

The Function of Fingerprints in the Investigation Process to Identify Criminal Offenders

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ABSTRACT

This study examines the role of dactyloscopy (fingerprinting) in criminal investigations, focusing on technical, procedural, and legal aspects to assess how fingerprints are integrated into the investigation process, the limitations of the method, and policy recommendations that strengthen the validity and admissibility of evidence. The method used is descriptive qualitative based on normative legal studies with in-depth literature review; data are analyzed through reduction, thematic categorization, and normative interpretation. The findings show that fingerprints serve as a primary identification tool, an elimination tool, and corroborative evidence that strengthens the reconstruction of events when integrated with other evidence; their effectiveness is highly dependent on the quality of the traces, the collection procedures at the crime scene, independent verification, and chain of custody documentation. The role of technology such as AFIS speeds up searches but should be treated as an aid that requires human verification, logging, and algorithm validation. Key challenges include degraded traces, contamination, procedural errors, analyst cognitive bias, algorithm limitations, resource constraints, and legal and ethical aspects related to the admissibility of evidence. Recommendations include standardizing crime scene SOPs, laboratory accreditation (e.g., ISO/IEC 17025), implementing blind verification, recording AFIS parameters, and providing legal education for practitioners and courts to improve transparency and legal certainty.

1. Introduction

Crime as a social phenomenon always demands a law enforcement response that is not only swift but also scientifically and legally accountable (Fahmi et al., 2025). Criminal investigation is a key stage that involves gathering facts, developing hypotheses, and presenting evidence that can be tested in court (Kurniawatie, 2025). One of the most frequently used forensic instruments in this process is fingerprint identification or dactyloscopy. Because human fingerprints have characteristics that are relatively unique and stable throughout life, this method allows investigators to match traces found at the scene of the crime with records stored in databases or samples taken from suspects (Levanon & Tully, 2025; Martins et al., 2024). Understanding the role of dactyloscopy in each stage of the investigation is important to improve the accuracy of identification and ensure legal certainty for both victims and suspects.

Historically and scientifically, dactyloscopy has evolved from a manual approach to the integration of modern technology such as the Automated Fingerprint Identification System (AFIS) (Bhuvaneshwari et al., 2023; Gibb & Riemen, 2023). In the early stages, fingerprint classification and matching were carried out through visual observation of basic patterns such as ridges, loops, and

minutiae; over time, these procedures were standardized and adopted by police institutions in various countries (G. Ferreira et al., 2021; Rivaldería et al., 2024; Wieditz et al., 2022). Technological developments have enabled much larger database processing and faster candidate searches, but at the same time require the implementation of human verification protocols to avoid automated errors (Patel & Abrol, 2024). The theoretical discourse on the uniqueness and permanence of fingerprints reinforces the legitimacy of this method, but developments in practice also indicate the need for clear technical and legal regulations so that dactyloscopic results can be relied upon in court (G. Ferreira et al., 2021; Sulyanwar, R., Badaru, B., & Fadil, 2020).

The operational application of fingerprint identification in the investigation process involves a series of structured technical steps: securing and documenting the crime scene, revealing and lifting traces (whether patent, latent, or plastic), forensic photography, and evaluating the quality of traces before matching (Martins et al., 2024; Shams et al., 2023). After the traces are processed, search systems such as AFIS provide a list of candidates based on similarity scores, which are then further analyzed by trained analysts (Gibb & Riemen, 2023). The analysis process generally follows the ACE-V (Analysis, Comparison, Evaluation, Verification) principle or equivalent verification procedures that prioritize peer review to ensure that the final decision is not merely the result of an algorithm, but also a human examination free from bias (Nawrocka-Świętkowiak et al., 2025; Pena et al., 2024). Therefore, documentation and chain of custody also play a crucial role in ensuring that evidence remains valid and admissible in court.

Nevertheless, the use of fingerprints in investigations is not without significant limitations and challenges that require serious attention. Environmental factors such as surface conditions, humidity, and exposure to physical or biological elements can damage or obscure traces, so that the traces found are often partial or degraded, complicating the matching process (Cader et al., 2023; Maiti et al., 2025). Additionally, the possibility of contamination due to undisciplined crime scene handling and procedural errors during the collection or recording stages can result in misleading candidate matches. From a human perspective, analysts are at risk of confirmation bias and misinterpretation if there is no blind verification mechanism (Alfaro et al., 2025; Pena et al., 2024). Hence, training, laboratory accreditation, and the implementation of QA/QC (quality assurance/quality control) are essential to minimize the risk of misidentification and its legal implications (Growth et al., 2022; Rad et al., 2024).

This study aims to comprehensively examine the role of dactyloscopy in criminal investigations, taking into account technical, procedural, and legal aspects. The study focuses on how fingerprints are integrated into the investigation process, the limitations inherent in this method, and policy and practice recommendations that can improve the validity and admissibility of fingerprint evidence in law enforcement. By placing the analysis within a legal-normative framework and reviewing the latest scientific literature, this study aims to contribute to the practical understanding of policymakers, law enforcement officials, and the forensic community, particularly in the context of implementing procedural standards that guarantee transparency, accountability, and legal justice.

2. Literature Review

The literature review covers the scientific basis of dactyloscopy, which places fingerprints as one of the most established identification methods in forensic science. Biologically, the ridge patterns and minutiae formed on the fingertips are relatively permanent after the neonatal period and exhibit high individual variation, making the principles of uniqueness and permanence the main theoretical basis (Wieditz et al., 2022). The history of fingerprint classification has given rise to several systems, such as the Henry and Vucetich systems, which were originally developed for the manual organization of ten-print collections (Bhuvaneshwari et al., 2023). Technological developments later introduced Automated Fingerprint Identification Systems (AFIS), which combine matching algorithms with large databases to speed up candidate searches, although algorithmic results still require human verification to be accountable (Gibb & Riemen, 2023).

The literature on forensic methods and practices highlights the technical procedures for collecting, revealing, and analyzing fingerprint traces at crime scenes, as well as the verification standards required to ensure the credibility of findings (Martins et al., 2024; Rivaldería et al., 2024). Revelation techniques include the use of powders, chemical reagents, and photographic techniques to handle latent,

patent, and plastic prints; followed by analysis using frameworks such as ACE-V (Analysis, Comparison, Evaluation, Verification), which emphasizes independent verification and detailed documentation of each step (Lohar et al., 2022; Nawrocka-Świętkowiak et al., 2025; Patel & Abrol, 2024). Legal studies emphasize chain of custody requirements, compliance with procedural rules, and the need for accreditation and QA/QC of forensic laboratories to prevent misidentification that could potentially undermine legal certainty. Contemporary literature also discusses limitations as a focus for improvement through training, blind verification, and protocol standardization, such as partial traces (Sun et al., 2023), contamination (Sant'Ovaia et al., 2023), and cognitive bias (Alfaro et al., 2025; Pena et al., 2024).

3. Methods

This research method uses a qualitative descriptive approach with a legal-normative basis to analyze the role of dactyloscopy in criminal investigations (Disemadi, 2022). Data were obtained through an in-depth literature review of relevant forensic literature. Analysis was conducted qualitatively through data reduction, thematic categorization, and normative interpretation. The results were analyzed to draw conclusions and formulate relevant policy recommendations. This study did not involve primary data collection, thus focusing on theoretical and legal synthesis. The recommendations were designed to be adopted by law enforcement agencies in a sustainable and measurable manner.

4. Results

4.1. The Role of Fingerprints in Criminal Investigations

Fingerprints play a primary role as a means of identifying individuals in criminal investigations. When latent prints are found at a crime scene, laboratory processing and matching with stored ten-print records enable rapid identification if there is a match that meets the standards of analysis (Lohar et al., 2022; Patel & Abrol, 2024). This role is not only related to establishing the identity of suspects, but also serves as a starting point for developing investigative hypotheses, such as determining possible involvement, time of presence, or the relationship between the perpetrator and a specific object. The reliability of the identification role depends on the quality of the traces, the collection procedures, and independent verification so that investigative decisions do not rely solely on algorithm results (Shams et al., 2023; Sun et al., 2023).

Besides the identification function, fingerprints play an important role in the process of elimination and focusing the investigation. By comparing the traces found with the database, investigators can immediately exclude irrelevant individuals and narrow down the list of suspects, so that investigative resources can be focused on individuals who are more likely to be involved (Shams et al., 2023). This elimination function is also important for protecting citizens from unfounded accusations; if records show no match, investigators need to explore other evidence (Levanon & Tully, 2025). Hence, proper documentation and chain of custody measures are necessary to ensure that the elimination process is transparent and accountable in court.

Fingerprints also play a corroborative role in strengthening other evidence found during the investigation. When fingerprints are linked to other physical evidence such as blood, fibers, or murder weapons, as well as witness statements or digital evidence, this combination of evidence increases the probability of a more accurate reconstruction of events (Cader et al., 2023). Information on the position and distribution of traces at the crime scene can help reconstruct the chronology of the perpetrator's actions, such as the direction of movement, points of contact, and interactions with objects or victims (Martins et al., 2024; Sun et al., 2023). This corroborative role is only effective, however, if the quality of the traces is carefully assessed and integrated with other evidence without ignoring alternative possibilities.

The role of fingerprints in investigations has significant legal and ethical implications. The use of fingerprints as evidence must meet legal standards regarding collection procedures, permissions, and documentation in order to be admissible in court. Failure to comply with these procedures risks evidence being rejected or legal proceedings being overturned (Levanon & Tully, 2025; Nawrocka-Świętkowiak et al., 2025). Due to the potential for human error and bias in analysis, the implementation of independent verification, laboratory accreditation, and ongoing training are prerequisites for

maintaining the integrity of evidence (Pena et al., 2024). As such, the role of fingerprints goes beyond technical aspects and requires well-developed procedural regulations to ensure certainty and fairness in the judicial process.

4.2. The Role of Technology and Analysis Protocols

The Automated Fingerprint Identification System (AFIS) has revolutionized the speed and scale of fingerprint searches in large databases, enabling the detection of potential candidates in minutes that would manually take days. AFIS works by extracting digital features from latent prints and matching them to ten-print records, then presenting a ranked list of candidates based on similarity scores. However, AFIS is an aid, not a final determinant; scores and candidate lists must be followed up by trained analysts. The system also requires threshold configuration, algorithm validation, and an audit trail mechanism to record each search so that every matching step can be audited later. Without proper logging or documentation of search parameters, AFIS results risk being questioned in court (Gibb & Riemen, 2023).

Formal analysis protocols such as ACE-V (Analysis, Comparison, Evaluation, Verification) serve as the primary framework for ensuring the integrity of human identification decisions after candidates are output from AFIS. In the Analysis phase, analysts assess the quality of latent prints and determine whether they are eligible for comparison (Cader et al., 2023); in Comparison, minutiae and patterns are compared against references (Lohar et al., 2022); Evaluation produces a conclusion (identification, exclusion, or inconclusive) (Nawrocka-Świątkowiak et al., 2025). Verification requires re-examination by a second analyst or through blind review to minimize confirmation bias (Pena et al., 2024). Strict implementation of ACE-V accompanied by detailed documentation of each step, comparison photos, and critical decision notes is essential for decisions to be replicable. In addition, blind verification or double-blind review practices are highly recommended to reduce the influence of case information on the analyst's technical assessment (Lohar et al., 2022; Nawrocka-Świątkowiak et al., 2025).

Given technical limitations and the potential for human error, QA/QC protocols and laboratory standardization are key components in the use of dactyloscopy technology (Growth et al., 2022; Rad et al., 2024). Laboratories that implement accreditation, such as ISO/IEC 17025 and routine proficiency testing programs, will be better able to demonstrate the reliability of their processes, including periodic validation of AFIS algorithms, sensitivity-specificity testing, and error rate documentation that can be presented in court (Bécue et al., 2025; Gibb & Riemen, 2023). The practice of storing raw data, recording processing parameters, and conducting external audits enhances scientific transparency. In addition, the integration of new technologies such as advanced image processing, automatic quality metrics for latent traces, and multimodal biometric combinations must be implemented with independent validation studies before being used as decisive evidence (Martins et al., 2024; Shams et al., 2023; Sospeter et al., 2024). Practical recommendations include establishing clear technology SOPs, complete logging of every action in AFIS, and regular training and evaluation for analysts to maintain operational standards and the legitimacy of results in the eyes of the law.

5. Discussion

Fingerprint identification faces various technical, environmental, and human challenges that can reduce the reliability of evidence. These factors affect the quality of the trace, the analysis process, and legal acceptance, so mitigation is needed through protocols, training, and QA/QC.

1. Trace Quality (partial/degraded): Traces that are only partial or degraded often do not contain enough minutiae for a reliable comparison, leading to inconclusive results or an increased risk of false matches/exclusions (Sun et al., 2023).
2. Environmental Conditions: Exposure to water, heat, corrosion, or biological and chemical activity at the crime scene can erase or damage ridge details, reducing the likelihood of revealing analyzable traces (Sun et al., 2023).
3. Crime Scene Contamination: Indisciplined handling of the crime scene—e.g., numerous people entering the scene or non-sterile evidence collection—can introduce irrelevant fingerprints and confuse interpretation (Sant'Ovaia et al., 2023).

4. Procedural Errors: Technical errors in the collection, removal, photographing, or storage of traces, as well as incomplete chain of custody documentation, can reduce the admissibility of evidence in court (Maiti et al., 2025).
5. Analyst Cognitive Bias: Unnecessary case information or certain expectations can influence an analyst's judgment (confirmation bias); blind verification practices are recommended to reduce this influence (Pena et al., 2024).
6. Limitations of AFIS and Algorithms: AFIS provides candidates based on statistical similarity, but algorithms have limitations (thresholds, false positive/negative rates) and results must be verified by humans; without validation, algorithmic results are vulnerable to questioning (Gibb & Riemen, 2023).
7. Lack of Resources and Technical Capacity: Laboratories that lack trained personnel, have outdated equipment, or are not accredited tend to have lower analysis quality and higher risk of error (Martins et al., 2024).
8. Legal and Ethical Aspects: Unclear legal procedures regarding fingerprinting, consent, or biometric data protection can lead to admissibility issues and violations of the rights of suspects/victims (Levanon & Tully, 2025).
9. Analog vs. Digital Traces & Evidence Integration: Challenges arise when integrating dactyloscopy results with other evidence (DNA, digital forensics), especially if the methodologies or standards of proof differ between disciplines (Bhuvaneshwari et al., 2023).
10. Limitations of Scientific Validation in Specific Cases: For some types of traces or surfaces, stronger validation research on error rates and reliability levels is still needed before they can be used as decisive evidence in court (Growth et al., 2022).

The use of fingerprints in the investigation process has direct implications for legal certainty because forensic evidence is often one of the determining elements in proving a case in court. In order for fingerprints to contribute to legal certainty, every process, from collection, lifting, processing, to storage, must be neatly documented and meet procedural standards so that the chain of custody is not in doubt (Rivaldería et al., 2024). Administrative or technical failures, such as incomplete documentation, manipulation of AFIS data without logging, or non-independent analyst verification, can lead to evidence being rejected or raise doubts that are detrimental to both the prosecution and the defense (Gibb & Riemen, 2023; Wieditz et al., 2022). At the court level, forensic experts must transparently present methods, limitations, and levels of uncertainty (Bhuvaneshwari et al., 2023). Absolute claims without disclosure of error rates or verification procedures increase the risk of wrongful convictions and undermine the legitimacy of the judicial process (Growth et al., 2022). Thus, technical integrity and scientific openness in the presentation of fingerprinting results are prerequisites for ensuring that the use of fingerprints strengthens (rather than weakens) legal certainty.

To maintain the evidentiary function of fingerprints while protecting the rights of suspects and victims, a series of policy measures and practices are needed to strengthen the legitimacy of forensic evidence. *First*, laboratory accreditation and analyst certification, as well as the implementation of periodic proficiency testing, must be operational requirements so that the quality of analysis can be accounted for (Bécue et al., 2025). *Second*, the application of blind verification and complete recording of AFIS parameters can reduce cognitive bias and provide an audit trail that can be examined by the court (Gibb & Riemen, 2023; Pena et al., 2024). *Third*, judges and legal practitioners need to receive basic education on the limitations and interpretation of biometric evidence so that decisions are based on adequate scientific understanding (Sospeter et al., 2024). *Fourth*, policies should require disclosure of methods, validation standards, and error rate estimates when presenting dactyloscopic evidence (Bhuvaneshwari et al., 2023; Martins et al., 2024). These steps not only increase transparency, but also help balance law enforcement interests with the protection of individual rights, so that legal certainty and substantive justice can be better guaranteed.

6. Conclusion

Fingerprints are crucial forensic evidence in criminal investigations, provided that their collection and analysis follow strict technical standards and QA/QC practices. The reliability of the results depends on the quality of the collection at the crime scene, the combination of technologies such as AFIS with human verification, and chain of custody documentation, while the main challenges include the physical

condition of the traces, environmental influences, the risk of contamination, and the potential for human error or bias. To minimize these risks, it is necessary to standardize crime scene SOPs and provide regular training, conduct independent verification such as peer review or blind verification for all important matches, use AFIS only as a recorded tool with an audit trail, accredit laboratories according to international standards such as ISO/IEC 17025 along with regular audits, as well as strengthening legal regulations regarding the collection and use of fingerprints to ensure the rights of suspects and the admissibility of evidence. This study is limited to a review of documents, so empirical studies at police forensic units, evaluations of misidentification cases, and psychological research on analyst decision-making to reduce bias are recommended.

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