# Fingerprint Recognition Algorithms for Partial and Full Fingerprints

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**Abstract—***An urgent need to develop accurate biometric recognition system is expressed by governmental agencies at the local, state, and federal levels, as well as by private commercial companies. Fingerprinting is the most practical and widely used biometric technique. The pattern of ridges and valleys of each fingerprint is unique. The minutiae based algorithm is widely used for fingerprint authentication. One of the significant parts of this algorithm is the classification of fingerprints which allows minimizing significantly the number of fingerprints referenced for each identification procedure. However, the minutiae algorithm has some serious drawbacks. If the core of a fingerprint is not visible, then identification cannot proceed. Yet in some cases, partial fingerprints need to be identified. We recently developed a novel Contactless Line Scanner for recognition of fingerprint pattern that converts a three dimensional object like a finger into a two dimensional image with minimal distortion. This novel imaging technique based on a line by line scanned image required the development of a new recognition algorithm. In this study, we propose two new algorithms. The first algorithm, called the Spaced Frequency Transformation Algorithm (SFTA), is based on taking the Fast Fourier Transform of the images. The second algorithm, called the Line Scan Algorithm (LSA), was developed to compare partial fingerprints and reduce the time taken to compare full fingerprints. A combination of SFTA and LSA provides a very efficient recognition technique.*

## INTRODUCTION

Fingerprints present a unique basis for personal identification. Although the dimensions of the finger change with age, the ridge arrangement on every finger of every human is unique and does not alter with growth or age [1]. The individuality of fingerprints has been discussed in detail in [2]. It has served most governments worldwide for many years to provide accurate identification of criminals. No two fingerprints have been found to be the same in the billions of comparisons that have been done to date unless they belong to the same person. It outperforms DNA and other human identification methods in identifying a large number of criminals.

The minutiae algorithm is widely used for fingerprint authentication. Minutiae points are local ridge characteristics that appear as either a ridge ending or a ridge bifurcation. A complete fingerprint contains about 100 minutiae points on average. The measured fingerprint area contains about 30 to 60 minutiae points depending on the size of the finger and the dimensions of the sensor area. These minutiae points are represented by a cloud of dots in a coordinate system. They are stored together with the angle of the tangent of the local minutiae point in a fingerprint code or directly on a reference template. A template can consist of more than one fingerprint code to expand the amount of information and to expand the encoded fingerprint area. In general, this leads to a higher template quality and therefore to a higher similarity value of the template and the sample. To overcome the drawbacks of the minutiae algorithm mentioned earlier, hybrid methods have been proposed [3]. The minutiae recognition algorithms which are based on the measurement of the distance between specific points have to take into account changes in the size of the finger. To the contrary, the two algorithms developed by our group do not depend on changes of the fingers physical dimensions. The Spaced Frequency Transformation Algorithm (SFTA) follows the frequency of the ridge patterns and the Line Scan Algorithm (LSA) is based on the correlation function. Both of these algorithms have been tested on fingerprints obtained from [4].

## FINGERPRINT CLASSIFICATION

English scientist, Sir Francis Galton suggested the first elementary system for classifying fingerprints based on grouping the patterns into arches, loops, and whorls. Fingerprints are classified in a three-way process: by the shapes and contours of individual patterns as rolled on finger left with wet ink. The attention was paid to relative size, determined by counting the ridges in loops and by tracing the ridges in whorls. The information obtained in this way was incorporated in a concise formula which was known as the individual's fingerprint classification.

F. Galton's classification system was expanded by Sir Edward Henry. There are several variants of the Henry Classification System [5], but the one used by the Federal Bureau of Investigation (FBI) in the United States recognizes eight different types of patterns: radial loop, ulnar loop, double loop, central pocket loop, plain arch, tented arch, plain whorl, and accidental. Whorls are usually circular or spiral in shape. Arches have a moundlike contour while tented arches have a spikelike or steeplelike appearance in the center. Loops have concentric hairpin or staple-shaped ridges and are described as "radial" or "ulnar" to denote their slopes; ulnar loops slope toward the little finger side of the hand, radial loops toward the thumb. Loops constitute about 65 percent of the total fingerprint patterns; whorls make up about 30 percent and arches and tented arches together account for the other 5 percent. The most common pattern is the ulnar loop. We use the system of classification mentioned in [6] before applying our algorithms for fingerprints comparison.

**Spaced Frequency Transformation Algorithm—**

The Spaced Frequency Transformation Algorithm uses the 2D Fast Fourier Transform (FFT) to compare fingerprints. The Fourier Transform is an important image processing tool which converts the image from the spatial domain to the frequency domain. The output of the transformation represents the image in the low and high frequency components. In the frequency domain, each point represents a particular frequency contained in the spatial domain image.

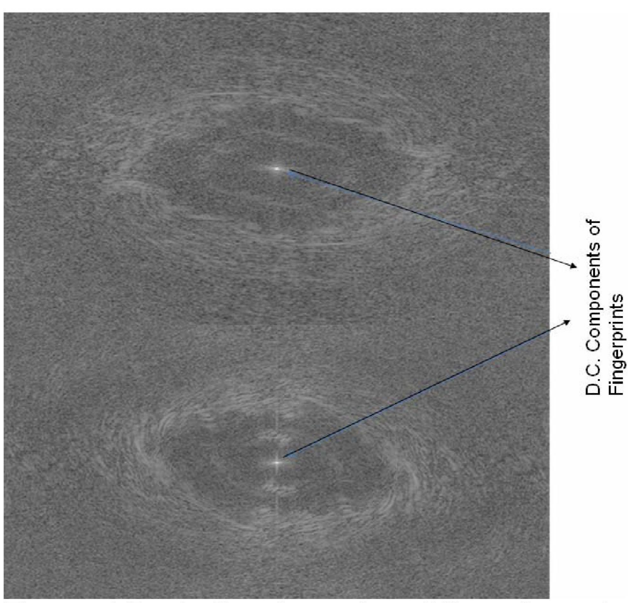


**Figure – 1** Fourier Transforms of two different fingerprints

Fig. 1 presents FFT of two different fingerprints. At the center of Fig. 1, the low frequency components are clearly visible at the  A professional analyst as well as an experienced engineer will notice the difference between the two images. The shapes, the type of swirls, and the position of symmetrical points on the figure are all attributes which identify the Fourier transformation of two different fingerprint images. The computer compares the FFT of the two images pixel by pixel and counts the number of similar elements in both. If this count is higher than a threshold value, then a match is found. Otherwise, it is a mismatch. This algorithm was tested on a database of 750 fingerprints. It has an accuracy rate of 99% for full fingerprints. The comparison of a fullly registered fingerprint with a small fingerprint portion yielded a success rate 85%. The failures were divided as a 13% false rejection rate and a 2% of false recognition rate. In the case of the comparison of partial registered fingerprints to another partial fingerprint, the success rate was 77%. Here, the failures were divided as a 15% false rejection rate and an 8% false recognition rate.

**Line Scan Algorithm—**

The Line Scan Algorithm was developed to reduce comparison time when the SFTA is used. The LSA could be described as a sequence of the following steps:

1) In the first step, the image is stored and a subroutine crops out the unwanted information present in the image. Fig. 2 shows the unwanted information which consists of a black portion on both the sides of the actual fingerprint image. Fig. 3 is the cropped image which only contains the desired portion of the fingerprint.

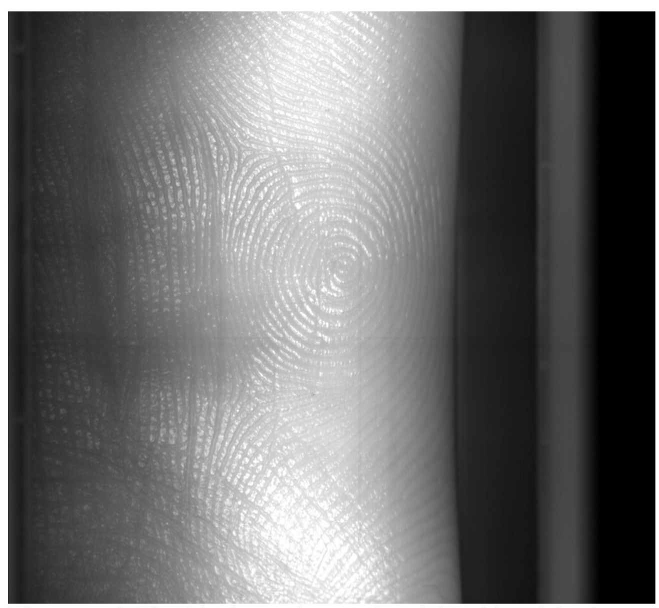

**Figure – 2** The black portion to the right side of the image is unwanted portion

**Figure – 3** Cropped image containing only the region of interest

2) In the second step, the program calculates the boundaries of the images undergoing comparison then resizes the images in such a manner that the tested areas are of equal dimensions.

3) In the third step, the correlation curves are found that correspond to the row intensities for the compared images. The symmetry of the correlation function is used to judge the final result of the comparison [7]. These curves are very similar for the same fingerprints and are much different for dissimilar fingerprints. The curves are smoothed. The similarity between the curves is defined in the frequency domain by taking a Fourier transform and then comparing the result to a threshold value to see if the prints are from the same finger. Fig. 4 presents a complete flowchart of the steps used in the algorithm.

A higher speed of analysis is possible using LSA as compared to SFTA and is therefore a relative advantage. Even a partial fingerprint can be matched. When we tested this algorithm on a database of about 150 partial fingerprints, we had an accuracy rate of 95% and in case of full fingerprints; we had an accuracy rate close to 99%. Combining the line scan technique with the line scan algorithm, we have a very efficient scanning as well as matching technique. The test statistics mentioned in both of the above algorithms are independent of the testing procedures mentioned in [8]. Further, we do not need to introduce any distortion into the fingerprint database before matching as mentioned in [9].

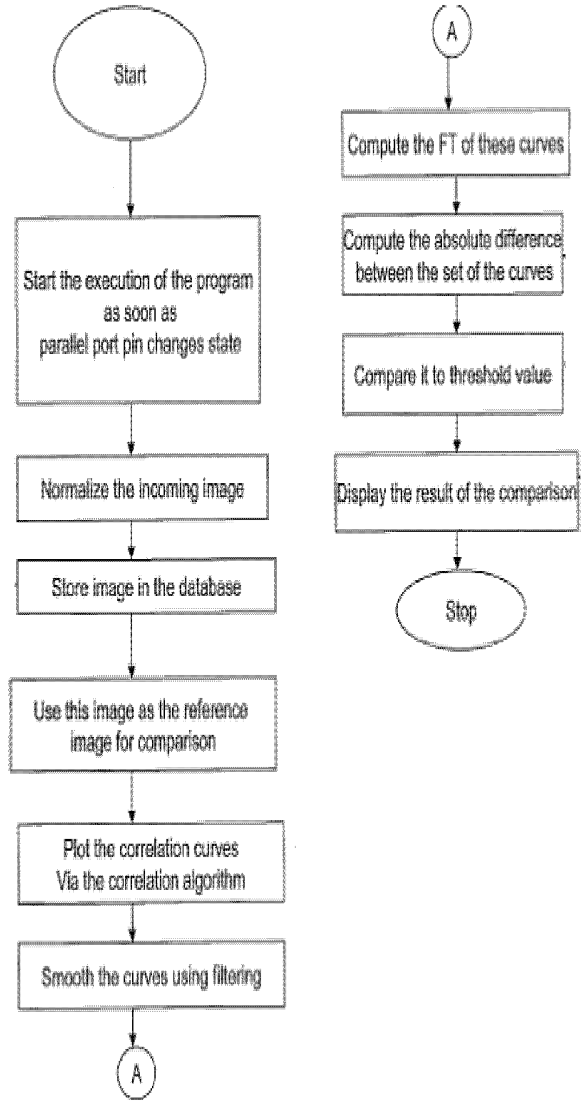


**Figure – 4** Flowchart for the Line Scan Algorithm

## CONCLUSIONS

The two algorithms reported in this paper are very powerful algorithms that can be used for both full and partial fingerprints. The most notable advantages of these algorithms are the high accuracy in the case of partial fingerprints. At this time, the major drawback of developed algorithms is lack of pre-classification of examined fingers. Therefore, we use minutiae classification scheme to reduce the reference base for given tested finger. When the reference base had shrunk, we apply the LSA and SFTA. We continue this development by creation of wide library of fingerprints which will be tested by novel algorithms.

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