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PALMPRINT RECOGNITION BASED GABOR WAVELET TRANSFORM USING K-NN CLASSIFICATION

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Palmprint recognition system is regarded as the reliable and accurate biometric identification system available. Viewed in the palmprint recognition system of biometric approaches, compared to other models because it is a new handheld biometric feature recognition system has recently attracted the attention of researchers. In this study, palmprint recognition system based on Gabor wavelet transform has been developed. Firstly, image coordinate system is defined to facilitate image alignment for feature extraction. Then, region of interest is cropped from the palmprint images. With developed system feature extracted of region of interest and given of k-NN classifier.

Keywords: *Biometric, Palmprint recognition, Gabor wavelet transform, k-NN.*

I. Introduction

Biometry deals with a number of measures which are naturally possessed by individuals. Biometric properties are classified into two groups which are known as physiological and behavioral properties. Talking, walking, body movements and signature could be given as examples for behavioral biometric properties. Finger-print, palmprint, face-shape, iris and retina may be given as well-known examples of physiological properties [1, 2].

Comparing to the other models, palmprint is a new biometric property throughout the biometric approaches [3]. In comparision with the other biometrics, there are some advantages of palm, as followings;

- It can be used for low-resolution images.
- Low-cost cameras could be adequate to obtain the images.
- It is too difficult to imitate the palmprint.
- Palmprint features are characteristic and persistent.

As a result of these reasons mentioned above, palmprint recognition systems are recently attracted interest by researchers.

There are many approaches conducted on hand geometry [4] such as line-based [5], texture-based [6] and appearance-based [7] methods.

So far, a lot of algorithms have been developed on palmprint recognition. Developed algorithms fundamentally include different methods such as feature extraction and distance mapping.

In proposed algorithm [8], they used Line Edge MAP (LEM) approach and Haussdorrf distance algorithm for feature extraction and distance mapping, respectively. The algorithms of Line Segment

Haussdorrf distance (LHD) and Curve Segment Haussdorrf distance (CHD) work with two sets of curves and the logic of matching two sets of lines.

As a distance matching algorithm, Modified Line Segment Hausdorf (MLHD) distance algorithm was proposed [9]. 2-D low passing filter was applied to sub-image obtained from a hand image. This process was applied to reduce the illumination effect of a 3-D object imagining on 2-D object imagining.

Each line from palmprint was defined by using various straight line elements through the steps of line capture, boundary detection and line cutting [10]. Finally, MLHD was used to measure the similarities between two palmprint images.

Shang L. [11] was proposed algorithms which using neural networks. Neural network model used by them was Radial-based Probabilistic Neural Networks (RBPNN). The RPBNN structure works with the Orthogonal Least Square (OLS) algorithm. In this structure, optimization was done by iterative OLS algorithm (ROLSA). A fast algorithm connection point was used for the analysis of independent components. Recognition rates varies between 95% and 98% after the tests applied in the database.

This study was conducted by using the database belonging to Hong Kong Polytechnic University (PolyU) [12].

PolyU palmprint database consists of 7752 gray-level images of 386 different palmprint images in bmp format. Approximately 20 images were captured in each section from each of the palmprint images. 10 samples were collected in the first section and the rest of samples were taken in the second section. The average process between the first section and the second section is 69 days [13].

Enhanced palmprint recognition system consists of the following steps; (1) reading the original imagining from the database, (2) determination of main lines, (3) removal of the interest region (ROI), (4) removal of the properties of Gabor wavelet transformation (GWT) and (5) comparison with k nearest neighbors (k-NN) classifier method [14]. It has been seen that the obtained performance values have achieved successful results for the palmprint recognition system.

2. Materials and Method

In this study, obtaining ROI region from palmprint images were done by the following processes; (1) determination of attributes by using GWT and (2) classification by k-NN.

Before feature extraction and coding step, the central region of each palmprint must be identified from all the images in the database as the region of interest [14]. Each palmprint image is pre-processed and the ROI region defined in the coordinate system is then removed.

2.1. Pre-Processing

In order to extract the ROI region from the images properly, finger spaces are defined as reference points for the coordinate system [14, 15].

Fundamental steps in pre-processing of ROI:

1. Step: After the threshold value is determined, the image is passed through the Gaussian low-pass filter and then it is converted to binary image.
2. Step: Edge information is obtained from binary image. Bottom points of finger space are determined as given in Figure 1 (c). ($F_i x_j$, $F_i y_j$), (i=1, 2).
3. Step: Tangent value between specified points is calculated. (x1, y1) and (x2, y2) are any two points of ($F_1 x_j$, $F_1 y_j$) and ($F_2 x_j$, $F_2 y_j$), respectively.

4. Step: (x_1, y_1) and (x_2, y_2) are sorted on the y-axis in the palmprint coordinate system and then an orthogonal line is drawn towards the center of the palmprint region. And finally, starting points of the coordinate system are determined.
5. Step: The sub-image whose dimension is determined in the coordinate system is subtracted. The bottom image is located in the center of the palmprint image which was used for feature extraction.

A pre-processing steps of an original palmprint image is given in Figure 1.

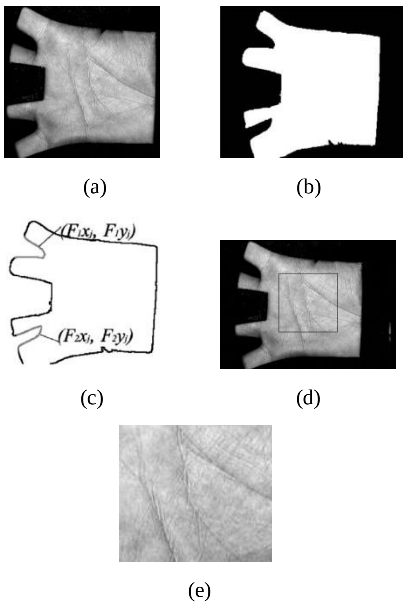

Figure 1. a) Original Image, b) Binary Image, c) Edge extraction and determination of finger space, d) Extracting the middle part of the image, e) ROI

2.2. Attribute Extraction and Coding

Since the images used in this study were in 3D bitmap format, images were converted to 2D images format and they made available to be used by the MATLAB program. Afterwards, GWT feature vectors of the images were obtained.

After the feature vectors of the images taken from the database were constructed in accordance with GWT, they were analyzed by k-NN classifier and then their success rates were determined.

The block diagram of the palmprint recognition system is given in Figure 2.

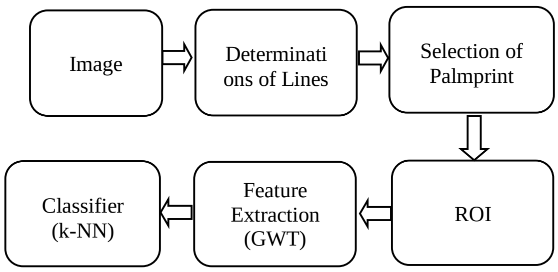

Figure 2. Block diagram of the palmprint recognition system

2.2.1. GWT Based Classification

The GWT based input parameters designed for classification are given in Figure 3 Feature vectors belonging to GWT were obtained through (1) calculation of images by 8 wavelets (2 scales and 4 directions) and (2) by a link to construct a vector. Since the dimensions of the feature vectors are very large (for ease of application), statistical values such as standard deviation, entropy and mean were obtained for each images and then the feature vector was reduced to a adequately small size. As a result, the statistical values of the 8 sub images belonging to each images were successively connected and the feature vector in a total length of 8*3=24 was given to classifier.

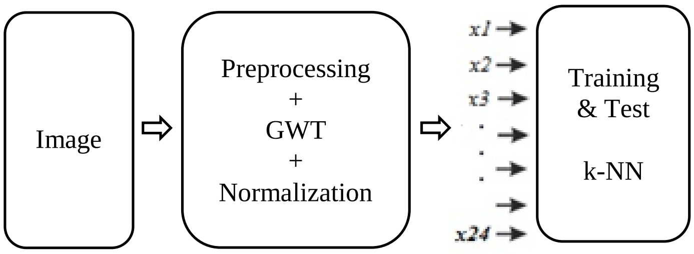

Figure 3. Structure of GWT based classification system

2.2.2. k-NN Classifier

The k-NN algorithm is a supervised learning algorithm that solves the classification problem. Classification is the examination of the attributes of a new image and is assignment of an image to a pre-defined class. It is important that the properties of each class are pre-determined [16]

In k-NN algorithm, by calculating the similarities of the data to be used in the classification to the data in the training set; taking the average of the nearest k values are classified according to a determined value.

In this classifier, the nearest "k" neighbor is examined and test data in which most members are involved is decided to be the real test data. The distributions obtained by the k-NN method were smoothed. As a result of the method smoothness of the distribution will vary in accordance with how neighborhoods were taken.

In Figure 4, the process of merging the largest areas with the training samples is shown within or close to the class boundaries. The process of combining two classes, four training samples and four domains is seen.

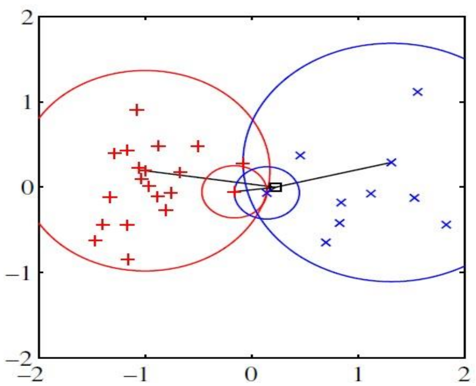

Figure 4. Bonding of the largest areas within the classes [16]

In Figure 5, nine nearest neighbors are seen in accordance with Euclidean distance measurement. Distance between two units is calculated by using Euclidean distance measure.

$$d(i,j)=\sqrt{(x_{i1}-x_{j1})^2+(x_{i2}-x_{j2})^2+\ldots+(x_{ip}-x_{jp})^2} \tag{1}$$

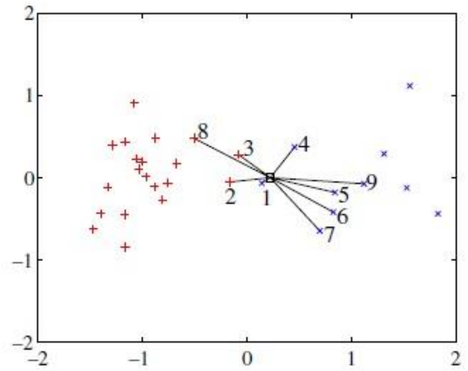

Figure 5. Classification in accordance with Euclidean distance measurement [16]

In Figure 6, nine nearest neighbors are seen according to the adaptive distance measurement. In adaptive distance algorithm, since all near neighbors are in the same class, it is an algorithm with no possibility of change in the result of the classification.

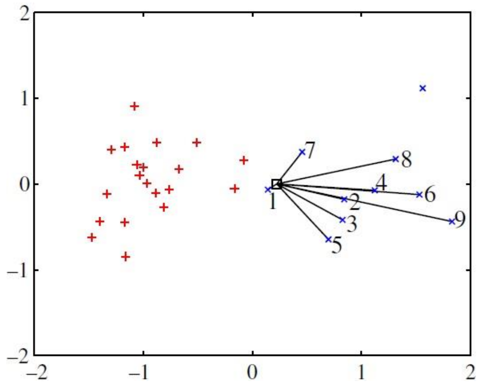

Figure 6. Classification according to adaptive distance measurement [16]

3. The Architecture of the Classification System

The structure of the model that is used for classification is given in Figure 2.

At the first stage, the feature vectors are produced according to GWT with data reading and each data is read according to the image number.

The input parameters produced in order to classify the images are the feature vectors and the success rates are shown while training and testing by the k-NN classification system.

4. Application and Successes

The performance informations of k-NN which his based on GWT is given in Table 1. In order to find the structure having the best performance, the k has been taken as a variable which is between (1-5).

When k-NN performance values are examined, it is observed that high performance values are provided with k = 1 and k = 2 values.

Table 1 gives the average success rates for the nearest neighbors that are increasing according to random sampling of non-reproducible data. Results are calculated for 1, 10, 50, 100, 500 test data structures.

Table 1. Average success rates for non- reproducible data selection for randomized sampling based on GWT

k	Performance (%)
1	93.76
2	88.44
3	84.44
4	85.22
5	83.96

Table 2 gives the average success rates for the nearest neighborhood values that are increased by the GWT based systematic sampling method to the non-reproducible data selection. Results are calculated for 1, 10, 50, 100, 500 test data structures.

Table 2. Average success rates by non-reproducible data selection for GWT based systematic sampling

k	Performance (%)
1	86.8
2	86.9
3	86
4	85
5	84.2

In Table 3 and Table 4, it is seen that the values of the forward data selection are tried for k = 1, 2, 3, 4, 5 according to random and systematic sampling types respectively and the performance is found to be 100%. Since the data selected in the training cluster, the neural network performance is fully realized.

Table 3. Average success rates by GWT based random sampling with forward data selection

k	Performance (%)
1, 2, 3, 4, 5	100

Table 4. Average success rates according to forward data selection for GWT based systematic sampling

k	Performance (%)
1, 2, 3, 4, 5	100

The highest success rate according to the non-reproducible data selection for GWT based random sampling is 93.76% performance value for k = 1 in the nearest neighborhood classifier system and the highest success rate k = 2 for GWT based systematic sampling 86.9% performance rating.

For randomized sampling based on GWT, success rate according to selection of forward data is seen as 100% performance value for k = 1, 2, 3, 4, 5. For the GWT based systematic sampling, success rate was also seen as 100% performance value for k = 1, 2, 3, 4, 5.

When the performance values of k-NN are examined, success rates are observed between 83.96% and 93.76% as shown in Table 1.

After the classification stage, it was observed that the highest performance was achieved at 93.76% for k = 1.

Other studies in the literature are as shown in Table 5.

Table 5. Comparison of Different Palmprint Recognition Methods

Reference	Size of Database	Feature	Matching	Performance (%)
This study	7752	Texture and Future Points	k-NN	93.76
[5]	200	Lines	Euclid Distance	92
[6]	200	Texture and Future Points	Hausdorff Distance	91
[8]	200	Eğriler	Hausdorff Distance	92
[10]	30	Future Points	k-NN	95
[13]	7752	Lines	Hamming Distance	97
[17]	600	Texture and Future Points	k-NN	97
[18]	600	Texture and Future Points	k-NN	84.67

5. Results

In this study, it is aimed to classification palmprint images with k-NN technique by using GWT feature extraction method.

In the first phase of the system analysis, the system is trained using GWT attribute parameters and the performance values of classifier systems are shown.

As a result, it was observed that the GWT based k-NN classifier was successful with 93.76% performance value in classifying palmprint images. A good identification of the feature vectors is the main factor that affects performance. Performance can be improved by finding more suitable feature vectors.

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