
A STUDY ON FINGERPRINT ANALYSIS IN CRIME SCENE INVESTIGATION

R. Bhuvaneshwari, B.B.A LL.B. (Hons.), LLM (Crime and Forensic Law), School of Excellence in Law (SOEL), The Tamil Nadu Dr. Ambedkar Law University, Chennai

ABSTRACT

The field of Fingerprint Analysis as a branch of forensic science that deals with the study of fingerprints as a means of identification in criminal investigations has seen significant advancements over the ancient time. Fingerprints, being unique and immutable to every individual, have long been regarded as one of the most reliable forms of biometric identification of the prisoners, convict or suspect under Prisoners Identification Act, 1920. In forensic science, fingerprint analysis includes latent fingerprints, comparing them to known fingerprints, and confirming identity. From manual identification to automated systems like AFIS (Automated Fingerprint Identification System), fingerprint technology has advanced, speeding up the process of matching prints and increasing the precision of criminal profiling for the identification of inmates and other accused people. Legal and ethical considerations surrounding the admissibility of fingerprint evidence u/s 45 of Indian Evidence Act, 1872 in court are discussed, emphasizing the necessity of ensuring reliability and accuracy. As it moves on to fingerprint databases, it offers a thorough rundown of state and federal frameworks, including their implementation and the associated difficulties. Applications of fingerprint investigation in the real world highlight the importance of distinct finger impressions in criminal examination and the role fingerprint databases play in crime solving, with a focus on cooperation with other quantifiable techniques. In this way, concluding it by highlighting the developing trends and future advancements in the field, encouraging sustained investigation and improvement for further enhancement. This comprehensive research in fingerprint analysis aims to enhance understanding and awareness of the pivotal role fingerprints play in modern criminal justice.

Keywords: Fingerprint analysis, Individual Identification, Forensic evidence, crime scene investigation, criminal justice system.

CHAPTER: 01

INTRODUCTION:

Fingerprint Analysis is a branch of forensic science that deals with the study of fingerprints as a means of identification in criminal investigations. The term “fingerprint” in its limited sense meant to be "an impression left by the friction ridges of a human finger." Fingerprint analysis as a cornerstone of crime scene investigation and a vital tool in the identification of individuals, have uniqueness to each and every person and remain unchanged throughout the life, making them a reliable biometric identifier. It is based on the scientific rule that “no two individuals or persons have the same fingerprints and that these unique ridge patterns of every single finger can be used to identify an individual”¹. They are often cleared out behind the crime scenes on surfaces such as glass, metal, or paper that can be helped to link and identify the suspects to the scene of a crime and also the victim. Law enforcement agencies and correctional facilities rely on fingerprint databases, such as the Automated Fingerprint Identification System (AFIS)², to maintain accurate records of offenders. These databases store and organize fingerprint data, enabling authorities to track those offenders, analyse their criminal history, and monitor repeat offenses. Such comprehensive record-keeping supports investigations and enhances the efficiency of the judicial system. In spite of its importance, unique finger impression examination is not without its challenges. The accuracy and reliability of results are dependent on factors such as the quality of the fingerprints collected, the conditions under which they were collected, and the skills and expertise of the fingerprint examiners. This brief study will provide a brief overview of the profound significance of fingerprint analysis which holds in aiding law enforcement agencies in solving crimes and bringing perpetrators to justice.

CHAPTER: 02

HISTORICAL DEVELOPMENT OF FINGERPRINT ANALYSIS IN INDIA:

From the colonial era to the current developments in criminal investigations, India's history of fingerprint analysis and labs tells a tale of important contributions to the field of forensic science. To begin with the first record of forensic fingerprinting analysis dates back to the

¹ Colin Beavan, *Fingerprints: The Origins of Crime Detection and the Murder Case That Launched Forensic Science* (Hyperion 2001).

² John J Dille, David D Makin. AFIS: Automated Fingerprint Identification Systems, 2006.

Chinese Qin Dynasty³ (circa 221 – 206 BC). These Chinese, and the Roman cultures have used fingerprints in ancient times. Fingerprints are believed to be the earliest known friction ridge skin imprints. The document “The Volume of Crime Scene Investigation – Burglary” had portrayed how hand impression were used as evidence in criminal trials over the years⁴. Later, in India, one of the most ground breaking contributions to fingerprint analysis in India came in 1897, when **Sir Edward Henry**, Inspector General of Police in Bengal came up with the introduction of the **Henry Classification System**⁵ for fingerprints. This technique made it possible to systematically record and categorize fingerprints for criminal identification under the direction of Sir Edward Henry. Sir Henry established the practice of keeping separate criminal records for each accused person using ten finger impressions in 1897. It was not only adopted across India but also became the global standard, revolutionizing forensic investigation worldwide.

Over the years in the evolution of fingerprint analysis system, the utilization of fingerprints in the system of criminal justice system was spread rapidly across India. The **first fingerprint bureau in India** was established in **Calcutta in the year 1897**. This bureau was instrumental in applying the Henry Classification System to catalog fingerprints of criminals, which laid the foundation for India’s fingerprint identification system⁶. The Henry categorization system was primarily developed by Indian fingerprint scientists Hem Chandra Bose and Azizul Haque. In 1877, Sir William Herschel carried on collecting convicts' fingerprints on contracts and transactions in India. The value of fingerprinting as a forensic technique was further highlighted in criminal investigations, especially in robbery, murder, and burglary cases. As the field of fingerprint analysis expanded, the need for specialized forensic laboratories became more apparent.

The first major forensic laboratory in India⁷ was established in **Madras** in 1949, focusing primarily on the examination of physical evidence in criminal investigations. This analysis of system had introduced the establishment of **State Forensic Science Laboratories** in various states in and across India. These labs started to focus on a variety of forensic scientific fields,

³ W. J. Herschel, *The Origin of Finger-Printing* (Oxford Univ. Press 1916).

⁴ Simon A. Cole, *Suspect Identities: A History of Fingerprinting and Criminal Identification* (Harvard Univ. Press 2001).

⁵ Edward R. Henry, *Classification and Uses of Fingerprints* (7th ed. H.M. Stationery Off. 1934).

⁶ G.T.C. Lambourne, A Brief History of Fingerprints, 17 J. Forensic Sci. Soc’y 95 (1977).

⁷ R.K. Tewari & K.V. Ravikumar, History and Development of Forensic Science in India, 46 J. Postgraduate Med. 303 (2000).

such as document analysis, toxicology, ballistic examination, and fingerprint analysis. Then in the year 1957, the Indian government established the **Central Forensic Science Laboratory (CFSL)** in New Delhi, which played a pivotal role in coordinating forensic investigations at the national level. The CFSL began focusing on advanced forensic techniques, including the detailed analysis of fingerprints, which became integral to solving criminal cases. Eventually, this lab grew, opening regional offices in Chandigarh, Hyderabad, and Kolkata, each of which contributed to different aspects of forensic investigations.

Over the decades, technological advancements further transformed the field of fingerprint analysis in India. The development of **Automated Fingerprint Identification Systems (AFIS)** in the late 20th and early 21st centuries⁸ revolutionized the process of fingerprint matching and identification. AFIS systems enabled faster and more accurate identification, transforming forensic investigations by automating the comparison of fingerprints in criminal databases.

Today, fingerprint analysis remains one of the most reliable and widely used methods for identifying individuals in criminal investigations in India⁹. The forensic labs in India continue to adopt cutting-edge technologies, ensuring the accuracy and efficiency of fingerprint analysis. With the integration of digital fingerprinting systems, fingerprint evidence has become an essential part of law enforcement, supporting both criminal investigations and legal proceedings across the country. Thus, the historical development of fingerprint analysis and forensic laboratories in India showcases the country's pivotal role in advancing this crucial forensic technique, from the early efforts of Sir Edward Henry to the sophisticated technologies used in modern criminal investigations.

CHAPTER: 03

PRINCIPLES OF FINGERPRINT ANALYSIS:

Fingerprints are a vital identification tool because each person's fingerprints are distinct and don't change over time. This phenomenon is rooted in the principle of **persistence** or **permanence**¹⁰, where newly formed skin cells adhere to the pre-existing friction ridge and

⁸ John Berry & David A. Stoney, History and Development of Fingerprinting, in *Advances in Fingerprint Technology* (Henry C. Lee & R.E. Gaensslen eds., 2d ed. 2001).

⁹ G.T.C. Lambourne, A Brief History of Fingerprints, 17 J. Forensic Sci. Soc'y 95 (1977).

¹⁰ Henry Faulds, The Permanence of Finger-Print Patterns, 98 *Nature* 388 (1917).

furrow pattern. These patterns of ridges, formed during fetal development, are categorized into three main types: **loops**, **whorls**, and **arches**. Remarkably, no person has ever been found to have identical fingerprints across multiple fingers, and even identical twins with the same DNA possess entirely different fingerprints. This highlights the unmatched uniqueness of fingerprints as a biometric identifier. Fingerprint analysis also includes comparison of an unknown fingerprint, often collected from a crime scene, with that stored in a database or directly with those of a suspect. In order to find particular points that correspond between an unknown print and a recognized one, experts concentrate on examining minutiae, or the ridge characteristics within the fingerprint.

Fingerprints are further classified based on their visibility and the medium in which they are found. **Latent prints** cannot be seen without enhancing methods like chemical treatments or powdering. **Patent prints** are typically left when fingers are coated with substances like blood, ink, or dirt that are visible to the naked eye. **Plastic prints** are three-dimensional impressions left on soft surfaces such as clay or wax. These classifications and methodologies make fingerprint analysis a robust and reliable tool for criminal identification.

CHAPTER: 04

CLASSIFICATION OF FINGERPRINTS AND TYPES OF PATTERNS:

The original fingerprint classification system, known as the Ten-Digit classification system, was created by Henry. It considered all of the fingers and transformed the ridge patterns on them into letters and numbers that could be readily arranged in a fraction. This classification was introduced to maintain the record of each and every criminal with their fingerprints. Years later, the fingerprint analysts classify there are three types of fingerprints that can be found:

1. Latent Fingerprint

2. Patent Fingerprint 3. Plastic Fingerprint

- **Latent fingerprints:** They are invisible to the naked eye and are composed of sweat and oil secreted on the skin's surface. To visualize these prints, forensic experts employ techniques such as applying powders or using chemical reagents.
- Conversely, **patent fingerprints**, when fingers come into touch with materials like

blood, oil, ink, or dirt, they leave behind visible prints known as patent fingerprints. No further processing is necessary to effectively view these prints.

- Three-dimensional impressions left on pliable or soft surfaces, including tar, soap, wax, or fresh paint, are known as **plastic fingerprints**. They can be seen with the unaided eye and don't need to be processed further for analysis, just as patent fingerprints.

Everyone's fingerprints are unique ridge patterns that are categorized into four primary types. These patterns are further subdivided based on specific characteristics.

1. **Arch:** The simplest and least common pattern, arches consist of ridges that enter from one side of the fingerprint and exit on the opposite side without forming recurves. Arches account for approximately 5% of fingerprints worldwide and are classified into plain arch and Tented arch.
2. **Loop:** This is the most prevalent fingerprint pattern, characterized by a ridges entering from one side of the fingerprint and bending around a core to form a loop pattern and then exiting back on the same side of the area. Loops are further classified into radial loop (The ridges flow toward the thumb) and Ulnar loop (The ridges flow toward the little finger).
3. **Whorl:** Whorl patterns in fingerprints are defined by two or more ridges forming circular or spiral configurations. They are categorized into **plain whorl**, **central pocket whorl**, **double loop whorl**, and **accidental whorl**. Each of these types is further classified into subtypes based on unique ridge structures and characteristics.
4. **Composite:** The composite pattern comprised of two or more different patterns, as separate and a combination of both patterns. It is further sub classified as Central Pocket Loop, Twinned Loop, Lateral Pocket Loop and Accidental Loop.

It is important to note that the variability in fingerprint patterns between individuals is influenced by genetics, environmental factors, and personal habits. Consequently, fingerprints serve as a highly reliable method for personal identification, playing a crucial role in forensic investigations.

CHAPTER:05

FINGERPRINT COLLECTION AND ANALYSIS TECHNIQUES:

Obtaining fingerprints from a crime scene and using the methods for analysis that follow are essential elements of forensic investigations. Before any evidence is collected, it is essential to secure the crime scene to prevent contamination or tampering with potential evidence. Latent fingerprints are meticulously examined at the crime scene and can be enhanced using a variety of methods, including powdering, magnetic powdering for sensitive surfaces, and the application of chemicals like ninhydrin to surfaces, which react with the fingerprint residues to reveal them.

For documentation purposes, a fingerprint is photographed as soon as it is visible. High-resolution photographs are taken from different angles to capture the details of the print before it is lifted or altered. After the fingerprint is developed, it needs to be carefully lifted from the surface using lift tape or gel tape. Lastly, Documentation is crucial for maintaining the chain of custody and ensuring that the fingerprint evidence is admissible in court. Fingerprint Analysis Techniques includes, Comparison of known samples, once when fingerprints are collected, they need to be compared with known fingerprints from suspects or databases. A variety of methods, including automated fingerprint identification systems (AFIS) and manual comparison, are used to accomplish this comparison. The ACE-V method, which stands for Analysis, Comparison, Evaluation, and Verification, is the main technique used by fingerprint experts. It describes the crucial processes in the fingerprint analysis procedure. Enhanced Modern Imaging Techniques¹¹ have emerged such as **three-dimensional scanning** and **digital enhancement**, allow forensic experts to enhance and analyse prints with extreme precision.

CHAPTER:06

ROLE OF FINGERPRINT ANALYSIS IN CRIME SCENE INVESTIGATION:

Criminal investigations rely heavily on fingerprint analysis, especially when suspects leave their prints at crime scenes. It plays a pivotal role in the criminal justice system, linking suspects to victims and crime scenes while exonerating innocent individuals. Fingerprints can be used as vital evidence in criminal investigations with the aid of technology and skilled

¹¹ Edward Rich, *Fingerprint Techniques* (1997).

fingerprint specialists. Investigators frequently obtain fingerprints from a variety of surfaces in cases involving homicide, burglary, and other felonies.

These prints can lead to suspect identification through database matches. Fingerprint analysis also aids in connecting multiple crimes by identifying the same individual across different scenes, enabling law enforcement to track serial offenders and uncover crime patterns. In many jurisdictions, latent prints recovered from cold cases are periodically re-analysed with new fingerprint databases or advanced technology, sometimes solving decades-old crimes. By looking at the angle and location of fingerprints on things, investigators can determine how and when those objects were touched. This can shed light on questionable behaviour and help establish the sequence of events leading up to a criminal act. Fingerprinting also serves as a warning sign for possible criminals. The fact that they can be identified by their fingerprints serves as a potent deterrent for those who might otherwise consider committing crimes. This preventive measure promotes safety and security for all citizens by helping to maintain law and order in society. Fingerprinting helps convict the guilty and identify innocent persons. Significant irregularities and discrepancies in fingerprints can be found by closely scrutinizing them, potentially clearing those who have been wrongfully accused. Advances in fingerprint analysis technology have led to several incidents of people being acquitted of erroneous convictions; this emphasises the vital role fingerprinting plays in assuring that justice is done.

CHAPTER: 07

FINGERPRINT ANALYSIS AS A CRUCIAL TOOL FOR PRISONERS IDENTIFICATION:

The Identification of Prisoners Act of 1920 and the Indian Evidence Act of 1872 regulate the use of fingerprints as evidence in criminal investigations in India.

- The Identification of Prisoners Act, 1920¹² lays down the procedure for collecting and preserving fingerprints of individuals who are arrested or imprisoned. India uses a number of systems to identify prisoners, including the National Automated Fingerprint Identification System (NAFIS) and Aadhaar verification.

¹² Identification of Prisoners Act, No. 33 of 1920 (India).

- In addition to that, section 53 of Criminal Procedure code, 1973, shall state that it is the duty of the police official/ prison official to collect the data which include Finger-impressions, Palm-Print impressions, Footprint impressions, Photographs samples and their analysis of the accused person or the prisoners.
- Indian law enforcement agencies can access and share biometric fingerprint data through the **National Automated Fingerprint Identification System** (NAFIS) managed by the National Crime Records Bureau (NCRB).
- The NCRB's Central Finger Print Bureau is a nationwide database of all fingerprints in the nation. It contains over a million ten-digit fingerprints of criminals who have been arrested and convicted, and it offers search capabilities on the Fingerprint Analysis and Criminal Tracing System (FACTS). It contains fingerprint information from every state and union territory. These documents may be kept for a maximum of 75 years.
- **Legal amendments like Identification of Prisoners Act, 1920**, for empowering investigating officers across the country to take advance biometrics from Arrested/Convicted persons.¹³ The Bureau has also started student internship programs for mutual benefit. It looks forward to fostering of partnership with universities, researchers, NGOs and public.
- On the direction of Hon'ble Supreme Court of India, a portal was created at national level for showing the details of Proclaimed Offenders to assist in inter-state cooperation, efficient Law Enforcement and in seeking Citizen help. The portal provides a photo of the proclaimed offenders along with their name, date of court order, State, District, PS, age, gender, and relative facts.
- Law enforcement agencies can use NAFIS to search for a person of interest and connect their name to any active warrants. A process that compares an inmate's biometric data, such as fingerprints, with the data stored in the Aadhaar database.
- Every criminal or convicted prisoner will have a unique 10-digit National Fingerprint Number (NFN) that they can use to register in the NAFIS system. Even across various law

¹³ Saumitra Basu, Forensic Science and Scientific Measures for Criminal Identification in British India, 54 **Indian J. Hist. Sci.** 177 (2019),

enforcement organizations and countries, fingerprints are traceable and organized to this number, which stays constant throughout the person's life and acts as a reference point.

CHAPTER: 08

LEGAL AND ETHICAL CONSIDERATIONS IN FINGERPRINT ANALYSIS:

The Indian Penal Code (IPC) of 1860, being a comprehensive criminal code, does not directly address forensic evidence like fingerprint analysis since these techniques were not prevalent at the time. Nonetheless, a number of laws, protocols, and court rulings that supplement the Indian Penal Code (IPC) regulate the legal environment for fingerprint analysis in India.

Indian Evidence Act, 1872: The act governs the admissibility of evidence, including fingerprint evidence. Under the act, section 45 gives the admissibility in opinions of experts, including fingerprint experts, can be used in courts. If a fingerprint expert has been qualified as an expert and their testimony is considered pertinent, then their testimony is admissible.

Identification of Prisoners Act, 1920¹⁴: This Act provides the legal framework for the taking of fingerprints in India. It allows law enforcement authorities to take the fingerprints of individuals:

Section 3: Authorizes fingerprints to be taken from convicts awaiting trial, those convicted of specific offenses, and those apprehended for them. A magistrate may order someone to provide their fingerprints for examination under **Section 4**.

- **Code of Criminal Procedure, 1973¹⁵:** Section 293 of the act explains that the report submitted by the Director of Forensics Bureau can be taken and accepted as evidence. This section allows to save time and avoid needless examination.
- **Bharatiya Sakshya Adhiniyam, 2023:** Section 39 of the Act gives admissibility in opinions of experts, including fingerprint experts, can be used in courts.
- **Bharatiya Nagarik Suraksha Sanhita, 2023:** Section 329 of the act replaces Section 293 of Crpc explains that the report submitted by the Director of Forensics Bureau can

¹⁴ Identification of Prisoners Act, No. 33 of 1920 (India).

¹⁵ Code of Criminal Procedure, No. 2 of 1974 (India).

be taken and accepted as evidence. This section allows to save time and avoid needless examination. Section 349 of this act specifies on order of the First-Class Magistrate the investigating Officer can take fingerprints of a person who is arrested for investigation.

Looking on the ethical consideration and consequences of Admissibility of Fingerprint Evidence in Courts, though the IPC does not directly deal with fingerprints, crimes such as murder, theft, forgery, and others defined under the IPC can be solved using fingerprint analysis. As per Section 45 of the Evidence Act, the opinion of fingerprint experts is crucial, and their analysis must be presented through expert testimony. Under Section 73 of the Evidence Act, expert opinions on the comparison of handwriting or fingerprints play a crucial role in aiding the Court. Whenever the Court needs to compare fingerprints or handwriting, it is essential to seek the assistance of experts, as handling such evidence without expert input could be risky. But, one of the major ethical issue raised is that the analysis of getting fingerprints from the accused is against the policy of Self-incrimination under Article 20(3) of Indian Constitution. It is well-established, however, that when an individual is asked to provide a fingerprint impression, it is not considered a personal testimony, and therefore does not fall under the protection against self-incrimination. For the purpose of this, Identification of Prisoners Act, 1920 makes it clear that the reason for passing a law of the kind is to prevent refusals made by prisoners in giving their fingerprints.

CHAPTER: 09

CHALLENGES IN FINGERPRINT ANALYSIS:

Though fingerprinting is still an essential technique for managing the criminal justice system, there are certain difficulties with it. Fingerprint analysis is a subjective field and the interpretation of ridge patterns and the comparison of fingerprints can be open to personal bias. The spread of biometric technology and worries about data security and privacy make it necessary to carefully analyse and control the use of fingerprint databases. The major challenges of the analysis is found to be the preservation of fingerprint evidence. Improper handling or inadequate preservation by investigating agencies can compromise the integrity of fingerprint data. There is a lack of standardization in the training and certification of fingerprint examiners, leading to inconsistent results and interpretations. The quality of latent fingerprints can vary significantly, making their development and analysis difficult. Low-quality prints can lead to incorrect identifications or failure to make any identification at all. The AFIS systems

used for fingerprint comparison are based on mathematical algorithms, and can result in false matches or false negatives. Fingerprint evidence, therefore, cannot be entirely relied upon, as there is a risk of fingerprint imitation¹⁶, where a person—whether a police official or another individual—could deliberately create false prints to falsely incriminate an innocent person.

In civil cases, fingerprint fraud is also possible. For example, when a pension recipient is required to provide a fingerprint as evidence of life, a family member may take advantage of this procedure after the person has passed away. The deceased's fingerprints might be fraudulently obtained by the relative, who would then embezzle the pension money.

CHAPTER: 10

CASE STUDIES AND REAL WORLD APPLICATIONS:

1. **In Ammini v. State of Kerala**¹⁷ in the house of the deceased, the fingerprints were discovered on glasses. The expert matched and assessed these fingerprints with those of the accused. However, the Trial Court did not consider this to be a significant piece of evidence because it was unclear and there was uncertainty as to whether the photos were of the original prints. The Trial Court's opinion was chastised by the High Court, and the Supreme Court decided to use the fingerprint evidence to prove the accused's guilt.
2. **Pathumma v. Veerasha case**¹⁸, The Kerala High Court ruled that fingerprints cannot be shared by two people. No two fingers leave the same mark; each fingerprint is unique to the individual. And if there are no differences, we can assume that the same person made them all.
3. **Bhaluka Behra v. State case**¹⁹, highlights that the significance and weight assigned to an expert's opinion is distinct. A fingerprint, in essence, is an unmistakable and forensically unique signature. Because of this, a fingerprint expert's testimony is accorded a lot of weight in court.

¹⁶ G.S. Sodhi & J. Kaur, The Forgotten Indian Pioneers of Fingerprint Science: Fallout of Colonialism, 53 Indian J. Hist. Sci. T184 (2018).

¹⁷ Ammini v. State of Kerala, (1998) 2 S.C.C. 301 (India).

¹⁸ Pathumma v. Veerasha, 1988 K.L.T. 798 (Ker.) (India).

¹⁹ Bhaluka Behra v. State, A.I.R. 1957 Ori. 172, 1957 Cri. L.J. 902 (India).

4. **H.P. Administration v. Om Prakash**, it has been held that the report of the Director, Fingerprint Bureau is treated as evidence without examining him because the comparison and identification of fingerprints have developed by now into a science and the results derived therefrom have reached a stage of exactitude. It has further commented that as long as the report shows that the opinion was based on observation, which led to a conclusion, that opinion can be accepted.
5. **In Balakrishna Das Agarwal v. Radha Devi**²⁰, the court stated that the forensic scientist is fundamentally a witness for the court, not for the prosecution or defence, and that an expert is a person who provides an opinion based on experience, expertise, and training.
6. **In James v. State of Kerala**²¹, some finger impressions and foot impressions were obtained from scene of crime and the pictures of the same were taken up. However, these images were hazy and rather unclean. However, the Kerala High Court stated that the court has the authority to determine whether or not fingerprints constitute a trustworthy form of evidence, even if they are unclean and blurry.
7. **In Chauthl v. State**, it was held that, "In a case of forgery in which the accused denied having put his thumb impressions, the accused was convicted on the evidence of expert who, after comparing the complainant's and the accused's finger prints, concluded that the thumb imprint belonged to the accused."
8. **In Prakash vs. State of Karnataka**, the High Court has taken the view that it is not incumbent upon a police officer to take the assistance of a Magistrate to obtain the fingerprints of an accused. The court further clarified that the provisions of the Identification of Prisoners Act are not obligatory in this regard.

Real-world application of fingerprinting analysis serves to underscore the impact of fingerprint databases in solving crimes. Through compelling case studies, this analysis illuminates the instances where fingerprint databases have played a pivotal role in identifying perpetrators, connecting criminal activities, and expediting investigations, thereby showcasing their

²⁰ Balakrishna Das Agarwal v. Radha Devi, A.I.R. 1989 All 133 (India).

²¹ James v. State of Kerala, 1994 K.L.J. 871 (Ker.) (India).

practical effectiveness. It explores collaborative efforts on how the integration of these techniques has led to more robust and conclusive evidence in criminal investigations.

CHAPTER: 11

TECHNOLOGICAL ADVANCES IN FINGERPRINT ANALYSIS:

Technological advancements in fingerprint analysis²² have revolutionized crime scene investigations, enhancing accuracy, efficiency, and speed. One major development is the **Automated Fingerprint Identification System (AFIS)**, which employs algorithms to rapidly scan and compare fingerprints across extensive databases, reducing human error. Improvements in latent print detection, such as fluorescent powders, advanced fuming techniques, and laser-based tools, have enhanced the visibility and clarity of prints on challenging surfaces. Even from uneven surfaces, digital scanning and imaging—including high-resolution and 3D imaging—ensure accurate fingerprint detail capture.

Artificial intelligence (AI) and machine learning further refine fingerprint matching, enabling the identification of degraded or partial prints with greater accuracy. Portable fingerprint scanners now allow real-time, on-site analysis, connecting directly to centralized databases for instant identification. Additionally, innovations like **mass spectrometry imaging (MSI)** enable the chemical analysis of latent prints, providing insights into substances handled by a suspect. Cloud-based systems facilitate secure, global sharing of fingerprint data, enabling cross-border cooperation in investigations. Cutting-edge forensic software helps with both active investigations and cold case evaluations by improving ridge pattern analysis and reconstructing damaged prints. These technological strides not only streamline investigations but also minimize errors, ensuring that fingerprint analysis remains a critical and reliable tool in modern forensic science.

CHAPTER: 12

CONCLUSION:

In conclusion, fingerprints are an essential instrument in the investigation of criminal cases. It has been said that the fingerprint evidence is a trustworthy piece of evidence. The objective of

²² A.R. Ikuesan & H.S. Venter, Digital Behavioral-Fingerprint for User Attribution in Digital Forensics: Are We There Yet?, 30 Digit. Investig. 73 (2019).

the Criminal Justice System in India is not only to punish wrongdoers or perpetrators of crime but also to prevent future criminal activity. This goal can be achieved not only through the efforts of investigating officers, police, courts, and lawyers, but also by assigning evidentiary value to various techniques. These scientific methods, such as fingerprint analysis, play a crucial role in solving and preventing crime. Ensuring that ethical considerations, privacy rights, and the potential for errors are addressed is vital to maintaining public trust in forensic processes. Future developments in artificial intelligence, machine learning, and image technology advancements should significantly improve fingerprint analysis. The advancements in forensic science, particularly in fingerprint analysis, have significantly enhanced the precision and reliability of crime investigations. From manual identification to automated systems like AFIS (Automated Fingerprint Identification System), fingerprint technology has advanced, speeding up the process of matching prints and increasing the precision of criminal profiling for the identification of inmates and other accused people. These advancements not only aid in solving cases more efficiently but also strengthen the evidentiary value of fingerprint analysis in legal proceedings. Thus, the continuous development of both forensic science and legal standards is essential to uphold the integrity and effectiveness of fingerprint analysis in crime solving.

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