Fingerprints: Historical Background And Future Trends

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Abstract

The work of police, judges, and juries would be much easier if criminals left signed confessions at the scenes of their crimes. That seldom happens, of course, but criminals often do leave identifying “signatures” in the form of fingerprints. No two people, not even identical twins, have ever been shown to have exactly the same pattern of raised, curved lines on their fingertips. Each individual possesses a unique set of minute raised ridges on volar pads called ‘friction ridge skin’. These clear and apparent unique outlines of the ridges are called fingerprints. A fingerprint is highly individualistic and forms the basis for personal identification in forensic examinations.

INTRODUCTION

Each individual possesses a unique set of minute raised ridges on volar pads called ‘friction ridge skin’. These clear and apparent unique outlines of the ridges are called fingerprints. A fingerprint is highly individualistic and forms the basis for personal identification in forensic examinations[1]. Fingerprints, along with forensic dental and DNA analysis, are also paramount in the identification of unknown deceased individuals and human remains. To this end, recent increases in homicides, mass disaster incidents, and combat casualties from wars in Iraq and Afghanistan highlight the vital role that forensic science plays in human/victim identification. While this responsibility is an emerging challenge for many forensic disciplines, fingerprint analysis has been the foundation of forensic identification efforts for decades[2].

HISTORICAL OVERVIEW OF FINGERPRINTS

The patterned ridges present on the bulbs of the fingers have been a source of intrigue for humankind since prehistoric times. The first practical application of fingerprints as a form of personal identification is credited to Sir William Herschel, a British officer based in India, who used fingerprints and handprints as signatures on native contracts to prevent fraud[3]. At about the same time, Dr. Henry Faulds, a Scottish physician working in Japan, published a letter in the journal Nature (1880) discussing his scientific observations on the identification potential of fingerprints. The pioneering research conducted by Faulds was broad in scope, forecasting the forensic use of fingerprints to catch criminals and describing the contemporary method of recording fingerprints using black printer’s ink. His theory regarding the evidentiary value of fingerprints was confirmed when he solved a minor crime involving the pilfering of purified alcohol from his hospital laboratory. Faulds was able to compare greasy fingerprints found on a piece of glassware with inked impressions he had collected from his staff, identifying one of his medical students as the offender and making what is considered to be the first fingerprint identification in history[4]. The work of Herschel and Faulds was further expanded upon by Sir Francis Galton in his landmark book Finger Prints, published in 1892. The studies performed by Galton detailed the individuality and persistency of friction ridge skin, providing empirical support to the underlying scientific principles of fingerprint identification. One of the most widely accepted and practicable systems of fingerprint classification involved the labors of an Englishman named Sir Edward Henry. By corresponding with Galton, Henry came to recognize the limitations associated with fingerprint classification and determined that, in order for fingerprints to be used as a systematic means of personal identification, a simplified method was required to allow law enforcement the ability to easily file and retrieve numerous fingerprint records. The creation of such a system was accomplished by Henry and two of his subordinates (Haque and Bose) working in India in 1897. Soon afterward, the resulting Henry classification system was adopted by the Indian government, establishing fingerprints as the official means of criminal identification in India. Four years later, in 1901, India’s fingerprinting success led England and Wales to implement

fingerprint as a means of criminal identification and establish a Fingerprint Bureau at New Scotland Yard [5]. The first official use of fingerprints in the United States began when the New York Civil Service Commission in 1902 and the New York State Penitentiary System in 1903 adopted the use of fingerprints for civil and criminal identification purposes, respectively[6]. The systematic utilization of fingerprints for personal identification soon became standard operating procedure and spread throughout the United States, as well as the civilized world, culminating in the establishment of a national repository for fingerprints with the newly created Identification Division of the Federal Bureau of Investigation (FBI) in 1924. While law enforcement initially adopted fingerprints as a means of criminal identification, their use for victim identification also became important. One of the first FBI identification cases occurred in 1925 when the Portland Police Bureau submitted fingerprints of a decapitated corpse, recovered from the Columbia River in Oregon, to the FBI for identification purposes[7]. When compared to fingerprint records in the national repository, the FBI was able to establish the identity of the body, providing a crucial lead in the open criminal investigation. Eventually, the use of fingerprints for human identification evolved into one of the primary tools used today by law enforcement, medico-legal professionals, and disaster mortuary response teams for personal identification. This expanded civil application of fingerprints was initiated by the FBI, which in 1940 recognized the need for the scientific determination of identity in mass fatality incidents. As a result, the FBI Disaster Squad, a worldwide response team that assists with disaster victim identification efforts through fingerprints, was established. This Disaster Victim Identification (DVI) team has responded to more than 225 disasters since its inception in 1940, identifying over half of the recovered remains the team has examined through fingerprint analysis.

PRINCIPLES OF FINGERPRINTS

The term fingerprint is used to describe a reproduction of the friction ridge arrangement present on the tips of the fingers when an impression is deposited on a touched surface. This arrangement of the friction ridge skin is permanent due to the underlying structure of the skin and unique because of complex physiological events, both genetic and environmental, that occur during fetal development. Friction ridge skin is present on the palmar and plantar surfaces of the hands and feet. As such, impressions from the fingers and palms of the hands as well as the toes and soles of the feet can all be used for personal identification purposes. The friction ridge skin found on the hands and feet differs from the relatively smooth skin that covers the rest of the human body. This corrugated skin, consisting of raised ridges and recessed furrows, assists individuals with grasping objects and gaining traction. Friction skin is composed of two main layers, an outer layer called the epidermis and an inner layer called the dermis. The epidermis has five different cell layers, whereas the dermis is one large layer consisting mainly of connective tissue and blood vessels. The epidermal ridges are supported by double rows of papillae pegs on the dermis, which can play an instrumental role in the recovery of fingerprints from deteriorating bodies. Detailed examination of the friction ridge skin also reveals that ridge path, in most instances, is not continuous across the entire surface of a finger. Some ridges, called ending ridges, will flow and abruptly come to an end, while other ridges, called dividing ridges or bifurcations, will flow and separate into two separate and distinct ridges. Additionally, some ridges are as long as they are wide and are called dots. These ridge events are commonly referred to as characteristics or minutiae, and their spatial relationship to one another in a friction ridge impression is the basis for fingerprint comparison and identification. Friction ridge arrangement at the ends of the fingers generally forms pattern types referred to as loops, arches, and whorls. For classification purposes, these basic pattern types can be further divided into eight distinct subgroups based on observed differences within patterns of the same type. Approximately 65% of all fingerprint patterns are loops, 30% are whorls, and 5% are arches. In a loop, the friction ridges enter from one side of the pattern, recurve, and pass out or tend to pass out the same side the ridges entered. An arch has ridges that enter from one side of the pattern, make a wave in the middle, and pass out the opposite side from which they entered. In a whorl, the friction ridges tend to have a circular or spiral ridge flow[2].

COMAPRISON THROUGH FINGER RIDGE DENSITY

No two fingers are found to have identical prints, and it is an overwhelming mathematical probability that no two ever will be found to match. The ridge patterns are formed in the human fetus before birth and remain the same throughout a person's life and even after death until they are lost through decomposition. Moreover, fingerprints are made up of a number of easily recognizable features that permit them to be classified and filed for later reference. The ever increasing pattern of crime has made fingerprinting an indispensable tool in the hands of investigating officers. If

the sex of the individual is established with certainty, the burden of the investigating officer would be reduced by half. In this context, sex based differences in fingerprint patterns and the density of the finger ridges becomes relevant. Recent studies have reported that females have a significantly higher ridge density than males [1].This information facilitates the investigating officer to narrow down the investigating process in a particular case and direct the criminal investigation towards suspects belonging to the most likely sex. The higher ridge density in females has been attributed to the level of ridge thickness and it is opined that females tend to have finer epidermal ridge details. Consequently, the females have significantly higher finger ridge density than males in a given area. In addition to the reason frequently cited, it was proposed that the difference between the finger ridge density in males and females in a given area may be attributed to the fact that on an average body proportions of males are larger than females thus the same numbers of ridges are accommodated among the males in a larger surface area and thus, a lower density is observed among males. Fingerprint ridge count is controlled by polygenic inheritance and strongly inherited [8-9.] Consequently, it may be assumed that given the same genetic makeup, males and females should both have the same number of ridges in a fingerprint. Therefore, difference in ridge density between sexes should be correlated with other parameters such as stature and built of an individual[10].

RECENT ADVANCEMENTS

While the terminology used to describe the fingerprint identification process has varied over the years, the basic methodology employed by forensic examiners has remained relatively unchanged. One aspect that has changed, however, is an increased awareness of the underlying scientific basis for fingerprint identification. This change has resulted in the standardization of the identification process based on the extensive research of former Royal Canadian Mounted Police Staff Sergeant David R. Ashbaugh, which centers around a quantitative-qualitative philosophy to fingerprint examination called ridgeology. Ridgeology is a holistic approach that focuses on the biological uniqueness of friction ridges and involves the sequential examination of the features and spatial relationship of ridges, noting the quality and quantity of the assessed information for identification purpose[5].This examination is conducted using a methodology that incorporates sound scientific protocols and practices, allowing for accurate and repeatable conclusions that meet rigorous scientific standards. The standard methodology used by fingerprint experts to conduct friction ridge examinations is called ACE-V, for analysis, comparison, evaluation, and verification, which are the four fundamental phases utilized in this process[11].

Los Alamos National Laboratory have developed a novel method for detecting fingerprints based on the chemical elements present in fingerprint residue, known as micro-X-ray fluorescence, or MXRF. This technique has the potential to help expand the use of fingerprinting as a forensic investigation tool [12.] In research presented at the 229th national meeting of the American Chemical Society in San Diego, Los Alamos scientist Christopher Worley described the detection of fingerprints based on elemental composition using micro-X-ray fluorescence showed how the salts, such as sodium chloride and potassium chloride excreted in sweat are sometimes present in detectable quantities in human fingerprints. MXRF actually detects the sodium, potassium and chlorine elements present in these salts, as well as many other elements, if they are present. The elements are detected as a function of their location on a surface, making it possible to ‘see' a fingerprint where the salts have been deposited in the patterns of fingerprints - the lines called friction ridges by forensic scientists [13]. A study by the National Institute of Standards and Technology (NIST) showed that computerized systems that match fingerprints using interoperable minutiae templates, i.e., mathematical representations of a fingerprint image can be highly accurate as an alternative to the full fingerprint image. NIST conducted the study, called the Minutiae Interoperability Exchange Test (MINEX), to determine whether fingerprint system vendors could successfully use a recently approved standard for minutiae data rather than images of actual prints as the medium for exchanging data between different fingerprint matching systems. Minutiae templates are a fraction of the size of fingerprint images require less storage memory and can be transmitted electronically faster than images [14].

For many years, law enforcement agencies have used automated fingerprint matching devices. Increasingly, smart cards, which include biometric information such as fingerprints are being used to improve security. The increased use and the desire to limit storage space needed on these cards had encouraged the use of minutiae rather than full images. Performance depended largely on how many fingerprints from an individual were being matched. Systems using two index fingers were accurate more than 98 percent of the time. For single-index finger matching, the systems produced more accurate results with images than with

standard minutia templates. However, systems using images and two fingers had the highest rates of accuracy, 99.8 percent[14]. Technology developed for roadside fingerprints using hand-held devices has also been pioneered in identifying the dead. The University of Leicester, working with Leicestershire Constabulary and the Institute of Legal Medicine, University of Hamburg, recorded the first ever use of the technology on the dead over six months ago. The purpose of developing the technique is to enable rapid identification of the deceased and would be of particular benefit in cases of mass fatalities. The researchers made use of a handheld, mobile wireless unit used in conjunction with a Personal Digital Assistant (PDA) device for the capture of fingerprints from the dead[15]. They also used a handheld single digit fingerprint scanner which utilizes a USB laptop connection for the electronic capture of cadaveric fingerprints. Moreover, according to a new study by researchers from the University of Michigan in Ann Arbor, new ultrasound fingerprint identification system suggested that diagnostic 3D ultrasound of fingers could be used for biometric identification based on matching paired images using internal fingerprint structures that would be difficult to fake, offering the possibility of a unique automated fingerprint identification system. Using a field portable system being developed by Chem Image and Oak Ridge National Laboratory (ORNL), investigators at crime scenes will be able to detect latent prints on human skin. The system takes advantage of surface-enhanced Raman spectroscopy (SERS)-based agents to visualize latent prints. The original intent of the Automated Fingerprint Identification System (AFIS) program was to provide a database of fingerprints to solve crimes. Paramount to the mission is the rapid identification of persons arrested, booked or adjudicated for adult and juvenile offenses. With advances in technology, the future holds great promise for more sophisticated integration of this technique and its applications to other local, state and national criminal justice systems[16].

CONCLUSION

Fingerprint identification is the oldest forensic discipline known to man. Fingerprints have proved over time to be the most rapid, reliable, and cost-effective means by which to identify unknown deceased individuals.

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