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# Content based Feature Combination Method for Face Image Retrieval using Neural Network and SVM Classifier for Face Recognition

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#### **Abstract**

Objectives: To propose a CBIR based face image retrieval and identification model. Method/Analysis: A model of hybrid face recognition system based on CBIR and SVM is proposed. The feature vectors from the face image database are generated by using Gabor wavelet (GW), wavelet Transformation (WT), and Principal Component Analysis (PCA). For the face image retrieval purpose, Artificial Neural Network (ANN) is adopted and its performance on the retrieval process is evaluated with PCA, WT, GW and their fusion as a feature vector. The query image is recognized from the faces returned by retrieval process by using Support Vector Machine (SVM). The experimental results indicate that the fusion of PCA, WT and GW features as a feature vector performs reasonably well for retrieval and recognition process. The experimental results also demonstrate the efficiency of the proposed approach for face recognition over existing methods when considering different performance measures such as system running time, Receiver Operating Characteristic (ROC) curve and recognition accuracy. The proposed model was evaluated with two face databases viz. Unconstrained Facial Image (UFI) and Oracle Research Laboratory (ORL) face database with a recognition accuracy of 95.42% and 98.75% respectively. Finding: The proposed system has been tested for retrieval and recognition and found with reasonable retrieval time and high recognition rate. **Novelty/Improvement:** The conventional model-based face recognition systems are limited in several aspects, like (1) It is usually time-consuming and expensive to collect a large amount of training facial images, (2) It is usually difficult to generalize the models when new training data or new persons are added, in which an intensive retraining process is usually required and (3) The recognition performance often scales poorly when the number of persons/ classes are very large. The proposed CBIR based retrieval and the recognition system is intended to take care of the above limitation.

**Keywords:** Artificial Neural Network (ANN), Content-Based Image Retrieval (CBIR), Face Recognition, Feature Extraction, Support Vector Machine (SVM)

## 1. Introduction

The state of the art Face recognition systems are actively being used at different places like airports, employee entries in organizations, criminal detection systems to protect their assets. For this task different face recognition algorithms have been proposed by different authors such as eigenfaces based Principal Component Analysis (PCA)<sup>1</sup>, Linear Discriminate Analysis (LDA)<sup>2</sup>, Fisher face based elastic bunch graph matching<sup>3</sup>, Tensor rep-

resented based Multilayer Subspace Learning, SVM<sup>4</sup> and Neural Network based algorithms<sup>5</sup>. Conventional face recognitions systems usually adapt existing face recognition techniques by training multi-class face classification models using supervised machine learning techniques. We refer to such kind of conventional techniques as "model-based face recognition". Such approach is however limited in several aspects, like (1) It is usually time-consuming and expensive to collect a large amount of training facial images, (2) It is usually difficult to gener-

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alize the models when new training data or new persons are added, in which an intensive re-training process is usually required and (3) The recognition performance often scales poorly when the number of persons/classes are very large. The face recognition system based on CBIR is one of the approaches to improve the performances of the existing system. The increased need of Content Based Image Retrieval (CBIR) technique can be found in anumber of different domains such as Data Mining, Education, Medical Imaging, Crime Prevention, Weather forecasting, Remote Sensing and Management of Earth Resources. The performance of the biometric face recognition system can be improved by incorporating CBIR technique into the system. A typical CBIR system for retrieving images from database based on their similarity to a query image consists of four main steps viz. Image Acquisition, feature extraction, similarity measurement and image retrieval. In the image acquisition process different images are acquired to form the image database. Unique features are extracted from query image and each of the database images and then performed the similarity measurement between query image feature and database image features and the images similar to query image are retrieved based on the similarity measurement.

In this paper, a neural network based CBIR for face recognition system has been proposed. The approach works in two stages: initially similar facial images of a query image are retrieved from a large data base and then correct association of face from database is established. Feature extraction is being one of the major factors that greatly impact faces retrieval and recognition rate of the system. In this work, the fusion of PCA, GW and WT features of the images are used. Initially, face image features are extracted by using PCA, GW and WT and then fusion operation based on Mutual Information (MI) are performed on these extracted features to create final feature vectors. A feed-forward neural network has been adopted for retrieval of face images and SVM is used to perform the recognition of query image from the images returned by retrieval process. The Content Based Image Retrieval (CBIR) technique which retrieves the images from the databases based on the content of the images and by incorporating the CBIR into the face recognition system, the recognition performance of the system can be improved as it reduces the search space of the system.

The main contributions in this paper are as follows:

 Obtained the coefficients of PCA, GW and WT as face features and fusion operation is per-

- formed on these features to obtain the unified features vectors.
- Implement modular neural network based image retrieval process to improve the retrieval performance of the system.
- Implement SVM for recognition of an individual from the images returned by retrieval process.

The face recognition system is a widely used biometric system in day to day life. The first face recognition system was proposed in a study done by Bledsoe<sup>6</sup>. Various authors proposed different algorithms for the improvement of the system. A fusion of texture and shape feature was adopted to represent a feature vector<sup>2</sup>. The Gabor Filter and Zernike moments (ZM) are used for extraction of texture and shape features respectively.

Besbas proposed a content based face sketch image retrieval using Walsh Hadamard Transform (WHT) for feature extraction8. A study has been done in which content based image retrieval is presented in different color space, based on the geometric or statistical features, automatically derived from the images<sup>2</sup>. A new approach for CBIR supported by a parallel aggregation of contentbased features extraction (shape, texture, color) using fuzzy support decision mechanisms has been proposed<sup>10</sup>. A new approach which was proposed with CBIR for facial images with three different feature extraction methodologies Gist, HOG, and DWT11. Each feature extraction method will extract facial features for the given query image. These facial features are stored in multidimensional feature vector form and used for classifying the query image using KNN algorithm. A study in which Content based face recognition system is done by using the three low level features: color, texture and shape to enhance the recognition system<sup>12</sup>. Multiple feature Content-based system shows robustness than a single feature Biometric system. Wang presented a content-based image retrieval method based on efficient combination of shape and texture features<sup>13</sup>. The shape and texture features are expressed through exponent moment's descriptor (EMD) and localized angular phase histogram (LAPH) descriptor respectively. By combination of above shape and texture information provided a robust feature set for the image. A new scalable face representation using both local and global features is developed by Wu<sup>14</sup>. For retrieval they have used an indexing scheme which exploits the special properties of faces to design new component-based local features, which are subsequently quantized into visual

words using a novel identity-based quantization scheme. An effective Weak Label Regularized Local Coordinate Coding (WLRLCC) technique has been proposed, which exploits the principle of local coordinate coding by learning sparse features, and employs the idea of graph-based weak label regularization to enhance the weak labels of the similar facial images<sup>15</sup>.

# 2. Feature Extraction Methods

# 2.1 Principal Component Analyses

PCA is an efficient and long term studied method to extract feature sets by creating a feature space. The main purpose of PCA is to reduce the large dimensionality of observed variable to the smaller intrinsic dimensionality of independent variable without losing any variance or mutual information in input data, classified by an unsupervised method since they do not apply the output value the class information of input<sup>1</sup>.

The Eigen face approach gives us efficient way to find this lower dimensional space. Eigen faces are the Eigenvectors which are representative of each of the dimensions of this face space and they can be considered as various face features. The eigenvectors of a linear operator are non-zero vectors which, when operated on by the operator, result in a scalar multiple of them. The scalar is then called the eigenvalue () associated with the eigenvector (X). Eigen vector is a vector that is scaled by a linear transformation 16.

#### 2.2 Wavelet Transformation

Wavelet decomposition is a multilevel dimension reduction process that makes time-space-frequency analysis. An appropriate result in robust face representation with respect to illumination and expression changes and is capable of capturing substantial facial features while keeping computational complexity low. Unlike Fourier transform, which provides only frequency analysis of signals, wavelet transforms provide time-frequency analysis, which is particularly useful for pattern recognition <sup>17</sup>.

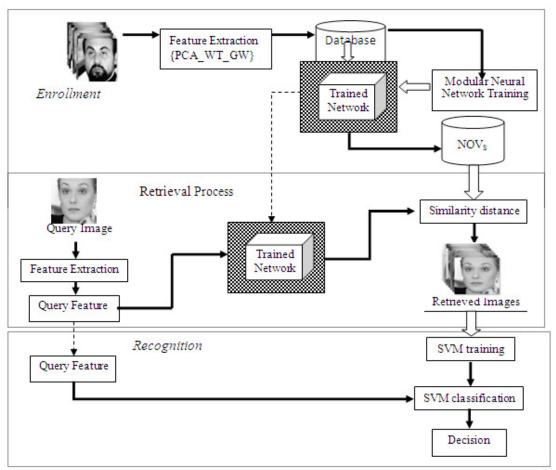


Figure 1. Block Diagram of the Proposed System.

#### 2.3 Gabor Wavelet

Gabor wavelets have also been applied in global form for face recognition. Gabor feature extraction is modeled after the human visual sense principles and exhibits exemplary characteristics such as the capability of capturing salient visual properties such as spatial localization, spatial frequency and orientation selectivity<sup>18</sup>.

# 3. Proposed System

The proposed face recognition system consists of three modules viz. enrolment, retrieval and recognition as shown in Figure 1. During enrolment, features are extracted from images and stored in the database. The feature extraction is based on the fusion of PCA, WT and GW features according to the algorithm 1 as explained in section 3.1. The modular neural network has been used to retrieve the face images from the database similar to query image based on the contents of the images. The SVM is used as a recognizer to recognize query image from the images returned by the retrieval process.

#### 3.1 Feature Extraction

The Feature extraction is one of the vital steps for face recognition that greatly impact the performance of retrieval and recognition process of the system. The proposed work, used the unique features from each face which are extracted by using Gabor wavelet (GW), wavelet transformation (WT) and principal component Analysis (PCA) independently and then fusion operation based on MI are performed on these extracted features to create final feature vectors of face database which is shown in algorithm 1. The details of PCA, GW and WT have been explained 19. Before performing the fusion operation, the feature values are normalized between 0 and 1 with min-max normalization scheme.

```
Algorithm:1
```

```
Input:Face Images
```

Output:PCA\_GW\_WT combination feature.

Procedure

Step 1: Begin

Step 2: Obtained PCA, GW and WT feature from input images.

Step 3:

for i=1: x

 $PCA_norm = (PCA[i] - min(PCA))/$ (max(PCA)-min(PCA))

```
f).
```

```
end
   Step 4:
          for i=1: y
              GW_norm = (GW[i] - min(GW))/(max)
(GW)-min (GW))
          end
   Step5:
          for i=1:z
              WT_norm = (WT[i] - min(WT))/(max)
(WT)-min (WT))
          end
   Step 6:
          for i: x
               PCA_GW_WT[i] =PCA_norm[i];
            end
   Step 7:
           for i=1: y
               PCA_GW_WT[x+i] = GW[i];
           end
   Step 8:
           for i=1:z
               PCA_GW_WT[x+y+i] = WT[i];
```

where, x,y and z represents the length of PCA, GW and WT feature vectors respectively.

Step 9: Mutual Information feature selecttion (MIFS) is used to reduce dimensionality of the concatenated feature vector which is described as follows21:

Initialization:

Set F  $\leftarrow$  initial set of *n* features Set S ← empty set

Computation of the MI with the Output class:

For each feature  $f \in F$  compute I(C;

Choice of the first feature:

Find the feature *f* that manimized I(C;*f*):

set  $F \leftarrow F | \{f\}; \text{ set } S \leftarrow \{f\}.$ 

• Greedy Selection:

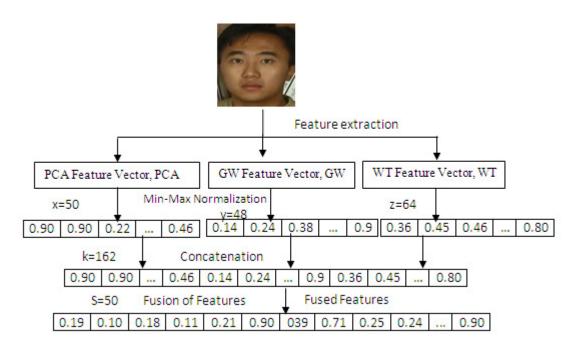
Repeat until |s|=k.

→Computation of the MI between

variable: for all couple of variable (f,s)

with  $f \in F$ ,  $s \in S$ , compute I(f, s), if it is not already available.

→ Selection of next feature: choose feature *t* as the one that maximise



**Figure 2.** Feature Level Fusion of Three feature Vectors (k represent length of concatenated features, S represent length of fused features).

$$I(C; f) - \beta \sum_{s \in S} I(f; s)$$
; set  $F \leftarrow F \setminus \{f\}$ ; set  $S(S \cup \{t\})$ .

• Output the set S containing the selected features.

The Fusion process in biometric provides increased reliability<sup>20</sup> i.e. biometric system with fusion process gives improved results as fusion is very promising process to enhance the strengths and reduce the weaknesses of the individual measurements. The fusion process in biometric system has four scenarios i.e. sensor level, feature level, matching score level and decision level. Fusion levels can be generally classified into two groups: pre-classification (or fusion before matching) which includes sensor level and feature level and post-classification (or fusion after matching) which includes match score level and decision level. Amongst these, fusion at feature level is gaining much research interest. The proposed feature level fusion scheme is shown in Figure 2.

Initially, three feature vectors *viz.* PCA={p1,p2,...,pn}, GW={g1,g2,...,gn} and WT={w1,w2,..,wn} (n represents total number of images) are obtained from face images by using Principle Component Analysis (PCA), Gabor Wavelet (GW) and Wavelet Transformation (WT) techiniques respectively. Next, min-max normalization scheme is adopted to normalized the each feature value between 0 and 1 and then these normalized features from

each of the techniques are concatenated to obtained the new feature vector PCA\_GW\_WT={f1,f2,...,fn}. Finally feature selection based on mutual information criteria is performed to obtained the fused feature vectors.

# 3.2 Face Image Retrieval Process

The goal of content-based image retrieval is to retrieve an image that is visually similar to a query image. The proposed content-based image retrieval process is performed by using the modular neural network which is shown in algorithm 2. Initially, extracted features are fed into all the trained networks to obtain network output vectors,  $O_{i,j}$  (i=1,2,..., m, j=1,2,...n). Here m stands for number of person and n stands for number of images. The set of vectors  $O_{i,j}$  is stored as network output vector. To retrieve images similar to the query image, extracted features from query image is fed into the trained networks which returns an output vector,  $O_{i,j}$  (i=1, 2...m). The Euclidean distance between vector  $O_{i,j}$  and the stored network output vector,  $O_{i,j}$  has been calculated and the images are retrieved with minimum Euclidean distance.

Algorithm: 2

**Input:** Query image, trained modular network.

Output: Retrieved images

**Procedure** 

- Apply features extraction technique on the query image to obtain the feature vector of it.
- Query feature vector is fed into the trained modular networks and obtain the network vector <sup>Q</sup><sub>i</sub>
   (i=1,2...m).
- Calculate Euclidean distance between vector
   O<sub>i</sub>
   and vectors O<sub>i,i</sub>.
- Retrieve the images which have minimum Euclidean distance between vector  $O_i^q$  and the  $O_{i,i}$ .
- Return retrieved images.

The recognition of query image is performed by using SVM based on the images returned by retrieval process. The Support Vector Machine (SVM) is considered as standout method for pattern classification problems as it can separate the data in complicated non-linear model. In complicated nonlinear modeling, the SVM transform the training data into a higher dimensional feature space and there is a linear hyper-plane that can separate the data<sup>4</sup>. The recognition procedure by using SVM has been explained<sup>19</sup>.

# 4. Experimental Results and Discussion

The experiments are carried out on windows 8 operating system with Intel core i3 3110M processors and 4GB RAM by using MATLAB 7.0 software. Two face databases viz. UFI (Unconstrained Facial Images) and ORL (Oracle Research Laboratory) were used for evaluation of the proposed recognition system. The UFI is a novel real-world database that images choose from real photo developed by the Czech News Agency (ctk). The images are stored in PGM format with size 128X128. The ORL face database was developed by AT & T laboratories, Cambridge. The files are in PGM format and size of each image is 92x112 pixels, with 256 grey levels per pixel. This database consists of 400 images of 40 individual i.e. 10 images of each individual with different facial expression. The number of persons and the number of images per person from each dataset that are considered for experiments are tabulated in Table 1.

In this present work, a modular neural network and SVM has been used to perform the recognition. The neural network is used as content-based image retrieval

Table 1. The number of persons and the images per person from each dataset.

	Number of sample used as	50	Image per person		Total		al	
			10 Training		esting	Traini	500 <b>ng</b>	) Testing
	reference		7		3	35	0	150
UFI	Number of sample used as imposter	30	10	)			300	)
	Total Number of sample	80	10	)			800	)
	Number		Image per person		Total			
	of sample used as	30	10			300_		
ORL				sting	Traini	_	sting	
	reference		6	4	18	0	120	<u> </u>
	Number of sample used as imposter	10	10			100		
	Total Number of sample	40	10			400		

technique and SVM as a classifier. The different performance measures such as precision, recall, F-score, ROC, recognition accuracy and system running time has been used to show the efficacy of the proposed system.

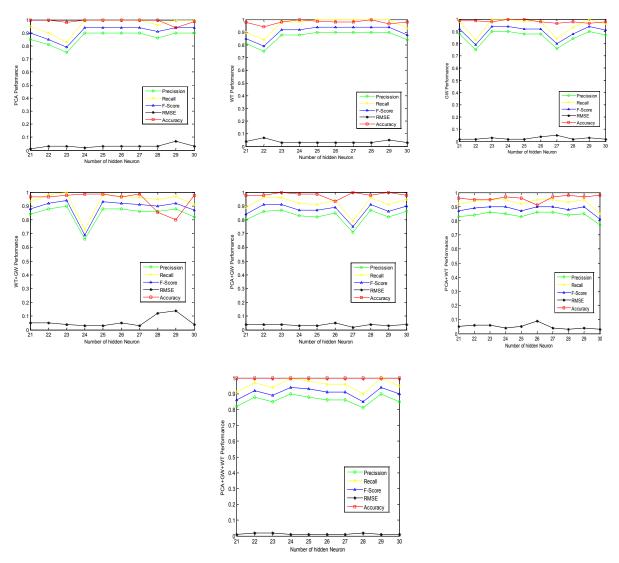
# 4.1 Selection of Neural Network Architecture

The modular neural network system consists of five networks with single hidden layer has been used for image retrieval process. The retrieval performance measures i.e. precision, recall, F-score and network performance such as RMSE and classification accuracy by varying the number of hidden layer neuron on different face feature vectors is shown in Figure 3. The precision, recall, and F-score are calculated as<sup>8</sup>:

$$\begin{aligned} \textit{Precision} &= \frac{\textit{RelevantFaceoftheretrieveface}}{\textit{totalretrieveface}} \\ \textit{Recall} &= \frac{\textit{Relevantfaceoftheretrieveface}}{\textit{totalrelevantface}} \\ \textit{F-score} &= 2 * \frac{\textit{Precision*Recall}}{\textit{Precision+Recall}} \end{aligned}$$

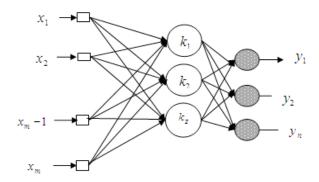
From the Figure 3 (a-g), the suitable number of the hidden neuron for each of the face feature vectors are found to be 24, 25, 23, 23, 24 and 24 respectively as tabulated in Table 2. The network architecture is shown in Figure 4 and optimalnetwork parameter is given in Table 3.

The average training and testing performance of the optimal neural networks are shown in Figure 5. This

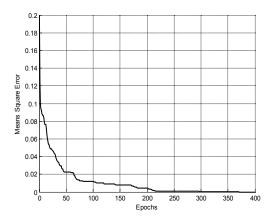


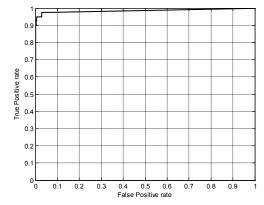
**Figure 3.** The retrieval performance of the modular neural network on (a) PCA feature vector (b) WT feature vector (c) GW feature vector (d) PCA+GW feature vector (e) WT+GW feature vector (f) PCA+WT feature vector (g) PCA+WT+GW feature vector.

Figure represents how well network converges towards its goal and how well networks performed with the testing data.



**Figure 4.** Network architecture: m varies from 50 to 160, z varies from 23-25, n=10.





**Figure 5.** Average performance of modular Neural Network: (a) Training Performance (b) Testing Performance.

#### 4.2 Results on Retrieval Process

The performances of the optimal modular neural network on image retrieval process with different feature vectors on UFI and ORL face database are tabulated in Table 4 and Table 5.

**Table 2.** Number of hidden neuron for different feature vectors

Feature Vector	No. of Hidden Neuron
PCA	24
WT	25
GW	23
PCA+GW	23
GW+WT	23
PCA+WT	24
PCA+WT+GW	24

Table 3. Optimal network parameter

Training Function	:'traintp'
Transfer Function	:'Tansig' for first layer 'purelin' for second layer
Initial learning rate	:0.3
Epochs	:2000
Error Goal	:0.001
Minimum Gradient	:0.00

**Table 4.** The retrieval performance of the neural network on UFI database

Method	Precision	Recall	F-Score
PCA	0.82	0.9	0.8
WT	0.73	0.81	0.77
GW	0.60	0.7	0.70
PCA_WT	0.73	0.81	0.77
WT_GW	0.65	0.72	0.68
PCA_GW	0.79	0.88	0.84
PCA_WT_GW	0.89	0.98	0.93

**Table 5.** The retrieval performance of the neural network on ORL database

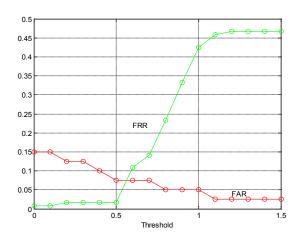
Method	Precision	Recall	F-Score
PCA	0.91	0.71	0.83
WT	0.83	0.91	0.87
GW	0.70	0.8	0.80
PCA_WT	0.83	0.91	0.87
WT_GW	0.75	0.82	0.78
PCA_GW	0.89	0.98	0.94
PCA_WT_GW	1	0.667	0.80

From the Table 4 and Table 5, it is observed that the fusion of PCA, WT, and GW as face features performs better on both UFI and ORL databases during retrieval process compare to other single and fused features. Therefore, the fusion of PCA, WT and GW features is suitable to choose as a face feature vector for the proposed face recognition system.

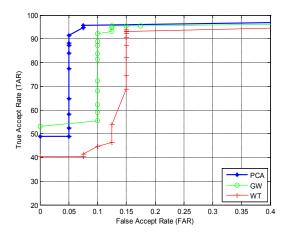
# 4.3 Recognition Performance

The threshold value for class separation is determined from the False Accept Rate (FAR) and False Reject Rate (FRR) of the system. The False Accept Rate (FAR) and False Reject Rate (FRR) is calculated to determine the inter-class separation. The FAR and FRR is calculated as:

$$FAR = \frac{Number\ of\ times\ unaut \textit{h}orized\ person\ accepted}{Total\ number\ of\ comparison} \times 100$$



**Figure 6.** The comparison of FRR and FAR at different threshold.



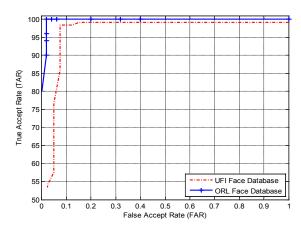
(Without Fusion) (Fusion)

Figure 8. The recognition performance on PCA, GW, WT feature vector.

Figure 6 represents the FAR and FRR at different threshold respectively. From this experiment, it is observed that the distance 0.50 is appropriate to choose as a threshold between inter-class separations as at this point FAR and FRR has minimum error rate.

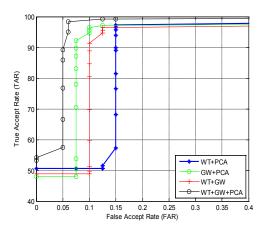
The recognition performance of the proposed approach on both UFI and ORL face dataset is shown in Figure 8 as a ROC curve. The curve is drawn between False Accept Rate (FAR) vs True Accept Rate (TAR) (TAR=100-FRR). From this, it is found that the system achieved the recognition accuracy of 95.42%, and 98.75% with UFI and ORL face database respectively. The Accuracy is calculated as:

$$Accuracy = (1 - \frac{FAR + FRR}{2}) \times 100$$



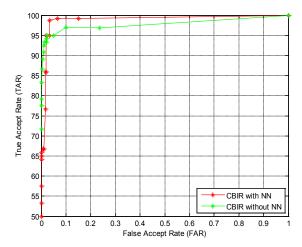
**Figure 7.** The ROC curve of the proposed system.

The recognition performances of the system, with and without fusion of different feature vectors as ROC



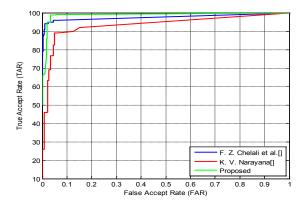
curve are shown in Figure 7. It is observed from these ROC curves that the PCA alone perform better in terms of recognition performance with error rate 2.5% compare to GW and WT. The fusion technique has been used to improve this error rate. From different fused features combination such as GW\_WT, PCA\_GW, PCA\_WT and PCA\_GW\_WT, the PCA\_GW\_WT feature combination has performed reasonably well, with error rate 1.25%.

From the results, as shown in Figure 9, it can be observed that the method CBIR with neural network (proposed) outperforms the method CBIR without neural network as reported<sup>19</sup>.



**Figure 9.** The Comparison of approach based on CBIR with Neural Network and CBIR without Neural Network.

The results of the proposed approach, also has been compared with the existing method *viz*. Chalali's method<sup>22</sup> and Narayana's method<sup>23</sup> for recognition accuracy and system running time as shown in Figure 10.



**Figure 10.** The Comparison of approach method and existing method.

From Figure 10, it can be observed that the proposed approach outperforms the existing methods in terms of recognition accuracy and system running time with the considered face databases.

# 5. Conclusion

In the present work, we proposed a hybrid model of face recognition based on CBIR and SVM for authentication of an individual. The major contributions of this paper are to perform fusion of PCA, WT and GW features, design of modular neural network for face image retrieval and implement of SVM as classifier for recognition. The UFI and ORL face database has been used to evaluate the performance of the proposed approach. The Proposed approach achieved the recognition accuracy of 95.42% and 98.75% on both databases respectively. From the experimental results it is observed that the proposed approach performed reasonably well in terms of Recognition accuracy and system running time compared to existing methods.

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