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A REVIEW ON FINGERPRINT AS AN IDENTIFICATION TOOL IN THE DISCIPLINE OF FORENSICS

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ABSTRACT

The unique and reliable method for identifying someone in the forensic field from decades has been fingerprints. The science of fingerprint recognition has advanced over the time. Initially finger prints were used to record business transactions and has progressed to its present utilization in biometric security systems and even as authentic evidence in courts proceedings across the globe. Dactylography, another name for the study of fingerprints, or dermatoglyphics has long been acknowledged as a reliable method for identifying people, in forensic investigations especially. Because they are detailed, distinctive, difficult to alter, and durable across a person's lifetime, human fingerprints are suitable as permanent markers of human identification. Authorities like the police can simply utilize fingerprints to locate those who are trying to hide their identity or to locate the deceased or incompetent, such after a natural calamity, for instance.

Keywords: Fingerprinting, Traditional methods, Data base, Print collection

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INTRODUCTION

A novel technique to record, lift, and develop prints under diverse field conditions is frequently developed in the study of dactylography [**1**]. In the most literal sense, the friction ridges of a human finger leave an imprint that is known as a fingerprint [**2**]. The concept that the skin on the thumbs and balls of the fingers is covered in ridges and grooves that differ from person to person and enable thorough identification is the basis of the fingerprint system. It has been used by governments all around the world for more than 100 years to accurately identify offenders [**3**]. No two identical fingerprint patterns have ever been recorded in a crime in the history of the globe. Even identical twins' fingerprints do not match exactly. This statement's foundation is derived from human embryology and genetics, starting with foetal development. Police take impressions of both hands' digits in the case of criminals and store them for further identification [**4**].

HISTORY

Fingerprint applications can be traced back to ancient Babylonian, Greek, Chinese, and Roman cultures. The earliest skin impressions left by friction ridges are thought to be fingerprints. Although, it is unclear whether its discovery in ancient cultures was the result of accidents or had a particular purpose, such as ornament or a symbol. It is believed that during this time, builders unwittingly imprinted their fingerprints on other ancient objects including the brick-making clay, a process known as offline fingerprint acquisition [**5**]. Fingerprints, in Babylon, were found on clay tabs, seals, and earthenware that had been utilized to record deeds in the second millennium BC. In Babylon, under King Hammurabi's era (1792-1750 BC), police officers used to collect the fingerprints of suspects after an arrest [**6**]. These can also be seen in Chinese and Greek ceramics, Egyptian tomb walls, ancient Roman and Babylonian bricks and tiles, as well as in ancient Chinese and Roman architecture [**7**].

Before 851 CE, Arab trader Abu Zayd Hasan and Chinese historian Kia Kung Yen both recorded seeing fingerprints utilized as a form of identification. In reference to the Chinese practice of using fingerprints to identify persons, the renowned Persian physician Rashid-al-Din Hamadani (1247–1318 AD) observed that "Experience has shown that no two people's fingerprints are identical" [**8**]. By 702, Japan permitted its illiterate inhabitants to sign divorce documents with their fingerprints. Despite the fact that ancient people employed fingerprints, it's likely

that they were unaware of their ability to individually identify people.

Gorarrd Bidloo described the papillary ridges and skin of the fingers in his book Anatomy of the Human Body. Marcello Malphigi published the earliest account of the purpose, appearance, and structural features of the friction ridge on the skin in his book in 1687 [9]. German physician JCA Mayer established the distinctiveness of the skin's friction ridge in 1788. Dr. Purkinge named each of the nine categories he created for fingerprint patterns in 1823. Later, the Henry Classification System was made possible by it [**10**]. When fingerprints were considered to recognize criminal defendants in courts, Argentina appeared as the 1st country to rely on fingerprints only as a technique of individualization [**11**]. It is being utilized on a global scale to identify people in cases of disputes and inquiries on judicial grounds.

FINGERPRINT DEVELOPMENT IN INTRAUTERINE LIFE

According to Bonnevie's 1924 a description of foetal life Fingerprints are created during the first four months of pregnancy by the formation of primary and secondary ridges in fingers and palms [**12**].

Dr. Henry Faulds' first publication on fingerprints, which valued the friction ridge skin for individualization, notably its usage as evidence. Additionally, Sir Francis Galton continued to work on it and revealed specifics regarding fingerprint identification and analysis in publications, demonstrating that the likelihood of a false positive results of fingerprint was approximately 1 out of 64 billion [**13**].

Juan Vucetich, a member of Argentina's Central Police Department, was another eminent expert in fingerprints. He started experimenting with criminals' fingerprints and developed his own system of classification. He established the first fingerprint bureau in the history of the globe in 1892 and used subsequent secondary ridge development or the presence of furrows between the papillary ridges. It is commonly acknowledged that there is a connection between the ridge pattern and volar pads on the distal portion of the palm between the digits, and in the thenar and hypothenar areas. After the tenth week of pregnancy, volar pads become less noticeable and eventually disintegrate in human embryos. According to Kucken et al., at the tenth to eleventh week stage. Primary ridges are formed when these projections fold the epidermis into the dermis and quickly become more noticeable. The future fingerprint pattern, which is created at week sixteen, is made up of these basic ridges. On the volar surfaces, epidermal ridges start to develop at this point. Dermal papillae are said to start to form during the 24th week of pregnancy, gradually taking on the characteristics of the distinct dermal ridges.

FINGERPRINT UNIQUENESS IN TWINS

Twin babies' fingerprints are unique because of the variations that can be found in them. Monozygotic twins are identical twins, while dizygotic twins are fraternal twins. Across all populations, there are around 0.4% of identical twins. Twin separation is possible using fingerprints **[14, 15]**.

UNIQUENESS AS PROOF OF IDENTIFICATION

Possibly nothing is more precisely is related with fingerprint identification than the general notion that “no two fingerprints are alike.” Kirk (1963) stated that "all objects in the universe are unique." There could be no identity in the sense used by the criminalist if this were not true. In many other forensic fields, we can find both the assertion that a certain class of items is 'unique' and the argument that the correctness of the approach can be deduced from that putative uniqueness [**8**].

SEX VARIATIONS AND FINGERPRINTS

The sex of a human must be analyzed if identification of that individual is required. This viewpoint makes sex-based differences in fingerprints pattern and finger ridge density important. In forensic investigation, the basis for personal identification is based on the sex variation in fingerprint ridge density, which are very idiosyncratic. According to studies, females fingerprints present a substantially higher density of ridges than males [**16-19**].

FINGERPRINTS FOUND AT CRIME SCENE

From crime scene, the purpose of fingerprint collection is to identify a person (suspect, victim, or witness). The fingerprints can be latent, patent or plastic [**20**]. The latent fingerprint cannot be observed with the naked eye. This print was created by oil and sweat on the surface of skin. Latent prints are more visible when dust, gases, or chemical compounds are present. When dusting a crime scene for prints just minimal amounts of fluorescent powder are needed because fluorescent techniques are so sensitive. As a result, it leaves the area significantly cleaner than when black powder is used [**21, 22**]. Patent fingerprints can be left by blood, oil, ink, or dirt [**23, 24**]

FINGERPRINT DATABASE IN THE WORLD

To manage a database and identify anyone as needed, several countries around the world now keep the fingerprints of persons who travel to, live in, and pass through their borders. In order to protect people's lives from terrorist actions, it is utilized to detect criminals. Currently INTERPOL's database contained more than 220,000 fingerprint records.

FINGERPRINT PATTERNS

The general visual appearance and patterns of fingerprints serve as the basis for their naming. They are known as whorls, loops, and arches. Loops, whorls, and arches are present in about 65%, 30%, and 5% of the population, respectively [**25**]. With a rise in the middle, arches have ridges that come from one side of the fingerprint and exit from the other. Whorls have two deltas (triangles) and resemble a bull's-eye. Loops come in from either the right or left and come out from the same side (Fig. 1).

WHORLS

Between 25 to 35 percent of people have whorls. It can be divided further into central pocket loop whorls, plain whorls, accidental whorls and double loop whorls.

Central Pocket Loop Whorls

The ridges in this pattern form a single, complete circuit. That circuit may be round, spiral, or oval as shown in Fig. 2(a).

Plain Whorls

To construct one full circuit with two deltas, the ridges are rotating. The plain whorls are therefore spiral or circular in form as shown in Fig. 2(b).

Accidental Whorls

It has two patterns and two or more deltas in the accidental whorls as shown in Fig. 2(c).

Double Loop Whorls

This design is made up of two unique loop creations. With one or more ridges, a full circuit is formed as shown in Fig. 2(d) [25].

LOOPS

Between 60-70% population exhibits loop pattern and further break down into radial loop and ulnar loop.

Radial Loop

The radial loop pattern is inclined towards the radial bone, the thick bone on the thumb side as shown in Fig. 3(a).

Ulnar Loop

The ulnar loop pattern is inclined towards the ulnar bone, the smaller bone of the arm and pinky finger as shown in Fig. 3(b). [**25**].

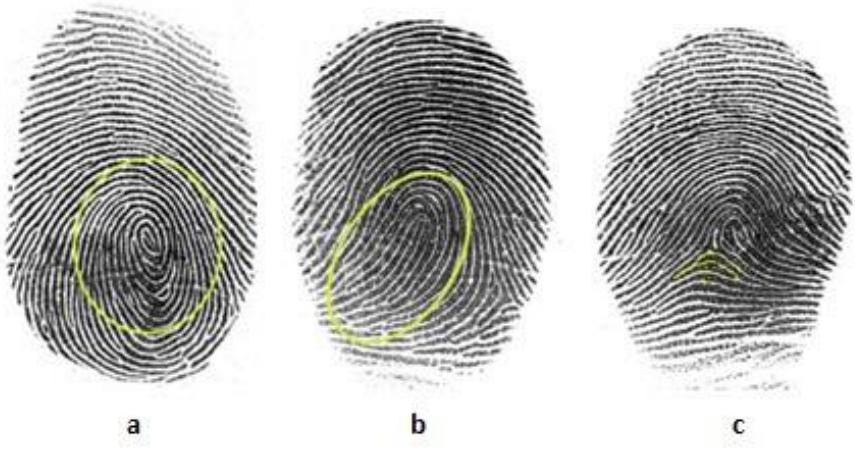

Figure 1: The three patterns of fingerprints, whorls (a), loops (b), and arches (c).

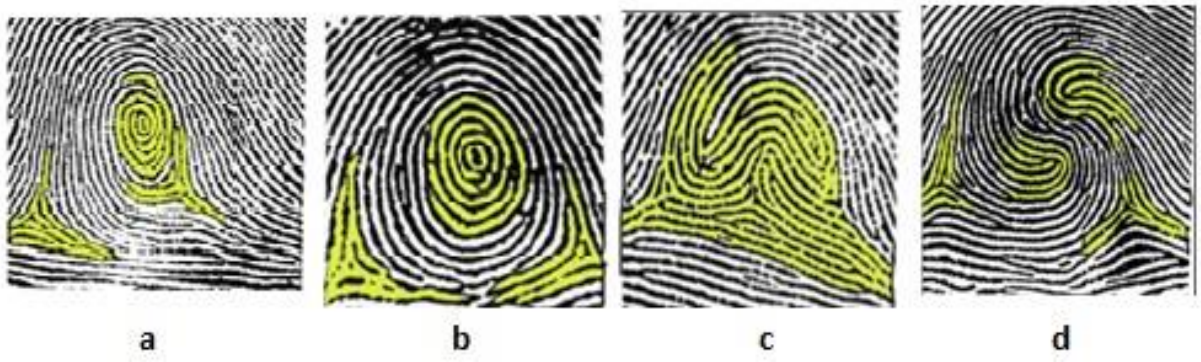

Figure 2: Whorl fingerprint pattern.

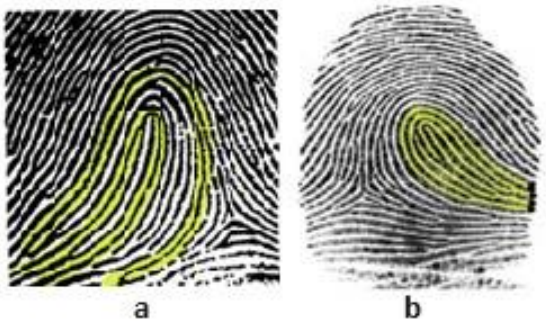

Figure 3: Loop fingerprint pattern.

ARCHES

5% of individuals contributed arches pattern. There are four distinct kinds of arch patterns: plain arches, radial arches, ulnar arches, and tented arches.

Plain Arches

Plain arches' ridges, which start from one side of the impression and slip into the print center as a wave or rise in height, flow continuously from one surface to the other as shown in Fig. 4(a).

Radial Arches

The ridges bend towards the thumb, and the radial arches have one delta, but no ridges recurve.

Ulnar Arches

Except for bending the ridges towards the little finger, the ulnar arches are identical to the radial arches.

Tented Arches

The tented arches feature an angle, a push form that points upward as shown in Fig. 4(b). [**25**]

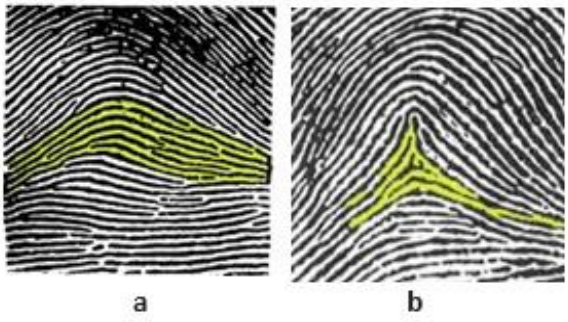

Figure 4: Arches fingerprint pattern.

COLLECTION OF FINGERPRINTS

Ink and paper method

The classic method of obtaining fingerprints has been utilized for many years and involves utilizing ink and paper. An ink impression of the friction ridge patterns on a person's fingertips is made throughout the process, and it is then transferred onto a paper card or fingerprint form. Here is a step-by-step explanation on how to generally take fingerprints using the ink and paper method.

Live scan technology

Compared to the conventional ink and paper method, live scan technology is a more contemporary and sophisticated way to capture fingerprints. It includes digitally storing a person's fingerprints using computerized fingerprint scanners. Several industries, including law enforcement, background checks, civil identity, and application screening procedures, have implemented live scan technology on a large scale. An explanation of how live scan technology for fingerprint collection works is provided below:

Electronic fingerprint scanner

Live scan devices are electronic fingerprint scanners that include a glass or silicon surface that can be used to take high-resolution pictures of a person's fingertip patterns. These scanners can be found in a range of sizes, from smaller portable models to bigger stationary ones.

Imaging in real-time

Live scan technology provides a real-time, digital image of the fingerprints as the subject places their fingers on the scanner. The live scan operator can check the accuracy of the images by viewing the collected fingerprints on a computer monitor.

Biometric analysis

Once the fingerprints are stored in the database, they may be checked against the data to see if there are any possible matches. Automated Fingerprint Identification Systems (AFIS) compare fingerprints and aid in identification using complex algorithms. Computers are increasingly being used to automatically read, categorize, and code fingerprints. It is based on the light that is reflected from a fingerprint and may be detected, transformed to digital data, and then stored for future comparison research.

The Fingerprint Identification System (FIS)'s common framework is formed by the last phases of the Automatic Fingerprint Identification System (AFIS), which compares fingerprints. Three categories of fingerprint matching techniques exist: feature-based matching, minutiae-based matching, and correlation-based matching [**26, 27**].

Employees of AFIS were taught to take high-quality fingerprints initially as a priority in order to maintain a reliable database. The main procedures in this system are the collection of fingerprints, segmentation of fingerprints, enhancement of fingerprint images, feature extraction, minutiae matching, and classification of fingerprints.

Database submission

The quality-checked fingerprint images are then electronically uploaded to the necessary databases. These databases could be repositories for criminal records, systems for screening job applicants,

databases for civil identity, or other law enforcement and governmental repositories [**28, 29**].

CONCLUSION

The distinctive ridges and patterns on a person's fingertips have long been acknowledged as a trustworthy tool for personal identification. In order to produce a biometric template that can be used to distinguish one person from another with an incredibly high level of accuracy, fingerprint recognition systems capture and examine these patterns. The ability to identify fingerprints can be crucial in protecting society from terrorists and criminals while also improving people's quality of life. This technique's use will improve more swiftly and accurately, even with partial fingerprints, as technology progresses and becomes more sophisticated.

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