Smart System to Avoid Car Accidents

Muhammed Saffarini
Information Technology Engineering
Al-Quds University
Jerusalem, Palestine
muh.900@gmail.com

Rasha Saffarini
Information Technology Engineering
Al-Quds University
Jerusalem, Palestine
rasha.saffarini92@gmail.com

Isam Ishaq
Computer Engineering Department
Al-Quds University
Jerusalem, Palestine
isam@alquds.edu

***Abstract*—Car accidents have different reasons, they are either caused by external (outside the car) or internal factors (inside the car). Accidents due to external reasons occur because of environmental reasons such as obstructed vision of the driver due to fog or bad road conditions. Internal factors include decreased amount of Oxygen, and in turn increase the amount of carbon dioxide, driver sleep, humidity and temperature ratio between outside and inside the car, which cause condensation on the front windshield which limits the vision of the driver. To avoid car accidents, one should minimize both external as well as internal accident reasons. In this paper, a system consisting of two parts is proposed to monitor the external and internal driving conditions. The first one focuses on external accident conditions, which monitors the road and notifies the driver about any problem in front of him and take action to avoid it, by reducing their speed, increase the lights of the car, or by using smart bumps that come out when needed (the risk of sliding for example) to enforce the driver to drive slowly and carefully. These smart bumps are needed also when the sensors detect that the driver feels sleepy. Activating them will reduce the probability of an accident. Additionally, if the humidity and temperature of the environments increased over a specified range, fans are activated to cool down the temperature inside the car. The other system works inside the car. If the air conditions pose a danger on the driver (the temperature, or CO2 increased for example), the system takes an action by starting the air condition or opening the windows to balance the temperature or CO2 ratios. The system will be applied by using sensors to measure factors inside and outside the car, which in turn tells the cars what to do by the interaction between both systems via the internet.**

***Index Terms*—IoT, Computer Vision, Sleepy Driver, Smart Car System, Smart Road System, Raspberry PI, Arduino**

I. Introduction

In recent days, the number of vehicles such as buses, trucks, and cars has increased significantly, which led to an increase in the number of accidents. According to World Health Organization (WHO), 1.35 million people die each year because of roadway crashes which happen for different reasons [9]. One of the main reasons of vehicle crashes is driver drowsiness. According to the National Highway Traffic Safety Administration, police reported about 100,000 crashes occur yearly in the United States because of driver drowsiness. Year after year, these crashes cause more than 1550 deaths and 71000 injuries. Another study conducted by the AAA Foundation for Traffic Safety found that around 328,000 accidents happened in the United States because of drowsy drivers, which is around three times the number reported by the police [6]. Other causes of roadway crashes are caused by road problems namely; ice, fog, humidity, high temperature, and other weather conditions. In [10] a study estimates number of car accidents because of wet pavement and rain is about 1.1 million crashes, which causes more than 5000 deaths annually.

In this research, a system is developed to reduce the possibility of car accidents because of the previously mentioned reasons. The proposed system is comprised of two parts. One part deals with road and weather conditions around the car. The other part deals with conditions inside the car itself which can affect the driver. The proposed system uses the Internet of Things (IoT) for this task. The IoT helps in this work by enabling the use of a huge number of sensors, actuators, cameras, controllers, and so on, and make it easy to connect these devices with each other via the Internet to interact with each other, exchange data, and take actions when needed [11]. These two parts of the proposed system work with each other to achieve the desired goal of the whole system, which is reducing the possibility of car accident, by mitigating the causes that may cause an accident. One of the systems works inside the car (smart car system), and the other works outside it, which studies the surrounding environment (smart road system), the systems communicate with each other via the Internet. The two systems are explained in detail in the following sections.

The rest of this paper is structured as follows: A literature review of related systems is provided in Section 2 followed by the explanation of our methodology in Section 3. In section 4 we present the output of our system and its results. Section 5 concludes the paper.

II. Literature Review

Several systems were proposed to detect the drowsiness of the driver to reduce the possibility of car accidents, such as in [5, 2, 8, 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 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 accident, 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.

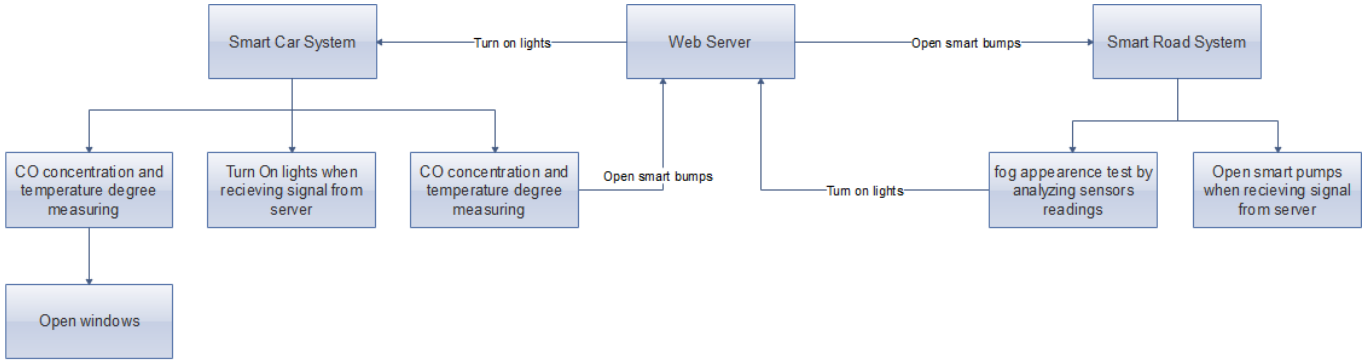

Fig. 1. Overall system block diagram

In [8], 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 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 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 of the 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 send messages to the drivers and traffic control systems to ensure traffic safety. In [1], authors developed a system for road winter maintenance using IoT hub. It utilized a wider meteorological test in Birmingham, UK. In [7], 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.

III. Methodology

Our system consists of two parts, that work together to achieve the desired goal of the whole system, which is reducing the possibility of car accident by solving the things may cause an accident. One of the systems works inside the car (smart car system). The other works outside it and studies the surrounding environment (smart road system). The two systems communicate with each other via the Internet, as in figure 1.

The first system contains several sensors and actuators to read information and take actions when a problem occurs inside or outside 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 sends them to the raspberry pi to analyze them. The Raspberry pi detects the driver's eyes from the images and analyzes their status to decide if they are opened or closed. If the driver eyes are opened, then the system does nothing, otherwise, the system analyze more image frames. In the case the eyes are kept closed for more than 2 seconds, then the system realizes that the driver is sleeping, subsequently the raspberry pi takes two actions:

- Send a signal to the Arduino to turn on the alarm, reduce the car speed, until the car is stopped unless a new signal is reached that driver woke-up.
- Send a signal to the web server to contact the smart road system to open the smart bumps on the road. This will make noise which helps in waking the driver up. The camera part of the system is shown in figure 2:

The second part of the first system addresses the probability of the decrease of O2 in the car and in turn increase in the amount of CO2 gas. Additionally, temperature rise in the car poses a danger and increase the probability of making the driver sleepy and increase the probability of a car accident. Consequently, to avoid these problems, a DHT22 and an MQ7 sensors are used to continuously measure the temperature and O2 and CO2 concentrations inside the car. The Arduino reads the measurements of the sensors each minute, and decide if it is normal or not. If the readings are normal, then no action is taken, otherwise, send a signal to the servo motor to open the car windows as in figures 3 and 4:

The second system focuses on the environment around the car. It works to avoid weather factors that may increase the probability of an accident. This system also has several sensors

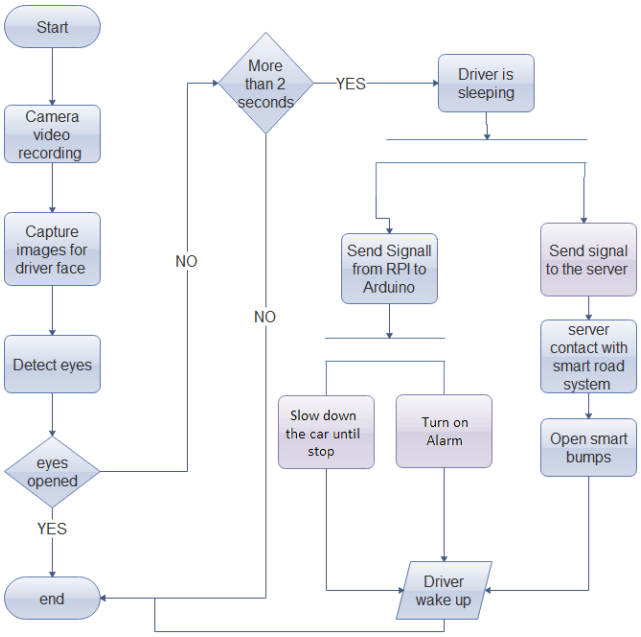

Fig. 2. Smart car - camera part for sleepy driver flowchart

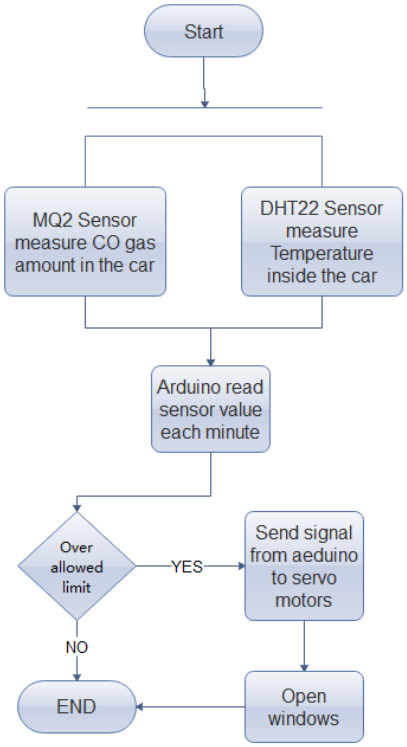

Fig. 3. Smart car- gas & temperature part flowchart

and actuators to achieve this goal. The second system works in two aspects:

- Firstly, when the web server receives a signal from the smart car system indicating that the driver is falling asleep, it sends a signal to the raspberry pi of the smart road system. This system in turn sends a signal to the

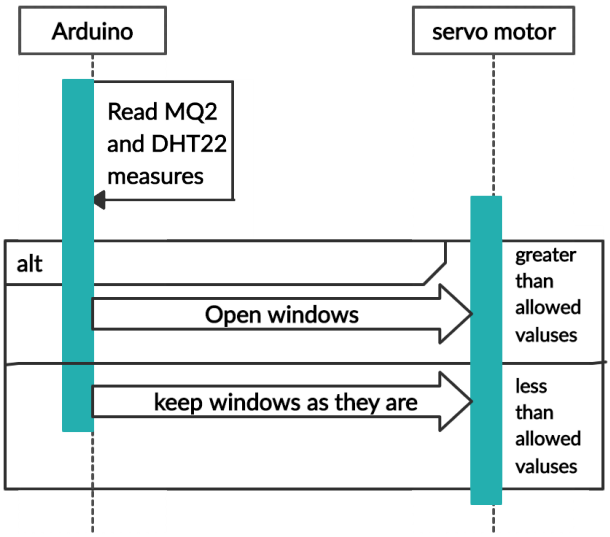

Fig. 4. Smart car- gas & temperature part sequence diagram

system Arduino that guides the servo motor to open the smart bumps in the road. The bumps remain open until a further message comes, stating that the driver has awakened. This process is described in Fig. 5.

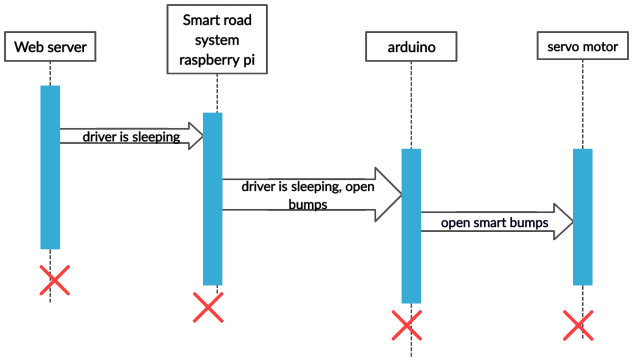

Fig. 5. open smart bumps-smart road sequence diagram

- The second aspect of the system studies and analyzes the weather conditions to know if there is fog on the road ahead of the car because fog impairs the driver's vision which also increase the probability of a car accident. The system has a DHT22 sensor to measure the temperature and the humidity in the environment around the car, and a photo resistor (LDR) to measure the light intensity. The Arduino reads the values of these sensors and analyzes it. If the measurements are in the normal ranges, nothing is done. Otherwise, the Arduino sends a signal to the raspberry pi that there is fog ahead. Which in turn directs the message to the web server to communicate with the smart car system to turn on the lights of the car. Finally, each 5 minutes the system reads the photo resistor

reading. This value is used to exchange messages between the two systems to make sure that the lights are turned on during the night. The fog detection system is shown in figure 6.

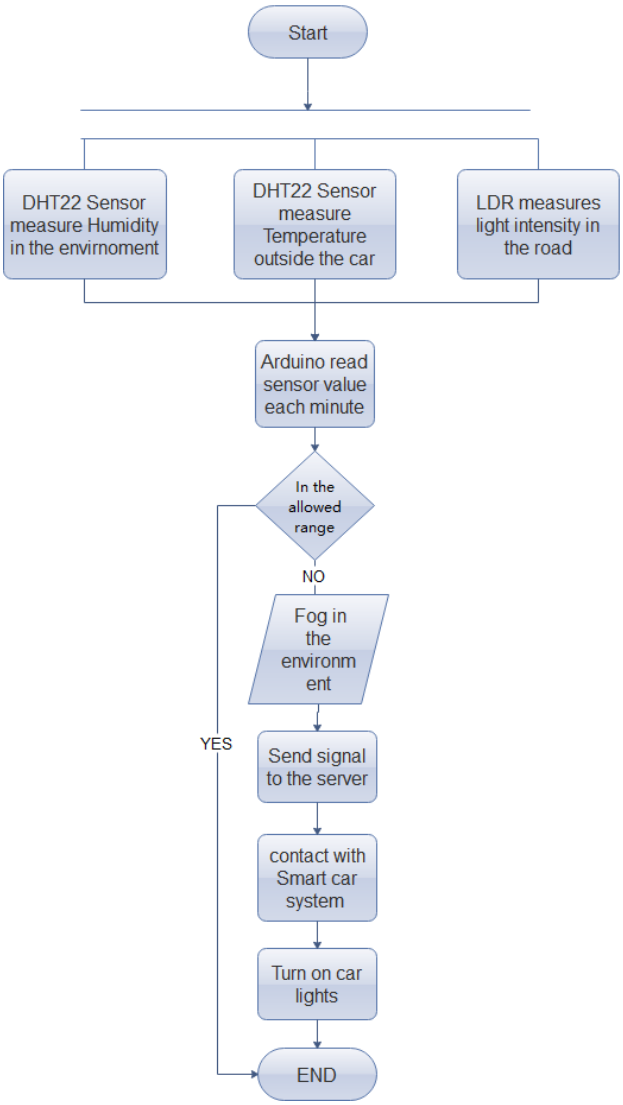

Fig. 6. Smart road- fog detection flowchart

IV. Output and Result

The proposed system is divided into two subsystems: smart car system and smart road system. Each subsystem contains a raspberry pi, an Arduino Uno, several sensors, and several actuators. Finally the overall system connects the two subsystems via the internet using a web server (Fig. 7).

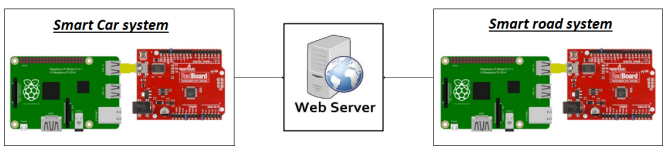

Fig. 7. overall system circuit diagram

The smart car system consists of several components that are connected together as shown in Fig. 8. The smart car system

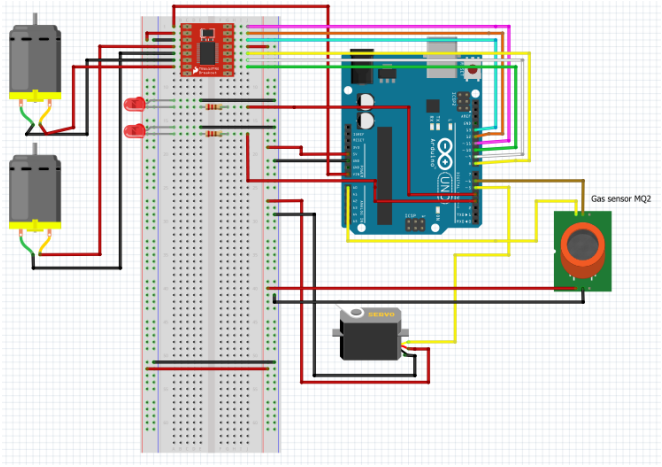

Fig. 8. Smart car system Arduino diagram

consists of the following components:

- Raspberry Pi Model B+.
- Arduino Uno.
- DHT22 (temperature sensor).
- MQ2 (gas sensor).
- Camera to capture images for the driver face to detect eyes and decide if the driver is sleep or not.
- Servo motor to open car windows
- Motors and motor driver to move the car.
- LEDs (car lights).

On the other hand, the smart road system consists of several components that are connected together as shown in Fig. 9. The smart road system consists of the following components:

- Raspberry Pi Model B+.
- Arduino Uno.
- DHT22 (temperature and humidity measurements).
- LDR (measure the light intensity in the environment).

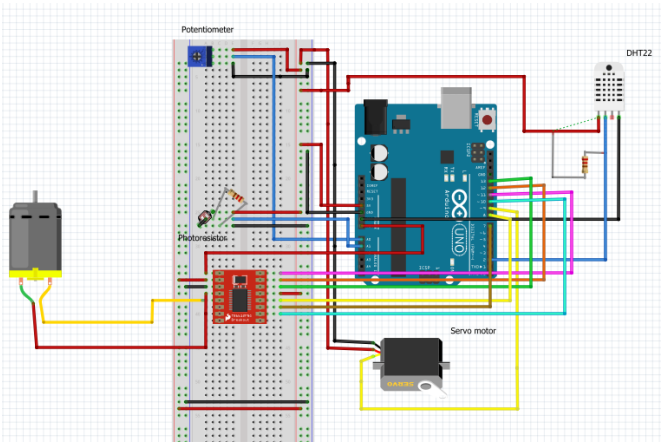

Fig. 9. smart road circuit Arduino diagram

The project 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 tasks needed from them depending on the sensor readings, and to define the pins in the Arduino each component is connected to.

Python is used to to program the raspberry pi to do all data analysis, such as when the camera captures an image. In this case, it sends the image to the raspberry pi, which in turn uses image processing techniques to analyze the image and detect the driver eyes from it. Then it analyzes the status of the eyes, whether opened, or closed, to perform the suitable action depending on that as in Figs. 10, 11, 12, and 13.

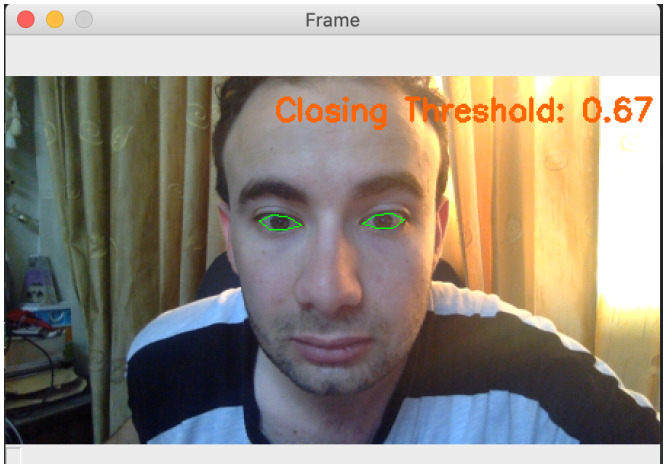

Fig. 10. The front view of the face and eyes are open

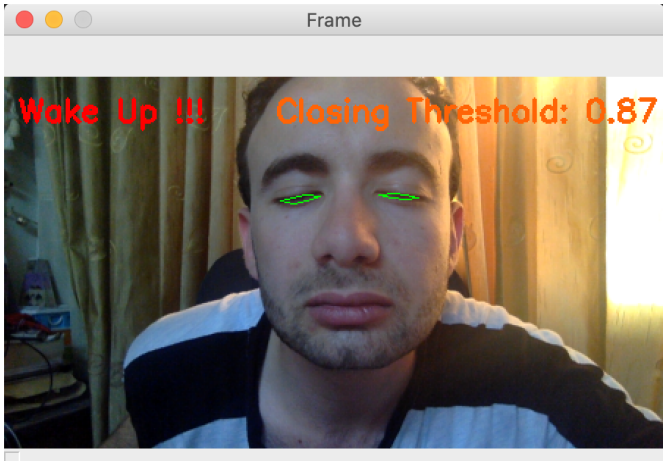

Fig. 11. The front view of the face and eyes are closed

The raspberry pi also manages the communications between the two Arduinos, through the internet, by communicating with the web server using RESTFULL APIs. This is done to program what the server should do and how it will deal with the received requests and how to direct them. To do so, php and SQL are used.

Fig. 12. The side view of the face and eyes are open

Fig. 13. The side view of the face and eyes are closed

Finally an android app was developed using java language. It works when Arduino reads data (temperature, humidity values, whether to turn on lights or not, and the status of the smart bumps) and send it to the raspberry pi which directs that data via the internet to the web server which in turn contacts with the android app to send the data to it, to display them to the user.

V. Conclusion

Traffic accidents numbers increased rapidly in recent days because of different reasons. Many accidents occur either because of environmental conditions surrounding cars or conditions inside the car that may affect the driver, or the driver drowsiness. To reduce the possibility of car accidents because of the mentioned reasons, a system is proposed in this paper. The system is a combination of two subsystems. The first subsystem deals with conditions outside the car such as: humidity, temperature, and so on, or the environmental conditions around the car like: fog, darkness and so on. The second subsystem focuses on the situation inside the car and the drowsiness of the driver. The system is designed to work

by connecting sensors that continuously read data from inside and outside the car, analyze these data and tell actuators to do the right action to avoid car accidents. The two subsystems interact with each other via the internet with the use of a web server to do the job as desired.

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