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Multi-View Algorithm for Face, Eyes and Eye State Detection in Human Image- Study Paper

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ABSTRACT
For fatigue detection such as in the application of driver's fatigue monitoring system, the eye state analysis is one of the important and deciding steps to determine the fatigue of driver's eyes. In this study, algorithms for face detection, eye detection and eye state analysis have been studied and presented as well as an efficient algorithm for detection of face, eyes have been proposed. Firstly the efficient algorithm for face detection method has been presented which find the face area in the human images. Then, novel algorithms for detection of eye region and eye state are introduced.
In this paper we propose a multi-view based eye state detection to determine the state of the eye. With the help of skin color model, the algorithm detects the face regions in an YCbCr color model. By applying the skin segmentation which normally separates the skin and non-skin pixels of the images, it detects the face regions of the image under various lighting and noise conditions. Then from these face regions, the eye regions are extracted within those extracted face regions. Our proposed algorithms are fast and robust as there is not pattern match.
Keywords –Image Processing, Skin Detection, Face Detection, Eye detection, Color Models.

I. INTRODUCTION

Human face analysis and detection of human face recognition has been received attention of the researchers during the past decades because of emerging applications such as person identification, video surveillance etc. Similarly the eye detection and eye state detection have been a emerging area of research due to wide variety of the application associated in these research areas such driver's fatigue monitoring system, to analyze the behavior parameters of the drivers to avoid the road accidents.

In current road accidents, loss of attentions of the driver is major reason for it. The driver's loss of attention due to drowsiness or fatigue is one of the major contributors in road accidents. According to National Highway Traffic Safety Administration [1] more than 100,000 crashes per year in United States are caused by drowsy driving.

By detecting the patterns of the faces, one can design an automatic face recognition system which is a first step in face detection, then normalization can be applied to normalize the face images using behavior parameters of the faces such as facial features, eyes and mouth. [3], [4]. Therefore we can say the detection of faces and facial behavior properties is a important and major step in face detection.

In the literatures, there are various approaches have been proposed for solving the problem of face detection [5] and these can be divided into basically two stage framework [6] as shown in the below figure. In the first stage, the face candidates those may contain the face are marked and sent as a feed to verifier state which verify the candidate region of the face. Face verifier is basically a validations module which validates the candidates regions of the face which will determine whether the candidate regions are the part of the face or not. Face detection and selection of candidate regions of the images is major research area in past which is the core components of the face detection.

There are several approaches have been proposed and discussed over the past decade for improvement in human face detection which are broadly categorized into two main categories known as knowledge based methods and machine learning based approaches also known as feature based approaches. Those human face features are describing the human faces. The model known as statistical model is usually developed for describing the relations among these human face features. In machine learning based approaches, the descriptions of these attributed and relationships among them is more useful in terms of human face detection.

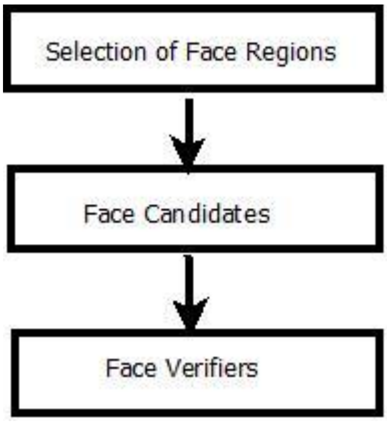

Figure 1: Face Detection framework

And for eye detection, there are many eye detection methods have been proposed and implemented during last two decades. Broadly these proposed approaches can be classified into two categories:

- Passive Approaches also known as Image Baaed Approaches
- Active Approaches also known as Infrared based approaches

Then further the image-based method is partitioned into three major approaches:

- Template-based [7, 8],
- Feature-based [9.10]
- Appearance-based [11, 12].

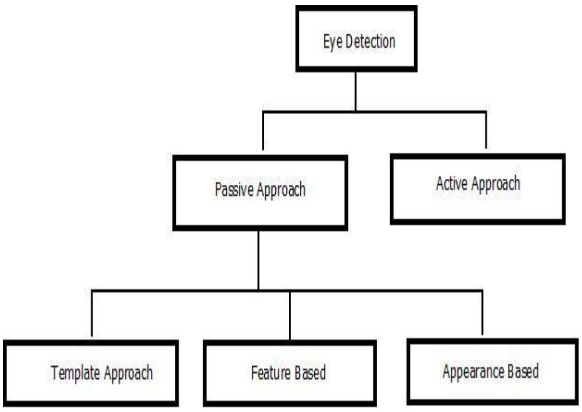

Figure 2: Eye Detection Approaches

In template based stated above, the eye model which is generic is designed, and then template matching is used to search the image for eyes. In terms of performance of this approach, it is very time consuming as it matches the whole image for eye regions. Here the detection of eye regions depend upon the model creation based on the shape of eye shape. The template is created for matching for the eye region in the whole image.

In case of the feature based approach, the behavior of the eyes to determination of some distinctive features around the eyes. However, eyebrow and face orientation may also degrade the performance of the discriminative function, since the performance of distinct features depends upon the candidate eye window detection.

In case of the appearance-based methods, the detection of eyes is based on their photometric appearance. In appearance based approach, there is usually requirement of large amount of training data which represent the eyes of different properties, under various and different facial structures, face orientations. The classifier based on machine learning algorithms such as support vector machine, Neural Networks etc has been trained with these types of data set. We can summarize the things like the above three methods extract the eye by selecting the eye regions under different appearances and geometric structure from the rest of the face.

The special features of eye such as dark pupil, white sclera, circular iris, eye corners, eye shape etc. are utilized to distinguish the human eye from other objects. However, because of changing of lighting conditions and face pose, these differences will be too trivial to distinguish. Particularly, illumination variations in eye detection applications could be greatly sensitive. In some applications, Hough transform is used to detect eye regions in face images [13]. Hough transform needs high computations, so it is time consuming; consequently it is not suitable for real time applications. IR-based methods [14, 15] are only restricted to some specific applications since they need the assistance of IR illuminating devices. The former is relatively application independent and more widely used with merit that no extra equipment is needed.

Similar to the facial features in human face detection, eyes can be a one of the most silent and stable features in a human face [16], [17]. The eye detection techniques can be seen in [18]. The main classical methods include the template matching method; eingen space method and Hough transform method [17], [18] as shown in figure 2 below.

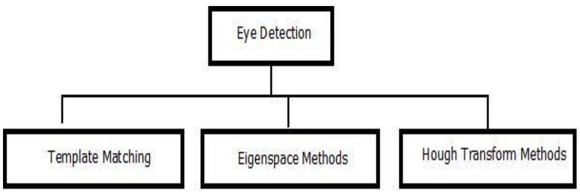

Figure 2: Eye Detection Methods

Along with these three classical methods, there are other techniques proposed in the literatures which are based on images for eye detection. Han et al. [19] uses the morphological operations to locate the eye-pixels in the input image, then the labeling process have been performed to generate eye-analogue segments. Further these segments are being used as a guide to search for potential face regions of the image. Finally a trained back propagation based on the neural network is used to identify faces and their locations. Similar ideas are used by Wu and Zhou [20].

II. BACKGROUND AND RELATED WORK

2.1 Face Detection

In face detection, the skin color of the human images is one of very crucial feature, however different researchers may have different skin color, various literatures have shown that major difference lies largely between their intensity rather than their chrominance [21], [22]. Many different color spaces have been employed. Among them one finds: RGB, normalized RGB, HSI, HSV, YCbCr, YES, YUV, CIE Lab [23].

2.1.1 Skin Color Segmentation

With the help skin color segmentation we can separate the skin and non-skin regions of the image. However this depends upon the color models in which we are representing the human image. Therefore the selection of color model is very important in skin segmentation to make it more effective.

Some potential color spaces:

- CIEXYZ
- CIEXYZ
- YCbCr
- YUV
- YIQ

A performance metric that others have used includes the computation of the separability of clusters of skin and non-skin pixels using scatter matrices. Another is to do a histogram comparison of the skin and non-skin pixels after colorspace transformation. The YCbCr colorspace was found to perform very well,

Here is the equation for transforming from RGB to YCbCr.

$$\begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix} = \begin{bmatrix} 16 \\ 128 \\ 128 \end{bmatrix} + \begin{bmatrix} 65.481 & 128.553 & 24.966 \\ -37.797 & -74.203 & 112 \\ 112 & -93.786 & -18.214 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

And to transform back…

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 0.00456621 & 0 & 0.00625893 \\ 0.00456621 & -0.00153632 & -0.00318811 \\ 0.00456621 & 0.00791071 & 0 \end{bmatrix} \left(\begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix} - \begin{bmatrix} 16 \\ 128 \\ 128 \end{bmatrix} \right)$$

Hit and trial methods were used to find the best skin filter. Attempts were made to retrieve online databases for reference to generalize the skin filter, however it was found that the values that work best were still those derived from the hit and trial method at the loss of generalization.

2.2 Skin Detection

Skin detection is defined as a process of extraction of skin pixels and non-skin pixels in an image or in a video. With the help of skin detector, the pixels of the images are divided into skin and non-skin regions. In computer vision, there are various approaches have been developed for skin detection. A skin detector typically transforms a given pixel into an appropriate color space and then uses a skin classifier to label the pixel whether it is a skin or a non-skin pixel.

In any given color space, skin color occupies a part of such a space, which might be a compactor large region in the space. Such region is usually called the skin color cluster. A skin classifier is a one-class or two-class classification problem. A given pixel is classified and labeled whether it is a skin or a non-skin given a model of the skin color cluster in a given color space. In the context of skin classification, true positives are skin pixels that the classifier correctly labels as skin. True negatives are non-skin pixels that the classifier correctly labels as non-skin. Any classifier makes errors: it can wrongly label a non-skin pixel as skin or a skin pixel as a non-skin. The former type of errors is referred to as false positives (false detections) while the later is false negatives. A good classifier should have low false positive and false negative rates. As in any classification problem, there is a tradeoff between false positives and false negatives. The more loose the class boundary, the less the false negatives and the more the false positives.

2.3 Eye Detection

In [24] and [25], eyes are detected based on the assumption that they are darker than other part of the face. Han at al. [25] use morphological operations to locate eye-analogue segments, while Wu and Zhou [24] find eye-analogue segments searching small patches in the input image that are roughly as large as an eye and are darker than their neighborhoods.

For eye detection, there are four methods are used which include Viola-Jones eyes detector, the algorithm described by Valenti and Gevers [18], the approach proposed by Timm and Barth [19], and feature extractor by Ribarić, Lovrenčić, and Pavešič [3].

2.4 Eye State Detection

For eye state detection, the method of [Sirohey, S., Rosenfeld, A., Duric, Z.: 'A method of detecting and tracking irises and eyelids in video', Pattern Recognit., 2001, 9,44444444444pp. 1389–1401] uses the distance between two eyelids. For a person being able to see, the upper eyelid should not cover the pupil. Thus, if the distance between the two eyelids is less than the iris radius, the eye is closed. However, this method is very sensitive to pupil centre location. In [1], eye property in saturation channel of HSI colour space is utilized for eye state detection. This property is used to extract iris region from skin region in iris circle. After choosing threshold value and creating binary image of iris circle, eye state is set to open if the number of white pixels in iris circle is more than the black pixels.

III. PROPOSED ALGORITHMS FOR FACE, EYE AND EYE STATE DETECTION

During the study and research we have found that there is no specific efficient model for face detection, eye-region detection and eye state detection methods. Academically, many researchers have worked in the field of face detection, eye detection and eye state analysis (open/closed) separately, but in a composite research and to determine the eye state analysis based on the facial features and eye regions, there is no efficient approach for it for public research.

Research in the determination of eye state (open/closed) is growing very fast these days. In the past, the face-detection algorithms are focused on the detection of frontal human faces, whereas in the current trends, the algorithms are more towards to solve the more general and difficult problem of multi-view face detection. In this paper, we aim to determine eye state (open or closed), for this purpose, we first need to detect face region, then we find eyes and after that, we detect eye state. Based on the region selection of human faces, here we propose the efficient face, eye and eye state detection algorithms. Based on facial behavior analysis, the facial regions of the image is being extracted which is a optimal face region of the human image. Briefly following are the steps followed in algorithm implementation:

1. Start.
    a. Input Image.
    b. Binary Image Conversion in a particular color model.
    c. Face region selection
    d. Eye region selection
    e. Left and right eye region selection
    f. Eye state determination.
2. End.

As stated, Face detection and eye detection can be considered as a specific case of object-class detection. In terms of object class detection, the objective is to find the location and size of the specific object in a image. Computer vision is a field that includes methods for acquiring, processing, analyzing, and understanding images.

The Computer Vision has been described as the processes and representations of vision perceptions. Computer vision covers the core technology of automated image analysis which is used in many fields. "Scientifically, the computer vision is mainly concerned with the artificial system that extracts the information from human images. The computer vision is a field which acquires, process, and extracts the important features of the images. The human image data can take multiple forms in terms of video sequences, views in the form of multiple cameras. To simulate the images, the computer mainly breaks down the images into constituents, such as light and shadow, edges and fields.

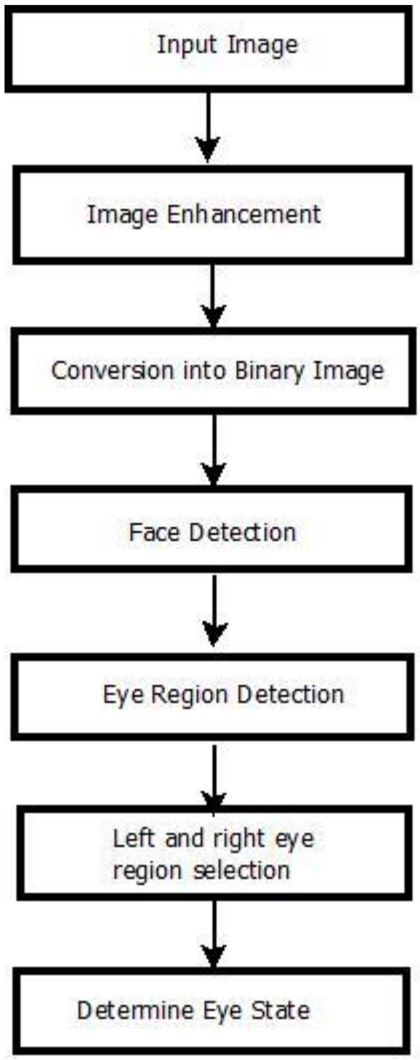

Figure 3: Block Diagram of proposed algorithm.

As shown in the above block diagram, the first step is image input, here in this research input image we are taking from various sources such as open database. Then the image is being converted into binary image using the color models which are further processed for region selection related to face, eyes. The selected eye regions are being the deciding parameters for the selection and determination of eye states.

IV. Conclusion

Here in this paper, we try to present our research for eye state analysis and detection of eye states which would be helpful in the applications such drive's fatigue monitoring system, determination of eye state of human image. During this, face detection based on human facial features and eye detection for determination of eye regions is presented which lead us to eye state determinations. We also try to present the research presented in the literatures for eye state detection and found that there is no efficient algorithm till now for eye state detection. Then based on the study, we presented algorithms for face, eye and eye state detection. This is initial research which we will take forward to detection of eye state in optimal way.

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