Enriched-BPNN Approach for Face Detection in Unconstrained Environment

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Abstract— In general, Face Detection and Recognition is a highly challenging problem in spite of being many methods available. Nowadays, most of the countries are struggling to find a solution for social and economic threats. Therefore, it is essential to have a well developed system to prevent from socio and eco threats. Keeping in view of these points author(s) propose a method Enriched-BPNN Approach for Face Detection in Unconstrained Environment (EBPNN). Quadrilateral forms a pyramid at different reduced scale of images. The output of this process is a collection of sub sampled images. These images are reshaped using reshaping technique and enhanced the quality of these images using Local Bin Modified Histogram Equalization. The BPNN finds sub sample images are containing face or non face. The paper aims to provide a better solution for high accuracy and better response for face detection in web video surveillance. Author(s) are focused on identifying a face from unconstrained face images i.e. real time images. The proposed system is experimentally evaluated on FJU and VIDTIMIT web video datasets in terms of different subjects, rotated faces, illumination, occlusion and compared with combined approach (SVM+HOG) on UR-Face 94 dataset. The report reveals that the EBPNN method has improved the performance in reference of statistical metrics such as accuracy, precision and recall.

Keywords— Face Detection, Recognition, Identification, BPNN, Quadrilateral, Local Bin Modified Histogram Equalization, Accuracy, Precision and Recall.

INTRODUCTION

In this paper, the Author(s) present Enriched-BPNN Approach for Face Detection in Unconstrained Environment. Face Detection pertains to identifying and locating a human face in images irrespective of the size, position, and quality of the images, that is, the specification of the images. In recent years of the computer era, Face Detection has been a widely researched domain to prevent from social and economic threats. So, author(s) focused on face detection. Face detection has numerous applications which include surveillance, human computer interfaces. There are several stages of Face Detection methods. Initially, Input images are obtained from web video dataset FJU, VIDTIMIT. Formation of input image from web video dataset is frame based at time t. In succession, these images are subjected to enhance and sub sampled because even best detection method also fails if compromised with the quality of the image and inadequate required features. Finally these images are to be detected whether it has face or non face.

Face Detection methods are classified in to four types [1]. These include Knowledge Based, Feature Invariant, Template Matching and Appearance Based Technique. The Knowledge Based Techniques are human programmed technique. The human programmed technique consists of set of rules to describe human facial features. The crucial drawback of the knowledge-based methods is the difficulty in building an appropriate set of rule. Feature Invariant approaches adopt the concept of structural features of the face like skin color, shapes, edges, texture. The predefined face templates are used to detect faces. Here, the correlation values are obtained between pre defined facial template and input image. This approach is simple to implement but not accurate for face detection. Superior quality results cannot be achieved when there are variations in pose, size and shape. However, the deformable templates have been proposed to deal with these problems. Appearance-Based Techniques initialize a collection of training face images to specify face models. The few examples of statistical methods are Eigen faces, Naive Bayes classifier, Support Vector Machine (SVM) and Neural Network. According to related work, Appearance-Based Techniques in comparison of other methods mainly for face detection.

The various pre-processing stages of Quadrilateral BPNN Approach for detecting Unconstrained face images. These include sub sampling technique, image enhancement.

The pyramid method of sub sampling technique is to form reduced form of multiple images and applicable in various fields like image data compression, segmentation [2], in age fusion techniques, and analysis. The most familiar data structure in image processing is the Pyramid. It helps to represent an image in multi resolution. It is useful for analyzing the image locally. The object of interest is placed in the small part of input image can also be highlighted approach.

The modified HE enhances contrast level of each sub sampled images. The modified HE is to overcome the limitation of conventional HE such as global detail enhancement. Further, these enhanced sub sampled images may or may not contain necessary detail but they are needed for detection. The quality of the image is to maintained and upgraded to yield better Face Detection rate. Therefore, the image is preprocessed to obtain the region of interest. Several pre processing techniques are existed such as contrast stretch, illumination equalization [3].

The accuracy of Face Detection is highly challenging task if images are three dimensional positions, orientation, lighting condition, complex backgrounds, different poses are considered in the Face Detection. The reasons are dissimilarity among facial features such as size, shape, and color and skin tone apart from quality of image. Therefore, literature review also conducted by considering the pose variation, lightening conditions, and occlusion. Many researchers suggest that the ANN with learning algorithm BPNN is more efficient [4].

Hence, an erroneous study has been taken on each stage of face detection such as sub sampling images, image enhancement and face detection methods. The studies also analyzed various existing methods suitable for each stage.

Here, it is worth to describe in detail about EBPNN. The proposed method has been enlightened on frontal, left and right tilted faces, occluded faces with unconstrained background; small portion of input image reserved for object of interest; frame based images of web video data sets.

The rest of the paper is organized as; Section 2 describes Related Works, Section 3 gives detailed study of proposed methodology Section 4 describes Experimental Result & Analysis and Section 5 Conclusion.

RELATED WORKS

The BPNN has the ability to detect faces in digital images. It is also proved that the BPNN has comparatively high detection rate. Even though, the performance of BPNN is more depend on preserved quality along with important information of the image. Therefore, the input image is to be preprocessed before inputted to BPNN. In this section, a complete survey has been studied on existing methods for formation of sub image, image enhancement, and detection. Finally, these methods are analyzed.

E.H.Adelson.et.al [5] presented variety of pyramid methods in their studies and developed for image data compression, enhancement and analysis. Here, the author(s) have made attempt to search a target pattern over multi scale original image. The main advantage of multi scale and multi resolution images is to prevent from loss of information and minimize the computational problems. There are two different ways to achieve this. The first way is to construct copies of target image at several scales and each scale is convolved with the original image. The second way is to construct a single copy of target image and this image is convolved with copies of the image reduced in scale. In the second case, the target image is large enough than the reduced images. Author(s) conclude that second way is better than first way due to its fourth power of scale factor.

David C. Zang.et.al [6] presented a method for fusing and enhanced images using Mask pyramid. The process is carried out in two stages. That is the qualities of fused images are deteriorated applying any fusion technique. The Laplacian fusion method is adopted by the author i.e. region based fusion technique. Author has proposed an algorithmic approach using Mask Pyramid. This method improves the quality of fused image by applying in different scale of images. The authors also demonstrate the performance of proposed system in many applications. However, the present scenario global selection rule is adopted to identify the object of interest. But the localized selection rule is preferably better than the global one. The Mask Pyramid method is introduced along with new hardware architecture to localize the pixels selection. This leads to more computational and implementation cost.

The pyramid algorithm works on multiple representation of input image instead of single representation. Here, each representation is also defined as level which is built by performing operation over lower level. Therefore, the level 0 is a base level of the pyramid to place an original image. [7]. The author has applied this concept on segmentation and the pyramid method is achieved desired result.

Most often, the range of scene illumination is uniformly spreading over an image. This procedure is called contrast stretch. The unusual appeared gray levels are replaced equally by a number of gray levels as the often appeared gray levels. It creates ambiguity to distinct the similar features due to obscure in nature. The Histogram Equalization is the sufficient method for contrast enhancement as per experimental result of their analysis [8]. The major characteristics of Histogram Equalization are effectiveness and simplicity [9]. Therefore, HE becomes popular.

Nicolas Sia Pik .et.al [10] studied methods with keeping in view of image enhancement. Author also studied about two more concepts of Equalization. It is well known that Histogram is main tools for enhancing the image. It is used to describe the characteristics and appearance of the image. Author defined that all intensity values lies in the image uses for its transformation function. So purpose is to uniformly distribute intensity of the image. Author reveals four different types of Histogram Equalization. They are Global Histogram Equalization (GHE), Mean Brightness Preserving Histogram Equalization (MBPHE), Bin Modified Histogram Equalization (BMHE), Local Histogram Equalization (LHE). Global Histogram Equalization does not perform well in terms of local brightness features of input images. In MBPHE, its application is limited not applicable to all. Apart from these two methods rest of the methods i.e BMHE and LHE has more advantages. As in the case BMHE object of the interest in an image is successfully enhanced by this method even it occupies small portion of the image. In the same manner local content of an image contains small or hidden details. This can be explained by LHE method.

Liyan Zhuang.et.al [11] intended a method for enhancing the image with the concept of mean and variance based sub image Histogram Equalization. This method effectively works on contrast of the input image without losing contents of the image. In this method, Histogram of input image is distributed in to sections, criteria based on mean and variance of luminance. Each section has been improved and equalized by Sub Histogram bins. Final outcome is achieved through concatenation of Sub Histograms.

A small window based concept for Face Detection is introduced to detect frontal face image [12]. A Neural Network is used to find whether each window contains a face or non face. A Bootstrap algorithm is also used along with Neural Network to find false detection rate. A major advantage of this method is replacing manual selection of non face training samples. This method is achieved detection rate between 77.9% and 90.2% with 130 test images. The test images inclusive wide variety of subjects, multiple faces and unconstrained background.

A new novel method was introduced for face recognition by Thai Hong Le.et .al [13]. It is a hybrid method by amalgamating AdaBoost and Artificial Neural Network (ABANN). This combined hybrid approach is used for detecting human faces. The face alignment is done by Multi Layer Perceptron- Active Shape Model (MLP-ASM). Feature extractions are extracted through combined approach of Geometric Feature Based Method and Independent Component Analysis. The experimental result is carried out on MIT+CMU dataset in all three stages. The performance of the EBPNN method is not only high but also decreasing false detection rate. ICA-Geometric feature classification is done through a Multi Artificial Neural Network. This method is compared with traditional technique, the MANN outperforms.

Baurel et al. [14] proposed a multilayer perceptron method to detect face region. A network has multilayer perceptron. The MLPs provides a class which is face or background. The network is trained for all images with various resolutions. The normalization technique is adopted for standardized the size of the image. Moreover, different lightening condition is controlled by mean and variations of intensity values. So normalized images are then classified by MLPs. Multi resolution is used to allow detection at various distances. The spatial fusion technique is adopted to filter the results.

Joseph et al. [15] introduced Fast Neural Network (FNN) method to minimize the computation time during searching process. The Neural Network searching process is adopted divide and

conquers strategy and involves image decomposition. The FNN divides image into small sub images and tests individually. This method is applied in clustered scene to find out the human faces. This method when compared with conventional and Fast Neural Network, found speed-up ratio in experiment results. This method is used to detect faces by using the parallel processing technique. The outcome of each sub image is simultaneously tested with the help of FNNs. In the Fourier space, the problem of centering the sub image and normalization is solved.

Aulestia et al. [16] proposed a Face Detection method using both real-time and unstructured environments. The Histogram of oriented gradients approach is applied by the researchers for feature extraction with the help of canonical window. The author has been used color images dataset to detect the faces in sequence to study and improves the performance of the EBPNN. The color images with patches of faces with different background are collected to form a dataset for their study. This created dataset is also used for training the Neural Network. The dataset has color images of 320 × 240 pixels. The method has been designed to have several modules. These modules perform the detection process in parallel to achieve real-time detection. The method had an accuracy of 91.4% even in the presence of illumination, pose, and occlusion-related changes.

The factors affecting the performance of BPNN are hidden layers and neurons. This is because of arbitrary decision, accuracy with activation function. So, S.Karsoliya [17] has made an excellent survey and finally suggests that, the network topology depends on number of training samples. Therefore, before designing the network, the training samples must be analyzed. Then only number of hidden neurons and hidden layers approximated.

Most of the researchers are only focused on developing software for Face Classification, Face Recognition not on Hardware Implementation. A Hardware Implementation real time image processing but other side of Hardware Implementation is the higher cost and time. Therefore author [18] proposed the Multi Layer Perceptron is for Face Detection to classify the Face or non Face. The author also proposed Hardware Implementation through the methodology based on VHDL. The experiment result suggests this methodology as it is very promising approach. The automation of Face Detection is accomplished by BPNN and Tanh activation function

Back Propagation Neural Network (BPNN) is not only used for face detection, pattern recognition but also used for face recognition [19]. The author has successfully implemented for automatic parking gate and automatic ticketing system. So this method is applied for automatic plate number recognition (APNR). According to training and recognition set the result concludes that Back Propagation Neural Network (BPNN) converges with desired recognition with high accuracy rate.

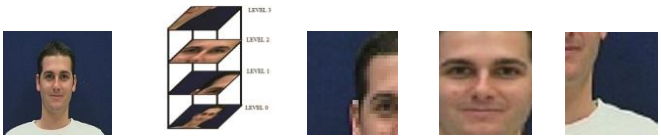
Quadrilateral –BPNN Approach for Identifying Unconstrained Face Image

Image pyramid is actually a representation of the image by using a set of various frequency band images. In the proposed method, the image pyramid is constructed for Level L= 0,1,2,3. Here, Level 0 is original image and multi scale images are constructed from Level 1. The pyramid is constructed for the Lower Level 1 by applying low pass filter on the upper Level is 0. The sub sampled images are obtained by reducing the image size by factor of ½. This process is accomplished by REDUCE operation. The repetition of sub sampled operation generate remaining Levels of Quadrilateral pyramid, obtained from the following equation:

$$p(i,j) = p_l(i,j) \sum_m \sum_n w(m,n)\, p_{l-1}(2i+m, 2j+n)\; l \forall [0,N] \quad (1)$$

As per the above equation the construction of pyramid is like convolved original image with weighting function w (m, n).Next, Band pass image is obtained by subtracting current Level from immediate previous level in the pyramid. Low pass pyramid is defined in equation (1) which specifies level of the Band pass pyramid and RESHAPE sub sampled images for the input image as Figure 1 below:

$$L_i = Pi - \text{RESHAPE}\ (P_{i+1}) \quad (2)$$



(a)Input Image (b) Quadrilateral Pyramid (c) Sub sampling Images

Figure 1: Quadrilateral Pyramid for sub sampling

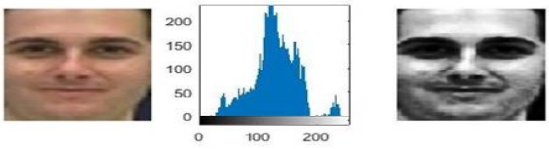
Each Level image is intended to equalize the intensity values across the sub sampled images. So, the Local Bin Modified Histogram Equalization is applied on each sub sampled images for equalization which improves the performance of the entire system.

Algorithm Quadrilateral Approach

1. Input image of size 120*128.
2. It is larger than 30*32; therefore apply Quadrilateral Pyramid to collect 30*32 images.
   a. Apply sub-sampling method by factorizing of 1.2.
   b. Repeat step (a) for 3 Level. (Up to 4 Level).
   c. Select the image from Level 2, 3, 4.
   d. Using reshape, obtain original 30*32 image window. Now Quadrilateral image is formed.
   e. Apply Low Pass Filter for smoothing this image.

Local Bin Modified Histogram Equalization

LBHM is introduced to explore the local contains of an image. The local contents of the image may possess tiny or some hidden information. The important details of the image even it resides slight portion of the image is also be explored. The entire process of the Local Bin Modified Histogram Equalization (LBMHE) is divided in to four stages. Initially, the first stage is formation of sub-histograms of histogram image and then controls the amount of gray level stretching, apply HE on each sub histogram images. Eventually, the brightness of the original image is to be retained.



(a) Sub-Sampled Image (b) Local Bin Histogram Image

Figure 2: Sub- Sampled and Local Bin Histogram Image

The complete algorithm of Local Bin Modified Histogram Equalization (LBMHE) is given below:

Algorithm

1. Fetch the image after processing the pyramid to be enhanced.
2. Apply traditional Histogram Equalization (HE) on it, obtain the Histogram image and Divide it into Sub Histogram images.
3. Find mean & standard deviation of the Gray Level (GL) frequency of each Sub Histogram region.
4. If No. of consecutive Gray Level $[\mu - \delta, \mu + \delta] >= 60\%$ then normal distribution of frequency otherwise influenced to dominating portion in the Sub Histogram.
5. Divide each Sub Histogram into further reduced Histogram.
6. Allocate gray scale range among sub histogram using Cumulative frequency (CF).
7. Apply Histogram Equalization to each Sub Histogram locally.
8. Final so that any portion of the input locally enhanced image is obtained.
9. Initially, number of cluster has to be formed according to intensity values.
10. Calculate weight for each cluster.
11. Check the conditions Cluster weight, Cluster Weight Ratio, Cluster Width. If these conditions are satisfied, begin merging process iteratively.
12. Find out the intensity threshold. Add one bin to each cluster if the intensity threshold value of the cluster is zero and brightness of the original image is retained.
13. Transformation function is applied on each Sub Histograms gray level for mapping operation to the result image.

BPNN Approach for Face Detection

Feed Forward Back Propagation Neural Network architecture contains of three layers namely Input layer, Hidden layer and Output layer. In this algorithm, given a set of input and output pairs, a procedure is adopted for changing the weights in a network to appropriately classify the given input patterns, where changing the weights implies that the error is propagated back to the hidden unit. The determination of the Neural Network is to train the network for the given input to realize balance among the responses of the network. The length of the extracted feature vector is considered as number of input neurons. The size of the sub sampled image is 30x32 pixels which represent human face or non face. Accordingly input neurons are specified in an input layer and number of output neuron is one. If it is human face the outcome is true, otherwise the result is false. The hidden neurons are $2 \times n + 1$. Here, n is the input layer neuron. The neurons in the hidden layer help to identify the local features. This hidden layer characterizes faces using an activation

function which is a sigmoid function in this case. The sigmoid function is used to form a relation between the value of the function at a point and the value of the derivative at that point which reduces the computation time during training:

$$f(x) = \frac{1}{1+\exp(-\lambda x)} \quad (3)$$

In this network system, there are three types of blocks to form number of neurons in the input layer which looks as four overlapping blocks of 20 × 1 2 pixels, sixteen overlapping blocks of 10 × 6 pixels, and five overlapping blocks of 24 × 12 pixels. The output layer neuron's final outcome is to detect whether face or non face image. An example for detected face image for the input face image is shown in Figure 3.

In general, an image is served as non face example. This is because non face image is much larger than the size of the face image. The framed based face dataset is formed during training of Artificial Neural Network in the following manner.

The trained Neural Network produced an output 1 for face image and 0 for non face image. Algorithm of training is the standard Error Back Propagation Algorithm. The Network weight is initially at random in the first iterative process.

After that, iterative process of training, weights are computed by the previously for the next consecutive iteration till scanning of all images. These weights are updated every iterations to minimize the error.

Figure 3: Input Face Image and corresponding Detected Face Image

The statistical measures, precision, recall and accuracy are used to find the detected accuracy of face image.

Algorithm:

1. Read the feature vector for each input image.
2. Initialize
   - i) Neurons-random weight
   - ii) Neurons- bias value in the range 1 & -1.
   - iii) Neuron-learning rate in the range 0 & 1.
   - iv) Neuron-momentum in the range 0 & 1
3. For each vector
   - (a) Calculate hidden layer neuron value with sigmoid function.
   - (b) Calculate output layer neuron value with sigmoid function.
   - (c) Find errors of output layer & hidden layer

     $$E_j = E_j(1 - O_j)(T_j - O_j) \quad (4)$$

     E_j- Error of j[th] neuron; T_j is Target value of j[th] neuron; O_j is output value of jth neuron.
   - (d) Update Weight:

     $$W_{ij} = W_{ij} + \Delta W_{ij} \quad (5)$$

     W_{ij}- Weight of ith neuron to jth neuron.
   - (e) Repeat the above step, if error is too small, and then stop the process.

Experimental Result and Analysis

In this experimental result and analysis, systematically apply the proposed system to two different video datasets. The performance of the proposed system is evaluated using FJU web video dataset under conditions where different lightening condition, occluded faces, unconstrained background are raised. The performance of the proposed system is evaluated using VIDTIMIT web video dataset under condition frontal, left and right tilted, different subjects of 70 face examples are created from these datasets [20]. In the preprocessing, each of 30 × 32 windows images in the set is processed by LBMHE before given to BPNN. Here, the LBMHE produces the enhanced smooth image. The quality of the image has been studied by using the quality metrics such as Peak Signal Noise Ratio (PSNR), Absolute Mean Error Brightness (AMEB). The original image and LBMHE image are considered where original image is the noisy approximation of LBMHE image. The PSNR value of the LBMHE method is obtained by the following formula.

$$PSNR = 10\ log_{10}\ (\frac{(M_I-1)^2}{MSE}) \quad (6)$$

Where M_I is maximum intensity value of the pixel image can taken as M_I =256. MSE is defined as in the following formula:

$$MSE = \frac{\sum_{LM}(I_0-I_H)2}{L\times M} \quad (7)$$

Here, L and M is number of rows and columns respectively of original imageI_O. I_H is enhanced image.

Similarly, AMEB is to evaluate brightness preservation in the enhanced image. It is defined as:

$$AMBE = |\mu_O - \mu_H| \quad (8)$$

Here μ_O & μ_H refers mean value of original image and enhanced image respectively.

It is found that the images with higher PSNR values and smaller AMEB values [21] are of good quality. Final observation is that the proposed method works better.

S.No.	Original Image	Histogram Image (LBMHE)	PSNR	AMBE
1.	Img-Org-1	Img-MHE-1	20.440	52.6094
2.	Img-Org-2	Img-MHE-2	20.5007	48.4268
3.	Img-Org-3	Img-MHE-3	20.4983	48.165
4.	Img-Org-4	Img-MHE-4	20.3182	91.1994

Table 1: PSNR and AMEB values of enhanced images

The resulting image (30 × 32 pixels) is inputted to the ANN. The ANN produces either 0 (false) or 1 (true). The original image is decomposed into three blocks such as 4, 16 and 5 overlapping blocks. Thus, the ANN has 960 input neurons. Every block has passed through hidden units for the purpose of detection of faces through local features. For representation of local features which characterize faces, 51 neurons are used at hidden layer in the system. For training the Neural Network, learning rate is initially defined 0.25 while momentum factor is less than 0.9 which is in such a way that it generates 1 for face and other for non face. The following Figure illustrates the detected ANN face image. The precision, recall and Accuracy is calculated for detected ANN face image as shown in the following. Overall, the proposed method for face detection is well performed according to the performance metrics.

Actual Face

Detected Face

Figure 4: Actual and Detected Face Image

Image No.	Precision	Recall	Accuracy
Img-MHE-1.	99.8%	100%	99.9%
Img-MHE-2.	98.9%	100%	99.7%
Img-MHE-3.	99.8%	100%	99.8%
Img-MHE-4	98.6%	99.7%	99.5%
Img-MHE-5	97.9%	100%	99.3%

Table 2: Detected Images –Precision, Recall, Accuracy

To study the performance of proposed Enriched method for face detection, it is essential to compare with combined approach (SVM+HOG) [22]. Here, the face dataset UR_Face 94 has been experimentally tested on combined approach and proposed Enriched method.

Database UR_Face 94	Combined Approach (SVM+HOG) Accuracy	Proposed Enriched Method Accuracy	Proposed Enriched Method	
			Database FJU+VIDTIMIT	Accuracy
URFimg_1	92.68%	94.9317%	Img-MHE-1	99.9%
URFimg_2	94.10%	88.7019%	Img-MHE-2	99.7%
URFimg_3	87.89%	88.8107%	Img-MHE-3	99.8%
URFimg_4	90.58%	95.0739%	Img-MHE-4	99.6%
URFimg_5	89.19%	96.7628%	Img-MHE-5	99.5%

Table 3: Comparison of Combined Approach (SVM+HOG) with Proposed Enriched Method Face Detection Accuracy

The Column 2 & 3 of Table 3 reflects result of this comparison. The proposed Enriched method has produced 92.69% average accuracy which is marginally higher than combined approach of 90.89%. The proposed method has also been tested on FJU and VIDTIMIT video databases and achieved very similar result 99.64%.

Therefore, conclusion is drawn that PEM achieves best performance with smallest variation

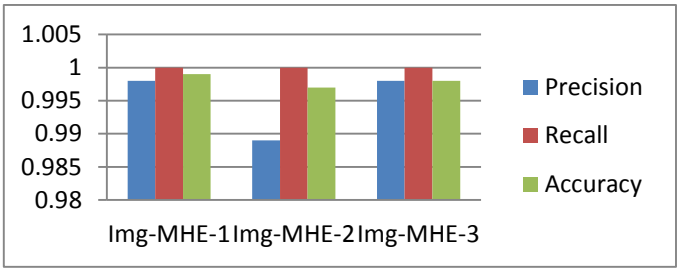


Figure 5: Analysis of Detection rate of different images

CONCLUSION

This paper presented Enriched-BPNN Approach for Face Detection in Unconstrained Environment to detect input face and non face image. Accuracy of extracted face image is higher as per the result of the metrics value and by visual inspection. Therefore, performance of proposed method is up to the desired level. This is because Quadrilateral Sub sampling image technique yielded best comparable size of sub images for input to the BPNN. Modified HE is applied for smoothing the image. The sampled input 70 images are collected from two different datasets VIDTIMIT and FJU. The parameters of proposed method are left, right occluded faces with unconstrained background. Performance of EBPNN Method has also been compared with combined approach. As a result of this comparison the PEM works better with small variation. Hence, this method is best suited for face detection.

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