Cross-correlation Based Algorithm for Fingerprint recognition Using MATLAB

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***Abstract*— This paper is a study and implementation of a correlation-based fingerprint recognition algorithm which is based on pixel values of images. This algorithm directly uses the gray-scale information of the fingerprints. The correlation-based fingerprint algorithm selects template, Pixel values of template is correlate with pixel values of all N number of images in existing database and looks for the maximum value in correlated data which is greater than some threshold value. Maximum value among correlated data gives the appropriate match of template from existing images in database. This paper involves implementation of cross-correlation based algorithm using MATLAB.**

Index Terms*— Cross-correlation algorithm, Fingerprint recognition, Image processing, Threshold setting.

I. INTRODUCTION

Fingerprint matching is a difficult problem due to the large intra-class variations (variations among different impressions of the same finger) and the small inter-class variations (images of different fingers may appear quite similar) [1]. Three fundamental reasons for the large intra-class variations are partial overlap, non-linear distortion, and sensor noise. Due to rotation and displacement of the finger placed on the sensor, there is often only a partial overlap between the template and query fingerprint images.

Further, changes in the applied finger pressure and skin conditions (dry skin, sweat, etc.) cause a change in the thickness of the ridges. Noise introduced in the fingerprint sensor in the form of residues left over the sensor surface due to repeated usage also contributes to the intra-class variations. Although it is unlikely that impressions of different fingers are identical in all respects [2], they may be quite similar in terms of their global structure and ridge orientations. This can lead to a number of false matches when the matchers rely on global features alone.

II. EXISTING FINGERPRINT RECOGNITION TECHNIQUE

A fingerprint usually appears as a series of dark lines that represent the high peaking portion of the friction ridge skin, while the valleys between these ridges appears as white space and are the low, shallow portion of the friction ridge skin.

Fingerprint identification is based primarily on the minutiae, or the location and direction of the ridge endings and bifurcations (splits) along a ridge path [3].Following are minutiae extraction and pattern based existing fingerprint recognition techniques.

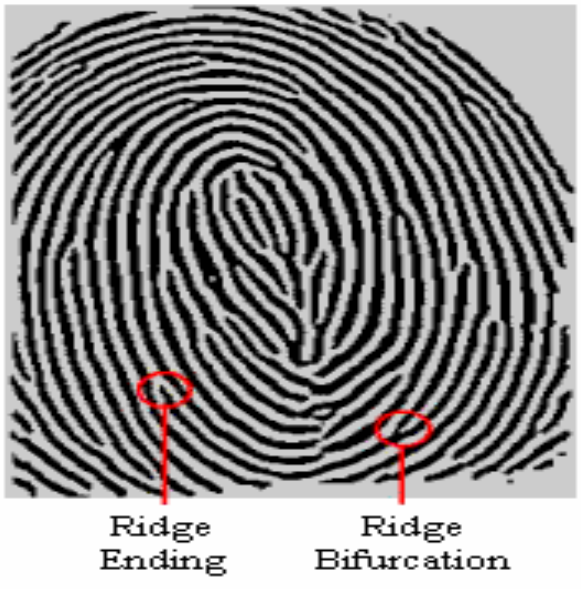
A. Minutiae Extraction Technique:

Most of the finger-scan technologies are based on Minutiae. Minutia-based techniques represent the fingerprint by its local features, like terminations and bifurcations. This is the most popular and widely used technique, being the basis of the fingerprint comparison made by fingerprint examiners. Minutiae are extracted from the two fingerprints and stored as sets of points in the two-dimensional plane. Minutiae-based matching essentially consists of finding the alignment between the template and the input minutiae sets those results in the maximum number of minutiae pairings.

Typical fingerprint extraction technique uses following four steps [3]:

1. Ridge orientation/frequency estimation
2. Fingerprint enhancement and binarization Ridge thinning
3. Minutiae extraction with spurious minutiae removal

Figure 1 shows the minutiae on fingerprint



Manuscript received March 17, 2014.
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Figure 1: Minutiae

B. Pattern Matching or Ridge Feature Based Techniques:

Feature extraction and template generation are based on series of ridges as opposed to discrete points which forms the basis of Pattern Matching Techniques. The advantage of Pattern Matching techniques over Minutiae Extraction is that minutiae points may be affected by wear and tear and the disadvantages are that these are sensitive to proper placement of finger and need large storage for templates.

Pattern based algorithms compare the basic fingerprint patterns (arch, whorl, and loop) between a previously stored template and a candidate fingerprint. This requires that the images be aligned in the same orientation. To do this, the algorithm finds a central point in the fingerprint image and centers on that. In a pattern-based algorithm, the template contains the type, size, and orientation of patterns within the aligned fingerprint image. The candidate fingerprint image is graphically compared with the template to determine the degree to which they match.

Figure shows patterns of fingerprints:

a)Arch pattern b)Loop pattern c)Whorl pattern

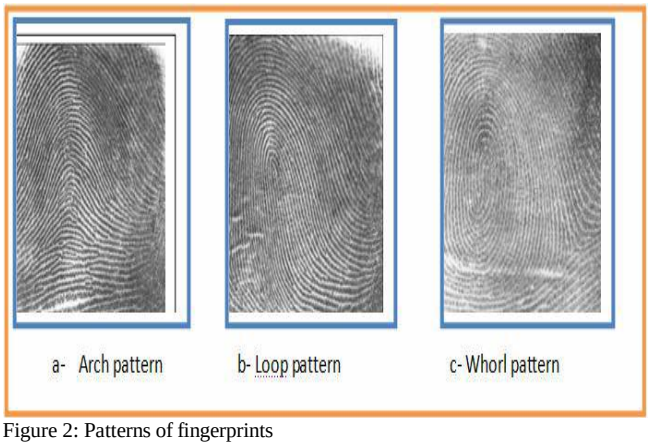

Figure 2: Patterns of fingerprints

III. IMPLEMENTED ALGORITHM

- Cross-correlation based matching technique:

Cross-correlation based matching technique belongs to the category of area based matching algorithms in which rectangular blocks of pixels from a pair of M X N images (left and right images) are compared and matched (see fig 3) [5].For each block of the right image (reference window), a corresponding block in the left image is sought, using a given similarity measure as main criteria (see fig 4).

During the search process, the left image block is displaced by integer increments (c, l) around a predefined region (search window), and an array of similarity scores d(c, l) is computed (see equation 1).The position (cM, lM) of the moving block corresponding to the maximum computed value of the considered similarity function (multiplication operator) for that search window is selected and chosen to obtain the optimum disparity vector corresponding to that reference window. Similarity measures based on cross-correlation function. Hence a matching dense field D(x, y) is computed by using as many overlapping search windows as the number of pixels of the image, thus obtaining a disparity vector for each pixel (see equation 3). Maximum value among the dense field is computed to give the appropriate match result and this should be greater than threshold value.

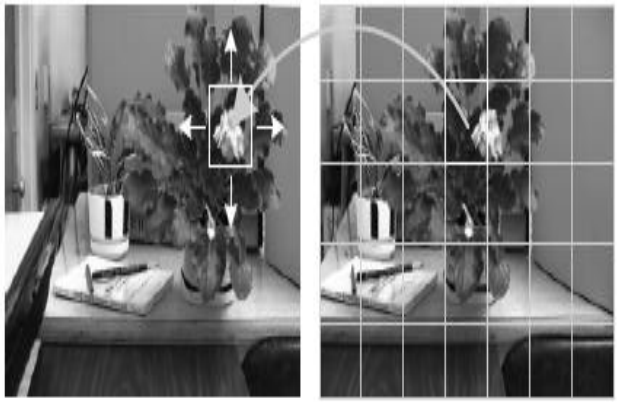

Figure 3: Disparity map estimation process

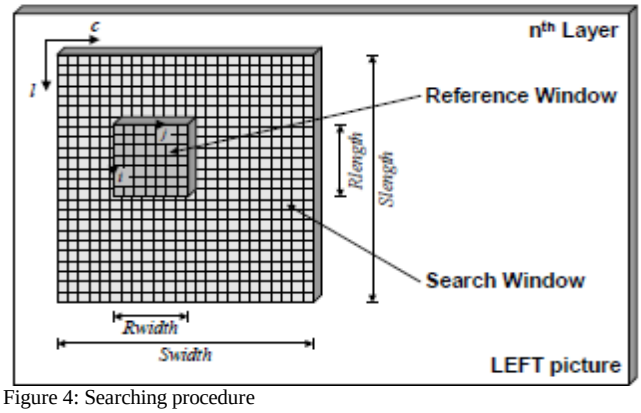

Figure 4: Searching procedure

- Mathematical expression for Cross-correlation Technique:

$$d(c,l) = \sum_{v=0}^{Rwidth} \sum_{u=0}^{Rlength} R(u,v) \cdot S(c+v, l+u)$$

---- equation1

$$d(cM,lM) = \max\{d(c,l); 0<=c<Swidth; 0<=l<Slength\}$$

---- equation2

$$D(x,y) = \max\{d(cM,lM) >= \text{threshold value}\}; \quad 0<=x<M; 0<=y<N$$

---- equation3

- Steps to get threshold value:
  - i. Get all the images of database.
  - ii. Compare each image of the database against all the images using cross-correlation function and compute matrix d(c,l) .
  - iii. Find the maximum value of matrix d(c,l) after every cross-correlation and d(cM,lM).
  - iv. Create meshplot of matrix d(cM,lM) using MATLAB function 'mesh(d(cM,lM))'
  - v. Observe peak values of mesh plot and according to it set threshold value which will give more accurate result to find match image.

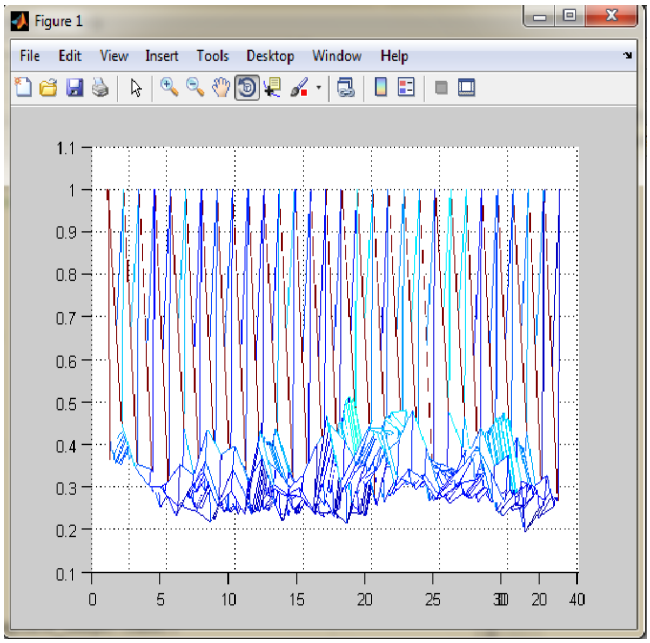

Figure 5: Meshplot to get threshold

IV. SUMMARY AND FUTURE WORK

This paper introduced limitations of Minutiae based and pattern based algorithm over cross-correlation based algorithm. Cross-correlation based algorithm is less time consuming and requires less preprocessing of image compare to Minutiae based and Pattern based algorithms but it is less accurate than other two.

Future work of this algorithm will focus on to implement more accurate matching with combining Minutiae based technique and cross-correlation algorithm for fast computing.

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