ISSN (Online) : 2278-1021
ISSN (Print) : 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 3, Issue 8, August 2014

Fingerprint Matching Using Correlation (In Frequency Domain)

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Abstract: To perform fingerprint matching based on the number of corresponding minutia pairings, has been in use for quite sometimes. But this technique is not very efficient for recognizing the low quality fingerprints. To overcome this problem, some researchers suggest the correlation technique which provides better result. Use of correlation-based methods is increasing day by-day in the field of biometrics as it provides better results.

Keywords: Fingerprint, Fingerprint Matching, Frequency Domain, Correlation, Recognition.

I. INTRODUCTION

Fingerprints have long been used for personal identification. It is assumed that every person possesses unique fingerprints and hence the fingerprint matching is considered one of the most reliable techniques of people identification. Automatic fingerprint recognition systems (AFRS) have been nowadays widely used in personal identification applications such as access control. Roughly speaking, there are three types of fingerprint matching methods: minutia-based, correlation-based, and image-based.

In minutia-based approaches, minutiae (i.e. endings and bifurcations of fingerprint ridges) are extracted and matched to measure the similarity between fingerprints. These minutia-based methods are now the most widely used ones. Different from the minutia-based approaches, both correlation-based and image-based methods compare fingerprints in a holistic way. The correlation-based methods spatially or in frequency domain correlate two fingerprint images to compute the similarity between them, while the image-based methods first generate a feature vector from each fingerprint image and then compute their similarity based on the feature vectors. No matter what kind of fingerprint matchers are used, the fingerprint images usually have to be aligned when matching them.

II. FREQUENCY DOMAIN

Frequency domain is a term used to describe the domain for analysis of mathematical functions or signals with respect to frequency, rather than time. A given function or signal can be converted between the time and frequency domains with a pair of mathematical operators called a transform. An example is the Fourier transform, which decomposes a function into the sum of a (potentially infinite) number of sine wave frequency components. The 'spectrum' of frequency components is the frequency domain representation of the signal. A spectrum analyzer is the tool commonly used to visualize real-world signals in the frequency domain.

III. CORRELATION

A coefficient of correlation is a mathematical measure of how much one number can be expected to be influenced by changes in another. It is closely related to covariance. Digital Image Correlation is a full-field image analysis method, based on grey value digital images that can determine the contour and the displacements of an object under load in three dimensions. Digital image correlation (DIC) techniques have been increasing in popularity, especially in micro- and nano-scale mechanical testing applications due to its relative ease of implementation and use. Advances in computer technology and digital cameras have been the enabling technologies for this method and while white-light optics has been the predominant approach, DIC can be and has been extended to almost any imaging technology. Digital Image Correlation and Tracking (DIC/DDIT) is an optical method that employs tracking & image registration techniques for accurate 2D and 3D measurements of changes in images. Correlation is an important measure is used to find the position of a target object in a given image. In frequency domain approach, we used FFT (Fast Fourier Transform) for correlation method. Any image is completely described by its two-dimensional (2-D) Fast Fourier Transform (FFT) in frequency domain. The correlation is best method for template matching.

IV. FINGERPRINT

Human fingertips contain ridges and valleys which together forms distinctive patterns. These patterns are fully developed under pregnancy and are permanent throughout whole lifetime. Prints of those patterns are called fingerprints. Injuries like cuts, burns and bruises can temporarily damage quality of fingerprints but when fully healed, patterns will be restored.

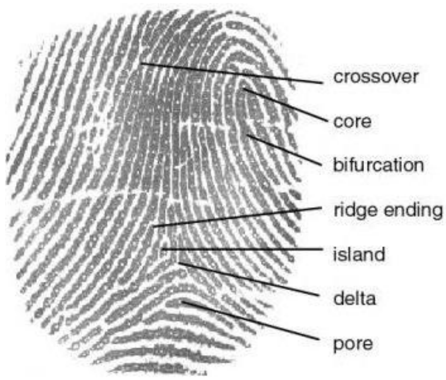

Fig 1: A Sample fingerprint

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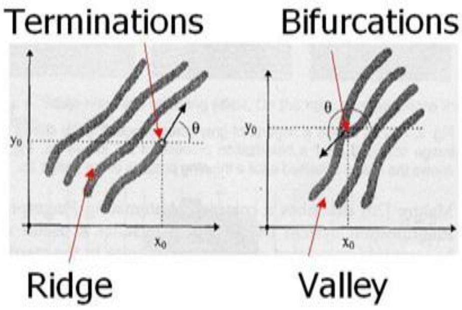

Figure 2: Fingerprints and Minutia

Figure 3: Different fingerprint patterns

A fingerprint image exhibits a quasiperiodic pattern of ridges (darker regions) and valleys (lighter regions).
The local topological structures of this pattern together with their spatial relationships determine the uniqueness of a fingerprint.

There are more than 100 different types of local ridge structures that have been identified. Nevertheless, most of the automatic fingerprint identification / verification systems adopt the model used by the Federal Bureau of Investigation. The model relies on representing only the two most prominent structures: ridge ending and ridge bifurcation, which are collectively called minutiae.

V. FINGERPRINT MATCHING

Large volumes of fingerprints are collected and stored everyday in a wide range of applications including forensics, access control, and driver license registration. An automatic recognition of people based on fingerprints requires that the input fingerprint be matched with a large number of fingerprints in a database. To reduce the search time and computational complexity, it is desirable to classify these fingerprints in an accurate and consistent manner so that the input fingerprint is required to be matched only with a subset of the fingerprints in the database. Fingerprint classification is a technique to assign a fingerprint into one of the several pre-specified types already established in the literature which can provide an indexing mechanism.

Fingerprint classification can be viewed as a coarse level matching of the fingerprints. An input fingerprint is first matched at a coarse level to one of the pre-specified types and then, at a finer level, it is compared to the subset of the database containing that type of fingerprints only.

We have trying to develop an algorithm to classify fingerprints into four classes, namely, *whorl, right loop, left loop, and arch.*

Fingerprint matching techniques can be placed into two categories: minutiae-based and correlation based. Minutiae-based techniques first find minutiae points and then map their relative placement on the finger. However, there are some difficulties when using this approach. It is difficult to extract the minutiae points accurately when the fingerprint is of low quality. Also this method does not take into account the global pattern of ridges and furrows.
The correlation-based method is able to overcome some of the difficulties of the minutiae-based approach. However, it has some of its own shortcomings. Correlation-based techniques require the precise location of a registration point and are affected by image translation and rotation.

VI. THE ALGORITHM FOR CORRELATION THEOREM IN SPATIAL DOMAIN

In spatial domain, SAD is a pre-processing technique for correlation method. It is one of the approaches which gives satisfactorily result in template matching.

Here the template must have same size as in the provided image. This method is normally implemented by first picking out a part of the search image to use as a template: We will call the search image S(x, y), where (x, y) represent the coordinates of each pixel in the search image. We will call the template $T(x_t , y_t)$, where (x_t , y_t) represent the coordinates of each pixel in the template. We then simply move the centre (or the origin) of the template $T(x_t , y_t)$ over each (x, y) point in the search image and calculate the sum of products between the coefficients in S(x, y) and $T(x_t , y_t)$ over the whole area spanned by the template.

As all possible positions of the template with respect to the search image are considered, the position with the highest score is the best position. This method is sometimes referred to as 'Linear Spatial Filtering' and the template is called a filter mask.

VII. THE ALGORITHM FOR CORRELATION THEOREM IN FREQUENCY DOMAIN

Template matching using correlation basically uses the Correlation theorem:

$$f(x, y) \circ h(x, y) \Leftrightarrow F(u, v) H^*(u, v) \quad (1)$$

Where f(x, y) is the search image having N x M sizes and h(x, y) is the template image having K x L sizes.

It consists of the following steps:

1. Multiply the search and the template image by $(-1)^{x+y}$ centre transformed.
2. Compute F (u, v), the FFT of the Zero padded search image from (1).

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3. Compute H (u, v), the FFT of the Zero padded template from (1).
4. Multiply F (u, v) by H* (u, v) (Conjugate of H (u, v)).
5. Compute the inverse FFT of the result in (4).
6. Obtain the real part of the result in (5).
7. Multiply the result in (6) by $(-1)^{x+y}$.

VIII. FINGERPRINT TEMPLATE MATCHING

Steps:

- Find effective area
- Match with stored template
- For each template find the point where the maximum matching is spotted
- For each template find the value at that point (different point for each template)
- Compare the values and get the point with the maximum value
- Store the point and also the value
- Find the point where the maximum matching is found amongst all the templates
- The fingerprint pattern will be of the type matched

IX. EXPERIMENTS

- Tried with spatial domain, need exact match for good result, means millions of templates, so it is not feasible
- Frequency domain gives a better result.
- If the database is small, experiments on spatial domain, as well as frequency domain correlation gives direct fingerprint identification (/verification) result, though it's not much feasible for spatial domain if the database is large, (position invariant features were must to be incorporated for achieving this type recognition system).
- A set of 100 different templates were used for matching (in frequency domain) and hence classification.

X. CONCLUSION

Correlation-based techniques require the precise location of a registration point and are affected by image translation and rotation.

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BIOGRAPHIES

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