Feed Forward Neural Network Based Eye Localization and Recognition Using Hough Transform

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***Abstract*— Eye detection is a pre-requisite stage for many applications such as face recognition, iris recognition, eye tracking, fatigue detection based on eye-blink count and eye-directed instruction control. As the location of the eyes is a dominant feature of the face it can be used as an input to the face recognition engine. In this direction, the paper proposed here localizes eye positions using Hough Transformed (HT) coefficients, which are found to be good at extracting geometrical components from any given object. The method proposed here uses circular and elliptical features of eyes in localizing them from a given face. Such geometrical features can be very efficiently extracted using the HT technique. The HT is based on a evidence gathering approach where the evidence is the ones cast in an accumulator array. The purpose of the technique is to find imperfect instances of objects within a certain class of shapes by a voting procedure. Feed forward neural network has been used for classification of eyes and non-eyes as the dimension of the data is large in nature. Experiments have been carried out on standard databases as well as on local DB consisting of gray scale images. The outcome of this technique has yielded very satisfactory results with an accuracy of 98.68%**

Keywords - ***Hough Transform; Eye Detection; Accumulator Bin; Neural Network;***

I. INTRODUCTION

Face recognition has become a popular area of research in computer science and one of the most successful applications of image analysis and understanding. There are a large number of commercial, securities, and forensic applications requiring the use of face recognition technologies. These applications include face reconstruction, content-based image database management and multimedia communication. Early face recognition algorithms used simple geometric models, but the recognition process has now matured into a science of sophisticated mathematical representations and matching processes.

Major advancements and initiatives in the past ten to fifteen years have propelled face recognition technology into the spotlight. Face recognition can be used for both verification and identification. Eye detection and localization have played an important role in face recognition over the years. Evidence gathering approach of Hough Transform has a major role to play in this field. Eye detection is the process of tracking the location of human eye in a face image. Previous approaches use complex techniques like neural network, Radial Basis Function networks, Multi-Layer Perceptron's etc. In the current paper human eye is modeled as a circle (iris), the black circular region of eye enclosed inside an ellipse (eye-lashes).Due to the sudden intensity variations in the iris with respect the inner region of eye-lashes the probability of false acceptance is very less. Since the image taken is a face image the probability of false acceptance further reduces. Since Hough transform has been effective at detecting shapes, and due to the circular shape of the iris, we have employed it in the eye detection and localization. The points obtained after applying Hough transform are fed to Back Propagation Neural Network (BPNN).

BPNN is a supervised method where desired output is calculated given the input and the propagation involves training input patterns through the neural network to generate the output activations. This is followed by Back propagation of the output activations through the Neural Network using the training patterns in order to generate the output activations and the hidden neurons. The back propagation used here is feed forward neural network as they can handle the high dimensional data very well.

II. HOUGH TRANSFORM

The Hough Transform, HT, has long been recognized as a technique of almost unique promise for shape and motion analysis in images containing noisy, missing and extraneous data. A good shape recognition system must be able to handle complex scenes which contain several objects that may partially overlap one another. In the case of computer vision systems the recognition algorithm must also be able to cope with difficulties caused by poor characteristics of image sensors and the limited ability of current segmentation algorithms. The Hough Transform is an algorithm which has the potential to address these difficult problems. It is a likelihood based parameter extraction technique in which pieces of local evidence independently vote for many possible instances of a sought after model. In shape detection the model captures the relative position and orientation of the constituent points of the shape and distinguishes between particular instances of the shape using a set of parameters. The HT identifies specific values for these parameters and thereby allows image points of the shape to be found by comparison with predictions of the model instantiated at the identified parameter values

Hough transform is a general technique for identifying the locations and orientations of certain types of features in a digital image and used to isolate features of a particular shape within an image.

Lam and Yuen [18] noted that the Hough transform is robust to noise, and can resist to a certain degree if occlusion and boundary effects. Akihiko Torii and Atsushi Imiya [19] proposed a randomized Hough transform based method for the detection of great circles on a sphere. Cheng Z. and Lin Y [20] proposed a new efficient method to detect ellipses in gray-scale images, called Restricted Randomized Hough transform. The key of this method is restricting the scope of selected points when detecting ellipses by prior image processing from which the information of curves can be obtained. Yip et al. [21] presented a technique aimed at improving the efficiency and reducing the memory size of the accumulator array of circle detection using Hough transform.

P.Wang [12] compares fully automated eye localization and face recognition to the manually marked tests. The recognition results of those two tests are very close, e.g. 83.30% vs. 81.76% for experiment 1 and 97.04% vs. 96.38% for experiment 2. The performance of the automatic eye detection is validated using FRGC 1.0 database. The validation has an overall 94.5% eye detection rate, with the detected eyes very close to the manually provided eye positions.

Zhiheng Niu et al. [13] introduced a framework of 2D cascaded AdaBoost for eye localization. This framework can efficiently deal with tough training set with vast and incompact positive and negative samples by two-direction bootstrap strategy. And the 2D cascaded classifier with cascading all the sub classifiers in localization period can also speed up the procedure and achieve high accuracy. The method is said to be very accurate, efficient and robust under usual condition but not under extreme conditions.

Mark Everingham et al. [14] investigated three approaches to the eye localization task, addressing the task directly by regression, or indirectly as a classification problem. It has yielded accuracy up to 90%.

Hough transform is used for circle and ellipse detection. Hough transform was the obvious choice because of its resistance towards the noise present in the image. Compared to the aforementioned models the proposed model is simple and efficient. The proposed model can further be improved by including various features like orientation angle of eye-lashes (which is assumed constant in the proposed model), and by making the parameters adaptive.

Hough Transform implementation defines a mapping from image points into a accumulator space. The mapping is achieved in a computationally efficient manner based on the function that describes the target shape. This mapping requires much fewer computational resources than template matching technique. Hough Transform also has the ability to tolerate occlusion and noise.

The set of all straight lines in the picture plane constitutes two-parameter family. If we fix a parameterization for the family, then an arbitrary straight line can be represented by a single point in the parameter space. For reasons that become obvious, we prefer the so-called normal parameterization. As illustrated in, this parameterization specifies a straight line by the angle α of its normal and its algebraic distance p from the origin. The equation of a line corresponding to this geometry is

$$x\cos\alpha + y\cos\alpha = \rho \quad (1)$$

If we restrict α to the interval $[0, \pi)$, then the normal parameters for a line are unique. With this restriction, every line in the x-y plane corresponds to a unique point in the α- p plane.

Suppose, now, that we have some set { $(x_l,y_1),..., (x_n,y_n)$ } of figure points and we want to find a set of straight lines that fit them. We transform the points (x_i, y_i) into the sinusoidal curves in the e-plane defined by

$$\rho = x_i\cos\alpha + y_i\sin\alpha \quad (2)$$

It is easy to show that the curves corresponding to collinear figure points have a common point of intersection. This point in the α -p plane, say (α_0,p_0), defines the line passing through the collinear points. Thus, the problem of detecting collinear points can be converted to the problem of finding concurrent curves.

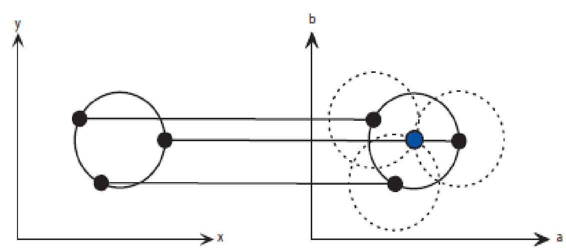

Figure 1. Circular Hough transform for x-y space to the parameter space for constant radius.

Rest of the paper is organized as follows: section III describes the proposed methodology used in this paper, experimental results are illustrated in section IV and section V & VI focus on conclusions & suggestions for further work.

III. PROPOSED METHOD

The method has 3 stages: Preprocessing, feature extraction by Hough transform followed by classification by Feed Forward Neural Network.

A. *Preprocessing*

The database images are initially cropped to a size of 100 x 100 resolutions. This will help us to fix the eye coordinates in a convenient and simple manner.

B. Feature Extraction by Hough Tramsfrom.

HT being the most efficient techniques is used to identify positions of arbitrary shapes most commonly circles and ellipses. The purpose of this technique is to find imperfect instances of objects in a parameter space within a certain class of shapes by a voting procedure. This voting procedure is carried out in a parameter space, from which object candidates are obtained as local maxima in a so-called accumulator space that is explicitly constructed by the algorithm for computing the Hough transform. The local maxima obtained from the accumulator array are used in training of back propagation neural network.

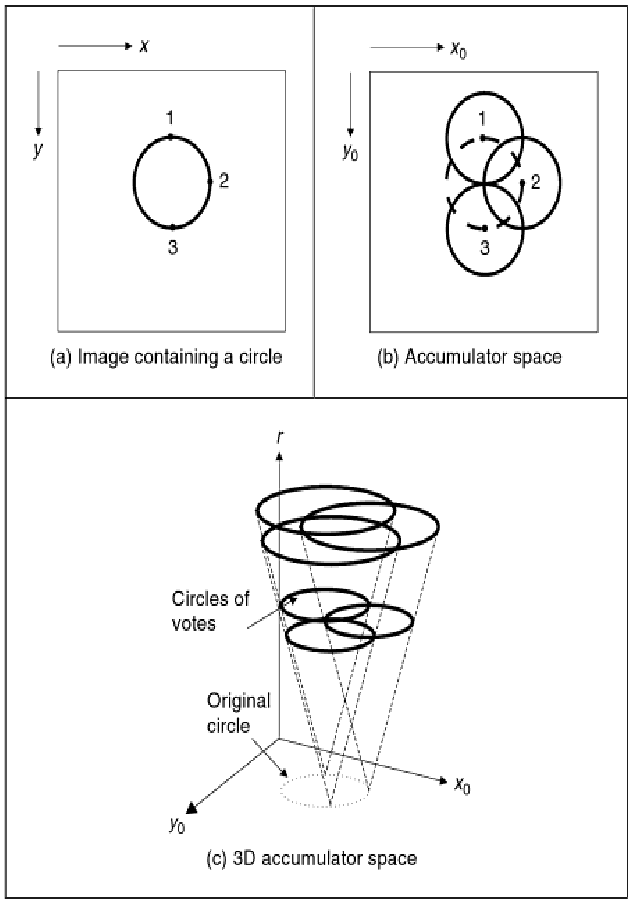

Figure 2. (a) x-y space (b) Accumulator space (c) 3D accumulator space.

For each input image in the x-y plane, a spherical filter is applied and the outcome of this is a set of points in the parameter space. These points represent the centers of probabilistic circles of pre-defined radii in the x-y plane. Mapping is done for each point in the original space to a corresponding point in the original space to a corresponding point in accumulator space and increment the value of the accumulator bin. Based on a pre-defined threshold, local maxima is identified which when back mapped on to a original space corresponds to a centre of probabilistic circle. The circle pattern is described by this equation

$$(x_p - x_0)^2 + (y_p - y_0)^2 = r^2 \qquad (3)$$

C. Feed Forward Neural Network (FFNN)

The Back propagation neural network used here is Feed Forward Neural Network (FFNN). FFNN was the first and arguably simplest type of artificial neural network devised. In this network, the information moves in only one direction, forward, from the input nodes, through the hidden nodes (if any) and to the output nodes.

The number of Input Layers, hidden layers and output layers are adjusted to fit the data points to the curve. During the training phase the training data in the accumulator array is fed into the input layer. The data is propagated to the hidden layer and then to the output layer. This is the forward pass of the back propagation algorithm. Each node in the hidden layer gets input from all the nodes from input layer which are multiplexed with appropriate weights and summed. The output of the hidden node is the nonlinear transformation of the resulting sum. Similar procedure is carried out in the output layer. The output values are compared with target values and the error between two is propagated back towards the hidden layer. This is the backward pass of the back propagation algorithm. The procedure is repeated to get the desired accuracy. During the testing phase the test vector is fed into the input layer. The output of FFNN is compared with training phase output to match the correct one. This can serve as a need to do recognition of facial objects.

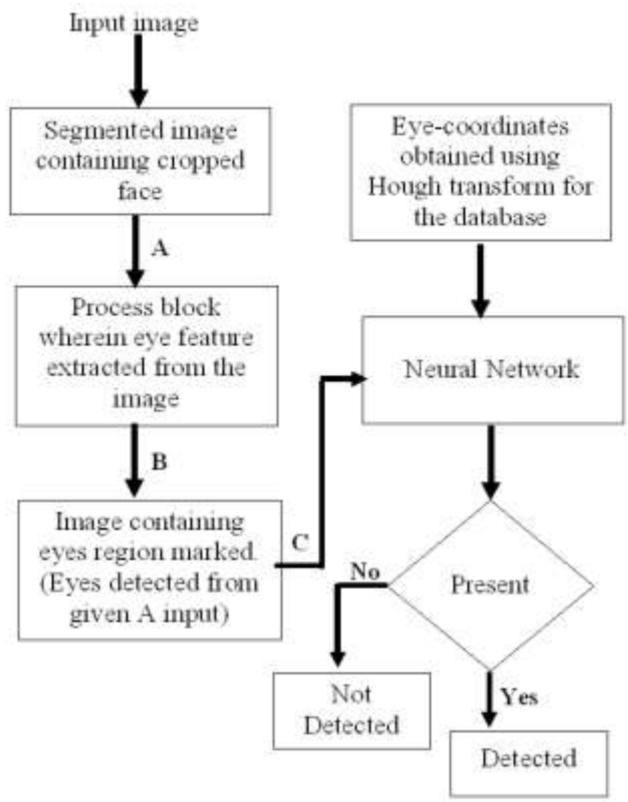

Figure 3. Block Diagram of the entire process

Note: A indicates segmentation of feature extracted face. B indicates pixel location of eye coordinates and C indicates vector (X1, Y1, X2, Y2) where (X1, Y1) and (X2, Y2) are the eye coordinates.

IV. Experimental Results

The algorithm has been extensively tested on two standard database namely Yale, BioID and a local database. The accumulator array from the Circular Hough transform has the same dimension as the input image which is of dimension 100x100. A filtering technique is used in the search of local maxima in the accumulation array and it uses a threshold value of 0.5 set using brute force technique. The local maxima obtained are represented by peaks in the 3D view of figure 5. The technique has yielded satisfactory results for some extreme conditions and has failed under certain conditions as shown in figure 6. The failure in figure 6 can be attributed to local maxima being present at a different location because of the extreme illumination effects.

A feed forward neural network with 200 hidden layers was trained and the regression plot is as shown in figure 10 and performance plot is as shown in figure 11. The x-coordinate, y-coordinate of the regression plot represents target requirement and output=99*target+0.0029 respectively. The plot indicates a perfect fit of the data and the accuracy obtained is very high with a computed value of 98.68%.

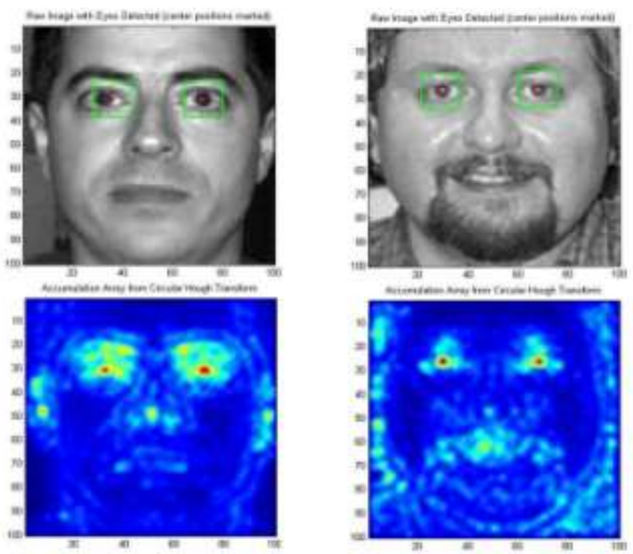

Figure 4. Eye Detections and Accumulator

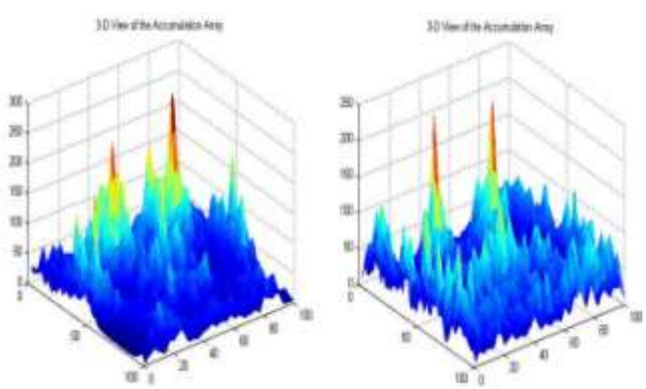

Figure 5. 3D view of accumulator array

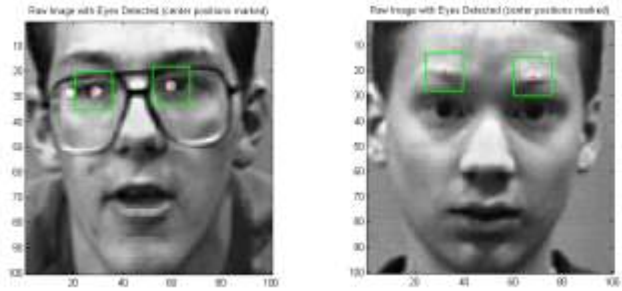

Figure 6. positive sample with occlusion and a negative sample

Figure 7. Database Images

Figure 8. Accumulator Bin

Figure 9. Eye localized images (green rectangle around eyes :Output)

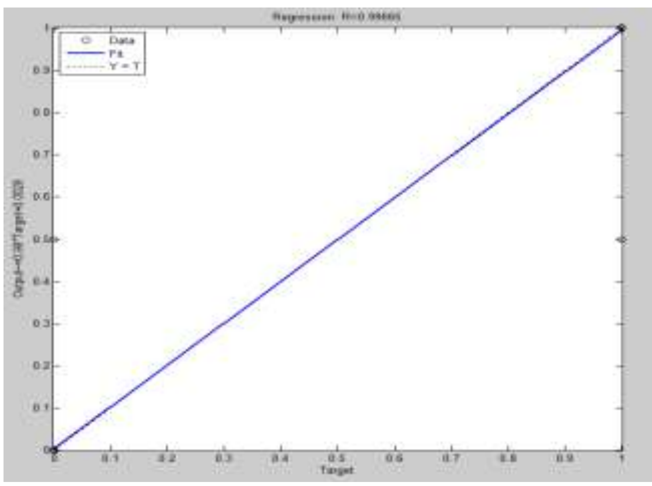

Figure 10. Regression Plot

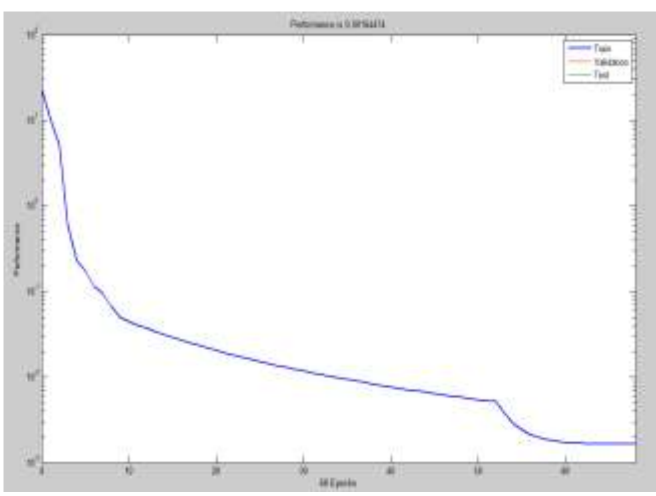

Figure 11. Performance Plot of Neural Network

TABLE I. TEST RESULTS

Database	No. of Images	No. of detections	Neural Network Results	Faulty Recognition	% Accuracy
Standard DBs	25	25	25	0	100
Built DB	127	127	125	2	98.42
Total	152	152	150	2	98.68

V. CONCLUSIONS

In this paper, we have presented a human eye localization algorithm for faces with frontal pose and upright orientation using Hough transform. This technique is tolerant to the presence of gaps in the feature boundary descriptions and is relatively unaffected by image noise. In addition Hough transform provides parameters to reduce the search time for finding lines based on set of edge points and these parameters can be adjusted based on application requirements.

The voting procedure has been successfully applied in the current method and is able to yield better results to effectively localize eyes in a given set of input images. The component can be effectively used as an input to the face recognition engine for recognizing faces with less number of false positives.

VI. FURTHER WORK

Hough Transform requires a large amount of storage and high cost in computation. To tackle these many improvements can be worked on. In addition, adaptable neural networks are coming in place which can probably save time and space complexities in computation. For face recognition like applications, future work can address to get other features under extreme conditions of images. They can be nodal points like width of nose, cheekbones, jaw line etc., which are sufficient for recognition of a particular face, within a given set of images.

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