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Face Recognition Using Approximated Bezier Curve and Supervised Learning Approach

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Abstract

Bezier curve are very strong for variety of application. Specifically in image processing it applies to object recognition, face recognition, and human gait recognition. It also works on fingerprint and other biometric system recognition. This paper presents a work to recognize digital images of human frontal faces using the approximated Bezier curve and an intelligent process of learning using neural network. The main structural features of faces like eye, eyebrows, nose, lips, and Face boundaries are extracted and using minimum of these features face is recognized efficiently.

Keywords*: Approximation, Bezier curve, Control Point, Face recognition*

1. Introduction

There has been tremendous improvement in the field of digital recognition system of the human face. In the recent time various techniques have been proposed for recognition of digital images [1-4]. However, one of the very strong ability of human being is to identify and recognize the human faces and its images. Geometrical feature based recognition can be applied when the individual features of eyes, mouth and their boundaries are clearly specified [5-6]. It is of utmost importance to extract the relative location and distance between these landmark features to get proper identification and recognition [7-9]. A computer program can also do the same task with satisfactory performance, if proper facial features are provided. There are large amount of facial features exist in human face [10-12]. Few of them are eyebrow thickness and from the centre of eye its vertical position, left eyebrow and right eyebrow, nose vertical position and width, shape of chin with boundaries of face, vertical position of mouth, width of upper and lower lips and its size and bigmial breadth. Identification of these features through a vector of geometrical features is having good impact over higher recognition speed and less memory requirement. We can further minimize the use of memory by optimizing the features necessary to recognize of human faces. As there are various face, various face recognition approaches are there; mainly classified as knowledge based approach, feature invariant approach, template based approach and appearance based approach. Knowledge based approach based on designing of rules from the knowledge base available about the face geometry. Most of these rules are based on relative distance and location of important geometrical facial features like eyes, nose, eyebrows and face boundaries. Feature invariant approach look for the structural features of digital facial images. Various features are observed and grouped according to geometry of face [13-14] and it is very important to select the set of good features. Template based approach works on template matching of single template of face. The matching procedure mostly is correlation based. The appearance based methods are used for recognition with Eigen face. This method is assumed the human faces as pattern of pixel intensities.

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1.1 Overview of Bezier Curve

Curve generation on constraining to pass exactly through the existing data points is a type of curve fitting [15]. This method is found to be robust and good when the basic shape is certainly determined by clear cut mathematical calculation like aircraft wings but where the aesthetic value and functionality is needed, combination of heuristic method and computational methods proves to be fruitful. Pierre Bezier invention Bezier curve meets both of these aspects. The main feature of Bezier curve is the interplay between geometry and algebra that leads to a powerful theory of intuitive geometric construction.

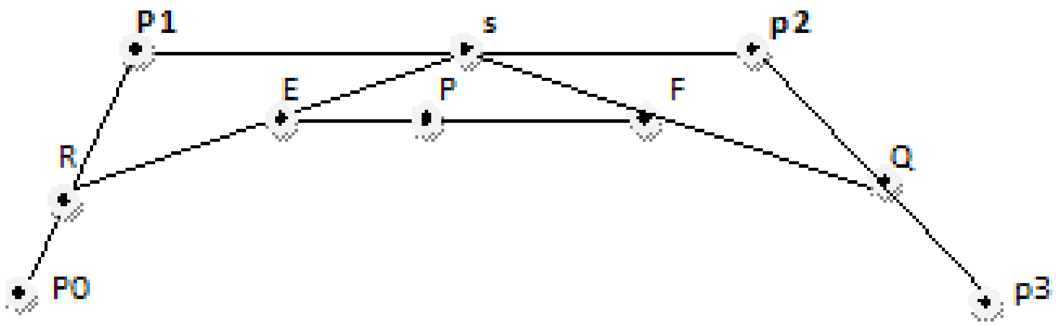

Figure 1. Bezier Curve Control Points

Bezier curves are based on four control points as shown in Figure 1, point R is placed between P_0 and P_1 at the given value of u in fraction. Point S and Q are also placed between p1p2 and p2p3.E is placed at a fraction u on R to S and F between S and Q. Finally, the desired point P is located at fraction u of the way from E to F. The process is repeated for every u between 0 and 1, the curve P(u) so generated from P_0, is attracted towards P_1 and P_2 and ends at P_3. This is how the Bezier Curve defined by four points. The Bezier curve can be generated by different configuration of four points. De Casteljau algorithm is generalizes gently for the case of M+1 control points P_1, P_2, P_3… P_M.The general expression for a Bezier-Bernstein polynomial

$$P(u) = \sum_{K=o}^{M} \frac{M!}{(M-K)!\,K!} u^{K} (1-u)^{M-K} P_{K}, \quad 0 < u \leq 1$$

Here $0!$ and $u^K = 0$ when u and k are both 0 So

$$P(u) = \sum B_{k,M}(u) P_k \text{or} \sum_{k=0}^{n} P_k B_k(u), \qquad 0 \leq u \leq 1$$

$$\sum_{k=0}^{n} P_k B_k(u), \quad 0 \leq u \leq 1$$

Where blending function $B_{k,M}(u)$ is defined as

$$B_{k,M}(u) = C(M,K), u^{k}(1-u)^{M-K}, C(M,K) = M!/(M-k)!\,k!$$

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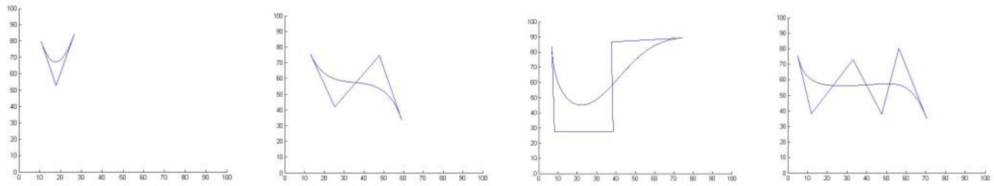

Figure 2. Sample of Bezier Curves with Different Control Points

Design and analysis of an intelligent framework of face recognition is an interesting task which is in research state. Its complications are that poses are angled (not frontal), presence of structural components *i.e.* mustache, beard, glasses .Facial expression, occluded faces, orientation and imaging conditions are the other problems. Face recognition and human facial expressions has been an area of research interest since few decades as area of computer science and cognitive science [16].An approach to recognize human face and facial expression using Interpolated Bezier curve was proposed [17] in which faces are recognized by calculating the Hausdroff distance of line segment. Detection and Recognition of Facial Emotion Using Bezier Curves was proposed [18] for the interaction among human and machine communication systems in which facial region is detected using color feature map than recognizing the emotional characteristics. Human Gait Recognition using Bezier Curves [19] was proposed in which Bezier curves are generated on human walking steps. Smile detection using interpolated Bezier curve [20] was proposed in which extraction of interest point using Shi & Tomasi algorithm were found out than Bezier curve are formed to detect the smiley face. An effective application in biometric based finger print recognition using Bezier curve [21] was proposed in which Bezier curves are formed for ridges and further recognized. Recognition of Facial Expression using Facial Movement Features [22] was also proposed in which distance features are obtained by extracting Gabor features. Hybrid approach of facial expression recognition was proposed [23] in which Rosten & Drummond method for measuring changes in movement of muscles were observed and Bezier curves are drawn to recognize the facial expressions.

1.2 Overview of Neural Network as Classifier

Neural network is found very good tool for image processing application and pattern recognition [24-25]. Multilayer perceptron (MLP), Feedforward network (FFN), principal component analysis and support vector machine are very effective as classifier to recognize the face and facial expressions. Training and testing faces of facial images are implemented and network activities are analysed using neural network as shown in Figure 3 and Figure 4.

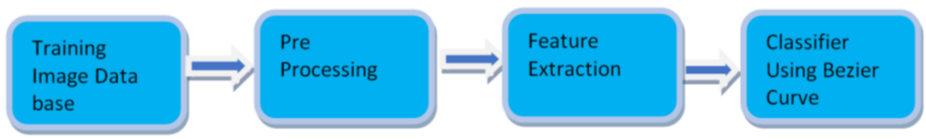

Figure 3. Traing Phase using Neural Network

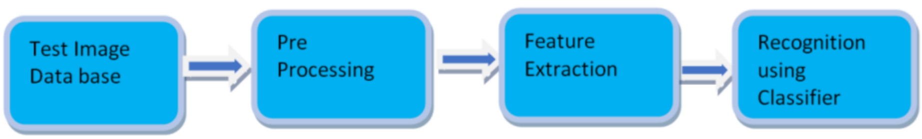

Figure 4. Testing Phase using Neural Network

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1.2.1 Back-propagation Neural Network (BPNN)

A multilayer Back propagation neural network [26] is a good solution in such of the problems, which appears to have overwhelming complexity. One of the most common applications of NNs is in image processing where in identifying hand-written characters; matching a photograph of a person's face with a different photo in a database; performing data compression on an image with minimal loss of content are good examples. Voice recognition; RADAR signature analysis; stock market prediction, character recognition [27] are the other examples of its applications. All of these problems involve large amounts of data, and complex relationships between the different parameters.ANN processes the information exceptionally good if compared with traditional computer machines. In BPNN supervised learning algorithm, set of input signal is given to the network then multiplied with weight, and products are summed up. This summation of product is calculated for the network and then passing it from nonlinear activation function in order to get the desired output. Forward input signal is propagated through this supervised learning network (ML Backpropagation) and error signals are propagating from right to left that is backwards.

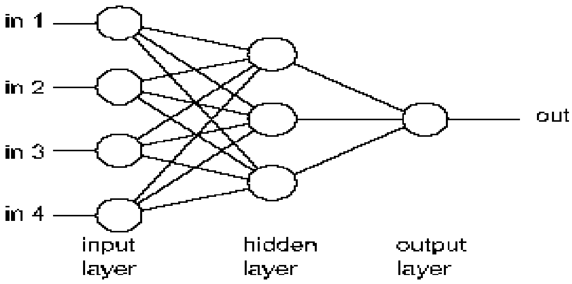

Figure 5. Multi-Layer Back Propagation Neural Networks

The Back Propagation Neural Networks consists of a number of input layers and output layers. The network is first initialized with the setting up of weights to all the input layers between -1 to +1. The proposed methodology implemented BPNN for Face Recognition using Bezier curves. It contains a number of input pattern Bezier curve points and on this basis output is calculated known as forward pass. Since the BPNN generates a different output of the target output due to the variation of random weights to the input layers, hence error rate is computed at each neuron and accordingly weights are changed to get the resultant target output. The formal algorithm of BPNN can be summarized in these steps:

1. BPNN starts with the setting of input pixel points generated using Beziers points on the face to the input layer and needs to work on output layer, which can vary for each iteration till the target output generated.
2. For each iteration of the BPNN error rate is computed using (sigmoid function)
   EB = OB (1-OB)(TB – OB)
   Where, E-error rate, O-output, T-Target
3. After each iteration on the basis of error rate weights of the network is changed using
   Wnew = Wold + (EB * OA)

   Where, Wnew is the new weight to be trained, Wold is the previous weight

4. Since the training is based on BPNN, hence error rate for hidden layer is computed but instead of calculating the error rate using above formula, it can be computed as
   EA = OA (1 - OA) (EB WAB + EC WAC)
5. Repeat from step 3 till training is complete.

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2. The Framework of Proposed System

The face recognition framework consist of various modules which should be applied before finally recognized the face image. These steps are image acquisition (frontal face), face detection, image preprocessing, image feature extraction, neural network supervised Training and recognition. The goal of proposed work is to design and analysis of intelligent and efficient face recognition framework. The primary requirement for this framework is to get frontal face images as input. The three band images (RGB) are to be converted in gray scale image because of convenience and less complex to process the gray scale images. Image pre-processing techniques that are histogram equalization are applied on these images. These frontal face images are Binarized and Thinned. Then edge detector operator is applied to get the edges of image and then Harris corner detection algorithm is applied to get the corner points of eyes and mouth. Bezier curve is drawn to consider these corner points as control point using parametric equation of Bezier curve. These corners are approximated to bring smoothness in the curves. These approximated control curve points are stored in order to train the neural network. Once the network is trained using back propagation method then test the performance of the network using test images and trained images.

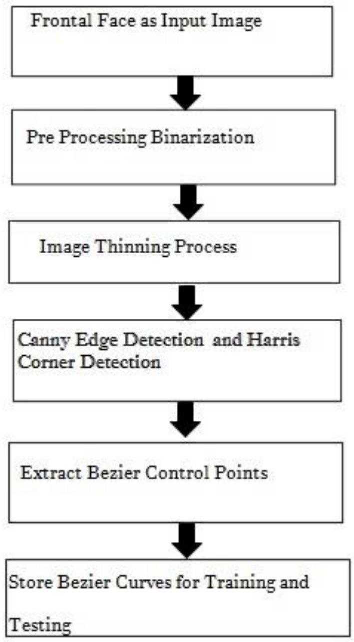

Figure 6. Flow Diagram of Proposed Frame Work

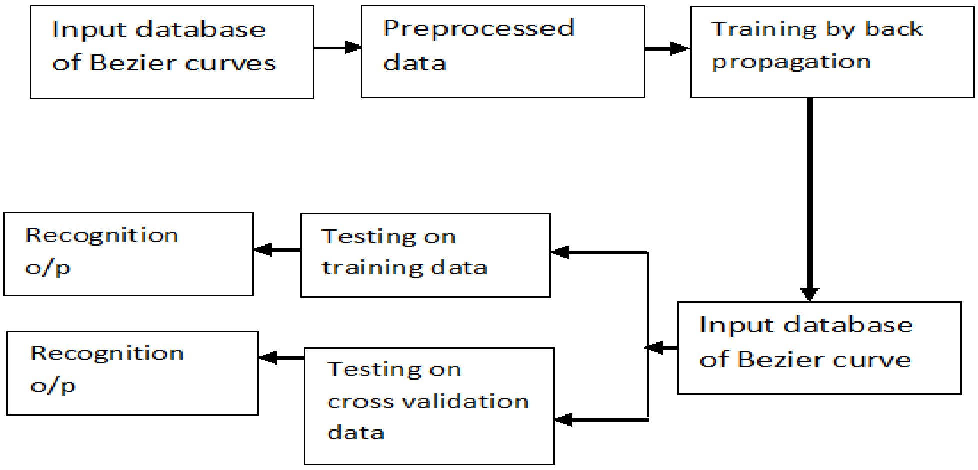

Figure 7. Proposed Flow Diagram for Supervised Training and Testing using Neural Network

3. Results and Performance Analysis

This section describes the framework and its performance using various parameters and their results for individual effect on recognition approach.

3.1. Image Acquisition

Most of the already developed face recognition techniques are generally based on two-dimensional images. Recognition rate of frontal facial images is also high. But for non frontal face images the quality decreases significantly. Partly occluded image of the person`s face may also create problem in recognition. In this face recognition framework frontal face images with normal expression would be considered very effective. In this work the frontal images considered are given in Figure to ascertain the image verification.

Figure 8. Sample Images (Frontal Face)

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3.2. Face Detection

The considered phase detection method using neural network acquires and extracts a region in which human face is contained. This module detect the face and then extracts the information about facial features. The image will be normalized and background will be eliminated from the scene, if any, which is not related with face. The results are given as histogram for the face before and the after face detection in Figure, which is clearly visible as equalized histogram.

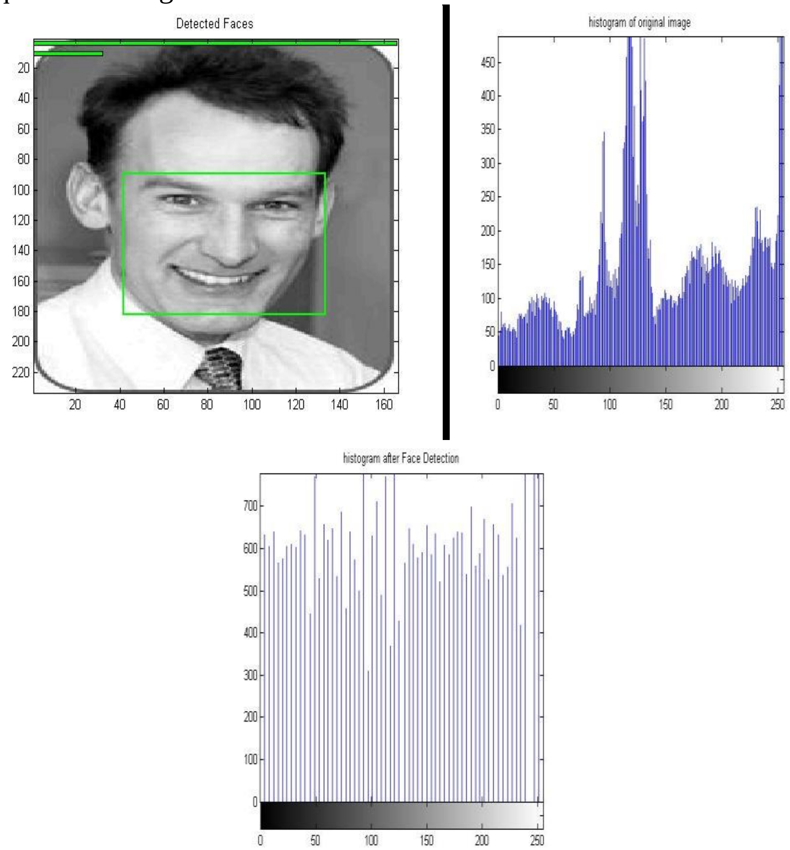

Figure 9. Face Detection, Histogram of Image before and after Face Detection

3.3 Image Pre-processing

Image preprocessing is needed before presenting the facial images to artificial neural networks (ANN).This is done to reduce the computational cost and increase the computational speed of neural networks so it will work as faster recognition system. The following Steps are adopted for the same.

3.3.1 Histogram Equalization: Histogram equalization is a widely accepted gray level transformation which transform the original image into equally distributed brightness level.The transformation allows for regions of lower local contrast to increase a higher contrast without affecting the global contrast. Histogram equalization create this change by spreading the most frequent intensity values to whole image. Consider a discrete grayscale image, and let n_i be the number of occurrences of gray level i. The probability of an occurrence of a pixel of level i in the image is

$$p(x_i) = \frac{n_i}{n}, i \in 0, ..., L-1$$

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L being the total number of gray levels in the image, *n* being the total number of pixels in the image, and *p* is the image's histogram, normalized to 0..1. Cumulative distribution function corresponding to *p is represented by c*,

$$c(i) = \sum_{j=0}^{i} p(x_j)$$,

c is the image's accumulated normalized histogram. Than create a transformation function $y = T(x)$ that will produce a level *y* for each level *x* in the original image, such that the cumulative probability function of *y* will be linearized across the value range. The transformation is described through this equation.

$y_i = T(x_i) = c(i)$, T maps the levels into the domain of 0.1.

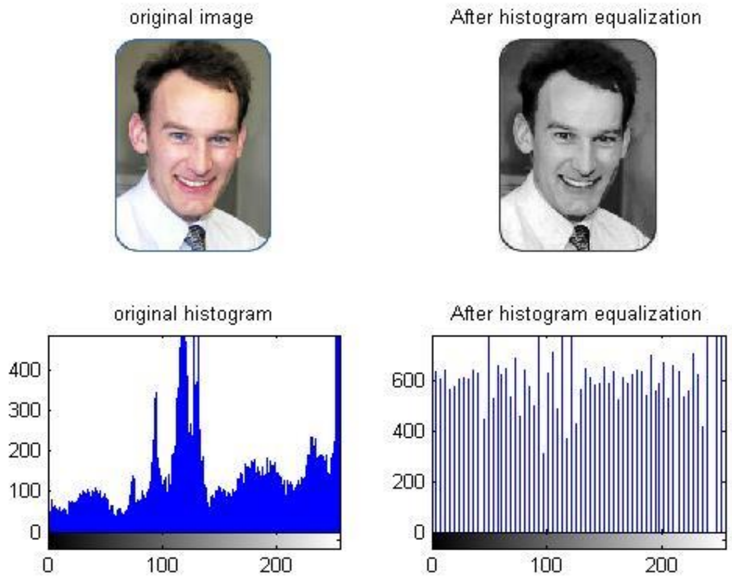

Figure 10. Original Image and Histogram Equalized Image with Histograms

3.3.2 Binarization and Thinning: Image Binarization translate a gray scale image of 256 gray levels to a black and white image. It is used as preprocessing before submitting the image for actual processing. The threshold value is decided and classify all value as bright pixel above this threshold and remaining are black. Adaptive image Binarization is required where optimal threshold is chosen for each image area. Thresholding creates binary images from grey-level ones by turning all pixels below some threshold to zero and all pixels above that threshold to one. If g(x, y) is a threshold version of *f(x, y)* at some global threshold T, *g(x, y)=1* if *f(x, y) ≥ T*, otherwise Zero. Image thinning is to be done to thin (remove redundant pixels) this thick and noisy boundaries which is having location of edges and can be easily represented in parametric form and easily distinguishable.

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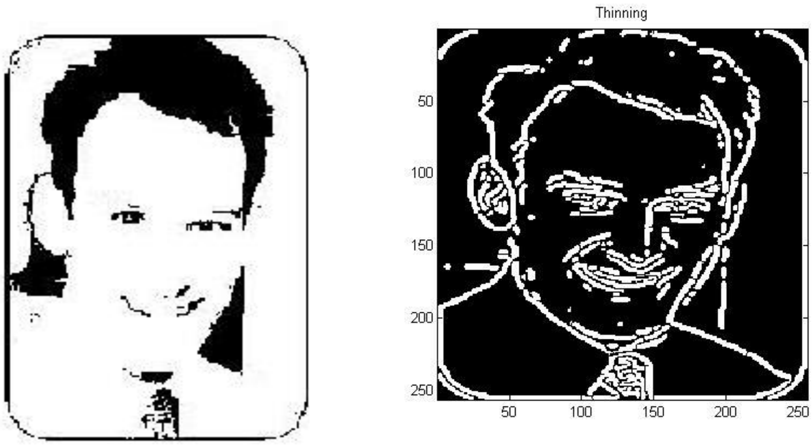

Figure 11. Image Binarization and Thinning

3.4 Canny Edge Detection and Harris Corner Detection

In the process of face detection and recognition the edge detection is a prime parameter to be considered with greater efficiency. The Canny edge detection [28] is one of the suitable method being considered for such detection mechanisms. This method of edge detection discovers the optimal value edges and marks most possible edges by using a filter based on first derivative of Gaussian. The Canny edge detector does this by defining edges as zero-crossing of second derivatives in the direction of greatest first derivative. The operator is also designed to perform as an optimal edge detector. It takes gray scale image as an input, and produces an image as output showing the positions of tracked intensity discontinuities. The Canny operator operational process is done in a multi-stages. In first stage, the image is smoothening is done by a Gaussian convolution. Then, a 2D first derivative operator is applied to the smoothed image to highlight regions of the image with high spatial derivatives and edge gives rise to ridges in the gradient magnitude image. The algorithm then tracks along the top of these ridges and set to zero all pixels that are not actually on the ride top as to give a thin line in the output, a process known as non-maximal suppression. The tracking process exhibits hysteresis controlled by two thresholds: *T1* and *T2*, with *T1>T2*. Tracking can only begin at a point on a ridge where it is higher than *T1.* Tracking then continues in both directions from that point until the height of the ridge falls below *T2.* Canny edge detector approximates the operator that optimizes the product of signal-to-noise ratio and localization. Apart from edge detection it is also required to find out the corners of image features and images to perfect the recognition system and identify the face with greater efficiency. In proposed work to find out corners of various features the Harris corner detection algorithm has been used. The corner detection is done on the basis of pixel gradient and the gradient values are used to judge the corner to identify and draw the Bezier curve for better feature detection and identification. Both the algorithms; the Canny edge detection and Harris corner detection[29] have been used for corner detection and feature points extraction, intern have been used for further processing of curve drawing, which has improved the method with better efficiency. As shown in Figure 12, the first part shows Canny edge detection and the other part shows the corner point detection.

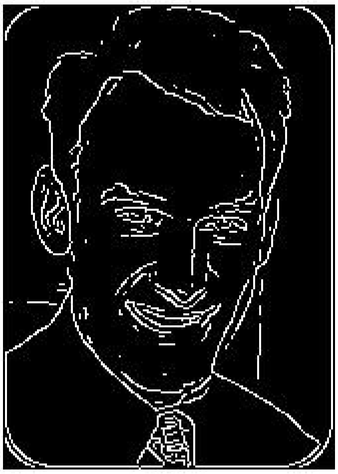

Figure 12. Canny Edge and Harris Corner Detection

Considering the corner points as control points of the Bezier curve the remaining intermediate points of the Bezier curves are being generated and have been given as input to the neural network to train the model and generate the results for comparing the feature vectors at the time of recognition. Figure 13 shows the training with epochs and error values.

3.5 Training Data of Neural Network

Here for the training of the Bezier curve pixels BPNN is used.

No of Input is 1(here input will be the pixels which are trained means all the pixels for creating the Bezier curves)

No. of Layers	2
Epoches	26
Mean Square Error	0.5476
Momentum	0.7
BiasConnect:	[1; 1]
InputConnect:	[1; 0]
LayerConnect:	[0 0; 1 0]
OutputConnect:	[0 1]
NumOutputs:	1
NumInputDelays:	0
NumLayerDelays:	0

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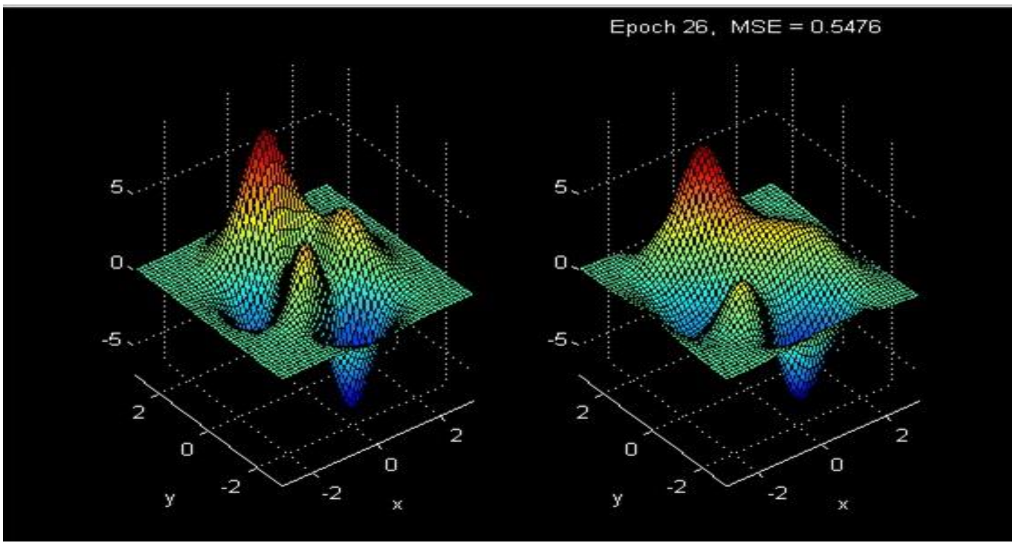

Figure 13. Neural Network and Training using 26 Epoch

On the basis of supervised training and the comparison algorithm the features have been compared and recognition of the facial images have been considered and the result of one the considered image is shown in Figure 14, which shows the recognition on the basis of Bezier curve formation on face (Face Recognition in the form of Bezier control points)

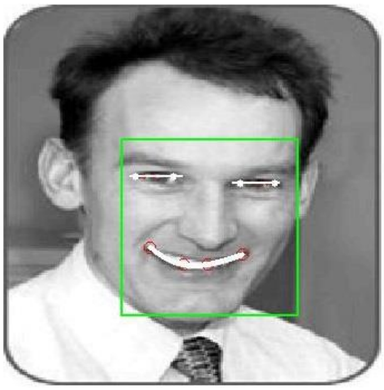

Figure 14. Face Recognition using Bezier Curves

The results shown above is the analysis of different images on the basis of training time, Measure of enhancement and No. of feature points contained in the image. Measure of enhancement is the term used to measure the changes done in the image during the detection of faces and can be measured as the Mean (I) /std (I) *i.e.* Mean of the image pixels and standard deviation of the image pixels. No. of feature points can be measured using the control points taken to recognize the eyes and mouth. We have chosen control end points of different features of face, the number of pixel points contained in these regions are the feature points.

Methods	Recognition Rate
Eigenfaces	84.7
Linear Subspace	79.4
Fisher Face	93.7
ICA	70.9
Kernel-Fisher	93.9
Edge Map	74.9

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LEM	85.5
RDA	97.6
LPP	84
Laplacianfaces	88.7
IROLS	95
Bezier Curve	96

The result shown above is the recognition rate of different face recognition techniques including our methodology using Bezier curves. The recognition rate denotes the number of images trained and no. of images when tested is recognized correctly. Accuracy rate slightly increase if the number of control points on the face increases.

4. Conclusion

The feature extraction and recognition techniques require longer evaluation and training time if the proper feature points with suitable algorithms have not been considered. In the proposed work suitable algorithm for edge detection, corner detection and feature extraction have been used with its hybridization in training process. To train the model 26 Epoch have been considered, which has reduced the training time and error rate. The feature extraction process has also improved considering the minimum features of the face which has resulted in better performance when compared with existing methods.

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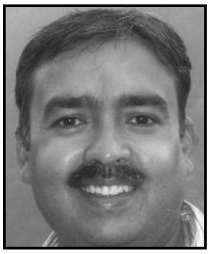

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