CHAPTER 3

Overview of Fingerprint

A print made from an impression of the distinctive pattern of lines and grooves on the skin of human fingertips is known as fingerprints. The line and grooves in fingertips also known as ridge and furrow are unique personal characteristics, and thus no two persons have identical fingerprints.

3.1 History of Fingerprint

The history of a thing indicates about the past and the present, which guides for the benefit of the futures. The history of fingerprints perhaps dates back to thousands of years B.C. There is a record of recovering fingerprint from the Tomb of Egyptian King, Tuken Khamen in the year 1340 B.C. [3]. During the year of 246-210 B.C. the Chinese importer Te-in-she was the first importer who used the fingerprint as a sign of manual in the form of a seal on the documents for the purpose of identification. The seal was being made on clay bearing thumb impression of the king on one side and the name of the owner on the other side [42].

In India during the Mughal period, the fingerprint along with palm print, known as 'Panja' were extensively used for the purpose of identification [4]. The fingerprint system was first officially used in India in 1858 by Sir William Hershel, I.C.S. officer to prevent the impersonation, but credit goes to Sir Francis Galton for having been systematized it for the purpose of identification of criminals.

In the year 1872 Dr. Henry Fauld, who was practicing in Japan came to India as a medical missionary in Darjeeling and observed the uses of fingerprint as a signature for official purposes. Afterward, Dr. Henry Fauld started recognizing the value of fingerprint and he collected the material which was gathered by Dr. Sir W. Herschel.

In 1890 Sir Edward Richard Henry with the help of two assistances Mr. Rai-Bahadur Hemchandra Bose and Mr. Khan Bahadur Azizul Heg had developed this system of fingerprint further by classifying the prints for practical applications in the field of identification of criminals.

In the year 1897 the fingerprint Bureau was established in Calcutta. Similar Fingerprint Bureaus have been established throughout the world. A case was reported in Argentina, where conviction was possible by using the fingerprint system. In India also a burglary case was reported in the year 1902 in Jalpaiguri, where a fingerprint system was used for the identification and later included in the Indian Evidence Act (Vide Sec. 45).

3.2 Different Fingerprint Patterns

The ridge and furrow configurations on the surface of the skin make some pattern. There are six types of fingerprint patterns like an arch, tented arch, left loop, right loop, whorl and accidental (unclassified) as shown in figure 3.1.

The fingerprint patterns can be classified according to the appearance of a singular point. A singular point is either a core or a delta point, which is characterized by its position and type.

Arch: An arch fingerprint has ridges that enter from one side, rise to a small bump, and go out the opposite side from which they entered. Arches do not have loops or deltas.

Tented Arch: A tented arch fingerprint is similar to the (plain) arch, except that at least one ridge exhibits a high curvature and one loop and one delta are present.

Left Loop: A loop fingerprint has one or more ridges that enter from the left side, curve back, and go out the same side they entered are called left loops. The core and delta singularities are present; the delta should be on the opposite side of the ridge entered.

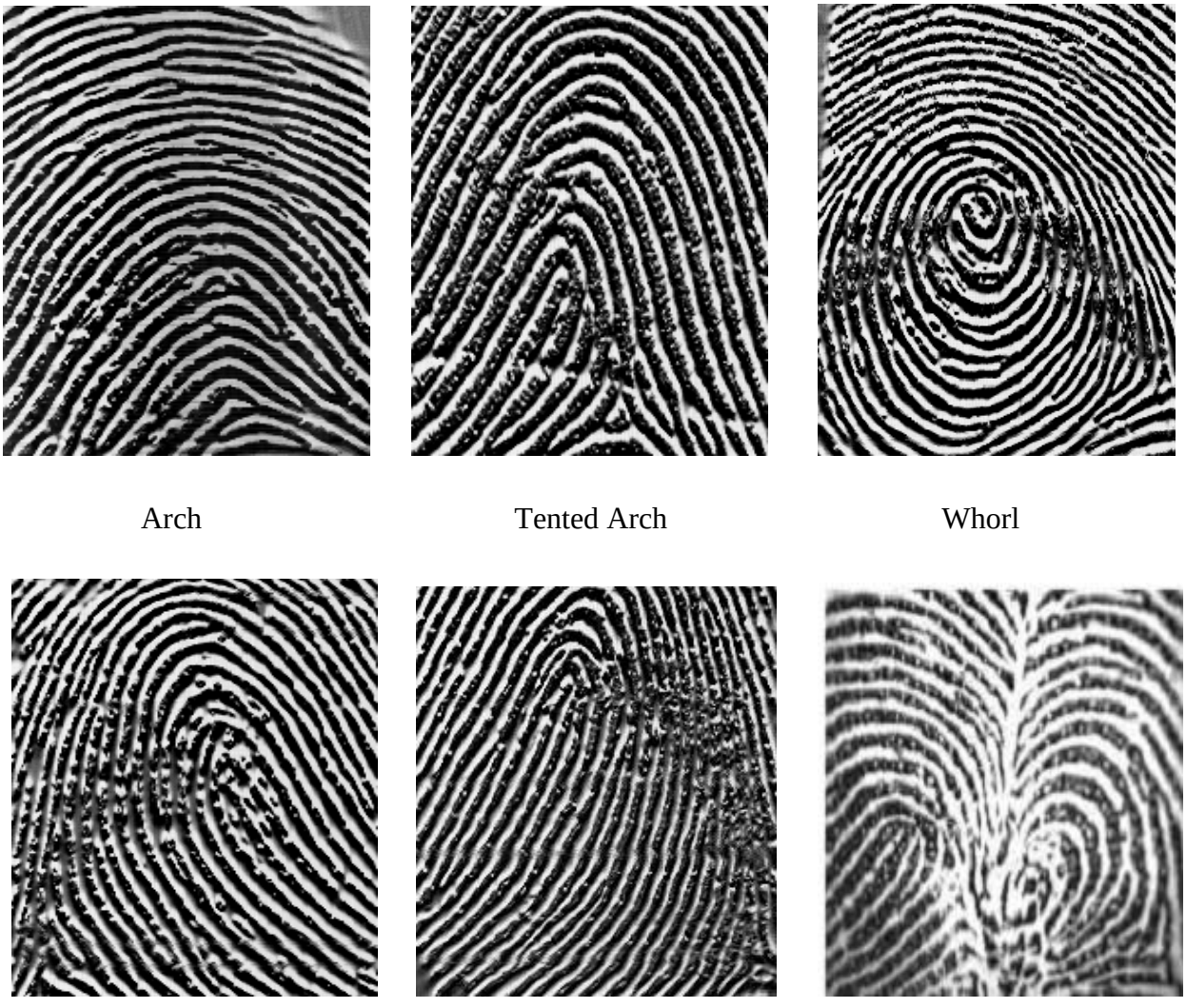


Figure 3.1 Different fingerprint patterns.

Right Loop: A loop fingerprint has one or more ridges that enter from the right side, curve back, and go out the same side they entered are called right loops. The core and delta singularities are present; the delta should be on the opposite side of the ridge entered.

Whorl: A whorl fingerprint contains at least one ridge that makes a complete 360° path around the center of the fingerprint. The two loops (or a whorl) and two deltas can be found in whorl fingerprints. The whorl class is quite complex and in some classification schemes, it is further divided into two categories: twin loop (or double loop) and plain whorl.

Accidental: Those fingerprint patterns which does not belong to the above classes is known as accidental.

3.3 Fingerprint Features

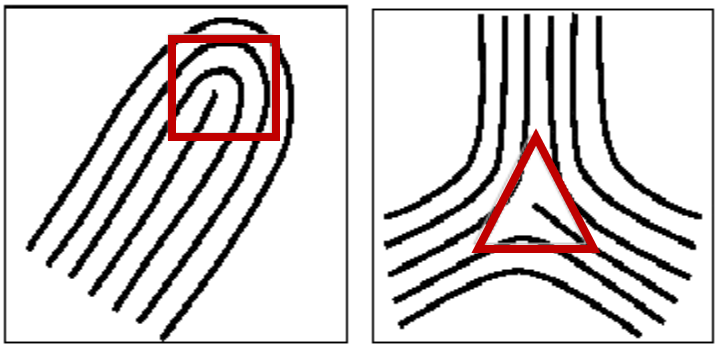
Fingerprint has a different level of features which are used for human identification and classification. These features are generally categorized into three levels:

- *Level 1 features* are macro details of a fingerprint such as ridge flow, singular point and pattern type and these features are used for fingerprint classification at a global level.
- *Level 2 features,* refer to minutiae, which have sufficient information at local level to identify the individuality of fingerprint.
- *Level 3 features* include all dimensional attributes of a ridge at micro level, such as sweat pores, ridge path deviation, width, edge contour, incipient ridges and other permanent details etc.

Level 1 Features

Level 1 fingerprint features are known as core and delta. These features are the most common features in fingerprint. These features are derived from the orientation field and global ridge shape. The orientation field of a fingerprint consists of the ridge orientation tendency on a local neighborhood and forms an abstraction of the local ridge structure. The orientation field is highly structured and can be roughly approximated by a core-delta model. Therefore, singular points and their relationship can be used to derive the fingerprint class. On the other hand, the

local ridge shape also provides important clues about the global pattern configuration of a fingerprint image. The figure 3.2 shows the core and delta shape. A core is defined as a point in the orientation field where the orientation in a small local neighborhood around the point has a semicircular tendency. A delta is defined as the point in the orientation field at which the orientation at a small local neighbourhood around that point presents a hyperbolic tendency.



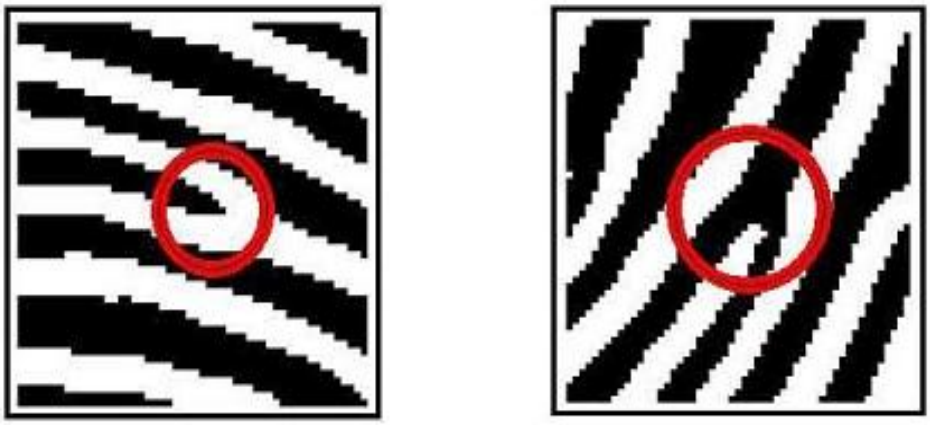
Core Delta

Figure 3.2 Fingerprint Singular point

Level 2 Features

Level 2 fingerprint features are most widely being used in both Automatic and human expert fingerprint recognition systems. These features are known as minutiae. The word minutia means small detail and in the context of the fingerprint it represents the unique points of the ridge lines. Ridge lines could form various combinations. There are more than 150 different minutiae formations [25].

Sir Francis Galton (1822-1922), a British anthropologist and a cousin of Charles Darwin, began his research on fingerprint and in the 1880's, it concludes fingerprints as a means of identification. He wrote a book 'Fingerprints' and published in 1892. It describes about the individuality and permanence of fingerprints. According to his calculations, the odds of two individual fingerprints being the same were 1 in 64 billion. Galton introduces some characteristics that are used for fingerprint identification.



Ridge ending Ridge bifurcation

Figure 3.3 Fingerprint minutiae

These characteristics are called minutiae. Therefore, minutiae are also called "Galton details" [37]. Most of the algorithms are focused only into the bifurcations and terminations because these features are not so dependent from the image quality and it is fast and easy to extract them as shown in figure 3.3. A ridge ending is a feature where a ridge terminates. A ridge bifurcation is a feature where a ridge splits from a single path into two paths at a Y-junction.

The level 2 features are used for individual fingerprint identification due to the advantage of wide accessibility and stability. Minutiae have been (historically) used as key features in the fingerprint recognition task and its template size of minutiae based fingerprint representation is small.

Level 3 Features

Level 3 fingerprint features are pores, dots, incipient ridges, and ridge edge protrusions. In recent years, researchers have focused their attention on level three features [27, 30, 38, 39, 43, 44, 45]. Pores appear as bright blobs on the ridges and the other three features appear between ridges as shown in Figure 3.4. With these extended features, it is not clear if and how much AFIS can benefit when ink and latent fingerprint images are used [36].

To extract these features, a fingerprint image should have higher resolution not less than 1000 ppi. If the resolution of the fingerprint image is low, then it is difficult to extract this feature. The advantage of using level 3 features is that it can use in the partial fingerprint image as it contain sufficient information for identification.

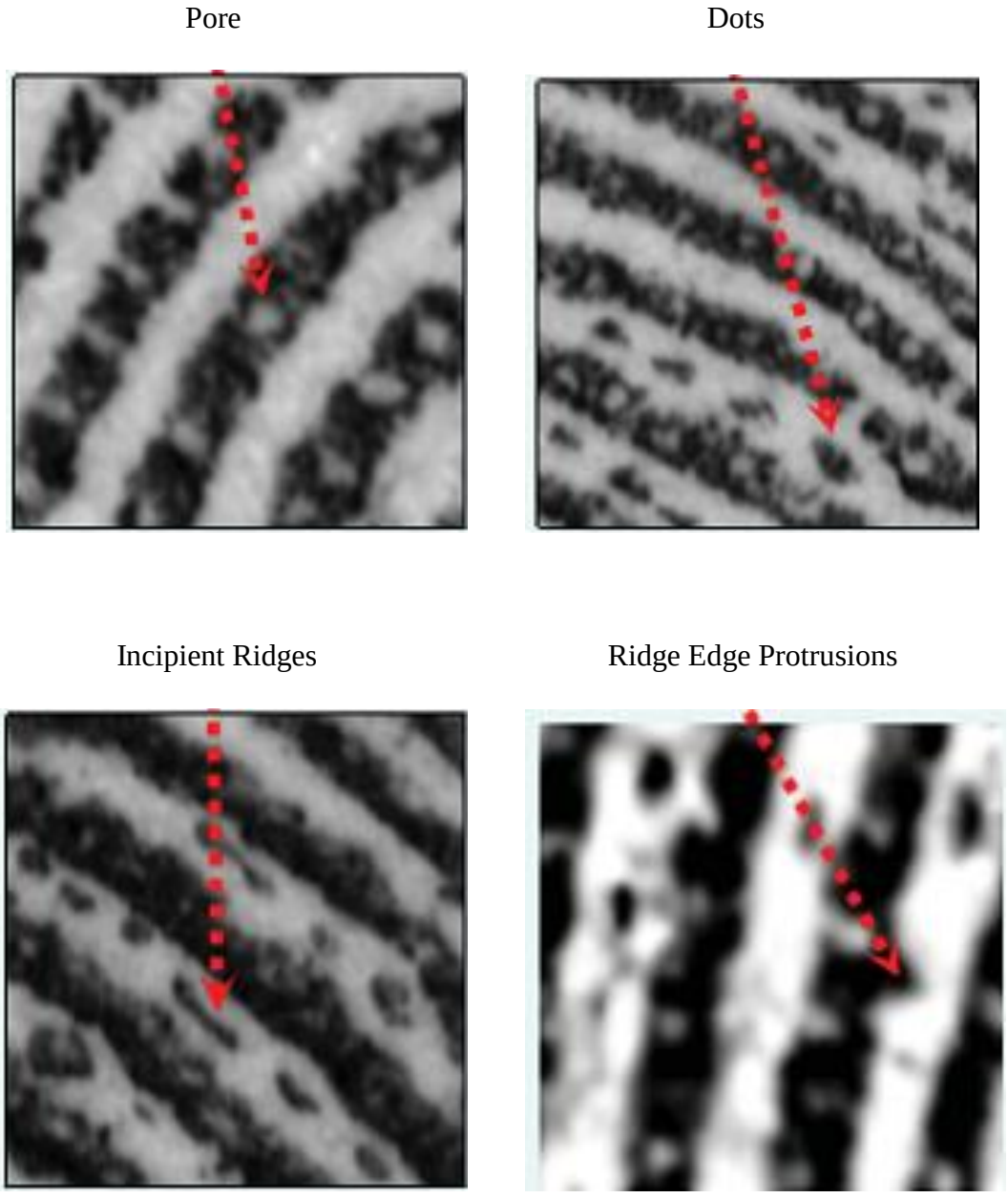


Figure 3.4 Fingerprint ridge dimensional features

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3.4 Requirement of Fingerprint Recognition System

Many attempts were made, to automate the process of personal identification, way back from 1910. IBM punch card sorters and other automated data processing technologies were employed to alleviate the problem of handling large number of data. In 1919 the California State Bureau of Identification introduced a mechanized punch card system called the Robinson F-index to assist, in storing and retrieval of information. In 1934 the Federal Bureau of Investigation (FBI) began using an IBM card sorter to code and classify the fingerprint. In 1937 the New York State Division of Criminal Identification Department started using an IBM card sorter, which could sort 420 cards per minute [5]. These approaches solved a part of the problem, but human examiners was still required to inspect fingerprints.

The need to automate the entire matching process was widely acknowledged, but technology constraints still remained a barrier to the progress. The first experiment with optical recognition of fingerprint images was developed around 1960 [6]. In 1963, Dr. Joseph Wegstein and Dr. Raymond Moore, National Bureau of Standards (NBS) scientists, began working on an automated fingerprint identification system under the auspices of FBI and NBS. In 1972 the FBI installed a system with a fingerprint scanner built by Cornell Aeronautical Laboratory (now

Calspan Corporation), of Buffalo, New York, and a prototype fingerprint reader system built by Automatics Division of North American Aviation. Inc. (now Rockwell International) of Anaheim.

With the progress achieved on digitization and automation of the matching process, the FBI started scanning all their fingerprint records for persons born after January 1, 1929 and by 1980 they had a database of 14.3 million records [7]. During 1980's, various city police departments and state criminal justice bureaus in the U.S.A. started deploying the Automated Fingerprint Recognition Systems, confirming the level of maturity of the technology.

3.5 Chapter Summary

This chapter provides a brief discussion on fingerprint history. It also provided a brief overview of fingerprint pattern and its different levels of features and the requirement of automation in fingerprint identification and verification systems.