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Facial Expression Recognition System Performance Using Various Database

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Abstract: *In the developing technology emotion recognition from the facial expression is one of the most important research areas. During the analysis process, one of the major challenges present in the system is wide range of variation in the human face image which leads to reduce the entire system performance while analyzing the face related emotions. So, the automatic facial related emotion recognition system is implemented using the different image processing and machine learning techniques. Initially the face image has been captured and the image is analyzed according to the skin color. After the color image is transmitted to the grey scale image and the noise present image is eliminated with the help of the non-local median filtering approach.The selected features are trained for improving the classification rate which is done by using the back propagation neural networks.. The classifier handle the 11 different basic expression with Blinking, Bilious, Agonized, Jeering, Hopeless and searching expressions by using the different datasets such as Jaffe, Cohn Kanade, Mmi and Feret.*

Keywords: *facial expression, emotion recognition, back propagation neural networks, hidden markov model.*

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I. Introduction

The main goal of the HCI system to improve the interaction between users and computers. The human face is important role in communication. in this communications are two way of communication (i)Verbal communication (ii)Non verbal communication.Facial expression is the one of the non verbal communication. The facial expression can be divided into three components.(i)Face detection(ii)Feature extraction(iii).Classification.

Now-a-days the computer vision based technology placed an important role to detect the human emotions. Human emotions are related with the people's daily activities for identifying the mental ability, thinking process [1]. In addition, the emotions are helps to recognize their personal health because, one continuous abnormal emotion is leads to create various health problems. So, the emotion recognition process is linked with the computer vision area which effectively utilizes the artificial intelligence techniques while detecting the emotions[2]. The human emotions are mostly detected from the people's facial expressions because the facial information is easy to captured, emotions also easy to detect with automatic manner. Facial expression is also called as the movement of the muscles in the face which leads to create various emotions depending on the personal situation [3]. The human facial expression has been created voluntarily according to their neural activity of the brain which is correlated with the social impacts for their situations. There are 100 types of facial expressions [4] such as blinking, cheerless, coy, blithe, deadpan, brooding, glowering, faint, grave, dejected, derisive, leering, moody, hopeless, slack-jawed and so on. These facial expressions are derived from the basic expressions such as Happy, Sad, Anger, Disgust, Surprise, Fear and Neutral [5]. According to this, the sample face expression is shown in the figure 1.

Figure 1: Sample basic Facial expressions

The above figure 1 depicted that the sample basic facial expressions, which helps to determine the emotions using the automatic and computational intelligence techniques[6]. The automatic emotion recognition process leads to detect the false emotion which creates problem while making the research process [7]. So, the facial expression has been detected by applying the computational techniques which effectively utilizes the different steps, methods[8] such as noise removal (median filter, Gaussian filter, wiener filter, mean filter, non-local filter), segmentation(canny, edge, threshold, clustering approaches), feature extraction (statistical, gray level matrix) feature selection (genetic algorithm, particle swarm optimization, ant colony, fireflies) and emotion recognition (support vector machine, neural networks, linear discriminate analysis). By using these steps, different researches creating their own facial expression related emotion recognition system. Shruti Bansal et al., [9] detecting human emotions from face using the Bezier curve approach. Initially author capture the human face using the digital camera which is converted into the grey image. From the converted image, different features are derived from the eye, lops, face and so on. The retrieved features are fed into the curve approach for detecting the human emotion with effective manner. During the analysis process, the author uses the various image processing steps for making the effective experimental results. Punitha, et al.,[10] examining the face image texture for retrieving the human emotion using the different image processing algorithm. Initially the face images are collected from the facial expression database. From the collected face image, different texture based gray-level-co-occurrence features are derived that are classified by applying the support vector machine with the help of the various kernels. Then the author introduced approach successfully recognizes the happy, disgust, neutral and surprise emotions. Spiros V.Ioannou et al.,[11] analyzing the various facial expressions and the emotions are recognized with the help of the neurofuzzy networks. Author initially defines the facial expression parameter depending on the ISO MPEG-4 standard tool which effectively extracts the facial information and feature from the face. The extracted features are fed into the neuro fuzzy system which utilizes the particular rules for determining the face emotions. The efficiency of the system is evaluated with the help of the EC IST ERMIS project related dataset and the author introduced system ensures the higher efficiency. Aruna Chakraborty et al.,[12] determining the human emotion from the face feature using the fuzzy relational approach. Initially human face expression has been captured by presenting the audio-visual movie. The captured images are preprocessed and the different expressions related frames are localized using the segmentation method. From the segmented image different features are derived which are fuzzified with the help of the mamdani type relational model. This model successfully recognizes the human features when compared to the traditional methods. The efficiency of the system is evaluated with the help of the experimental results and discussion. According to the above discussions, the facial expression related human emotions are recognized with the help of the image processing methodologies such as preprocessing, segmentation, feature extraction, selection and recognition. Based on the information, the rest of the section is organized as follows, section 2 describes about the proposed facial emotion recognition methodologies, section 3 analyze the efficiency of the system and conclusions are defined in section 4.

II. Proposed Methodology

In this section discusses about the facial expression related emotion identification process which includes the several stages such as image preprocessing [13] that completely eliminates the noise from image which is performed by non-local median filter, feature extraction that derive several features from the face using the progression invariant sub space learning method, feature selection using the particle swarm optimization method which selects the optimized features from the collected feature. Finally feature training that is done by back propagation neural network and the emotion recognition is performed by hidden markov model. Based on the above process the facial expression related human emotion recognition structure is shown in the figure 2

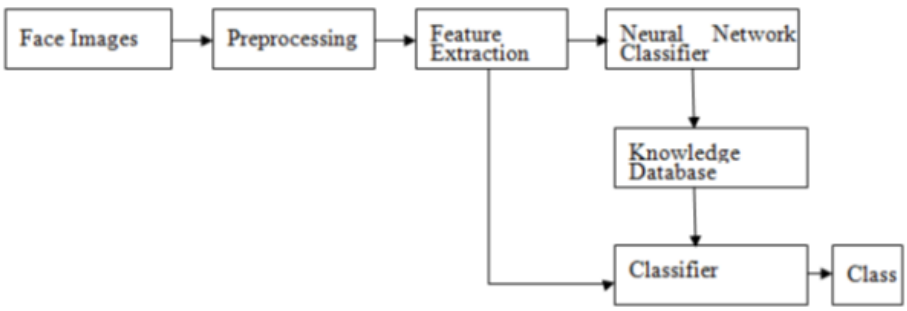

Figure 2: Proposed Emotion Recognition System Architecture

2.1 Noise Removal

The first stage of the work is facial image capture with the help of the digital camera. The collected images are in color which is difficult to process in upcoming steps. So, the images are needed to be converted [14] into the grey scale image which is done by as follows,

$$\boldsymbol{GS = 0.2989 * Intensity(r) + 0.58701 * Intensity\ (g) + 0.1140 * Intensity\ (b)} \quad (1)$$

The converted images are consists of black pixel has (0,0,0) values, white pixel has (255,255,255) values and the gray pixel has (127, 127, 127)Medium values. Thus the grey scale conversion is done by using the weighted average of these above red, green and blue value of the pixel. After converting the image color, the noise present in the images is eliminated by computing the self-similarity [15] values which is done with the help of the non-local median filter. Initially the intensity of the image is computed as follows,

$$\boldsymbol{v(i) = u(i) + n(i)} \quad (2)$$

where $\boldsymbol{v(i)}$ is defined as the observed value from the given image, $\boldsymbol{u(i)}$ is defined as the "true" value and $\boldsymbol{n(i)}$ is defined as the noise agitation at a pixel $\boldsymbol{i}$. Then the noise influenced by the images are examined, then the images are mostly affected by Gaussian noise that is eliminated with the help of the following assumptions, $\boldsymbol{n(i)}$ are independent, identically-distributed Gaussian values with variance $\boldsymbol{\sigma^2}$and zero mean. Based on the assumptions, the neighborhood pixel value is estimated with the help of the weighted values $\boldsymbol{w(p,q1)\ and\ w(p,q2)}$, According to the above process, each pixel,$\boldsymbol{p}$ is investigated and the non-local median filter is estimated as follows,

$$\boldsymbol{NL(V)(p) = \sum_{q\varepsilon V} w(p,q)V(q)} \quad (3)$$

Where $\boldsymbol{V}$ is defined as the noisy image, and weights $\boldsymbol{w(p,q)}$ meet the subsequent conditions $\boldsymbol{0 \le w(p,q) \le 1}$ and$\boldsymbol{\sum_q w(p,q) = 1}$. After estimating the non-local value, the similarity value between the neighborhood values is calculated as follows,

$$\boldsymbol{d(p,q) = \|V(N^p) - V(N^q)\|^2_{2,F}[1,2]} \quad (4)$$

Where $\boldsymbol{F}$ is defined as the neighbourhood filter employed to the neighborhood's squred difference. The weights is defined as follows

$$\boldsymbol{w(p,q) = \frac{1}{Z(p)} e^{\frac{-\max(d^2 - 2\sigma^2(p,q))}{h}}} \quad (5)$$

where $\boldsymbol{\sigma}$ is as defined as the standard deviation of the noise and $\boldsymbol{2\sigma^2}$ are set to 1.

Where $\boldsymbol{Z(p)}$ is defined as the normalizing constant is defined as follows

$$\boldsymbol{Z(p) = \sum_q e^{\frac{-d(p,q)}{h}}[1,2]} \quad (6)$$

Where $\boldsymbol{h}$ is defined as the weight-decay control parameter. As earlier mentioned, $\boldsymbol{F}$ is known as the neighborhood filter with $\boldsymbol{R_{sim}}$. The weights of $\boldsymbol{F}$ are computed is as follows

$$\boldsymbol{F = \frac{1}{R_{sim}} \sum_{i=m}^{R_{sim}} 1/(2 \ne i|1)^2} \quad (7)$$

Where $\boldsymbol{m}$ is defined as the distance the weight is from the neighborhood filter's center. This process is repeated until to eliminate the noise from the image with effective manner. After eliminating the noise from image, different features are derived which is done with the help of progression invariant sub space learning method which is explained as follows,

2.2 Feature Extraction

The next important step is feature extraction which is done with the help of the progression invariant sub space learning method [16]. This method extracts the features with different relative position, direction, rotation of the input image because the features are changed depending on the human facial expression. During the feature extraction process, Gaussian filter is combined to work with the method for deriving the effective features. Initially the maximum and minimum value of the corner information is obtained as follows,

$$\boldsymbol{D(x,y,\sigma) = L(x,y,K_i\sigma) - L(x,y,K_j\sigma)} \quad (8)$$

Where $\boldsymbol{D(x,y,\sigma)}$the difference of the Gaussian image is, $\boldsymbol{L(x,y,K\sigma)}$ is the convolution value of the image, $\boldsymbol{I(x,y)}$ is the Gaussian blur value,

$$\boldsymbol{L(x,y,K\sigma) = G(x,y,k\sigma) * I(x,y)} \quad (9)$$

Based on the above process, particular key point is detected from the noise free image, the extracted key point has been located in different position using the Taylor series which is done by as follows,

$$\boldsymbol{D(x) = D + \frac{\partial D^T}{\partial x} x + \frac{1}{2} x^T \frac{\partial^2 D}{\partial x^2} x} \quad (10)$$

Then the orientation has been assigned as follows, which is used to identify the direction of the particular key point is measured by the magnitude and orientation estimation.

$$\boldsymbol{m(x,y) = \sqrt{\big(L(x+1,y) - L(x-1,y)\big)^2 + \big(L(x,y+1) - L(x,y-1)\big)^2}} \quad (11)$$

$$\boldsymbol{\theta(x,y) = atan2\big(L(x,y+1) - L(x,y-1)\big), \big(L(x+1,y) - L(x-1,y)\big)} \quad (12)$$

Where, $\boldsymbol{m(x,y) = magnitude\ of\ the\ key\ image}$,
$\boldsymbol{\theta(x,y) = orientation\ \ the\ key\ point\ image}$

Based on the above process, the key point features are derived in different orientation using the 4*4 histogram orientation process that consists of 16*16 region of the key point which has 8 bins and 28 elements. The extracted elements are normalized with the help of the threshold value 0.2. The extracted features consist of lot of information which is difficult to process, so, the optimized features are selected for making the system so effective.

2.3 Feature Selection

The next process is feature selection which is done with the help of the particle swarm optimization process [17]. The effectively analyze the collection of features and the best features are selected which is used to estimate the human emotion with effective manner. Each feature considered as the particle which is moved in the searching space with relevant position and velocity value. Each particle's movement is influenced by its local best known position but, is also guided toward the best known positions in the search-space, which are updated as better positions are found by other particles. This is expected to move the swarm toward the best solutions. PSO is a metaheuristic as it makes few or no assumptions about the problem being optimized and can search very large spaces of candidate solutions. However, metaheuristic such as PSO do not guarantee an optimal solution is ever found. According to the above process the optimal features are having been selected using the feature which helps to optimize the facial expression related feature. The selected features are trained and stored in the database for improving the recognition process which is explained as follows.

2.4 Feature Training

The next important step is feature training which completely helps to the selected features for enhance the facial emotion recognition process. In this work, the feature training process is done by applying the back propagation neural networks [18] which is one of the supervised learning methods but in this work it is considered as the unsupervised form of learning. This unsupervised concept of learning compute the activation value for competes with every neuron. The network consists of three layers such as input, hidden and output layer each having the particular weight and bias value that used in the time of training process. During the training process the network use 70 input nodes,1 hidden nodes and 70 output node with mean square error function as the training function. Initially the activation value of the layer has been computed as follows,

$$\boldsymbol{Activation\ value} = \sum \boldsymbol{X_i} * \boldsymbol{w_{ij}} \quad (13)$$

In eqn (13), $\boldsymbol{X_i\ is\ the\ input\ value\ of\ the\ neuron}$
$\boldsymbol{w_{ij}\ is\ the\ weighted\ value\ of\ the\ node}$

By using the activation value, the minimum activation is saved as the index pair and the output value 1 is assigned to the maximum activation value else the output is assigned as 0. Thus the output value of each neuron weighted value is estimated as follows,

$$\boldsymbol{w_{ij}\ (new) = w_{ij}(old) + c\left(x_i + w_{ij}(old)\right) Y_j} \quad (14)$$

In eqn (14), $\boldsymbol{w_{ij}\ (new)\ is\ updated\ weighted\ value}$
$\boldsymbol{w_{ij}(old)\ old\ weighted\ value}$

These weight updating process helps to minimize the error value while train the features. The trained features are stored as template in the database for further emotion recognition process in the testing stage.

2.5 Testing Stage- Emotion Recognition

The last step is emotion recognition which is done with the help of the hidden markov model [19] approach. In the testing stage, the human facial expression related images are captured which is processed by above training stage step such as preprocessing, feature extraction, selection and training process which is discussed in the above steps from 3.1 to 3.4. After that the features are compared with the trained features present in the database using the hidden markov model (HMM). This model works according to the statistical Bayesian network approach which utilizes the probability value. Then the probability value of each feature is computed as follows,

$$\boldsymbol{P(Y) = \sum_x P(Y|X)P(X)} \quad (15)$$

In the above eqn (15), the P(Y) is the probability value of the testing feature sequence which is compared with the trained features. Based on the comparison process the human emotions are effectively recognized. At last the efficiency of the system is examined with the help of the experimental results and discussions which is explained as follows.

3. Performance Analysis

In this section examines the excellence of the proposed back propagation neural networks with hidden markov model based facial expression related emotion recognition process which is done by using the different datasets such as Jaffe, Cohn Kanade, Mmi and Feret. Each dataset has several facial expressions which helps to determine the emotions with effective manner.

JAFFE Database

JAFFE (Japanese Female Facial Expression) database [20]consists of collection of female facial expression which has 213 images of 7 different facial expression. Among the various expressions, 6 expressions are basic expression and one is neutral expression which is collected from the 10 different Japanese models. Each model facial expression is related with the 6 emotions that is used for this automatic facial expression emotion recognition process and the sample images are shown in the figure 3.

Figure 3: JAFFE Facial Expression Database Images

Cohn Kanade database

The data set[21] consists of collection of images which are captured from different persons in the digital image format. The patients are fed into the different activities and the human face expressions are captured and the sample image is shown in the figure 4.

Figure 4: Cohn Kanade database Images

MMI Facial Expression Database

The another database is MMI facial expression database [22] which is collected from the 75 subjects which is captured by showing 2900 videos. The captured images are high resolutions which is captured in neutral, apex, onset and offset phases. This database is freely available in public for research purpose. Then the sample facial expressions are stored in the figure 5.

Figure 5: MMI Facial Expression Database Images

FEERET Database

The last database is face recognition technology images [23] which consist of 2413 images. These captured images are colored images that have been captured from 856 individuals. These 4 dataset images are processed by above discussed image processing steps and the efficiency of the system is evaluated with the help of the following performance metrics.

$$\textbf{True Positive rate } (TP) = \frac{\textbf{Numbers of features detected} \times 100}{\textbf{Number of features in the dataset}} \quad (16)$$

$$\textbf{False Positive rate } (FP) = \frac{\textbf{Number of false detections} \times 100}{\textbf{Number of features detected} + \textbf{Number of false detection}} \quad (17)$$

$$\textbf{False Negative Rate } (FN) = \frac{\textbf{Number of features missed} \times 100}{\textbf{Number of features in the dataset}} \quad (18)$$

$$\textbf{Precision} = \frac{TP}{TP+FP} \quad (19)$$

$$\textbf{Recall} = \frac{TP}{TP+FN} \quad (20)$$

$$\textbf{Accuracy} = \frac{\text{number of true positive} + \text{number of true negative}}{\text{number of true positive} + \text{false positive} + \text{false negative} + \text{true negative}} \quad (21)$$

Based on the above experimental metrics, the excellence of the proposed back propagation neural networks with hidden markov model is analyzed using the above four datasets Jaffe, Cohn Kanade, Mmi and Feret. The effectiveness of the proposes back propagation neural networks with hidden markov model and particle swarm optimization method feature selection process is examined using the different feature selection methods such as genetic algorithm[24], wrapper method [25], correlation selection [26] method which is shown in the figure 6. Thus the proposed system selects the minimum number of features for all dataset which shows that the proposed feature selection method effectively identifies the optimized features from the dataset that helps to retrieve the human facial emotions successfully.

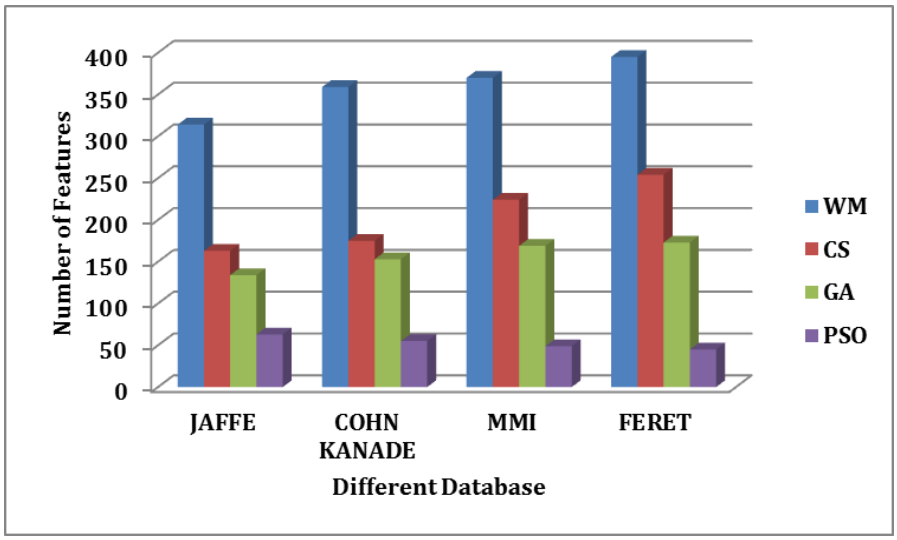

Figure 6: Efficiency of the Proposed Feature Selection Methods

Based on the above feature selection methods, the retrieved features are fed into the proposed back propagation neural networks approach for making the feature training process. Then the back propagation neural network trained features are compared with the traditional training methods such as support vector machine (SVM) [27], Radial basis Function (RBF) [28] which is shown in figure 7.

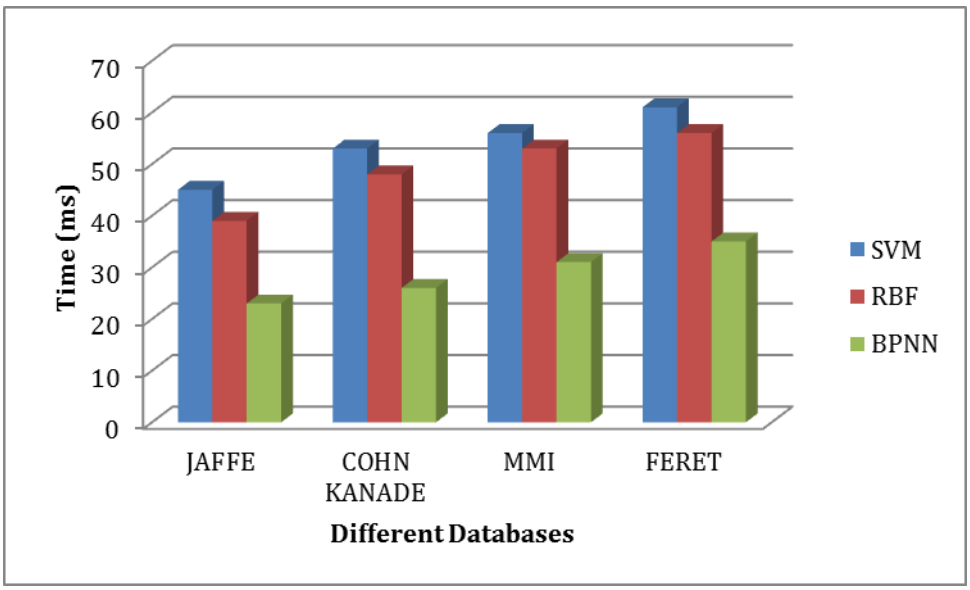

Figure 4: Training Time for Training Methods

The above figure 7 depicted that the proposed back propagation neural network trains the selected features with minimum time when compared to the other training methods. In addition, the training method ensures the high accuracy that shows that the proposed method selects the correct feature while recognizing the face emotions. Then the accuracy of the training process is shown in the figure 8.

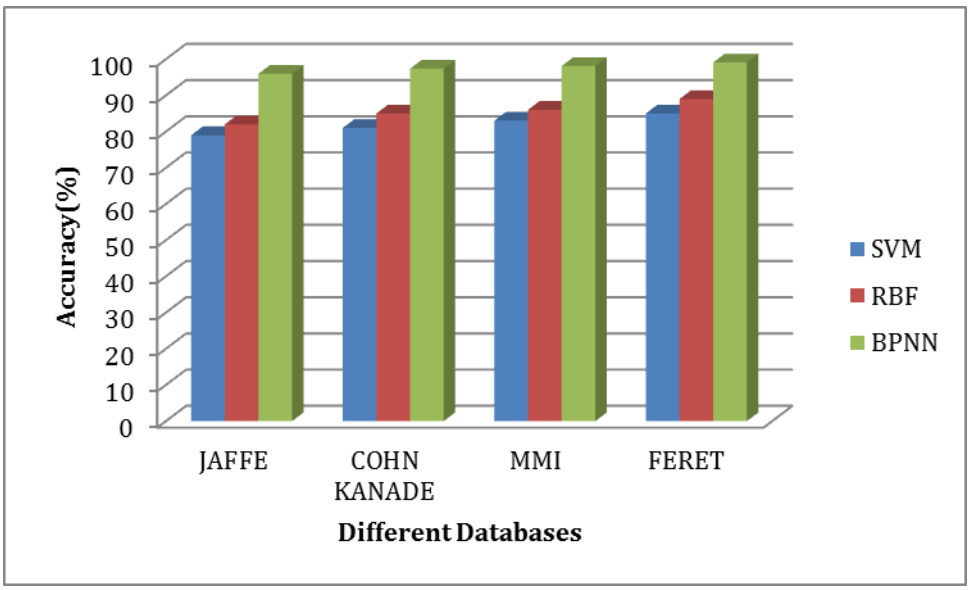

Figure 8: Accuracy of the Different Training Methods

The above figure 8 depicted that the proposed method successfully train the feature with effective manner and the trained features are stored in the database in terms of the template. Then the back propagation neural networks based trained features are matched with the testing features using the hidden markov model which consumes the minimum error rate when compared to the traditional methods such as K-Nearest Neighbor (KNN) [29], Neural Networks (NN) [30], Back propagation Neural Network (BPN) [31] which is shown in figure 9.

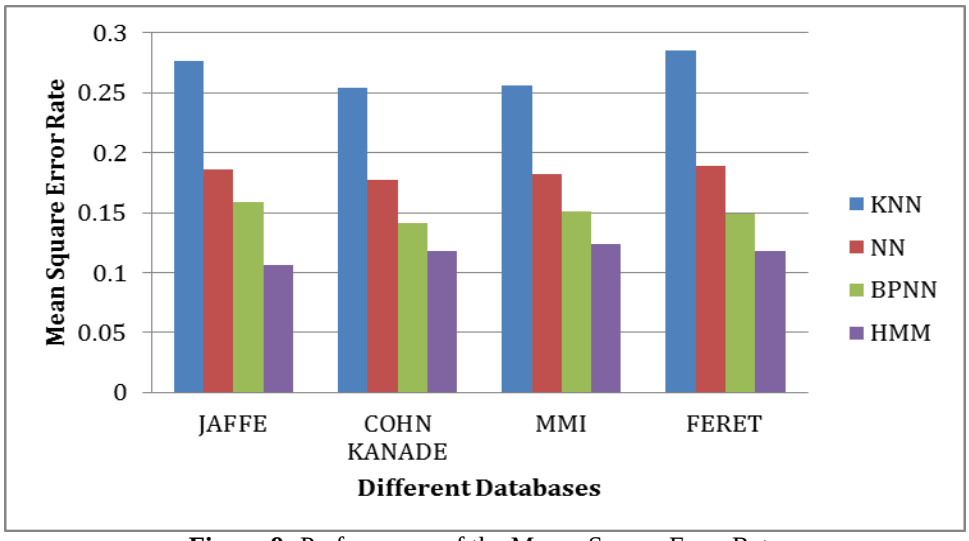

Figure 9: Performance of the Means Square Error Rate

Thus the above figure clearly shows that the proposed method consumes the minimum error rate while classifying the face emotion related features. This minimized error rate increased the classification accuracy which is shown in figure 10.

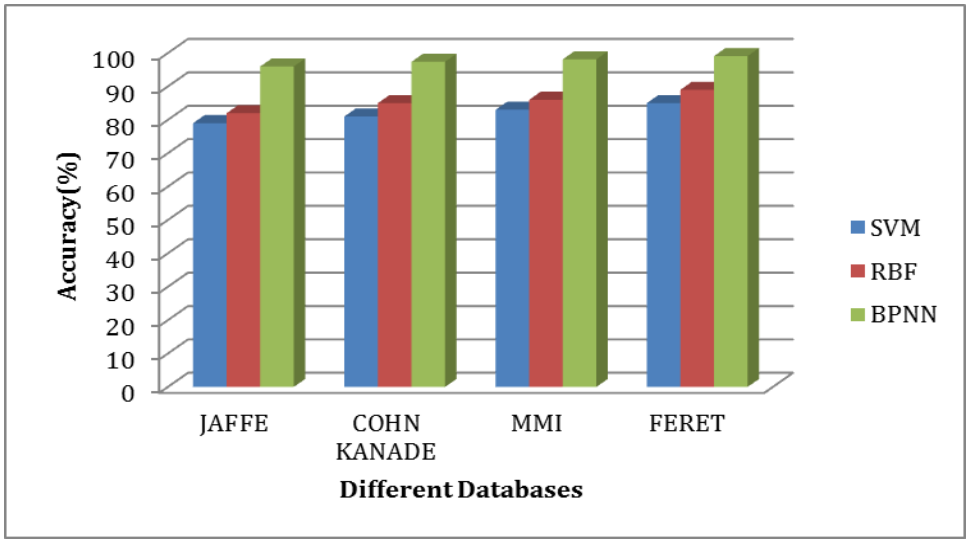

Figure 10: Performance of the Accuracy

Thus the proposed system successfully recognizes the face expression related emotion features from the extracted features with 99.19% accuracy when compared to the other traditional methods due to the minimum error rate also the effective feature selection method. Thus the efficiency of the proposed method well worked in different face database. Also the proposed back propagation neural network ensures the high accuracy while classifying the face expression emotion with effective manner.

III. Conclusion

This paper examining the effectiveness of the proposed neural networks based face emotion recognition process using the different face database such as Jaffe, Cohn Kanade, Mmi and Feret. The captured images are color image which is transferred into grey scale image after that the noise present in the image is eliminated by calculating the pixel self-similarity values. According to the neighborhood values the noise are eliminated and the different key point features are extracted. These features are trained using the neural networks which trains the feature with effective manner and stored as the template in database. Then the face emotions are successfully recognize
l. Then the efficiency of the system is examined with the help of the experimental results and the proposed system ensures high accuracy while extracting the face related emotions.

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