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Combined Approach for Face Detection, Eye Region Detection and Eye State Analysis- Extended Paper

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Abstract:- Computer vision is a subject which process, understand and analyse the human images and produce the output in terms of some symbolic values in the form of decisions. In computer vision, the multi-view analysis of face is currently an active research which helps in many applications such as driver's fatigue monitoring system, surveillance system. The determination of eye sate and tracking the status of eyes of the driver which help in avoidance of many road accidents. Here in this paper, we propose combined approach for face detection, eye detection and determination of eye state based on the conditional values of the number of white pixels lies in the human eyes after the selection of upper 60% of the image and then the eye regions, and finally the state of the eyes is determined whether it is closed or open. During the implementations, we discuss and present the various modules of the system. Based on the implementation of the algorithms we are successfully able to determine the state of the eyes of the human image. Therefore we can say that our algorithmic implementation of the combined approach of detection is accurate and working properly. For the implementation, we have chosen the YCbCr color model for image representation.

Keywords:- Computer Vision, Digital Image Processing, Face Detection, MATLAB, Data Structure, Eye Detection

I. INTRODUCTION

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

Face detection and eye detection are active research area since the last few decades which is highly oriented as specific case of object class detection. Early algorithms were majorly focused on the detection of frontal human faces, but newer algorithms are more towards to solve the problem by using the multi-view face detection algorithms. That is, face detection is basically the detection of human face by rejection of illuminations or background effect in the human images. The current newer algorithms are more accurate which takes into considerations of variations of image by multiple factors such as face appearance, lighting, and pose.

A computer vision is subject or field which includes methods for processing and understandings of the images and produces the numerical or symbolic information in the form of decisions. Moreover the processing the human images electronically by the computer, analyse the image, and produce the output. It can be defined in another way, Computer vision is a technology which perform the automated image analysis and produce the output after processing of those images. Scientifically, computer vision is a theory behind artificial systems that basically process the images and extract the useful information from the images. The data input here is the set of human images which can be taken in many forms, such as video sequences, views from multiple cameras, or multi-dimensional data from a medical scanner". The computers used in computer vision systems include a high end technology, which involves fast processors, high storage capacity and ability to simulate or execute the image processing and understanding algorithms.

On the basis of these face detection algorithms the next steps are being taken in this field as major research areas. These detection methods had facilitated the society with new applications for security like detection of fatigue, biometric passwords, etc. Detection of fatigue for drivers while driving in this project is taken as major issue. This detection will be performed by firstly finding the face in the image, then eyes in the face and then finally analyzing the eyes. Analysis will involve calculation of distance between eyelid and pupil of eye; if distance is less than a threshold value then the driver will be considered sleeping.

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.

II. PROPOSED SYSTEM AND ALGORITHMS

Here we present the proposed system design and algorithm implemented during this research.

A. *System Design*

Here we discuss the system architecture of the system which we have implemented during the course of the research implementations. The following figure 2 depicts the modules involved in the complete system design.

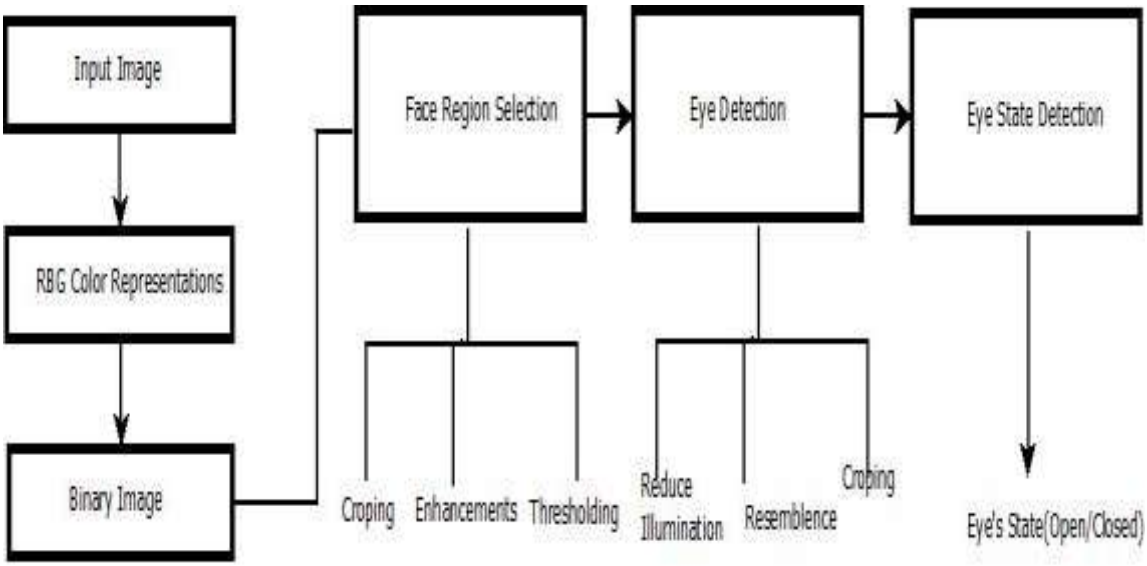


Fig 1: Block Diagram for entire face, eye and eye-state detection

In the scope of the implementations, the followings are various modules of the system. Here we present the novel algorithm which detects the eye states based on hybrid approach of face region selection and eye region selection. The regions selection of human face and eyes is performed basically by using the color representations and thresolding

a. Image Representation and Conversion

Here in this module, the input image in the form of the human image is being represented in the particular color model. The gray scale image is represented into the YCbCr color model.

b. Face Region Selection

For accurate eye detection, the image should be in the form of face area which is completely isolated from background effects such as illuminations, light effects etc. The characteristics of face skin of different humans are almost similar. Here in this module, the face region is selected by rejecting the non-pixels of the image and retains only the pixels related to the face only. The binary image presented into color model is being submitted to this module which selects the face regions of the image.

Face Region Selection:

- Original Image
- Enhance of image by increasing the brightness of the image
- Representation of original image in color model
- Skin portion selection
- Binary Image
  - Black and white image
- Fill the connected components of the image
- Image with face in rectangle shape

c. Eye Detection

As shown, after the selection of face region, and face are detection, next step is detection of eye regions. Eye detection is one of the important steps to determine the eye state of the human image. Therefore the accurate eye region selection is very important which should provide the enough and sufficient information for fatigue detection by analyzing the state of the eyes such close or open states. Following are the general steps of the eye detection algorithm:

1. Original Image
2. Image enhancement with 60% upper of face image.
3. Binary Image
4. Eye region candidates
5. Selected left and right eye region.

Following figure 2 depicts the flowchart of the eye detection algorithm:

a. Eye State Detection

Following figure 3 depicts the flowchart of the eye state detection to determine the state of the eye whether the eyes are opens or closed. As shown in the figure, the total numbers of pixels are calculated for both left eye and right eye. Then the no. of white and black pixels is calculated. After this calculation, the white pixels of the eye region are matched with the total no. of pixels which help to determine the state of the eye. If the white pixels are smaller than the total number of pixels then the eye is closed, else the eye is open.

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.

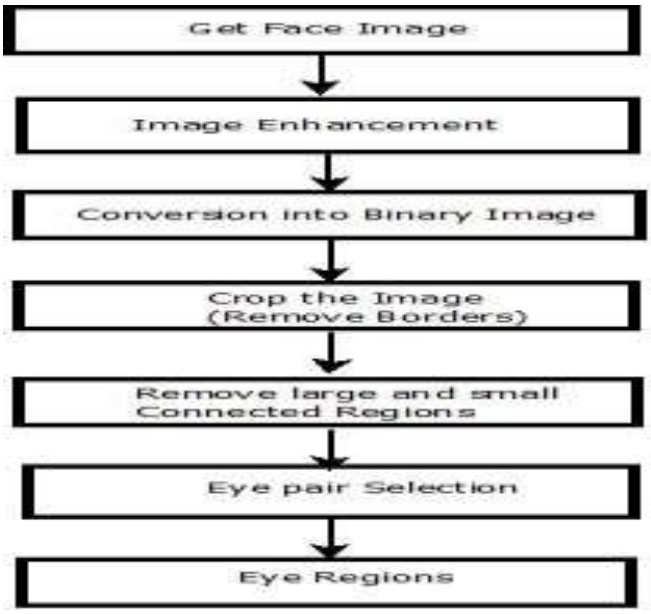


Fig 2: Flowchart for Eye detection

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.

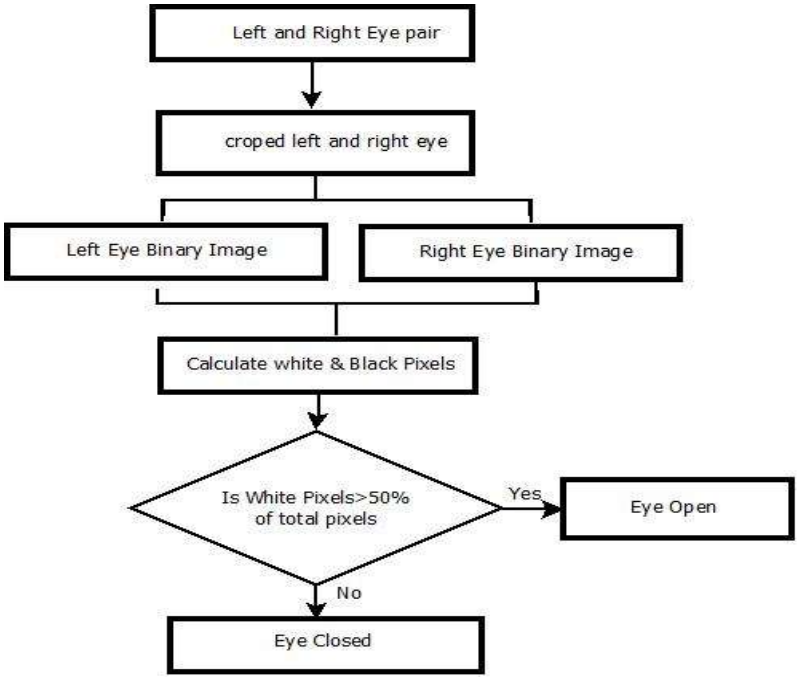


Fig 3: Flowchart for Eye State Detection

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.

III. EXPERIMENTAL RESULTS

A. Results of Simulation

III.A.1 Here we discuss the experimental results; the results are shown as per the phases of the algorithm. Several experiments have been conducted to test the validity of our proposed algorithms with respect to various modules of the system such as face detection, eye detection and then eye state analysis. As discussed, first phase of the implementation is face detection which face region selection in human images, then the eye detection and finally the eye state detection to determine whether the eyes are open or closed.

Tools and Techniques Used:

MATLAB software is used during the course of implementation to implement the face detection, eye detection and eye state analysis of the human image.

III.A.1.1 Results of Face Detection Algorithm

- ***Original Image-*** The original image shown in figure 4 is the image from which face is needed to be detected. This image can be acquired by any camera and later stored in the system so that it may be retrieved for analysis purpose.

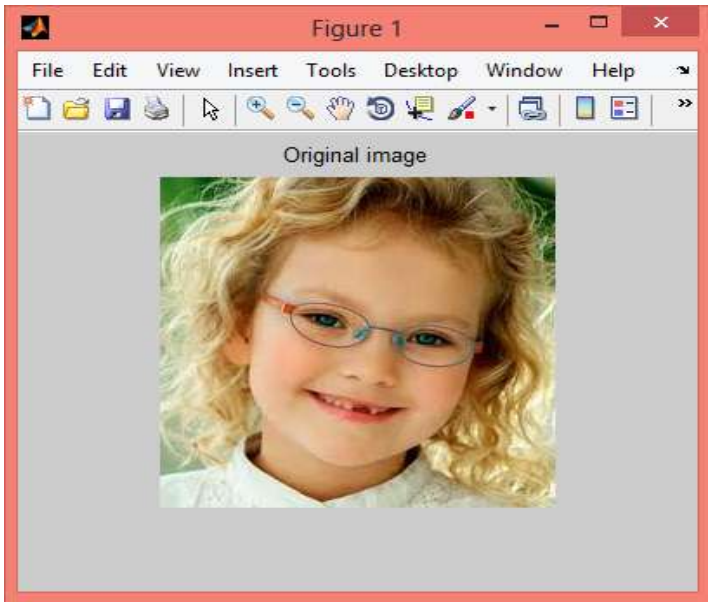


Fig.4. Original Image

- ***Enhanced Image:*** When the original image is obtained it is first enhanced so that face may be easily detected from the image. For the enhancement of image, its brightness is enhanced by preserving rest of the image components as shown in figure 5.

- ***Binary Image:*** Then from the enhanced image skin portion is detected using YCbCr model and then the final obtained image is converted in to binary image. Binary image is an image having only two colors that is white and black as shown in figure 6.

Fig 5. Enhanced Image for face detection

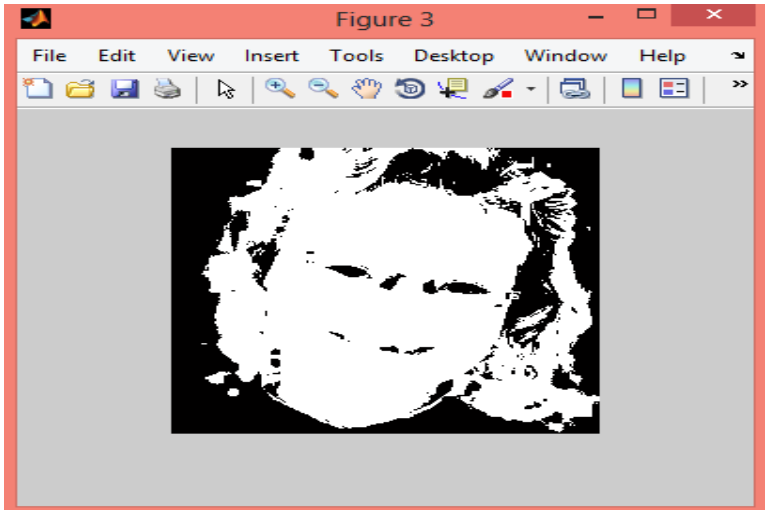


Fig 6. Binary Image for face detection

- **Image after filling holes (Connected Components)**: Then the connected components of the images are found by filling the holes in the image. This step finds the candidate face regions in the image as shown in figure 7.

- ***Final Image with detected face:*** After the filling of holes an image with clear connected regions are formed in figure 8. The obtained regions are compared to the specified range to find whether it is face or some small part. The finally an image with detected face shown with the help of bounded rectangle is obtained.

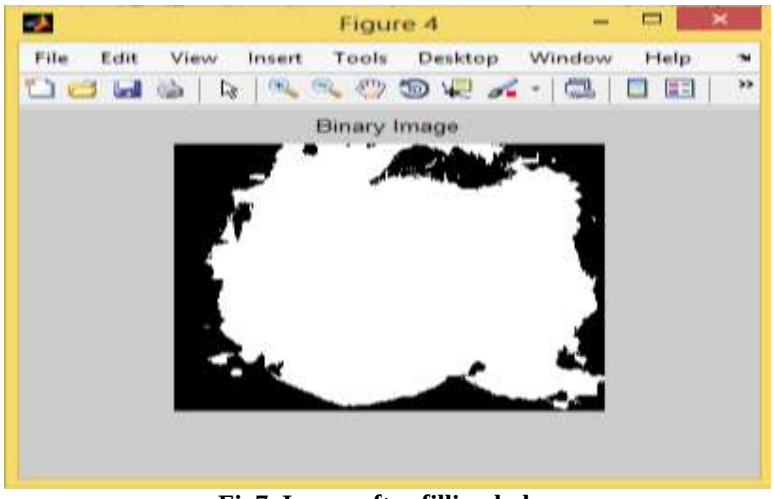


Fig7. Image after filling holes

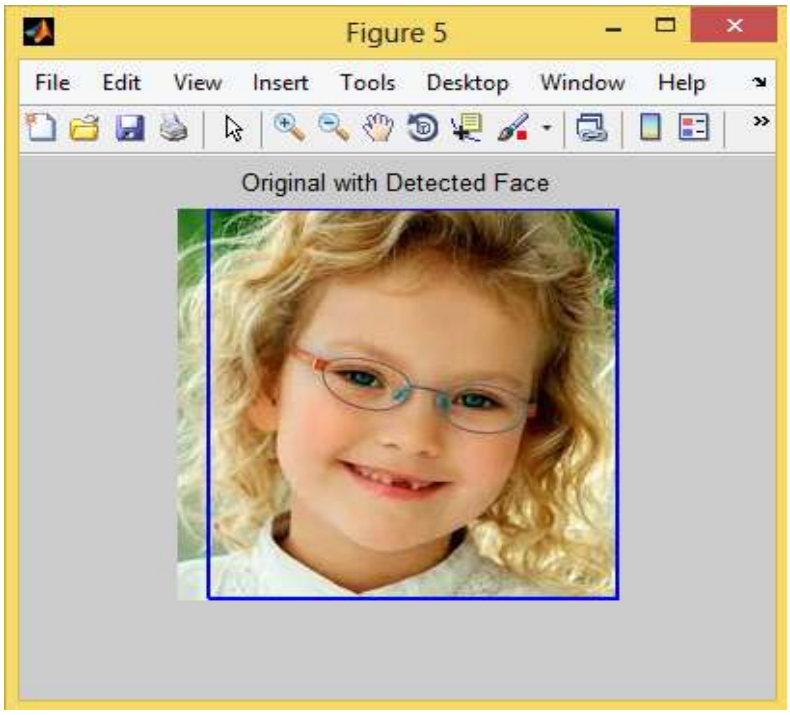


Fig 8. Detected Face Image

III.A.1.2 Results of Eye Detection Algorithm

- **Extracted Face region of Image** (figure 9): Firstly the face image is extracted from the original image. This is done by cropping the face region obtained from the original image.
- **Upper portion of face (40% of face region cropped):** Then the upper portion of the face is cropped from the extracted face image. This is done to speed up the detection speed of the algorithm. In general eyes are located in the upper portion of the face hence the lower 40% portion which is unwanted is removed from the image as shown in figure 10.
- ***Enhanced Image (figure 11):*** Then enhancement of the image is performed. In order to reduce the illumination in the image, intensity of the image is enhanced. For this image is first converted in to gray scale and then intensity enhancement function is applied on the image.

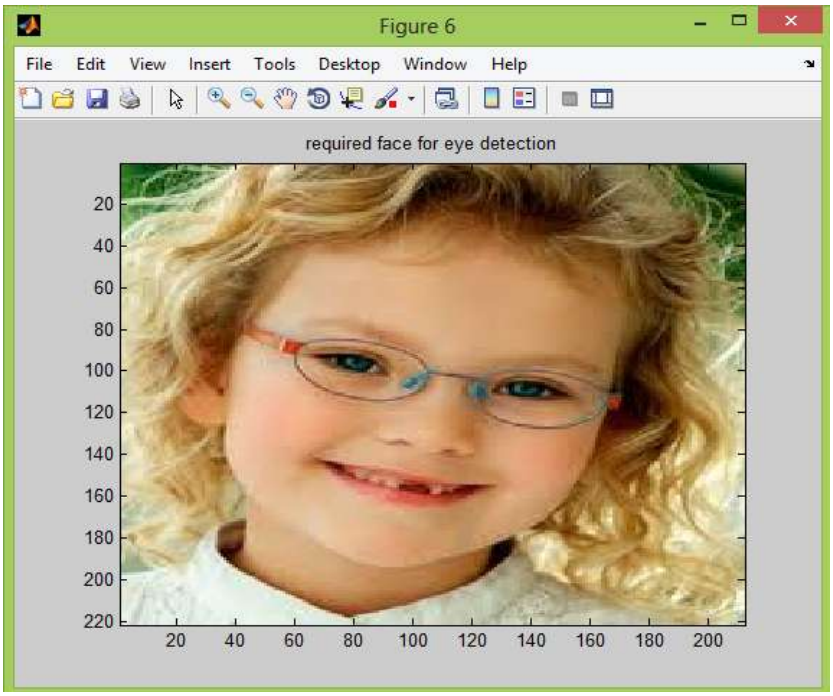


Fig 9. Extracted region for Eye detection

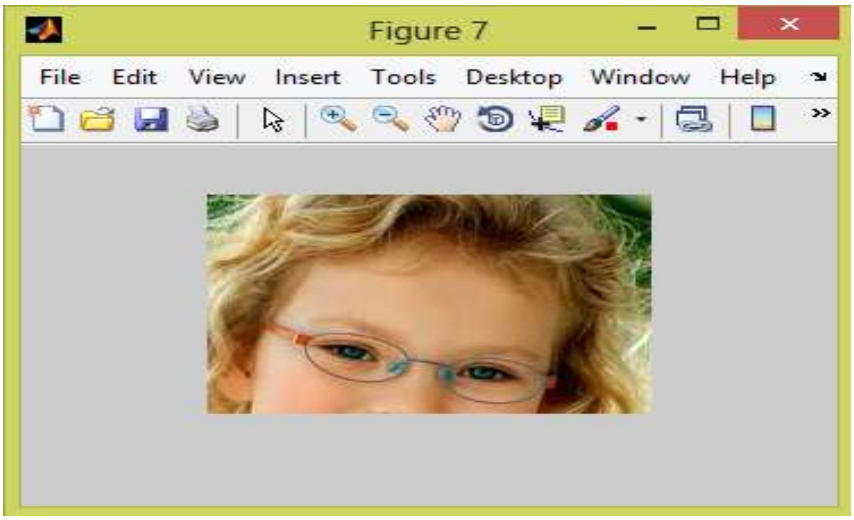


Fig 10. Upper portion of the face for eye detection

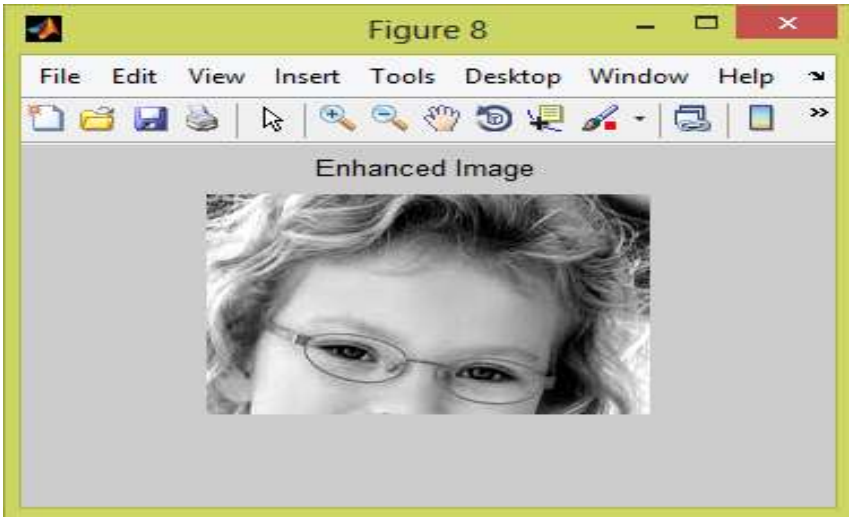


Fig 11 Enhanced Image for Eye detection

- ***Detected regions resembling eye (figure 12)***: After enhancement of the image the candidate regions for the eye in the image are found. The regions in the image showing similarity with the eye region are considered as candidate regions and from these candidate regions eye region in the image is found.

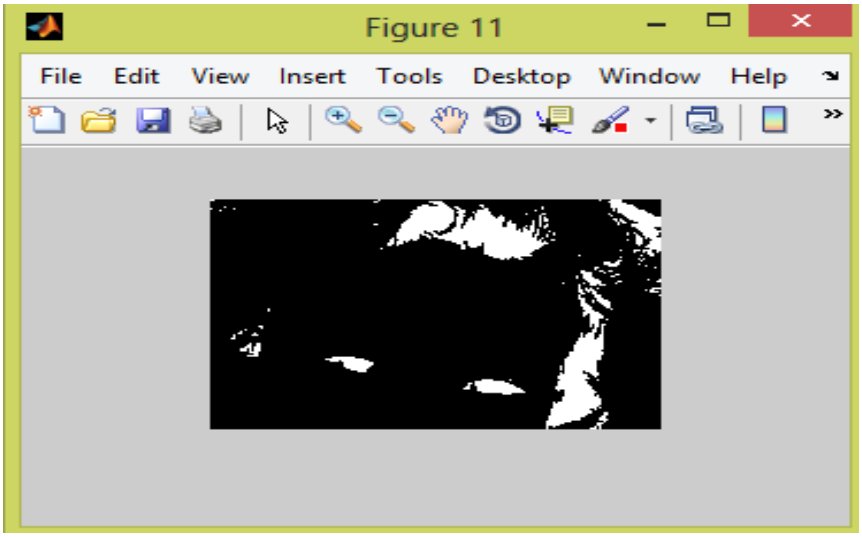


Fig 12 Detected regions of the image

- ***Image after removal of unwanted regions (figure 13)***: After finding the candidate regions in the image the pair matching the criteria for the eye pair is found. That pair is considered as eye region and rest all regions are deleted from the image.

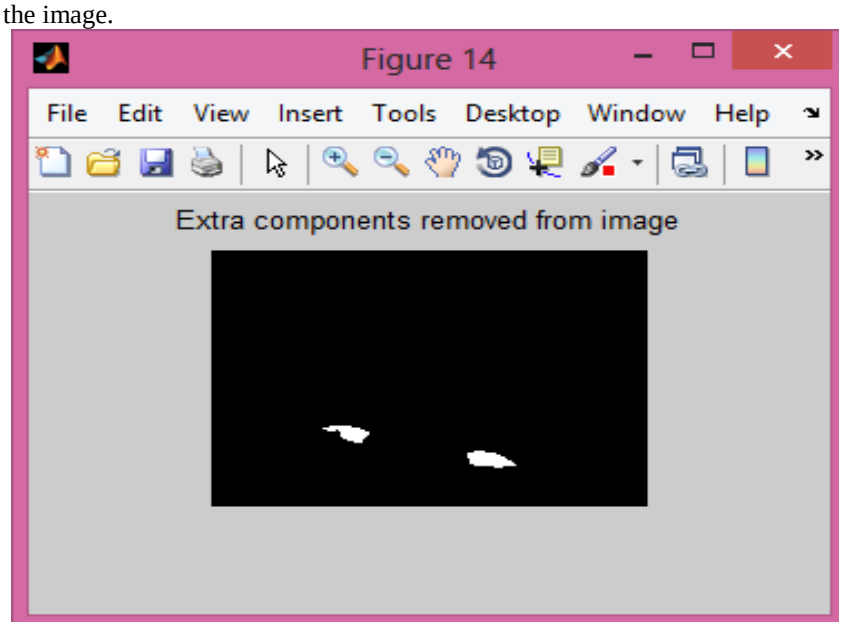


Fig 13 Image after removal of unwanted regions

- ***Final Image with detected eyes (figure 14):*** Then finally image with detected eye regions is obtained. The detected eye regions are bounded with the rectangles in the figure below.

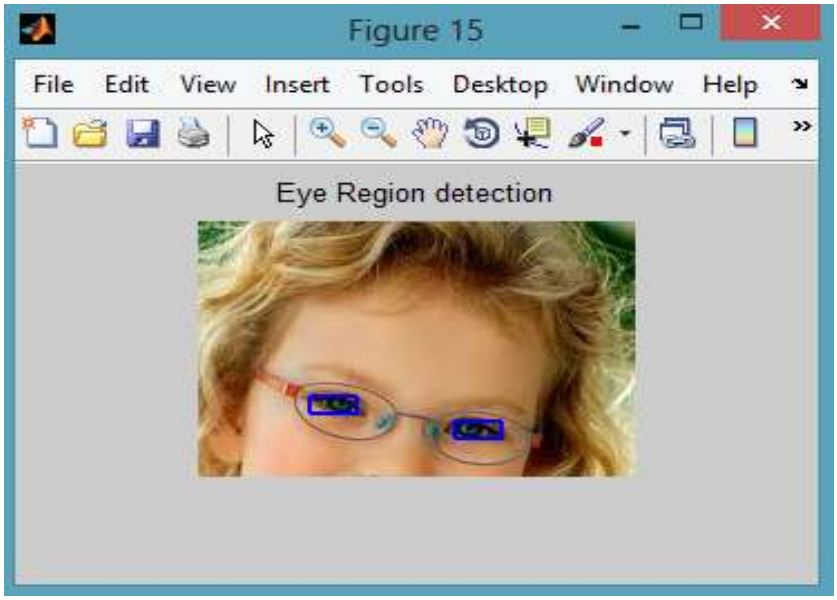


Fig 14. Detected Eyes

III.A.1.3 Results of Eye State Determination Algorithm

- ***Image of Left eye and Right eye:*** After detection of eyes each eye is cropped from the image to perform further operations on them in order to analyze their state. Cropped left and right eye images are shown below as shown in figure 15 and figure 16.

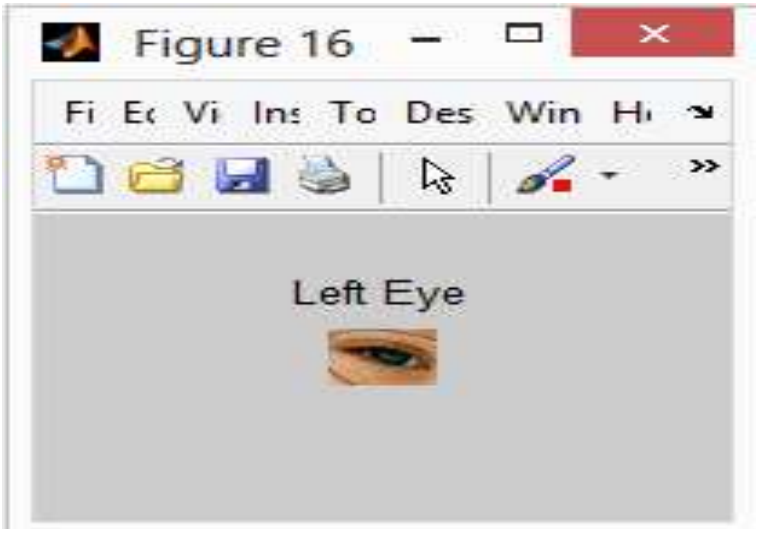


Fig 15. Cropped Image of left eye

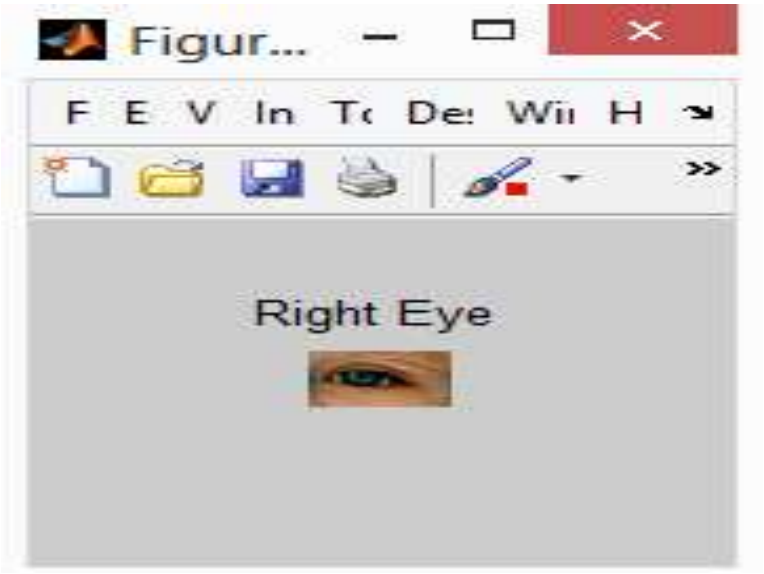
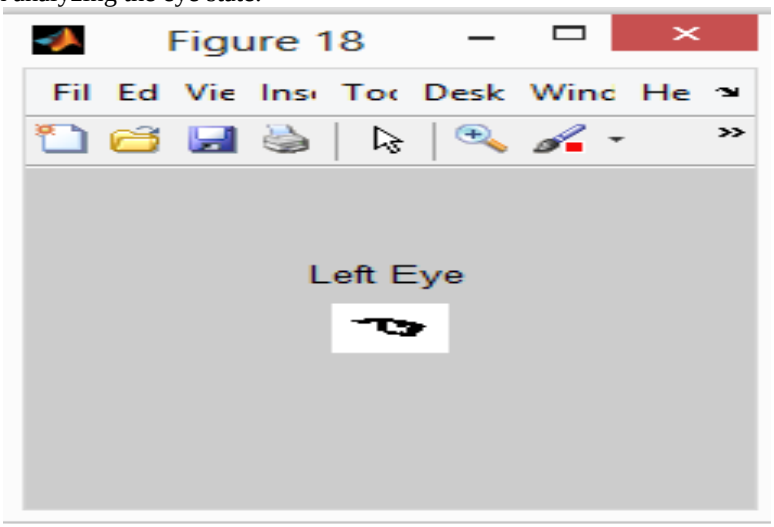


Fig 16. Cropped right eye image

- ***Converted Images of Eyes (figure 17)***: Then both the cropped eye images are enhanced and are converted so as to determine number of white pixels and black pixels in the eye region. Calculation of these pixels further help in analyzing the eye state.



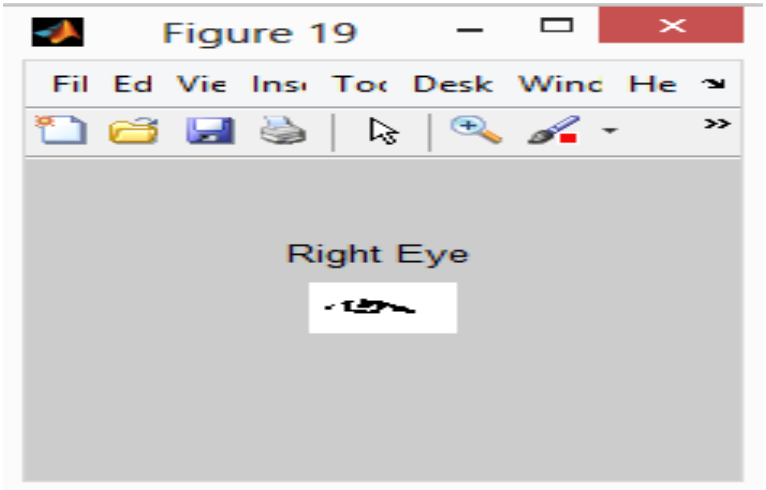


Fig 17. Converted Images of left and right eye

- ***Eye Analysis Result*** (figure 18) In the end on the basis of evaluated number of pixels in the image eye state is detected. If the number of white pixels in the eye region are more than half of the total number of pixels then the eyes in the image are open otherwise eye is detected as closed.

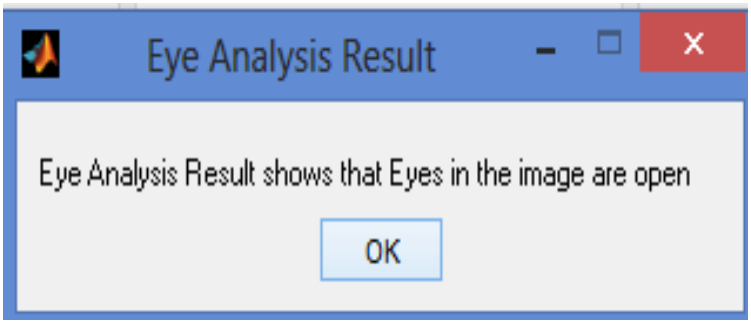


Fig 18. Eye analysis result

IV. CONCLUSIONS

In this paper, we 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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