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A Novel Face Biometric Framework based on Various Levels of Distinctions of Faces

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Abstract: The face recognition biometric technique based on whole-face images is continuing in research still due to various levels of distinctions namely, distance, appearances, expressions, eyes variations, illumination conditions, and type of camera. In this work, two feature extraction algorithms were used for the face recognition system for biometric applications namely, the filtered approximate band of Discrete Wavelet Transform (DWT_LL) and LOG Gabor (LG). Here significant filters namely, Gaussian (G), Difference of Gaussian (D), Laplace of Gaussian (L) utilized for smoothing face images which were fed into DWT to extract definite DWT_LL features. The examination of our work is assessed on a large face database containing 5000 face images of 25 different individuals of each 200 face images which are captured using a 5 Megapixel camera. The Multiclass Support Vector Machine classifier (MSVM) classifier consolidates filtered DWT and LG features to evaluate various boundaries of performance and tries to yield palatable outcomes contrasted with past strategies and here also shows that the L_DWT_LL &LG combination produces the best performance compared to D_DWT_LL & LG and G_DWT_LL & LG hybrid strategy.

Keywords: Filtered DWT, LG, MSVM, RBF, ROC.

1. Introduction

For biometric applications, symbols such as the voice, hand, mark, eye, finger, and face are commonly used. The survey shows that face gives more than 90 % of the effects compared to other signs, and this helps greatly in various applications of security use in society. The verification of the human face and searching for similarity is also called face recognition biometric system which is the consolidation of four steps namely, detection of a human face in an image, preprocessing to enhance features of the detected face image, feature extraction to generate features coefficients for each preprocessed face image by considering interest points or a whole face image and finally, the classification strategy is prescient displaying used to isolate highlight vector setpoints into various classes. Various face recognition methods namely, eigenface, artificial neural networks (ANN), principal component analysis (PCA), gabor wavelets, morphable model in the 3D domain, hidden markov models, support vector machines (SVM), independent component analysis (ICA), and elastic bunch graph matching were reviewed [1]. The face recognition techniques and challenges by considering various issues expressions, pose presents, occlusion, aging, and resolution either in images or sequence of images from the video were explained [2]. The face detection and recognition techniques were surveyed on different databases based on key points namely, eyes, and lips measurements [3]. The local, global, and hybrid approaches were reviewed for face recognition. Here the concept of face image feature vector extraction process based on two approaches namely, interesting points of face image and whole face image were explained [4]. The local binary pattern histogram (LBPH) technique was proposed for the recognition of faces [5]. The log-gabor filter banks with the polygonal algorithm and color histogram for image retrieval were proposed and here recall and precision parameters were considered for evaluation [6]. The various biometric symbols namely, whole face, expression, fingerprint, hand,

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were reviewed, and here a new Iris biometrics technique based on the log gabor enhanced filter technique was proposed and experimented on the CASIA database with valuable results [7]. The binarized statistical significant log-gabor feature descriptor with PCA, linear discriminant analysis (LDA), and the nearest neighbor classifier were proposed for the finger knuckle print recognition [8]. A new symmetrical approach was proposed based on the flipping of face images with gabor filter and local binary pattern (LBP) face recognition and here the experiment was conducted on an ORL smaller database [9]. The frontal face image recognition based on discrete wavelet transform (DWT) with PCA and singular valued decomposition SVD algorithm was proposed and experiments were conducted on JAFFE, MIT. Here DWT decomposes the image into four frequency subbands namely, approximate, vertical, horizontal, and diagonal, and only an approximate band was considered for the experiment [10]. The Viol-Jones face detector along with DWT feature extraction and deep neural network classifier was proposed and evaluated on a smaller frontal face image database. Here Histogram equalization preprocessing algorithm was utilized to represent the enhanced version of the original image. Here three networks layers namely softmax regression, fully connected, and pooling layers were considered for the evaluation [11]. The feature dimension reduction methods namely, grey level co-occurrence matrix (GLCM), DWT, and principle component analysis (PCA) were compared by utilizing the Euclidean distance classifier and here shown that PCA and wavelet features are produces satisfactory results compared to GLCM features [12]. Many hybrid approaches were developed in the past year for face biometric applications by considering various metrics. The consolidated or hybrid face recognition framework was proposed using the approximate band of DWT, linear discriminate analysis, and contrast adaptive histogram equalization (CLAHE) on CMU–PIE, extended YALE databases[13]. A new approach for face recognition using histogram of gradient (HOG) was proposed. Here image normalization, adaptive histogram equalization, and DWT were used for preprocessing and the PCA dimension reduction algorithm and multi-layer perceptron (MLP) neural network classifier were used for evaluation on FERET, ORL databases [14]. The approximate band of DWT and support vector machine (SVM) classifier with an image translation model with Gabor filters and here experiment was conducted on Indian, L speack, JAFFE, and ORL databases [15]. A new hybrid technique for face recognition was developed by combining DWT and local binary pattern (LBP) feature extraction methods. Here K-nearest neighbor (KNN) classifier was utilized to evaluate the accuracy [16]. Similarly, the hybrid features namely, local binary pattern preprocessing and wavelet transform, but here firstly LBP is applied for each LBP image, secondly, the DWT method was decomposing LBP images to get LL band image [17]. A new face identification approach was proposed based on two features namely, DWT and HOG. Here LL band of DWT was chosen for the experiment and Euclidian distance was used for classification purposes [18]. The image noise reduction approach was proposed by using difference of Gaussian (DOG) smoothing filters to recognize the face in the photos. Here the DOG helps to enhance the image by subtraction process by blurring the original image using two kernels of the Gaussian [19]. The assessment platform with various parameters or metrics was proposed for the testing of image quality by considering different types of images [20]. A hybrid system for the recognition of faces was proposed using various image illumination preprocessing, image feature extraction, reduction of feature points, and classifier techniques [21]. The different classification confusion matrix boundaries namely, accuracy, recall, precision, Mathews correlation coefficient, the score of f1, f2, g1, g2 were reviewed for real-time security applications [22]. Various classification and selection of feature methods were compared for analysis in the grading of glioma and here L type SVM gives the best performance [23]. The multiclass SVM classifier was used with Histogram of Oriented Gradients (HOG) and Viola-Jones for the face acknowledgment system [24]. A hybrid approach for face recognition using DWT_LL or approximate band of DWT and LOG Gabor filter with contrast normalization preprocessing technique and this work was carried out for the face database containing 3000 face images in both regular and unregular environmental conditions [25].

From the survey, it is observed that the face recognition biometric technique in the frequency domain may be helpful to produce satisfactory performance. Another important key approach is to choose the experimental stages by considering whole face images instead of interesting points of the face and also that instead of a single feature extraction algorithm, hybrid feature extraction algorithms can be chosen to generate face image features for better results. The feature extraction algorithm in the frequency domain namely, DOG and LG may be chosen due to its low-frequency accurate features.

Next is the suitable filter needed to smoothen the image both in low or high frequencies before extraction of features of the image. There are various types of image filtering algorithm surveyed that helps to enhance the face image that may be useful further to generate accurate feature coefficients. The D filter makes smoothens images at a moderate level and still suffers from noise or maybe contains high frequencies and here it is necessary to change the D filter with other smoothing filters namely G, L filters. Finally, in the preprocessing stage where is necessary to take suitable precautions to generate enhanced version images, and here gamma correction levels, histogram equalization, contrast normalization and resize may be helpful. In part 2 the proposed methodology was described where face detection, preprocessing, feature extraction using filtered DWT and LG, classification using MSVM were followed. In part 3 the results of the proposed methodology by considering various boundaries or parameters on a large database of 5000 face images were discussed and finally concluded this paper in part 3.

2. Proposed methodology

The flow of proposed face verification and similarity search flow is shown in Fig. 1.

The proposed flow function is evaluated on a database containing a total of 5000 face images of 25 different individuals of 200 different types of face images and the central issue here is that the same phases are followed for both the training and testing parts.

2.1 Face detection

Viola-Jones is a significant technique used to detect human faces from an image using three steps namely, Haar classification, integral imaging, and

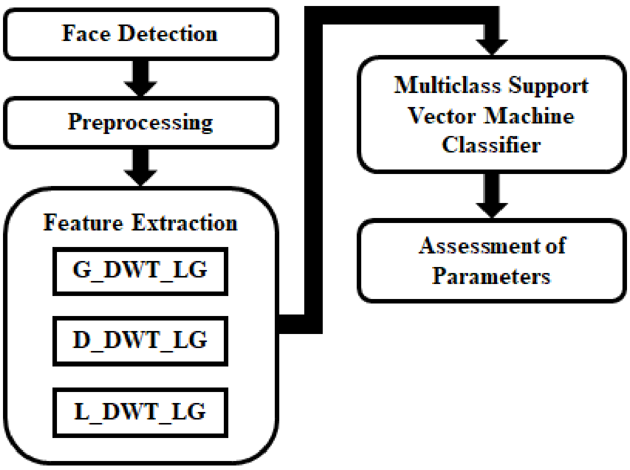
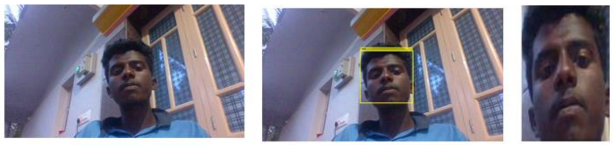


Figure. 1 The flow of proposed face verification and similarity search



(a) (b) (c)

Figure. 2 The detection of human face phases: (a) Colour image, (b) Detection of the human face using Viola-Jones algorithm, and (c) Detected human face edited

(a) (b) (c) (d)

Figure. 3 The Preprocessing phases: (a) Grey converted face image, (b) Gamma correction face image, (c) Histogram equalization, and (d) Contrast Stretching and resized face image

cascading classifier [5, 24]. The detection of the human face from captured image phases using the Viola-Jones algorithm is shown in Fig. 2.

2.2 Preprocessing

The preprocessing phase helps to enhance the feature elements of the image by eliminating unwanted noise or distortions and making the feature extraction stage more robust [21]. Here, firstly, the greyscale version image was extracted from a detected face-colored image. Secondly, gamma correction assists with controlling or changing the brilliance of the greyscale face image. Thirdly, histogram equalization is furthermore included here to increase the global contrast of the face images and to obtain greater contrast to areas of low local contrast. Fourthly, contrast stretch normalization was continued by using high-low edge potential gains of the picture with high and low-power regards is used to audit for picture contrast. Lastly, the face image was resized to a 128 x 128 face image. The preprocessing phases are shown in Fig. 3 below.

2.3 Feature extraction

The feature extraction phase helps to generate face image feature points by consolidating two techniques namely. 1) filtered discrete wavelet transform 3) log gabor filter.

2.3.1. Filtered discrete wavelet transform

The 1st level or single level of DWT expands face images into LL, LH, HL, and HH frequency subbands face images [10, 11, 12].

$$w_{\varphi}(j_0, m, n) = \frac{1}{\sqrt{MN}} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x, y) \varphi_{j_{0},m,n}(x, y) \quad (1)$$

$$w_{\Psi}(j, m, n) = \frac{1}{\sqrt{MN}} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x, y) \Psi^{i}{}_{j,m,n}(x, y) \quad (2)$$

Here i is the addendum or subscript for HH, HL, and LH, J_o is the scaling factor, $w_\psi(j_o, m, n)$ is the LL coefficients f(x,y) at level scales j_o, $w_\psi(j,m,n)$ is the sum of HL, HH, LH coefficients of f(x,y) at scale j > j_o, $\psi^{i}{}_{jo,\, m,\, n}$ (x, y)is scaled translated function. The most important task here is that before applying discrete wavelet transform on the face images it must be smoothened using suitable filtering techniques which help to blur the face image, remove the detail and noise. In this work, three filtering techniques are utilized namely, Gaussian, difference of Gaussian, and laplace of Gaussian [21]. The Gaussian filter (G) is a low pass linear filter used here to blur edges and reduce contrast in the frequency domain [15]. The Gaussian filter is given by

$$G(x) = \left(\frac{1}{(\sqrt{2\pi})\sigma} e^{\frac{x^2}{2\sigma^2}} \right) \quad (3)$$

Here, σ = 2 is considered which is the standard deviation of the distribution which controls the smoothing level of the image and when x = 0 it is referred as to a zero-mean distribution.

Next, is the difference of the Gaussian filter (D) acts as a bandpass filter used to preserve spatial information of the grayscale image that helps to enhance the image and also to organize subtleties present in an image [19, 21]. Here the first grayscale image of one obscured adaptation is deducted from one more obscured form of the first grayscale image by using different Gaussian qualities (σ1 and σ2). The D filter is given by,

$$\Gamma_{\sigma,K\sigma} = I * \left(\frac{1}{2\pi\sigma^2} e^{\frac{-(x^2 + y^2)}{2\sigma^2}} - \frac{1}{2\pi K^2 \sigma^2} e^{\frac{-(x^2 + y^2)}{2K^2\sigma^2}} \right) \quad (4)$$

Here * indicates convolution operation of Image with the gaussian kernel such that σ1 = 0.5 and σ2 = 1.5 and x and y are coordinates and the original image was convoluted with the variance of Gaussian values.

Next, is the laplacian of Gaussian filter (L) used to identify edges of the grayscale picture helps distinguish edges that show up at different picture scales or levels of the picture center [21]. The specific upsides of the sizes of the two values of kernels that are utilized to rough the L filter will decide the size of the distinction picture, which might seem hazy thus. The L filter is given by

$$LOG\ (x, y) = \left(-\frac{1}{\pi\sigma^4} \left[1 - \frac{x^2 + y^2}{2\sigma^2} \right] e^{-\frac{x^2 + y^2}{2\sigma^2}} \right) \quad (5)$$

Here, Image I is convolved with Gaussian variance σ1 = 1.75 and x and y are coordinates.
The procedure for the DWT is as follows

1. Apply filters G or D or L to each preprocessed face image. The specific filtered face image pixel values will have lesser values due to the smoothing effect, for example, filter pixel values [Row Column] = [15 17 3 3 ….., 1 4 18 ….., 18 …., 17 32 21 ….,]
2. Apply DWT using Eqs. (1) and (2) to each filtered face image to get the LL, LH, HL, and HH frequency subbands face images.
3. The filtered output image contains more feature set points and noise due to the presence of higher frequencies. So, only the approximate band of DWT or DWT_LL band was considered for the next stages by suppressing the HH, HL, and LH bands to highlight most visual parts of image features. Filtered DWT_LL pixel values [Rows, Columns] = [17 16.5 .., 36.1 23 .., 23.5 10.5 .., 18 16.75 .., 2.89 13.46 .., 16.86 …..,]
4. Normalize the filtered DWT_LL faces image using Eq. (6) by concerning grey values 0 to 255 to match features coefficients concerning all face images.

$$Normalization = 255 \left[\frac{P_{input} - P_{min}}{P_{max} - P_{min}} \right] \quad (6)$$

   where Pinput is the image intensity or pixel value, Pmin and Pmax are the minimum and maximum image intensity or pixel value of filtered DWT_LL face image. Normalized image pixel values [Rows, Columns] = [72.8571 77.7143…., 97.1429 167.572 …., 133 67.42 ….,]
5. Apply FFT to normalized filtered DWT_LL segment band face image to get the real and imaginary values. The FFT Values = [2.1786 + 0.0010i 0.0687 + 0.1090i ..., 0.0006 - 0.0064i ...,]
6. Find image fourier shift (IFS) or absolute values to get the zero frequency shift (ZFS) image. The ZFS values = [0.0031 0.0015 0.0075 0.0011 .., 0.0007 …., 0.00345 0.0024 ….,]
7. Normalize ZFS image using Eq. (7) by concerning grey values 0 to 255 to obtain filtered DWT_LL feature coefficients and were taken in

zigzag order wisely. Normalized ZFS or filtered DWT_LL feature coefficients = [0.3282 0.1005 0.2616 .., 0 0.3922 0.1234 0.2067 0 ..,]

$$Normalized\ ZFS\ image\ \ values = \frac{(IFS - MinIFS)}{(MaxIFS - MinIFS)} 255 \quad (7)$$

2.3.2. Log gabor (LG) filter feature extraction

The LG is the no DC components significant filter used for getting limited frequency image data by considering both real and imaginary parts at all frequency components [6], [7], [8]. The log gabor filter is represented as follows,

$$LG(f) = exp\left(\frac{-\left(log\left(\frac{f}{fO}\right)\right)^2}{2\left(log\left(\frac{\sigma}{fO}\right)\right)^2}\right) \quad (8)$$

where fo is the frequency at the center, σ is the bandwidth, the σ/fo is the filter bandwidth. The LG feature extraction algorithm is as follows

1. LG filter is applied on each preprocessed face image by choosing parameters namely, sigmaOnf = 0.5, minWaveLength = 18, and the radius calculated using Eq. (9) to set frequency values between 0 to 0.5. and by calculating the radial filter component set the frequency value between 0 to 0.5.

   $$Radius\ = [0: fix\ (columns/2)]/ fix\ (columns/2))/2 \quad (9)$$

   Radius = [0 0.0089 0.0179 …, 0.0071 0.081 0.0446 0.0536 0…., 0.00784 0 0.007 0.1287..,]
2. Choosing a filter's center frequency, fo = 1.0/minWaveLength, constructs the LG filtered coefficients for each preprocessed face image using Eq. (8) such that, LG filtered values = [0 0.0309 0.2617 0.5747 ..., 0.9514 0.9857 ..., 0.0018 0.709 ….,]
3. Represent the preprocessed face image in terms of signal concerning row-column values such that, face image signal pixel values = Row 1: [49 171 168 …., 52 112 …,], Row 2: [53 50 163 ...., 167 ..,] ..., Row 92: [47 78 184 …, 68 ..,] …,
4. Find the FFT values for face image signal pixel values, such that FFT value = Row 1: [.9300+ 0.0000i 3.5813- 0.1420i 2.0096 - 0.3894i ….,], Row 2: [0.9462-0.6404i 0.6979-0.7729i 0.6027 - 0.7132i …,] …, Row 92: [0.2901-0.7661i 0.2327- 0.2201i …,] ….,
5. Apply inverse FFT Back transform by consolidating FFT and LG filtered values to get LG feature coefficients by choosing only real coefficients here only real coefficients were considered to construct filter coefficients bank and LG filter image. LG feature coefficients = Row 1: [1.3306 + 0.0000i ...,, 0.0006 - 0.0038i - -0.3703 + 0.0358i ...,], Row 2: [1.8360 + 0.0000i …, -0.3853 + 0.0427i…,] …, Row 92: [.0.0003+0.0017i ..... ,0.1942 - 0.0445i ...,] .....,

2.4 Classification using multiclass support vector machine classifier (MSVM)

The filtered DWT and LG feature coefficients are consolidated into a multiclass support vector machine classifier with an RBF kernel function in a nonlinear fashion [22], [23]. The Φ: X →F is the transform function that addresses the point from the space of input and guides all information focuses to a point in another space. The nonlinear support vector machine with radial basis kernel function (RBF) was defined from (10) to (14) equations. The ideal isolating hyperplane is given by,

$$W = \sum_{i\epsilon SV} h_i y_i k(x_i) \quad (10)$$

The hyperplace function with transform is given by,

$$\left(w^*, \phi(x)\right) = \sum_{i\epsilon SV} h_i y_i k(x_i, x) \quad (11)$$

The offset of the hyperplane is given by,

$$b = \frac{1}{|SV|}\sum_{i\epsilon SV}\left(y_i - \sum_{j=1}^{n}(h_i y_i\ k(x_i, x)\right) \quad (12)$$

The classification rule is given by,

$$s = \sum_{k}^{Ns}(h_i y_i e^{\frac{\left\|(x_i - x)\right\|^2}{\sigma^2}} + b \quad (13)$$

Here h is the coefficients of lagrangian, X is a rundown preparing vector main informative elements, and SV is the sets of vectors. The radial basis kernel function (RBF) is represented as follows,

$$k(x, z) = e^{\frac{\left\|(x_i - x)\right\|^2}{2\sigma^2}} \quad (14)$$

Here σ boundary is normally 1 and $\left\|(x_i - x)\right\|$ is Euclidian distance part.

2.5 Results and discussion

The proposed framework function is assessed on a database containing a total of 5000 face images of

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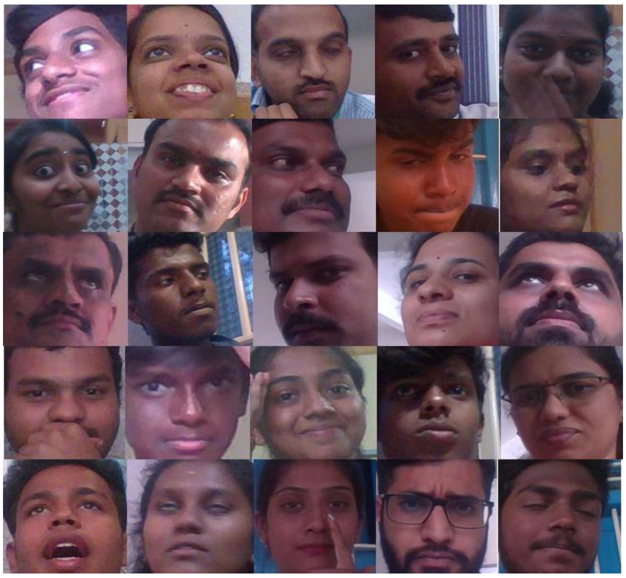

Figure. 4 The sample of 25 individual face images with various distinctions

25 different individuals of 200 different types of face images and these were aimlessly found using 5-megapixel a low objective or resolution camera in both controlled and uncontrolled nature. Here experiment was executed in the platform of MATLAB by thinking about the normal of 10 emphases and was evaluated on 500 test faces of different persons (training 90: testing 10) by thinking about different parameters. The sample of 25 individual face images with various distinctions was shown in Fig. 4 below. The caught face images will have different qualities specifically, 1)All the face images are captured at a distance of not more than 10 feet; 2)Face present types namely, front, minor and huge side, up and down, and wearing; 3)Different intensity level (low, medium, high) considered at all types of face presents; 4)Eyes movements like open, marginally open, fully closed, 5)Variety of expressions like bliss, sadness, fear, disgust, anger, contempt, and surprise.

2.5.1. Assessment of parameters

In this work, four significant confusion matrix elements were used to find out the parameters namely, TP (true positive): positive parts expected as sure; TN (true negatives): negative parts expected assure. FP (false positive): negative parts expected as sure; FN (false negative): positive parts expected as regrettable [20]. The parameter and their formulas were listed in Table 2 below.

The recognition rate or accuracy (AC) is the proportion of the sum adequately perceived as both TP and TN parts to the sum of complete positives (TP, TN) and negatives (FP, FN) parts to find indisputably

Table 2. Parameters and their formula

SL.No	Name of Parameter	Formula
1.	Accuracy (AC)	$AC = (TP + TN)/(TP + TN + FP + FN)$ (15)
2.	Recall (RC)	$RC = TP/(TP + FN)$ (16)
3.	Specificity (SP)	$SP = TN/(TN + FP)$ (17)
4.	Precision (PR)	$PR = TP/(TP + FP)$ (18)
5.	g1 and g2	$g1 = \sqrt{(PR)(RC)}$ (19) $g2 = \sqrt{(SP)(RC)}$ (20)
6.	f1 and f2	$f1 = \left(\frac{2(RC)(PR)}{RC + PR}\right)$ (21) $f2 = \left(\frac{5(RC)(PR)}{4(RC + PR)}\right)$ (22)
7.	Matthews Correlation Coefficient (MCC)	$MCC = ((TN)(TP) - (FN)(FP))/(\sqrt((FP + TP)(FN + TP)(FP + TN)(FN + TN))$ (23)

the quantity of exact faces of particular. The recall (RC) is the degree to which all out was successfully considered to be sure TP parts to the specific total (FN and TP) parts. The specificity (SP) is the extent of what total was enough seen as TN unfortunate parts to what in particular specifically total was negative parts (FP, TN).

The precision (PR) is the extent of total satisfactorily seen as TP certain parts to the total positive assessing parts (FP, TP) which help with expecting the exact positive part regards as certain. The g1 is the mathematical common score of RC and AC and the g2 is the mathematical standard score of RC and SP. The RC and PR are changed which relates to the f1 values and RC and PR are not changed which relates to the f2 values with the ultimate objective that here RC is extended and PR regards are cut down makes limits parts of FN and avoid parts of FP.

In matthews correlation coefficient (MCC), exact positive parts are identified by considering all false parts and help to generate a definite quantifiable rate. The 45^0 slope curve is the receiver operating characteristic or the ROC curve used for the graphical evaluation that helps to identify performance standards per RC and SP measurements. The assessment of parameters namely, AC, RC, SP, PR, MCC, g1, g2, f1, f2 are listed in Table 3 and Table 4 concerning the proposed method Vs existing procedures. The ROC bend consequences are shown in Fig.5 to 14.

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Table 3. The assessment of the AC, RC, SP, PR and MCC parameters of propose technique Vs existing strategies

Strategy used	AC	RC	SP	PR	MCC
DWT_LL [10] [11] [12]	0.9186	0.9166	0.9186	0.3246	0.5128
G _DWT_LL [15]	0.9216	0.9185	0.9219	0.3211	0.5139
ECLAHE_ Gabor_DWT _LL [13]	0.9266	0.8866	0.9285	0.3418	0.5225
LG filter [6] [7] [8]	0.9006	0.8809	0.9014	0.2815	0.4655
DWT_LL & LBP [16]	0.9286	0.9238	0.9288	0.3626	0.5532
D_DWT_LL_ LG	0.8522	0.9291	0.8485	0.2031	0.3938
DWT_LL & LG	0.9212	0.9238	0.921	0.3244	0.5208
G_DWT_LL & LG	0.9233	0.9463	0.9219	0.3351	0.5366
D_DWT_LL & LG [25]	0.9312	0.9452	0.9289	0.3578	0.5573
L_DWT_LL & LG (Proposed)	0.9422	0.9607	0.9414	0.4109	0.6075

Table 4. The assessment of the g1, g2, f1, f2 parameters of propose technique Vs existing strategies

Strategy used	g1	g2	f1	f2
DWT_LL [10] [11] [12]	0.5457	0.9173	0.4783	0.6698
G _DWT_LL [15]	0.5404	0.9196	0.4723	0.6631
ECLAHE_ Gabor_DWT_LL [13]	0.5491	0.9066	0.4914	0.6691
LG filter [6] [7] [8]	0.498	0.8911	0.6179	0.6179
DWT_LL & LBP [16]	0.5787	0.926	0.5208	0.7054
D_DWT_LL_LG	0.4337	0.8872	0.3327	0.54
DWT_LL & LG	0.5474	0.9224	0.4802	0.6745
G_DWT_LL & LG	0.562	0.9336	0.4934	0.6906
D_DWT_LL & LG [25]	0.5815	0.937	0.5191	0.7116
L_DWT_LL & LG (Proposed)	0.6283	0.951	0.5756	0.7579

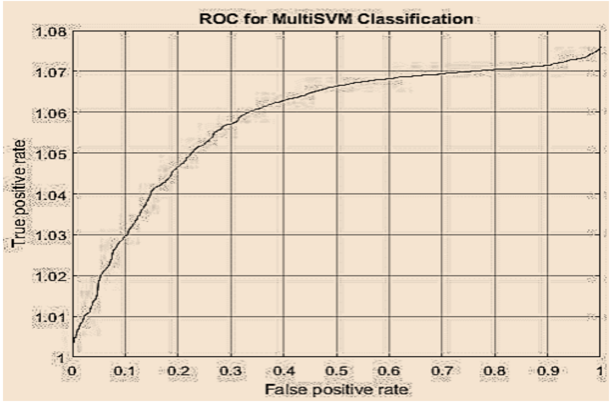

Figure. 5 The ROC curve of only DWT_LL

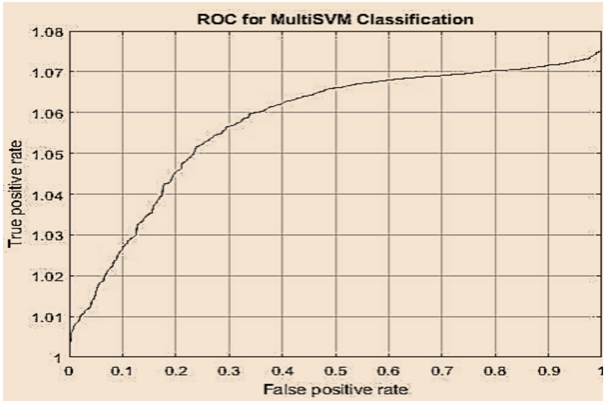

Figure. 6 The ROC curve of G_DWT_LL

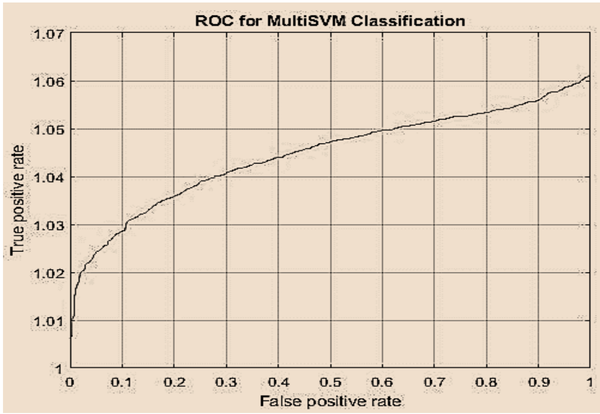

Figure. 7 The ROC curve of only LG

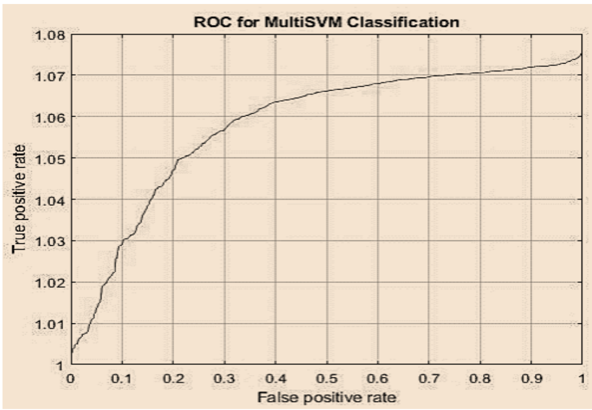

Figure. 8 The ROC curve of DWT_LL & LBP

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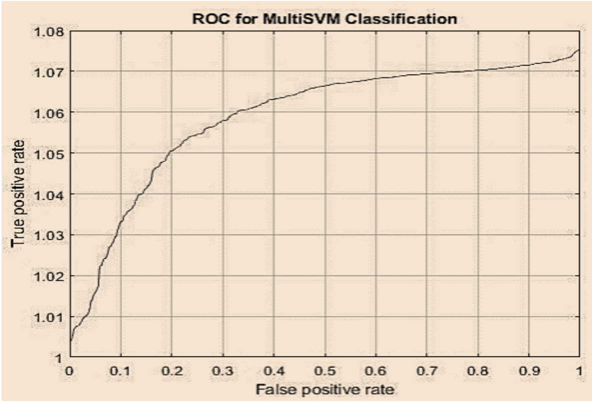

Figure. 9 The ROC curve of DWT_LL_LG

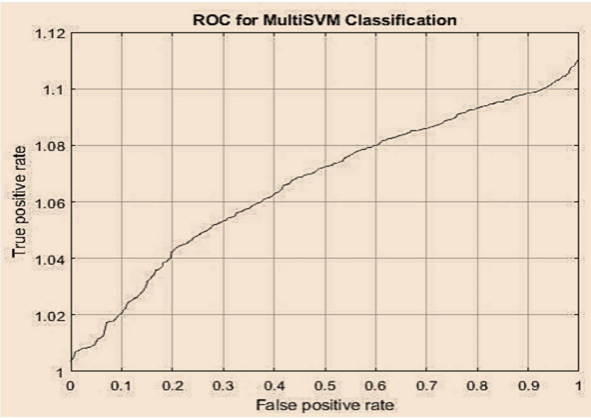

Figure. 10 The ROC curve of D_DWT_LL_LG

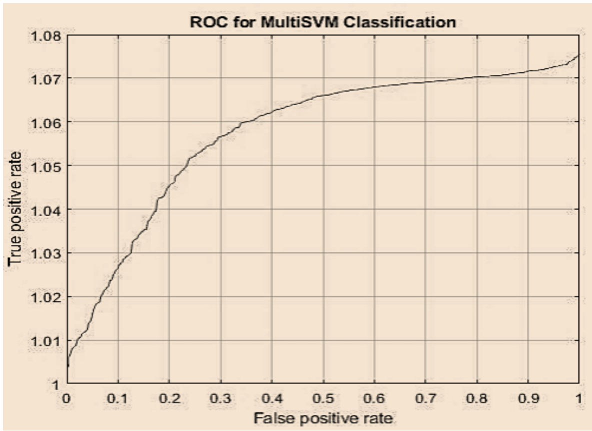

Figure. 11 The ROC curve of DWT_LL & LG

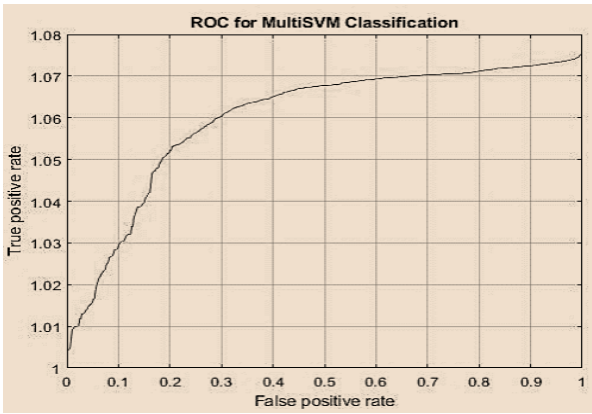

Figure. 12 The ROC curve of G_DWT_LL & LG

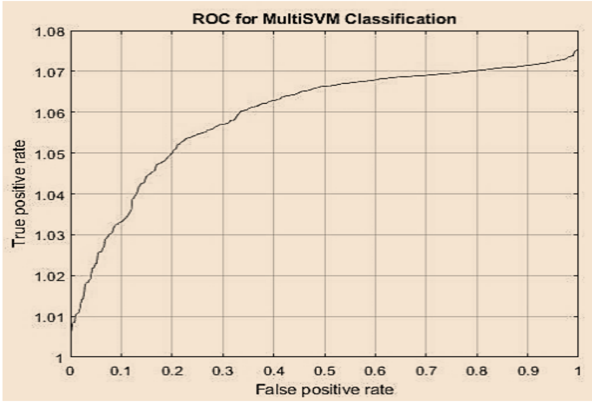

Figure. 13 The ROC curve of D_DWT_LL & LG

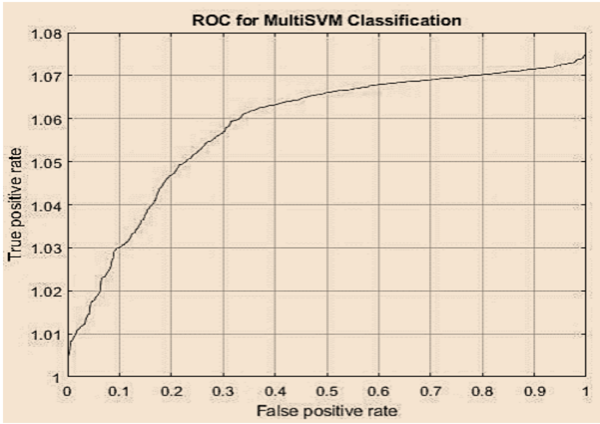

Figure. 14 The ROC curve of L_DWT_LL & LG

It is observed from the results that using a single feature extraction method namely, only DWT_LL, G_DWT_LL, DWT_LL_E-CLAHE_Gabor, LG gives a bad performance on parameters. The hybrid combination DWT_LL & LBP where DWT_LL and LBP features produce a moderate level of performance. In Our work firstly, D_DWT_LL & LG where D filtered DWT is fed to LG filter gives the worst performance on all parameters. Secondly, DWT_LL & LG DWT_LL and LG feature separately and here we are getting good performance compared to previous strategies.

Thirdly, G_DWT_LL & LG where G filter is used for smoothing purpose then applied it to DWT to get DWT_LL feature combined with LG features and secured better performance compared to previous strategies. Fourthly, D_DWT_LL & LG where D filter is used for smoothing purpose then applied it to DWT to get DWT_LL feature combined with LG and here better performance compared to G_DWT_LL & LG strategy. Finally, L_DWT_LL & LG where L filter is replaced D filter in smoothing process to produce the best performance on all assessment of parameters compared to all strategies.

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3. Conclusions

In this work, filtered DWT_LL and LG hybrid features have been developed for biometric applications based on various levels of distinctions of faces. Here G, D, L filters were utilized for smoothing purposes which helps highlight DWT_LL features effectively. The gamma correction, histogram equalization, contrast normalization, and resize preprocessing stages are employed to enhance the face images. The filtered DWT_LL and LG features are consolidated into the MSVM classifier for the assessment of parameters on a large database. From the evaluation, the proposed hybrid combination namely L_DWT_LL & LG will prove the best performance on all parameters compared to all remaining strategies. In future work, it needs to improve the performance by making use of various filters and other classifiers.

Conflicts of interest

The author pronounce no conflicts of interest such that the proposed paper and research work was not taken any subsidizing.

Author contributions

This paper was not published or submitted anywhere previously and justifies that it is qualitative research work by the authors. Mr. Vijaya Kumar H R developed this new framework as part of his research, participated in conceptualization, methodology, software, investigation, resources, writing-overall draft preparation, and Murugavelu Mathivanan supervised the research and participated in data curation, writing- review, editing, validation.

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