VOL. 10, NO. 3, FEBRUARY 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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A MULTIMODAL BIOMETRIC DETECTION SYSTEM VIA ROTATED HISTOGRAMS USING HOUGH LINES

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ABSTRACT

Several systems require full identification of a user, as any misclassification may deteriorate the performance of the entire system. Such systems must grant access only to the genuine user. For this reason, single biometrics becomes insufficient for authentication and identification**.** Consequently, the need for implementing highly integrated systems is necessary to promote security of such systems. At the same time, multi-biometric attracts much attention. The current study put forward a pioneering multimodal biometric detection approach using the principle of detecting lines through Hough Transform (HT). The images were converted in to histograms using histogram plot function. However, these histograms images were rotated by 30 degrees and HT functions were applied on the rotated histograms to detect the query biometric features. The new technique was tested on face, iris, palm and fingerprint. The final plot accomplished detection of whole biometric features with an average detection time of 4.506 seconds per individual. The new technique can be used to detect the aforementioned biometric traits using the same feature extraction algorithm at limited time, since each biometric trait's dimensions was drastically reduced. The new system outperformed many methods in the literature reported using conventional detection methods. Hence, the modified algorithm is applicable in multi-biometrics detection prior to recognition especially where little computation and fast performance is highly demanded.

Keywords: histogram, multi-biometrics, HOUGH transform (HT).

INTRODUCTION

Massive advancement has been reached in the field of biometrics, which is primarily used for verification of certain features for the purpose of security or authenticity. Recognition through single biometrics often fails to extract adequate information for verifying the identity of a person (Jain et al., 2004). The biometrics test studied in Summary of NIST Standards for Biometric Accuracy (2002) has revealed that, to achieve acceptable identification accuracy for large user applications, multimodal biometrics is required. The justifiable reason of combining two or more modalities is to improve the recognition accuracy (Teddy, 2005) and that is very possible when features of independent biometrics, are statistically combined. Many studies including Mohammad et al. (2013) have recommended multimodal biometrics for current and future applications. Multimodal biometric systems own ability to withstand spoof attacks and enhance performance reliability. It was stated by Jain et al. (2004) that, due to the presence of multiple, fairly independent pieces of evidence, multi-biometrics are expected to be reliable. Combining different modalities result in a system, which can outperform single bometrics was conducted by Kittler & Hojjatoleslami (1998). Several methods have been proposed by researchers on the multimodal biometrics, such methods were reported having significance improvement over traditional biometric traits. Although the cost of the system is substantially higher due to requirement of new sensors, and development of the system is complex (Hanuma, 2011; Mohammad et al., 2013). However, application of higher integrated biometric system in a highly security demanding applications will be remarkable.

Human detection has been a major concern in system protection and monitoring applications. HT is one of the feature extraction techniques used in image analysis, computer vision and digital image processing (Shapiro and Stockman, 2001). It was patented by Paul Hough in 1962 "How the Hough Transform was invented (2009)" and assigned to the U.S. Atomic Energy Commission with the name "Method and Means for Recognizing Complex Patterns". The HT universally applied today was invented by Duda and Hart (1972), it was called "Generalized Hough Transform" . The HT finds application in identifying straight lines and positions of arbitrary shapes, most commonly circles, ellipses and curves. Some of the researches on biometrics using HT were reported by Porwik (2007) on feature extraction in signature recognition, Bevilacqua et al. (2008) on nose tips detection, Mohamed et al. (2005) regarding coconut detection, Aparecido & Jain (2005) studied on extraction of fingerprint ridges. Another algorithm adopted in iris segmentation, was introduced by Qi-chuan et al. (2004). To the best of authors' knowledge, HT algorithm has never been applied to detect multiple biometric features.

This paper introduces a multimodal biometric detection using principle of Hough lines applied on the rotated histograms obtained from the original images**.** The houghlines function is used here to detect a reduced feature of biometric traits within shortest time, since the images features were highly compressed using histograms. The system aimed at detecting whole biometric traits (irregular features) automatically using single algorithm. The new approach reduces the complexity of hybrid system and minimizes storage capacity in the database, so that many users can be enrolled. Therefore, the problem of storage in a multimodal system can be controlled. In addition, this

VOL. 10, NO. 3, FEBRUARY 2015 ISSN 1819-6608
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approach can further be used to classify the type of biometric feature and any other objects enrolled. The new approach of using the HT hoped to make this algorithm work in diversified areas just like a neural network in classifying all objects.

This is another benefit derived in image processing beyond the conventional detection method using HT. The study will drastically reduce spoof attacks, thereby promote security of authentication. Figure-1 and Figure-2 demonstrate a set up and system model of multi-modal biometrics respectively.

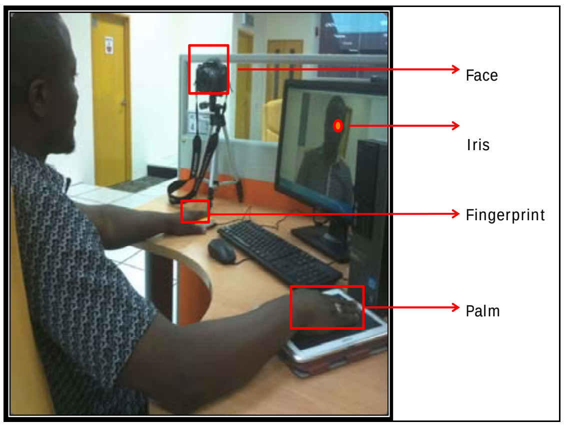

Figure-1. An image demonstrating multi-modal biometric detection process.

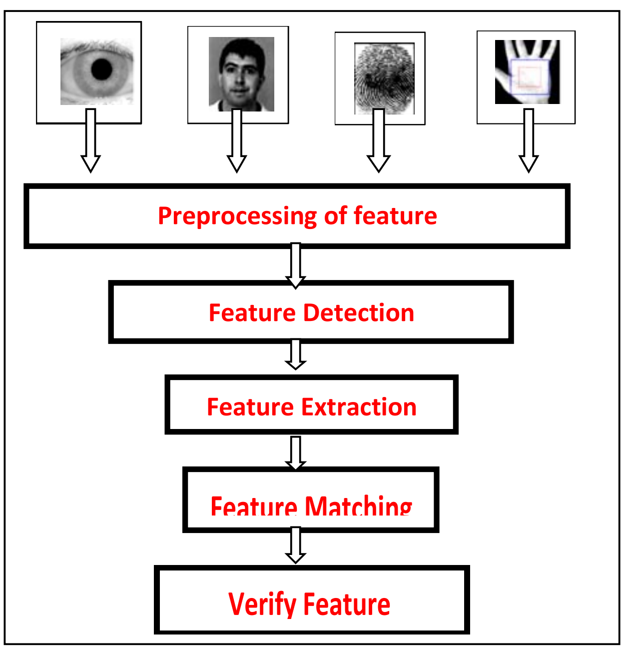

Figure-2. A multi-modal biometric detection and recognition process.

DEFINITION OF TERMS

Multi-modal system

Multi- biometrics refers to the use of more than one biometric feature of a person to form a sole identification. It takes input from single or multiple sensors depending on the application. Combining more than one characteristic generally form multimodal system irrespective of whether the images are acquired by same or different measuring devices. Other classes of multi-biometric systems are: multi-algorithm systems, multi-instance systems, multi-sample systems and multi-sensor systems. In this study the images are obtained from standard databases. Figure-3 shows one of the preprocessed images in the experiment.

Figure-3. Sample of the preprocessed images.

Normalization

Histogram is a graphical display of tabulated frequencies defined by Howitt & Cramer (2008). It transforms total pixel of images (Fatma et al. 2010), and always a solution to comparison of colors. Illumination variations in the input images affect the image histograms. As a result of that, the preprocessed images ought to be normalized. Contrast stretching operates by stretching the range of pixel intensities of the input image to occupy a larger dynamic range in the output image was introduced by Chris & Toby (2011). Figure-4 shows effect of contrast stretching on face image where (a) and (b) are the images before and after contrast stretching, while (a') and (b') are the equivalent histograms before and after histogram distributions. The image pixel range is stretched based on these four values (a, b, c and d) according to this relation (Chris & Toby, 2011):

$$I_{output}(i,j) = (I_{input}(i,j) - c)\left(\frac{a-b}{c-d}\right) + a$$

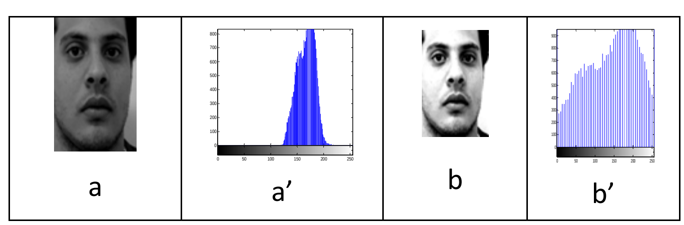

Figure-4. The effect of contrast stretching on face image.

Canny edges detection

An edge is a curve that follows a path where the intensity changes rapidly in an image. Edge detection is used to identify the edges in an image using appropriate

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edge function. The function looks for places where the first derivative of the intensity is larger in magnitude than some threshold or it looks for Places where the second derivative of the intensity has a zero crossing. The Canny method is generally acknowledged as the best 'all-round' edge detection method developed to date (Chris & Toby, 2011). It can easily detect strong and weak edges and it is less sensitive to noise. This canny method is applied on the gray-scale image prior to computing the HT.

Line detection using Hough transform

In the operational scenario, the individual biometric traits from the person to be identified are processed, taking each feature separately, and produces a compact representation using histogram. To determine the appropriate feature, `hough` function implements the Standard Hough Transform (SHT) using the parametric representation of a line shown in equation 1, where rho (r) and theta (θ) are polar coordinates. For an arbitrary point on the image plane with coordinates, for example (x_1, y_2), the lines that get through it are represented in equation 2, this corresponds to a sinusoidal curve in the (r, θ) plane, which is unique to that point. Figure-5 shows the main idea in the HT (Harsh & Alpesh, 2013) where `r` represents perpendicular distance from origin to the line, θ is the angle produced by r from the base(x) axis. The `hough` function generates a parameter space matrix whose rows and columns correspond to these `r` and θ values respectively. The potential lines in the input image are represented by peaks values, these peaks are found in the Hough matrix using the `houghpeaks` function. Finally, `houghlines` function is used to find the endpoints of the line segments corresponding to peaks in the HT. This function automatically fills in small gaps in the line segments and detects the feature.

$$rho = x\cos(theta) + y\sin(theta) \quad (1)$$
$$rho((theta) = x_1\cos(theta) + y_1\sin(theta) \quad (2)$$

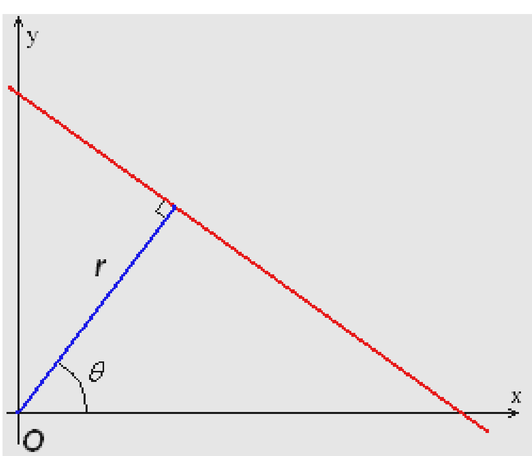

Figure-5. Line and polar coordinates representation.

MATERIALS AND METHODS

The experiment was conducted using MMU1 iris database, FEI face database, COEP (College of Engineering, Pune) palm print database, and FVC (Fingerprint Verification Competition) 2004 database. Figure-6 shows sample of the images from the aforementioned databases in grayscale. Five samples were taken from each biometric, and a total of 20 images were used. Mat lab R2012b software is used on PC Intel core of 2.10 GHz, 3.00 GB DDR3 Memory.

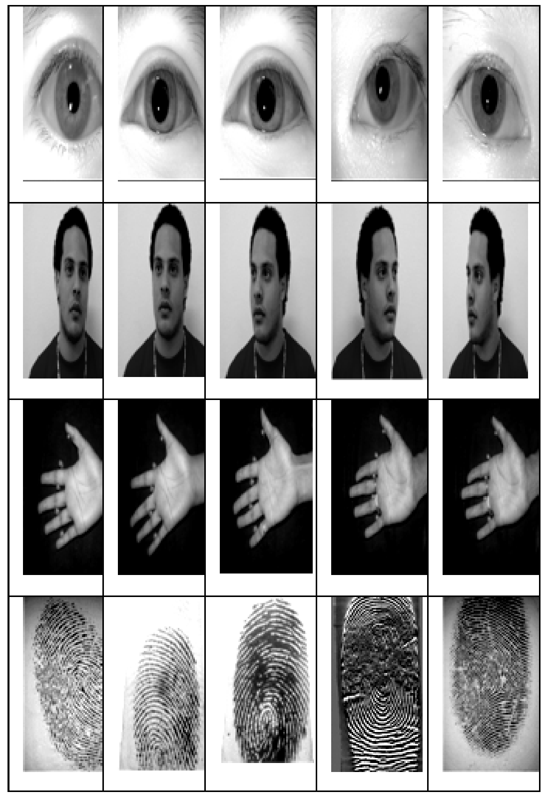

Figure-6. Sample of images taken from MMU1, FEI face, COEP and FVC 2004 databases.

Preprocessing involves all stages of converting the picture element of each biometric feature into its required boundary, intensity and format. It is always carried out before extracting or detecting the interested region. In the proposed scheme, biometric feature (query image) of size M×N is processed, the image was converted to grey-scale which essentially reduces the amount of information in the image. The images were resized to varying sizes to remove the background and select the region of interest (ROI), depending on the original image dimensions. Iris sizes were segmented to 115x105pixels; faces were cropped to 120x220, palms were trimmed to 120x240 and fingerprints were reduced to 128x165 accordingly. Then noise was removed using median filter. The preprocessing stages applied in this paper are depicted in Figure-7.

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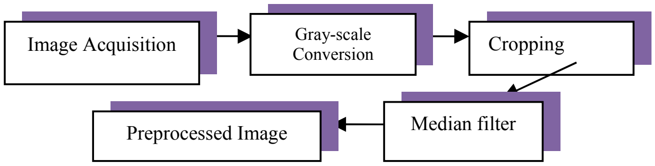

Figure-7. The block diagram of the new detection system.

Subsequently, the image was normalized by enhancing the intensity (often called contrast stretching), and equivalent histogram of the normalized image was obtained using histogram plot function. This resulted to a distributed histogram of separated bins that is easy to extract the features. However, the histogram plot was rotated by 30 degrees to prevent a distorted Hough matrix and guarantee appropriate peaks. Rotated histogram produced short dashes image resembling a line, and the edges were properly detected using edge detection operator (canny). The result of the 'canny' which is a reduced feature represents the original image (iris, face, palm or fingerprint). Besides, Hough function was computed on the canny detected image (the binary image) which implemented the Standard Hough Transform (SHT) using the parametric representation of a line. This result was stored in a matrix often called an accumulator. After computing the SHT, the houghpeaks function was used to locate the peak values in the HT matrix. These peaks represent the most likely line in the input image. Appropriate line was found using the houghlines function. A plot that superimposes the line on the original image (rotated histogram image) was therefore created. Figure-8 depicts block diagram of the new detection approach.

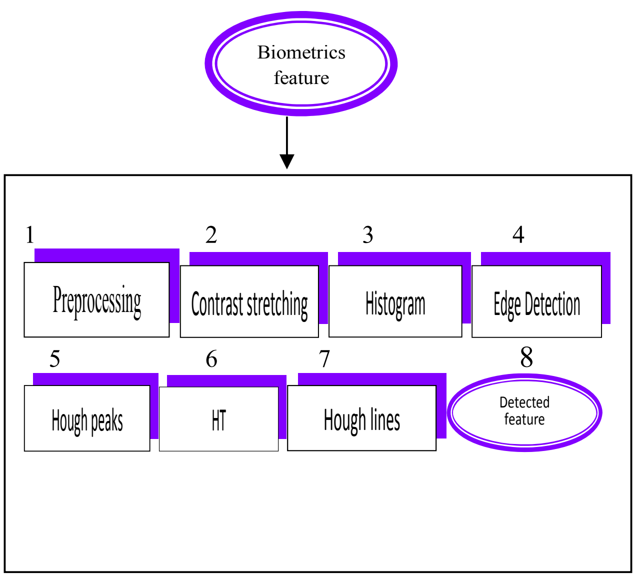

Figure-8. The block diagram of the new detection system.

RESULTS AND DISCUSSIONS

All the four biometric features took the same process of preprocessing stages and detection (methodology). Figure-9 illustrates the experimental results of palm and fingerprint of the new detection system. The results of the face and iris were not shown here since only little changes appeared by visual inspection of the results. Image (a) is the histogram plot of the preprocessed image; image (b) is the histogram of the normalized image. The contrast stretching enhances intensity of the images; consequently, distributed histograms are produced in (b) which reduces the complexity of extracting the features. Besides, the effect of poor illumination in each image is eliminated using stretchlim ( ) function at 0.05 and 0.95 (minimum and maximum) pixel points of the normalized histogram image. However, (c) demonstrates the rotated histogram which was meant to reduce the features sizes, meanwhile prevent computation of distorted HT. Image (d) is the detected image using canny method. Whereas (e) and (f) represent the plots of Hough matrix and the Hough lines, respectively.

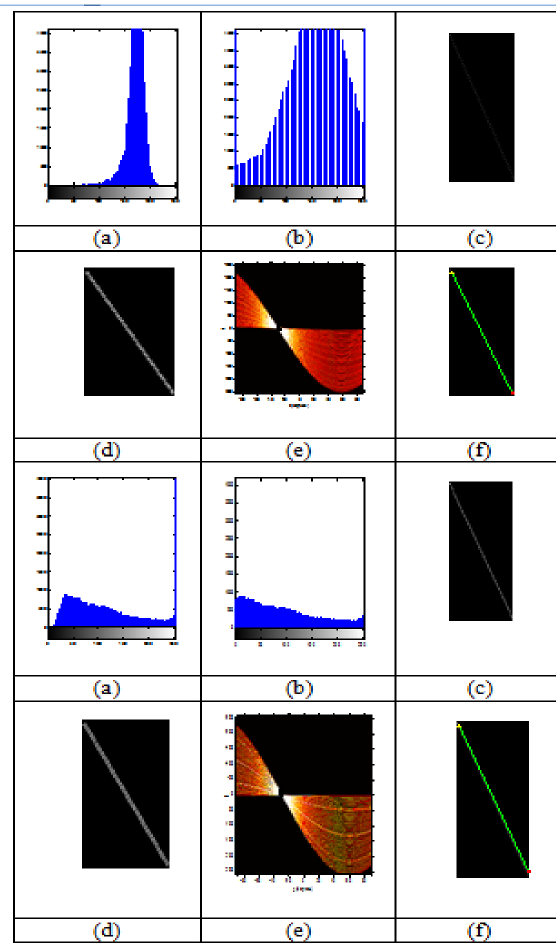

Figure-9. Experimental results of a palm and a fingerprint.

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The rotated histogram shown in (c) contains different pixel elements compared to other features, and the variations of such images can be further observed in the canny results as shown in (d). The Hough matrix of ‘θ’ against ‘r’ with peaks values indicated in (e) determined the appropriate line as depicted in (f).

The following observations were made from the detection process: Images (a) and (b) of the fingerprint histograms were lowered in heights compared to others, since the ridges and valleys in the finger resulted in less dense pixel. The limit at which fingers were stretched was not sufficient as well, this might affect the detection time. The higher bins of the irises occurred as a result of pupil (black portion in the center of the iris). Figure-10 illustrates the effect of normalization of iris; images ‘a’ and ‘b’ are the histograms of the iris before and after the stretching respectively. It was observed that the effect of the contrast stretching of the iris is hardly noticed, this is because iris is not easily affected by illumination. Regard to that, both the original histograms before and after the stretching were almost similar. Therefore, the transform shown in ‘c’ is unique to the iris, though slightly resembles fingerprint’s matrix. The high bins of the histogram was as a result of the black color of the pupil in‘d’.

Additionally, since the finger pixel is lesser than that of face and palm we expect its detection time to be faster. At the same time, transform of faces and that of palms slightly resemble each other. The canny results in all the four features were different but similar features from different subjects (such as face and face) appeared nearly the same in their canny results. Therefore, the Hough matrix will never be the same since it applies on binary image (the canny in this case) and the final detected features were not the same.

Moreover, the faces produced distributed histograms of higher bins than palms, so their detection rates were slower than the palms’. Table-1 demonstrates detection time of the 20 images used in this paper. The results were truncated to three decimal places. According to the results, Iris acquired shortest time, followed by fingerprint, then palm and face in that order. The variation of time during detection of each group of features may also occur due to ROI error, as the cropped features may not exactly be in the same position in the image. The average results of each biometric were calculated and plotted using bar graph shown in Figure-11. The results of this system are quite encouraging since the rate of detections corresponds to the size of the original images used (ROI). The lower the dimensions of the images, the lower the detection time.

In real life application, the results may be bettered, because databases are formed for a desired purpose. Therefore, the images are taken from desired directions, backgrounds and resolutions. To avoid such errors, images from the same database designed for such multimodal system are required.

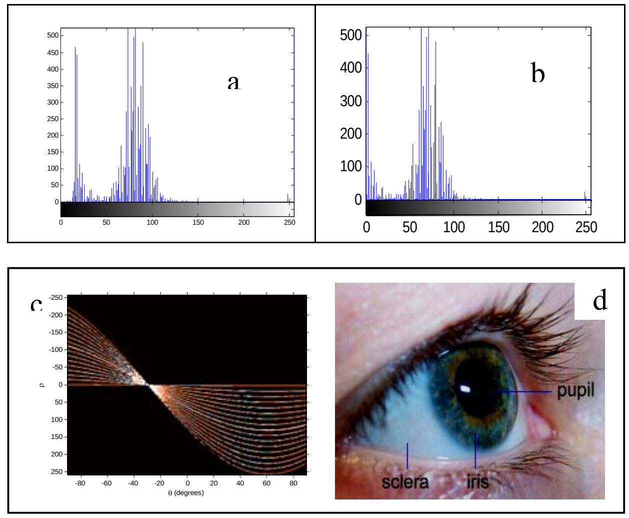

Figure-10. The effect of normalization of iris image.

Table-1. The detection results of the multi-modal biometrics experiment.

S/N	**Iris**(sec.)	**Face**(sec.)	**Palm**(sec.)	**F. Pringer**(sec.)
1	0.967	1.118	1.443	0.988
2	0.978	1.143	1.365	1.001
3	0.990	1.403	1.331	1.056
4	0.965	1.020	1.243	1.012
5	0.911	1.098	1.288	0.993
Average	0.962	1.156	1.334	1.010

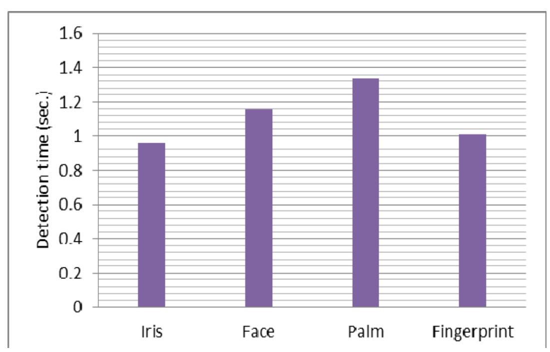

Figure-11. Graph displaying average detection time.

The proposed method is incomparable to other traditional detection approaches, where some portion/portions of the original images are segmented and detected. This is because; its detection rate is far faster than the latter. This method outperformed many techniques in the literature, despite detection of multiple biometric traits. In this, the quadruple features of an individual can be detected within 4.506sec. The modified method applied HT on the extracted features which were reduced drastically prior to the detection. This enabled the algorithm to detect the whole images of face, iris, palm and fingerprint within the reported time.

With regard to this experiment, the only undesirable behaviour encountered are choosing the

'FillGap' and 'MinLength' of the houghlines in the codes that detects the features. Since the images are of different sizes, in case an image of large dimensions these settings will vary in order to detect the complete feature. This is subject to verification.

Table-2 shows few comparisons of existing techniques with the modified HT algorithm reported in this paper.

Table-2. Comparison of other technique with the proposed method.

S/N	Techniques	Detection time (sec.)
1	PCA & ICP (Drira etal.,2013)	6.180
2	ICP (Faltemier et al.,2008)	7.520
3	PDM & ICP (Haar et al.,2010)	3.000
4	Gabor Wavelets & ICP (Hose et al.,2007)	16.000
5	Our New (HT) method	4.506

The above comparisons were reported based on facial landmark detection and expression. This is a pioneering detection method of multiple traits using their extracted features via rotated histograms, and detected using the HT. The reduced features fairly resemble one another, so we might suspect to have False Accept Rate (FAR) when treated for recognition. On the other hand, for recognition purposes the extracted feature vectors has to be matched with the extracted template in the database, to classify each biometric feature. And if those biometric features were grouped to represent an individual, the individual's features matching scores have to be the same with the output scores obtained from the decision module during testing in order to authenticate a user; this is beyond the scope of this paper.

CONCLUSION AND FUTURE WORK

This paper presented biometric detection using four modalities, namely: face, iris, palm and fingerprint using Hough lines. Contrary to existing detection methods, the whole features in each biometric trait were detected very fast since the images were highly compressed. Hence, single algorithm was modified to extract and detect four biometric features within shortest time. The research emphasized additional benefit that can be derived from the old algorithm (HT) which is popularly known to detect images that can only be represented in to set of parameters. In this research, HT was applied on a whole iris in a different way and whole irregular images of face palm and fingerprint. Neither this technique resemble any biometric detection method in the literature, nor it resemble any work reported using HT. The result of this paper proved the essence of modifying the HT algorithm and explored its flexibility. In the same vein, the detection through this approach outperformed the conventional detection methods where the original portions of images are detected. In addition, this technique indirectly detected the biometric traits through their extracted features. This is the uniqueness of the study. In conclusion, our future work focuses on recognition of persons using all the biometric modalities used in this paper. Thus, the system will fuse the four modalities and be able to make decision upon all the biometric features, and recognize an individual. We will closely measure and report the accuracy of the subsequent recognition system by False Accept Rate (FAR) and False Reject Rate (FRR) using many subjects. The detection and recognition study using similar approach will prevent spoof attacks, guarantee users' identity, deliver services within shortest time, and promote security of authentication. We will also reduce detection time by rotating the original images.

ACKNOWLEDGEMENTS

We acknowledge Universiti Sultan Zainal Abidin (UniSZA), Kuala Terengganu, Terengganu, Malaysia for supporting this work and Kano State Government, Nigeria for the financial support.

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