Fingerprint Identification - What You Need to Know

Courtesy of the Pattern Recognition and Image Processing Lab, Department of Computer Science and Engineering, Michigan State University

Among all the biometric techniques, fingerprint-based identification is the oldest method which has been successfully used in numerous applications. Everyone is known to have unique, immutable fingerprints. A fingerprint is made of a series of ridges and furrows on the surface of the finger. The uniqueness of a fingerprint can be determined by the pattern of ridges and furrows as well as the minutiae points. Minutiae points are local ridge characteristics that occur at either a ridge bifurcation or a ridge ending.

Fingerprint Matching:

Among all the biometric techniques, fingerprint-based identification is the oldest method which has been successfully used in numerous applications. Everyone is known to have unique, immutable fingerprints. A fingerprint is made of a series of ridges and furrows on the surface of the finger. The uniqueness of a fingerprint can be determined by the pattern of ridges and furrows as well as the minutiae points. Minutiae points are local ridge characteristics that occur at either a ridge bifurcation or a ridge ending.

Fingerprint matching techniques can be placed into two categories: minutae-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.

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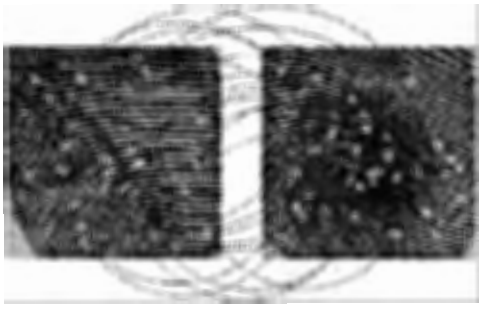

Fingerprint matching based on minutiae has problems in matching different sized (unregistered) minutiae patterns. Local ridge structures can not be completely characterized by minutiae. We are trying an alternate representation of fingerprints

which will capture more local information and yield a fixed length code for the fingerprint. The matching will then hopefully become a relatively simple task of calculating the Euclidean distance will between the two codes.

We are developing algorithms which are more robust to noise in fingerprint images and deliver increased accuracy in real-time. A commercial fingerprint-based authentication system requires a very low False Reject Rate (FAR) for a given False Accept Rate (FAR). This is very difficult to achieve with any one technique. We are investigating methods to pool evidence from various matching techniques to increase the overall accuracy of the system. In a real application, the sensor, the acquisition system and the variation in performance of the system over time is very critical. We are also field testing our system on a limited number of users to evaluate the system performance over a period of time.

Fingerprint Classification:
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 (FBI database contains approximately 70 million fingerprints!). 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 developed an algorithm to classify fingerprints into five classes, namely, whorl, right loop, left loop, arch, and tented arch. The algorithm separates the number of ridges present in four directions (0 degree, 45 degree, 90 degree, and 135 degree) by filtering the central part of a fingerprint with a bank of Gabor filters. This information is quantized to generate a FingerCode which is used for classification. Our classification is based on a two-stage classifier which uses a K-nearest neighbor classifier in the first stage and a set of neural networks in the second stage.

The classifier is tested on 4,000 images in the NIST-4 database. For the five-class problem, classification accuracy of 90% is achieved. For the four-class problem (arch and tented arch combined into one class), we are able to achieve a classification accuracy of 94.8%. By incorporating a reject option, the classification accuracy can be increased to 96% for the five-class classification and to 97.8% for the four-class classification when 30.8% of the images are rejected.
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Fingerprint Image Enhancement:
A critical step in automatic fingerprint matching is to automatically and reliably extract minutiae from the input fingerprint images. However, the performance of a minutiae extraction algorithm relies heavily on the quality of the input fingerprint images. In order to ensure that the performance of an automatic fingerprint identification/verification system will be robust with respect to the quality of the fingerprint images, it is essential to incorporate a fingerprint enhancement algorithm in the minutiae extraction module.

We have developed a fast fingerprint enhancement algorithm, which can adaptively improve the clarity of ridge and furrow structures of input fingerprint images based on the estimated local ridge orientation and frequency. We have evaluated the performance of the image enhancement algorithm using the goodness index of the extracted minutiae and the accuracy of an online fingerprint verification system. Experimental results show that incorporating the enhancement algorithms

improves both the goodness index and the verification accuracy.

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