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COMPARATIVE ANALYSIS OF GABOR FILTER AND FTT FILTER BASED FINGERPRINT RECOGNITION SYSTEM

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Fingerprint recognition is one of the most reliable and popular biometric recognition methods in these days. In this, we describe a fingerprint recognition system consisting of three main steps-fingerprint image preprocessing, feature extraction and feature matching by two different processes. First processes is based on Gabor filter and second is based on FFT(Fast Fourier Transform) filter and we use these process in the fingerprint image preprocessing steps and after getting result by first step then use feature extraction and feature matching steps simultaneously and separately for each process. After apply all steps we calculate the FAR (False Accept Rate) and FRR (False Reject Rate) for both process separately and compare results on the basis of FAR and FRR of Gabor filter based and FAR and FRR of FFT Filter based. Which process has the reduced FAR and FRR this is the best process than other. In this, The FFT filter based process has reduced FAR and FRR than the Gabor filter based process. So we can say that the FFT filter is much better than the Gabor filter for matching the Fingerprint Images.

Keywords: Biometrics, False Accept Rate (FAR), False Reject Rate (FRR), Fast Fourier Transform (FFT), Gabor Filter

1. INTRODUCATION

Biometrics is automated methods of recognizing a person based on a physiological or behavioral characteristic. Among the features measured are; face, fingerprints, and geometry, handwriting, iris, retinal, vein, and voice. Biometric technologies are becoming the foundation of an extensive array of highly secure identification and personal verification solutions. As the level of security breaches and transaction fraud increases, the need for highly secure identification and personal verification technologies is becoming apparent. Biometric-based solutions are able to provide for confidential financial transactions and personal data privacy.

2. FALSE REJECTION RATE (FRR)

The FRR is the frequency that an authorized person is rejected access. FRR is a non-stationary statistical quantity, which does not only show a strong personal correlation, it can even be determined for each individual biometric characteristic. This is also called False non-match Rate (FNMR). In other words the probability that the system incorrectly declares failure of match between the input pattern and the matching template in the database. It measures the percent of valid inputs being rejected.

The probability for lack of success (FRR (n)) for a certain person is measured.

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$$\text{FRR}(n) = \frac{\text{Number of rejected verification attempts for a qualified person(or feature)n}}{\text{Number of all verification attempts for a qualified person(or feature)n}}$$

3. FALSE ACCEPTANCE RATE (FAR)

The FAR is the frequency that a non-authorized person is accepted as authorized. Because a false acceptance can often lead to damages, FAR is generally a security relevant measure. FAR is a non-stationary statistical quantity, which does not only show a personal correlation, it can even be determined for each individual biometric characteristic. This is also called False Match Rate (FMR). In other words the probability that the system incorrectly declares a successful match between the input pattern and a non-matching pattern in the database.

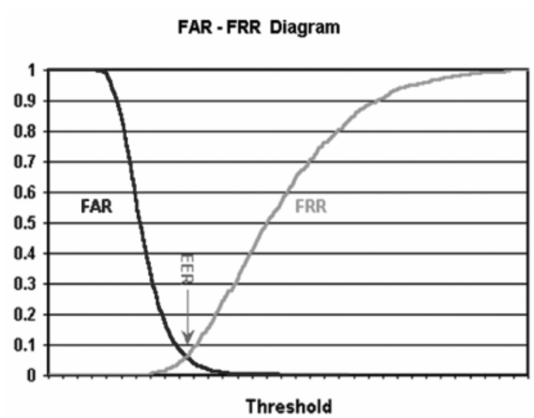


Fig.: Graphical Representation of FAR and FRR at the Threshold Value

The probability for success (FAR (n)) against a certain enrolled person n is measured:

$$FAR(n) = \frac{\text{Number of successful independent fraud attempts against a person n}}{\text{Number of all independent fraud attempts against a person n}}$$

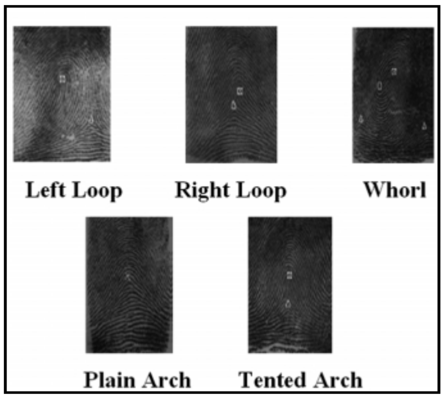
Setting a similarity rating th as the threshold to differentiate between authorized and non authorized users, results in the experimental estimation of false acceptance rate FAR (th), as the number of similarity ratings of non authorized users that fall above this threshold in comparison to all trials / number of similarity.

4. FINGERPRINT

A fingerprint is the feature patterns of one finger see Fig 4.1. It is believed with strong evidences that each fingerprint is unique. Each person has his own fingerprints with the permanent uniqueness. So fingerprints have being used for identification and forensic investigation for a long time. This is the one type of Biometric Technology.

4.1. Classification of Fingerprint

The rectangle represents a special singularity in a fingerprint, which is called core point or reference point. The triangle are so called delta, which are another unique feature. These are points in the fingerprint where there is a triangulation or a dividing of the ridges.



5. SYSTEM LEVEL DESIGN

A fingerprint recognition system constitutes of fingerprint acquiring device, minutia extractor and minutia matcher see Fig.

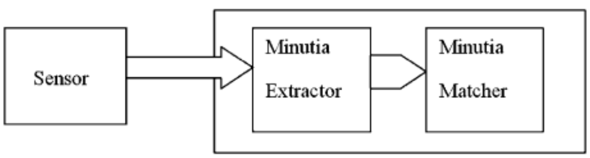


Fig.: Simplified Fingerprint Recognition System

5.1. Algorithm Level Design

To implement a minutia extractor, a three-stage approach is widely used by researchers. They are preprocessing, minutia extraction and post processing stage see Fig. For the fingerprint image preprocessing stage, I use Histogram Equalization and Fourier Transform to do image enhancement. And then the fingerprint image is binarized using the locally adaptive threshold method.

For minutia extraction stage, three thinning algorithms are tested and the Morphological thinning operation is finally bid out with high efficiency and pretty good thinning quality. The minutia marking is a simple task as most literatures reported but one special case is found during my implementation and an additional check mechanism is enforced to avoid such kind of oversight.

5.1.1. Fingerprint Image Binarization

Binarization is a method of transforming grayscale image pixels into either black or white pixels by selecting a threshold. Fingerprint Image Binarization is to transform the 8-bit Gray fingerprint image to a 1-bit image with 0-value for ridges and 1-value for furrows.

5.1.2. Fingerprint Image Segmentation

To separate foreground and background block wise variance threshold is used. In general, only a Region of Interest (ROI) is useful to be recognized for each fingerprint image. The image area without effective ridges and furrows is first discarded since it only holds background information.

5.1.3. Fingerprint Ridge Thinning

Ridge Thinning is to eliminate the redundant pixels of ridges till the ridges are just one pixel wide. In each scan of the full fingerprint image, the algorithm marks down redundant pixels in each small image window (3x3). And finally removes all those marked pixels after several scans.

Fig. : Image Preprocessing: (a) the Extracted Ridge, (b) the Thinned Ridge

5.1.4. Minutia Marking

After the fingerprint ridge thinning, marking minutia points is relatively easy. But it is still not a trivial task as most literatures declared because at least one special case evokes my caution during the minutia marking stage.

5.2. Match Score : Minutia Match

The correlation of minutiae is also taken into account in existing work. This technique can overcome effect of rotation problem with a large angle. The alignment utilizes less information and performed efficiently by using the following condition.

With the help of two equations find out the match score.

$$\sum_{j=b1}^{b2}\sum_{i=1}^{Nj}\left|S_k(Q_{ij})-T_{ij}\right|+\sum_{j=b3}^{b4}\sum_{i=1}^{Nj}\left|S_{2K}(Q_{ij})-T_{ij}\right|<TH \quad (1)$$

$$\text{matching\_score} = M\left[\sum_{j=1}^{M}\exp(D_j)\right]^{-1} \quad (2)$$

$$D_j = \sqrt{\sum_{i=1}^{N_j}(Q_{ij}-T_{ij})^2}$$

6. FAST FOURIER TRANSFORM FILTER

The most well known FFT algorithms depend upon the factorization of N, but (contrary to popular misconception) there are FFTs with O(N log N) complexity for all N, even for prime N. Many FFT algorithms only depend on the fact that $e^{-\frac{2\pi i}{N}}$ is an Nth primitive root of unity, and thus can be applied to analogous transforms over any finite field, such as number-theoretic transforms. An FFT computes the DFT and produces exactly the same result as evaluating the DFT definition directly; the only difference is that an FFT is much faster. Let x_0, ..., x_{N-1} be complex numbers. The DFT is defined by the formula

$$X_k = \sum_{n=0}^{N-1} x_n e^{-i2\pi k\frac{n}{N}} \quad k = 0,\ldots,N-1.$$

Evaluating this definition directly requires $O(N^2)$ operations: there are N outputs X_k, and each output requires a sum of N terms.

7. GABOR- FILTER

Enhancement is the process of improving the clarity of the furrow and ridge structures in fingerprint images. This facilitates the feature extraction process and reduces the noise in the fingerprint image.

A Gabor filter has general form

$$G(x,y,f,\theta) = \exp\left\{-\frac{1}{2}\left[\frac{x'^2}{\delta_{x'}^2}+\frac{y'^2}{\delta_{y'}^2}\right]\right\}\cos(2\pi f x')$$

Where:

Y ' = x cos (θ) – y sin (θ);

X ' = x sin (θ) + y cos (θ);

Where θ is the orientation of the Gabor filter is the frequency of inter-ridge distance along an angle q from the x–axis. dx, dy are the standard deviations of the FFT envelope along the x and y axes respectively.

8. EXPERIMENTATION RESULTS

The performance of a fingerprint identification system can be evaluated by measuring its false reject rate (FRR) and false accept rate (FAR). By evaluating the FRR and FAR, the threshold of matching score deciding whether to reject or accept a match is set to optimizing the performance. If I take less threshold value it means the probability of accepted image will be high and rejected image will be low and due to this, chances of occurring error will be increased and vice-versa.

The Simulation results of Gabor filter based and FFT filter based fingerprint matching with different Threshold and findings false accept rate and false reject rate is given below:

Table 8.1
Simulation Results of Gabor Filter based Fingerprint Matching with Different Threshold

Gabor Filter	TH=1	TH=2	TH=3	TH=4
FRR	22.4%	18%	12.5%	10%
FAR	0.9%	1.6%	2.2%	3.0%

Table 8.2
Simulation Results of FFT Filter Based Fingerprint Matching with Different Threshold

FFT Filter	TH=1	TH=2	TH=3	TH=4
FRR	16.2%	12.5%	10.2%	9.0%
FAR	0.21%	0.48%	1.83%	1.96%

The simulation results are shown in Table [8.1] and Table [8.2]. I get better result by using FFT filter so we can say the FFT filter is better than Gabor filter see Fig 8.1 and Fig 8.2.

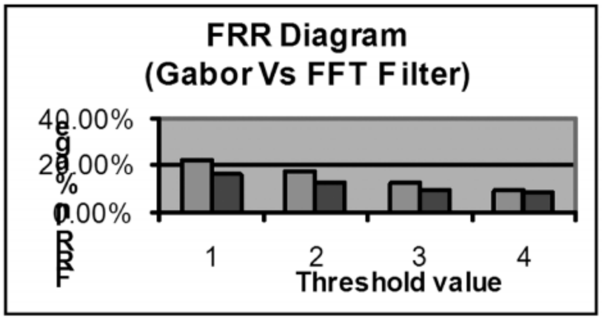


Fig. 8.1: FRR Curve Gabor Filter Vs. FFT Filter
Blue color: Gabor filter based FRR
Red color : FFT filter based FRR

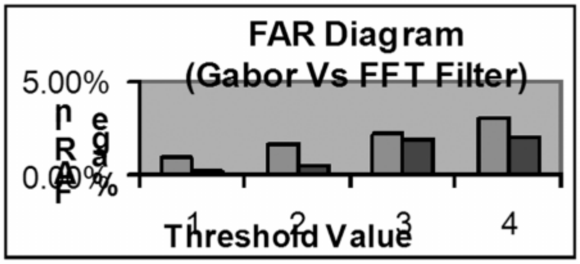


Fig. 8.2: FAR Curve Gabor Filter Vs. FFT Filter
Blue color: Gabor filter based FAR
Red color : FFT filter based FAR

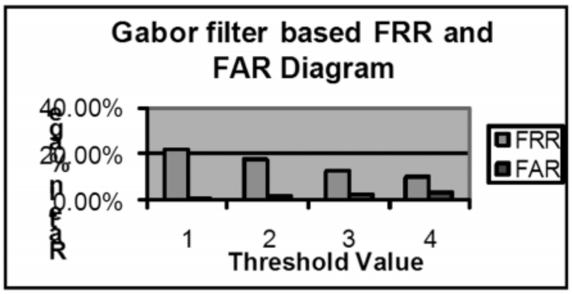


Fig. 8.3: Gabor Filter based FRR and FAR Curve
Blue color: Gabor filter based FRR
Red color : Gabor filter based FAR

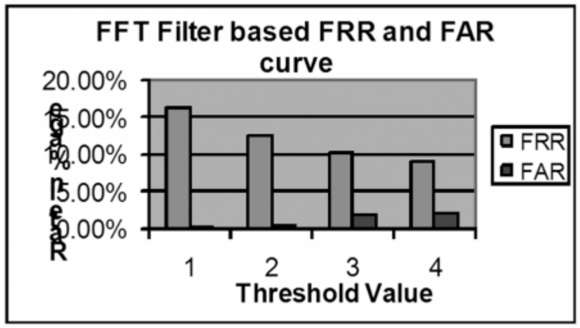


Fig. 8.4: FFT Filter based FRR and FAR Curve
Blue color: FFT filter based FRR,
Red color : FFT filter based FAR

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