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Fingerprint Recognition Using Hybrid of STFT and INLM with Rayleigh CLAHE

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Abstract— Existing security measures rely on knowledge-based approaches like passwords or token based approaches to control access to physical and virtual spaces are not very secure. Biometrics such as fingerprint offers means of reliable personal authentication. Human fingerprint exhibit some certain details marked on it known as Minutiae. In order to have a good quality minutiae extraction this paper represents an enhancement method which is a hybrid of Short Time Fourier Transform (STFT) and Interference-Normalized Least Mean Square (INLM) with Rayleigh Contrast Limited Adaptive histogram equalization (RCLAHE). Furthermore, we are using minutiae extraction and minutiae matching techniques for fingerprint recognition system.

Keyword— Fingerprint recognition, Minutiae matching, RCLAHE, STFT, INLM

I. INTRODUCTION

The skin of our fingers is made up of many ridges of skin that are created when we are still in the mother's womb. The fingerprint remains same for the rest of our lives, even surviving injury if not too severe. Each of the ridges connects to other ridges, forming a pattern that is unique to all others. No two people in the world have exactly the same fingerprint. This unique feature of fingers is used in many forensic cases to solve crimes [1]. Fingerprints are easily collected compared to other biometric signals. Fingerprints can be easily stored in a database. The required storage space depends on the representation of fingerprints that is chosen for the system. Fingerprint features are of two types global and local. The fingerprint surface is made up of a system of ridges and valleys that serve as friction surface when we are gripping the objects. The surface exhibits very rich structural information when examined as an image. The fingerprint images can be represented by both global as well as local features. The global features include the ridge orientation, ridge spacing and singular points such as core and delta. The singular points are very useful from the classification perspective. However, verification usually relies exclusively on minutiae features. Minutiae are local features marked by ridge discontinuities. Minutia is divided into two parts such as: termination and bifurcation. The performance of fingerprint minutia extractor and minutia matcher relies on the quality of the input fingerprint image. Due to various factors like skin conditions, noise introduced by sensor and inherently poor quality fingers, a significant percentage of fingerprint images is of very bad quality. Some bad quality fingerprints are shown in figure 1. These fingerprints are taken from some sensor of the same person. Thus an enhancement algorithm is required to improve the quality of the input fingerprint image.

Fig 1: Poor Quality Images

II. RELATED WORK

Several methods have been proposed for enhancement of fingerprint images. One of the approaches was given by M. Sepasian, W. Balachandran and C. Mares [2] which uses CLAHE with clip limit. This approach enhances the contrast of small tiles and combines the neighbouring tiles in an image using bilinear interpolation which eliminates the artificially induced boundaries. Another enhancement approach was given by Sharat et al. [3]. This approach consists of two steps. The first step contains STFT analysis and the second step does the contextual filtering. The STFT analysis gives the ridge orientation image, frequency image and the block energy image which is then used to perform the region mask. This approach utilizes the orientation, frequency and angular coherence for enhancement purpose.

Another method proposed by Jean-Marc Valin and Iain B. Collings [4]. They proposed INLMS algorithm for robust adaptive filtering which extends the gradient-adaptive learning rate approach. This algorithm is highly suitable for nonststionary signals.

III. PROPOSED METHODOLOGY

Our purposed approach for fingerprint recognition is described in the given flow chart figure 2. Firstly load the fingerprint image then the enhancement is done by using Rayleigh CLAHE method. Then the information extraction stage performs its operation on the enhanced image. The resultant image then passes through the various stages of minutia extractor and minutia matcher.

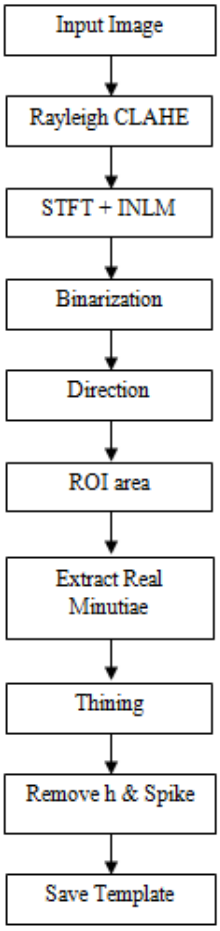

Fig 2: FLOW CHART OF PROPOSED METHOD

IV. IMAGE ENHANCEMENT

Image enhancement is a process in which the contract of the input image gets enhanced so that the features in the poor quality image can be easily extracted for better feature extraction process. Image enhancement process improves the contrast in the case of poor quality image. In this paper Rayleigh CLAHE (RCLAHE) process is used to enhance the input fingerprint image. RCLAHE limits the amplification of noise by clipping the histogram at a predefined value before calculating the cumulative distribution function (CDF) that limits the slope of the output CDF. The advantage of CLAHE is that it equally redistributes the part of the histogram above a clip limit among all the histogram bins.

RCLAHE process performs the following steps:

1. Firstly the input fingerprint image is divided into non-overlapping contextual regions.
2. In the second step the height of each histogram tile is clipped by the input clip value.
3. In this step the intensity value of the tile after clipping is transformed into Rayleigh distribution.
4. In this last step the resulting mapping at each pixel is interpolated using bilinear interpolation of the neighbouring sample points.

Figure 3 shows the effect of RCLAHE on the original fingerprint image.

Fig 3: EFFECT OF RCLAHE

V. INFORMATION EXTRACTION

A. STFT Process

During STFT process, the image is divided into overlapping windows. It is assumed that the image is stationary within this small window and can be modelled approximately as a surface wave. The fourier spectrum of this small region is analyzed and probabilistic estimates of the ridge frequency and ridge orientation are obtained. The STFT analysis also results in an energy map that may be used as a region mask to distinguish between the fingerprint and the background regions.

B. INLM Process

The INLMS algorithm extends the normalization to the interference signal. This approach is based on the gradient-adaptive learning rate class of algorithms but improves upon these algorithms by being robust to nonstationary signals.

Figure 4 shows the fingerprint image after the information extraction stage.

Fig 4: EFFECT OF STFT+INLM ON ENHANCED IMAGE

VI. MINUTIAE EXTRACTION & MATCHING

A. Fingerprint Ridge & Thinning

Ridge Thinning is to eliminate the redundant pixels of ridges [5].

B. Minutia Marking

After the fingerprint ridge thinning, marking minutia points is relatively easy

C. False Minutia Removal

It involves removal of h and spikes.

D. Minutiae Match

From the given two sets of minutia, the minutia match algorithm determines whether the two minutia sets are from the same finger or not.

VII. EXPERIMENTAL RESULTS

The evaluation and testing of the proposed approach has been done on fingerprint samples which are scanned with a sensor. Each sample is matched against the remaining samples of the same finger to compute the matching percentage. Table 1 shows the comparison of STFT process with the proposed method. Column first represents the sample fingerprint images, column second represents the matching percentage between samples using the STFT method and column third represents the matching percentage using the purposed method. From the given table it is clear that percentage matching gets improved in the proposed method.

Table 1: COMPARISON OF STFT WITH PROPOSED METHOD

SAMPLE FINGERPRINT	STFT (% MATCHING)	STFT+INLM (%MATCHING)
Figure 1(a)	100	100
Figure 1(b)	41.6667	33.333
Figure 1(c)	25	20.833
Figure 1(d)	25	25

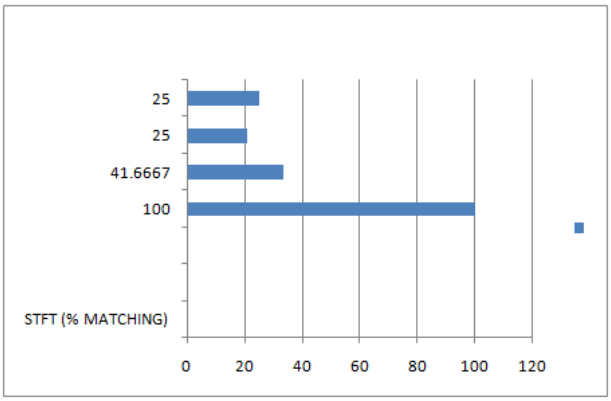

Fig 5: GRAPH BETWEEN STFT AND PROPOSED METHOD

VIII. CONCLUSION & FUTURE WORK

The reliability of any fingerprint recognition system strongly relies on the precision obtained in the minutia extraction process. A number of factors are detrimental to the correct location of minutia. So to increase the efficiency of fingerprint recognition system we proposed a method which is a hybrid of STFT and INLM with Rayleigh CLAHE. The performance evaluation shows that the matching percentage gets improved in the proposed method. In the future some other filter can be used or some other enhancement methods can be used.

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