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RESEARCH ARTICLE

Eye Localization under Different Lighting Ambiance using ANFIS

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Abstract*— *Neurocomputing is bountifully used in eye detection, which is a vital feature in face recognition. The challenge that influences eye detection is different lighting environment. A unique schema is proposed for achieving proficient eye detection under different lighting ambiance, with initially using normalization method for sharpening edges using adaptive smoothing method followed by which Adaptive Neuro Fuzzy Inference System is employed in eye detection under varying lighting condition, which results in great accuracy in classification and organize the discussion towards proficient eye detection with results on Real-DB, CMU-PIE and LFW face databases.

Index terms* – *Illumination Normalization; Feature Extraction; ANFIS; Eye Localization

I. INTRODUCTION

Neurocomputing is a method inspired by working of neurons in human brain in perception, which has its proficient application in various fields. Eye Detection is an important aspect to be considered in face detection which has its appliance in many places including video surveillance, driver fatigue analysis, security and entertainment. Eye is a one of distinct feature of human face with its shape, size and color. Though it is important feature eye detection is difficult with changing lighting conditions with computer vision.

As mentioned above, Illumination condition is one of the challenges in eye detection which is a barrier in efficient eye detection. Table 1, describes various challenges in all the Image Processing applications including eye detection application because human perception is high than computer vision, but trying to adopt working of human brain leads to the listed challenges. Here the application of eye detection is mainly focused in the second condition that is Illumination conditions.

In this paper, we use a unique schema proposed for achieving proficient eye detection under different lighting ambiance starting with Illumination Normalization using adaptive smoothing filter which results in sharpening the edges of the image. The resultant image obtained above after normalization is used for wavelet based feature extraction in order to identify all the features of the object in image which helps in perception of human face in case of computer vision. Followed by which eye is classified among other features of face ANFIS (Adaptive Neuro Fuzzy Inference System), a non- linear methodology is used. Thus detection the eye positions in the image used in various applications of face detection.

A. Organization of the Paper

The Paper is organized in the following manner that is, Section 2 contains Literature review related to our work, followed by Illumination Normalization processing methodology in Section 3. Section 4 explains the process of feature extraction. Section 5 contains methodology used for Eye Localization and finally this paper is concluded with Experimental Results of this work in Section 6 and conclusion in the next Section which may provide several directions in further research on eye detection.

II. RELATED WORK

The main contribution of this paper is based on the schema used for eye detection under different lighting ambiance. Various methods have been used in eye detection done by researchers in [3-5, 10, 11, 13, 16-18]. In [5], a complete description of various methods used by various researchers in eye detection and a comparative study is given. In [3], Eye Detection is done by using a schema with first illumination normalization with using adaptive smoothing filter in retinex theory followed by Edge Histogram Descriptor for highlighting the features of face and Support Vector Machine (SVM) for localization of eye. SVM is widely used in eye detection with providing a better accuracy [3, 5, and 16]. Earlier in [18] K- means clustering which is another method, used in eye detection but that was less accurate that using SVM.

A.L. Yuille et. Al., proposed feature extraction from human faces using definable patterns in [1]. Where feature extraction is based human psychology based perception which helps in adopting the human perception. Here Gabor filters are used in achieving such a process. Eye features are extracted from image along with all other features in the facial image. Before which Illumination normalization is basic and important starting step in achieving eye localization. In [2] Illumination estimation is explained and describes methods involved in achieving successful illumination estimation which is necessary in illumination normalization process. F.Yang, et. Al., describes some methods involved in this case of normalizing illumination which equalizes the lighting effects in the image in order to extract the facial features. In [7, 8] ANFIS technology is used which is human inspired method used in better classification of features which is done based on wavelet coefficients. In [9] Takagi Sugeno fuzzy modeling which is used in selection of parameterized functions which is uncertain in case of eye localization , since it is a uncertain application using a combination of least squares and back propagation. Gradient descent method is used for training FIS Member function parameters. In [11] describes about driver fatigue analysis for eye localization is an important aspect to be considered. This method used here will help in addition to achieve efficient driver fatigue analysis and also in other face recognition applications.

TABLE I
CHALLENGES IN DIGITAL IMAGE PROCESSING

The viewpoint from which an object is observed	
Various Illumination Conditions	
Occlusion Conditions	
Appearances including Shape, Size, Color and Texture.	

III. ILLUMINATION NORMALIZATION

The First step in overcoming such a barrier that is varying lighting condition is Illumination Normalization. Retinex Theory [3] is used in achieving the process of normalizing the illumination effects in the image. This process of normalizing involves two basic steps as given in [16] where illumination estimation followed by normalization is done with using a 3x3 mask to equalize lighting in the image.

Adaptive smoothing filter is employed in this case in order to equalize the pixel values in the image which obviously sharpens the edges of the image. In [16] Illumination estimation denoted by L obtained from Input image I with t + 1 iterations. The output image must be with same size of I,

$$L^{(t+1)}(x,y) = \frac{1}{N(x,y)} \sum_{i=-1}^{1} \sum_{j=-1}^{1} L^{t}(x+i, y+j) W^{t}(x+i, y+j) \quad (1)$$

$$N^{t}(x,y) = \sum_{i=-1}^{1} \sum_{j=-1}^{1} W^{t}(x+i, y+j) \quad (2)$$

$$W^{t}(x,y) = g\left(d^{t}(x,y)\right) \quad (3)$$

In equations (1) and (2) $N^t(x,y)$ denotes the normalization of illumination in the input image I. In (3) ‘g’ denotes the decreasing function , where $d^t(x,y)$ denotes the discontinuity in the pixel values of the image I, which is initialized to 0 resulting in g(0) = 1 and as $d^t(x,y)$ increases g value decreases towards achieving 0 finally. Both d and g the functions used as the deciding factor of the smoothing nature of the filer used here. This method used in [3] is used effectively towards achieving equalizing the pixel values to normalize the lighting condition in the image.

Followed by the process of illumination estimation L, normalization of the image is done by considering the difference between the input image I and illumination estimated image L, which is denoted by A(x,y)

$$A(x,y) = \log(I(x,y) + 1) - \log(L(x,y) + I) \quad (4)$$

$$A_1(x,y) = \frac{A(x,y) - A_{min}}{A_{max} - A_{min}} \quad (5)$$

Where $A_1(x,y)$ is the illumination normalized image with A_{min} and A_{max} denoting maximum and minimum values across the image $A_1(x,y)$. The resultant image $A_1(x,y)$ has the size equal to the size of I(x,y) as shown in fig 1.

Fig. 1 Illumination Normalization Results with a) Original Image and b) Illumination Normalized Image. Three Databases: RealDB, LFW, CMU-PIE respectively from left to right.

IV. FEATURE EXTRACTION

A method for detecting and describing the features of faces using definable patterns [1]. The feature of interest, an eye, is described by patterns with eyes and non-eyes parameters. An energy function is described which links, edges, valleys, and peaks in the input image intensity to the corresponding properties of the pattern based on the illumination normalization. The pattern of parameters is used to interact when required, with the image by changing its parameter values to reduce the energy function, for changing itself to find the matches in the image. The final parameter values can be used as description for the feature. The Feature extraction method shows definable patterns detecting eyes in input images.

A barrier in detection of edges and other features seem to lie in collaborating local information, which may be not difficult in obtaining into a global structure. Detecting facial features of the input image require a lot more prior information which is available and a definable pattern is not only able to detect a feature but can also provide a description of it for classification and testing with the database.

Gabor Filter is used in achieving the process of feature extraction which is a method for extracting all the data about features of face from images is used. Features of face images are excerpted using various orientations, and in varying resolution set of Gabor filters which are topologically ordered and aligned approximately with the face.

A set of Gabor filters with different frequencies and orientations may be helpful for excerption of useful features from an image. Gabor filters are directly related to wavelets uses discrete wavelet transform.

The Feature Extraction process is used for increasing the accuracy and Efficiency here. Using ANFIS on a set of images takes high duration which may result in increased computing time, which could be avoided by using Gabor filters to extract features as pre-processing before Processing classification by ANFIS which will reduce the computation time and increase the accuracy in eye detection.

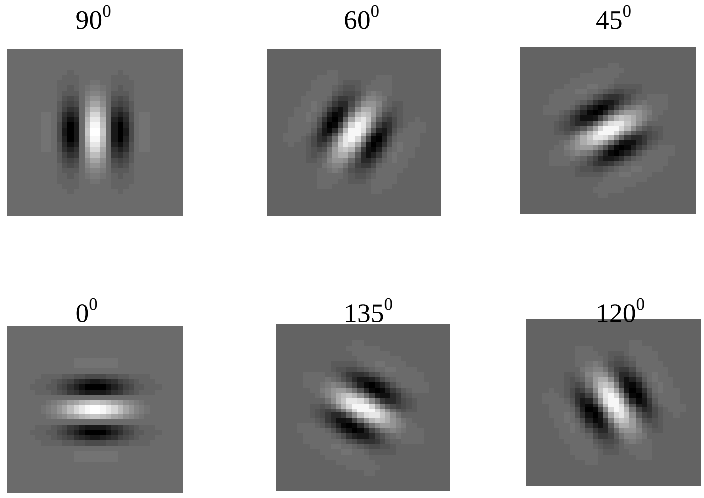

Fig. 2 Gabor feature extraction filter

Feature Extraction on A(x,y) in (5) is conducted, i.e., illumination-normalized facial images, for the fast computation. A(x,y) is somewhat different from Input facial images. That is, edges and features in A(x,y) are extracted using Gabor filter. Thus, the Feature Extraction is used considering the characteristics of A(x,y) for eye candidate detection.

The Feature Extraction is applied on the illumination normalized images as its features will be obtained due to use of Gabor filters using various orientations and frequencies: 0^0, 45^0, 90^0, 135^0, 180^0, 225^0, 270^0, and 360^0. This is done to obtain various features of an image based on the population in the image.

V. EYE LOCALIZATION USING ANFIS

The eye candidates are verified by ANFIS using normalized-gray features. In the eye verification, the training database and verify the eye candidates on A(x,y) are constructed, i.e., the illumination normalized facial images.

Eye verification is done using Adaptive Neuro Fuzzy Inference Systems (ANFIS), to get the real eyes from eye feature extraction results. The ANFIS-based methods have been widely used and achieved considerable high accuracies in eye detection. After the process of feature extraction, verification is required to get the real eyes from all the features extracted based on the edges and population. In the eye verification procedure, Adaptive Neuro Fuzzy Inference Systems (ANFIS), one of the powerful tools in pattern classification is used. Its main idea of ANFIS is a hybrid learning algorithm used for membership function parameters. The eye detection problem is an uncertain problem which may involve uncertain parameters. Using the set of uncertain parameters may degrade performance due to instability.

Finally, Eye position determination using Eye Probability Map (EPM) is done to determine the eye position in the facial image. It is necessary to determine the real positions of eyes from the verified eye regions. To determine the eye positions, an eye probability map (EPM). Therefore, experimental results show that this method achieves both high detection accuracy and fast computation speed in eye detection.

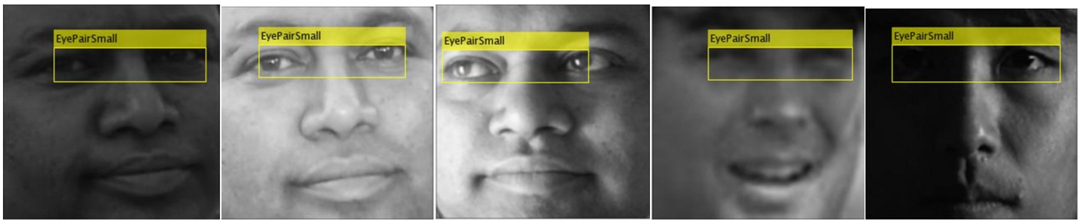

Fig. 3 Eye Localization Results with three Databases: RealDB, LFW, CMU-PIE respectively from left to right.

VI. EXPERIMENTAL RESULTS

Experiment of Human eye localization using various real time images instead of using the images taken under certain constraints where images are taken in a specific constant ambiance. The proposed method is implemented in MATLAB R2013a, and all the experiments are conducted on a PC running Windows XP with Pentium IV and 3 G RAM. Notice that facial images with glasses are not included evaluating performance. Here, the successful detection means that the eye positions located in the facial images. It can be observed that the proposed method achieves demonstrable eye detection results even in facial images with cast shadows and drastic lighting change. The experimental results show that our method has obvious advantages in accuracy and reduced time complexity especially under complex illumination conditions. This is done using the method of ANFIS classifier using three face databases: Real Database, LFW facial database [6], CMU-PIE Databases [14]. A Total of 257 images are used in demonstrating the experiment. With using 47 images from Real Databases, 166 CMU-PIE images and 44 images from LFW database.

The comparison is made with the eye detection done using SVM along with Edge Histogram Descriptors (EHD) in [3] with eye detection using Feature extraction followed by ANFIS. Time Complexity is one of parameter used in classification of performance between two methods as given in Table 2. Another parameter used is Reliability measure as shown in Table 3 done based on the number of correct detection and wrong detection. That is identifying the ability to do the work correctly gives a description about its performance.

TABLE II
TIME COMPLEXITY COMPARISON

DATABASES	IN + EHD + SVM	IN + FE + ANFIS
CMU-PIE	0.1502	0.1672
LFW	0.2179	0.1833
Real DB	0.1783	0.1512
AVERAGE	**0.1795**	**0.1672**

TABLE III
RELIABILITY OF VARIOUS SYSTEMS IN EYE DETECTION

METHODS	CMU-PIE	LFW	Real DB
IN + EHD + SVM	0.9013	0.8621	0.8723
IN + FE + ANFIS	0.9819	0.9318	0.8932

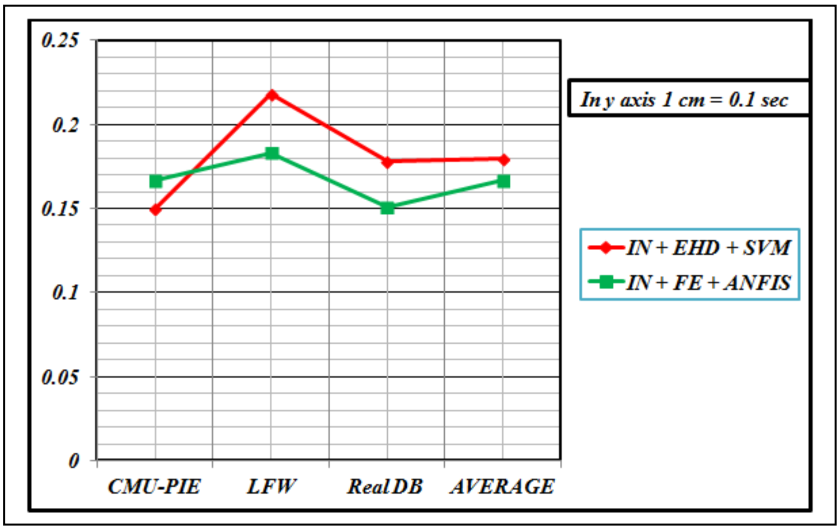

Fig. 4 Comparison graph denoting Table 2 with X axis denoting databases used and Y axis Time Complexity in seconds.

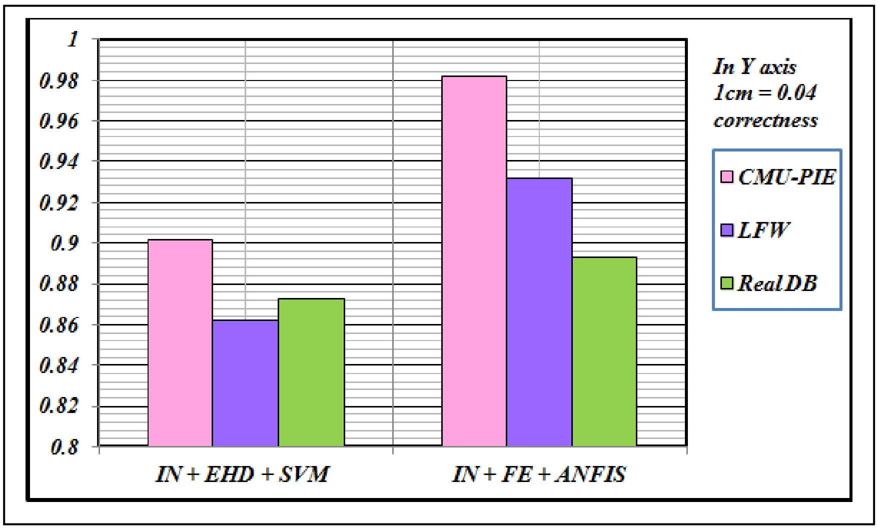

Fig. 5 Comparison graph denoting Table 3 with X axis denoting method used and Y axis reliability measure.

VII. Conclusions

A schema for eye Localization under varying lighting ambiance is been proposed. To achieve this eye position localization under different lighting conditions, the proposed method employs illumination normalization based on the retinex theory followed by feature extraction using Gabor filter, eye verification by ANFIS, and EPM based eye position determination. Due to the illumination normalization, this schema consistently achieves demonstrable results even in extremely bad illumination conditions. This schema greatly improves the computation time because of the feature extraction as pre-processing. Experimental results demonstrate the superiority of this method in terms of both reduced time complexity and efficiency in eye localization. The experimental results are reported in detail, thereby confirming that the proposed method can be effectively employed for dealing with the eye detection problem.

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