Development of Palmvein Recognition System Using Fire Fly Algorithm

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Abstract- Palmvein technology is one of the most popular fields in pattern recognition. The most distinguishing advantage of vein features are high level of accuracy, difficult to forge and more table features. In this study, palmvein images of individuals were acquired; a Linear Discriminant Analysis and Firefly Algorithm (LDA-FA) model for feature extraction was formulated and implemented and the performance of the developed system was benchmarked with the LDA model. Five (5) palmvein images of each one hundred (100) individuals were captured using an infrared CCD sensitive camera. Linear discriminant Analysis was enhanced with Firefly Algorithm to extract sufficient features. Back Propagation Neural Network (BPNN) was used to determine the class the training and the testing image belong. 270 images were used in training the database and 230 images were used for testing the created database. The system was tested using False Positive Rate, False Negative Rate, Recognition Accuracy and Average Recognition Time. The system was tested for False Positive Rate, False Negative Rate and accuracy at threshold values of 0.25, 0.46, 0.60, 0.85. The LDA-FA achieved a false positive rate of 18.00%, 10.00%, 6.00%, 2.00%, false negative rate of 1.11%, 2.22%, 2.78%, 3.33% and accuracy of 95.22%, 96.09%, 96.52% and 96.96% at the threshold values respectively. The LDA achieved a false positive rate of 22.00%, 14.00%, 10.00%, 4.00%, false negative rate of 4.44%, 5.00%, 5.56%, 6.67% and accuracy of 91.74%, 93.04%, 93.48% and 93.91% at the threshold values respectively. The average training time generated by LDA-FA are 200.32s, 199.87s, 201.94 and 202.91 while that of LDA are 219.76s, 219.93s, 220.38s and 220.71 at the threshold values respectively. The result shows that the LDA-FA is less computationally expensive in terms of training time compared to the LDA model. The study concluded that the LDA-FA is more accurate with minimal false positive and false negative than LDA.

Indexed Terms- Palmvein Technology, Recognition System, Firefly Algorithm.

I. INTRODUCTION

Biometrics refers to the identification (or verification) of an individual (or a claimed identity) by using certain traits associated with the person. Biometric traits can generally be classified into two main categories: Physiological techniques include fingerprint recognition, palmvein recognition, retinal and iris scanning, facial recognition, hand and finger geometry and DNA analysis. Behavioral techniques include handwriting recognition, voice authentication, gait, and keystroke dynamics just to name a few (Jain, Flynn & Ross, 2008). Biometric-based system should meet the specified recognition accuracy, speed and resource requirement, be harmless to users, be accepted by intended population and be sufficiently robust to various fraudulent methods and attacks to the system (Anil, et al.2008). Among the various biometric characteristics that can be used to recognize a person, the human hand is the oldest and the most successful form of biometric technology (Kumar, Wong, Shen, & Jain,2003). The rich sets of biometric features that can be extracted from hand include: fingerprint, hand geometry, palmprint, palmvein. These properties are stable and reliable. Palmprint biometrics uses the features of palmprint that is principal lines, wrinkles, ridges, minutiae points, singular points and texture etc. (Zhang, Kong, You, & Wong, 2003) The palm region has a very rich texture and is much larger than the fingertip region therefore the research possibilities for palm featured extraction are very extensive. From application point of view, forensic and non-forensic palmprint recognition can be distinguished. Recent researches focus on the contactless palmprint acquisition (Doublet, Lepeti, & Revenu, 2007) because of the user's discomfort caused by the contact surpalm due to hygienic reason and dirty surpalm. Also, Palm has a broad and complicated vascular pattern and thus contains a wealth of differentiating features for personal identification. As the blood vessels are believed to be "hard-wired" into the body at birth, even twins have unique vein pattern. The pattern of blood veins is unique to every individual, this does not change significantly from the age of ten (Vein recognition in Europe, 2004). External conditions like greasy and dirty, wear and tear, dry and wet hand surpalm do not affect the vein structure. The properties of stability, uniqueness, and spoof-resilient make hand vein a potentially good biometrics for personal authentication. The benefits of palmvein technique are: difficult to forge, highly accurate, capable of 1:1 and 1: many training, contactless, hygienic and non-invasive.

II. BIOMETRIC SYSTEMS

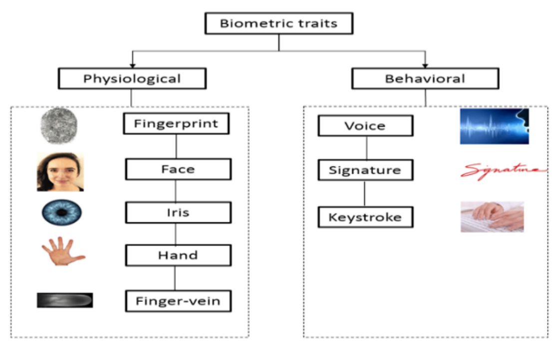
Biometrics is a field of science and technology whose goal is to identify or verify a person's identity using physiological or behavioral characteristics (Jain & Demirkus, 2008). It is more reliable, convenient and secure than the traditional identification technology such as passwords and keys. Biometric based systems have found their use widely in different areas such as banking, criminal identification, education, access control and security system. There are several physiological and behavioral body traits that can be used for biometric recognition (Nandakumar, 2008) as shown in Figure 2.1. Physiological traits include palm vein, palmprint, fingerprint, hand geometry, ear shape and iris while behavioral traits include gait, signature and keystroke. Voice can be classified as a physiological or a behavioral trait because some characteristics of a person's voice such as pitch, bass/tenor and nasality are due to physical factors like vocal tract shape, and other characteristics such as word or phoneme pronunciation (e.g., dialect), use of characteristic words or phrases and conversational styles are mostly learned. Ancillary characteristics such as gender, ethnicity, age, eye color, skin color, scars and tattoos also provide some information about the identity of a person. However, since these ancillary attributes do not provide sufficient evidence to precisely determine the identity, they are usually referred to as soft biometric traits (Jain, Ross & Prabhakar, 2004). Biometric systems are better than the traditional means of identification like cards or badges. Because they provide a non-transferable means of identifying people. The success of a biometric system depends on two (2) factors. The first is the proper choice of biometric data and on the applied techniques. The choice of biometric data to be used depends on the intended application domain of the system. The desirable characteristics of biometrics data are Universality, Uniqueness, Collectability, Performance, Acceptability, Circumvention, Permanence and Measurability. These are explained as follows:

1. Universality: All persons using the biometric application must posses the characteristics. For instance, an iris biometric recognition cannot be used to identify blind people. Likewise, a signature recognition system cannot be used in a situation where most of the population cannot write.
2. Uniqueness: The underlying characteristics should be different enough to be able to distinguish between two individuals
3. Performance: There must be an acceptable degree of performance. This include time, matching accuracy and resources used in building the recognition system.
4. Acceptability: This is a measure of how people are willing to cooperate with the system in terms of presenting their biometric trait to the system.
5. Circumvention: This is a measure of the robustness of the system, that is, how easy is it to fool the system into making the wrong decision or to compromise information about the users' biometric data.
6. Permanence: The biometric trait used in developing the biometric system should not change significantly ove rtime.
7. Measurability: The biometric trait must be quantitatively measurable to be further processed by a machine.

The general framework of a typical biometric recognition system consists of a sensor module, feature extraction module, matching module and decision-making module. Given an input data (for instance, palmprint image), the first action a biometric recognition system does is to perform detection or segmentation, which is the extraction of the modality of interest from the input. The next step is preprocessing, which involves noise removal, data alignment, or data enhancement. Afterwards, features are extracted from the preprocessed data, which will serve as input to the classifier for recognition. The goal of the recognition process may be to associate an identity with the input data (biometric identification) or determine if two instances of input data belong to the same identity biometric verification). A simple biometric system has four (4) major components as shown in Figure. These components are discussed as follows:

i. Sensor module: This is used for biometric data acquisition. It is used for capturing the biometric trait from the subject and converting it to a digital form that can be used by the subsequent module. The quality of the acquired biometric data greatly affects the overall performance of the biometric system. Factors such as noise, technology of the reader and the degree of interoperability of the user with the system affect the quality of the acquired biometric data;
ii. Feature extraction module: The data obtained from the sensor is preprocessed for quality enhancement. Then, some important discriminatory features are extracted to generate a representation known as template. The template is then stored in the system;
iii. Matching module: The feature vectors generated by the feature extraction module are compared with the template. When the system is requested to identify an individual, it does this by extracting the discriminatory features called query. Then the query is compared to the stored template. The comparison is to establish that the query and the stored template belong to the same subject.
iv. Decision making module: This component is used to establish an individual's identity based on the comparison done by the matching module. It also accepts or rejects a claimed identity.

Biometric systems typically operate in two modes. These are the enrolment and authorization modes. In the enrolment mode, the biometric features of the users are captured and stored as templates in the system's database. In authorization mode, the templates gotten from the user's biometrics characteristics (live-template) are compared to the templates already stored in the system's database. Biometrics systems can be classified into identification and verification systems (Jain, Chen, & Demirkus, 2006). The goal of identification is to determine who is the unknown individual from all the individuals enrolled in the database. In other words, identification answers the question "Who am I?" while verification answers the question "Am I who I claim to be?" Identification is further classified into open-set and closed-set. In closed-set, the individual to be identified must be enrolled in the database. In the open-set, this is not necessary, and the system should be able to verify if the individual is enrolled in the database or not. A number of physiological and behavioural body traits can be used for biometric recognition Examples of physiological traits include palm, fingerprint, iris, palmprint, hand geometry and ear shape. Gait, signature and keystroke dynamics are some of the behavioural characteristics that can be used for person authentication.



Biometric

Figure 2.1: Examples of body traits that can be used for biometric recognition (Nandakumar, 2008)

2.1 Review of Related Works

A number of studies showing the advantages of LDA have appeared in literature. In order to solve the singularity problem of LDA, Rizk et al, 2016 developed a system for identity recognition based on palmvein feature using two-dimensional linear discriminant analysis. The two-dimensional linear discriminant analysis was used for feature extraction.

The Chinese Academy of Sciences, Institute of Automation (CASIA) Multi-Spectral Palmprint Database with the length of infrared 850 nm was used. Dataset consist of 600 palmvein images collected from 100 persons. Each person has six palmvein images which were taken in two sessions. Images with id 1,2 and 3 were taken at the first session while id 4,5,6 were taken at the second session and were darker than the first. Dataset is divided into training and testing with ratio 3:3. The system was tested using four (4) scenarios. These are the effect of quality of image acquisition, effect of ROI dimension, the effect of 2DLDA dimension and performance based on error rates. In the first scenario, the highest accuracy obtained was 75.00%. In order to get a better performance, the training image should contain images of first and second session. The training that consist of only bright or dark image obtained worse accurate than training data that consist of bright and dark images. In the second scenario, the result showed that the larger the ROI dimension, the smaller the accuracy. In the third scenarios, the 12x12 2DLDA dimension had the fastest computation time. In the fourth scenario. The best performance obtained 8.00% of EER with threshold 0,4933. Based on the result of the four (4) scenarios, the parameters of the final testing were set and an accuracy of 94.67% was obtained.

Chan et al (2010) designed a framework for face identification using principal component analysis (PCA) and linear discriminant analysis (LDA). Two (2) different databases were used. These are the AT and T and the centre for biometric engineering CBE databases. The AT and T database consists of ten (10) different images of forty (40) distinct subjects, giving a total of 400 images. The images vary in lightning, facial expression and facial details (such as glasses and without glasses. The CBE database consists of three hundred and twenty (320) images (forty (40) distinct subjects with eight (8) different images). For face identification, PCA achieves accuracy of 91.90% (AT and T) and 76.70% (CBE) while LDA achieved an accuracy of 94.20% (AT and T) and 83.10% (CBE). For face verification, PCA achieves equal error rate of 1.15% (AT and T), 7.30% (CBE) while LDA achieved an equal error rate of 0.78% (AT and T) and 5.81% (CBE). This shows that the LDA outperformed the PCA algorithm.

Khan et al. (2011) developed a facial and speech multimodal biometric identity system using Linear Discriminant Analysis. The system identifies the user based on facial and voice information.

Ekinci &Aykut (2013) designed an online palmprint identity verification system using Gabor-based kernel Fisher discriminant (KFD). They made use of two (2) databases. The KTU and PolyU databases. The database consists of one thousand four hundred and forty-two (1442) images from one hundred and fifty-three (153) subjects. Out of this, six hundred and twelve images were used for training while eight hundred and thirty (830) images. The system consists of both the enrollment and verification stages. During enrollment, the users enters their identity number and the system capture four different images of their right hand. These images make up the database. During verification, the user inputs his/her identity number and places their hand on the frame grabber. The palmprint is then extracted by selecting the ROI of the palm image. This is then matched with the patterns in the database. If the score is greater than the predefined threshold, the user is accepted as genuine. Otherwise, the user is seen as imposter. Comparing the result with principal component analysis, fisher discriminant analysis (FDA) and kernel principal (KPCA) component analysis, the KFD had an error rate of 0.396% while others had a higher rate.

Sahl et al. (2015) developed a system that recognizes people through their iris print using LDA. The dataset consists of two hundred (200) images of twenty (20) subjects. Each subject has ten (10) left iris images and ten (10) right iris image. During verification, the captured image is compared with features of the twenty (20) subjects that exists in the training dataset. The system achieved a false acceptance rate and false rejection rate of 0.05 and 0.15 respectively.

A number of studies showing the advantages of palmvein biometrics have appeared in literature. Shar et al. (2015) developed a palmvein pattern-based recognition system. Images were acquired using a web camera and an infrared light emitting diode (LED) that highlights the veins. The region of interest (ROI) was extracted from the images and processed. Three techniques were used. These are Principal component analysis (PCA), 2D-wavelet transform and template matching. The accuracy of these techniques is 85.48%, 39.00%, 93.54% respectively.

A palmvein recognition system using multimodal features and Adaptive sequential floating forward search (ASFFS) neural network was developed. The effects of fusion of multiple features at various levels were demonstrated. The shape and texture features were considered for recognition of authenticated users and it was validated using adaptive sequential floating forward search. The recognition accuracy of the developed system was found to be 99.61% when the multimodal features fused at matching score level. The recognition system developed provides reliable security (Deepamalar and Madheswaran, 2010).

A number of studies showing the application of fire fly have appeared in literature. The dataset was collected from students and staff of a particular University using a near infrared (IR) imaging. The topological structure of the vein patterns is extracted from the segmented region of interest. To enhance the image, the images were subjected to histogram equalization using local gray level information. The combination of knuckle tip extraction of dorsal hand vein with firefly increases the recognition rate and more secure. Al- Ta'i & Al-Hameed (2003) worked on feature extraction using fingerprint. Firefly algorithm is applied to four (4) sub bands of the transformed image. For each location, the fitness function is calculated using statistics. These calculations are X-position , Y-position, mean and variance. Four features were extracted by firefly algorithm according to four sub bands. The four sub bands are LL, LH, HL and HH. If the matching ratio between any of the sub bands is lower than 90.00%, then the individual will not be authorized. Otherwise, the individual is authorized

III. STAGES OF PALMVEIN RECOGNITION SYSTEM DEVELOPMENT

The required stages involved in developing palmvein recognition are highlighted as follows: STAGE1: Palmvein Acquisition, STAGE2: Palmvein Pre-processing, STAGE3: Feature extraction, STAGE4: Training and Classification, STAGE5: Recognition/Testing.

1. Palmvein Image Acquisition

Data acquisition is the first stage of any pattern recognition process. It is the process that involves the sampling of biometric feature and the conversion of these features into the form that can be manipulated by the computer. Palmvein images of 100 individuals were captured. This acquisition was achieved using an infrared CCD sensitive camera. For each individual, 5 images of both left and right hand was captured. Users are required to stretch their palm straight on the platform of the scanner. Five palmvein images were captured (100*5 images). Figure 3.1 shows the captured palmvein samples stored in a database. 270 images (were used for training the system while 230 images were used to test the system and finally saved in jpeg format.

2. Palmvein preprocessing stage

Preprocessing activities involves the following:

1) Scaling of Pictures

Palmvein images were cropped from its original captured sizes and were later resized from the original dimension of 480*640 to 180*200 pixels.

2) Organizing the captured images into palmvein folder

The resized images of each individual were grouped into two major folders. One folder contained training images while the other was used for testing the system. The folder containing the training images were sub-divided into five (5) folders with each containing different resolutions of training images.

3) Cropping

The images were cropped to sizes of 50*50 pixels from the center of the image by the program in order to extract features. The different pixel sizes indicate varying number of important palm feature.

4) Gray Scale Conversion

The cropped images in the database were converted into gray scale to make it suitable for the palmvein recognition system. This was done because most of the present palmvein recognition algorithms require two-dimension arrays in their analysis.

3. Feature Extraction

This is the process of using the most important information of the cropped palmvein images for classification purpose. Enhanced Linear discriminant Analysis with Firefly Algorithm was used to extract sufficient (set of) features that will enhance the recognition rate.

4. Training and Classification Stage

Computed Eigen palms (eigenvectors) were ordered at this stage to form Eigen space. The centered training image vectors were then projected onto the Eigen palm space. Back Propagation Neural Network (BPNN) was used to determine the class the training and the testing image belong.

5. Palmvein Recognition/Testing Stage

Testing and recognition were performed on different training images per individual to determine performances under different threshold.

3.1 Performance Metrics of the developed system

The performance on trained and recognized subjects was measured against recognition rate, total training time, Sensitivity, Specificity and false positive rate.

The following parameters were used to measure and evaluate the overall performance of the developed system:

False Positive Rate = $\frac{FP}{FP+TP}$ (3.12)

False Negative Rate = $\frac{FN}{FN+TP}$ (3.13)

Overall Accuracy = $\frac{TP+TN}{TP+TN+FP+FN}$ (3.14)

Where,

True Positive (TP): If a neutral template is verified present in a dataset and the system test also confirms the presence of the template, the result of the system is true positive. Therefore, classified images are in the created database

True Negative (TN): If a neutral template is verified absent in a dataset and the system test also confirms the absence of the template, the result of the system is true negative. Therefore, classified images are not in the created database

False Positive (FP): If the system confirms the presence of template in a dataset who actually does not have such, the test result is false positive. Therefore, misclassified images are in the created database

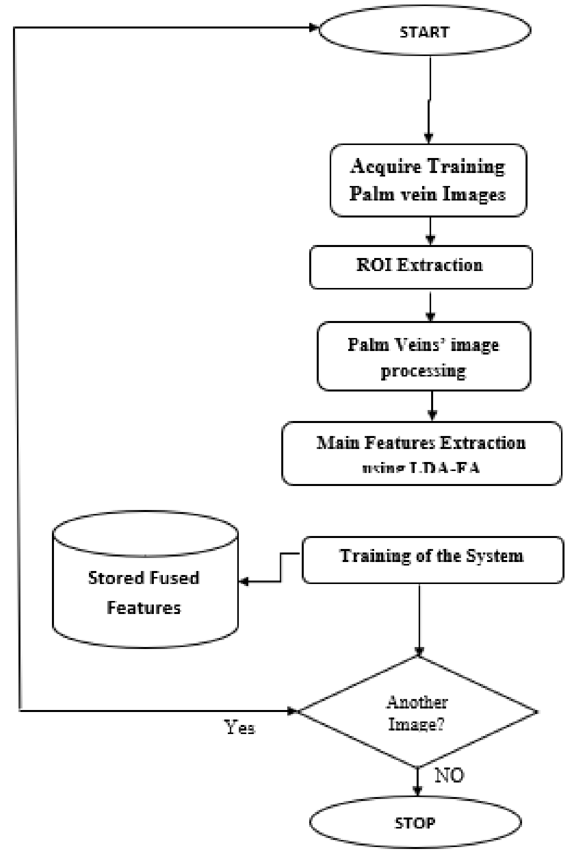


Figure 3.3: Flowchart of Training Stage of the Developed System

IV. RESULTS

The code implementing the palmvein recognition system was tested on a core i3 system board with 2.4GHz processor speed. The experimental results got were basically limited by the medium level state of the computer system, palmvein scanner, different environmental conditions, and the quality of palmvein images. The palmvein database under consideration was developed entirely from the scratch and the facilities for proper palmvein alignment used were the ones at our disposal. The palmvein recognition system was experimented with a total of 500 images, out of which 270 images were used in training the database and 230 images were used for testing the created database. This represents five images (three training and two testing) for 100 individuals representing a class each. The model was experimented using threshold value 0.25, 0.46, 0.60 and 0.85. The choice of the selected threshold was gotten from the graph of Threshold against Accuracy as shown in Figure 4.1.

The comparative results of the developed LDA-FA system and only LDA systems were generated and reported.

CONCLUSION

The palmvein recognition system using Firefly Algorithm (FA) and Linear Discriminant Analysis (LDA) has been developed. Back Propagation Neural Network (BPNN) classifier was used to classify the vein patterns for making necessary decision and the work has resulted in an overall success, being able to perform reliable recognition in a constrained environment. This work presents results of experiments using Firefly Algorithm to Enhanced LDA. LDA-FA and LDA model gives recognition accuracies of between (95.22% and 96.96%) and (91.74% and 93.91%) respectively at a threshold of between 0.25 and 0.85. Also, further experiments were performed to determine the error rate at the above-mentioned threshold values. These were to investigate the efficiency of the developed system either to legitimate users or imposers. The palmvein images that were used for the False Positive Rate (FPR) were not part of the training set and were tagged imposers while those used for the False Negative Rate (FNR) were those included in the training set of the developed system. The FPR and FNR were between (18.00% and 2.00%) and (22.00% and 4.00%) respectively. Errors in recognition can similarly be attributed to poor normalisation. Emphasizes should be placed on the importance of strictly standardised databases. The design of the palmvein recognition system was separated into four major sections: Image acquisition and standardization, Dimensionality reduction, feature extraction, Training and testing for recognition. The application of the algorithms for palmvein recognition requires a perfectly standardized and aligned database of palmvein; palmvein cropping and image resizing were done before the dimensionality reduction stages to account for background removal and uniformity in sizes of the images for the training and testing of the image to be able to really take place in the palmvein recognition system. Different results obtained from the algorithms considered showed that standard palmvein recognition system can be developed.

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