CHAPTER 1
INTRODUCTION AND SCOPE OF THE WORK

1.1 INTRODUCTION

This research work focuses on fingerprint recognition with artificial neural network methods. The motivation for using fingerprint in this research work is due to vast usage of this technology in passport verification, employee tracking in industries.

Fingerprint is a unique facility which is present in human anatomy. The ups and downs of the curvature present in the finger among human are different. The curvature present among male and female are also different. In general, the image of a finger either a thumb or index finger is scanned by a compact fingerprint scanner with high resolution. The image is preprocessed to remove noise such as the dirt present in the finger and the dirt present on the scanner glass.

In general, it is sufficient to confine to statistical methods for extraction such information from a given fingerprint image for identifying a person. However, it so happens that, the person will not always orient his or her finger in the same way and hence it is always a difficult task even for identifying a person as the wrapping of the finger would appear will change. This is one major problem that limits the fingerprint identification. Moreover, warping techniques can be applied to the scanned image which can improve the performance of fingerprint identification, the concept of artificial neural networks can overcome such limitations of warping by learning all possible shifting of the coordinates of the features within the allowable range. Hence, warping approach can be avoided and extracted features can be directly fed into ANN module for identifying a fingerprint.

The fingerprint scanned will go through preprocessing followed by wavelet decomposition. Subsequently, at the n°th level decomposition, statistical features are computed from the coefficients of approximation and
detail. These statistical features are further used as training, as well as, testing patterns for the proposed ANN algorithms.

1.2 PROBLEM STATEMENT

Fingerprint recognition algorithms by using Wavelets, Artificial Neural Networks and Fuzzy Logic. Fingerprint recognition has gained popularity in identifying a person.

The purpose of identifying a person is to verify his passport at the immigration to create attendance in the employee database in an organization, to identify culprits who involved in many unlawful cases.

Many Commercial softwares have been developed, and they are in use at various organizations. These algorithms use statistical methods to extract information from a fingerprint and compare with template information that has similar features.

In this research work, the concept of intelligence is incorporated to identify a fingerprint. We would like to claim that, the concept of intelligence will accept the fingerprint with slight distortion during fingerprint scanning.

The commercial software’s claim that 100% accuracy could not be achieved, and they could reach very close to 85%. The accuracy percentage is with the request to the huge amount of fingerprint database used wherein many fingerprints features may be as close as possible, and hence wrong identification is equally possible.

1.3 SCHEMATIC FLOW FOR FINGERPRINT RECOGNITION

1. Input Fingerprint image.
3. Obtain statistical features and form a pattern.
Fig. 1.1 Schematic flow for fingerprint recognition
4. Patterns of each Fingerprint image are used for training and testing ANN / Fuzzy logic algorithms.
5. By using training patterns store final weights of the Ann at the end of training.
6. During the testing process adopt steps 1-3. Process with the final weight as obtained in step 5. The output of the ANN / Fuzzy logic is used to identify the Fingerprint.

1.4 OBJECTIVES OF THIS RESEARCH WORK
1. To identify fingerprint in slightly shabby condition.
2. To use intelligent algorithms for overcoming the unambiguity in identifying the fingerprint.

1.5 METHODOLOGIES
2. Wavelet with Back propagation algorithm.
3. Wavelet with Radial basis function.
4. Wavelet with Fuzzy Logic.

1.6 SCOPE OF THE RESEARCH
To accomplish the objectives, compatible algorithms have to be developed in fingerprint recognition. A procedure has been followed to decide the required topology of the ANN. Different types of fingerprint image will be analyzed. The fingerprint scanned will go through preprocessing followed by wavelet decomposition. At the n\textsuperscript{th} level decomposition, statistical features are computed from the coefficients of approximation and detail, These statistical features are further used as training, as well as, testing patterns for the ANN / Fuzzy logic algorithms.
1.7 DETAILS OF FINGERPRINT

Fingerprint image databases are characterized by their larger size. Distortions are very common in fingerprint images due to elasticity of the skin. Commonly used methods for taking fingerprint impressions involve applying a uniform ink on the finger and rolling the finger on the paper. Over-inked areas of finger, which create smudgy areas in the images, breaks in ridges, created by under-inked areas, the elastic nature of the skin can cause positional shifting, and The non-cooperative attitude of criminals also leads to smearing in parts of the fingerprint images.

Although inkless methods for taking fingerprint impressions are now available, these methods also suffer from the positional shifting caused by the skin elasticity. Thus, a substantial amount of research reported in the literature on fingerprint identification is devoted to image enhancement techniques.

The problems associated with fingerprint identification are very complex, and an inappropriate representation scheme can make it intractable. For the purpose of automating the process of fingerprint identification, a suitable representation of fingerprints is essential. This representation should have the following properties.

1. Retention of the discriminating power of each fingerprint at several levels of resolution.
2. Easy computability.
3. Amenable to automated matching algorithms.
4. Stable and invariant to noise and distortions.
5. Efficient and compact representation.

But these representations do not guarantee exact matching because of the presence of noise or availability of a partial image. Hence, high-level structural features, which can uniquely represent a fingerprint, are extracted.
from the image for the purpose of representation and matching. Some of these features are described below.

### 1.7.1 Structural Features of Fingerprint Images

The global pattern of papillary lines occurring in the central area of the tip of the finger constitutes a specific configuration, which is sufficient for a rough systematic classification. For fingerprint classification purposes, only a part of the entire image, called Pattern Area, is used. The Pattern Area is defined as the inner area, which is limited by two lines, so-called Type Lines. Two singular points are part of this central area of the fingerprint image (Figure 1.2): (a) the delta (several of which may exist; only sample arches do not have deltas) and (b) the nucleus. Delta, which is sometimes also called "outer border" is usually located at the fringe of the fingerprint image. An image of papillary lines is called a delta if it is similar to the Greek capital letter delta. It is formed by two parting ridges or by a ridge bifurcation and a third ridge that is convex and coming from another direction. Some examples of a delta configuration are shown in Figure 1.3. It is rather hard to define the nucleus of an individual fingerprint due to vast variations in the curving of the inner lines. Therefore, a specific point is simply chosen as the nucleus as though it was the center of the corresponding pattern. Figure 1.4 shows some examples of a nucleus configuration. Another important quantitative factor in classifying images is the number of lines.

![Fig.1.2 Type lines](image)
This means the number of lines that touch or cross the imaginary connection between the nucleus and the delta. Due to the great complexity of various line configurations, it is often difficult to clearly determine the number of lines. Figure 1.5 shows three simple examples for the number of lines.

According to the definitions given above, fingerprint categories can be described as follows (pursuant to the Henry classification system [Henry, 2003]). In loops, one or more ridges enter into the central area, they form a curve, touch or cross the imaginary lines between the delta and the nucleus and return to the same side from which they came. There are three decisive characteristics for classifying lines as a loop: (a) at least one suitably curved papillary line, (b) a delta, and (c) a number of lines other than zero. Depending on the orientation of the line's curve, a differentiation is made between right (clockwise) and left (anticlockwise) loops. Approximately 60 to 65 % of human fingerprints belong into this category.
Whorls have at least two deltas. In their nucleus, ridges form a twist. Even though this definition is very general, it expresses the main characteristic of this category. Whorls can be split up into further categories: (a) flat whorls, (b) whorls with a medium slant, (c) double whorls, and (d) random whorls. About 30 to 35% of all fingerprints belong into this category.

Arches are a rather special type of fingerprint. Less than 5% of all fingerprints belong into this category. Arches can be split up into two categories: (a) flat arches and (b) high arches. In flat arches, the ridges enter at the side, form moderate and nearly parallel waves in the center and exit on the opposite side. In high arches, the wave is stronger in the middle. The route of all lines is no longer parallel and part of the lines seemingly exerts pressure from below.

![Fig. 1.6 Flat arch, left loop, right loop, high arch, and whorl](image)

Obviously, due to the vast variation in the spectrum of fingerprints, the classification is always a big problem both for experts as well as for automatic systems. The allocation into categories is a very complex task. Dactyloscopy experts need a lot of experience in order to do their work reliably. Figure 1.6 shows some examples for individual categories. Figure 1.7 demonstrates examples of fingerprint images, which are very difficult to classify.
1.7.2 Major Factors Affecting Fingerprint Biometric System Accuracy

While fingerprint biometric systems are known for their ability to accurately authenticate an individual, there are numerous factors that affect this ability. Users must consider the following factors as they choose a fingerprint biometric solution:

1) **Live scan quality**—Live scan quality directly affects the number of biometric features that can be extracted from the fingerprint. Remember that the number of features is directly related to overall biometric system performance. The scan device must reliably deliver high-quality fingerprint scans each and every time the scanner is used and under all use scenarios.

2) **Enrollment scan quality**—Poor enrollment scan quality permanently degrades accuracy for that user and drags down overall system performance. Thus, a higher standard of fingerprint scan and biometric template quality should be applied to the enrollment process.

3) **Scan device usability**—The location and orientation of the scanning device should be such that the user can quickly and accurately place their finger in a manner that reliably leads to a high-quality live scan with one touch.

4) **User skin condition**—Many types of scanners are sensitive to user skin conditions and placement pressure since they rely on a measurement approach that only differentiates areas in contact with the scanner (fingerprint ridges) from areas not in contact (valleys). As a result, dry or damp skin can degrade the quality of the live scan, as can surface contaminants or variability in pressure applied to the sensor by the user.

5) **User fingerprint expression**—Some individuals have poor fingerprint expression or very fine fingerprint features. In addition, as a person becomes older, the collagen level in the skin is reduced enough to cause complications in fingerprint scan reliability.
6) **Closed vs. open biometric systems**—An open system is one where a variety of fingerprint scan devices, biometric template generators, and automatic biometric template matchers are used. Open or interoperable systems offer convenience in the design and implementation of the system. However, open systems have lower performance because of least common denominator effects.

7) **Liveness detection**—A scanner with liveness detection is one that prevents the use of copies of the fingerprint to be used. This includes means to prevent the activation of a latent print, the use of a 2-D paper copy, or the use of a sophisticated 3-D copy. A scanner lacking this capability will accept copies, and this would result in a system breach similar to a stolen user ID/password pair.

### 1.7.3 Fingerprint Image Comparison

Data about the fingerprint category and further global characteristics, such as the number and position of the centers, deltas, and ridges, does provide enough information for a certain differentiation of fingerprints. However, the true individuality of fingerprints is determined by the anatomic characteristics of the ridges (minutiae) and their respective orientation. Whether they can be recorded in their entirety depends on the conditions when the fingerprint was taken as well as on its quality. The most frequently occurring minutiae are: Ridge ending and Ridge bifurcation.
Fig.1.8 Ridge ending, simple ridge bifurcation, twofold ridge bifurcation, threefold ridge bifurcation, simple whorl, twofold whorl, and side contact; Hook, point, interval, X-line, simple bridge, twofold bridge, and continuous line

Ridge ending defines the end of a line, while ridge bifurcation is defined as a point in the ridge where the line is separated into two branches. Minutiae are usually stable and robust with regard to conditions occurring during the scanning process. Figure 1.8 shows some examples. Minutiae can be characterized by their type, by x- and y-coordinates in a coordinate system, and by their direction.

If two fingerprints belong to the same category and have a certain number of identical minutiae, it is quite safe to say that they come from the same finger.

The general definition for the identicalness of any two fingerprint images consists of four criteria and says:

1. The general pattern configuration has to be identical,
2. The minutiae have to be qualitatively identical (qualitative factor),
3. The quantitative factor says that a certain number of minutiae must be found, and,
4. There has to be a mutual minutiae relationship specifying that corresponding minutiae must have a mutual relationship. In practice, a large number of complex identification protocols for fingerprint image comparisons have been proposed. These protocols are derived from the traditional dactyloscopic methodology and prescribe an exact procedure for trained specialists.

Even though various protocols differ in the process flow of the comparison procedure and the definition of the decision, the basic steps remain the same. Typically, comparison is done in an iterative three-phase-process. It is hardest to compare two fingerprints that have similar feature configurations. If,
however, both fingerprints are totally different as far as their feature configuration is concerned, it is impossible that these images are from the same finger. In the next step, significant minutiae are examined, the central area is located, and the minutiae are compared with each other.

Afterwards, the decisive comparison of the minutiae is carried out where all minutiae of the fingerprints are compared with each other. A decision is made based on identified pairs and their configuration. Due to variations in fingerprint qualities, not all points are always clear or defined with the same quality. In such cases, experts use their discretion and experience in deciding whether images are identical or not. For instance, ridge bifurcations could be identified as ridge endings if little pressure was exerted in taking the fingerprint. Obviously, the experience of the experts always plays a certain key role when comparing fingerprints. As an example, Figure 1.9 shows the comparison of 18 such minutiae.

**Fig.1.9 Dactyloscopic comparison with 18 corresponding minutiae**

**1.8 ORGANIZATION OF THE THESIS**

This chapter presents an introduction to fingerprint recognition and requirements of the study, need for the research work, problem definition, the Second chapter provides methods and tools used for fingerprint recognition by different researchers.

The Third chapter describes the fingerprint database collection for the experiment analysis.
The Fourth chapter deals with feature extraction using wavelet decomposition for fingerprint recognition.

The Fifth chapter presents with implementation of ANN algorithms like BPA / RBF and Fuzzy logic for fingerprint recognition.

The Sixth chapter describes the results and discussions.

The Seventh chapter presents the conclusion and future scope of the work.

1.9 SUMMARY

This chapter has presented the purpose of implementing artificial neural networks with wavelet features. The chapter 2 presents a detailed review of literature about fingerprint recognition.