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FRPAC: FACE RECOGNITION BASED ON PIXEL ARITHMETIC COMPUTATION

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Abstract: *An enhanced method has been proposed in this work to detect different face angles of the same individual and the ability to recognize them correctly within appreciable amount of time is being presented. Image enhancement is an important part of facial recognition. In this work, Histogram Equalization is employed to adjust the image intensity and enhance the contrast. Feature extraction is a significant step to detect and subsequently recognize the face. To extract more productive features from these static images, this work recommends an algorithm based on the concatenation of the Modified Pixel Difference Value (MPDV) and Two Power Term features. MPDV is a modified version of PDV where due to immense pixel preservation the information in the image is highly conserved. Since the Two Power Term follows a pattern that is uniformly growing it increases the information of the pixels by a great amount that helps in obtaining efficient features to be compared. To generate a row vector, the features are concatenated from above two techniques, which are restructured into a column vector. Utilizing Euclidean distance column vectors of all the images from the database are compared against the column vectors of the test image. To perceive the individual minimum distance between the specific image and the location of the image in the database is obtained.*

Index Terms - *Biometrics, Physiological traits, Face Recognition, Arithmetic Computation, ED*

1. INTRODUCTION

Biometric system sensing and proceeding are important mechanism used for identification & authentication of individuals. In today's world, security is the major concern to avoid unauthenticated access to one's property. Biometric authentication plays a vital role in data protection and public security domains because they provide automatic verification and identification of person. Biometric system uses human body features, normally these will not change such as face, iris, retina, fingerprint, vein geometry and handprints. Also utilizes behavioral features such as voice, signature, typing uniformity and gait. Biometric attributes exhibit a strong relation with an individual, which cannot be shared or forged. Traditional methods like PIN, password, and ID card fail to fulfil security needs because these can be shared and forged.

Face perception, as a standout amongst the most illustrative uses of picture examination and comprehension, has gotten huge consideration in security applications and research fields. The Biometric software maps mathematically an individual's facial characteristics and involves deep learning algorithms for comparing a real time face image with stored face image to ascertain an individual's identity. Face recognition algorithms are used extract specific, distinctive information about individual's face. The information includes shape of the chin, distance between the eyes etc.

The particular face data is usually referred to as face template which will be unique from a photograph as it is designed to contain certain features that can be utilized to distinguish one face from another. The Face recognition performs capturing face pictures from camera and live videos and compared with database pictures. Training and classification of images is done and kept in the database during face recognition biometrics. Different challenges faced during face recognition includes facial expression, occlusion due to fixtures, different gestures, aging, modifications in head pose, change in lighting etc. The Face recognition algorithms are comprised of two types such as image prototype and geometric feature-based recognition.

The face and one or more model templates computer correlation is used by template-based approach to find the face identity whereas face templates used Principal Component Analysis and Linear Discriminate Analysis methods. Ridge lets and contour lets tools were found to be useful for analyzing the images information content. These tools find its application in image processing, computer vision and pattern recognition. The Curve lets transform is usually adopted for image de-noising along with texture classification. Facial recognition has the capacity to obtain demographic information on crowds, hence face biometrics results make it most important in retail marketing business.

The face recognition system consists various modules such as face detection and normalization, face feature extraction and matching. The face recognition process can be applied in face watch which can be comprised of face tracking and surveillance along with face verification and face identification. In face tracking and surveillance, the face images are tracked and compared with the available face image data set from stored databases. The main difference between face verification & identification is that, in face verification process a test face image which is being queried is compared against an available template face image whose identity is being established or claimed. Similarly in face identification a queried face image is compared against all available templates in the database to ascertain the claimed identity.

Face detection is a basic step in face recognition operation the limitations such as pose variation, illumination problem, occlusions etc need to be addressed to get best result. Various approaches have been proposed to address these issues but it can resolve only few limitations. For obtaining promising results, there is need to use combination of different approaches such as geometrical features of the face extracted from face boundary and eyes, shape of mouth etc.

In face recognition, detection, facial expression determination, animation, face modelling and various other models, the facial features extraction is an important method involved. As feature extraction process is very sensitive to illuminations, pose and noise variations, various techniques were used to resolve these problems. Hence to increase the performance of the system, the used techniques are Colour segmentation, appearance based, geometric based and template-based techniques.

CONTRIBUTION: Our proposed method is simple, compact and achieves high accuracy for the standard databases mentioned in our work. It proved to be better than some of the existing methods in terms of recognition rate. We could achieve very high success rate for all the databases considered and simultaneously reduce the error rate. The processing rate is reduced hence the memory requirement was decreased considerably.

2. LITERATURE SURVEY

The literature survey on the existing techniques of face recognition which have been presented by researchers previously referred by us during the course of our work are discussed in this section.

He Jun et al., [1] proposed a LBP fusion method for facial expression in which to extract the texture feature LBP method is used. Usually for extraction, the full image is used by neglecting key areas of facial appearance. To address this question, in this paper the authors have put forth a expression recognition method by combining features of key facial parts constructed on LBP, by separating into numerous parts like: eyebrows, distance between-eyebrow, eyes, mouth characteristics, nose and the characteristics extracted using the whole face to get a new attribute known as combine feature level fused key expression areas. To identify dissimilar expressions SVM and NN are used for classification.

Bin et al., [2] anticipated 2D-LBP to tally the weighted occurrence number of the variation invariant unchanging LBP pattern sets where sliding window concept is used for the same. This original technique's texture data extraction was not rotation invariant and severely limited, as this method only focuses on the histogram of LBP patterns and ignores the spatial related data between the LBP patterns. The new proposed method [2] uses multi-resolution 2D-LBP sideways through sliding window where resolution of 2D LBP is changed. By this method the obtained features are rotation invariant and additional discriminative compare to the original method.

Xiaojing Liu et al., [3] presented "Surface defect detection algorithm based on gradient LBP". This work improves the conventional LBP technique by proposing a surface defect detection technique, in which image sub-blocks are used for LBP data matrix size decrease which is based on GLBP-gradient local binary pattern. To suppress the property of light and noise on the recognition results, weighted binary output values in eight guidelines within the neighborhood to specify local gray changes has been adopted in the technique.

Jiali Yu et al., [4] has discussed in the paper about Face Recognition in which to define texture feature of facial image gray level co-occurrence matrix of the image is constructed first. Then for fulfilling the matching and identification of face, classification method of minimum weighted Euclidean distance is used.

M.M. Fakhir et al., [5] anticipated an algorithm on Face Recognition which is based on Features measurement technique. This uses a method to obtain the actual dimensions of three points ear to ear to recognize faces. The methodology enables images taken by different camera with minimum resolutions in the determination of the dimensions.

Melkye Wereta Tsigie et al., [6] introduced a solid facial recognition process by utilizing histogram with local binary pattern of oriented gradient characteristic extractor. T. Samartzidis et al., [7] authored the paper, in which they have presented melanin face pigmentation (MFP) as a new approach to extend classical face biometrics.

Tomesh Verma et al., [8] discussed about how face recognition is performed using PCA and LDA. In the paper, it has been presented how PCA gives class representations which are in an orthogonal linear space followed by LDA based dimension reduction techniques.

Adrian K. Davison et al., [9] proposed in the paper "Objective Classes for Micro-Facial Expression Recognition" that when a person tries to conceal their true emotion a micro expression is revealed. The showing of the true facial expression at a point maybe my not appropriate and when they consciously realize that they try and conceal it.

Wuming Zhang et al., [10] proposed model driven approach to generate chromaticity intrinsic image (CII) in a log chromaticity space which is robust to illumination variation. Face analysis offer advantages for a wide variety of applications in commerce and law enforcement compared to other biometrics such as easy access or avoidance of explicit cooperation from users. But there are many non-ideal challenging imaging environments cause severe problems. Hence it is to be focused on unconstrained real-scene face images. Divya A et al., [11] proposed Face Recognition Based on Windowing Technique using DCT. In this paper to divide each image into windows of sizes 4X4, 8X8 and 16X16 windowing technique is used [11].

Munikrishna D C et al., [12] proposed that to generate a square matrix, the features from the LBP and PDV are convolved then reshaped into a column vector. The column vectors of all the test data images from database are compared against the column vectors of the test image and the Matching is done by Euclidean Distance (ED). Baochang Zhang et al., [13] proposed LDP to capture the high order local derivative variations.

Juwei Lu et al., [14] proposed algorithm using Kernel Direct Discriminant Analysis (KDDA) which addresses issues such as small sample size problem and non-linearity of face patterns distribution. There are two main issues in FR which are classification of a new image based on chosen samples and feature selection for face representation. The Appearance based approach which directly operates on face images is the most successful and two powerful tools used in the appearance-based approaches are PCA and LDA which are used for data reduction and feature extraction. Two state of the art FR methods, Eigen faces, and Fisher faces are based on these two tools. In pattern classification LDA outperforms PCA.LDA simply does object reconstruction while PCA extracts most discriminative feature. LDA based algorithms face SSS problem, to solve this PCA was used in conjunction with LDA(PCA+LDA), but in this the null spaces which carried significant information was eliminated. There are other linear approaches such as D-LDA and F-LDA. But linear methods fail to perform when there is large variation in viewpoints. Hence to overcome all these a non-linear approach based on kernel machine technique which uses the strengths of F-LDA and D-LDA and which also overcomes its limitations is used.

Jiyun Cui et al., [15] proposed an approach under unconstrained scenarios to improve 2D face recognition accuracies where discriminative depth estimation method uses a cascaded fully convolutional network (FCN) and convolutional neural network (CNN) architecture. YueqiDuan et al., [16] proposed an unsupervised local feature-learning method to learn context aware binary descriptors for face representation where in a given face image pixel difference vectors (PDV) in local patches are extracted. In an unsupervised manner using discriminative mapping each pixel difference vector (PDV) into a context-aware binary vector is learnt to project. Yanpeng Liu et al., [17] proposed a framework that combines the LBP and gray-values to classify the facial expressions. Softmax regression method was used in the classification step. Instead of using the whole face they used only the active patches of the face which helped them get the key information of the different expressions.

3. PROPOSED FACE RECOGITION MODEL

The block diagram of the proposed Face model is shown in Figure 1.

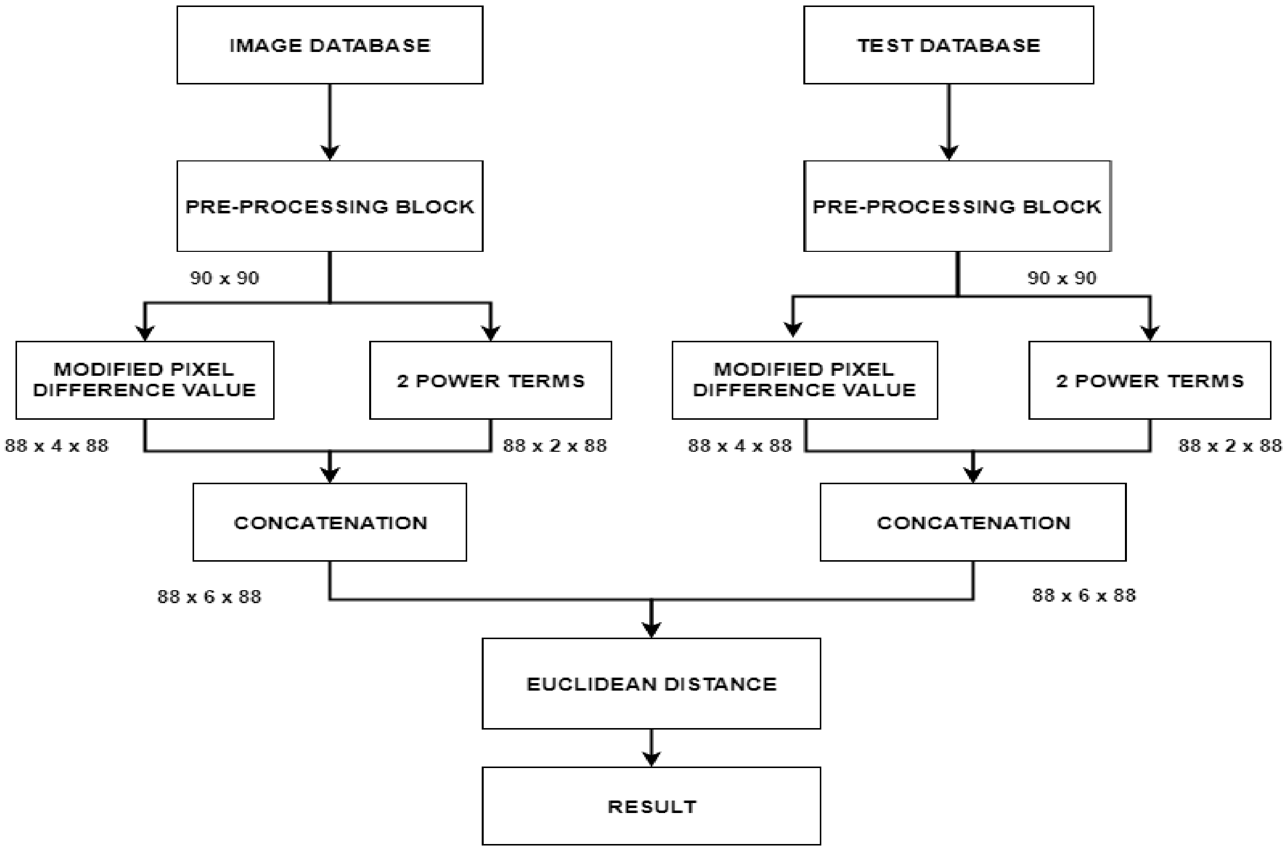

Fig. 1 The proposed model

3.1 AVAILABLE FACE DATABASES

In face identification research the accurate outcome is completely based on the kind of database we use. As face recognition is one of the popular research areas in Machine learning & computer vision, we can find different face databases created by companies as well as top universities and researchers. The standard databases such as ORL, Indian Males, Indian Females, Yale B and Extended Yale B, JAFFE databases are openly accessible face databases containing ample number of representative samples [12].

3.1.1 ORL FACE DATABASE [22**]** The Olivetti Research Laboratory (ORL) database is one of the most popular face database being used. The database contains pictures which were taken at different dissimilar times for different subjects by varying the lighting conditions. The data base is used in Cambridge University for face recognition in Speech, Vision and Robotics Group. The data base consists face images of 40 persons with each person's 10 different poses totaling around 400 images stored in 40 directories with one directory for each subject. Dark uniform environment has been used to take all the face images in different positions such as standing, anterior position etc with acceptance for some side movement as well.

3.1.2 INDIAN MALE DATABASE [23] Indian male database contains face images of 20 different subjects each person's 11 distinct images totally 220 images organized in 20 directories (one for each subject). . For each 256 RGB components per pixel, the size of each distinct image is 480 x 640 x 3 pixels where the face images were taken across an upright, Frontal position.

3.1.3 INDIAN FEMALE DATABASE [23] The Indian female database contains 20 different subjects face images with each person's 11 distinct images totally 220 images organized in 20 directories (one for each subject). The size of each distinct image is 480 x 640 x 3 pixels, each 256 RGB components per pixel.

3.1.4 JAPANESE FEMALE FACE EXPRESSION DATABASE (JAFFE) [26] The JAFFE database contains Japanese female face images of 10 different subjects each person's 20 distinct images totally 200 images organized in 10 directories (one for each subject). The size of each distinct image is 256 x 256 pixels, each gray scale image with 8 bits/pixel.

3.1.5 YALE B DATABASE [25] *The* database consists of 576 viewing conditions having 9 poses x 64 illumination conditions of 10 subject's total 5760 single light source images for all the subjects with ambient illumination also captured in a particular pose. Total size of the database after compression is 1GB.

3.2 PRE-PROCESSING TECHNIQUES

In this stage by removing noise and improving resolution, the face images with the noise and low resolution are enhanced to get better accuracy and improved performance of the system. To raise speed of computation number of bits per pixels are decreased by converting the RGB images in to greyscale images. As we know the processing time will be lesser for the smaller images, hence Re-sizing is another pre-processing operation that is performed on the images. However, the catch here is that the image cannot be minimized beyond a certain threshold, otherwise we would be compromising with the important features of that specific image which makes it different from the rest of the images in the database. Therefore, there always exists a trade-off between the image size taken into consideration and the processing time required.

3.3 PIXEL DIFFERENCE VALUE (PDV)

The PDV algorithm is used to get the input image sharp representation of lines and edges. The PDV delivers a strong discriminative power, after application of PDV the features obtained are very stable to local changes. Mathematical representation of PDV in equation (1) and (2), for a 3X3 matrix.

$$X = [(C_g-C_{p1}), (C_g-C_{p2}), (C_g-C_{p3}), (Cg-C_{p4}), (C_g-C_{p5}), (C_g-C_{p6}), (C_g-C_{p7}), (C_g-C_{p8})] \text{ -------------- } (1)$$

$$X = [(C_g - C_{pi})] \text{ for all i where i € 1 to 8 --------------------------------- } (2)$$

Where Centre pixel is C_g and the neighboring pixel is C_{pi}. In an attempt to explain the PDV, we consider the following example; the 3X3 matrix is considered as shown in figure 2,

51	45	47
50	49	46
48	51	49

Fig 2. Sample 3X3 matrix for depicting PDV

In this feature extraction overlap or non-overlap can be considered, we have considered overlap as it was providing better results. Irrespective of that consideration, the usage of formula remains the same and the output for this particular example is as follows: The central pixel Cg (49) is need subtract from all its neighboring pixels Cpi as per PDV algorithm

51-49=2; 45-49=-4; 47-49=-2; 50-49=1; 46-49=-3; 48-49=-1; 51-49=1; 49-49=0;
Therefore, the obtained PDV vector of the 3x3 matrix is as follows:

X= [2 -4 -2 1 -3 -1 1 0]

On applying PDV to the entire 90x90 sized image with overlap we get 88x8x88 vectors for a single image i.e. 88 matrices each with 88 rows and 8 columns. The complete dimension is 7744x8.

3.4 MODIFIED PIXEL DIFFERENCE VALUE

In an attempt to decrease the error rate and the computational time and increase, the effective efficiency we were able to modify PDV to obtain the required results. The modified PDV focuses on preserving most of the pixel values, which leads to increase in information that can be used for comparison between the database image and the test image therefore obtaining better results compared to PDV. In this method, approximately 78% of the information is preserved which is a preferred characteristic in the feature extraction. To understand Modified PDV, the following table has been put forth and the formula follows:

$X1 = (C_{p1}+C_{p7})$; ----------------------------- (3)

$X2= (C_{p3}+C_{p9})$; -------------------------------(4)

$X3 = (C_{p2}+C_{p8}-C_{p4}-C_{p6})$; ----------------------(5)

$X4 = (C_{p5})$; -------------------------------------(6).

C_{p1}	C_{p2}	C_{p3}
C_{p4}	C_{p5}	C_{p6}
C_{p7}	C_{p8}	C_{p9}

Fig 3. Sample 3X3 matrix for Modified PDV

This method is a modified version of PDV. For every 3x3 matrix there are 4 values instead of 8 values as in PDV. The first two values are the sum of corner pixels on either sides and the third value in this new proposed method has both addition and subtraction and fourth value is same as the central value of the 3x3 matrix. The equations (3), (4), (5) and (6) enunciate the proposed method mathematically. Finally, we get a 9x4 matrix for each 3x3 matrix, as below,

23	45	78	90
45	77	67	89
34	88	-78	0
66	98	56	-2
79	53	78	23
34	45	45	34
32	90	23	5
-6	45	29	66
45	54	87	34

9 x 4

Fig 4. Modified Pixel Difference Vector

For a complete image of size 90x90 the vectors obtained are of the dimension 88x4x88 i.e., 88 matrices with each containing 88 rows and 4 columns.

3.5 TWO POWER TERMS

In this method those values are being used for comparison where the terms which were not completely preserved in Modified PDV by using their information which has been increased. The increase in the information has resulted in better Equal Error Rate and Maximum Total Success Ratio. This method compliments the Modified PDV and helps achieve good results for colored images as well. Consider a 3x3 matrix, here we are assigning each term with powers of 2 i.e., multiplying them with respective powers of 2.

$C_{p1}-2^0$	$C_{p2}-2^1$	$C_{p3}-2^2$
$C_{p4}-2^3$	C_{p5}	$C_{p6}-2^4$
$C_{p7}-2^5$	$C_{p8}-2^6$	$C_{p9}-2^7$

Fig 5. Representation of 3X3 matrix of Two Power Terms

The center pixel is not assigned any value as that is being completely preserved in the Modified PDV. Now, we consider only the terms C_{p2}-2^1, C_{p6}-2^4, C_{p4}-$2^3$and C_{p8}-2^6.

The two terms added to the features extracted from MPDV are the values obtained from the equations (4) and (5)

$$Y1=C_{p2} \times 2^1 + C_{p6} \times 2^4 \quad \text{------(7)}$$

$$Y2=C_{p4} \times 2^3 + C_{p8} \times 2^6 \quad \text{------(8)}$$

Here we get an 88 x 2 x 88 as the dimension per image.

3.6 FINAL FEATURES USING CONCATENATION

The values obtained from the MPDV are concatenated with the Two Power Term values of the face image. The final matrix dimension for each image is 88 x 6 x 88 and the column vector is of the sized 46464. From the equations (3), (4), (5), (6), (7) and (8) we get,

[Z] = [X1, X2, X3, X4, Y1, Y2];

3.7 EUCLIDEAN DISTANCE

Euclidean distance validates the root of square differences between the pair of coefficients values of images. Image is considered the most similar image in the database, when its calculated distance value is small.

$$d(x,y)=(\sum_{i=1}^{l} |x_i-y_i|^2)^{1/2} \quad \text{------(8)}$$

Here the coefficients of database is x_i and test images is y_i.

4. PROPOSED ALGORITHM

Identification of human beings based on face images with variations in intensity values, expressions etc. using Modified PDV features. The values obtained from the middle value, which is completely preserved, are concatenated with the other terms, which undergo mathematical computations to get final features for maximum face recognition in Modified PDV and with the terms obtained from Two Power Terms Method.

The novel face recognition algorithm is developed to reduce the Equal Error Rate - EER and to increase the Optimum Total Success Rate – OTSR and Maximum Total Success Rate - MTSR using Modified PDV.

The proposed algorithm is illustrated in the table 1.

Table 1. Proposed Algorithm

PROPOSED ALGORITHM
Input: Images of faces from Standard databases
Output: Obtaining results in the form of performance parameters
Step 1: The face databases from ORL, Extended Yale B, JAFFE, Indian Female, Indian Male are considered.
Step 2: Pre-processing to resize the image to 90x90 and to convert image from Colour image to Grayscale image and Histogram Equalization is applied.
Step 3: Run a loop to consider only 3x3 matrix at a time and with overlap
Step 4: Apply Modified Pixel Difference Value to matrix obtained in Step 3
Step 5: Apply Two Power Terms to matrix obtained in Step 3
Step 6: The terms obtained in Step 4 and Step 5 are concatenated.
Step 7: The process is repeated from Step 1 to Step 6 for the test-data
Step 8: Comparison of test face with the database faces using Euclidean Distance
Step 9: Compute performance parameters which are EER, OTSR, MTSR

5. PERFORMANCE ANALYSIS

FAR (False Acceptance Ration), FRR (False Rejection Ration), ERR (Equal Error Rate) and TSR(Total Success Rate) are important performance parameters studied here. Maximum TSR (MTSR) can be defined as the maximum value of the TSR extracted from the graph and similarly the Optimum TSR (OTSR) is the TSR optimum value which is extracted by drawing a straight line at the intersection of FRR and FAR with the TSR.

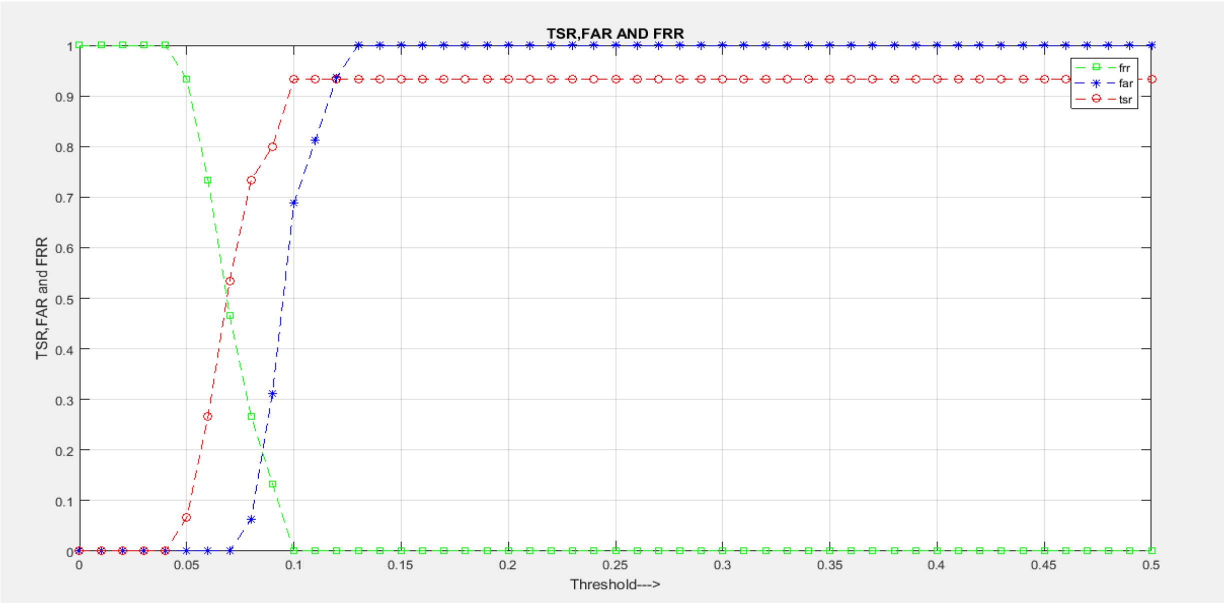

Fig 6. Total success rate showing OTSR and MTSR Here, MTSR is 0.93 while OTSR is 0.8

5.1 ORL Database: The ORL Database performance graphs for different values of PID - Persons inside Database and POD-Persons outside Database with respect to threshold values is shown below in the figures

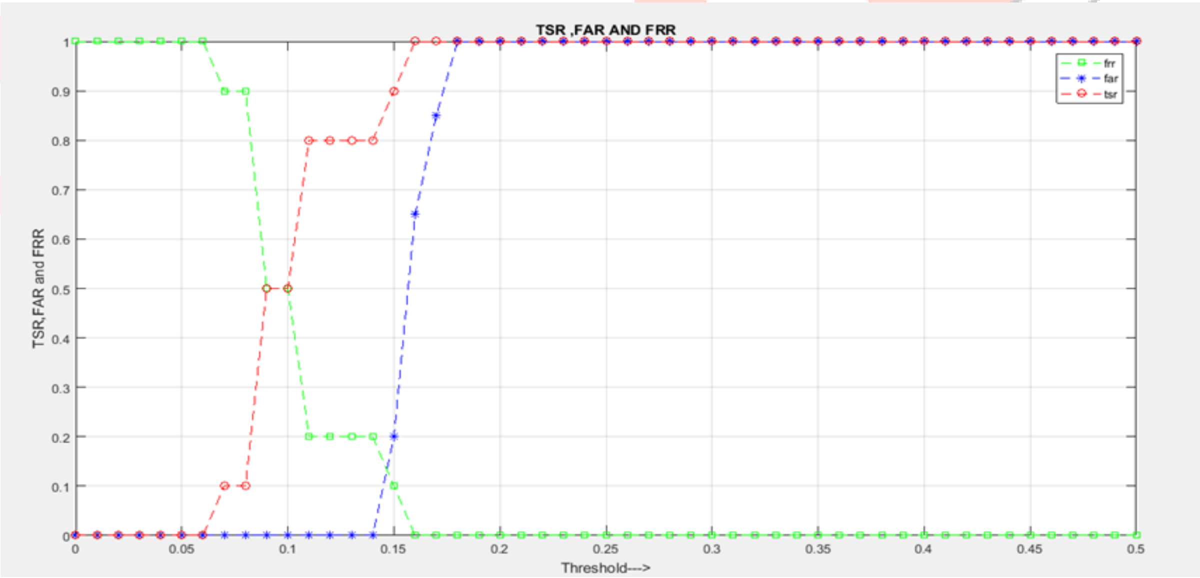

Fig 7. Evaluation parameters variation of 10:20 for ORL Database for different combinations PID and POD

The graph above depicts the performance parameters for ORL database with PID = 10 and POD = 20. We see that EER = 11.5%, where FRR = FAR, at the threshold 0.145. The OTSR is observed to be 87% while MTSR shoots to 100%.

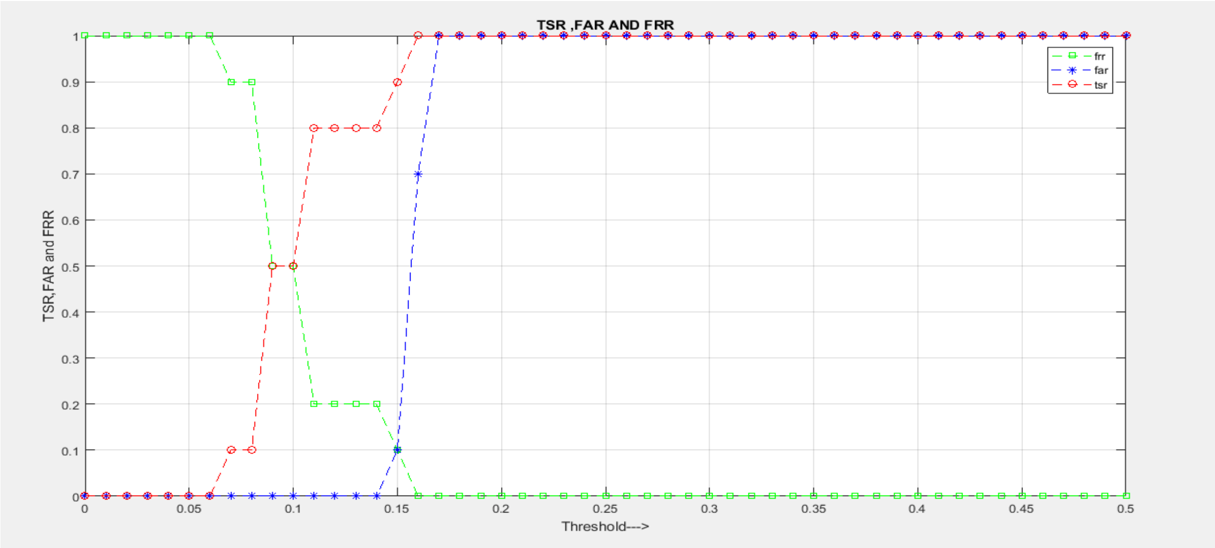

Fig 8. Evaluation parameters Variations of PID and POD of 10:10 for ORL Database for different combinations

The graph above depicts the performance parameters for ORL database with PID = 10 and POD = 10. The result was observed slightly different from earlier. We see that EER = 10%, at the threshold 0.15. The OTSR is observed to be 90% while MTSR is still to 100%.

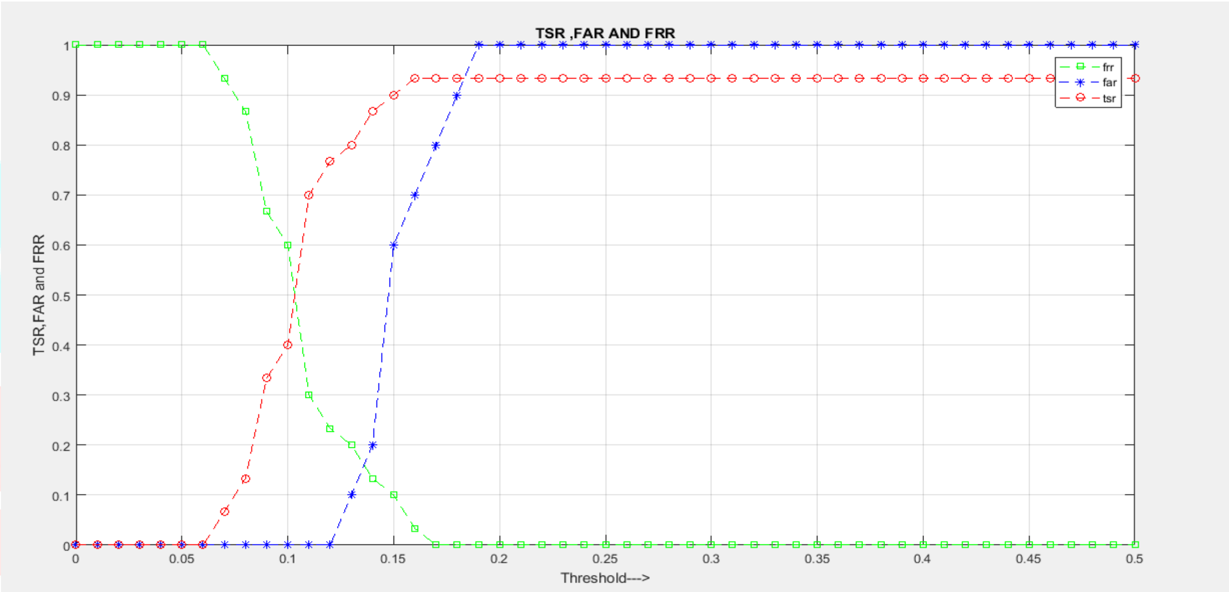

Fig 9. Evaluation parameters variations of 30:10 for ORL Database for different combinations PID and POD

For PID = 30 and POD = 10 the EER was observed to be 15%, where FRR = FAR, at the threshold value 0.13. The OTSR is observed to be 87% while MTSR decreased to 92%.

Performance parameter variations with respect to PID and POD: The ORL database analysis of performance has been tabulated in Table 2, which consists of PID, POD, EER, Maximum TSR and Optimum TSR.

Table 2. ORL Database Performance values for different values of PID and POD

PID	POD	EER%	OTSR%	MTSR%
10	20	11.5	87	100
10	10	10	90	100
10	30	15	81	100
20	10	12	87	95
30	10	15	87	92

The above table has the performance characteristics of ORL database. From the table it is inferred that as the values of PID and POD increases, the EER value also increases but the values of MTSR and OTSR values decreases.

5.1 Indian Female Database: The evaluation parameters of Indian Female Database for different values of PID and POD with respect to threshold values is shown below in the figures.

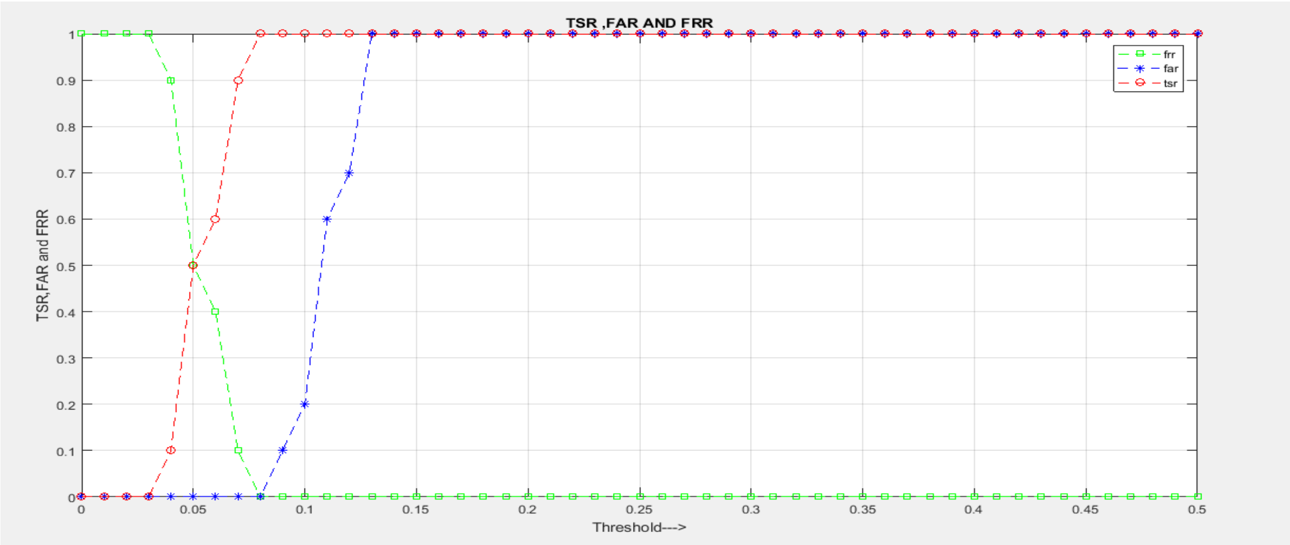

Fig 10. Evaluation parameters variations of 10:10 for Indian Female Database for different combinations PID and POD

The graph above depicts the performance parameters for Indian Female database with PID = 10 and POD = 10. We see that EER = 0%, where FRR = FAR, at the threshold value 0.13. The OTSR is observed to be 100% while MTSR shoots to 100%.

For PID = 13 and POD = 9 EER was observed to be 8%, where FAR = FRR, at the threshold value 0.135. OTSR was observed to be 91% while MTSR = 100%.

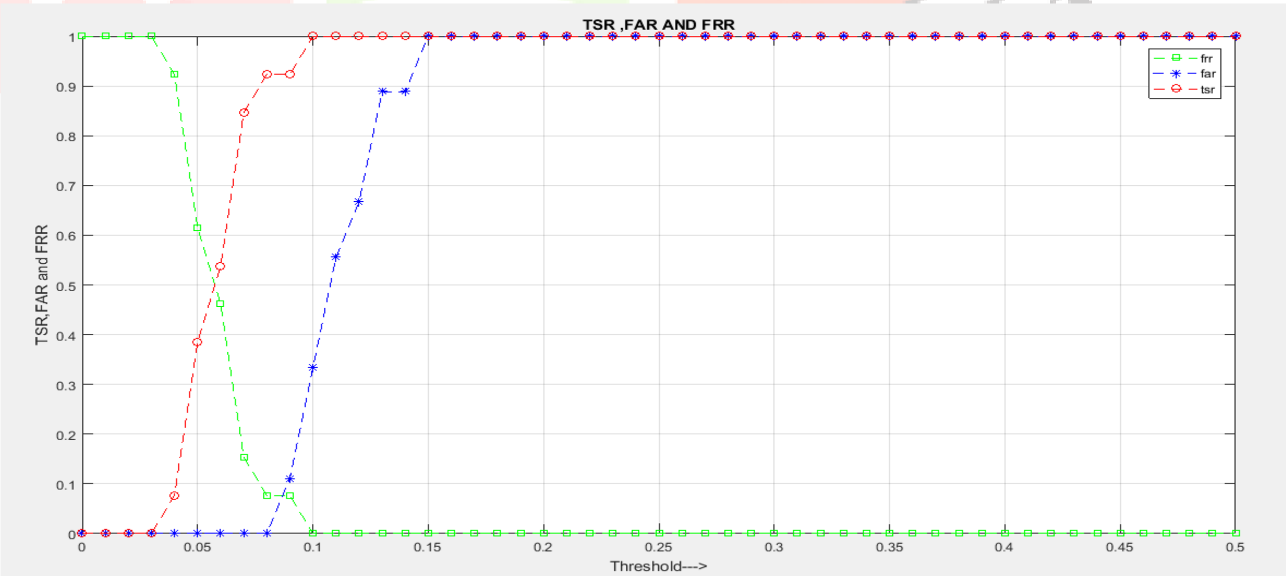

Fig 11. Evaluation parameters variation of 13:9 for Indian Female Database for different combinations PID and POD

Performance parameter variations with respect to PID and POD: The Indian Female database analysis of performance has been tabulated in Table 3 which consists of values from PID, POD, EER, Maximum TSR and Optimum TSR.

Table 3 Indian Female Database Performance values for different values of PID and POD

PID	POD	EER%	OTSR%	MTSR%
10	10	0	100	100
13	9	8	91	100
7	15	0	100	100
17	5	5	92	100

The Indian Females database performance characteristics has been tabulated in above table. From the table it is inferred that as the value of PID increases, EER value increases, OTSR value decreases. Similarly, when the POD values increases, EER value decreases and OTSR value increases whereas the values of MTSR remains constant throughout.

5.3 Extended Yale B Modified Database: The performance graphs of Extended Yale B Database for different values of PID and POD with respect to threshold values is shown below in the figures

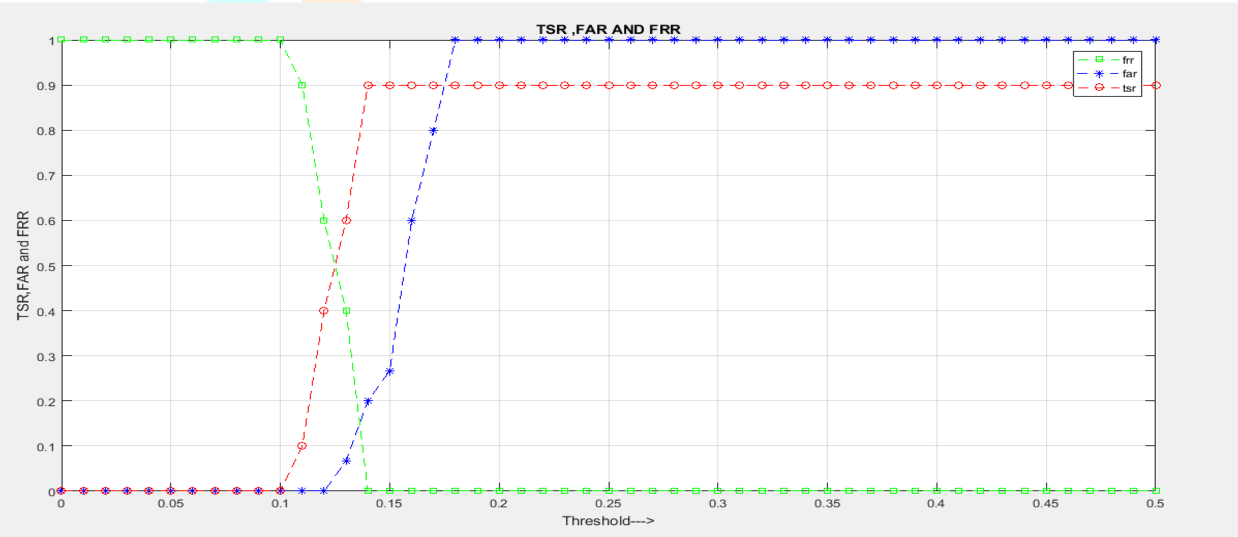

Figure 12. Evaluation parameters variations of 10:15 for Extended Yale B Database for different combinations PID and POD.
While considering Extended Yale B database with PID = 10 and POD = 15 EER was observed to be 15% while OTSR equalled 90% and MTSR was also 90%.

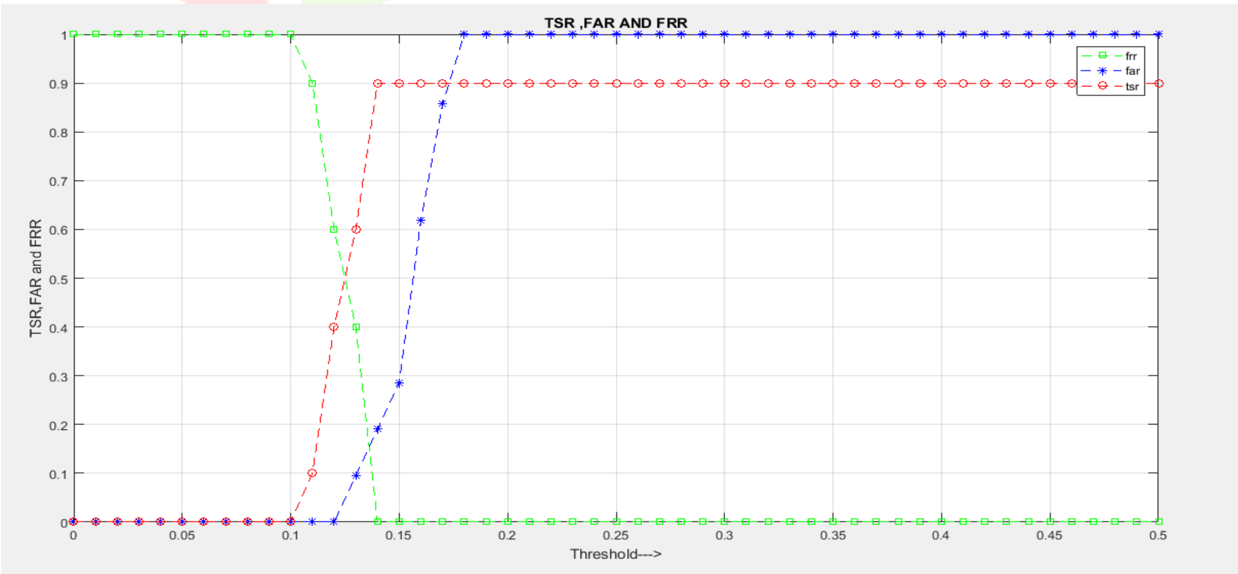

Figure 13 Performance parameters variations of 10:21 for Extended Yale B Database for PID and POD.
For PID = 10 and POD = 21 EER was 15% at 0.13 with OTSR = 90% and MTSR = 90%.

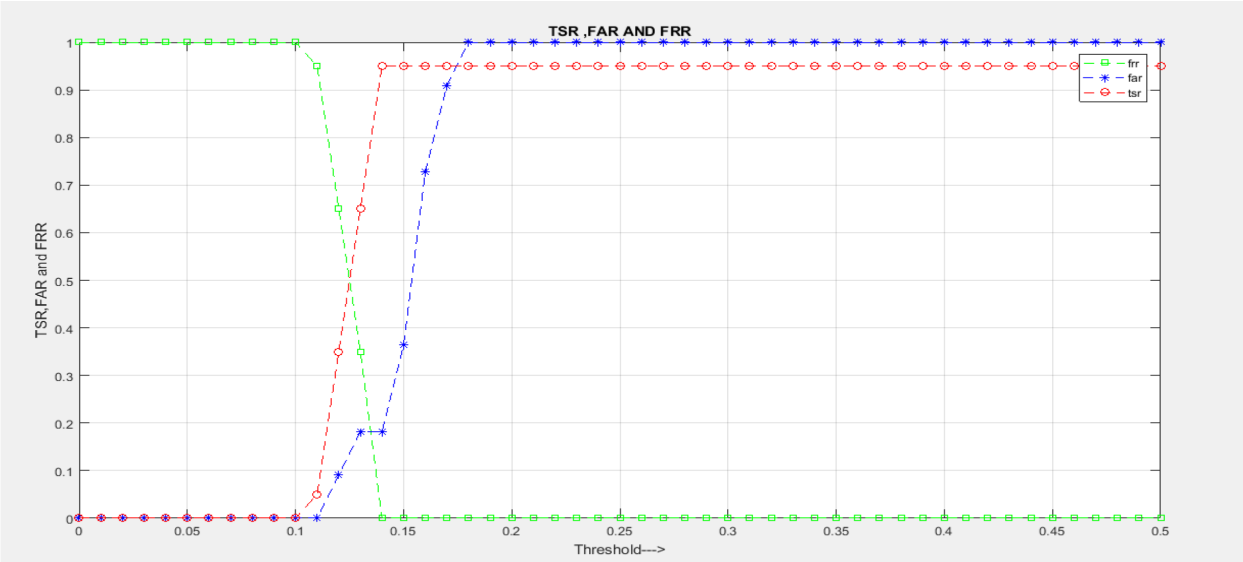

Figure 14 With PID and POD of 20:11 for Extended Yale B Database performance parameters variations.

The above graph shows the value obtained for the variation of PID:POD as 20:11 respectively in the Extended Yale B database. The EER was found to be 19% obtained at threshold 0.13. The OTSR obtained is 94% while, MTSR is 94% as well.

Performance parameter variations with respect to PID and POD: The Extended Yale B database analysis of performance has been tabulated in Table 4 which consists of the values of PID, POD, EER, Maximum TSR and Optimum TSR.

Table 4 Extended Yale B Database performance values for different values of PID and POD.

PID	POD	EER%	OTSR%	MTSR%
15	16	18	92	92
20	11	19	94	94
10	21	15	90	90
10	10	12	90	90
10	15	15	90	90

The above table has the performance characteristics of Extended Yale B database. It can be inferred from the above table that as the value of PID increases, EER value increases, MTSR value and OTSR values also increases.

5.5 Yale B Database: The Yale B Database performance analysis has been shown in the given graphs and table.

Performance parameter variations with Threshold: The performance graphs of Yale B Database for different values of PID and POD with respect to threshold values is shown below in the figures

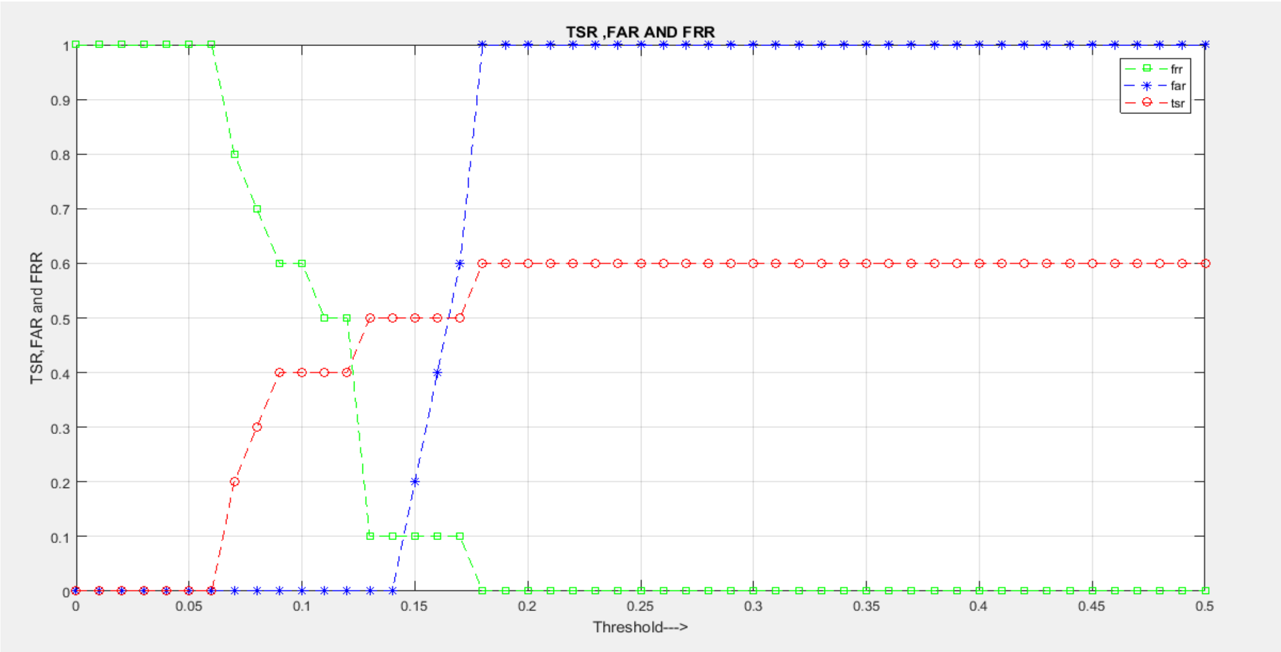

Figure 15 Yale B Database Performance parameters variations with PID and POD of 10:5

The above graph shows the value obtained for the variation of PID: POD as 10:5 respectively in the Yale B database. The EER was found to be 10% obtained at threshold 0.14. The OTSR obtained is 50% while, MTSR is 60%.

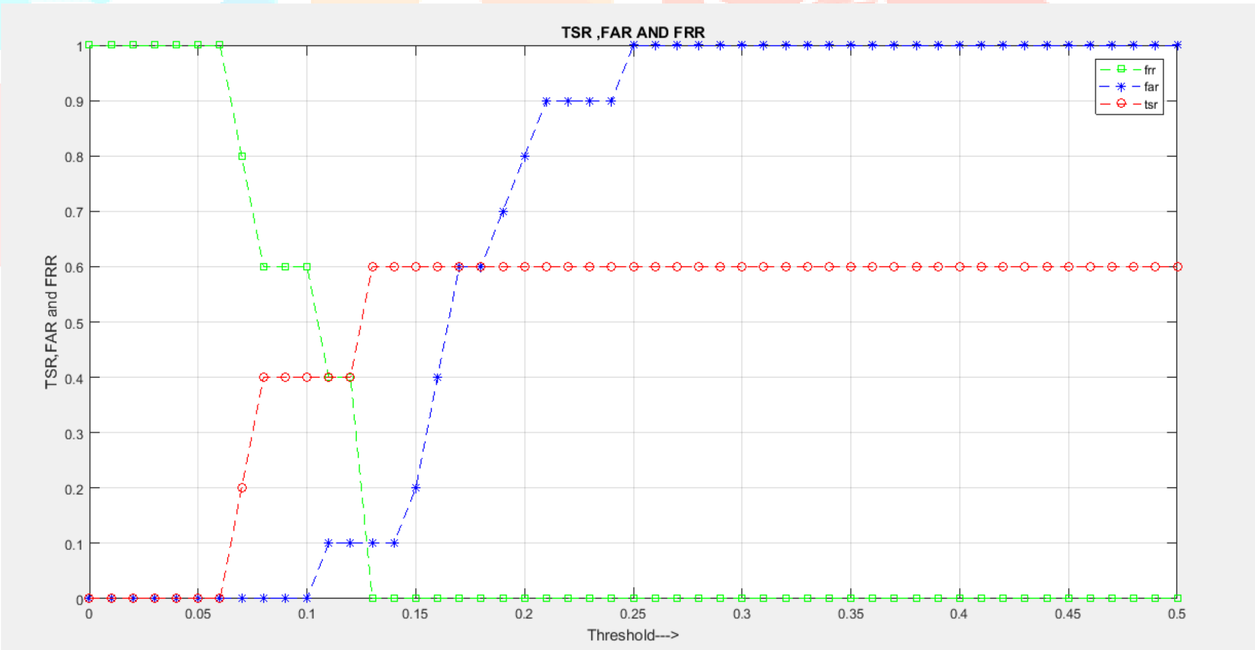

Figure 16. Yale B Database Performance parameters variations with PID and POD of 5:10

While considering Yale B database with PID = 10 and POD = 10 EER was observed to be 10% at the threshold 0.13 while OTSR equalled 50% and MTSR was 60%.

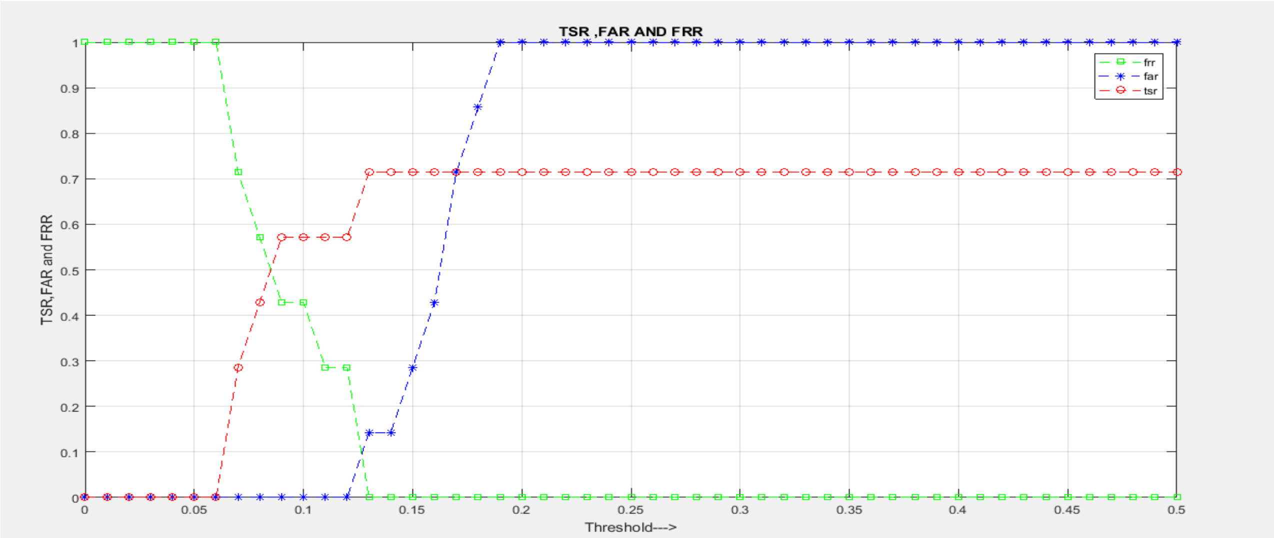

Figure 17. Performance parameters variations with PID and POD of 7:7

Finally, Yale B database was considered with PID = 7 and POD = 7 then, EER was found to be 10% at the threshold 0.125 while OTSR = 58% and MTSR = 71%.

Performance parameter variations with respect to PID and POD: The Yale B database analysis of performance has been tabulated in table 5 which consists of values of PID, POD, EER, Maximum TSR and Optimum TSR.

Table 5 Yale B Database performance values for different values of PID and POD

PID	POD	EER%	OTSR%	MTSR%
10	5	10	50	60
5	10	10	50	60
5	5	20	45	60
11	3	9	55	62
7	7	10	58	71

The above table has the Yale B database performance characteristics and it can be inferred from the table that as value of PID increases the EER value decreases while MTSR value increases.

5.5 JAFFE Database: The JAFFE Database performance graphs for different values of PID and POD with respect to threshold values is shown below in the figures.

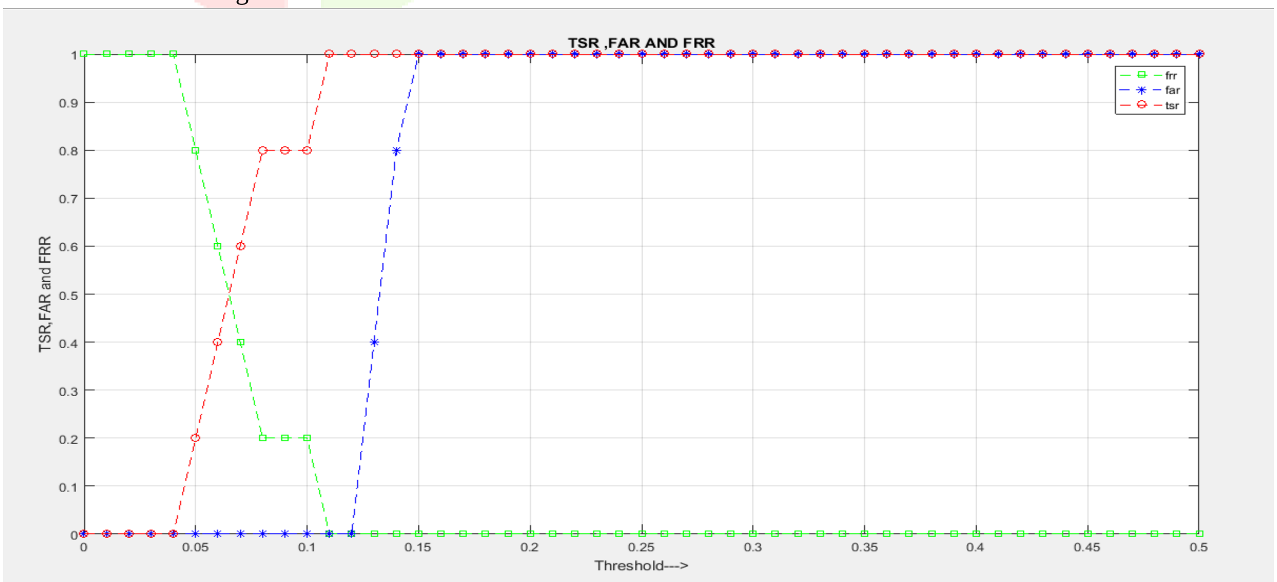

Figure 17 JAFFE Database Performance parameters variations with PID and POD of 5:5.

The above graph shows the value obtained for the variation of PID: POD as 5:5 respectively in the JAFFE database. The EER was found to be 0% obtained at threshold 0.12. The OTSR obtained is 100% while, MTSR is 100%.

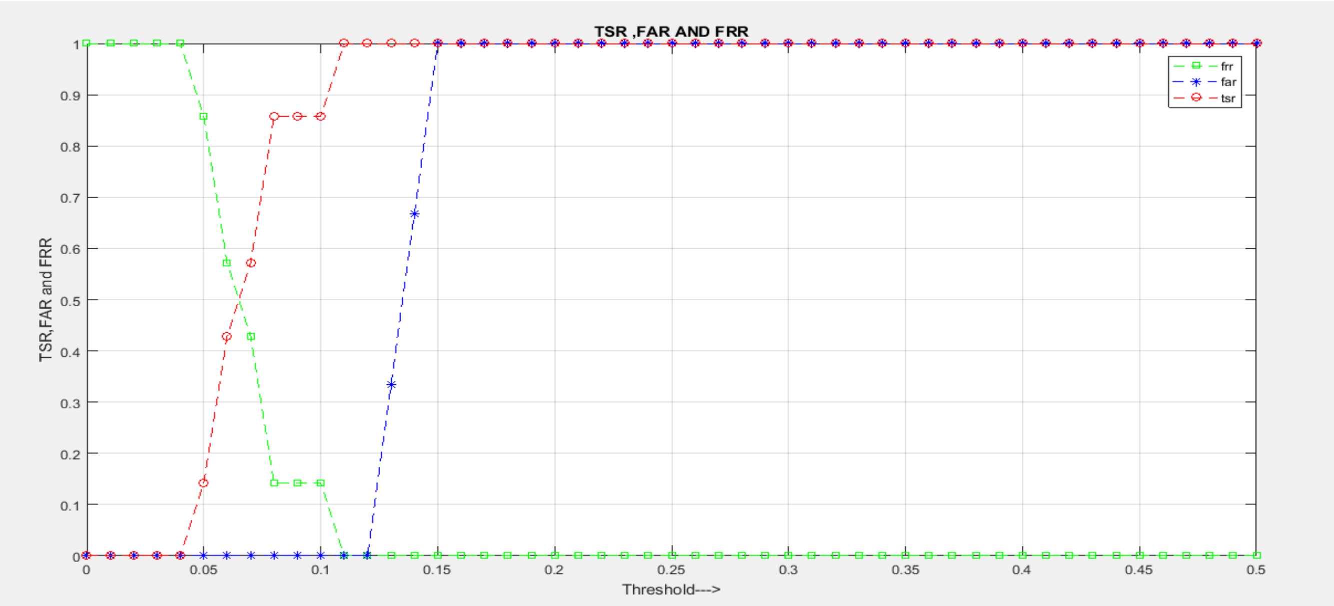

Figure 18 JAFFE Database Performance parameters variations with PID and POD of 7:3.

Next, we considered JAFFE database with PID = 7 and POD = 3. The result was observed where EER = 0% at the threshold 0.12. The OTSR is observed to be 100% along with MTSR which was 100%.

Performance parameter variations with respect to PID and POD: The JAFFE database analysis of performance has been tabulated in table 6 which consists of values of PID, POD, EER, Maximum TSR and Optimum TSR.

Table 6 The Performance values of JAFFE Database for different values of PID and POD.

PID	POD	EER%	OTSR%	MTSR%
5	5	0	100	100
7	3	0	100	100
4	5	0	100	100
6	4	0	100	100

The above table has the performance characteristics of Extended Yale B database. We can infer from the table that for any combination of POD and PID the EER is always 0% while OTSR and MTSR is always 100%.

5.6 Indian Male Database: The Indian Male Database performance graphs for different values of PID and POD with respect to threshold values is shown below in the figures.

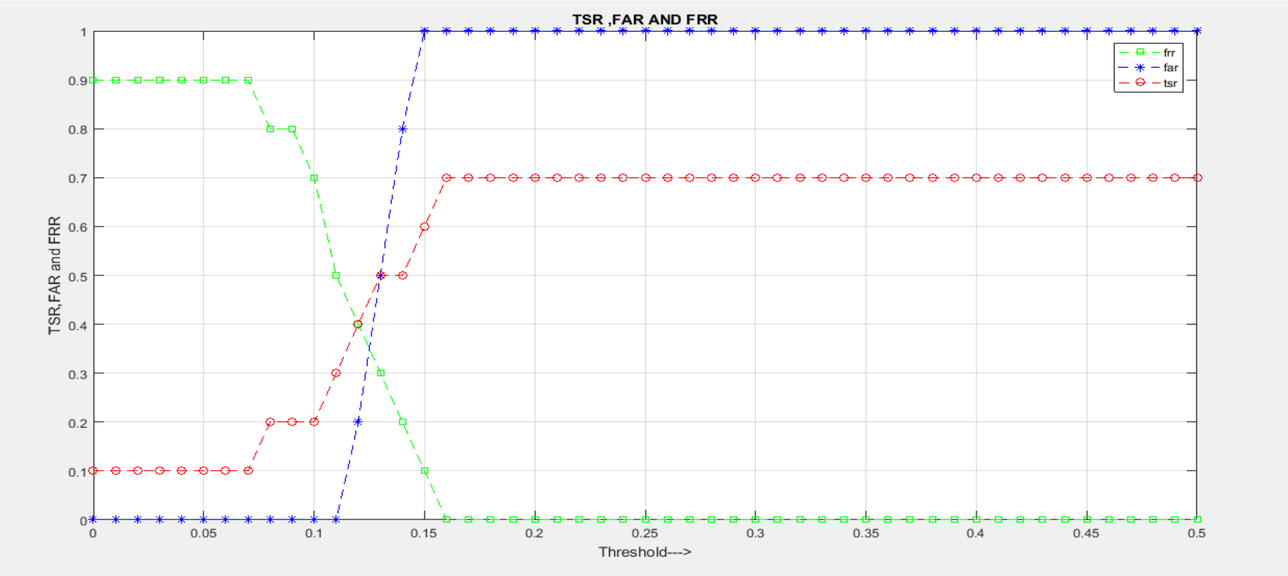

Figure 19 Indian Male Database Performance parameters variations with PID and POD of 10:10

The above graph shows the value obtained for the variation of PID: POD as 10:10 respectively in the Indian Male database. The EER was found to be 33% obtained at threshold 0.13. The OTSR obtained is 45% while, MTSR is 70%.

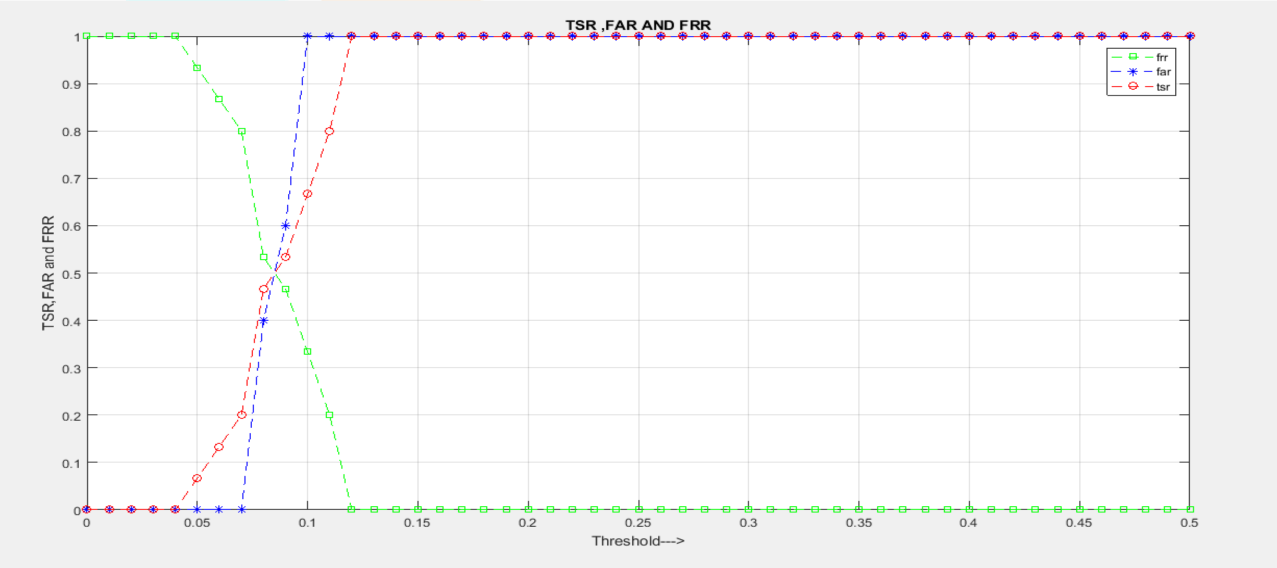

Figure 20 Indian Male Database Performance parameters variations with PID and POD of 15:5

Next, we considered Indian Male database with PID = 15 and POD = 5. The result was observed where EER = 50% at the threshold 0.08. The OTSR is observed to be 50% along with MTSR which was 100%.

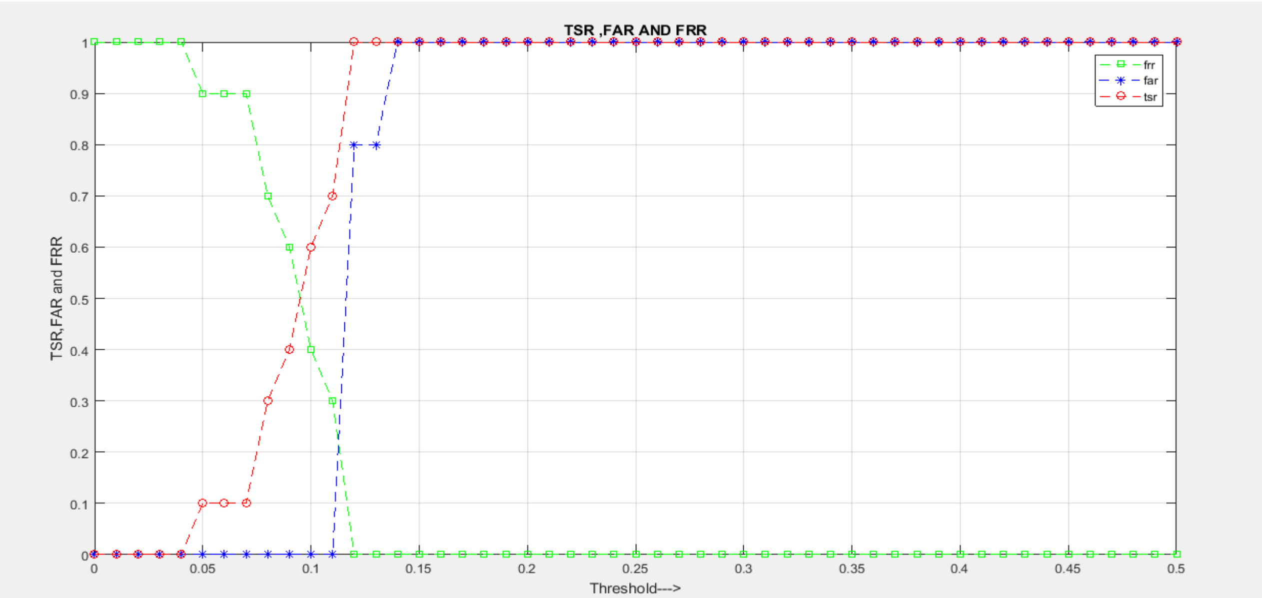

Figure 21 Indian Male Database Performance parameters variations with PID and POD of 10:5.

For PID = 10 and POD = 5 EER was observed to be 20% at the threshold 0.09 with OTSR = 80% and MTSR equalling 100%.

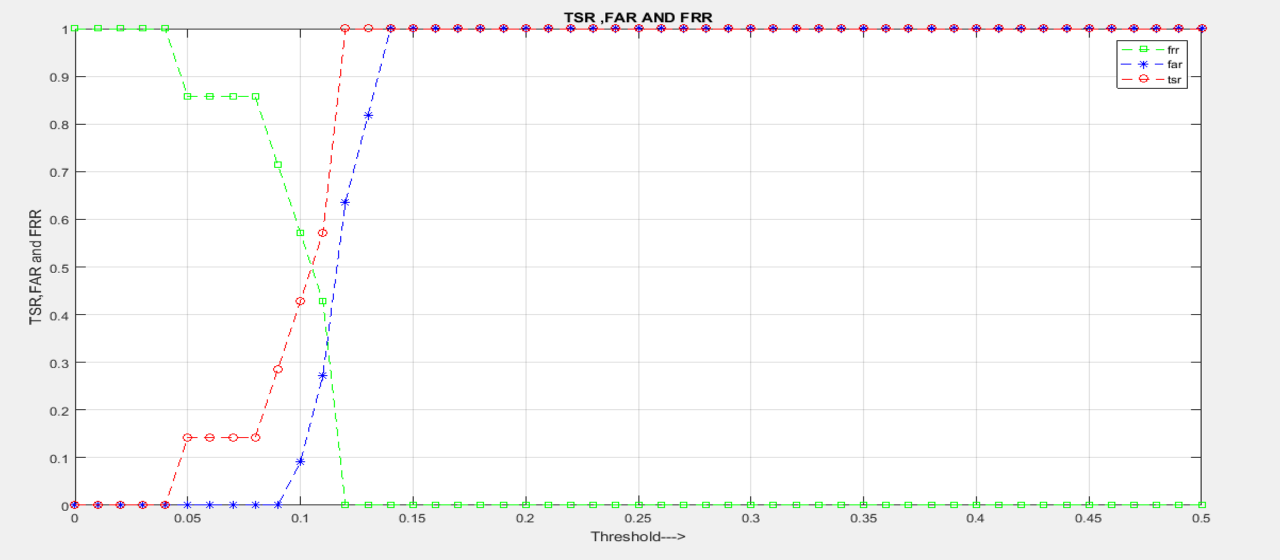

Figure 22 Indian Male Database Performance parameters variations with PID and POD of 7:11.

The above graph shows the value obtained for the variation of PID: POD as 7:11 respectively in the Indian Male database. The EER was found to be 32% obtained at threshold 0.12. The OTSR obtained is 90% while, MTSR is 70%.

Performance parameter variations with respect to PID and POD: The Indian Male B database analysis of performance has been tabulated in table 7 which consists of values of PID, POD, EER, Maximum TSR and Optimum TSR.

Table 7 Indian Male Database Performance values for different values of PID and POD.

PID	POD	EER%	OTSR%	MTSR%
10	10	33	45	70
15	5	50	50	100
10	5	20	80	100
7	11	32	90	100
11	9	20	95	100

The above table has the performance characteristics of Indian Male database. The inference can be drawn from above.

5.8 Proposed model comparison with existing methods

In Table 8 results of the performance and comparison of proposed method with the existing methods on ORL database has been tabulated. In the LBPH, Multi-KNN and BPNN method [28] using the Euclidean distance technique, the recognition rate was found to be 0.935. (ii) By applying the Joint Feature Vector [29] on the ORL Database a maximum of 0.855 recognition rate was achieved. (iii) PCAand LDA were adopted in Fisher face [27] and it resulted in 0.85 recognition rate. (iv) The convolution of LBP and PDV on ORL Database observed a maximum of 95% MTSR. The results demonstrate clearly that our approach provides the highest recognition rate when compared with other methods.

Table 8 Using ORL Database comparison of the proposed method performances with the existing methods

Sl No	Author Names	Method Used	% Value of MTSR
1	Xiaoyu Xu et al.,[27]	Fish (PCA+LDA)	85.0
2	Mohannad A Abizneid and Auzif Mahmood [28]	LBPH, Multi-KNN and BPNN	93.5
3	Saleh Albelwi and Auzif Mahmood [29]	Joint Feature Vector	85.5
4	Munikrishna et al.,[12]	Convolution of LBP and PDV	95.0
5	Niranjana Kumara M	Proposed Model	100

CONCLUSION

Face Recognition is a concept that has become widely popular due to its high efficiency and non-intrusive nature. It is an extremely secure way to help identify an individual. In this project, we proposed face recognition in view of Modified Pixel Difference Value and Two Power Terms. The face images of different sizes from various databases are converted into a uniform dimension of 90 x 90. Following the resizing the pre-processing method called Histogram Equalization is applied which enhances the contrast of the images. Feature Extraction, the next step in the face recognition process is done using two methods. One being the Modified Pixel Difference Value where maximum possible pixel preservation is done and the other is the Two Power Terms method where information in the pixels is increased for better comparison. The features extracted then are concatenated. The features of the images of the database and the test images are compared using Euclidean Distance to obtain performance parameters. It can be inferred from the results that the performance of the proposed method is better than the compared existing methods. In the future improvised pre-processing techniques can be applied to the images and the number of features can be reduced to increase speed of computation, which might help give better performance parameters.

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