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An Efficient Multi-Modal Biometric Authentication System Using Face, Iris and Finger Knuckle Print

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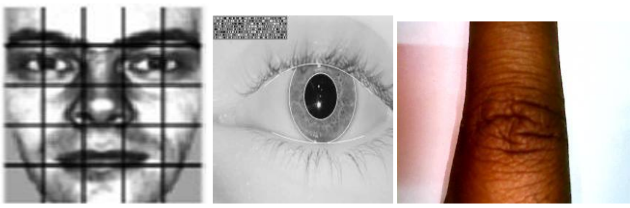
Abstract: In modern world, the demands of authentication and identification techniques are increases due to security concern. There are different traditional methods for authentication i.e. password, pin, or some patterns but the drawback of these methods are that these could be easily stolen, broken, forgotten and can be hacked. The solution of such fraud activities could be addressed by using e.g. biometric system. The biometric system is based on physical and behavioral characteristics of humans. This paper suggests a new way to provide high degree of security by using three different modalities face, iris and Finger Knuckle Print (FKP). In this paper we use score level fusion and Min-Max normalization method and weighted sum for implementation. Here we extract the feature of FKP by using Scale Invariant Feature Transform (SIFT) algorithm. The value of these key points is stored in a database. These values are then compared with the query image of FKP. The performance of proposed system has been examined by public database PolyU for FKP and CASIA iris database and Yale database for face. We have used the MUBI tool for plotting the ROC Curve of the different modalities and after fusion to compare the efficiency of proposed system.
Keywords: Multimodal Biometric, Face Recognition, Iris Recognition, FKP Recognition, SIFT, LBP, Min-Max Normalization, Score level Fusion.

I. Introduction

Many decades ago, biometric features become very special tools for authentication. Biometric characteristics have the stability for long time and also able to cope with theft forgery [1]. The multimodal biometric system provides high degree of security and overcomes the problems of unimodal biometric system. Recently the Finger Knuckle Print technique becomes a robust biometric identifier for authentication. Researcher has found that FKN is correlated modality with a fingerprint. Finger-knuckle print is one of the emerging and highly secure biometric modality uses for authentication. This motivated to propose a new efficient multimodal verification method using Face, Iris and FKP. In our work, we used three modalities "face, iris and FKP". In the very first stage image pre-processing is performed on face, iris and FKP by using different techniques for the biometric modalities which we used. In next stage feature extraction technique are applied. The Local Binary pattern (LBP) used for face images in which face image is distributed into cells then for all cells an 8-digit binary number is generated and converted to decimal form [2]. To extract the feature set from iris we used the Log-Gabor Wavelet is used. For extraction the feature set from FKP is done by using Scale Invariant Feature Transform (SIFT) algorithm. The global and local orientation's average value for features of FKP are considered and matched with features of query image. Figure 1 show the used biometric modalities.



(a) (b) (c)

Figure1. Three modalities used in proposed scheme (a) Face (b) Iris (c) FKP

The objective behind this research as follow: designing and implementing a secure multimodal biometric system that combined the "Face, Iris and FKP" modalities. The reason behind this research is to get the high degree of discrimination in case of large users or population. This paper is organized as follows: in section II illustrate related work. Section III illustrates the proposed multi-modal biometric method. Section IV describes the results of the proposed method. At last, the conclusion is given in the V section.

II. Related Works

Many researches are going on the multimodal biometric system for making the system more efficient and secure by using different and multiple recognition techniques. Here we present some related work on the proposed system. Meraoumia et al. [3] proposed a multimodal biometric system using palm print and FKP with An Efficient Multi-Modal Biometric Verification System Using FKP And Iris EER 0.003%. Kim et al. [4] presented a multibiometric system using soft biometric suitable for a surveillance system. Zhang et al. [5] had proposed a novel biometric trait, named finger knuckle print for personal authentication.

Multimodal biometrics has been proposed by Ross and Jain in 2003 [6]. regarding fingerprint, iris and face biometrics fusion any pair of them" fingerprint and iris " , " iris and face" or "fingerprint and face" has attracted a lot of attention and different researches have proposed many of approaches. Houda benaliouchi et al. [7] in 2014 presented comparative study on fusing iris and fingerprint at score level and decision level. [8] in 2013 had used two uni-modal biometrics, iris and fingerprint as multi-biometrics and found that using these biometrics give good result with high accuracy.In (Zhang et al.,2012), three local features viz. phase congruency, local orientation and local phase are fused at score level.

Kisku et al. [9] proposed a multibiometric system including face and Palmprint biometrics at feature level fusion. The system attained 98.75% recognition rate with 0% FAR.

Meraoumia et al. [10] presented a multimodal biometric system using hand images and by integrating two different modalities Palmprint and finger-knuckle-print (FKP). EER = 0.003 %. Kim et al. [11] introduced a multibiometric system using soft biometrics suitable for video surveillance system, face and gait.

Aggithaya et al. [12] proposed a personal authentication system that simultaneously exploits 2D and 3D Palmprint features. The sum rule classifier achieves the best EER of 0.002.

Kazi and Rody [13] presented a multimodal biometric system using face and signature with score level fusion. The results showed that face and signature based bimodal biometric system can improve the accuracy rate about 10%, higher than single face/signature based biometric system.

Ramachandra and Abhilash [14] introduced a multimodal biometric system using face and fingerprint with fusion at feature level. The best recognition rate was 90% at EER 0.13%.

Ashraf Aboshosha, Kamal A. El dahshan, Ebeid A. Ebeid and Eman K. Alsayed experiment on the Fusion of Fingerprint, Iris and Face Biometrics at Decision Level and give the result FVC2004 DB3_A database is collected to evaluate fingerprint recognition systems by using minutia-based algorithm, the best accuracy given by the system equal 82.5 %. The experimental results on CASIA database evaluate iris recognition system which use log-Gabor filter algorithm; the best accuracy achieved by the system is 95.15%. the experimental results on face94 (university of Essex, UK) database are presented to evaluate face recognition system which use local binary pattern algorithm, the system gives accuracy equal to 97.58 %.[15]

Sheetal Chaudhary and Rajender Nath worked on a New Multimodal Biometric Recognition System Integrating Iris, Face and Voice and get the result by compared with existing result, given blow in table 1[16].

Table 1 Result of Iris, Face and voice based system.

S.No.	Biometric Technologies	GAR (%)	FAR (%)
1.	Iris	92	4
	Proposed System		2
2.	Face	92	6
	Proposed System		2
3.	Voice	92	64
	Proposed System		2

III. Proposed Work

Generally it is accepted that a single biometric trait or unimodal biometric is not provided high degree of discrimination. Multimodal biometric system overcomes the limitations of unimodal biometric system. In this paper we use develop afused face-iris-FKP recognition system which overcomes a numbers of difficulties which can be inherits.

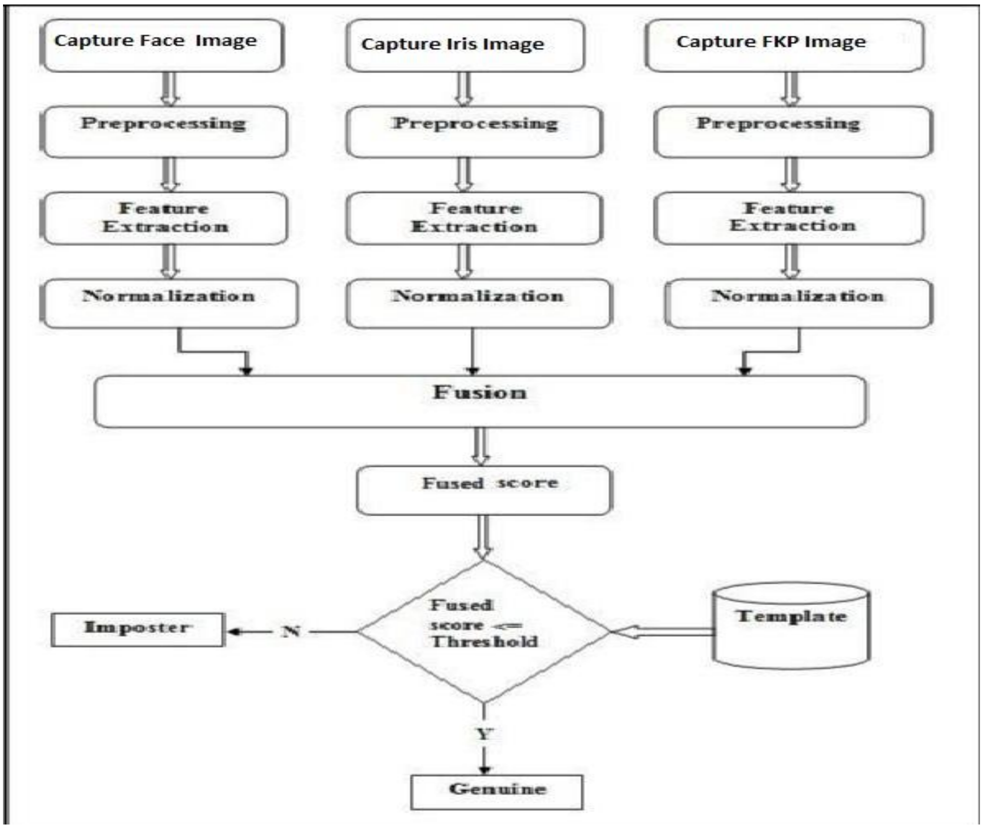


Figure 2 Block Diagram of the proposed system

A. Image Acquisition And Feature Extraction

The images of used traits (face, iris and FKP) are acquired by using sensors. The feature set is extracted by different methods for the taken modalities.

i. Face Feature Set Extraction: it has involves extracting features from 2D face images and match it with the templates stored in the biometric device database. Human faces are made of eyes, nose, mouth and chin etc. Principal Component Analysis (PCA), and Linear Discriminant Analysis (LDA) based methods, has significantly face recognition methods. In PCA, a face subspace is formed to

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represent optimally only the face; by using LDA, a discriminant subspace is formed to discriminate faces of different subjects. Gabor wavelet based and Local features analysis are other approaches which build a local appearance-based feature space, these approaches are more robust against various changes by using appropriate image filters[17]. We use Linear Binary Pattern (LBP) method to extract the feature from face.

Fig 3: facial image divided into 5x5 regions

Face recognition with LBP: - Ojala et al. introduce original LBP operator. It has a powerful meaning to texture description. Here the image area is divided into small regions from where the LBP histograms are extracted and by combineall the regions a single vector is made. The operator labels the image pixels by the threshold the 3x3 neighborhood of each pixel with center value and calculates the result into binary or decimal number. The mathematical formula to calculate the LBP are given below

$$LBP = \sum_{p=0}^{p-1} s\left(f(x,y) - f(x_p, y_p)\right)2^p$$

$$S(Z) = \begin{cases} 1 & if \quad z \geq 0 \\ 0 & if \quad z < 0 \end{cases}$$

Then use texture descriptor that is a histogram of labels.

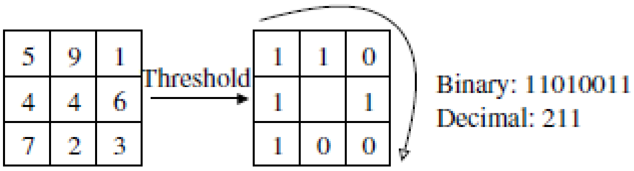

Figure 4 Basic LBP operators

Another modification to the original operator uses so called uniform pattern. A Local Binary Pattern is known as uniform if it involves at most two bitwise transitions 0 to 1 or vice versa when binary chain is considered.

ii. Iris feature Set extraction

The feature extraction of Iris trait is shown below in Fig.3:

Knuckle Print feature extraction steps

a. A sensor captures an iris image in good quality and well framed Iris texture.

b. Sensor will capture Iris as a part of a larger image containing data from the surrounding areas and performing Iris matching, it is necessary to localization the area corresponding to Iris, only.

c. After localization, the important patterns are taken for analysis and a corresponding vector is made.

d. An algorithm (wavelet transform) used to change vector set into an IrisCode of 256 bytes.

e. Distance between the IrisCodes (Hamming Distance) corresponding to the captured image and stored template is used for deciding whether both the Iris patterns were derived from same Iris source or not. Iris feature set extraction steps has shown in Fig. 5.

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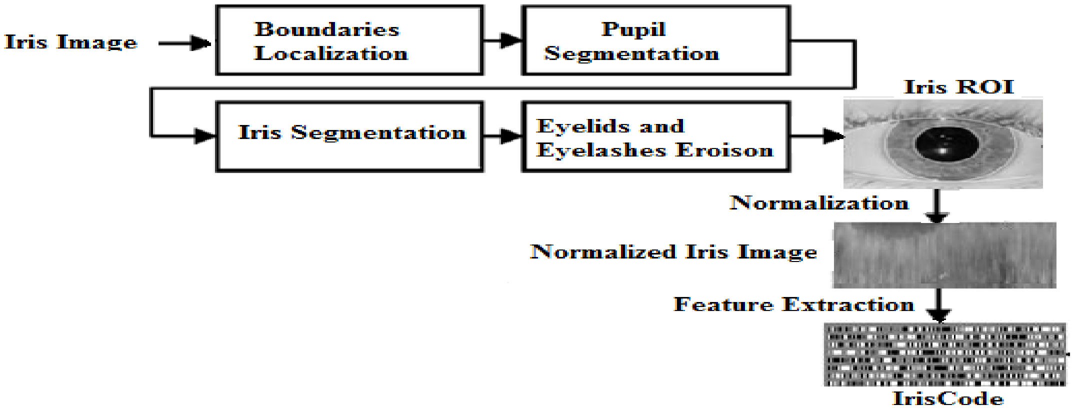

Fig. 5 Iris feature set extraction

iii. FKP Feature Set Extraction

Finger knuckles of the human hand are characterized by the creases on back of finger as shown in Fig. 6

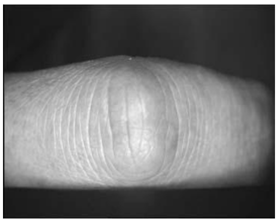

Figure 6 Finger Knuckle Print

Steps to extract feature set form FKP are given below

a. Capture the FKP images through data acquisition device.
b. Perform Localization of region of interest.
c. Extract segmented finger knuckle image.
d. Enhance the FKP images by the image enhance technique.
e. The Knuckle features set extraction, by uses 2D Gabor filters to image local orientation information [18].
f. The matching score is generated by Euclidean distance between Gabor feature vectors of query and enrolled images of FKP.

B. Normalization of score

The min-max normalization method is used to map the row score in range [0, 1].
Equations to normalize the scores are

$$N_{face} = MS_{face} – min_{face} / max_{face} – min_{face}$$
$$N_{iris} = MS_{iris} – min_{iris} / max_{iris} – min_{iris}$$
$$N_{FKP} = MS_{FKP} – min_{FKP} / max_{FKP} – min_{FKP}$$

Where, N_{face},N_{iris} and N_{FKP} are the normalized scores of face, iris and finger knuckle print, terms of min and max are the minimum and maximum for corresponding subscript [15].

C. Fusion

Biometric fusion can be defined broadly as the use of multiple types of biometric data or methods of processing to improve the performance of biometric systems. There some fusion methods like feature level fusion, matching score level fusion and decision level fusion.In our work we have used the simple sum rule fusion method to fuse the score of face, iris and FKP modalities.
Mathematical formula for this method is

$$Sum = \sum_{i=1}^{n} Si$$

here*i* is the normalized score and *Si* is the matching score[19].

IV. Experiment result

i. System Feature: - the experiment is done on HP pavilion G6 with "4GB" RAM, Windows 10and Matlab2016a and Mubi Tool.

ii. Database: - in our proposed systemwe used three databases set to evaluate the performance of multimodal system. The dataset for face is taken from Yale face database [20], dataset for the iris is taken from the CASIA iris database [21] and PolyUfinger knuckle print dataset is taken for FKP [22].

iii. Performance metric

In this research work, two measures are selected named false Genuine Accept Rateand False AcceptRate (FAR) which are computed on the given databases. False accept rate is the probability of accepting an imposter as a genuine and false reject rate is the probability of rejecting a genuine as imposter. Here the aim to reduce the FAR and FRR for better accuracy.

iv. ROC of the system: - the Receiver Operating Characteristics curve is used to show in a graphical way the connection/trade-off between every sensitivity and specificity for possible cut-off for a single test or combination of tests.

The mathematical formula for accuracy is given below [23]

$$Accuracy = 100 - \frac{FAR + \mathrm{FRR}}{2}$$

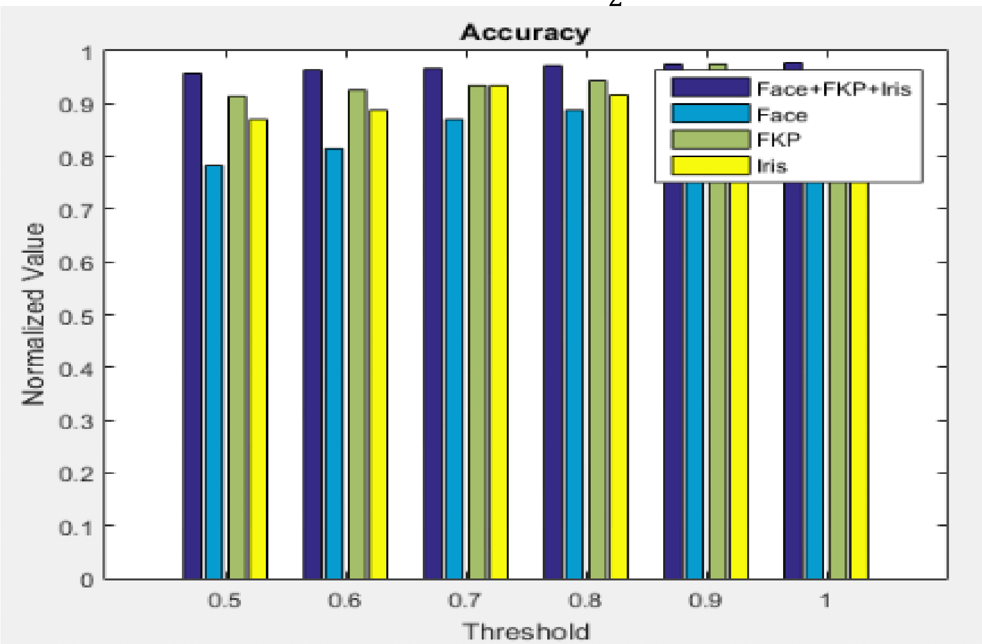

Figure 7 Bar Chartrepresenting of the accuracy of each modality

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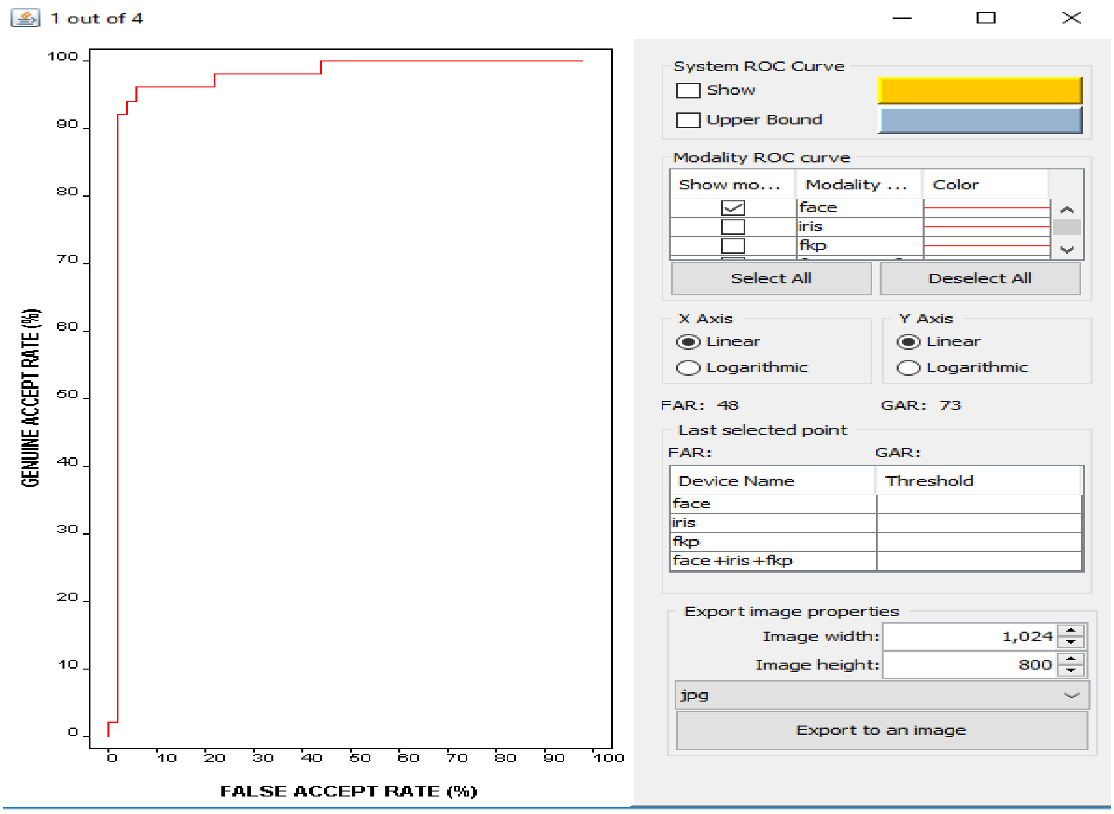

Figure 8ROC curve of the Face Modality

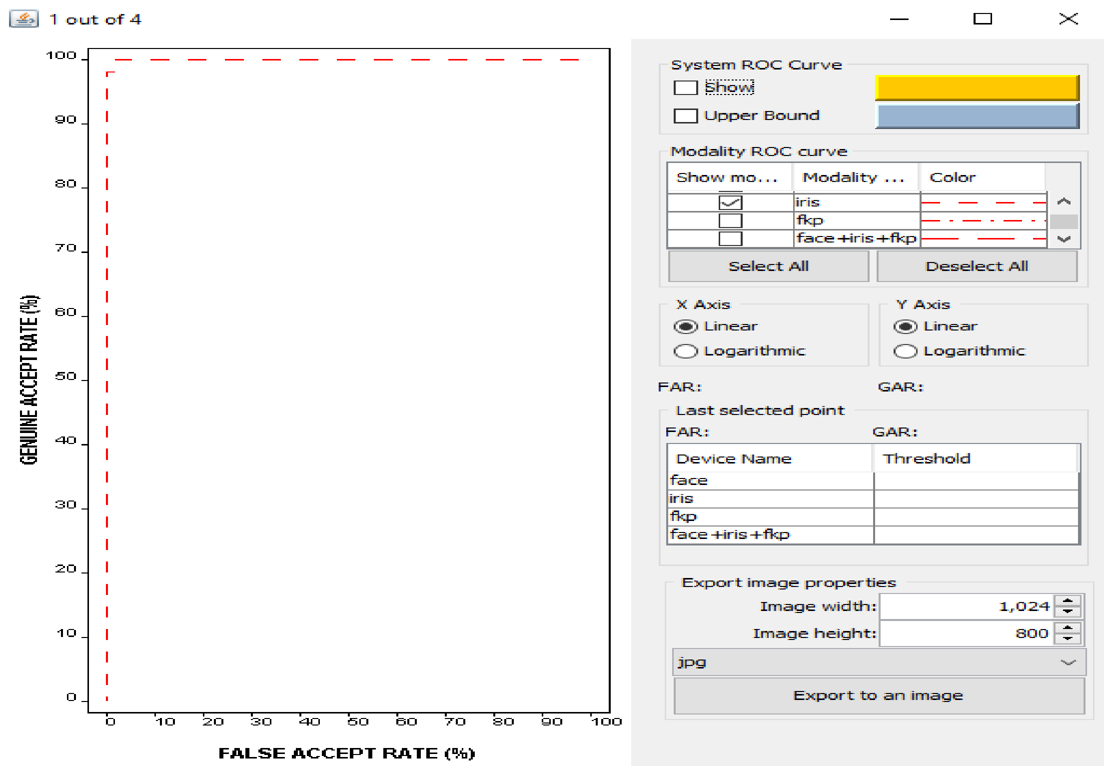

Figure 9 ROC curve for Iris modality

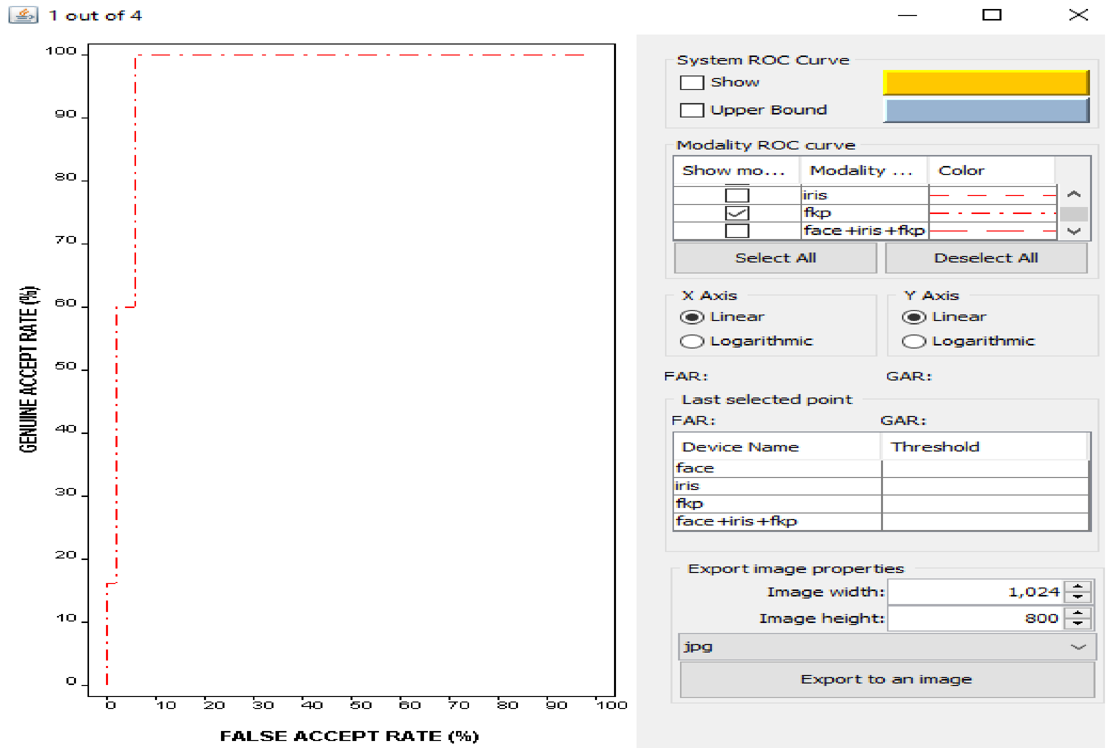

Figure 10 ROC curve for FKP modality

The ROC Curves of proposed system

The ROC Curves of the proposed system is shown below in Figure 11 by using MUBI Tool with respect to the Genuine Accept rate and False Accept rate.

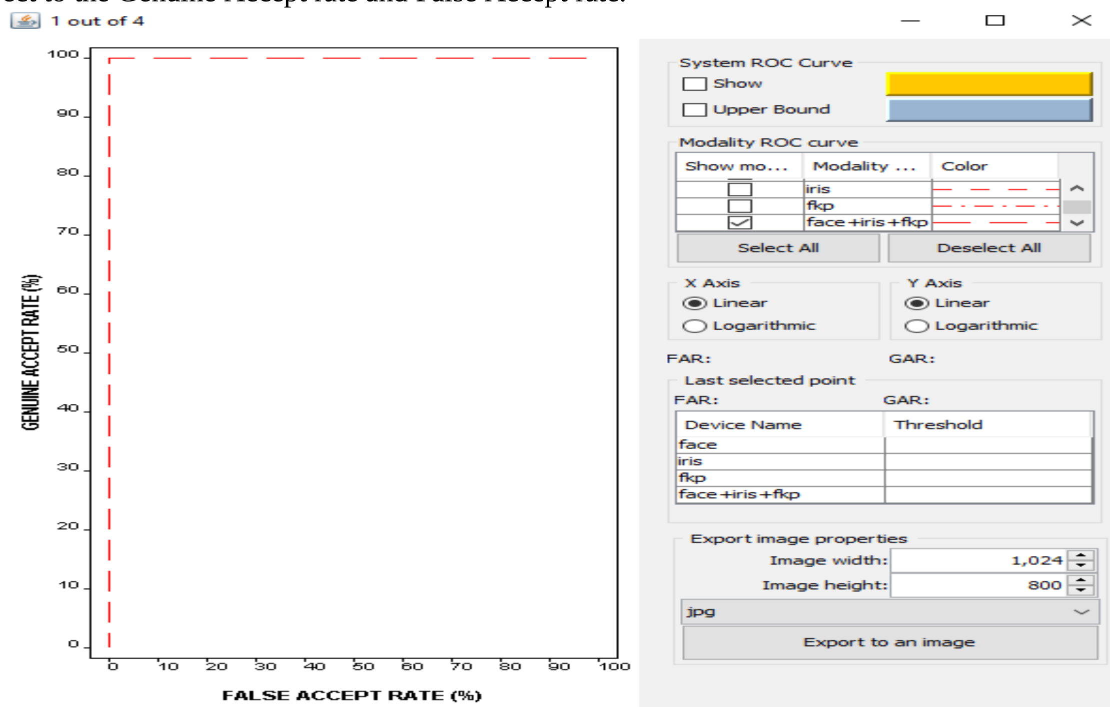

Figure 11 figure of the ROC Curve for proposed system

From the ROC curve, we say that the proposed system reduce FAR and FRR and enhanced the performance, improve the GAR and provide better security than the single modality based biometric system (unimodal) or other system which exist in now days. Here we have used linear curve draw method for both x-axis and y-axis. Table2 show the GAR and FAR of the proposed biometric system.

Table 2 Result of the experiment

System	Algorithm	Database	GAR	FAR
Face	LBP	Yale Face database	100	44
Iris	Gober filter	CASIA	100	2
FKP	SIFT	PolyU FKN	100	6
Face+Iris+FKP	LBP, Gober, SIFT	Yale Face, CASIA, PolyU FKN	100	0

The table 2 is based on the ROC Curve and the GAR and FAR with different thresholds values shown in figure 12.

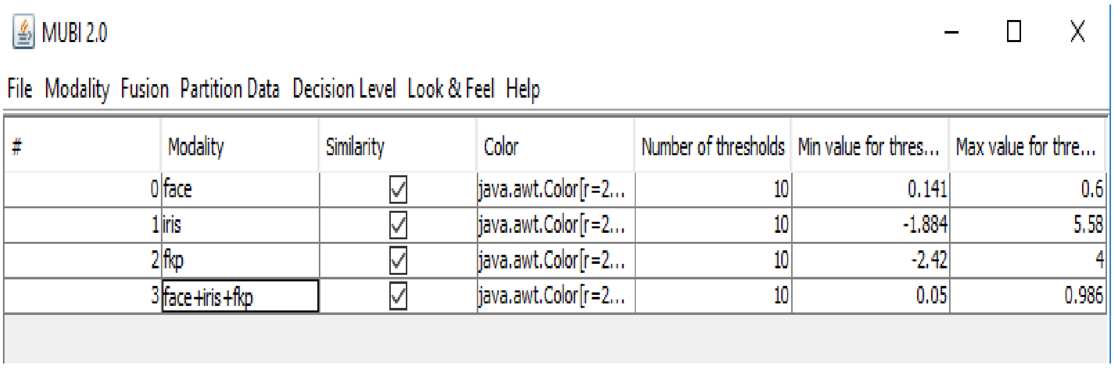

Figure 12 different thresholds values for different modalities.

IV. Conclusion and Future Scope

In this research, a multimodal biometric recognition system using three modalities Face, Iris and FKP with fusion at matching score level is proposed. Also, the effect of different fusion methods and score level normalization function on our research are studied. We show that our system also exhibits an excellent recognition performance and outperforms unimodal systems weather we use two or three biometrics.

The work can be used in the development of multimodal biometrics system that can be in multi-fusion rules in a dynamic architecture to ensure varying security levels using the adaptive combination of multibiometrics. The proposed system in developed for the small datasets.

In future, the work will extend to build the hybrid biometric system for enhancing the security by using face, FKP and the iris as the primary traits and the fusion may be apply at sensor level, feature extraction level or at decision level. Soft biometric parameters like ethnicity, height, skin color, hair color etc. can also be used to enhance the system performance.

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23 Sukhdev Singh, dr. Chander Kant An Efficient Multi-Modal Biometric Verification System Using FKP and Iris , IOSR Journal of Engineering (IOSRJEN) www.iosrjen.org ISSN (e): 2250-3021, ISSN (p): 2278-8719 Vol. 08, Issue 4 (April. 2018), ||VI|| PP 28-35