohibited list of substances and methods. Since the first publication of a direct and urine-based detection method in 2000, which uses changes in the Epo isoform profile as detected by isoelectric focusing in polyacrylamide slab gels (IEF-PAGE), the method has been constantly adapted to the appearance of new ESAs (e.g., Dynepo, Mircera). Blood had to be introduced as an additional matrix, because Mircera (a PEGylated Epo) is best confirmed in serum or plasma after immunoaffinity purification. A Mircera ELISA was developed for fast

screening of sera. With the appearance of Dynepo and copy epoetins, the additional application of sodium dodecylsulfate polyacrylamide gel electrophoresis (SDS-PAGE or equivalent) became necessary[11].

Risks of Blood Doping

The simple act of increasing the number of red blood cells in blood may be associated with hyper viscosity syndrome which is characterized by increased blood viscosity and decreased cardiac output and blood flow velocity which results in the reduction of peripheral oxygen delivery. Because blood doping increases the volume of red blood cells, it effectively introduces a condition called polycythaemia, a blood disorder that has known adverse outcomes such as heart attacks or strokes[13].

Blood doping via transfusion carries additional risks. Tainted blood can spread infectious diseases such as HIV, hepatitis B etc Blood contamination during preparation or storage is another issue. Contamination was seen in 1 in every 500,000 transfusions of red blood cells in 2002.[9] Blood contamination can lead to sepsis or an infection that affects the whole body[14].

Over time, repeated blood transfusions can cause a dangerous buildup of iron in the body. Improperly stored blood and improperly administered transfusions can cause acute lung injury , bacterial infection ,allergic reactions such as fever and rashes. Other risks of EPO injections include: hyperkalaemia (potentially dangerous elevation of plasma potassium levels in the body),high blood pressure, mild flu-like symptoms[15, 16].

Erythropoietin (EPO) injections can cause a variety of side effects, some of which can be serious.

The most common side effects of EPO injections include Hypertension (high blood pressure), Headache, Nausea and vomiting, Joint pain, Fever, Dizziness, Edema (swelling of the legs, feet, or hands). Injection site reactions, such as pain, swelling, or redness[17,18].

The following are more severe adverse effects of EPO injections:

- Thrombosis (blood clots), including deep vein thrombosis (DVT), pulmonary embolism (PE), and stroke.

- Increased risk of heart attack.
- Seizures.
- Allergic reactions, including anaphylaxis.
- Pure red cell aplasia (a rare condition in which the bone marrow stops producing RBCs).
- Hypertension (high blood pressure)[19,20].

Conclusion

Blood doping is not only means of unfair method of being selected in recruitment process or enhancing performance in sports but also carries many risks such as Blood clot, heart attack, Stroke , HIV, Hepatitis B, Hepatitis .Individual can even die during performance due to heart blockage as viscosity of blood gets increased by high mass of RBCs.

The recent advancement in technology can resolve the cases based on blood doping. The upgraded technology would be helpful in fair selection in Police and Defense recruitment.

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Prediction Accuracy of Irisplex Tool in Different Population

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Abstract

Forensic DNA phenotyping is a rapidly advancing field that seeks to predict an individual's physical appearance from their DNA profile. The ability to infer phenotypic traits, such as eye colour, hair colour, skin colour, and facial features from DNA evidence holds significant potential for criminal investigations especially when traditional investigative methods such as DNA profiling yield limited results. Forensic DNA Phenotyping (FDP) has now become one of the beneficial methods which aids in police investigation to narrow down the investigative procedure in various types of forensic cases such as identification of unknown in mass disaster case or unknown perpetrator who cannot be identified by the help of forensic STR- profiling. Benefits of FDP is that it has overcome to limitations that exist with conventional methods of human identification as it can predict individual's externally visible characteristics (EVCs) from DNA as well as it is more focused on obtaining genetic profiles from crime scene samples not harming dignity or integrity rights of individual. Phenotype of individual can be identified by help of Tools which can predict physical characteristics of individual. IrisPlex is the first tool which predict Eye colour, HIrisPlex is the tool which can predict both eye colour and Hair colour whereas HIrisPlex-S can predict skin colour, hair colour as well as eye colour so, Forensic DNA Phenotype has benefits over other traditional methods and can help law enforcement to solve criminal as soon as possible.

Keywords- Forensic DNA Phenotyping, External visible characteristic, STR, Irisplex tool, HIrisPlex tool, HIrisPlex-S tool, DNA Profiling.

Introduction

Forensic science is the practical implementation of scientific principles, methodologies, and techniques to analyse and investigate crimes and provide evidence for legal proceedings. It involves the systematic and meticulous examination of physical evidence, such as biological materials, trace substances, and other relevant items, to establish facts, reconstruct events, and support or refute claims within the criminal justice system.

The first technique used for the DNA profiling is Restriction Fragment Length Polymorphism (RFLP) by Sir Alec Jeffery. DNA profiling approach (RFLP) was first utilized to assist the English Immigration issue and thereafter it was used to solve the double homicide case but DNA profiling also have some demerits. To overcome the demerits of DNA Profiling FDP has been introduced which is a Robust technique which help in identifying an unknown individual with help of biological evidences found at crime scene. FDP provide additional information that can aid in the investigation by providing investigators with a physical description of an unknown individual. This information can help in narrowing down the list of suspects especially in cases where there are no witnesses.

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The rapid advancement of genetic sequencing methods has resulted new forensic genetics applications, one of which is able to predict the suspect's physical characteristics based on the biological evidence collected at the crime scene that is known as Forensic DNA phenotyping which can provide more objective and accurate description of an unknown individual and can prevent wrongful convictions. Today, it is possible to identify a person's approximate age, biogeographical ancestry (BGA), hair, eye, and colour of the skin with acceptable accuracy. Prediction of biogeographic ancestry can give an indirect indication of a person's physical characteristics However, for individuals of Indian ancestry there are variations in eye colour. A direct description of the eye colour of a perpetrator could aid police investigation. Forensic DNA phenotyping is used in different countries such as United States, the Netherlands, Germany, China, Belgium, Australia but it is not used in India yet. There are different tools used for the prediction of externally visible characteristics (EVC) of the individual the most common tools used for forensic DNA phenotyping are IrisPlex tool HIrisPlex tool and HIrisPlex-S tool. IrisPlex is a significant tool introduced in a research paper titled "Predicting eye colour from DNA with the IrisPlex system" which was published in the journal Forensic Science International: Genetics 2010. It was developed to examine at a particular genetic marker such single nucleotide polymorphism (SNPs) linked to eye colour. The Irisplex system is based on analysis of six Single Nucleotide Polymorphisms (SNPs) that are found in six distinct genes: rs12913832 (HERC2), rs1800407 (OCA2), rs12896399 (SLC24A4), rs16891982 (SLC45A2), rs1393350 (TYR), and rs12203592 (IRF4).

The advanced tool known as the HIrisPlex system can simultaneously predict both eye and hair colour from DNA. It consists of a single multiplex assay that targets 24 eye and hair colour-predictive DNA variants including all six IrisPlex SNPs as well as two prediction models: a newly constructed model for hair colour categories and shades, and the previously existing IrisPlex model for eye colour. This FDP system consists of two Snapshot- based multiplex assays targeting 41 SNPs which Include 17 skin colour predictive SNPs, 24 eye colour SNPs and 19 SNPs for skin colour. FDP stands for Forensic DNA Phenotyping. It is an emerging technique introduced in the field of forensic genetics to predict externally visible characteristics (EVC) and the biographical inference of ancestries of an individual based on their DNA. This technique analyses specific variations in the DNA sequence called single nucleotide polymorphisms (SNPs) that are associated with certain physical characteristics such as eye color, hair color, skin color, age estimation, baldness, height and facial features to create a profile of a person's appearance's stands for Single Nucleotide Polymorphism, which is a common type of genetic variation that occurs when a single nucleotide (A, T, C, or G) in the DNA sequence is altered which can be substituted, inserted, and deleted. SNPs can occur in both coding and non-coding regions of the genome and can have different effects on gene function and protein structure[9].

Forensic DNA Phenotyping (FDP) has now become one of the beneficial tools which aids in police investigation to narrow down the investigative procedure in various types of forensic cases such as identification of unknown in mass disaster case or unknown perpetrator who cannot be identified by the help of forensic STR- profiling. Benefits of FDP is that it has overcome to limitations that exist with conventional methods of human identification as it can predict individual's externally visible characteristics (EVCs) from DNA as well as it is more focused on obtaining genetic profiles from crime scene samples not harming dignity or integrity rights of individual. The IrisPlex tool is a forensic DNA phenotyping tool that is used to predict the eye colour of an individual based on their DNA. Eye colour may be regarded as one of the characteristics of humans with the greatest colour variation ranging from bright blue to dark brown or black to intermediate colours like grey, hazel, yellow, and green. IrisPlex prediction shows high accuracies for blue and brown eye colour but low accuracy for intermediate eye colour[8].Some individuals do not follow the expected genotype–phenotype patterns of rs12913832 and for these individuals, the IrisPlex eye colour predictions are incorrect The IrisPlex tool is just one of several tools used in forensic DNA phenotyping. There are other tools as well which can predict other physical traits such as hair color, skin colour, and facial features. Irisplex Tool is a highly sensitive and robust DNA tool that allows forensic experts to accurately predict blue and brown eye colour when conventional profiling techniques provides DNA of limited quantity and quality[9].

The workflow of forensic DNA phenotyping involves various steps and these steps can vary depending on the specific techniques and tools used.
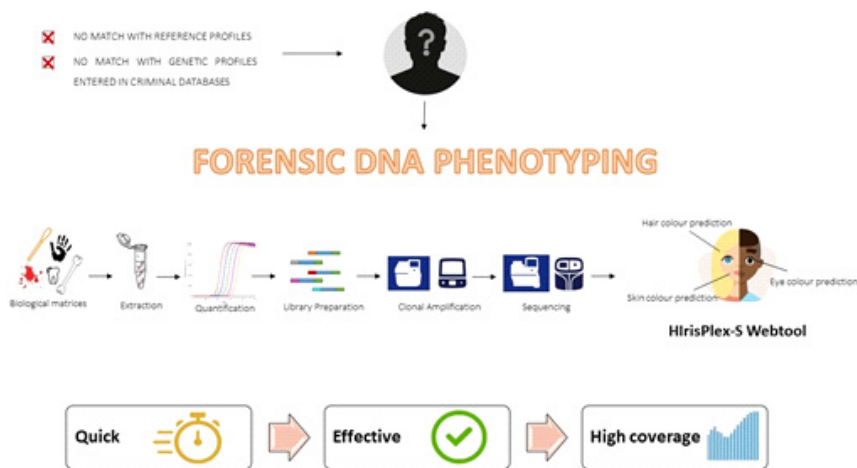
Figure-1 Workflow of FDP

STEP-1 <u>Sample Collection:</u> The first step is to collect DNA samples from the biological samples such as blood, saliva, hairs etc. To preserve the integrity of the DNA and avoid contamination, proper sample collecting methods and protocols are used

STEP-2 <u>DNA Extraction:</u> In order to separate the genetic material from the biological matrix, the acquired samples go through DNA extraction methods such as Phenol-Chloroform Extraction, Chelex Extraction, Silica Column-based Extraction, Magnetic Bead-based method etc.

STEP-3 <u>DNA Quantification:</u> Techniques like spectrophotometry or fluorometry are used to evaluate the concentration and quality of the isolated DNA. This step ensures that the DNA sample contains sufficient genetic material for subsequent analysis.

STEP-4 <u>Genetic Analysis:</u> Genetic analysis refers to the process of studying and examining an individual's genetic material to study genetic makeup, traits, and potential genetic disorders or diseases. It involves the examination of DNA, which carries the genetic information that determines an individual's unique characteristics. DNA Sequencing, Polymerase Chain Reaction (PCR), Genotyping, Microarray Analysis, Next-Generation Sequencing (NGS) and Bioinformatics Analysis are some of the genetic analysis techniques.

STEP-5 <u>Data Analysis:</u> The genetic data is analysed using bioinformatics tools and software. It is interpreted and physical characteristics or ancestry of the individual are predicted using statistical models or algorithms.

STEP-6 <u>Phenotype Prediction:</u> Based on the genetic analysis and statistical models' predictions of individual's physical characteristics are done. This may include predictions of eye colour, hair colour, skin colour, facial features, or other relevant traits.

STEP-7 <u>Reporting and Interpretation:</u> The results of the DNA phenotyping analysis are compiled into a report that outlines the predicted physical traits and any associated statistical probabilities

Figure 2: Flow Chart of DNA Phenotyping

Methodology

Sampling Strategies

The success of any genetic study relies on a well-crafted sampling strategy to capture the broadest representation of genetic diversity.

Materials and Method

For the analysis of DNA different approaches were taken such as:
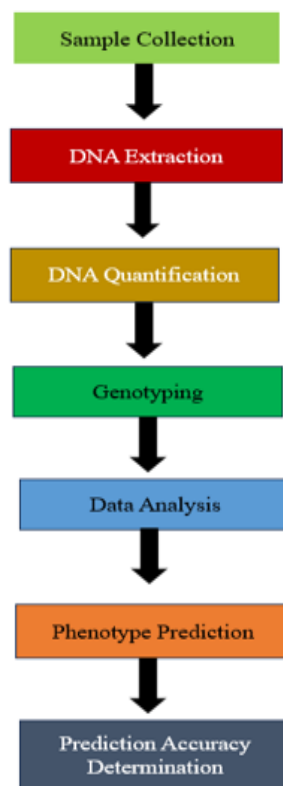
1. DNA Extraction (By QIAGEN Kit)

2. DNA Quantification (By BioTek Cytation™ Cell Imaging System)

3. Polymerase Chain Reaction (By Proflex Thermal Cycler)

4. Agarose Gel Electrophoresis

5. PCR cleanup (Exo-SAP)

6. Cycle Sequencing / Sanger Sequencing

7. Sequencing clean up

1. **Silica-Based DNA Extraction**

DNA extraction is a critical step in genetic analysis, and to this end, the Silica-Based Extraction method using the QIAGEN kit was chosen. The protocol was strictly followed, with minor adjustments for optimal yield and purity. A small volume of blood (50 µl) was carefully collected from each donor using a sterile syringe and a vacutainer blood collection tube, while saliva samples were gently collected using sterile cotton swabs. The collected samples were handled with great care to minimize contamination and stored at a constant temperature of 4°C to preserve DNA integrity.

2. **DNA Quantification**

Accurate quantification of DNA is essential to ensure uniformity and reliability of subsequent analyses. The BioTek Cytation™ Cell Imaging System was employed to measure the DNA concentration in each sample. The Nucleic Acid Quantification protocol, encompassing measurements at three wavelengths (260nm, 280nm, and 320nm), provided precise and reproducible DNA quantification. The absorbance readings of the elution buffer used during DNA extraction were subtracted to calculate the absolute absorbance of the DNA in the extract.

3. **Amplification Technique (PCR)**

PCR, a revolutionary technique in molecular biology, enables targeted amplification of specific DNA sequences. Primers were custom-designed to amplify regions of interest, reflecting key genetic markers associated with various traits and diseases. PCR reactions were set up using a master mix and DNA elute, followed by thermal cycling to achieve multiple rounds of DNA amplification.

Table 1: Volume of master mix for PCR

Components	Initial Concentration	Final concentration	Quantity per reaction (µl)
Taq buffer	10X	1X	1.5
dNTP	2mM	0.2mM	1.5
F primer	10uM	0.3uM	0.45
R primer	10uM	0.3uM	0.45
Taq polymerase	3U/ul	1U	0.34
DNA	-		4
NFW			6.76
Total reaction volume			15

Note: There were 6 different primers so 6 Master mix (MM) were prepared separately with primer (P1, P2, P3, P4, P5, P6).

4. **Agarose Gel Electrophoresis**

To verify the success of PCR amplification and assess the size of amplified DNA fragments, agarose gel electrophoresis was

employed. A gel with a reduced pore size (4%) was selected to increase the resolution of DNA bands. PCR products, along with a DNA ladder serving as a size reference, were loaded into wells and subjected to electrophoresis. The gel was then visualized using a UV transilluminator.

5. **PCR Cleanup (Exo-SAP)**

To prepare PCR products for downstream applications, a PCR cleanup step was performed using Exonuclease I and Shrimp Alkaline Phosphatase (Exo-SAP). This enzymatic treatment effectively removed unincorporated primers and nucleotides, ensuring purified and high-quality PCR products.

Table-2 Protocol for the PCR clean-up (Exo-SAP)

ExoSAP Cleanup Reaction	Per Reaction (µl)
Exonuclease 1	0.4
Exonuclease 1 Buffer	0.3
Shrimp Alkaline Phosphatase (SAP)	0.3
SAP Buffer	0.3
Nuclear Free Water (NFW)	0.3
DNA (PCR Product)	3
	4.6 µl

6. **Cycle Sequencing**

Clean PCR products underwent cycle sequencing, a widely used method to determine the precise DNA sequence of target regions. Sanger sequencing, based on the incorporation of chain-terminating dideoxynucleosides, facilitated accurate DNA sequence determination.

Table -3 Cycle Sequencing master mix component

Sr. No.	Cycle sequencing component	Volume
1	Nuclease Free Water (NFW)	5.575 µl
2	BigDye Terminator v1.1/3.1 Sequencing Buffer (5X)	1.875 µl
3	Ready Reaction Mix (BigDye)	0.25 µl
4	Control Primer (Forward / Reverse)	0.3 µl
5	DNA (cleaned)	2 µl

7. Cycle sequencing clean up (Post clean up)

To further refine the sequence data, a post-cycle sequencing cleanup step was performed. Ethanol precipitation was employed to purify the sequencing products and eliminate any remaining contaminants, thus enhancing the sequencing quality.

Table 4: Component for Master Mix -1 and Master Mix-2

Master Mix 1	Sr No	Reagents	Volume
	1	3M Sodium Acetate	2µl
	2	Absolute Alcohol (100% Ethanol)	50µl

Master Mix 2	Sr No.	Reagents	Volume
	1	0.5M EDTA	0.5µl
	2	Nuclease Free Water (NFW)	11.5µl

8. **Purification of the Pellet**

The final purification step involved washing the DNA pellet with 70% ethanol, further refining the quality of the sequencing data.

Table-5 Component for Purification of pellet

S.No.	Reagents	Volume
1	70% Ethanol	70µl

9. **Sequencing**

The purified DNA samples were subjected to the cycle sequencing method, generating high-quality DNA sequence data for downstream analysis.

Result

The IrisPlex tool, designed for eye color prediction based on DNA analysis, has been extensively studied in various populations worldwide. The accuracy of the tool's predictions has been assessed in diverse ethnicities and geographic regions to evaluate its applicability and reliability for forensic and genetic research purposes.

In European populations, the IrisPlex tool demonstrated high prediction accuracy for blue and brown eye colors, with an overall accuracy rate exceeding 94% (Walsh et al., Reference 1). The validation studies in European cohorts confirmed

the tool's robustness for populations of European descent. In non-European populations, such as East Asian and African/African-American cohorts, the accuracy of the IrisPlex tool was slightly lower compared to European populations. Discrepancies were particularly observed in blue eye color prediction (Chen et al., Reference 2; Hancock et al., Reference 3). These findings indicated that the tool's performance might vary across different genetic backgrounds and necessitated population-specific adaptations.

Discussion

The results of the IrisPlex tool's validation in diverse populations emphasize the importance of considering genetic variations and eye color diversity when applying the tool for forensic purposes. The high accuracy observed in European populations validates the tool's reliability in regions where blue and brown eye color are prevalent. However, the lower accuracy in non-European populations underscores the need for further calibration and adaptation to enhance prediction accuracy.

Despite the advancements in calibration, challenges remain in achieving universal accuracy across all global populations. The genetic basis of eye color is complex and influenced by multiple factors, making it challenging to develop a one-size-fits-all prediction model. Additionally, the accuracy of the tool can be influenced by the sample size and diversity of the reference databases used for validation. Ethical considerations also arise concerning the use of genetic information, such as eye color prediction, for forensic purposes. Proper informed consent and transparent communication with individuals whose eye color is predicted are vital to ensure ethical and responsible use of the tool.

Conclusion

IrisPlex tool has shown exceptional prediction accuracy in European populations, making it a valuable asset in forensic science applications, particularly in cases where eye color identification is critical for criminal investigations and human remains identification. The tool's ability to accurately predict blue and brown eye color with an overall accuracy rate exceeding 94% in European cohorts demonstrates its robustness and reliability.

Furthermore, population-specific calibration efforts have proven to be effective in enhancing the tool's performance in non-European populations. Studies conducted in diverse Asian and African/African-American populations have showcased the potential of fine-tuning the prediction model and incorporating region-specific genetic markers to improve accuracy. This progress is crucial as eye color variations are influenced by population-specific genetic factors, and population-specific calibration can help adapt the tool to the unique genetic backgrounds of different ethnicities. Despite the promising results, the IrisPlex tool encounters challenges in achieving universal accuracy across all global populations. The genetic basis of eye color is complex, involving multiple genes and interactions, which may vary significantly among different populations. As a result, a one-size-fits-all prediction model might not be sufficient to accurately predict eye color in all individuals worldwide. Therefore, it is imperative to further investigate and understand the genetic underpinnings of eye pigmentation in diverse populations to enhance the tool's accuracy and applicability. Additionally, ethical considerations play a crucial role in the utilization of genetic information, including eye color prediction. The responsible use of the IrisPlex tool requires informed consent from individuals whose eye color is predicted. Transparent communication is essential to ensure that the predictions are understood in the context of probabilities and limitations. Moreover, strict adherence to ethical guidelines and privacy protection is necessary to safeguard individuals' genetic information from misuse and potential stigmatization. To overcome the challenges and improve the IrisPlex tool's accuracy and applicability, collaborative efforts are needed between researchers, forensic experts, and geneticists from diverse disciplines and geographic regions. Large-scale collaborative studies encompassing a wide range of global populations can help expand the reference databases and enhance the prediction model's reliability. Moreover, sharing data and knowledge across international research networks can facilitate the identification of novel genetic markers associated with eye pigmentation, leading to a more comprehensive and accurate prediction model. In summary, the IrisPlex tool has demonstrated high prediction accuracy in European

populations and shown encouraging results in non-European populations through population-specific calibration. Nevertheless, challenges related to universal accuracy and ethical considerations necessitate further research, collaboration, and ethical practice to maximize the tool's potential in forensic and genetic applications. As the scientific community continues to explore the intricacies of eye pigmentation genetics, the IrisPlex tool stands as a promising tool for unlocking the secrets of human eye color diversity across the globe.

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Role of Forensic Science in the Perspective of Human Trafficking

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Abstract

In this article, the status of human trafficking in India will be presented. Human trafficking is one of the speediest expanding and profitable types of offence not only in India but Internationally too. This form of modern-day slavery contains miscellaneous exercises of human exploitation such as sex trafficking, forced labour, marriage, begging, and illegal organ transplantation. On the other hand, central reasons or vulnerability components of trafficking such as structural inequality, culturally sanctioned traditions, deprivation or financial insecurity, bonded labour, and gender violence, which are outlying and aggravated by disintegration, have stuck around unrecognised in intellectual and policy provinces. The significance of Human trafficking impacts all nations and destroys sufferers and society while affecting social, economic, and health costs. This paper argues that the focus is required to be conveyed to such underlying sources and manners by which this corruption is expanding. There is high need to look out for the laws made for crimes related to human trafficking, to protect the human of the trafficked persons in India. Hence, it furnishes some preventive actions to restrain and deal with the nuisance.

Keywords: Human Trafficking, Victim, Clinical Forensic Examination, Age estimation, Preventive measures.

Introduction

Trafficking in human beings (THB) is identified as an international public health problem as well as a violation of human rights. The main goal of Trafficking is sexual exploitation and it's evolving into an increasingly predominant subject around the world. The international and Indian lawful explanations of bonded labour, child labour and sex trafficking taken up throughout the report are underlined in this section. Under section 370 IPC, trafficking of individuals for "physical exploitation or any form of sexual exploitation, slavery or practices similar to slavery, servitude and the forced removal of organs" is forbidden. Heretofore, India signed the Palermo Protocol and amended its Penal Code, and trafficking of individuals for the intention of sexual exploitation has been exhaustively restricted. The Immoral Traffic in Persons Act 1956 also restricts the procuring, inducing or taking of an individual for the intention of prostitution. The Protection of Children from Sexual Offences Act 2012 restricts the capacity of sexual offences against juveniles under the age of 18[1]. Trafficking can incorporate numerous diverse ingredients which can contain sex trafficking, labour trafficking, and organ trafficking. Sex trafficking is human trafficking into prostitution. Labour trafficking is when an individual is trafficked into employment that is non-sexual. Lastly, organ trafficking is when the public is trafficked so their organs can be traded to be utilised for transplants[2]. Illustrations of commitments may incorporate false job possibilities or marriages in foreign nations. To ascertain that human trafficking is still going on around the world. As per the Walk Free Foundation

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Global Slavery Index 2014, India is home to an estimated 14 million victims of human trafficking, incorporating victims of sex trafficking, bonded labour, child labour, domestic servitude and forced marriage. According to India's 2008 Integrated Plan of Action to Prevent and Combat Human Trafficking, the scale of the situation is tremendous "both in [the] number of trafficked persons and an increasing number of zones". To tackle human trafficking, prosecution and punishment of offenders must be tracked down as well as lawful measures to snatch the acquisitions and earnings of traffickers. Trafficking has been distinguished to be associated with various health threats comprising psychological trauma, damages from violence, and substance misuse. People and media reports indicate that the morbidity and mortality associated with trafficking are tangible. The essential for medico-legal healthcare for THB sufferers is being overlooked. Trafficking is one of the extensively dynamically prospering structures of crime because of its remarkable regional and international market, increased earnings (approximately $180 billion/year), minimum risk, and frequently downward starting costs. Human trafficking is one of the most promising multinational crimes situated only after the drug and arms trade. In contrast, an individual can be sold without advanced activities, e.g., by simply operating the internet. Victims are usually compelled by a person who they probably believe is a friend, boyfriend/girlfriend, or even by family. In multiple circumstances, women can be lead recruiters for sex trafficking since they can more likely inspire faith in girls and other women[3].

What is Human Trafficking?

Trafficking denotes an unlawful business. Human trafficking is conducting marketing on humans. Human trafficking across the globe is primarily done for sexual exploitation where women and children turn into victims to it. Human Trafficking is defined as "the recruitment, harbouring, transportation, provision, or obtaining of an individual for labour or services, through the use of force, fraud, or coercion for subjection to involuntary servitude, peonage, debt bondage, or slavery". Additionally, more than half of the sufferers are in forced or bonded labour they are performing 12 or more hours a day in brick kilns, textile factories, agriculture, or stone quarries.

Their lives, and oftentimes the lives of their entire families, are marked by inhumane working and residency situations, handled by leaders who consider them commodities.

COVID-19 expanded the cases of bonded labour, as traffickers attracted the jobless with money betterment, simply to catch up with them in the cycle of debt bondage.

Indian expatriates pursuing employment in low-skilled sectors, such as household work and construction, also become tangled in labour trafficking in diverse nations, mostly in the Gulf countries, such as the U.A.E., and Malaysia[4].

For what purpose do humans get trafficked?

Human trafficking in India concerns those extensively vulnerable in the community. The most at-risk are those from lower social categories, living in deprivation, without a substantial lineage facility, and with nominal education.

Women and girls from the downward "Dalit" caste in India are sometimes "married" in a ritual to a regional temple deity. However, they become, in essence, sex slaves of the higher caste villagers.

Women and girls from Nepal and Bangladesh are constantly cheated into obtaining deceitful jobs in India, only to become-caught up in sex trafficking. Traffickers also manipulate women and girls from Central Asia, Europe, and Africa for commercial sex in Goa State[5].

There are several contributing characteristics for marketing in human beings particularly in women and children. The characteristics of trafficking in women and children can be divided into two categories: push and pull factors. The push factors include poor socio-economic conditions of a large number of families, deprivation associated with frequent, practically annual natural disasters like overflows leading to virtual deprivation of some public, scarcity of education, skill and earnings possibilities for women (and for their family members) in rural regions, lack of awareness about the exercises of traffickers, coercion to gather money for dowries which directs to transmitting daughters to outlying areas for employment, dysfunctional family life, domestic violence against women, low quality of girl children,

etc. Usually, the prostitutes, who have no choice but to come out of the exploitative environment, slowly evolve inseparable relations with the traffickers and follow in their footsteps.

The pull factors are lucrative occupation offers in large cities, manageable money, the assurance of better wages and satisfied life by the trafficking touts and dealers, the market of young girls for weddings in other areas, demand for low-paid and underage sweatshop labour, prospering demand of young kids for adoption, rise in the market for women in the rapidly boosting sex industry, the market for young girls in places of military engagement like Kashmir in India in current periods, the market for young girls for sexual exploitation as a consequence of the deception that physical intimacy with young girls diminishes men's probability of contracting HIV/AIDS, or of the myth that sex with a virgin can cure HIV/AIDS and impotence. The uncontrolled tradition of female foeticide in the northern states of Haryana and Punjab has also fuelled interior trafficking. Since there is a deficiency of women in these States having a low female-to-male ratio, they have evolved as fertile ground for the process of traffickers.

Traffickers procure girls from faraway states like Assam and Orissa; and trick their families into believing they are to be married, only to drive them into prostitution.

These cause direct improved migration but a situation of provincial migration due to multiple guidelines of the State. People use smuggling channels for human trafficking disclosing themselves to exploitation, cunning, brutality and misusage[6].

Impact of Human Trafficking on the Indian Economy

Despite human improvement in civil rights, slavery goes on to be an approvingly promising crime because:

- The perpetrators are infrequently seized and assembled to encounter criminal prosecution (because most of the public is woefully unknowing of the indications)

- The existing sentences are excessively indulgent to fit the criminality, failing to prevent prospective ones

- The unlawful market for forced labour and sexual exploitation around the globe is greedy

- unlike drugs and numerous other unlawful entities, human beings can be resold multiple times, making them an "attractive investment" for black market customers[7].

All of these aspects make human trafficking a "low risk / high reward" venture for organised crime and other underground factions, with a net profit margin of over 70 per cent of the 150 billion, a third of the profits are made from forced labour, while the other two-thirds are gained from commercial sexual exploitation (typically of women and children).

❖ The Financial Impact of Human Trafficking

Similarly engaging in performs that are unspeakably evil and illegal, human traffickers are stealing from their homelands as well as the transnational economy by utilising outside of ancestral regulations.

❖ Black Market Profits Are Not Taxed

Payoffs earned from trafficking human beings cannot boost economising as they are preserved disseminating between unlawful associations and terrorist groups, financing illegal drugs, arms deals, and corrupt, abusive regimes. Undercover markets of this nature vandalise the economy and syphon money away from legitimate corporation exchanges.

❖ Human Trafficking Victims Need Government Funding Help

Child labour and sexual exploitation cause irreparable, unbearable trauma for life, taking away victims of normalcy and putting some on the path to perpetuate the process of misusage onto others. Adults pushed or misled into captivity are psychologically (and often physically) harmed for life as well[8].

As such, trauma, suffering, and illness can generate whole generations incompetent to perform and function on their own, retaining to evolve reliant on administration welfare systems to make ends meet. The ones who are competent to work frequently have a difficult time acquiring employment due to criminal records associated with their backgrounds (such as past prostitution charges).

In other words, we can say trafficking survivors struggle with re-integrating into the community and require taxpayer funds to survive floating. And they earn that subsidy for what they have been through! But the truth stays: these individuals could have been fully operating fellows of the community contributing to its economy, had their psyches and bodies not been eradicated by having been ensured assistance[9].

Crimes related to Human Trafficking in India:

- Heads of crime which are related to human trafficking.

- Importation of girls from foreign countries (Sec. 366B IPC)

- Procuration of minor girls (section 366-A IPC)

- Buying of minors for prostitution (section 373 IPC)[1](previously known as buying of girls for prostitution)

- Selling of minors for prostitution (Section 372 IPC (in previous editions, data was collected under buying of girls for prostitution)

- Immoral Traffic (Prevention) Act 1956

- Human trafficking (section 370 & 370A IPC), after enactment of the Criminal Law (Amendment) Act 2013.

- The Indian Constitution of India prohibits trafficking in individuals and guarantees many of the internationally recognised diverse human rights criteria such as the right to life and personal liberty, the right to equality, the right to freedom, and the right to constitutional remedies. The right to be free from exploitation is also assured as one of the fundamental rights of any individual living in India.

- Around 3.13 lakh girls and women went missing in the country in the three years between 2019 and 2021, with Madhya Pradesh accounting for the highest at nearly two lakhs, closely followed by West Bengal, the Ministry of Home Affairs has informed the Rajya Sabha. Minister of State for Home Affairs, Ajay Kumar Mishra told the Rajya Sabha on July 26 that 10,61,648 women above 18 years and 2,51,430 girls below 18 years went missing between 2019 and 2021 across the country. "In 2019, the number of girls and women who went missing was 82,084 and 3,42,168 respectively, while in 2020, 79, 233 girls and 3,44,422 women went missing," he said[10].

Role of Forensic Science regarding Human Trafficking

In Human Trafficking Forensic Science plays a vital role. Forensic medical examination should cover a "Head-to-toe" assessment, necessarily systematic and detailed, that strives to uncover all injuries and marks. If deemed necessary, the assessment should expand to the use of imaging procedures, laboratory examinations, and other additional diagnostics. The discoveries of such assessment must be accurately written down and recorded.

Although damages are primarily non-specific, the so-called routine of injury has a tell-tale identification for the tool that imposed it. The index of tools is indefinite. Naturally used ones are hands, belts, baseball bats, kitchen utensils and curling irons.

Each of these tools takes off a skin footprint that recollects its outline and is, therefore, striking to it. Pattern injuries are invariably reproducible. They can be categorised into three major classifications, according to their origin: blunt force, sharp force and thermal. Understanding pattern injuries and the detailed documentation as to the anatomic spot of each injury will aid the PS and law enforcement authority in specifying what implement, tool or weapon was accountable for assembling a respective wound. Comprehending which tool or weapon was used will enable the experimenter to specify if the injury is persistent or inconsistent with the chronology given. The offending weapon, periodically of extraordinary shape or composition, when adequate coercion is pertained to, will forge a mirror image of itself onto the skin. Examples contain slap marks from the hand digits traced, looped or flat contusions from belts or cords, contusions from fingertip force, scratches from fingernails, parallel contusions from communication with a linear entity, and contusions from the heels and soles of shoes.

The courting or ageing of a contusion or bruise has been the preoccupation of much controversy within the forensic community. Examples of practice bruises include fingernail scratches, bite marks, imprints of carpet fabric, and ligature marks around

the wrist or neck. A thermal pattern injury is an injury whose humiliating force is hectic and whose physical formation misrepresents the warmth source, such as flat iron burns, curling iron burns, splash burns, and immersion burns.

Forensic assessment of sexually maltreat and/or played with victims of trafficking may give further evidence such as with a contemporary cessation of pregnancy (abortion), as well as genital and/or anal injuries. Similarly documenting injuries, a medical assessment may demonstrate disorders such as malnutrition, vitamin shortcomings or other alterations due to, for example, inhuman therapy. Such evidence may be used to verify a victim or witness statement. Occasionally it will be essential to compile more evidence, such as inconclusive, by on-site examination that may deliver further details on the confinement in slave-like situations.

Reasonable and convenient collection of forensic specimens (orifice swabs, hair, blood, urine, etc.) is an essential element of victim assessment. Specimens should be svs-automatically accumulated, marked and stored for future investigations if required. Forensic age diagnosis for criminal research should consist of a clinical assessment, containing the recording of body proportion and an evaluation of indications of sexual maturity, an X-ray examination of the left hand, and a dental examination that records the dentition situation and assesses the dental radiography (ortho-pantomogram). A lot of investigation has already been done in the domain and the consequences furnished by the overseeing Study Group for Forensic Age Estimation which has 50 members from Germany, Austria, Norway, and Switzerland are available.Ultimately, clinical assessment of a victim of trafficking in human beings is a good screening prospect for sexually transmitted diseases (syphilis, gonorrhoea, chlamydia), as well as for other diseases that may be sexually transmitted (HIV/AIDS, hepatitis B and hepatitis C). The significance of such testing is numerous - for the victims themselves, but also public health and epidemiological connotations[11].

Preventive action we can take to control human trafficking such as:

> ➤ Border measures

Rigorous punishment should enforce cross-border trafficking, invulnerable Vigilance in Trafficking highways and reasonable colonial accountability are required.

> ➤ Economic and social approaches

- Enduring actions to increase levels of social preservation and to develop occupation possibilities.

- Putting up rightful measures to eradicate intolerance against women in the field of employment to ensure, based on gender equality, the right to equal pay for equal work and the right to equality in employment opportunities.

- Developing programmes that offer livelihood opportunities and incorporate basic education, literacy, communication and other skills, and decrease obstacles to entrepreneurship.

- Facilitating gender sensitisation and education on equal and respectful connections between the sexes, thus averting violence against women.

- Assuring that approaches are in place that allow women equal access to and control over economic and financial resources.

> ➤ Awareness-raising measures

With the assistance of NGOs and Police officials there can be some kinds of advertisements through the widespread media in respective locations and by performing some awareness programs in villages, local schools, among kids of the poor society and public to be alert of being oppressed.

> ➤ Legislative measures

Embracing or maintaining legislative, proper law enforcement, uncorrupt officials, educational, social, cultural or other measures and, where appropriate, penal legislation, comprising through bilateral and multilateral cooperation, to prevent the ultimatum that fosters all forms of exploitation of individuals, especially women and children, and that oversees to trafficking.

> ➤ Project Swayangsiddha

- A similar movement, undertaken by West Bengal police in 2018, project swayangsiddha which in English

means self-reliant, intended to decrease the preponderance of child marriage and human trafficking. Through awareness-raising activities in schools and education dissemination to lower vulnerability to trafficking, the West Bengal police's purpose is to make a difference. "Strengthening credentials to schemes and entitlements on education, training, livelihood and food protection for vulnerable parties is also a significant portion of Swayangsiddha," an article by All India Trinamool Congress says.

- The prosperous Bengal model of Swayangsiddha has been enlightened by NGO Shakti Vahini and the U.S. Consulate Kolkata to enforce the program in 2022 in the states of Bihar, Jharkhand and Assam.

- Though eliminating human trafficking is not an easy feat, actions such as spreading awareness among people, reinforcing law and order, investing in education and employment and working together with civil societies can enormously decrease the prevalence of human trafficking in India.

The National Commission for Women (NCW) established a new anti-trafficking department to construct the accommodation of Anti-Human Trafficking Units (AHTUs). The government endorsed a new program to subsidise state and territory development of protection assistance for child victims of crime, including trafficking[12].

Conclusion

Human trafficking is a multidimensional offence, and because of its tremendous hierarchy likely will not be eradicated. Human trafficking endangers the dignity and protection of trafficked people and harshly infringes their human rights. Indian Constitution guarantees the equal rights of men and women, but they are constantly merely rhetoric when it comes to the question of realistic enactment. To fight trafficking and thus defend the human rights of helpless people, the powerful political will of the administration is important in executing their anti-trafficking proclamations. Thus, we can say any offence that can be utilised as a business one day

evolves into a major sociable evil as in the case of human trafficking.

The issue is still in our hands to be decoded if substantial actions are carried out gradually and policies are made and executed strictly. If timely efforts are not taken, then in a very short time it will be too late.

Regardless, every probable action should be carried out to support victims in attaining a better quality of life; diminish the number of issues; boost detection, prosecution, and convictions of traffickers; and increase awareness of the public about the human trafficking problem.

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The Role of Forensic Psychology in Profiling Serial Killers

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Abstract

This research paper delves into the critical role of forensic psychology in profiling serial killers, seeking to understand their motives and behaviors to enhance law enforcement efforts and prevention strategies. It explores the historical development of profiling, from intuitive judgments to current empirical methodologies, and delves into the psychological theories underpinning serial killing, such as psychopathy, childhood trauma, and personality disorders. The paper discusses the multidimensional approach employed in profiling, combining crime scene analysis, victimology, and behavioral analysis, and addresses the potential benefits and limitations of this investigative tool, highlighting its successes in solving notorious cases but also acknowledging concerns about biases and subjectivity. Ultimately, the study emphasizes that forensic psychology plays a crucial part in advancing our understanding of the psychological dynamics of serial killers, aiding in their identification, apprehension, and the development of effective prevention measures.this research paper extensively examines the pivotal role of forensic psychology in profiling serial killers, focusing on the historical development, psychological theories, methods used, and the potential benefits and limitations of profiling. By understanding the psychological dynamics involved in serial killing, forensic psychology greatly contributes to the identification and apprehension of dangerous offenders, ultimately enhancing society's ability to protect against such threats in the future.

Key words: Psychology, psychopathy, geographic profiling, motivational models, training and education.

Introduction

Forensic psychology plays a critical role in profiling serial killers, a topic that has captivated public curiosity for decades. These elusive and chilling offenders commit multiple heinous crimes over an extended period, making their identification and apprehension a daunting challenge for law enforcement. Forensic psychology, situated at the crossroads of psychology and the criminal justice system, offers invaluable insights into the psychological, emotional, and environmental factors influencing such violent behaviors. This research paper explores the historical background and evolution of forensic psychology, delving into the methodologies and approaches employed by forensic psychologists to construct accurate profiles of serial killers. By comprehending the motivations and thought processes driving these criminals, forensic psychology not only aids in apprehension but also informs preventative measures and interventions to curb such violent tendencies[1].

The research paper delves into the multifaceted applications of forensic psychology in criminal profiling, particularly within the context of serial killers. These insights are not only essential for law enforcement but also for understanding the psychological and societal factors that contribute to the development of such individuals. By

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identifying these underlying mechanisms, targeted interventions can be implemented to identify and deter individuals predisposed to violent criminal behavior. Additionally, the paper explores how forensic psychology findings can significantly influence legal proceedings, shaping trial processes and informing decisions related to sentencing and treatment of serial killers. However, it also addresses ethical challenges and limitations surrounding the use of forensic psychology in criminal profiling, such as concerns about accuracy, biases, and privacy rights[2].

Historical development of profiling

The historical development of profiling is marked by key influences and milestones across various disciplines:

➤ Early Influences: Pioneers like Cesare Lombroso in the late 19th century proposed the concept of "criminal anthropology," suggesting physical characteristics could indicate criminal tendencies.

➤ Birth of Modern Profiling: In the 1950s, FBI agent Howard Teten introduced "Psychology profiling," emphasizing analysis of crime scene evidence and behavioral clues to understand offender motivations.

➤ Profiling and Serial Killers: In the 1970s-80s, FBI agents like John E. Douglas and Robert K. Ressler made significant contributions by studying incarcerated serial killers, establishing patterns and typologies associated with serial murder[3].

➤ FBI's Behavioral Science Unit: The establishment of the FBI's Behavioral Science Unit (now Behavioral Analysis Unit) in the late 1970s propelled profiling, focusing on serial killers and violent criminals, refining techniques through research and practical application.

➤ Academic Contribution: Profiling models like the FBI's "organized/ disorganized" typology and "geographical profiling" techniques expanded profiling methodologies, increasing accuracy.

➤ Technological Advancements: Forensic science, data analysis, and geographic information systems advancements, including DNA analysis and geospatial mapping, enhanced profiling precision and objectivity.

➤ International Influence: Profiling techniques developed in the US influenced global practices, adapted by countries like the UK, Canada, and Australia with cultural and legal considerations.

➤ Contemporary Developments: Recent advancements in AI, machine learning, multidisciplinary approaches, and research collaboration are shaping the future of profiling[4].

Profiling, born from criminal anthropology and forensic science, has evolved into a specialized field. Pioneers, technological advances, and research have transformed profiling into a vital tool for criminal investigations, especially with serial killers. As techniques advance further, profiling is expected to become more sophisticated and effective in aiding law enforcement to identify and capture offenders[5].

Psychological theories of serial killing

Serial killing is a complex and disturbing phenomenon that has captured the attention of psychologists, criminologist, and the general public. Understanding the psychological factors underlying serial killing is crucial for gaining insights into the motivation, behaviors, and psychopathology of these individuals. This section explores some of the key psychological theories that have been proposed to explain serial killing, shedding light on the inner workings of the minds of these offenders[6].

1. **Psychopathy and Antisocial personality Disorder**

   One prominent theory in understanding serial killing is the association with psychopathy and antisocial personality disorder. Psychopathy is characterized by a lack of empathy, remorse, shallow affect, along with manipulative and impulsive behaviors. Individuals with psychopathic traits often exhibit a disregard for societal

norms and rights of others. ASPD, which shares overlapping features with psychopathy, involves a pervasive pattern of disregard for and violation of the rights of others. Both psychopathy and ASPD are commonly associated with a higher risk of engaging in violent and criminal behaviors, including serial killing.

2. **Motivational Models**

Various motivational models have been proposed to explain the underlying drives and desires that lead individuals to commit serial murders. These models attempt to elucidate the different motives that can fuel serial killing. Some common motivational factors include :

a) **Power and control:** Serial killers may seek a sense of dominance, control, and power over their victims. They derive pleasure and satisfaction from exerting authority and manipulating others lives.

b) **Sexual Gratification:** sexual motivations are often intertwined with serial killing. Some individuals derive pleasure from the sadistic acts committed during the killing or engage in necrophilia. (Sexual acts with corpses).

c) **Thrill seeking:** For certain serial killers, the primary motivation is the pursuit of excitement and arousal derived from the act of killing. They may enjoy the adrenaline rush and the sense of danger associated with their crimes.

d) **Financial Gain:** Although less common, some serial killers may engage murder as a means to acquire material benefits such as financial gain or inheritance[7].

3. **Typologies and categories:**

Psychologists and criminologist have proposed various typologies and categories to classify different subtypes of serial killer based on their motivation, behaviors, and patterns. Some well known typologies include:

A. **Organized /disorganized typology:**

This typology, developed by the FBI, categories based into two broad categories based on the behavior at crime scenes. Organized killers are typically methodical, organized, and calculated in their approach, often leaving minimal evidence and exhibiting premeditation. Disorganized killers, on the other hand, exhibit impulsive and chaotic behaviors, leaving behind disorganized crime scenes and often acting on sudden urges.

B. **Visionary, mission oriented, and Hedonistic typology:**

This typology, proposed by the FBI'S crime classification Manual, categorizes serial killers based on their primary motivation. Visionary killers are driven by hallucinations or delusions, mission-oriented killers believe they are eliminating a particular group of people for a perceived greater good, and Hedonistic killers seek personal pleasure or Gratification from their crimes[8].

C. **Lust, thrill, gain, and power typology**

This typology, proposed by researchers Holmes and Holmes, classifies serial killers based on their primary motivation. Lust killers derive sexual gratification from their murders, thrill killers are motivated by excitement and stimulation, gain killers commit murders for material benefits, and power killers seek dominance and control over their victims.

These psychological theories provide frameworks for understanding the complexities and motivations behind serial killing. It is important to note that individual cases may involve a combination of factors, and not all serial killers fit neatly into specific typologies. The application of these theories assists forensic psychologists and criminal profilers in contributing accurate profiles, aiding law enforcement agencies in identifying and apprehending serial killers[9,10].

Psychological profiling methods and techniques

Psychological profiling, also known as offender profiling, is a specialized investigative tool that combines psychological principles, behavioral analysis, and crime scene analysis to create a detailed profile of an unknown criminal[11]. Various methods and techniques are used in this process:

➢ Crime Scene Analysis: Examining the physical evidence and context of a crime scene provides insights into the offender's behavior, modus operandi, and signature characteristics. Factors like location, staging, and evidence left behind help deduce personality traits, organization level, and potential motivations.

➢ Victimology: Studying victims' demographics, backgrounds, and behaviors helps uncover patterns and connections between the offender and victims. This identifies vulnerabilities, selection criteria, and modus operandi, shedding light on motivations and preferred victim types.

➢ Offender Characteristics: Analyzing offender demographics, education, employment, and criminal history provides insight into their psychological makeup, social background, and risk factors contributing to their criminal behaviour

➢ Behavioral Analysis: Focusing on offenders' actions during and after crimes, this identifies behavioral patterns, rituals, and emotional states. Analysis of violence, approach method, weapons used, and signatures provides insights into mindset, aggression, planning, and emotions.

➢ Motivational Analysis: Understanding the motivations behind criminal actions—like power, control, revenge, or gain—provides insights into psychological needs, fantasies, and triggers contributing to the behaviour.

➢ Geographic Profiling: Particularly useful for serial crimes, this technique uses spatial analysis, crime mapping, and statistics to predict the offender's likely area of residence or operation. It narrows down the research

area based on crime scene distribution and other factors.

➢ Case Studies and Empirical Research: Profilers draw from past cases and research to refine their techniques. Studying similar cases and outcomes helps identify patterns and offender behaviors[12].

Psychological profiling is not rigid; methods vary based on crime type, evidence, and expertise. Profilers use a multidisciplinary approach, combining psychological knowledge, crime scene and behavioral analysis. Continuous research, collaboration, and technology integration further advance the field[13].

Role of Psychologists

1. **Collaboration with law enforcement**

   Forensic psychologists collaborate closely with law enforcement agencies, working alongside detectives, investigators, other professionals involved in criminal investigation. They provide psychological perspectives and expertise, assisting in the interpretation of crime scene evidence, analyzing behavioral patterns, and helping to develop investigate strategies based on their understanding of the offenders psychology.

2. **Creating investigative leads:**

   By examining crime scene evidence, victimology, and offender characteristics, forensic psychologists, contribute to the creation of investigative leads. They identify patterns, modus operandi, and potential, and potential motives that can guide law enforcement in narrowing down the list of suspects or focusing their efforts on specific areas or aspects of the investigation. This information helps Prioritize leads and allocate resources effectively[14].

3. **Informing criminal investigation**:

   Forensic psychologists provide valuable insights into the psychological aspects of criminal investigation. They offer guidance on interview and interrogation techniques, helping investigators elicit information from witnesses and suspects more effectively. Their understanding of the psychological

dynamics involved in serial killing can inform decision making throughout the investigative process, aiding in the development of strategic approaches to gathering evidence and solving the case.

4. **Assisting in apprehension and conviction:**

   Forensic psychologists may actively participate in the apprehension of serial killers by advising on offender behaviors, psychological vulnerabilities, and potential strategies for apprehension. They assist in the planning and execution of operations to capture the offender, considering factors such as the offenders psychological triggers, potential escape routes, and likely responses to law enforcement actions. Additionally, they may provide expert testimony in court presenting their psychological analysis and profiling findings to help secure convictions.

5. **Expert testimony and courtroom presentation:**

   Forensic psychologists with expertise in profiling may serve as expect witnesses in criminal trails involving serial killers. They provide specialized knowledge and insights to the court, explaining the psychological dynamics of serial killing, discussing offender behavior, and jury and understand the complexities of the case, evaluating the significance of the psychological evidence and the reliability of the profiling process[15].

Forensic psychologists bring a unique and valuable perspective to the investigation and prosecution of serial killers. Their expertise in understanding the motivations, behaviors, and psychological factors driving these offenders enhances the accuracy and effectiveness of criminal investigations. By collaborating with law enforcement, creating investigative leads, informing criminal investigation, assisting in apprehension and conviction, and providing expert testimony, forensic psychologists play a vital role in advancing our ability to identify, apprehend, and prevent the actions of these dangerous offenders[16].

Benefits and limitations of psychological profiling:

Psychological profiling, when used effectively, can provide numerous benefits in criminal investigation, particularly in cases involving serial killers. However, it is essential to recognize the limitations and potential challenges associated with this investigative tool. This section explores the benefits and limitations of psychological profiling.

Benefits of psychological profiling:

Psychological profiling is a useful tool in criminal investigations, particularly with serial killers, but it has both benefits and limitations.

➤ Focused Investigation: Profiling narrows down potential suspects by providing insights into offender characteristics, saving time and resources.

➤ Investigative Leads: It identifies patterns, modus operandi, and motives, guiding law enforcement in their search for evidence and witnesses.

➤ Offender Identification: Profiling connects seemingly unrelated crimes, helping to identify unknown offenders and their patterns.

➤ Preventing Future Crimes: Understanding serial killers' motivations aids in developing prevention strategies, targeting potential victims, and implementing prevention programs.

Limitations and Challenges:

➤ Not Infallible: Profiling is based on assumptions and probabilities and does not guarantee accurate offender identification.

➤ Lack of Scientific Validation: Some aspects lack rigorous scientific backing, and the subjective nature of profiling techniques raises concerns about consistency and reliability.

➤ Ethical Considerations: Delving into offenders' personal lives and mental health raises ethical dilemmas related to privacy, stigmatization, and confidentiality.

➤ Cognitive Biases: Profilers can be influenced by biases that impact the accuracy and objectivity of their analysis.

> ➢ <u>Legal Admissibility</u>: The admissibility of profiling evidence in court can be challenged due to lack of empirical validation and perceived speculation.

Psychological profiling aids investigations through focused efforts, leads, offender identification, and prevention strategies. However, its fallibility, lack of scientific validation, ethical concerns, cognitive biases, and legal challenges must be recognized. Ongoing research, adherence to ethics, and efforts to validate techniques are essential to improve profiling's accuracy and acceptance as an investigative tool[17].

Conclusion

This research paper has highlighted the critical role of forensic psychology in profiling serial killers. The analysis of serial killers motives, behaviors, and patterns is crucial for effective law enforcement and the development of prevention strategies. Forensic psychology combining psychological principles with investigative techniques, plays a pivotal role in creating accurate and comprehensive profiles of serial killers. The historical development of profiling, along with psychological theories, has provided a foundation for understanding the complex dynamics of serial killing. The methods employed in profiling, such as crime scene analysis, victimology, behavioral analysis, contribute to the identification, apprehension, and comprehension of serial killers. While there are benefits to psychological profiling, it is important to acknowledge it's limitations and the potential challenges associated with its application. Nevertheless, by depending our understanding of the psychological aspects of serial killing, forensic psychology continues to play a crucial role in improving our ability to identify, apprehend, and prevent the actions of these dangerous offenders.

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Visualization and Comparison of Latent Fingerprints on Various Surfaces Using Neem and Turmeric Powder

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Abstract

In the research, various methods for developing latent fingerprints on various surfaces have been reported. This paper describes a new powdering method for the development of latent fingerprints that is simple and non-toxic and can be used on a variety of substrates. In this study, non-toxic, simple, and easily accessible turmeric powder and Neem powder were used, all of which are commercially available natural powders with a variety of domestic and traditional applications. These powders have been used to decipher latent fingerprints on ten different substrates, including glass, lamination sheet, transparency sheet, metal surface, wooden surface, plain paper, cardboard, plastic, tile, and steel. It has been discovered that it produces very clear results on most surfaces. The powders were used to give the best results on all surfaces except plain paper. The prints are clear with all the ridge characteristics present.

Keywords: Neem powder, turmeric powder, latent fingerprint, development, fingerprint powder

Introduction

Impression evidence is the evidence that is left behind by the criminal. The impression is from some part of the criminal, such as his shoes, his vehicle tires, his fingerprints, or a tool or instrument that he used, and it is left behind on some of the materials on the crime scene like soil, dust, or cement[1].

Fingerprints

Fingerprints are the most important evidence found at crime scene from the past till now it is considered as the most important type of impression evidence used in identification. Fingerprint Science resides in Fingerprint since time immemorial. This science is a unique one and even today it is a subject of mystery to the general public. It is not known who and when first used the Fingerprint for identification purposes. But the study of palms and the uses of fingerprints can be traced back to the beginning of civilization[2].

History of Fingerprints

Slabs of clay with fingerprints 3000 years old were found in King Tut-en- Khamen's tomb in Egypt. Chinese Emperors used thumb impressions as a seal on the documents. The seals were of clay with the impression of a thumb on one side and the name of the owner on the other. Emperor Ts-in-She was the first Emperor to use such seals[3]. This shows clearly the importance of fingerprints for identification purposes. Under the law of Taiho in 702 A.D, when a Japanese husband preferred divorce charges, he had

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to imprint the mark of his index finger after his name on the document transcribed by another. Soleiman, an Arabian merchant wrote in 851 AD that in China Creditor's bills were marked by the debtor with their middle and index fingers together. Fingerprints along with palm prints known as 'Panja' were used for some centuries in India[4].

Forms of Fingerprint Evidence Found on the Crime Scene

- **Visible prints**

  The naked eye can see these types of chance prints. Typically, it is composed of blood, dirt, dust, oil, or any other coloured substance. It can be photographed directly if the ridges are clear enough for comparison. Only after direct photography has been taken. Every effort should be made to make it clearer.

- **Plastic Print**

  Plastic prints are three-dimensional impressions found on wax, soap, paint, and muddy surfaces. To obtain plastic print direct photography and plaster of Paris are used.

- **Latent Print**

  Latent means "hidden" or "invisible." This is the most significant print commonly found at the crime scene. This cannot be seen with the naked eye or even with a magnifying glass. The truth is that every time we touch something, we leave our impression on it. Science and technology have progressed to the point where Fingerprint Experts can develop or enhance latent fingerprints from almost any object using a variety of techniques, as they cannot be observed with the naked eye[5].

Methods used in Developing Latent Prints

- ➤ **Chemical method**

  Chemical methods are used for developing chance prints because they do not rely on moisture remaining in print but rather on a chemical reaction taking place between the developer and sweat pores. The different methods used for developing these latent prints are Iodine fuming, Ninhydrin, Cyno-Acrylate, and Silver Nitrate.

- ➤ **Powdering technique**

  The powdering technique has been used as a technique since the early 1900s. The powder is applied on the surface where the latent Fingerprint is present using brushes. Different types of brushes are used like a camel hair brush, ostrich feather brush, etc. To develop the latent fingerprint, the powder is sprayed onto the surface using an atomizer, and the excess powder is removed using an ostrich brush. The furrows do not adhere to any powder on them. The powder applied sticks to the ridges and the ridges are clearly visible. Since the applied powder is coloured the print becomes visible and is said to be developed[6,7].

Factors Influencing the Effectiveness of Fingerprint Powders

- **Surface type**: The type of surface on which the fingerprint is deposited can affect the effectiveness of fingerprint powders. Porous surfaces, such as paper or cardboard, may require different powders than non-porous surfaces, such as metal or glass.

- **Age of the fingerprint**: The age of the fingerprint can also impact the effectiveness of fingerprint powders.

- **Environmental conditions**: The environmental conditions in which the fingerprint was deposited can also affect the effectiveness of fingerprint powders. For example, humidity, temperature, and exposure to sunlight or other environmental factors can impact the visibility of the print.

- **Quality of the powder**: The quality of the fingerprint powder used can also impact the effectiveness of fingerprint powder. High-quality powders are more likely to produce clear and visible prints.

- **Application technique**: The technique used to apply the fingerprint powder can also influence the effectiveness of fingerprint powder. Applying the powder too thickly or too thinly can impact the visibility of the print.

- **Chemical composition of the surface**: The chemical composition of the surface can also impact the effectiveness of fingerprint powder. For example, surfaces treated with certain chemicals may require different powders to visualize latent fingerprints[8].

Some of the chemical substances used in the fingerprint powders are toxic and cause potential health hazards and also these methods are expensive in nature. In order to overcome this disadvantage in this research new powders, which are simple, nontoxic to human health, easily available, cheap in nature, has many medical uses, and as well can be utilized for the development of latent fingerprints on various surfaces[9,10]. This method is simple and easy. The powders which are used in this research are Turmeric powder and Neem powder.

Turmeric Powder

Turmeric (Curcuma longa) is a Zingiberaceae (ginger) rhizomatous herbaceous perennial plant. Turmeric rhizomes are short, thick, and stubby. Turmeric powder is a yellow-orange spice that is made from the ground root of the turmeric plant. It has a warm, slightly bitter flavour and is commonly used in cooking, particularly in Indian and Middle Eastern cuisines. Turmeric is also used as a natural food colouring agent, and it has been used for medicinal purposes for thousands of years in traditional Ayurveda and Chinese medicine. Turmeric is rich in curcumin, which is a natural anti-inflammatory and antioxidant compound. Curcumin is believed to have numerous health benefits, including reducing inflammation, improving brain function, and reducing the risk of chronic diseases such as heart disease, cancer, and Alzheimer's disease. In addition to its health benefits, turmeric powder has several culinary uses. It is commonly used to flavour curries, stews, and soups, and it is often added to rice dishes to give them a bright yellow colour. Turmeric can also be used as a natural food colouring agent to give a yellow hue to baked goods and other foods. Turmeric powder was used for body, clothing, utensils, and ceremonial purposes in Micronesia, according to Friedrich Ratzel's 1896 report in "The History of Mankind". Colour is one of the functional uses of curcumin as a food additive.

Neem Powder

It thrives in tropical climates such as India and Myanmar. Neem powder is a natural powder made from the leaves, seeds, and bark of the neem tree (Azadirachta indica), which is native to the Indian subcontinent. The neem tree has a long history of traditional use in Ayurvedic medicine for its antimicrobial, antifungal, and anti-inflammatory properties. Neem powder is rich in antioxidants, flavonoids, and other biologically active compounds, including nimbin, nimbidin, and nimbinene. These compounds are believed to provide numerous health benefits, including supporting healthy digestion, boosting the immune system, promoting healthy skin, and helping to reduce inflammation and oxidative stress. In addition to its medicinal uses, neem powder is also commonly used in cosmetic and personal care products due to its antimicrobial and anti-inflammatory properties. It can be found in products such as soaps, shampoos, and toothpaste. When using neem powder, it is important to use high-quality powder from a reputable source. Neem powder can be used internally, in the form of capsules or tea, or externally, as a paste or oil applied to the skin. However, it is important to consult with a healthcare professional before using neem powder or any other natural supplement or remedy, especially if you have a medical condition or are taking medications.

All of these powders are safe and simple to use. These powders are used to create prints from surfaces. The surface on which the print is present on the scene helps in determining which method of the collection must be used. The surface has three general properties: porous, non-porous smooth, and non-porous rough.

The ability to absorb liquids distinguishes porous from non-porous surfaces. When liquids are dropped onto a porous surface, they sink in, whereas non-porous surfaces sit on top of them. Paper, cardboard, and untreated wood all have porous surfaces. Varnished or painted surfaces, plastics, metal surfaces, and glass are all examples of non-porous smooth surfaces.

Importance of Fingerprint Development

Fingerprint development can help in finding the real culprit and also in eliminating suspects.

If Fingerprints are found on any surface at a crime scene, then they can be matched with older records or with inmates, or with suspect Fingerprints, this can help in finding the real culprit who might have done the crime. Latent Fingerprints found on a crime scene can be developed and marched with other records and the perpetrator can be found. The development of Fingerprints has helped a lot in solving cases for years and it is still considered the most trustable method for identifying the culprit[11,12].

Importance of Using Natural Powders

Natural Powders are easily available in the market and can be used for the development of latent Fingerprints. The powders which we normally use in the laboratory for the development of latent fingerprints are harmful and contain toxic chemicals that can affect our health very badly. The toxic chemicals have adverse effects on our health. The naturally available powders don't contain any harmful chemicals which may affect our health. As these natural powders are easily available everywhere we can use these powders for developing latent fingerprints when the chemical powders are not there. Chemical powders are not available everywhere whereas natural powders are easily available and are present in our homes as those are mainly for traditional purposes[13,14].

Methodology

There are various crimes that are going on across the world like murders, theft, suicide, homicide, kidnapping, and abduction in which fingerprints can be left as evidence. The most common type of fingerprint found at the crime scene is a Latent Fingerprint which cannot be seen by the naked eye. The type of surface, effectiveness, and simplicity are the only factors that affect whether a technique for creating latent fingerprints is adopted. Latent Fingerprints can be developed by various methods. Powder methods are most commonly employed for the development of such prints. These techniques exhibited quite effective results for many surfaces but to increase their efficiency and simultaneously diminution the price, some advances were needed. The powder used is made up of chemicals that may be harmful to us and may have adverse effects on our bodies. And most of the powders are not easily available and it's expensive. So, in order to overcome this disadvantage, developed latent fingerprints using powders like Turmeric and neem. These powders are simple, nontoxic, and may be easily available. The powders used in the study are household products that have so many medicinal uses also.

Materials and Methods

1. **Surface selection:**

   Different types of surfaces were selected such as plastic, Wood, plain paper, steel, metal, Lamination sheet, cardboard, transparency sheet, Glass, and Tile.

2. **Preparation of powders:**

   Commercially available turmeric powder was taken and then further ground in a blender in order to get a very fine powder to the level of talcum powder. Then keep it in the glass tubes and seal it. Maintain it in laboratory condition. Similarly, the above method was followed for the preparation of neem powder.

3. **Procedure for developing latent fingerprints:**

- Prepared powders (Neem and Turmeric) are used for the development of latent fingerprints present on different types of surfaces like plastic, wood, plain paper, steel, metal, cardboard, transparency sheet, Glass, and Tile.

- Powders are applied on the surface containing the Fingerprint using an Ostrich feather brush

- After the development of the latent fingerprint photograph of the developed print is taken.

- Then the print is lifted using adhesive tape. Then the tape is stuck on the fingerprint lifting card.

- At last, the prints are compared to each other based on the Clarity of the developed Fingerprint on different surfaces
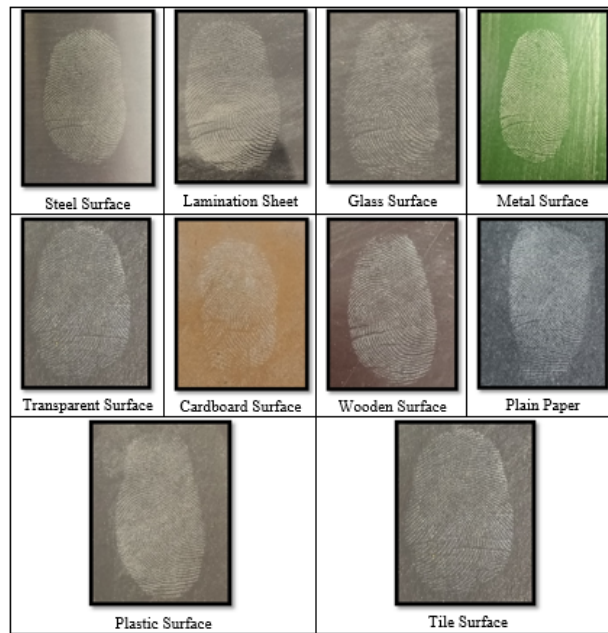
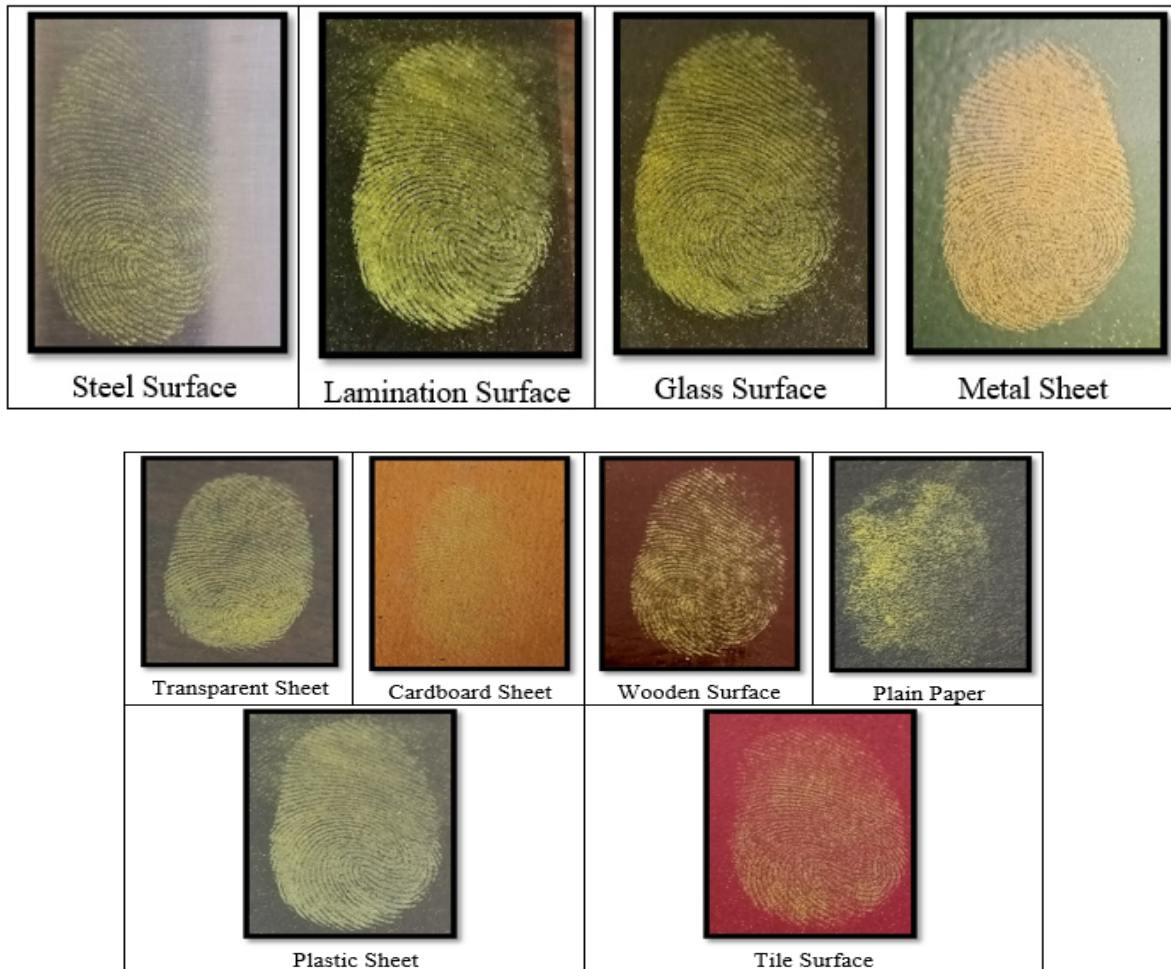**Figure 1: Development of Latent Fingerprint Using Neem Powder**

Figure 2: Development of Latent Fingerprint Using Turmeric Powder

Data Analysis

Table 1: Development of latent fingerprint using Neem powder

Surface	Development
Glass	Developed
Lamination sheet	Developed
Metal	Developed
Tile	Developed
Cardboard	Developed
Transparency sheet	Developed
Steel	Developed
Plain paper	Developed
Wood	Developed
Plastic	Developed

Latent Fingerprint on different surfaces using Neem powder was successfully developed. The ridge characteristics can be clearly seen on almost all the surfaces like lamination sheets, glass, plastic, steel, cardboard, transparency sheet, metal, wooden surface, and tile. On paper, the print was developed, and the ridge characteristics can be seen but the absence of clarity was noticed.

Table 2: Development of latent fingerprint using Turmeric Powder

Surface	Development
Glass	Developed
Lamination sheet	Developed
Metal	Developed
Tile	Developed
Cardboard	Developed
Transparency sheet	Developed
Steel	Developed
Plain paper	Not developed
Wood	Developed
Plastic	Developed

The latent fingerprint was developed using turmeric powder on ten different surfaces (plain paper, cardboard, glass, plastic, wood, transparency sheet, lamination sheet, metal, steel, and tile).

The latent print was successfully developed on all surfaces except plain paper. The developed print was clearly visible with all the ridge characteristics.

Comparison

The powders give positive results on all surfaces. Prints can be developed on surfaces like glass, tile, wood, and steel using both powders (neem and turmeric). The ridge characteristics are also visible. The print was successfully developed using neem powder on metal, lamination, plastic, and transparency sheet but in turmeric, the print developed and little smudging was observed. On the cardboard surface, the print developed using neem powder contain all the ridge details but with turmeric powder, the print-developed and ridge characteristics were not visible. On plain paper the print was developed using neem powder but ridge characteristics were absent. In turmeric powder, the prints were not developed.

Major Findings

Turmeric powder

- The latent fingerprint developed using Turmeric powder on glass, tile, Steel, and wooden surface was successfully developed all the ridge characteristics were clearly visible.

- On transparency sheets, lamination sheets, plastic, and metal the latent fingerprint was developed the ridge characteristics can be seen but little smudging was observed. On the cardboard surface, the print developed but the ridge characteristics were not visible and can't be used for any further analysis.

- On plain paper the latent fingerprint can't be developed because the sweat is being absorbed by the paper and the power doesn't attach to the surface.

Neem Powder

- Latent print on different surfaces using Neem powder was successfully developed all the ridge characteristics were clearly seen on almost all the surfaces like lamination sheet, glass, plastic, steel, cardboard, transparency sheet, metal, wooden surface and tile.

- On paper the print was developed the ridge characteristics can be seen but absence of clarity was noticed the developed print was used for further comparison

Conclusion

Turmeric powder and Neem powder which are natural, easily available, non-toxic and simple can be used successfully on various surfaces to develop prints in crime investigations. And the print developed on most of the surfaces has clear ridge characteristics present. Neem powder gives positive results on all surfaces (Plastic, Wood, paper, steel, metal, cardboard, transparency sheet, Lamination sheet, glass, and tile). All the latent fingerprints get developed using these powders. But in turmeric powder, the print developed on all surfaces except on plain paper.

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