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Driver Fatigue Detection and Accident Prevention using Live Video Processing

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Abstract: The aim of this project describes a modern approach that will detect driver fatigue considering the facial features. Previous researches utilize multi fusion schemes for feature identification for additional data which may considerably increases the image processing time. Accidents happens in a fraction of second hence systems with slow detection methods are not viable for practical purposes. The idea is to implement a detection method with secure high-speed feature detection scheme. The focus is placed on designing a system that will accurately monitor the open or closed state of the driver's eyes. It also explains the vision-based driver fatigue detection method. Initially the driver's face with open eye and closed eye features are captured and saved in a database. Then these images are trained for pattern recognition i.e. eye area, average height of the pupil, width to height ratio and eyelid covering area over the iris. Secondly, the fatigue is confirmed by analysing the real time image and comparing it with the previously trained images for changes of eyes state. For feature detection Viola-Jones algorithm is employed. Finally, the output state result is then sent to an Electronic control unit (ECU) in the vehicle. The ECU decides the course of action depending upon the fatigue state. If the eyes are open then no action is taken, in case of fatigue state the ECU reduces the vehicle speed and an alarm sound is generated. The experimental results show validity of our proposed method. This technology is implemented in a prototype model rover.
Keywords: Accident prevention, Image processing, Haar classifiers, Electronic control unit, RF transmission

I. INTRODUCTION

Drowsiness while driving increases the risk of human-error related accidents. A Driver's state of mentality and tiredness are some of major reasons in traffic accidents. The overall studies in France, the National Police Administration shows that of insufficient sleep can cause more road accidents than drink driving. Drivers with a decreased observation level suffer from a serious danger to their own life and the lives of other people. Physiological signals from human body like EEG, ECG and brain waves can be used to identify fatigue but it requires instruments attached to human body surface, which makes this type of fatigue detection unfavourable. People in fatigue also exhibit certain visual behaviours that are easily observable from changes in facial features such as the yes, head, and face. Visual behaviours that typically reflect a person's level of fatigue include eyelid movement, gaze, head movement, and facial expression [1]. A Vision based system can be utilised to identify these visuals. Capturing these visual cues should be executed in a non intrusive way i.e., the camera device should not cause any distraction to the driver. [2],[3] discuss about obtaining facial features of a driver through a live camera feed. An onboard or remote computer system can be used to process the camera feeds. Various algorithms and image processing techniques for extraction of facial features such as eye state, blink rate and mouth movement are discussed in [4]-[9]. This project employs Viola-Jones algorithm for fatigue detection.
The second and important part of this project is to develop a control system to stop the vehicle once driver fatigue has been identified. An Electronic Control Unit (ECU) is a part of the vehicle electronics dedicated to perform only one task. Modern vehicles contain many such ECU's for safe operation of the vehicle. These control units can communicate with each other and also to onboard main computer. The proposed control unit has a microcontroller at its heart and uses Radio frequency modules to communicate with the remote computer.

II. PROPOSED SYSTEM

The formation of fatigue is not a process of steady development. The transition of sobriety and fatigue may appear frequently when humans are influenced by environmental interferences during the process from the fully sobriety state to the fully fatigue state. This process is a transitional hence it is mandatory to continuously track the eye feature for proper fatigue detection, for this purpose a camera-based vison system is used. The facial features of a well-rested person consist of clear and vibrant eyes. Their blinking rates are normal and yawns rarely occur. Figure 1 and 2 shows the eyes of a rested person and fatigued person respectively.

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Fig. 1 Eyes of rested person

Fig. 2 Eyes of fatigued person

A person with fatigue primarily has red eyes. Due to tiredness their eyelids droop and have high blinking rate. Drowsiness is usually accompanied by frequent yawning. After the detection process, the control system has to prevent the vehicle from accident. This is accomplished by the Electronic control unit. The block diagram of the proposed system is shown in figure 3.

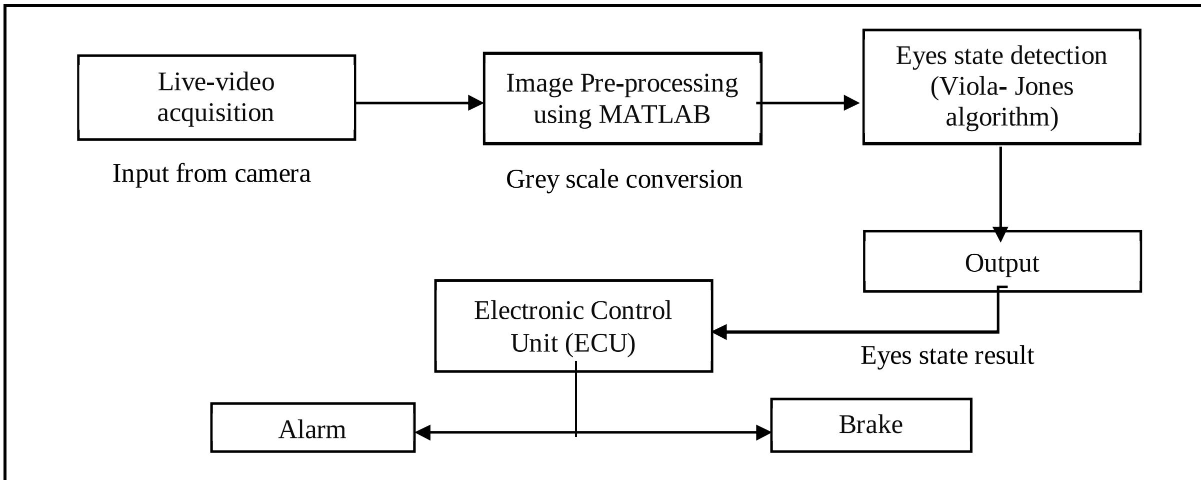

Fig. 3 Block diagram of Proposed system

A. Viola-Jones Algorithm

Viola-jones approach is a very common approach for object detection. The algorithm is a machine learning approach for object detection that emphasizes on rapid result generation and high object detection rates with figures of up to 99% detection being registered by different the method uses integral images as the image detection structure that guarantees speed in detection. The features are calculated by taking the sum of pixels within multiple rectangular areas. Extensions such has addition of Ada boost algorithm allows training of classifiers to detect integral images of the face and those of the background and increase the speed of the detection.

The first step of the Viola-Jones face detection algorithm is to turn the input image into an integral image. This is done by making each pixel equal to the entire sum of all pixels above and to the left of the concerned pixel. This allows for the calculation of the sum of all pixels inside any given rectangle using only four values. These values are the pixels in the integral image that coincide with the corners of the rectangle in the input image. This is demonstrated in Figure 5.

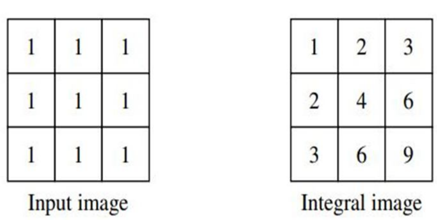

Fig. 4 Integral conversion

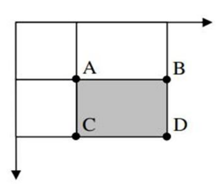

Fig. 5 Sum calculation

Since both rectangle B and C include rectangle A the sum of A has to be added to the calculation. It has now been demonstrated how the sum of pixels within rectangles of arbitrary size can be calculated in constant time. The integral image is defined by the following recursive relationship.

$$ii(-1, y) = 0$$
$$s(x, -1) = 0$$
$$s(x, y) = s(x, y-1) + i(x, y)$$
$$ii(x, y) = ii(x-1, y) + s(x, y)$$

s(x, y) is the cumulative row sum at point (x, y), ii(x, y) is the integral image value at the same point, and i(x, y) is the pixel value at that point.

B. Vision System Setup

The vision system includes a camera and a computing system for image processing. In the proposed system Logitech USB webcam (shown in figure 6) is used for demonstration purpose. The camera is connected to a PC through USB cable. MATLAB software is used for image processing. The camera has the frame rate of 30FPS, each frame has to be checked for fatigue pattern continuously and hence it is necessary to pre-process the video and isolate each frame into a separate image for feature detection. The Image acquisition tool in MATLAB is employed for image pre-processing.

For better imaging in actual implementation, the camera has to be placed on the dashboard behind the steering wheel as shown in figure 7.

Fig. 6 Logitech Camera

Fig. 7 Optimal Camera Location

C. ECU Setup

The primary function of the ECU is to stop the vehicle and create an alarm when the driver is found to be in fatigue state, thereby avoiding any accidents. The Microcontroller present in the ECU analyses the result and makes the decision for either sounding the alarm or stopping the vehicle or both. The various components used in designing the ECU are explained below.

1) *PIC16f877A Microcontroller:* The PIC16f877A microcontroller acts as the heart of ECU. It is well known for its various applications in low powered embedded system designs. The important reasons for its selection in this project are Flash memory, low operating voltage 4.2v to 5.5v (typically 5v), multiple peripheral interface protocols, low cost and serial programming capability.
2) *CC2500 RF Transreceiver:* CC2500 is Serial Transreceiver Wireless Module designed to meet the requirement for the low cost, low power wireless device to transmit and receive serial data. The module operates on 2.4 GHz frequency band. It satisfies Zigbee wireless standards.

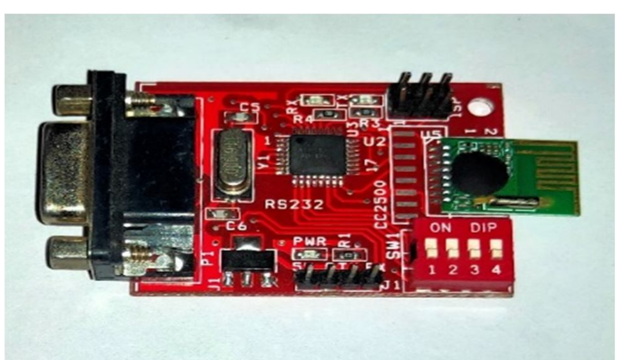

Fig 3.2.2.2 CC2500 RF Module

It can be used to transmit and receive data at multiple baud rates from any standard CMOS/TTL source. It works in Half Duplex mode i.e. it provides communication in both directions, but only one direction at same time (not simultaneously). This switching from receiver to transmitter mode is done automatically.

RF Module operates on 5v source, it can be used for applications that need two-way wireless data transmission. It features high data rate and longer transmission distance. The communication protocol is self-controlled and completely transparent to user interface. It also supports multiple Channel Selection (CH0/CH1/CH2/CH3), which can be selected using the dip switches on the module for communication. There is a RS232 port present in the board for serial communication.

For this project two RF modules are used. The first module is connected to the PC using RS232 to USB serial cable. The eye state results from the MATLAB is serially transmitted to this RF module by MATLAB serial port functions at baud rate of 9600. This module acts as transmitter and sends the data wirelessly to the other RF module. The CC2500 receiver module is interfaced with PIC16f877a through UART. The Tx(25) and Rx(26) pins of PIC microcontroller are connected to the Rx and Tx terminals of CC2500 module respectively. Baud rate of 9600 is selected inside of the program code for data transfer speed. Power for the RF module is supplied by the 5v and Gnd pins present in the standalone board. It receives data from the transmitter module and this data is serially transferred the microcontroller. The communication channel 0 is used for data transmission.

III.SYSTEM IMPLEMENTATION

The Electronic Control Unit functions in a sequential manner. On start, the rover moves forward simulating the movement of a vehicle. The web camera captures the facial features of the person representing driver. This feed is processed in MATLAB image processing tool. Viola-Jones algorithm detects the eye features and looks for fatigue presence in it. Each frame of the camera feed is subjected to image processing thus, a continuous monitoring is achieved. Partial or full closing of eyelids for more than 2 seconds longer are treated as drowsiness in this project. This threshold can be varied inside of program.

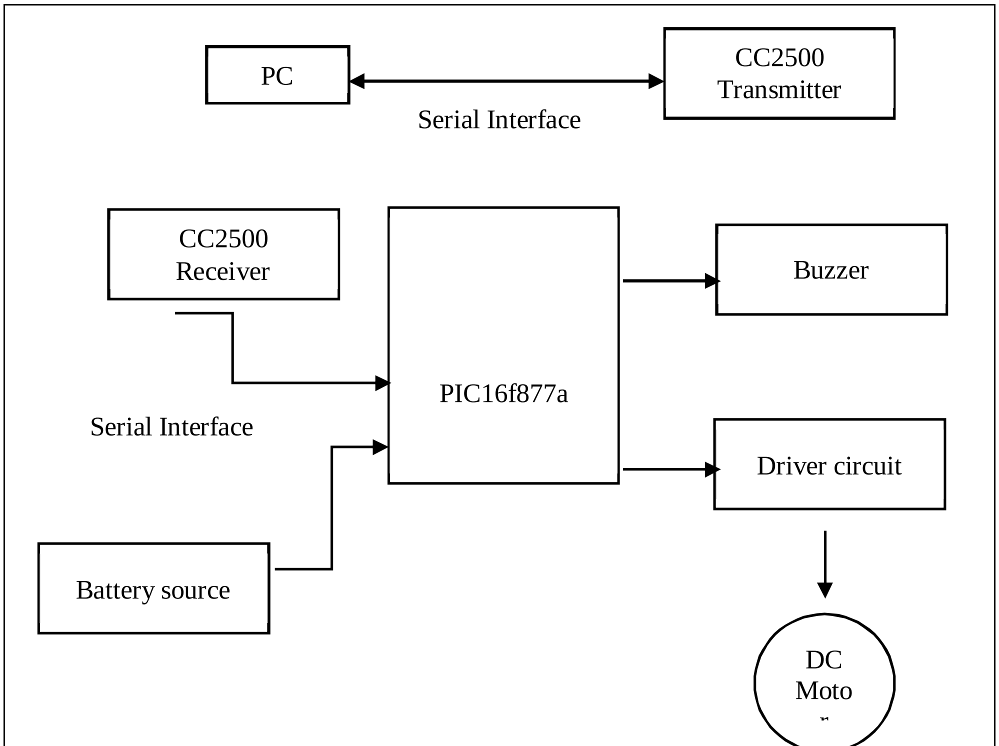

Fig 4.3 Working of ECU in rover

Once the drowsiness or fatigue is detected, this data is transmitted to the ECU through radio frequency signals by the RF transreceiver unit connected to PC. The ECU present in the rover receives the fatigue data through the RF module. Then it sends instructions for the rover to stop movement and sounds the alarm.

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A. Rover Setup

The ECU is implemented in a model rover for demonstration purpose. The rover used in this project is a Li-Po battery powered model to represent the actual vehicle. The Rover includes a Motor driver circuit that operates four DC motors for movements. The PIC microcontroller is interfaced with the motor driver module. Thus, it is possible to operate the rover based on the instruction received from the PIC6f877A. The battery pack consists of four individual 3500mah rechargeable batteries. This powers the PIC16f877a microcontroller, RF module and a L298N motor driver circuit.

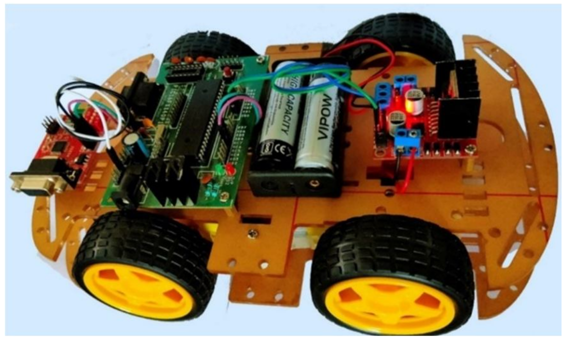

Fig 3.2.3 Rover for demonstration

The L298N is a high-powered motor driver circuit that can operate up to 4 DC motors simultaneously. It accepts 4 control inputs and 2 enable inputs for motor control. It operates on 12v and 5v power supplies. The motors used in the rover operates in 3v range hence, it is sufficient to use 5v source for the driver. The RB0, RB1, RB2, RB3 GPIO pins of microcontroller are connected to the input pins of motor driver circuit. Enable pins are connected to RB4 and RB5. The rover is programmed to move forward on start and stop when the fatigue state result is received from the MATLAB program. This validates the real-time operation of ECU. A buzzer is attached to the rover unit to sound alarm when fatigue state is identified.

IV. RESULTS

The output of driver eye state after image processing is displayed in the command window. In addition, the preview window displays the current image frame under process.

1) *Open eyes state:* Here, the current image feature contains eyes in open state so the output is displayed as "Normal" in a command window.

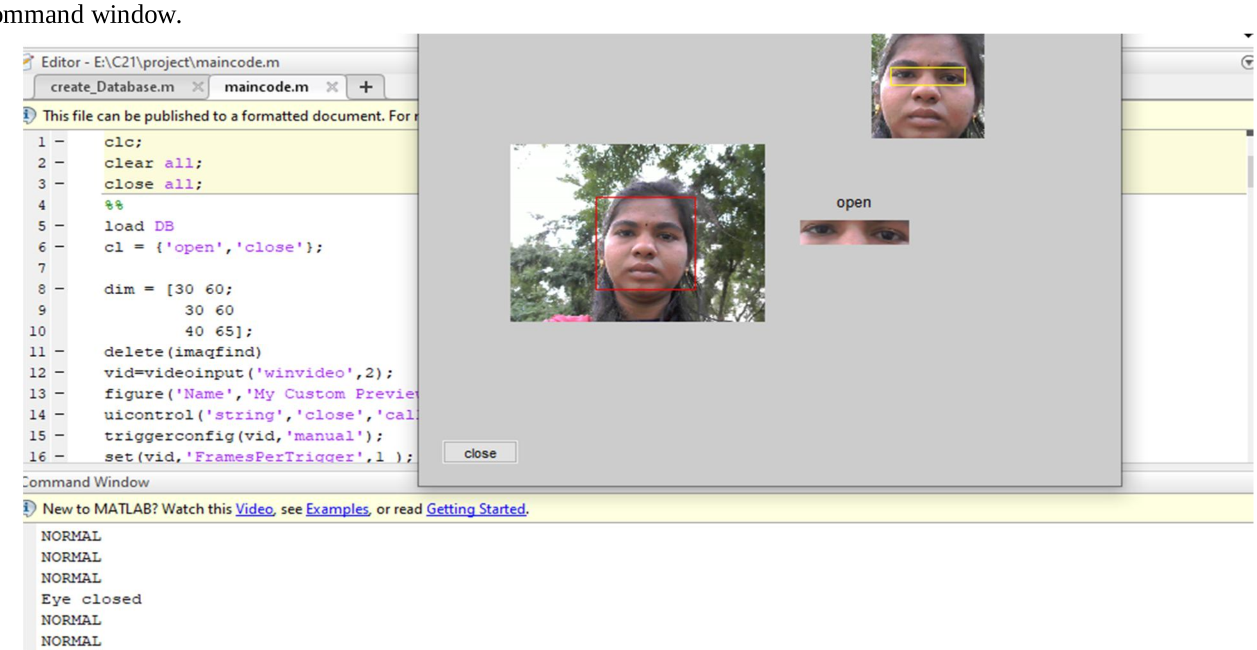

Fig 5.1 Output in eyes opened state

2) *Closed eyes state:* From the figure 5.2 it is evident that eyes are in closed state so the output is displayed as "Eye closed" in a command window.

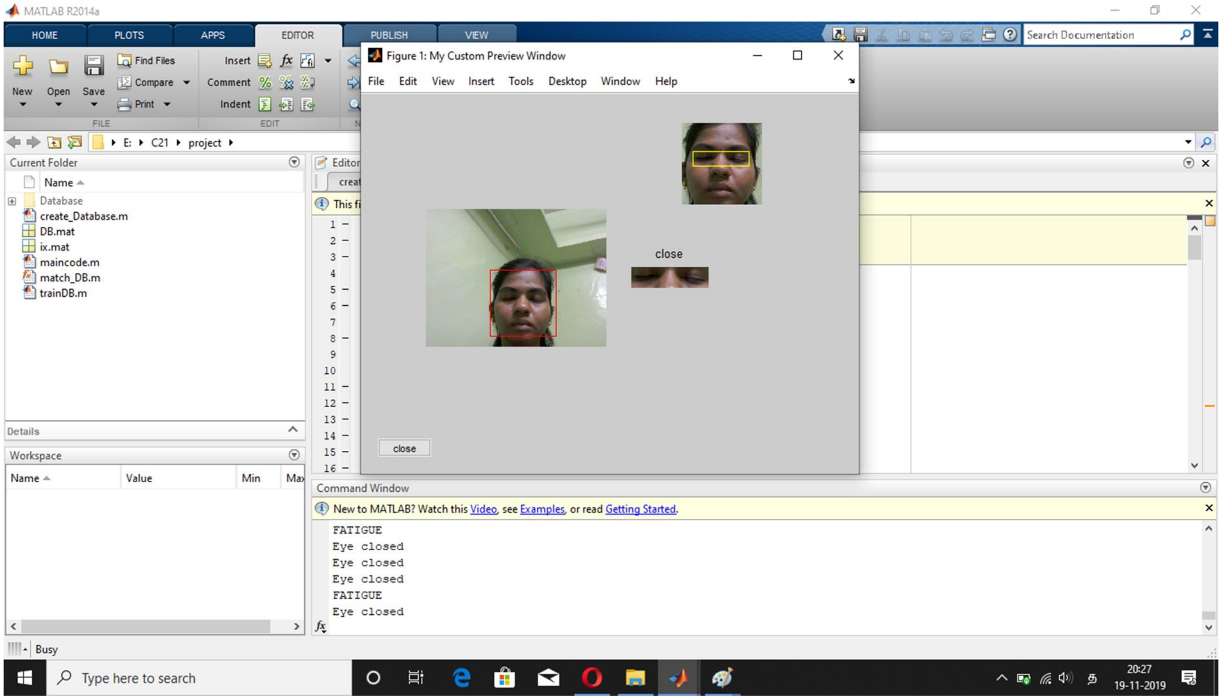

Fig 5.2 Output in eyes closed state

3) *Fatigue State:* The fatigue state is the state in which eyelids cover about 60% of the iris. This is represented in the figure 5.3.

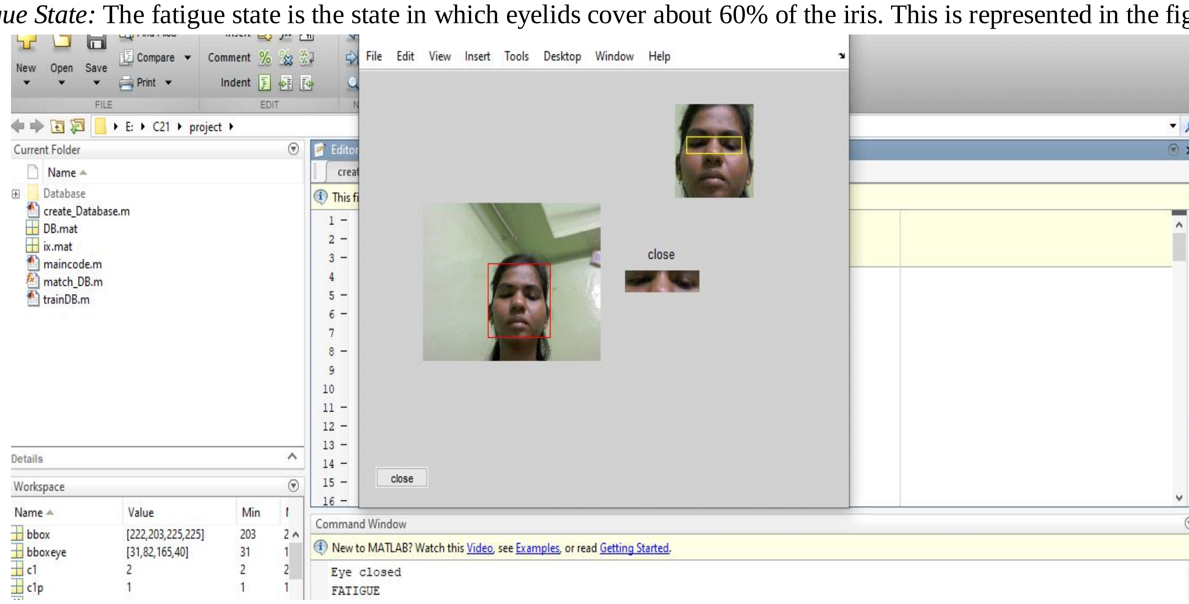

Fig 5.3 Output in Fatigue state

V. CONCLUSION

The proposed method detects the blinks and the drowsiness quickly and the success rate is high because independent Haar-classifiers are used for left and right eye detection. Viola Jones face detection algorithm has proven to be fastest and most accurate among the face detectors. The blinking detection of drivers with eye glasses are not accurate when compared with drivers without glass. The ECU model is the efficient and affordable solution for stopping the vehicle from accidents. The system can be very useful to avoid accidents and can save people life. It can make the world a much better and safe place to live.

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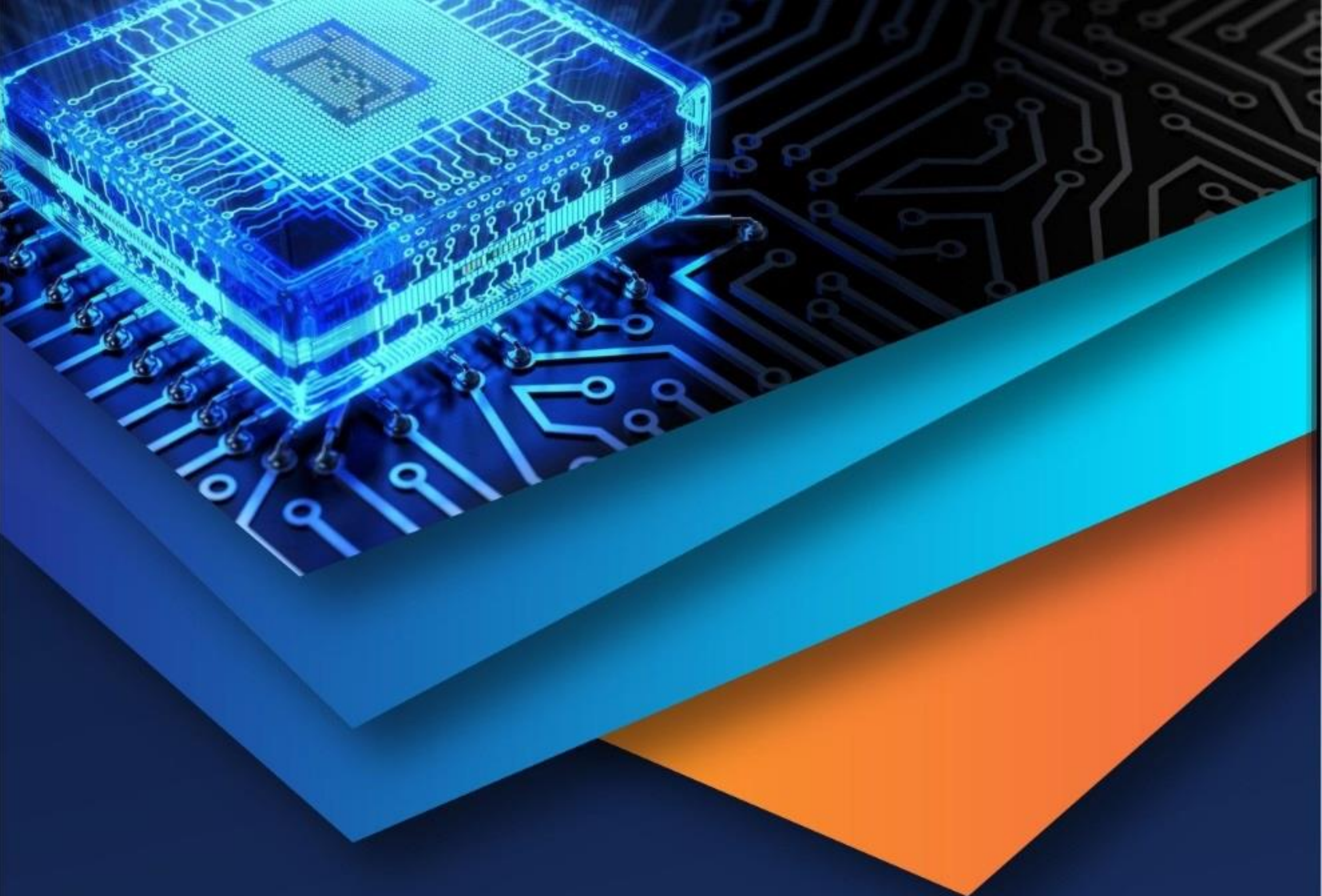

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