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A Novel Method for Fingerprint Recognition Using Trifurcation, Eye Enclosure

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ABSTRACT

The paper presents an offline fingerprint detection technique using a novel minutiae detection approach which considers trifurcation and Eye Enclosure points. Features like bifurcation, ridge ending, core and delta points were being used as unique identifiers. This approach advances bifurcation in the form of trifurcation and combines it with eye enclosure feature. The technique is based on the number of computation points obtained along with the location of these minutiae points in the morphed image. The novel approach utilizes the Self Organising Feature maps for classification.

Keywords: Fingerprint recognition, Self Organising, Feature Map, Trifurcation and Eye enclosure points

I. INTRODUCTION

Fingerprint classification is used to claim the identity of an individual due to its uniqueness [10]. Being one of the most useful biometric technologies, a fingerprint is distinguished by the relationship amongst its local characteristics. The three basic patterns of fingerprint ridges are the arch, loop, and whorl. Fingerprint matching techniques are divided into three main types [14]:

- Correlation based matching – After aligning the fingerprints, the relationship between each corresponding pixel is computed, but since the displacement and rotation are not known beforehand, it is imperative to apply the correlation for all possible alignments.
- Minutiae based matching - This technique refers to the analysis of some unique point's display on fingerprint called minutiae points whose extraction and representation is also known as minutiae set Minutiae based matching is implemented in our proposed algorithm.
- Pattern based matching – This algorithm compares the following fingerprint patterns: loop, arch, and whorl. Fingerprint representations are of two types:

  Global (Level 1)

  Local (Level 2)

In this paper, minutiae based technique has been employed. The accuracy of this technique is fingerprint quality dependent. The most popular minutiae features are Terminations and Ridge Bifurcation. In our approach, we have proposed a new set of features such as, Trifurcations and Eye Enclosures. The simplest way of representation of the minutiae based features constitutes of a structure of points determined by their coordinates and calculating their location as a feature. The use of Self Organising feature maps decrease the computation by classifying fingerprints into 4 classes.

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II. RELATED WORK

In [1], Neeraj Bhargava et al. proposed a Minutiae-based technique by establishing correspondence between two fingerprints based on ridge ending and bifurcation points using 3x3 window size. Kekre and Bharadi[2] proposed a correlation based technique to detect a singular point such as core (loops). In [3], Paulino et al., the approach consisted of combining minutiae, singular points, and orientation field and frequency information. In [5], Kamil Surmacz et al. used core and delta points of a fingerprint as singular points. In [17], Khalil detected core points based on Poincare Index methods for camera based fingerprint imaes.

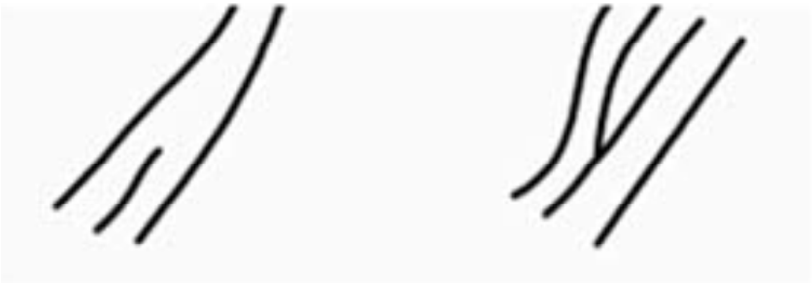

Figure 1(a): Ridge ending and (b) Ridge bifurcation

Previously following features were used as unique fingerprint identification:

- Bifurcation - A point in a fingerprint image at which two ridges meet
- Ridge – A ridge is continuous line in a fingerprint like a ridge termination.

Singular points are often used as a distinctive feature. The two types of singular points usually seen in practice are as follows:

- Core – A U-turn in the ridge pattern. Core point is the uppermost point of the innermost ridge.
- Delta – A Y-shaped ridge meeting. Delta is formed by the bifurcation of a single ridge or by an abrupt divergence of 2 ridges. It is a triangular shaped pattern where the ridge flow diverges i.e. the point where ridges from three directions meet Delta is much more difficult to obtain which is why usually core points are used.

When a fingerprint is obtained from an individual, minutiae is computed for each image along with the precise locations of the minutiae which is further stored in a computer database. Using suitable classifiers, the input image is compared to the data set belonging to that particular class.

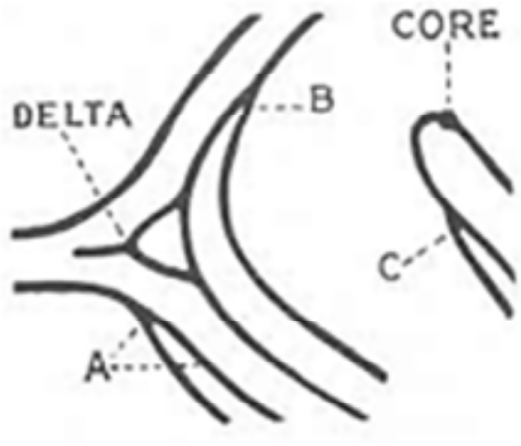

Figure 2: Core and Delta Singular points

III. ALGORITHM PROPOSED

The input to the algorithm is a fingerprint and the desired output is a matched fingerprint from the training dataset. For this work we have used NIST-4 [12] database. The algorithm proposed for fingerprint recognition has the following steps as shown in figure 3.

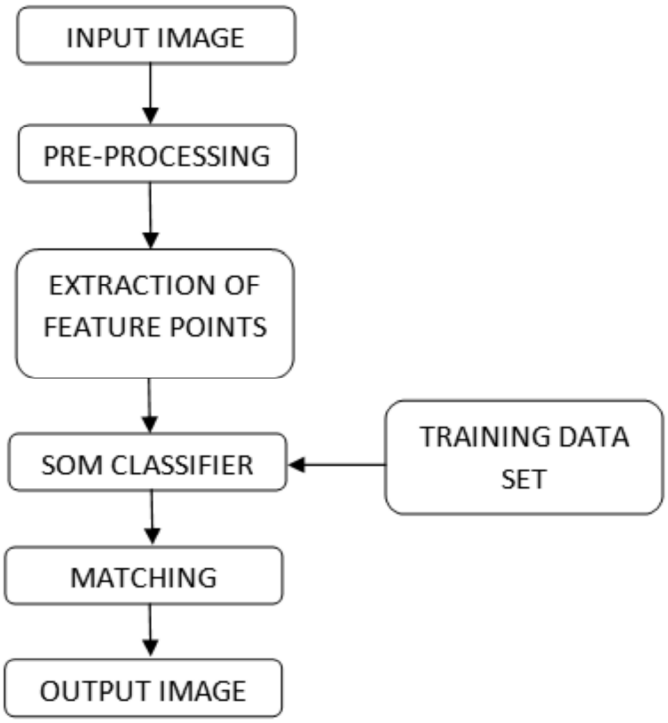

Figure 3: Steps in Algorithm Proposed

3.1. Input enhancement

i) Histogram Equalization: The first step in pre-processing is to adjust the intensity values so that the histogram of output image matches a flat histogram.

ii) Binarization: In this process the input image of the fingerprint which is in grayscale is converted to binary image which is black and white image (also known as binary image). Each pixel value is compared with an incoming threshold value. Those pixel values which have luminance greater than a predefined "level" is assigned value 1 and the rest of the pixels are assigned value 0. At the end of this process the value of each pixel is either one (representing fingerprint ridge line) or zero (representing empty space).

iii) Image thinning: It is a morphological process to set the thickness of all ridges lines present in the fingerprint into single pixel width [13]. This process does not convert the original pixel location and angle of direction, which assures no loss of information and true calculation of minutiae points. This method is also known as Block Filtering. In this step it is important to ensure that the ridges are thinned to their respective centre pixel as shown in Figure 4.

3.2 Feature detection

i) *Trifurcation points:* A trifurcation is basically the forking or dividing of one line into three or more branches. We have used trifurcation as one of the key features because the frequency of bifurcation is higher than trifurcation. As the size of the database increases the number of comparisons also increases. The binary representation for a trifurcation used in our algorithm is shown in figure 5(b). A matrix of 5x5 pixels is taken and trifurcations are detected as per the shape depicted.

Figure 4: Thinned Image

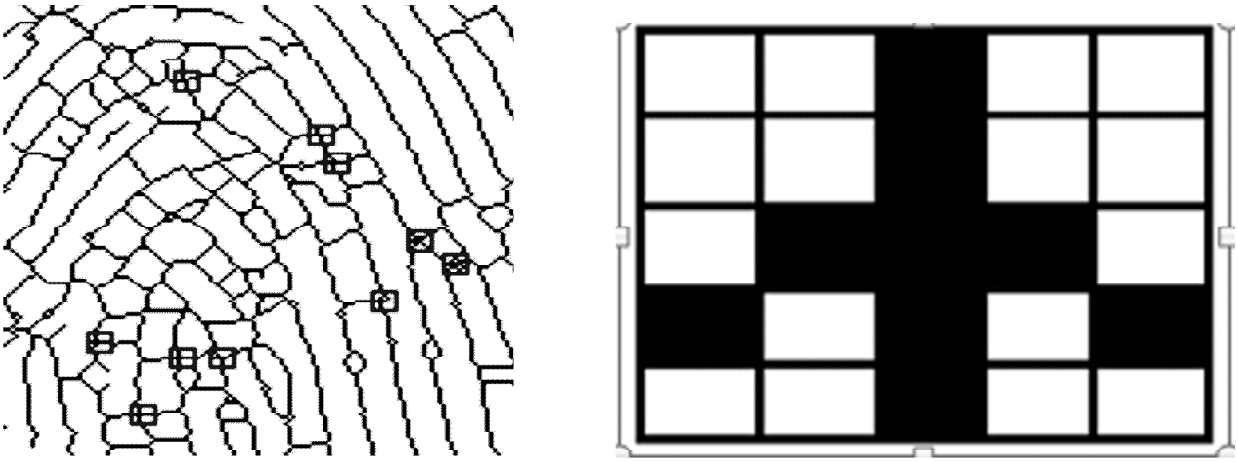

Figure 5(a): Trifurcation Detection (b): Binary Representation for Trifurcation

ii) Eye Enclosure points: An eye enclosure can be considered as a collection of two bifurcations depicting an eye like structure. They are simply small circles present in between a line and can be used as another feature for fingerprint detection. The binary representation of the eye enclosure is shown in Figure 6(b).

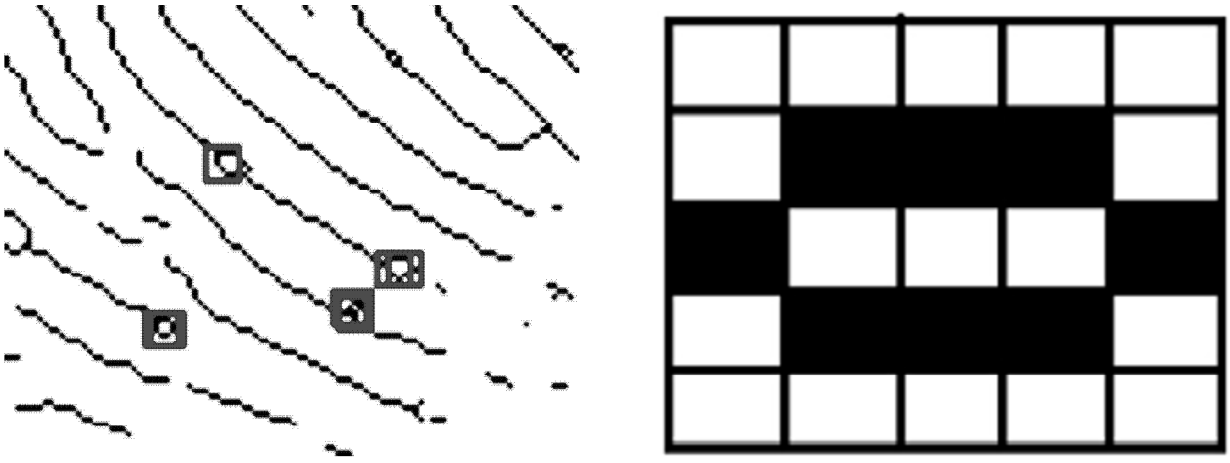

Figure 6(a): Eye Enclosure Detection (b): Binary Representation for Eye Enclosure

3.3. Computation of points

The points of trifurcations and eye enclosures were detected on a dataset of 500 fingerprints (NIST-4 [12] database) some of the results are shown in Table 1). Due to lower number of trifurcation points but it's significance as a feature, eye enclosure points were used to enhance the fingerprint quality. The combination of trifurcation and eye enclosure points in the results shown can act as a basis for fingerprint recognition due to its significant presence.

Table 1
Points computed for detection

Images	*Trifurcation Points*	*Eye Enclosure Points*
101_1.jpg	7	94
101_2.jpg	32	349
101_3.jpg	24	170
101_6.jpg	24	265
102_1.jpg	36	376
102_2.jpg	10	103
102_3.jpg	23	279
102_5.jpg	14	152
102_6.jpg	13	154
102_7.jpg	12	127

3.4. Classification

Classification of fingerprints is done using the Self Organising Map Neural Network Technique to minimize the future computation complexity for fingerprint matching. This algorithm classifies the fingerprints into 4 classes. Figure 7 shows the weighted positions of the sample points during training. SOM technique works on principles of competitive learning which delivers better results. The aim of this technique is to set the dimensionality of vectors to a predefined value and hence converting the input space into classes by providing linear transformations.

3.5. Matching

After the classification, the next step involves recognizing the class of the input sample and calculating intra-cluster distance using the Euclidean Classifier. Utilizing the axis coordinates of the point locations, the matched fingerprint is returned. This includes evaluating sum of squared differences of feature vectors of the input image with every image of the recognized class. If the matching score is less that a predefined threshold then the image is returned as a match.

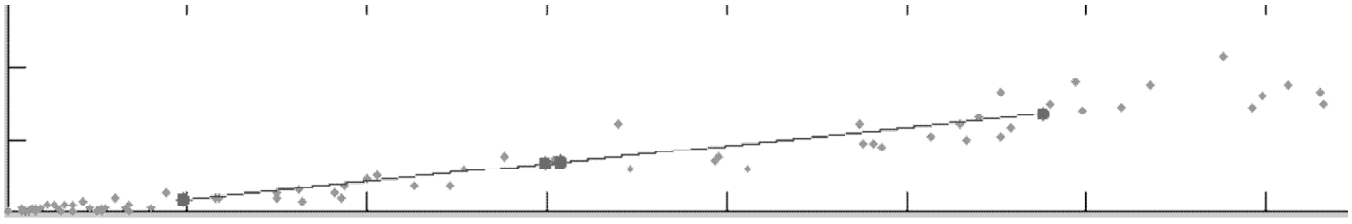

Figure 7: Weighted positions of sample images using SOM

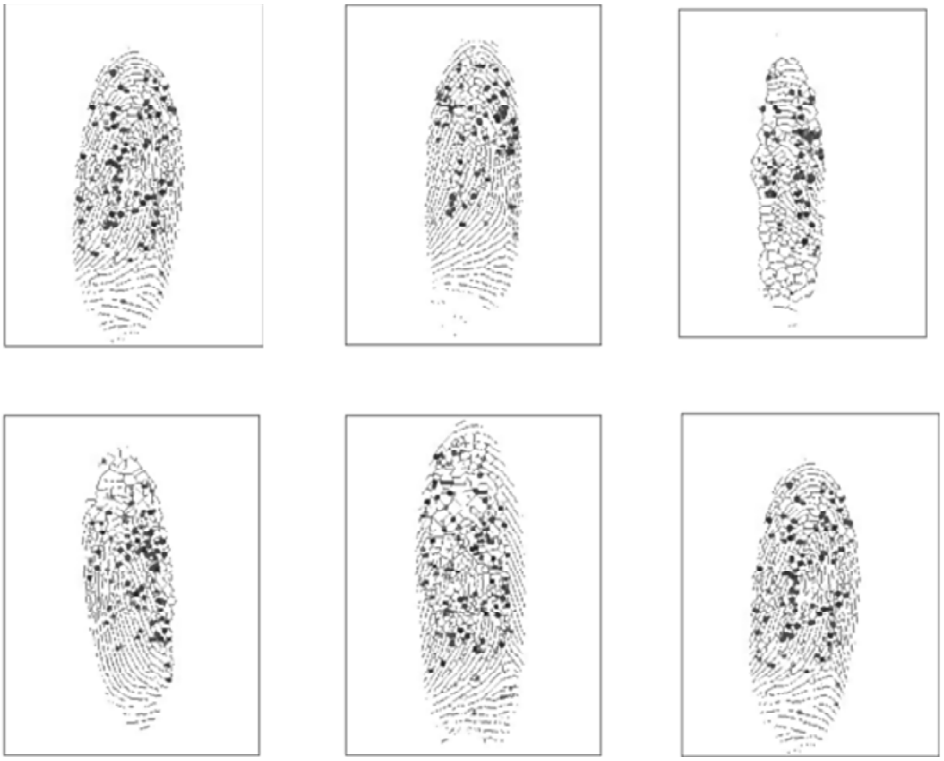

Figure 8: Results obtained after trifurcation and eye enclosure detection

IV. RESULTS AND DISCUSSIONS

The results obtained after the trifurcation and Eye enclosure point detection in Figure 8 show distinctive features found throughout the fingerprint image. The points obtained in blue are Trifurcations and the ones in red are Eye Enclosure features. These are then classified using Self Organising Feature map into four classes based on computational points. Based on the percent of correct samples classified, the efficiency of Self Organising Maps was explored. Self Organizing Maps gave quite impressive results with the fingerprint classification. The classification decreases the computational efficacy as the required calculations are now reduced to one-fourth. Due to the competitive learning approach of the Self Organising Maps rather than error-correcting technique, the results obtained were worth consideration.

V. CONCLUSION

Fingerprint Recognition has been achieved using the novel method for detection of trifurcation and eye enclosures as described above. The combination serves as a distinctive feature and produces more accurate results. After the feature detection, the points extracted were divided into classes to decrease the computation number. Finally, on comparison of their coordinate points, the fingerprint is successfully recognized. This research paper shows that minutiae detection can be done through minutiae point calculation as well as location of minutiae points through Self Organising Maps Neural Network Technique which yielded impressive results.

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