IJREAT International Journal of Research in Engineering & Advanced Technology, Volume 9, Issue 2, April- May, 2021
ISSN: 2320 – 8791 (Impact Factor: 2.317)
www.ijreat.org

Coma Patients Eye Blink Detection

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Abstract

Coma is a state of unconsciousness where the person is totally insensitive to oneself and also the outside surroundings, thereby incapable to react definitively to the external stimuli. This may occur due to a difficulty of an underlying sickness, which may be an outcome of injuries that are caused due to accidents, such as head trauma and various other reasons like a disease or infection, intoxication which affects the central nervous system. Coma patients are treated on a universal scale called Glasgow Coma Scale (GCS). Unconscious patients are challenging to manage and a systematic team approach is required. Thereby keen monitoring of them is required which is difficult to achieve. This project helps in treating a coma patient based on one important factor of GSC that is eye movement. Eye movements can be helpful in assessing an unconscious patient by calculating the Eye aspect ratio (EAR). The Openness of eye i.e. EAR is measured using OpenCV library where the algorithm recognizes the facial features and characteristics. This system gives an alert using the Labview tool to the medical assistant whenever the patient blinks.

Keywords: Coma, Stimuli, trauma, Glasgow Coma Scale, Eye Aspect Ratio, OpenCV library, LabVIEW.

I. INTRODUCTION

There are many accidents taking place in and around the world. According to a survey, the most critical accidents are related to head injury. It is one of the important issues in general health injuries, considering the need of intensive medical care and long term rehabilitation. Most of the head injuries don't lead to death while at times they put the person in a prolonged state called coma. It is a state of unconsciousness which might occur due to a result of some traumatic accident such as medical condition or a blow to the head. The coma patients are assisted to take immense care to determine the health status of the patient. Although there are some departments in the hospitals where caretakers monitor, observe and record the eventual progress data of a patient. This is quite time consuming and also might miss the minute attention that should given to the patient resulting in lot of errors and burden on the medical assistant.

There are many devices in the hospital which may give information regarding the observation of the coma patient but there is a necessity to observe even the smallest possible movements and activities which cannot be done by the regular devices. Considering these problems we have designed a project which deals with eye blink mechanism. We have used a Raspberry PI which finds the difference between the eye positions

The eye blink monitoring is one such idea that tracks the patient's eye movement by analyzing Eye Aspect Ratio (EAR). Using a camera, Real-time patient observation is performed and an alert is sent to the concerned person and caretaker. The Raspberry Pi connected to an USB camera is used for measuring the eye movement by using an algorithm which recognizes the facial features and characteristics. Later using the detection, the Eye aspect ratio is compared and the Raspberry Pi sends the signal to the LabVIEW, which is a graphical programming language tool to give an alert message to the concerned person whenever the patient blinks his/her eyes. This eye blink tracking is potentially a simple and low-cost effective solution that can be used for measuring real-time patient monitoring.

II. LITERATURE SURVEY

The author Naveen Kansal et al. [1] has proposed a paper titled "Advanced Coma Patient Monitoring System" which uses image processing techniques like pattern recognition and pattern rejection algorithms using MATLAB software.

The author Malika et al. [2] has proposed an "Indoor Wireless Zigbee based Patient Monitoring system for Hospitals". This system consists of four sensors which are temperature sensor to check the body temperature of the patient, humidity sensor used for measurement of moisture, PIR sensor which is used for sensing the movement of the patient and a smoke sensor which are connected to the patient's body wirelessly. These sensors are also connected to the transmitter which later gives an alert to the doctor.

The author Josphine Leela et al. [3] in the paper titled as "Body Movement and Heart Beat Monitoring For Coma Patient Using IoT" has presented that Flux sensors are fixed in two hands of the patient and Eyeball sensor is fixed in the patient's eye when there is any movement in hands or the eye these sensors send the information to the doctors by wireless communication using IOT.

The author Navya et al. [4] has developed a "Zigbee based wireless sensor-based network for patient health monitoring". This system comprises of various sensors like the heartbeat sensor, MEMS sensor, body temperature sensor, saline level sensor and the obtained results are sent via Zigbee.

The author Dhaval Pimplaskar et al. [5] have proposed a system titled "Real Time Eye Blinking Detection and Tracking Using Opencv". This paper uses centroid analysis technique to determine the eye position.

The author Chopade et al. [6] has proposed a paper on "Remote patient health monitoring system using Zigbee protocol". This is used to monitor patient who require continuous health supervision. It is done using temperature and heartbeat sensor where these values are transmitted using ATMEGA and the Zigbee unit.

The author Chen et al. [7] has developed a "Wearable inertial sensor for human motion analysis to continuous track motions and positions of ageing people". This system consists of inertial measuring unit such as a MEMS sensor for motion tracking.

The author AlSharqi et al. [8] has developed a "System for monitoring the health condition of elderly people". This system consists of heart rate sensor, pulse sensor, ECG sensor and Muscle sensor and a local monitoring PC and Zigbee transmitter and receiver.

III. PROPOSED SYSTEM

This project is implemented based on the principle of OpenCV's HOG based algorithm. This project can also be used for Driver Drowsiness by only reversing the greater than symbol of the Eye Aspect Ratio. The system comprises of individual components like Raspberry PI, camera, SD card and monitor. The Raspberry PI which is a quad-core processor is interfaced with USB webcam and the monitoring unit. Firstly, the camera module will start to capture the video frame. Then using Histogram Oriented Gradients (HOG) algorithm a rectangular box is drawn around the face. The dlib facial landmark predictor is used to mark the 68 salient points on the face which can help in differentiating the facial features like eyes, nose, jaw line and mouth. The 68 indexes are converted into (x, y) coordinates using a NumPy array. The coordinates of both the eyes are which help to check if the eyes are open or not. The Image pre-processing is done using the python code with the help of OpenCV After the image acquisition is done by the Raspberry PI. The processed image is compared with the actual image to check if there is any variation. In case of any variation there is a buzzer alarm and an alert is sent to the medical assistant through LabVIEW.

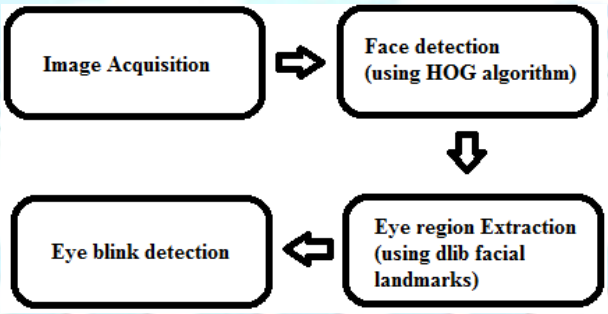


Figure 1 : System flow

IV. FIRMWARE IMPLEMENTATION

- Flowchart

Image Acquisition is done by the mini-computer Raspberry pi connected to a USB Camera. After acquiring the image, using python code in the OpenCV library, processing of the image is done. Now, the dlib library will try to detect the eye and If no eye edge is detected it will again start acquiring again. If the eyes of the person are detected then it again checks for the eye edges and draw an ellipse around them. Using this python code we try to find the blink of an eye by calculating the distance between points marked i.e. calculate the EAR. If any blink is detected i.e., Ear Aspect Ratio (EAR)>0.2 then with the help of the LabVIEW code, email will be sent to the respective guardian of that person.

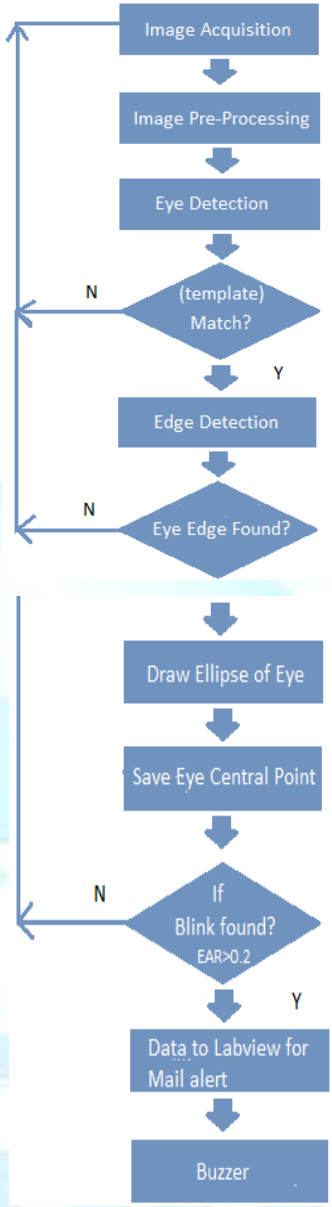


Figure 2: Flowchart of the system

❖ **Eye blink Implementation**

In this section, the detailed project is presented. Follow necessary steps and install *NumPy, dlib, OpenCV, and imutils* on the Raspberry PI for performing the required operations through the terminal or SSH connection. Firstly, The Raspberry PI acquires the image through the USB camera connected to it by using HOG extractor. After the Image acquisition, image preprocessing is done using the OpenCV python code. In this Image preprocessing phase, the image captured is converted into a grayscale to perform further operations. Now, using the Dlib's face landmarks detection technique we can find 68 specific landmarks of the face where a specific index is assigned to each point. The indexes for the eyes should be identified separately; Left eye coordinates: (37,38,39,40,41,42) and right hand coordinates: (43,44,45,46,47,48).

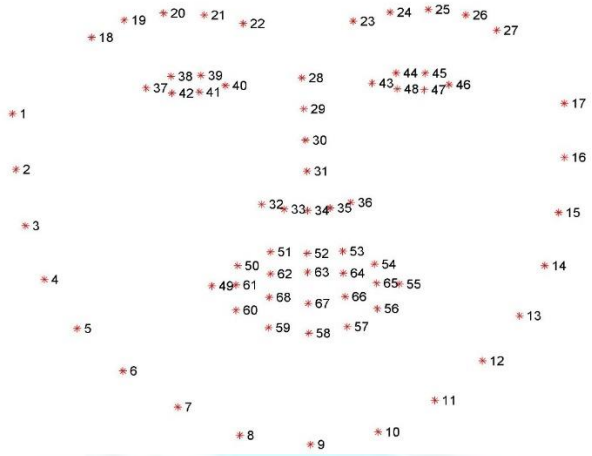


Figure 3: Plotting of 68 facial landmark coordinates

Finding the coordinates of the eye we can find the EAR using the algorithm. Each eye has 6 unique coordinates as shown below.

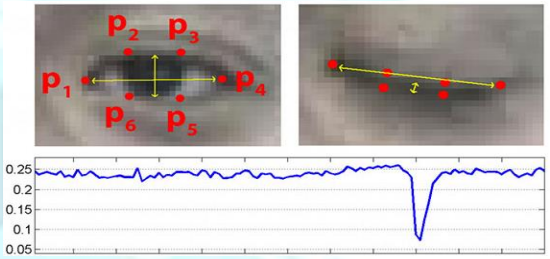


Figure 4: Eye Aspect Ratio

Top-left: Marked Eye landmark coordinates

Top-right: Eye landmark coordinates when

the eye is closed.

Bottom: Graph or eye ratio over period of time.

The lower peak of EAR indicates a blink.

The 6 coordinates are marked on the eye in clockwise direction as shown above. The linear distance between the two point's i.e.p1 and p4 are estimated using the popular method called the Euclidean distance which is available in the NumPy library of the python. Equation (1) is formula for EAR which is mentioned below. The numerator is used for calculating the vertical distances and denominator is used for calculating the horizontal distance. This formula is used for checking if the eyes are open or closed. This is one of the easy method to find the eyes are closed or not while other methods require more power for processing.

$$\mathbf{EAR} = \frac{||p2 - p6|| + ||p3 - p5||}{2||p1 - p4||} \quad (1)$$

Eye Aspect Ratio Equation

In Real Time Eye Detection and Tracking Method for Driver Assistance System proposed by Ghosh says that the eyes are open if there is a bright light on the pupils. This bright light is produced when the eyes are exposed to IR rays and thus reflect the light and produce a bright pupil. If there no bright pupils then the eyes are assumed to be closed. For this type of estimation method the processor has to find the pupil accurately thereby reducing the speed of the system. But the calculation of EAR is easy and results in accurate and quick results.

In the figures below, the top left figure show the points plotted on the eye in clockwise. For top-right, the points on a closed eye are shown. Bottom figures show the variation of EAR over a period of time and the peak downwards indicate a

blink. In our case, the EAR is monitored to check if it is increasing and doesn't decrease again which ensures that the patient has opened his eyes.

Follow the algorithm and implement the code. Execute the implemented code and the image of the setup is displayed below. The Eye blink detection program is run on the Raspberry Pi using the HOG and dlib facial landmark detector.

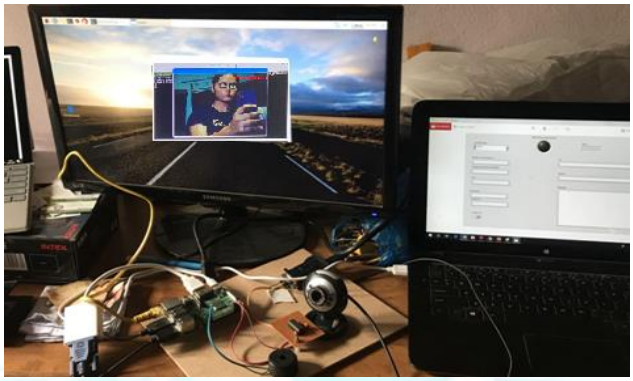


Figure 5: Hardware setup of the system

❖ Implementation of Labview alert mail

The final part is to record the data collected in a file. For this, initially, the file path is created. The collected data from the raspberry pi through a serial data transmitter is converted to a number from a decimal string. A file is made to create/open and a loop is created so as to save values upon requirement. Write to text file function on LabVIEW is used and written to the source file. In the end, the file is closed. Later on, whenever the patient blinks a Boolean expression is given to the case structure in the LabVIEW to execute true or false condition depending on the signal from the patient.

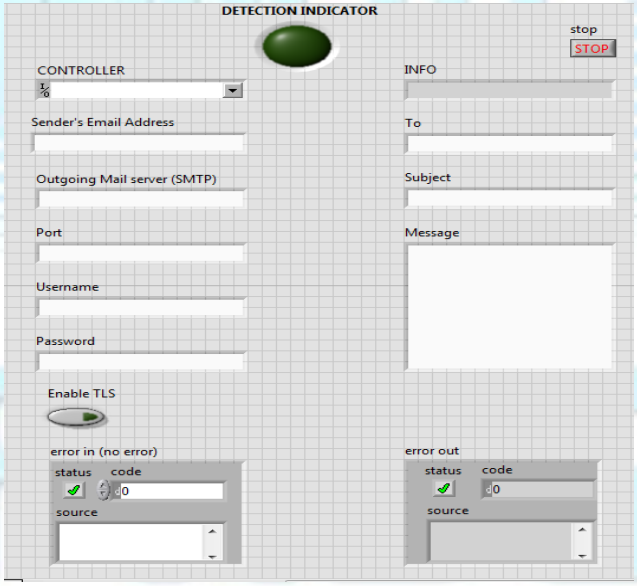


Figure 6: LabVIEW graphical user interface

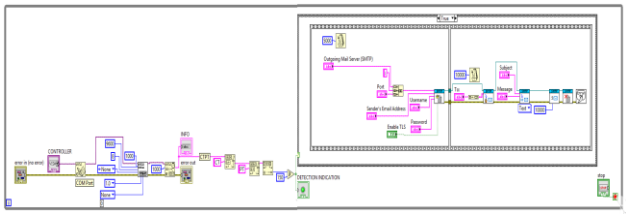


Figure 7: LabVIEW block code (backend code)

An SMPT protocol is created in the LabVIEW using various functions and internet is connected. The mail id, senders mail id, receiver's mail id, text required to be sent and Boolean led blink to indicate patients alert on the monitor. When the

Boolean expression becomes true then a pre-written message is sent to the concerned person through a mail using Simple Mail Transfer Protocol. Upon running the program, a WordPad with data is created and an alert is sent to the guardian.

V.ALGORITHM

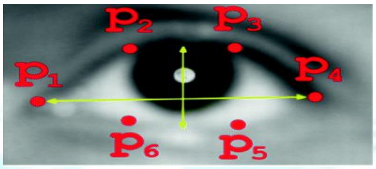
Step 1: Start the program.

Step 2: Import all the necessary packages.

Step 3: Select a serial port and fix the baud rate.

Step 4: Define a function def Eye_Aspect_Ratio (eye): which is used for calculating the Eye Aspect Ratio.

- This function calculates the two vertical and one horizontal Euclidean distances of each eye.



- Distance between P1 and P4 is horizontal distance named as C. Distance between the points P2 and P6 named as A, P3 and P6 named as B are the two vertical distances.
- Calculate EAR using formula :
  EAR = (A+B)/2*C
- Return EAR

Step 5: Construct an argument parse for displaying the data on the command line.

Step 6: Initialize the variables EAR_Threshold =0.3, Blink_frame=1, counter =0 and Alarm_ON= false.

Step 7: Load the dlib face detector HOG based and then create the facial landmark predictor for marking the 68 points.

Step 8: Grab the indexes marked from both the eyes.

Step 9: Use a while loop

If while true execute the below steps:

- Get the video frames
- Read and resize them to the given width
- Convert to grayscale

Step 10: Then detect the face in gray scale frame and convert the facial coordinates to NumPy (Numerical Python) array.

Step 11: Extract the left and right eye coordinates to calculate the EAR of both eyes. Average both the EAR values obtained.

Step 12: Converhull of OpenCV is used to mark the points around the eyes and drawcontours function is used to join the points and form a closed path around the eyes.

Step 13: Use an if loop to check if calculated EAR > EAR_Threshold; increment the counter and make Alarm_ON=True.

Step 14: If counter > Blink_frame the use port.write to write a command to given an alert through Labview.

Step 15: Else Alarm_ON= False and while loop repeats again

Step 16: Display the string alert message on the frame.

Step 17: End the program.

VI.RESULTS

Many devices are available in the markets which depend on eye movement. Among all the different devices, this would be one the accurate technique which is dependent on the human measures. There are also Projects like IR based eye blink detection and Eye movement-controlled wheelchair which depend on monitoring eye movement**.** This procedure is executed by capturing the changes in the physical signs like eye blinking i.e. closing and opening of eyes. MATLAB based cursor control system also exists.

Regardless of the way that these methodologies are generally exact, these are not sensible in certain tasks, since identifying some different sensors that would be put on the patient's body, and subsequently be disturbing the patient.

Additionally, long time without movement would bring sweat on the sensors, decreasing their ability to screen definitely. Henceforth our methodology will be for the most part concentrating on measure of eye closure likewise called (PERCLOS) level of conclusion as it gives the most exact data on eye flicker which utilizes PC vision by python programming which makes it better than different gadgets introduced.

The eye blink detection results are displayed below:

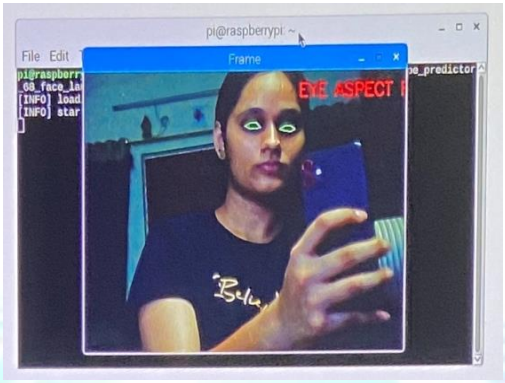


Figure 8**:** eyes closed — normal coma patient condition

Figure 9: EAR is high because the eyes were opened — the patient has blinked.

The labview mail alert when the patient blinked is shown below:

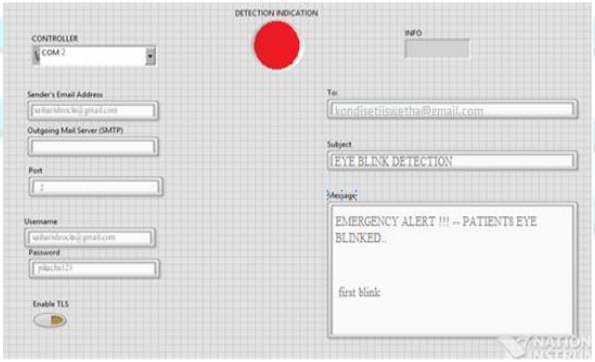


Figure 10: Graphical User Interface for Mailing

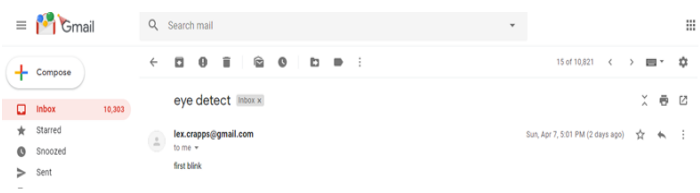


Figure 11: Received Mail Alert

Now again this project is designed with some basic similarities but it is designed using computer vision by python programming which makes it superior to other devices presented. Using image processing, a better night vision camera helps in making the device a better one. This device helps in not only detecting the eye blink but also by slightly changing the code can be used for drivers sleep detection.

VII. CONCLUSIONS AND FUTURE SCOPE

A system that is compact and provides fast processing is presented in this thesis. The main objective of the project is to build a portable and easy handled device which can get the patient's health condition information to the concerned person or doctor within short duration. The model that is designed is for betterment and improvement in the health care service to get the comatose level of the person. So, that the data acquired can be stored in the database with the help of the internet and can result in a quick response. The Internet of Medical Things (IoMT) showcase includes assortment of keen gadgets, for example, wearable and clinical/imperative screens, in the home, or emergency clinic; and related ongoing area, telehealth and different administrations. Thus, with the assistance of these gadgets specialist can without much of a stretch inspect his patient at whenever. In this proposed system eye flicker sensor is used to identify movement of the eyes of the out cold. Likewise the structured framework is reasonable to the patients.

This system has the following advantages mentioned below.

Advantages:

- It is reliable and energy efficient for monitoring the coma patient by sending an alert message to the concerned person.
- Compact and easy to transport the system.
- Low power and more accuracy.
- All the parameters are embedded into a single system which makes the easy for a normal person to handle.
- Very instantly the status of the patient is a given.
- It can also be used as the drowsiness detecting system.
- Sending alert message is very fast and secure through LabVIEW.

This system in future might be designed using one's own mobile phone for processing rather than using a Raspberry Pi board which is a slow comparatively. This can simply be done by developing a proper mobile application which would perform the same work as Pi board in a fast and efficient way. It can be combined with many other components to monitor all other necessary functions of a patient like heart beat, temperature, etc. It also helps in detecting the drowsiness of the drivers such as for cars, vans and other heavy vehicle by changing the EAR. . In later work it can also be combined with the yawn detection technique.

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