Road Safety Measures Using Sleeping Alert System

Derar Eleyan, Muhammed Saffarini, Rasha Saffarini, Amna Eleyan

Abstract: Driver fatigue and sleepiness are major causes of road accidents. Road accidents increase gradually every year due to drivers' drowsiness and fatigue which cause fatal casualties and deaths. Several researches have focused on developing systems for detecting drivers' drowsiness and fatigue to overcome their consequences on traffic safety. This paper proposes a drowsiness detection and alert system. The aim of the proposed system is taking the appropriate action based on the driver's status and the danger level. Furthermore, it presents an empirical study on using image processing techniques to analyze the real- time captured images of the driver's eyes' position and the eyelids closure span for detecting and measuring the drowsiness and fatigue level. The alert system is activated when a signal is received from the drowsiness detection system to perform an appropriate action based on the danger level 0, 1, 2 or 3. A danger flag is set indicating the danger level in which the alert system chooses the right action correspondingly. Initially, a danger flag has a state of 0, which indicates the safety status. However, if a danger flag has a state of 1, 2 or 3, the alert system will be activated to take the right action such as beeping of the buzzer, activating the hazard light, reducing speed and auto-parking at the side of the street as well as sending information to the nearest traffic police and medical emergency centre. The proposed system is an integrated smart system consisting of two microcontrollers (Raspberry Pi 4 microcontroller and Arduino microcontroller), sensors and actuators that are connected and communicated over the Internet. Raspberry Pi detects the driver's eyelids from the captured images and analyzes their status to decide whether they are opened or closed. If the eyelids are kept closed for more than 2 seconds, Raspberry Pi would send a signal to the Arduino to control the activation process of the alerts and the GSM texting service.

Index Terms: Image Processing, Sleepy Driver, Smart Car System, Drowsiness Detection System, Raspberry Pi, Arduino, Sensors, Actuators

1 Introduction

The world faces an enormous number of road and traffic accidents annually, which causes deaths and casualties. These accidents are a result of various reasons, internally which be- long to the car or vehicle itself and its functions, also externally which belong to the environment as weather, humidity, temperature, road conditions, etc. Fatigue and sleep apnea increase the proportion of traffic accidents around the world. [9] shows that 16% to 20% of serious highway accidents in the UK, Australia, and Brazil are because of sleep disorders including sleep apnea symptoms. Oxford university press released a study on sleep deprivation and car crashes shows that people who have less than seven hours of sleep in the past 24 hours are more likely to be involved in car crashes. The risk is higher with those who have been diagnosed with sleep apnea. [10]. Oxford university press released a study on sleep deprivation and car crashes, where it shows that people who have less than seven hours of sleep in the past 24 hours are more likely to be involved in car crashes. The risk is higher with those who have been diagnosed with sleep apnea syndrome according to [11]. Our project concerns with avoiding car accidents, the project consists of two parts: the first part is concerned with solving the problems in the environment around the car that may cause an accident, there are a lot of accidents happened because of environmental reasons namely; lack of vision of the driver because of fog, and forgetting to turn on car lights. On the other hand, the second part focuses on accident causes that occur inside the car which are; the decreased amount of Oxygen and in turn increase the amount of carbon dioxide and increase the humidity and temperature ratio in the car which cause condensation on the front windshield which limits the vision of the driver**.**

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2 Previous Studies and works

As road accidents increase gradually every year due to driver's drowsiness and fatigue, several researches and projects have focused on developing a technology to detect drowsiness and fatigue and to overcome their consequences on traffic safety. [11] has proposed a system to detect drowsiness based on an eye-blink sensor, where this sensor was responsible to detect the unusual eyelid closure, and by that take an action to alert the driver. Using this system has shown several disadvantages, such as: devise any of the current designations.

- Since that this sensor uses IR signals to interpret the status of the eye lid, these signals might suffer from noise interference and attenuation from other IR signals, and this would alter the result of the received signals.
- Its mandatory that the driver should wear the system, where some people might find this unpleasant.
- The alert outcome is presented as a buzzer, where in some cases it is not enough to awake the driver and get his attention.
- Some attention should be given to the health factor regarding continuous exposure of eye to IR signal.

Beside the mentioned disadvantages of this system, it has some good advantages such as being cheap and simple to implement. As a result, it can detect drowsiness, and by that decrease road accidents. Other techniques for detecting driver's drowsiness have been presented by [12]. These techniques were based on image processing, they are divided into three main categories that are widely used by researchers, which are:

- Template based technique: this is an easy to use and simple technique, but it requires training to be applicable.
- Eye blink measurements technique: in this technique two factors are considered, the rate of eye-blinking and the

duration of eye closure.

- Yawning based technique: in this technique there is a focus on one of the fatigue symptoms, which is yawning. It depends on the duration and frequency of mouth opening, since that opening the mouth while yawning is totally different in size while doing other things.

The techniques presented by [12] have proposed a robust and accurate algorithm for face and image tracking and eye detection that is subject to various external influences, such as: varying light, external illumination interference, vibrations, changing background and facial orientation. One big disadvantages of this algorithm is that it sometimes creates false alarms. Another method for detecting driver's drowsiness was developed by [12]. This method has considered the eye's blinking rate and flickering span as the main factors in determining the drowsiness level. The detection principle is based on Artificial Neural Network learning and a combination of data collected from the driver's images. Several systems were proposed to detect the drowsiness of the driver to reduce the possibility of car accidents, suchas in [5, 2, 7, 3]. In [5] a system is proposed to avoid car accidents caused by sleepy or drunk drivers, by using image processing HaaR algorithm to detect driver's eyes. If the driver is drowsy or drunk the system uses IoT technologies to send messages via the internet about the condition of the driver, and his location. In [2], authors developed a system to detect a drowsy driver to reduce the possibility of car accidents, it also continuously measures the distance between the car and surrounding obstacles. This is done by sending alarms to the driver if the distance is less than a specific value. Also, if a collision happens the system sends messages to call for emergency help to the driver. In [7], a system was proposed to detect the drowsiness of the driver in an attempt to avoid car accidents. This system used machine learning to achieve this goal. The system continuously detects the driver head motion, yawning, and blinking from an instantaneous video. The detected motions are passed to a classifier which predicts if the driver is asleep or not. The accuracy of prediction reached around 90%. In [3], the authors proposed a system that uses a Pi camera and Raspberry Pi to continuously take images of the driver's face. Then from the captured images the system detects eyes, and calculate the eye aspect ratio (EAR) to detect the closure of the driver's eyes. If the EAR is below a specific threshold for too long, the system alerts the driver using a buzzer, and if this situation repeats for more than two times the system sends a message to the owner ofthe car through e-mail. On the other hand, several systems are proposed to manage road maintenance in winter as in [4, 1, 7]. In [4], a multi- level system for managing road maintenance in winter was proposed. The system works by automatically monitoring, collecting, and predicting the weather conditions and the condition of the selected road surface. The collected information is sent to the road weather station, which in turn sends warnings about that road by analyzing and processing the data to take the proper actions to maintain the road. The system also sends messages to the drivers and traffic control systems to ensure traffic safety. In [1], the authors developed a system for road winter maintenance using IoT hub. It utilized a wider meteorological test in Birmingham, UK. In [6], the author reviews the possible intelligent transportation system applications which can help in improving the road maintenance in winter. They worked on:

- improvement of automatic remote weather and road surface information sensing.
- the use of GPS/GIS for the maintenance operations.
- equipping roads with sensors to measure and record the friction of the roads when snow, or ice, are present and many others.

The Internet of Vehicles has attracted a lot of attention in the automotive industry and academia recently [13]. rapid advances are witnessing in vehicular technologies that comprise many components, such as onboard units (OBUs) and sensors. These sensors generate a large amount of data, which can be used to inform and facilitate decision making (e.g., navigating through traffic and obstacles). One particular focus is for automotive manufacturers to enhance the communication capability of vehicles to extend their sensing range. However, the existing short-range wireless access, such as dedicated short-range communication (DSRC), and cellular communication, such as 4G, is not capable of supporting the high-volume data generated by different fully connected vehicular settings. Millimeter-wave (mmWave) technology can potentially pro- vide terabit data transfer rates among vehicles. Therefore, the paper presented an in-depth survey of the existing research, published in the last decade, and described the applicationsof mmWave communications in vehicular communications.In particular, it focused on MAC and physical layers and discussed related issues, such as sensing-aware MAC protocol, handover algorithms, link blockage, and beam width size adaptation. Finally, it highlighted various aspects related to smart transportation applications, and discussed future research directions and limitations. In the article [14], the authors generated a dataset collecting 14 hours of driving in the city of London. The route was 8.1 miles long and included various road conditions such as roundabouts, traffic lights, and several speed zones. We identify and rank the features from the driving segments, classify our sample using Random Forest, and optimize the learning-based model with 98.84% accuracy (95% confidence) given a small 10 seconds driving window size. Differences in driving patterns were uncovered to distinguish between femaleand male drivers especially through variations in longitudinal acceleration. The paper [15] presented a Sensing-as-a-Service run-time Service Oriented Architecture (SOA), called 3SOA, for the development of Internet of Things (IoT) applications. 3SOA aims to allow interoperability among various IoT plat- forms and support service-oriented modelling at high levels of abstraction where fundamental SOA theories and techniques are fully integrated into a practical software engineering approach. 3SOA abstracts the dependencies of the middleware programming model from the application logic. The authors demonstrate 3SOA using an intelligent transportation system functional prototypes as proof of concepts. The use cases show that 3SOA and the presented abstraction language allow the amalgamation of microprogramming and node-centric programming to develop real-time and efficient applications over IoT. SOA was found to outperform its best rivals in the literature in terms of end-to-end delay and service managementoverhead.

3 Methodology

the proposed system is programmed using different programming languages, namely; C++, Python, PHP and SQL, with the use of RESTFULL APIs. C++ is used to program the Arduino, to read data from sensors, direct actuators to do the task needed from them depending on some readings, and to define the pins in the Arduino each component is connectedto. Python used to write code using Raspberry Pi to do all data analysis such as when the camera captures an image, it sendsit to the raspberry Pi, which in turn uses image processing techniques to analyze the image and detects the driver eyes from it, then analyzes the status of the eyes, whether opened or closed, to perform the suitable action. In Figure 1, are some parts of the base code to distinguish whether or not a driver is sleepy from Python code. The code was written in Python, using a neural network for classification, and then uploadedto Raspberry Pi.

```
def sound_alarm(path):
    # play an alarm sound
    music = pyglet.resource.media('alarm.wav')
    music.play()
    pyglet.app.run()


path_m = "alarm.wav"

def eye_aspect_ratio(eye):
    # compute the euclidean distances between the two sets of
    # vertical eye landmarks (x, y)-coordinates
    A = dist.euclidean(eye[1], eye[5])
    B = dist.euclidean(eye[2], eye[4])

    # compute the euclidean distance between the horizon
    # eye landmark (x, y)-coordinates
    C = dist.euclidean(eye[0], eye[3])

    # compute the eye aspect ratio
    ear = (A + B) / (2.0 * C)

    # return the eye aspect ratio
    return ear
```

```
import ...
ser = serial.Serial('/dev/ttyUSB1',9600)
url = "http://192.168.1.100:8888/IoT/getData.php"
preValue = "0"
val = json.loads('{"bumbs":"-1"}')
while True:
    res =requests.get(url)

    if res.status_code != 200:
        print("Error: ", res.status_code)
        continue
    preValue = val['bumbs']
    val = res.json()
    if val['bumbs'] != preValue:
        if val['bumbs'] == "1":
            ser.write(b"1\n")
        elif val['bumbs'] == "0":
            ser.write(b"0\n")

#       time.sleep(0.5)
```

```
while True:
    read_serail = ser.readline().decode('utf-8').rstrip()
    data = str(read_serail)
    if data == "a":
        res =requests.get(url+"1")
        if res.status_code != 200:
            print("Error1: ", res.status_code)
            continue
        val = res.json()
        print(val)
    elif data == "b":
        res =requests.get(url+"0")
        if res.status_code != 200:
            print("Error2: ", res.status_code)
            continue
        val = res.json()
        print(val)
    elif data.find(",") != -1:
        print("hum,temp"+data)
        arr = data.split(",")
        url2 = url2 + "temp="+arr[1]+"&hum="+arr[0]
        res =requests.get(url2)
        if res.status_code != 200:
            print("Error3: ", res.status_code)
            continue
        val = res.json()
        print(val)
```

```
while True:
    res =requests.get(url)

    if res.status_code != 200:
        print("Error: ", res.status_code)

    val = res.json()
    ledOp = int(val['lights'])
    if ledOp == 1:
        ledOpS = "2\n"
    else:
        ledOpS = "3\n"
    ser.write(b""+ledOpS.encode("ascii"))

    time.sleep(1)
```

Fig. 1. *parts of python code*

4 System Design

In order to reach a better road safety and avoid traffic accidents due to driver's fatigue and drowsiness, an efficient system is developed that responds to the drowsiness and fatigue behavior of the driver before losing the vehicle's control on the road. This system cares about the common major factor among the symptoms that would lead to accidents on road, which is losing focus and early-stage unconsciousness while driving. Its uniqueness is represented in having a robust and sequential alerting system, which assures either stimulating the driver's attention or leading the vehicle into safety and avoid accidents. The proposed system is an integrated system, where it consists of two main parts. The first part represents the drowsiness detection system, which is responsible for detect- ing the signs of the driver's fatigue and drowsiness and sending out informative signals. The second part represents the alert system, which is responsible for taking action according to the received signals from the drowsiness detection system. The complete integrated solution includes a variety of hardware and software components that assure its quick response when chances of traffic accidents are present.

A. The drowsiness detection system

This system consists of a high-quality camera connected toa Raspberry Pi microcontroller that has ability to perform real-time image processing. The camera is placed in front of the driver's face to be able to capture continuous video sequences of it. These captured videos are processed by the RaspberryPi in the following stages:

- Detecting the driver's face.
- Detecting the eyes position.
- Determining whether the eyes are closed or not, and measure the eyelid closure span.

The main purposes of this system are determining the following:

- The status of the driver, whether he is awake or suffering from drowsiness or fatigue symptoms. This is achieved by measuring two things: the first one is the opening span of the eyes and the second one is the time period where the eyes are considered closed. At start, the driver has a state of 0 that he is awake, and this represents the safety status. If the opening span of the eyes decreases down to less than 60%, then they are considered as closed. When the driver blinks, the eyes opening span normally goes down to 0%, and here comes the role of measuring for how long the eyes were considered as closed and how many times, because this is the threshold that determines if the driver is suffering from drowsiness or not. If the eyes were closed for longer than 2 seconds and for more than three times, then a flag is set indicating that the driver is in danger state.
- The danger level, where this decides what kind of alert should be activated. Each time a danger flag is set, the state of the driver changes into a higher level. The first time a danger flag is set, then driver's state changes from 0 to 1, and the alert system is directly informed. The next time a danger flag, this detection system checks the current state and changes it into a higher one, leading to a maximum of state 3. If no danger flag was received for more than 10 minutes, then the driver's state is reset to 0, where the alert system is informed whenever the state is changed.

B. The alert system

When a signal is received from the drowsiness detection system, some actions will be done, and this is the role of the alert system to choose the right action to do. Once the driver's state enters the danger region, a buzzer is used to give the driver an alert for a few seconds. If the driver gets awake by the beep of the buzzer and stay focused for longer than 10 minutes, then the flag of danger state is reset. But if the beep alertwas not helpful and the driver is still suffering from fatigue and drowsiness, then hazard lights are activated for another few seconds beside the beep alert. If the driver responds to these alerts within time, then the flag of danger state is reset. Otherwise, the vehicle enters a mode of reducing speed and auto-parking at the side of the street, and information is sent to the nearest traffic police and medical emergency center. This information includes the following:

- Position of the vehicle.
- Status of the vehicle, whether it stopped properly or a crash has happened.
- Registration information of the driver and the vehicle.

The alert system is divided into three main sub-systems, where they function in a series and each one depends on the driver's response after activating the previous sub-system. These sub-systems are:

- 1st alert sub-system: Beep sound.
- 2nd alert sub-system: Flasher lights.
- 3rd alert sub-system: Auto-parking, where in this state two main actions are taken, the first one is sending information about the vehicle to the police station as an SMS, and the second one is reducing the speed of the vehicle and leading it to the side of the road.

These three sub-systems are effective enough to alert the driver in case of suffering from drowsiness and in case the driver is not alerted, then it leads to a safe parking and clearing the road, which reduces the risk to cause vehicle accidents. Figure 2 shows a conceptual model of the entire system:

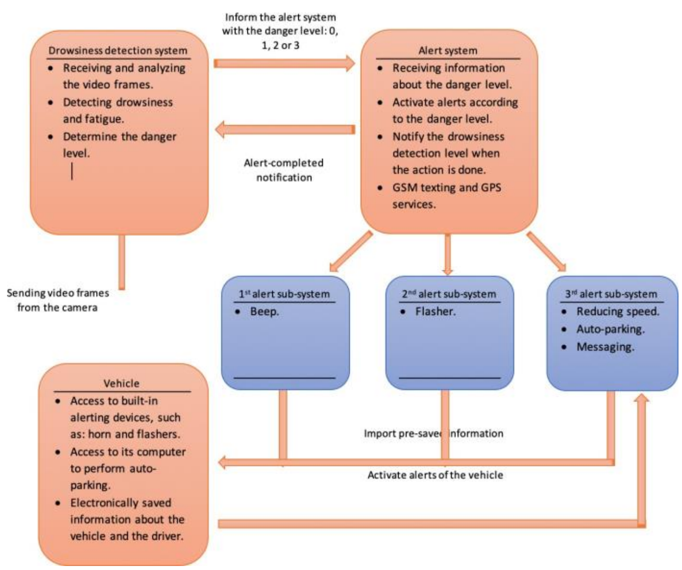

Fig. 2. *Conceptual model of the proposed drowsiness detection system*

5 The Proposed System

Our system consists of two sub-systems, these sub-systems are working with each other to achieve the desired goal of the whole system, which is reducing the possibility of the car accident. A comprehensive solution will be designed and implemented taking into consideration all the causes of the accident. One of the systems works inside the car (smart car system), the systems communicate with each other via the Internet, as shown in Figure 3:

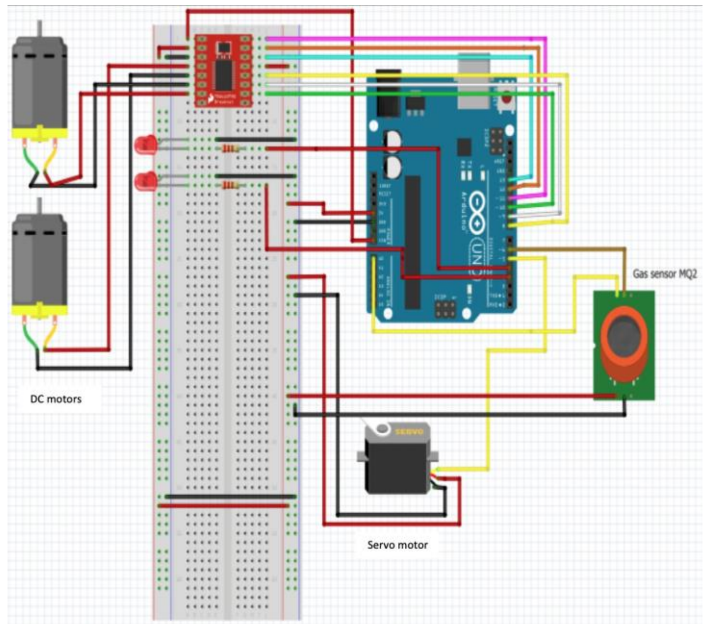

Fig. 3. *overall system diagram*

The development of this efficient drowsiness alert system has gone through two main stages, first a design of integrated hardware components was prepared to assure we have a robust and solid device with the desired outcome quality. Then a stage of coding is followed, where programming the used hardware components was necessary to make them functional and to setup certain characteristics of the system such as: thresholds in image processing, work flow of the system, etc. These two stages are described in details as follows:

A. Hardware tool and components

- Raspberry Pi 4 (RP4) microcontroller. It is chosen for its ability to perform real-time image processing, and for its high accuracy and fast response comparing to other microcontrollers.
- An 8-Mega pixel Raspberry camera. It is a compatible high-resolution camera than can be used with RP4 micro-controller, and its small in size where it can be positioned in any desired place inside the vehicle without causing a distraction.
- Arduino Uno microcontroller. This microcontroller was chosen to be responsible for controlling the activation process of the alerts and the GSM texting service.
- Arduino sim808 GSP/GPS shield. This module is compatible with the Arduino microcontroller, it performs basic GSM services such as: calls and text messages. It can also provide with the position using its GPS.
- Power supply. One main 12v power supply was used to operate all the circuits. It was distributed to each circuit according to its need using a DC buck converter, while keeping high available current.
- A buzzer and a flasher. These activators were used to simulate the actual alerts in the vehicle.
- Cables and extras. Different types of cables were used for example, USB cable and copper wires.

B. Software tools

The two microcontrollers are used in this system required to be programmed in order to be functional. Each one was programmed using a different programming language, as follows:

- Python. This was used to setup and program the RP4 microcontroller, where a specific library called OpenCV is used to implement the image processing using this microcontroller. This library includes all the functions required to capture images from the camera, analyze them and recognize the desired objects (i.e.: eyes in our case) and make decisions according to the changes in the captured images. It also includes a communication protocol to manage incoming and outgoing signals between both microcontrollers.
- C language. This was used to program the Arduino microcontroller. It included a function of alerts activation sequence that performs according to the received signal from the RP4 microcontroller. Also, It's responsible for controlling the GSM/GPS module and managing its services.

In order to perform programming in the above-mentioned languages, some tools and platforms were necessary to beused, such as:

- OpenCV – 4.3.0 library. It contains algorithms for image processing.
- Pycharm platform. It is used to program in Python.
- Arduino software IDE. It is used to the program the Arduino microcontroller in C.
- Raspbian buster. It is the operating system of the RP4 microcontroller, and it is required to install it first to run the Python code on this microcontroller.

Some other tools are needed during the process of setting out the microcontroller such as disk partitions creator, disk imagers, IP network scanners, etc. Figure 4 shows the workflow of the proposed drowsiness alert system.

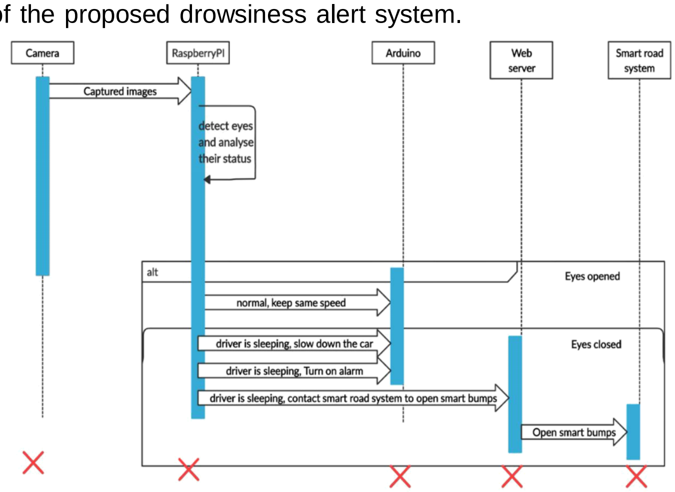

Fig. 4. *Workflow of the proposed system*

The first system contains several sensors and actuators to read some information and take actions when a problem occurred inside the car. The first part of the system is a video camera which is positioned in front of the driver, the camera captures images continuously and send them to the Raspberry Pi to analyze them, Raspberry Pi detects the driver eyes from the images and analyzes their status to decide if they are opened or closed. If the driver's eyes are opened, then the system does nothing, otherwise, the system analyzes more image frames. whoever, if the eyes are kept closed for more than 2 seconds, then the system realizes that the driver is sleeping. Subsequently, Raspberry Pi takes two actions, which are; sending a signal to the Arduino to turn on the alarm and reducing the car speed until the car is stopped unless a new signal is reached that driver woke-up. The second action the Raspberry Pi takes is sending a signal to the Web server to requesting to contact with smart road system to open the smartbumps on the road to make noise which helps in waking the driver up. The camera part of the system is shown in Figures5, and 7:

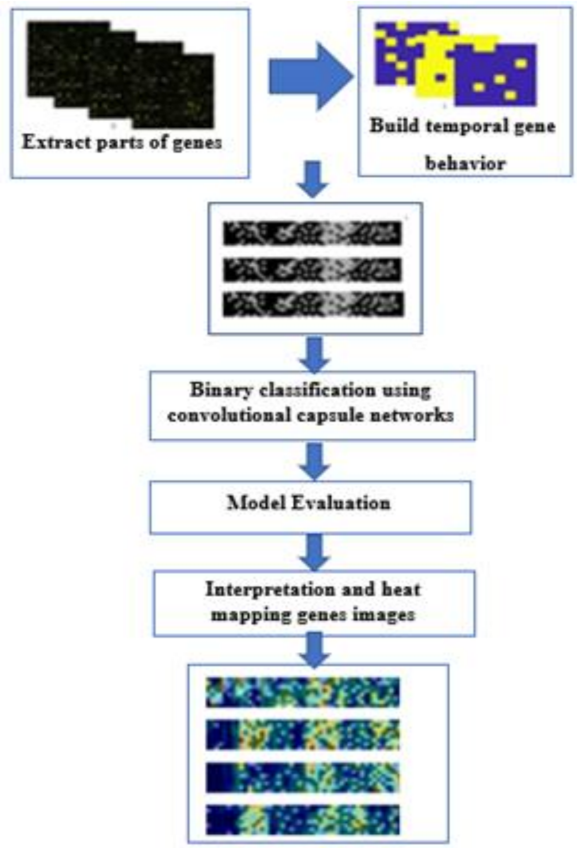

Fig. 5. *Smart car- camera part for sleepy driver flowchart*

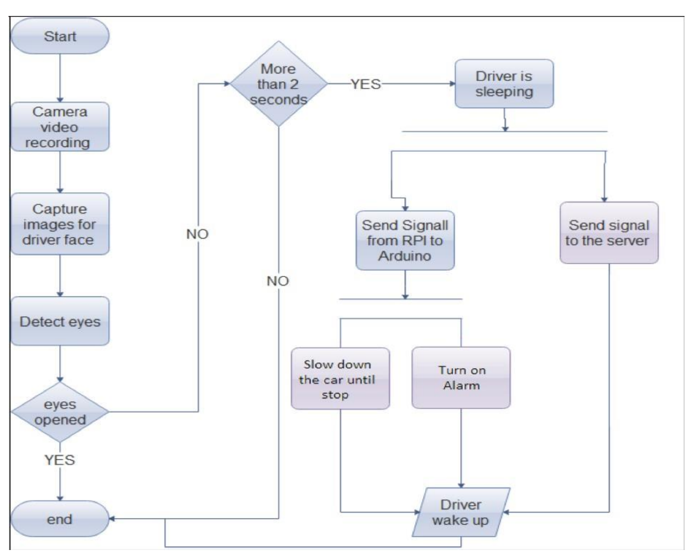

Fig. 6. *Smart car-camera part for sleepy driver sequence diagram*

6 SYSTEM IMPLEMENTATION

To avoid car accidents, we should focus on the accidents causes outside the car by the environment, or inside it. Based on this, we have proposed a system to monitor roads, to tell cars about any problems in front of them to take care of it by reducing their speed, increase the lights of the car, which will reduce the probability of an accident. Additionally, if the humidity and temperature of the environments increase over the allowed ranges, fans inside the car start to cool them down. Secondly, inside the car, if the air conditions become danger on the driver, (the temperature, or CO2 increased for example), the system takes an action by opening the condition or windows to balance the incorrect ratios. The system has been applied by using sensors to measure factors inside and outside the car, which in turn tells the car what to do by connecting them over the internet. The following explains the use of sensors and actuators.

A. Sensors and actuators

1) Sensors:

- DHT22 (humidity temperature): Digital-output relative humidity temperature, DHT22 is a sensor to measure temperature and humidity, it is a low-cost digital sensor. It measures the surrounding air using a capacitive humidity sensor and spits out a digital signal on the data pin. It is simple to use, but it needs 2 seconds between each reading from the sensor, that means you can read new reading every 2 seconds. This sensor is used to measure the temperature and humidity in the environment around the car, which besides other factors the fog can be determined and the system can take the proper action inside the car to avoid accidents such as opening windows when temperature increased.
- MQ2 (gas sensor): This sensor is a long-life sensor which is used to measure the concentration of gases such as LPG, Alcohol, Propane, Hydrogen, Methane, and CO-gas in the air. It is easy to use this sensor, the response time of this sensor is fast, and the sensitivity is high. The sensor's output is an analog resistance. This sensor specifications are divided into two types; general specifications and sensitivity characteristics.
- Photo resistor (LDR) This sensor is a very small sensor, also called light dependent sensor (LDR).It is a sensor which is used to determine the existence or absence of light, or to measure the intensity of light. Sensor resistance depends on the light intensity, in the dark the resistance is very high.
- Web cam: This webcam is a small video camera which captures images continuously, by detecting moving objects and start stream to start recording. It sends images over the internet to the system to analyze it and takes the appropriate actions. This web camera is used to detect the sleep of the driver, the camera positioned in front of the driver to take images for his face and by detecting his/her eyes from the image the system can decide whether his eyes are open or not. If the eyes are closed for 10 consecutive captured frames, then the system knows that the driver is sleeping and takes an appropriate action.

2) Actuators:

- Servo motors: The servo motors are a rotary actuation device, used for precise control of speed, acceleration, and position. Servo uses position feedback to control its motion speed and the desired final position. Servo motor consists of a DC motor, potentiometer and a controller. The DC motor is connected to gears to control wheels motion. The potentiometer resistance changes when the motor rotates and finally the controller decides precisely the amount and direction of movement, if the shaft of the motor arrived at the required position (which sent through the signal wire as electrical pulses), motor power supply turns off to stop the motor. The motion speed of the motor is proportional to the final position, such that it calculates the difference between the needed position and the actual position. if the difference is small the desired position is not far, subsequently the motor moves at slow speed, otherwise, it rotates at high speed.
- Gear Motors motor driver: a Gear motor is an electrical motor combined with a gearbox or a gear system. the gearbox rotates in response to the electrical current flow. While Motor driver TB6612FNG is a controller that controls gear motors, it can control up to two gear motors at a constant current of 1.2 A (3.2 A peak). the two motors can be separately controlled, motors speed can be controlled via PWM input signal with a frequencyup to 100KHz. Gear motors are used in our project to represent car wheels to move the car, the controller is used to control the motors, their movement, speed, and movement direction.
- LED actuator: light emitting diode: LEDs can be con- side red as tiny lightbulbs with considerable differences especially when talking about power consumption. LEDs require very less power in comparison with lightbulbs, which makes them ideal for use in low-power applications, such as; phones for example. LEDs are specific type of diodes that convert electrical energy into a light direction.

7 RESULT AND DISCUSSION

The proposed system of drowsiness alerting was successfully implemented, where its components have perfectly communicated to each other. The RP4 can capture images and analyze them. The system has acted as planned, where a com- bination of alerts is activated when eyes closure is detected. The first alert is a beep that ran for few seconds, followedby flashing lights, and finally initiate a signal to a relay (that represents the auto-parking function) combined with sending an SMS to a mobile phone indicating an emergence state. The response of the system is very fast that in completed situation it takes 1.15 second and the success percentage is very high thatits 96.1%. The 10 minutes' period for going back to a normal state between alerts was suitable and enough to show that the driver is awake again. Figure 7 shows different states of the system outcomes. Images 1 and 2 show that the camera has detected the eyes closure when it is above the threshold, whereno alerts are activated. However, in images 3 and 4, the systemhas detected eyes closure below the threshold and for longer than the allowed time, so the flag of danger was set and alertswere activated.

Fig. 7. *Smart car-camera part for sleepy driver sequence diagram*

8 Conclusions And Recommendations

The proposed system has shown excellent behavior and high efficiency that make it very appropriate to be embedded in any vehicle. Both hardware and software components are appropriate to be transferred into a compact solution and to be considered as a major and essential part of the vehicle. It is recommended to approve this solution by the traffic authority to be a mandatory system for all drivers who suffer from fatigue and sleep apnea symptoms. This proposed system is useful for long drives to ensure drivers safety and to reduce the accidents possibilities that way.

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