Hybrid Fingerprint Recognition Algorithm Based on Self Organized Map Neural Networks

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Abstract

Fingerprint recently has quite unique applications in many fields such as crime investigation and workers attendance control. The fingerprint is a personal identification tool as it differs from one person to another. Recent advances in computer programming and software production led to facilitate the use of fingerprint as a powerful computerized tool. This paper aims to develop a modified hybrid fingerprint recognition system, based on artificial neural network with Kohonen self-organized map (SOM), with minutiae matching technique. In order to recognize fingerprints, the acquired fingerprint data sets should be processed to enhancement the image for minutiae extraction. Image segmentation technique was implemented to localize the effective area of the fingerprint followed before applying the minutiae extraction that includes ridge thinning and minutiae marking. Then removal of the H-breaks, isolated points and false minutiae is applied.

Keywords: *Kohonen Self Organizing Map, Binarization, Minutiae Extraction, Fingerprint, Biometrics, Ridge Thinning.*

1. Introduction

The fingerprint is a unique identification print of humans that represents the most used biometrics ever. Even though, it is less unique than the voice and iris, but it considered to be the best and the oldest method used in biometric identification of humans. That was due to easy access, stability, and rigidity via environmental variations. It's unique, very secure and reliable to use and does not change over all lifetime. This paper gains the advantages of finger print properties to implement a minutiae matching technique with Self-Organized Map (SOM) which is a neural network algorithm that uses a competitive learning technique to train itself in an unsupervised manner.

To automatically recognize the fingerprint, this paper doesn't depend on the similarities or semantics, but it uses minutiae which one characterized by abnormal points on the ridges. There are two main significant of minutiae that is processed in this paper; the "Termination" which mean the immediate ending of a ridge, and the
"Bifurcation" that mean the point that is located on the ridges [3].

An important goal of the presented technique is to be cheap, reliable and accurate up to satisfactory limits; here this paper are going with, minutiae matching technique for fingerprint recognition which can be divided into two sub-domains: one can be classified as fingerprint verification and other one can be classified as fingerprint identification. The verification is one-to-one, while the identification is one-to-many recognition [5].

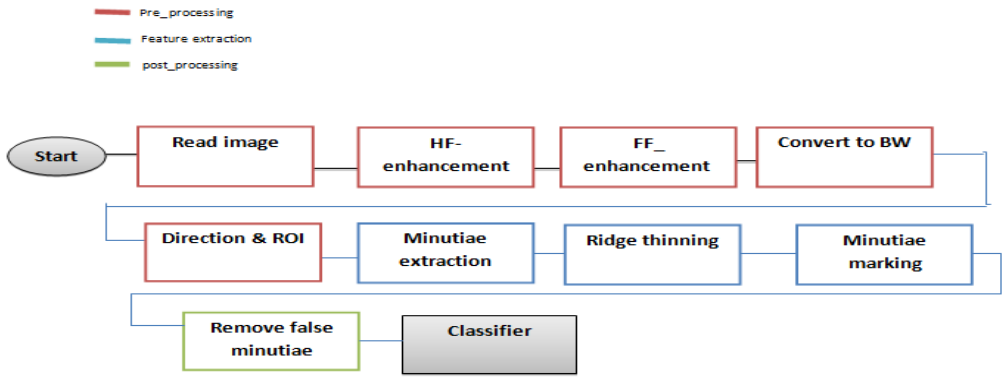

Figure 1. Block diagram of the presented algorithm

Figure 1 illustrates the block diagram of the presented algorithm. The colors in the figure represent the stage of processing; the red represents the preprocessing operations, the green represents the post-processing operations, and the feature extraction operations are colored in blue.

The first phase of the presented algorithm is to preprocess the acquired images for figure prints. The preprocessing is being done in terms of image processing and digital signal processing. The image should be subjected to the following operations: history equalization, fast Fourier transforms, image binarization, and ridge flow estimation. This is being done in order to extract the region-of-interest (ROI).

The minutia extraction process is consists of two parts; ridge thinning, and minutiae marking. The post processing process aims mainly remove false minutiae [1].

2. Literal Review

Many fingerprint identification systems were developed to automatically either verify or identify the human by his biometrics. Some researchers were depending on minutiae. Recently non minutiae based systems as well as systems that use a combination of the features has been developed.

(Jea et al, 2005), propose a fingerprint recognition system based only on minutiae matching. This method was satisfactory for partial images of fingerprint, where the core points or other important features of the fingerprint cannot be fully estimated.

(Ross et al, 2006) used the thin-plate spline function (TPS) for the estimation of an “average” deformation model based on ridge curve correspondences for a specific finger, when several impressions of that finger are available. The benefits of this method are that minutiae are extracted only on the template image. So it is error-tolerant with respect to the precise evaluation of such points, and function of the pre-processing techniques.

3. Methodology

Neural network improves the problem solving techniques for the problems where analytical solutions are computationally complex, heavy or even do not exist. The problem that commonly gotten in feature extraction and classification is that, it offers significant speed advantages over conventional techniques.

The algorithm that is presented in this paper implies edge detection techniques that are based on derivatives-based techniques (i.e. Sobel), which will be combined together with connected component algorithm in order to enable extraction of the features using histogram. The SOM neural network is being used to classify the extracted features.

SOM cause different parts of the network to react similarly to certain input pattern, by dividing the area into classes based into training data, in this case the features of the fingerprint. The nature of the automatic fingerprint recognition stating that, the most neural network that is suitable for this problem solving is almost the SOM. That comes from the fact that, the SOM is fast running algorithm, unsupervised and low memory size data structure. This is why this paper implemented the SOM in the presented algorithm.

4. Image Processing

Histogram equalization technique is used to increase the contrast of the image in case of unbalanced light intensity or illumination.

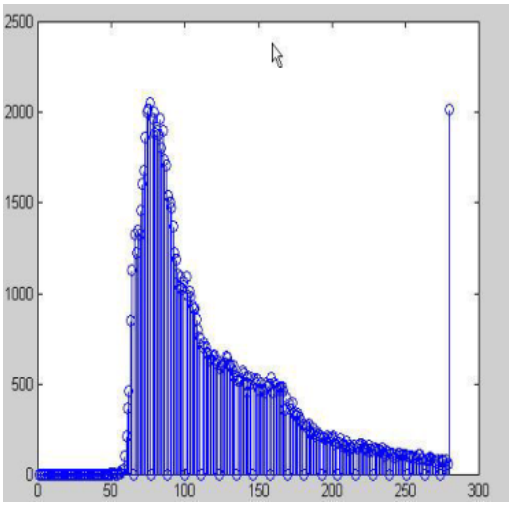

Figure 2. Original histogram of the image of sample image

Figure 2 illustrates the histogram of a sample fingerprint image. The figure print image itself is shown in the Figure 3 to the left.

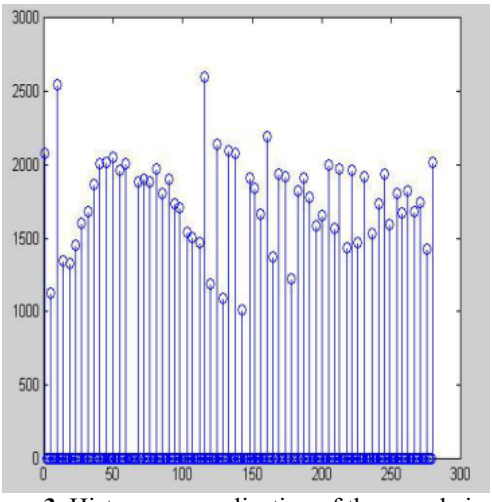

Figure 3. Histogram equalization of the sample image

Figure 2 represents the original histogram of the image, while Figure 3 shows the histogram after equalization filter.

The used equalization filter is the histogram density function with histogram specification transformation function. The contrast of the resulted image is equalized and the light intensity is distributed over the image with more enhancements.

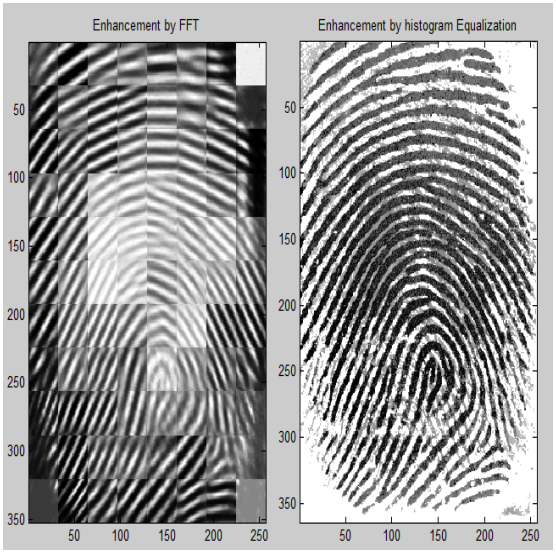

Figure 4. Histogram equalization filter

Figure 4 shows the histogram equalization of real fingerprint image, where the left image is the original one, and the image to the right is the histogram equalized image.

By the use of fast Fourier transform (FFT), the image is divided into sub images for processing each of size 32 x 32 that contains the FFT constant (0-1) to fill the small holes in depth variations, and connect falsely broken points on depth variations, and remove some non-real connection between depth variations or ridges [4].

Fingerprint image binarization should be done to transform an 8-bit gray image to a 1-bit binarized image where 0-value holds for ridges and 1-value for furrows. The complete features those are required to perform the recognition process are available in the binary image. So, there is no actual need for the gray image. Then, the ridges in the binarized image are highlighted with black color and furrows are highlighted with white color. The highlighting technique is performed by the means of Laplacian edge detection operator filter. Thus the resulted image will be black and white one.

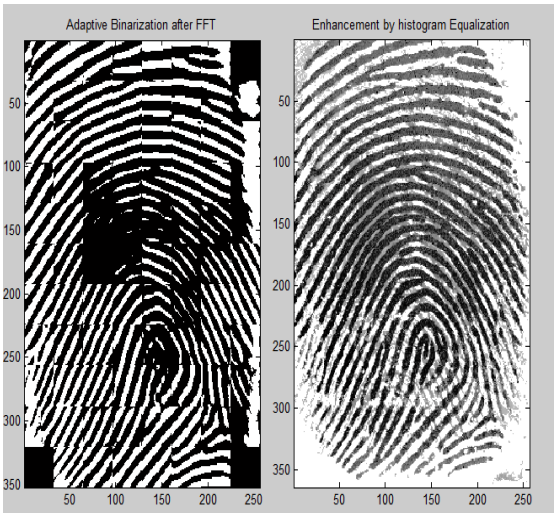

Figure 5. Image binarization result

Figure 5 shows the binarization results in comparison with un-binarized image. The left image represents un-binarized image that is gotten by histogram equalization as shown in Figure 4. The left image shows the binarization result for the same image.

The next step is applying thinning algorithm to enhance the binary image. Thus, it reduces the ridges to a skeletal structure.

5. Fingerprint Image Segmentation

The region of interest (ROI) represents the part that holds meaningful information that is required to be recognized. The regions or parts of the image that don't contain any important furrows or ridges should be ignored during the processing. It will be considered to be background information.

The ROI could be extracted in over two steps; block direction estimation or direction variety checking, and morphological operator processing. The extracted ROI is shown in Figure 6 at the right side.

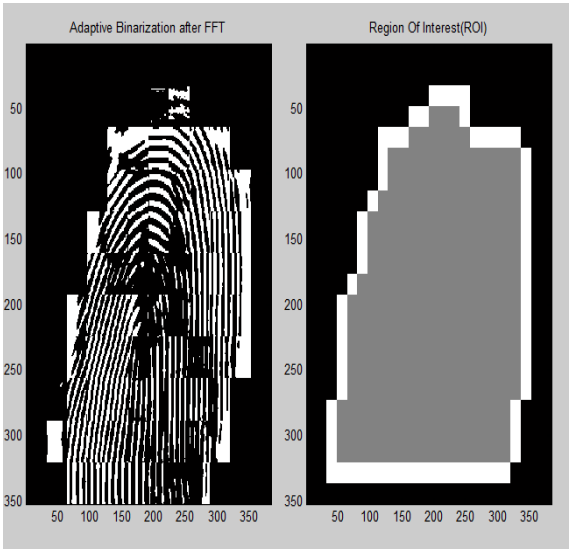

Figure 6. Fingerprint Image Segmentation-ROI

6. Minutiae Extraction

An efficient way to represent the structural shape of a plane region is to reduce it to a graph. Applying thinning algorithm which called also Skeletonizing enables to build that reduction. The thinning algorithm deletes the unwanted edge points, but it should not delete end points, break connectedness and cause redundant attrition of the region. Minutiae extraction results are shown in Figure 7.

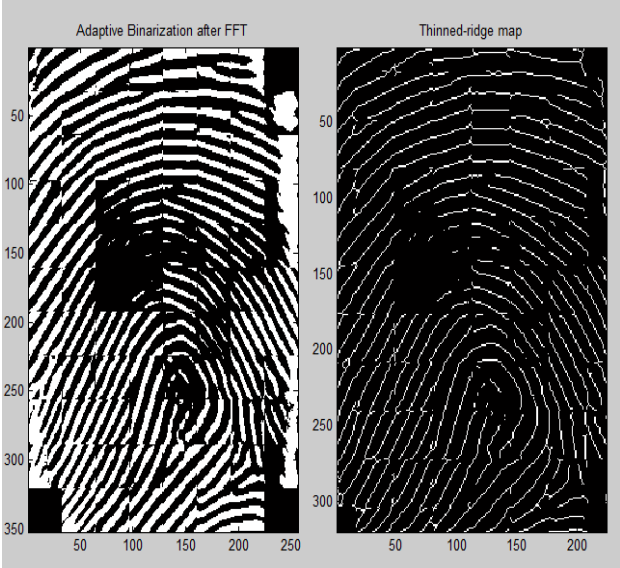

Figure 7. Minutiae Extraction

The region of interest (ROI) is shown in Figure 7 at the left, while the minutiae extraction is shown at the right side of the figure [1].

7. Feature Extraction

Feature extraction is the process of selecting the best features in the signal / image where such features represent the major signal discriminators and characteristics. The feature extraction process minimizes the data that is needed to be used in matching, as the case of SOM in this paper.

Actually there are a very large number of minutiae types that could be identified, that could be more than 150. Whereas, practically, just the depth variation ridge ending and ridge bifurcation will be used in this paper.

The feature extraction phase aims to localize the ridge endings and ridge bifurcations from the input image. It structured of consists of three stages; orientation field estimation, ridge extraction, and minutiae extraction and post processing.

8. Classification Algorithm

The neural network based classification algorithm initially inputs the orientation of input image and the ridge extraction results to the neural network neurons. This image is used for Minutia Point extraction to train neural network. After matching there is a difficult problem due to large variability in different impressions of the same finger.

The class variations in this paper is determined by rotation direction, rotation value, displacement, distortion (non-linear), partial overlapping, and sometime the skin characterizations. As shown in Figure 8.

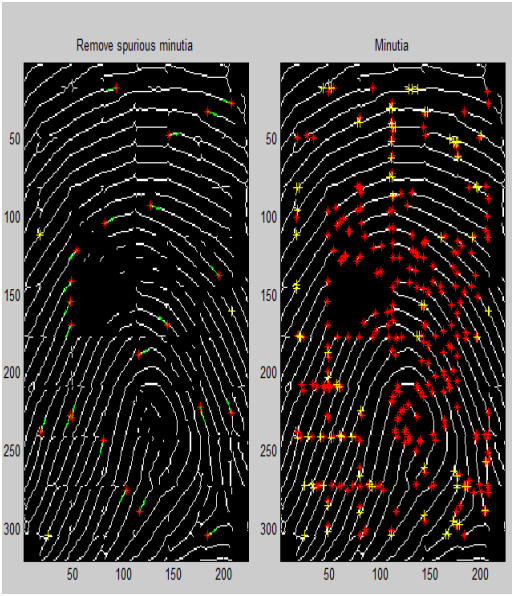

Figure 8. Minutia matching

Matching of figure print patterns could be done achieved through many techniques. The most common and efficient techniques are the correlation based matching, ridge feature based matching, and minutiae based matching.

As shown in Figure 8, the extracted minutiae (red dots), represent estimated minutiae as obtained by the proposed scheme (yellow dots).

9. Neural Network

The Self-Organizing Map (SOM) neural network is a computational network algorithm with unsupervised learning (i.e. no large historical data set is required) based on a grid artificial neurons whose weights are adapted to match input vectors in a training set. SOMs differ from other ANN algorithms that they use a neighborhood function to maintain the topological properties of the input space and they have been used to create an ordered representation of multi-dimensional data that make the relationships of reveals meaningful and complexity simpler.

The training set of fingerprint recognition algorithm that is implemented in this paper depends on two types of learning; competitive and cooperative learning.

In competitive learning, the prototype vector which is most similar to data vector is modified so that even more similar to it. In such, the map learns the position of the data cloud. On the other hand, the cooperative learning comprises the most similar prototype vector and its neighbors on the map are moved towards the data vector. This type of mapping is considered to be self-organized [2].

The SOM networks have two primary quality properties; high accuracy of data representation, and high topological representation accuracy of the data set. These two criteria led the accuracy of any system designed based on SOM.

10. Result

SOM neural network based algorithm for fingerprint identification is presented in this paper as hybrid algorithm with feature extraction technique. The minutiae of the template image are used as neurons of neural network and algorithm detects the set of minutiae in the input in an iterative way.

The implemented system of fingerprint recognition performance measurements in this paper is being done in terms of two performance criteria; false acceptance rate, and false rejection rate. The false acceptance rate (FAR) is a percentage that is being calculated as equation (1), and false rejection rate (FRR) is a percentage that is calculated as illustrated in equation (2).

$$FAR = (FA/N) X100\% \quad (1)$$

Where,
FA: number of cases of false acceptances of sample
N: number of sample.

$$FRR = (FR/N) X 100\% \quad (2)$$

Where,
FR: number of false rejections
N: number of sample

The simulation results are presented in table 1. It shows that, error in the presented algorithm is very low and accepted; the false rejection rate is 1% over the training sample. The false acceptance is also has similar percentage. This means that, the accuracy and precision of the proposed algorithm reaches 99%.

Table 1.**Simulation results**

Sample	Training	Testing
FAR	1%	2%
FRR	1%	1%

11. Conclusion

This paper presented a hybrid algorithm that is based on SOM neural network with minutiae matching that finds the correspondences between input minutiae and the stored template minutiae pattern. It has been found that after training and storing the weights, the system will recognize any new weight matching those stored in the database.

The unsupervised learning neural network provides two benefits for the intelligent machine learning recognizer; the speed and memory efficiency. Hence, it doesn't need large historical data, it saves a lot of memory space, and that also help to speed up the training process. The self-organized map (SOM) structure removes redundancy in neural network nodes thus, speed up the weights propagation while simulating output of a specific results.

The problem that faces the evaluation of this system exists in training of SOM the networks. The best number of iterations to be used sometimes needs several trials to be determined. The suggested preprocessing extracts the meaningful features that hold important discriminating features to recognize the signal and to classify it. Thus, the feature extraction that is suggested is an important stage to help the neural network classification phase. In that way, the network will not undergo any un-wanted data information less input data.

12. References

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