Helmet-Mounted Display System Based on IoT

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Abstract- Many people enjoy motorcycle riding, but there are thousands of people lost their lives because of road accidents. This is mainly due to the delayed response to emergencies that must be provided to the injured and victims. The helmet-mounted display system that uses the Internet of Things (IoT) reduces accidents and informs its contacts in emergencies, as the helmet module contains sensors to determine the passenger's pulse rate, alcohol content, and vibration intensity. The pulse rate sensor is used to determine whether the rider has worn the helmet and which will be connected to the rider's start of his trip on the road. That's why a prototype proposal was implemented using the (IoT) to connect all devices and make it easier for the user to reduce road accidents by displaying all their needs in full on the helmet screen. Furthermore, in the implementation of our proposal, several systems were connected with Raspberry Pi 4, which are Global Positioning System (GPS) applications, camera systems, and sensors that display all output data in the background, such data will be transmitted after that from Raspberry Pi 4 to Raspberry Pi 3 through User Datagram Protocol (UDP), which Raspberry Pi 3 connected with Digital Light Processing (DLP) projector to display all background data as a hologram to the user giving him safety on the road without any distractions.

***Keywords*— Helmet; Internet of Things; Global Positioning System; Raspberry Pi; Digital Light Processing.**

1. INTRODUCTION

Over the past few years, the world witnessed many road accidents, most of which were caused by drivers' and pedestrians' failure to comply with traffic rules and signs, driving over the speed limit, and the use of phones to talk or exchange messages or browsing social networking while driving, and that most drivers drive their cars, despite feeling sleepy, exhausted, tired, or driving under the influence of a drug that causes drowsiness, or lack of concentration. Despite medical and security warnings, most drivers ignore this, exposing their lives and the lives of others to certain danger [1,2].

Over 3,000 individuals lost their lives on September 11, 2001, when terrorists attacked the World Trade Center's twin towers. Few people are aware that roughly the same number of people globally pass away on roadways every day. This data excludes at least 30,000 more victims of injury or disability. More than a million people die in traffic accidents every year, and it is clear that road traffic injuries represent a significant public health problem worldwide [3]. For instance, more people in Iraq die due to traffic accidents than any other cause, as Iraqis lose their lives on the roadways on average 7,000 times a year, or around two every hour. This means that 25 Iraqis from those who leave their homes every day for work, school, university, shopping, or social events never return home because of traffic accidents [4, 5].

According to Bassam 2017, the number of Iraqis who have died in all of the wars that their country has witnessed is still much lower than the significant number of persons who die in traffic accidents. As a result, the safety of Iraqi society will suffer greatly if the issue of traffic accidents in that country is not properly addressed. A helpful environment for engineers, students, and decision-makers to implement traffic accident prediction and control methods is created when expert system technology is combined with traffic accident prediction and control tactics [6].

The Internet of Things (IoT), which is used to link and establish communication among various devices over the internet, has become an essential component of both industrial and personal duties. The IoT system consists of four basic elements: sensors/devices, connectivity, data processing, and user interface. These elements work together to create a network infrastructure that makes it possible to connect and communicate with things from any location at any time. The gadgets of IoT can be used to remotely monitor a motorcycle without a person being there [7].

Although the IoT has fundamentally altered the way to work, play, and communicate, its full promise has yet to be realized. The full potential of this technological monster will be realized when technology touches people's lives constantly. It will change people's point of view about technology, and the resulting cascade effect will domesticate IoT [8, 9]. Technocrats are building new technologies and protocols, businesses are developing new applications, corporate players are manufacturing the devices, and people are utilizing IoT solutions and services. Despite all the work that has been done, the IoT paradigm will still take some time to develop because the technology and associated ideas are still in their infancy.

The advancement of IoT globally will benefit from the current economic and technological period. However, the strength of this potential technology shouldn't blind us to the problems and difficulties that come with it. To take full advantage of IoT potential and global exposure, more strong implementation techniques must be developed [10,11]. The future of the IoT is evolving from loosely connected devices that will expand the boundaries of the world with physical entities and virtual components. The term IoT was coined recently to represent objects having digital features that may communicate via the Internet and are regarded as a component of the Internet of the future.

In the development of the IoT, the smart helmet was developed so that many devices were connected via the Internet, which facilitated the addition of some things Which meets our needs in the helmet, not only in mechanical safety but also in linking it to communications and electronics by connecting sensors, navigation, cameras for a warning from accidents [12,13].

In the 1960s, many functions were linked to the use of the IoT, and the Head-Up Display (HUD) was first invented to assist pilots while flying, as it was implemented in the cockpit then it was used in many fields such as tanks, modern cars, medical uses, industrial uses & education, and it was also upgraded in fighter planes to also include the pilot's helmet not only the cockpit. Many types of research that have been made on motorcycle smart helmets didn't use this technology which can be added to the driver's helmet as it is also used in the pilot's helmet [14].

In our proposal, the smart helmet display system based on IoT will be introduced, which is an important thing for the driver to preserve his life and also for the people around him to be exposed to road accidents that cause death, and for this, a full safety system was implemented which includes the three main things as follows:

- Projector: Digital Light Processing (DLP) [15] system is used as projector a to show all information forward to the driver as a hologram projection.
- Camera systems: They were used instead of two mirrors in motorcycles and also for image processing to detect the objects on the road.
- Five sensors: MAX 30100, MLX90614, MQ-3, Motion Processing Unit (MPU 9250) [16], and Range Finding Sensor (GY-US42V2) were used to measure Heart rate, measure driver temperature, measure alcohol percentage, detect any accident or fall by measuring the (X, Y, Z) axis, and measuring the distance between the driver and the object forward to the driver respectively.

Our proposal will be presented in several sections, starting with the related works in section II, the main objectives presented in section III, and then identifying a block diagram to clarify what happens inside the helmet during its operation in section IV, some of the main components used in our proposal presented in section V, and finally, the hardware implementation, results, and the final product will be described in section VI and VII respectively.

2. RELATED WORKS

Some products are made for marketing and selling, but not for research. These products focus on the features more than the safety, as they are just presenting speed, back mirror, phone calls & navigation, but in our proposal, some more features were added with more safety. The system will be able to detect any accident by using MPU 9250 sensor and send an e-mail with the driver's coordinates to the emergency contact, the system will be able to detect the driver if he is doing to fall asleep and warn him with a sound warning.

In [11], this study described the design and creation of an IoT-based smart helmet for monitoring the health and safety of underground mine employees in real time. The LoRaWAN wireless protocol was used to connect the intelligent helmet's collection of ambient and flexible body sensors to the cloud, allowing it to communicate with the control center.

In [12] the authors introduced a system quickly connects the Narrow-Band (NB-IoT) module through Microcontroller Units MCUs. Temperature and humidity detection, Global Positioning System (GPS) positioning, and falling alarm technologies were used to get employee and environmental information to the cloud platform.

In [13] This paper introduced helmet circuits, car circuits, and mobile applications to prevent accidents. The helmet circuit used Infra-Red (IR) and alcohol detection sensors, the car circuit used a 3-axis accelerometer, Bluetooth module, relay, and load sensor, and after an accident was detected, a mobile application automatically sent the accident location to police and emergency contact numbers via the database.

In [17] the vibration sensors and accelerometers were used by the system to find accidents. GPS and Global System for Mobile communication (GSM) modules were employed for locates the site of the accident and correspondingly inform the person's near and nearby hospitals through a text message. Additionally, this approach provided a method for identifying whether the individual riding the bike has current license driving privileges, if any, or even driving privileges at all driving license Radio Frequency Identification (RFID).

In [18], the authors used the Helmet Unit (HU) and a Motorbike Unit (MU). Both units communicate via Radio Frequency (RF). The helmet unit has sensors to determine the pulse rate of the rider, the alcohol content in the breath of the rider, and the intensity of vibration. They used also the GPS and GSM modules in MU to send messages with location to emergency contacts in case of any mishap. Each unit has a separate accelerometer for detecting an accident. The sensor used on MU helps in ensuring that the rider is sitting properly, not overspreading, and driving safely.

In [19] the author used an MQ-3 alcohol sensor [13], to detect any kind of alcohol, an IR sensor to detect if the driver is wearing a helmet or not, and also used a GPS & GSM module to chase the location of the bike rider and send a text message to the members of the family. In [20] an accident detection system based on the acceleration difference was used, also an alcohol sensor to avoid the driver from driving while drunk, and a face recognition system was used to allow only authorized persons to use the vehicle, Vehicle to Vehicle (V2V) communication system and drowsiness detection were used also to detect if the driver is going to fall asleep. In the previous related works, none of them offered all the features at once in addition to the presence of a set of loopholes, our proposal was managed more efficiently and more effectively through hardware implementation and system verification by using many features at the same time. Table 1 summarizes the previous studies in the related works.

3. OBJECTIVES OF THE PROPOSED HELMET

There are many smart helmets on the market but our smart helmet is a special one it is special because it has a very important feature which is the projection style in addition to many cool and safety features which will be projected in front of the driver to help him while driving. Furthermore, a range finder sonar distance measuring sensor GY-US42v2 [21] is used to detect an object and warn the driver in the form of a warning sign. So, object detection was needed to be able to detect objects from the front side so webcam-1 and webcam-2 were used instead of the mirrors in motorcycles. These cameras are used as follows:

- **Webcam-1** is used for the driver's eye-tracking to see what is the driver looking at. And used for the iris scanner.

Table 1. The previous studies in the related works

Ref.	Date of Publication	Main Contribution
11	2016	The LoRaWAN wireless protocol was used to connect the smart helmet's collection of ambient and flexible body sensors to the cloud.
12	2021	An NB-IoT module was connected through MCUs. Temperature and humidity detection, GPS positioning, and falling alarm technologies were used also.
13	2020	It used many types of sensors such as IR and alcohol for the accident detection algorithm and the mobile application was used to send an accident location automatically to police and emergency contact numbers.
17	2018	The system used accelerometers and vibration sensors to detect accidents. RFID was used to determine whether the person riding the bike had a valid driver's license and GPS and GSM modules were employed also for locates the site of the accident
18	2020	The sensors in The HU unit and the GPS, and GSM module in the MU are connected via RF to implement the proposed for enhancing Safety in a two-wheeler
19	2020	A GPS & GSM module was used to track down the location of the bike rider, an IR was used also to determine whether or not the driver was wearing a helmet, and an MQ-3 alcohol sensor detected any amount of alcohol.
20	2021	An alcohol sensor was used to prevent drivers from operating vehicles while intoxicated, an accident detection system based on acceleration difference was used also, in addition, a face recognition system to ensure that only authorized users operate the vehicle.

- **Webcam-2** is used for object detection, recording videos, and saving them & it is used to warn the driver of any obstacles and differentiates between many objects that can be found in the street.

For the driver's safety, some sensors were added that will keep track of his health such as MAX 30100 [22] a sensor to measure heart rate and O_2 in the blood. if the driver's O_2 in the blood goes lower than 85% or the heart rate goes more than 150 or lower than 55 the sensor will send acknowledgment if he didn't respond it will call the emergency contact, MLX90614 [23] it is a temperature sensor used to measure driver temperature if it goes over 38.5 the sensor will send an acknowledgment if he didn't respond it will call the emergency contact, MQ-3 it is an alcohol sensor is used to measure alcohol percentage and MPU 9250, it is a multi-functional sensor detects any accident or fall by measuring the (X, Y, Z) axis the sensor will send an acknowledgment that if he didn't respond it will call the emergency contact. It will also measure the speed and the atmospheric temperature.

4. BLOCK MODEL OF THE SMART HELMET

In this section, the main four sections of our proposal will be described as shown in Figure 1. Firstly, the DLP [15], secondly the camera system, thirdly the sensors system, and finally GPS Application [17,18,19,24]. The first section is DLP or hologram projection which is used to present all information or outputs data from all systems as shown in Figure 1 which are GPS application systems, camera systems, and sensors as a background that come from Raspberry Pi 4 through User Datagram Protocol (UDP) to Raspberry Pi 3 which is connected to DLP.

The second section is the camera system which includes two webcams, the first webcam is used instead of two mirrors on a motorcycle while the second webcam is used for object detection on the road and makes any warning if seeing objects or traffic lights to take attention.

The Third section is sensors, five sensors were used, four of them are connected with "Raspberry Pi 4" through I2C protocol [25], and the last one is connected to the "Raspberry pi" as GPIO 25 at PIN 22, the first sensor is called MAX 30100 that is used for measuring heartbeat rate and oxygen in the blood, the second sensor is called MLX90614 which used for measuring the temperature for the body, the third sensor is called GY-US42V2 which used for measuring the distance between the driver and the object forward to the driver, the fourth sensor is called MPU 9250 which was used for falling detection, measuring velocity, magnetometer and outside temperature, the last GPIO sensor is called MQ-3 which used for detecting alcohol.

The last section is GPS Application, which was used for navigating the directions for the users from starting point to the ending point with latitude and longitude. So, after collecting all directions from GPS, it will be sent to "Raspberry Pi 4" by using UDP [26] to show all directions gradually on the helmet's glass through a projector as arrows to track it and follow the directions to his destination point.

5. COMPONENTS USED IN THE PROPOSED SYSTEM

In this section, the main components used in our proposal will be described (see Table 2) as follows:

A. Raspberry Pi: It is used as computer hardware, technology, and free and open-source microcontroller that can be programmed, erased, and reprogrammed at any time, in our proposal, Raspberry Pi 3 was connected with a DLP projector through a PCB board circuit, and Raspberry Pi 4 was connected with all sensors, cameras, and GPS Application.

B. DLP: It connects to Raspberry Pi and presents all information that comes from (sensors, GPS Applications, and Multi-cam).

C. GPS Application: It is an important technology for determining location. it collects data direction and presents with a DLP projector by using the mobile phone.

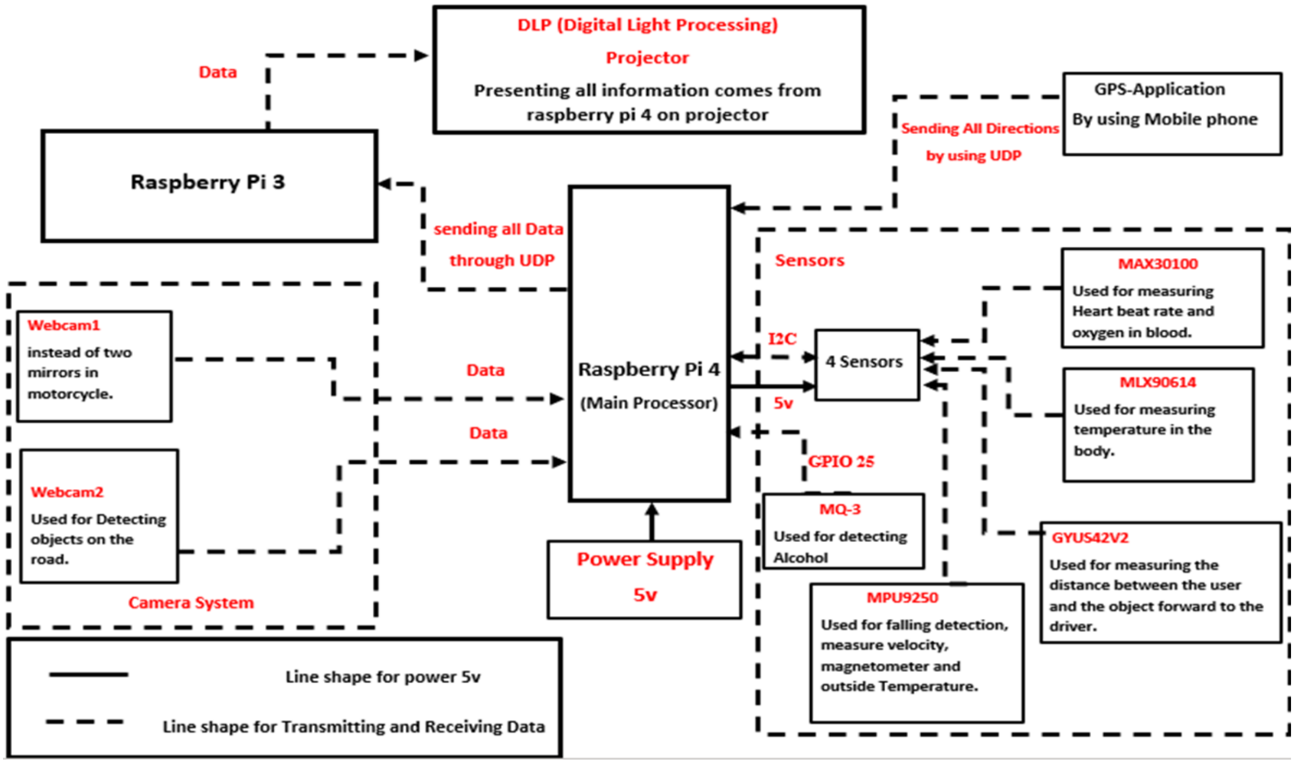


Figure 1. Block model for smart helmet system

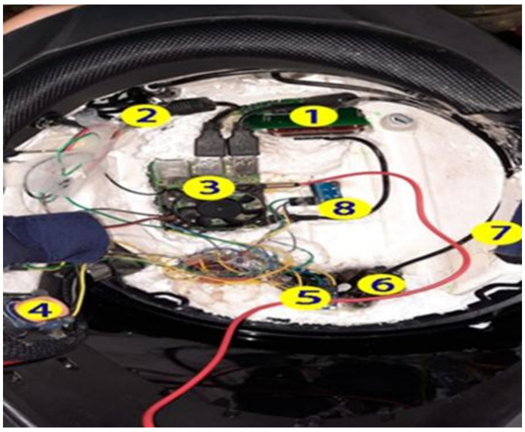
D. GY-US42v2: This is an instrument that measures the distance to an object using sound waves, ultrasonic sensor uses a transducer to send and receive ultrasonic pulses that relay back information about an object's proximity and collect the data and sent it to Raspberry Pi to present data with DLP.
E. MPU 9250: This is used for fall body detection, measuring velocity, magnetometer, and outside temperature. It connects to Raspberry Pi by using I2C protocol and presents the data with DLP.
F. Alcohol sensor MQ-3. It connects with Raspberry pi 4 by using I2C and is used here for detecting the alcohol concentration present in the driver's breath.
G. MLX90614 [23, 27]. It connects to Raspberry Pi 4 by using the I2C protocol and it is used for measuring body temperature.
H. MAX 30100 EGC Oximeter sensor: It connects to Raspberry Pi 4 by using I2C and is used to measure heartbeat rate and oxygen in the blood.
I. Webcam-1: It connects to Raspberry Pi 4 through Universal Serial Bus (USB) and is used instead of two mirrors to see all roads from his back.
J. Webcam-2: It connects to Raspberry Pi 4 through USB and is used to detect objects, record video and save it, and is used to warn the driver about any object especially if he didn't catch it, and differentiate between a pedestrian or a car or a van or a lane or a traffic light or a zebra crossing.

6. HARDWARE IMPLEMENTATION

In a hardware implementation, (Interior and Exterior designs shown in Figure 2a and Figure 2b respectively), each component inside and outside the helmet will be described as follows: no.1 is Raspberry Pi 3 connected with a DLP projector through a PCB board circuit, no.2 is the region for webcam-1 to show the user all road from his back instead of two mirrors in motorcycle. No.3 is the region for Raspberry Pi 4 which connect with all sensors, cameras, and GPS application, no.4 is the region for MQ-3 sensor which detect any alcohol and deciding to take an action, while no.5 is the region for MLX90614 sensor which is used to detect the temperature of the user and taking an action.

Table 2. The main components Used in The proposed system

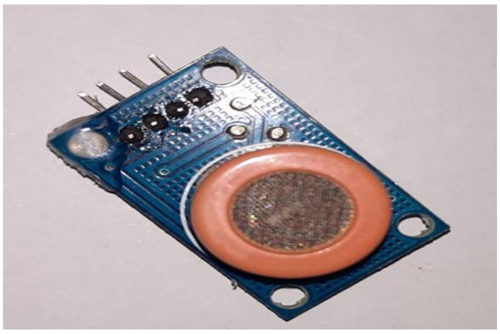
Items	Names	benefits	Cost/LE
1	Raspberry Pi 3	Connected with a DLP projector through a PCB board circuit	1200
2	Webcam1	Show the user all road	80
3	Raspberry Pi 4	Connect with all sensors, cameras, and GPS Applications	2600
4	MQ-3 sensor	Detect any alcohol	55
5	MLX-90614 Sensor	Detect the temperature	400
6	Webcam-2	Detecting objects, lanes, and traffic lights on the road.	80
7	MAX 30100	Measure heart beat rate and oxygen in the blood	85
8	MPU9250 Sensor	Body detection, measuring velocity, and magnetometer and outside temperature.	220
9	GYUS42V2 Sensor	Measure the distance between the user and the object	290
10	Packaging	It's a packaging shape to protect the DLP projector and Raspberry Pi 3	1500
Total cost			6,510



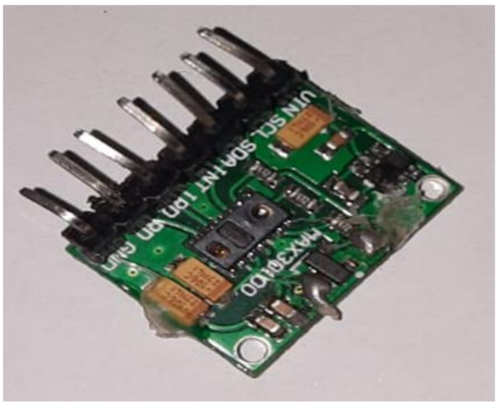
(a)

(b)

Figure 2. Hardware implementation
(a) Interior design, (b) Exterior design.



(a)



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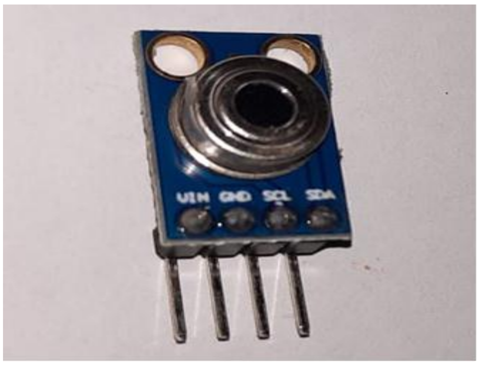

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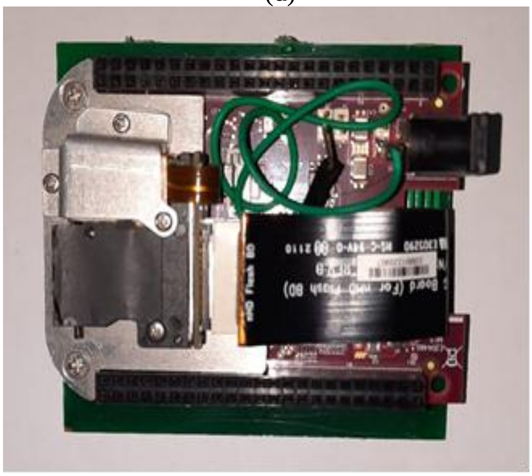

(e)

Figure 3. (a) MQ-3, (b) Max30100, (c) MLX90614, (d) GY-US42V2, and (e) DLP

No.6 is the region for webcam-2 which is used for detecting objects, lane and traffic lights on the road, and no.7 is the region for MAX 30100 sensor which is used for measure heart beat rate and oxygen in the blood. No.8 is the region for the MPU9250 sensor which is used for fall body detection, measuring velocity, and magnetometer and outside temperature, no.9 is the region for Range Finding Sensor (GYUS42V2) which is used to measure the distance between the user and the object give him warning on the screen for making him slow his speed. Finally, no.10 is the Packaging; It's a packaging shape to protect the DLP projector and Raspberry Pi 3. For more clarification of the main components used in our proposal, in Figure 3, MQ-3, Max30100, MLX90614, GY-US42V2 sensors, and DLP will be shown beginning with the MQ-3 in Figure 3a to DLP in Fig.3e.

7. RESULTS FOR THE DIVER AND THE FINAL PRODUCT

A. *Results for diver*

As shown in Figure 4, the GPS application shows the user the direction from his current location to another position, and also, the map was created to be centralized on the location sensor which the map moves with the user. The map is updated or rerouted to new position place, so after that, all these data send to the Raspberry Pi through UDP. Finally, the DLP projector, as shown in Figure 5, concatenates the directions that come from GPS Application, date, and time to be easy for the user. The output of sensors was shown for the user, and functions that if the person has an emergency with his temperature, heartbeat rate and percentage of his oxygen in the blood. So, the system will send this emergency as an email to save him, also by using a sensor the system will show warning you have to drive slowly because there is an object exists in front of him.

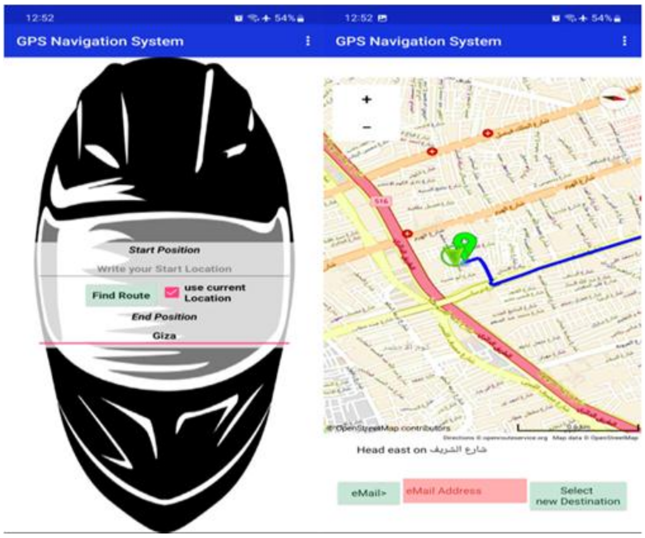

Figure 4. GPS application

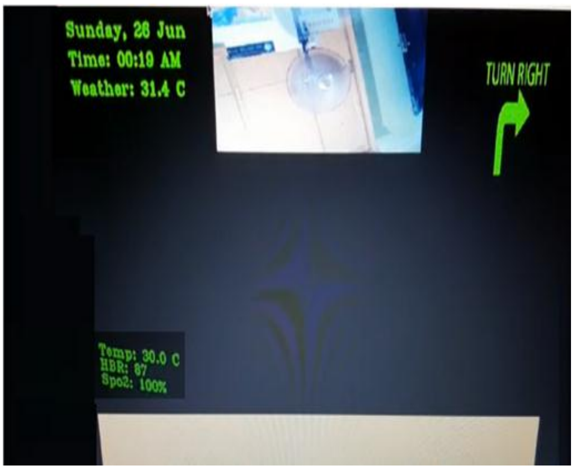

Figure 5. All outputs from the DLP projector

Two cameras were added to the system one of them is used to show the road from his back instead of using mirrors and the other is used for detecting objects and also warning him in night mode. In the DLP Projector shown in Figure 5 on the top of the left side the date and name of the day in the first row, followed by time and weather temperature will be presented in the last row. At the top of the right, the direction of the driver's trip taken from GPS will appear. Finally, on the left down of the projector, the temperature of the driver, Heart Beat Rate (HBR), and percentage of his oxygen (SPO2) appeared, respectively.

B. *Final product*

In Figures 6 and 7, the final product of our proposal which contains all components described in previous sections will be presented in the plan and front view respectively, in the plan view, the adaptor with a +5 v power supply was needed, in marketing-wise, the adaptor will be replaced by a simple battery +5 v. In the front view the final product which ready to be used by clients at a compatible cost (see Table 2), and without any external tools that can disturb the driver in driving the vehicle.

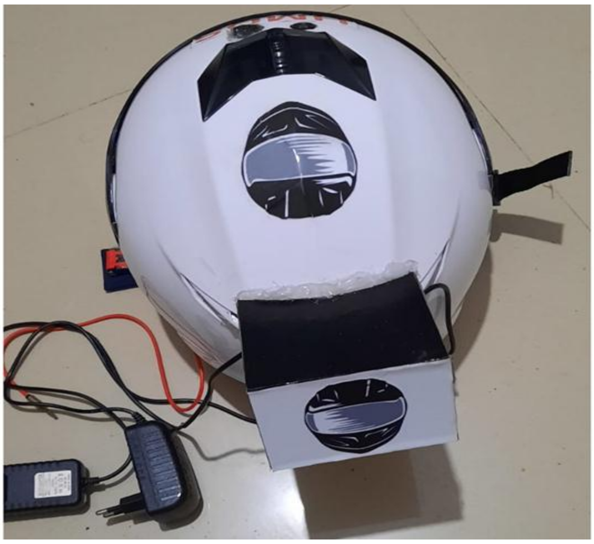

Figure 6. Plan view of the final product

Figure 7. Front view of the final product

8 CONCLUSION AND FUTURE WORKS

The proposed smart helmet based on IoT was managed more efficiently through hardware implementation and system verification by using many features with minimum cost. The MQ-3, MLX-90614, MAX 30100, MPU9250, and GYUS42V2 sensors were connected through Raspberry Pi 4 with cameras, and a GPS application to establish the main part of our proposal which is responsible for collecting important data such as alcohol percentage, the temperature of the driver, heartbeat rate, body detection, as well as measuring velocity, and measure the distance between the user and the object. all systems were easy for the user which is displayed from the DLP projector as a hologram and presents all information that is coming from sensors, GPS applications, and two webcams, all these systems are connected with Raspberry Pi 4 due to the strength of the processor which can process or running all systems in parallel without reducing the strength of processor in Raspberry Pi 4, by using UDP all systems compressed and transmitted to Raspberry Pi 3 which is connected to DLP for displaying all information to the user, which is very clear and easy to use. Finally, our helmet has been practically tested over 3 months and all the data shown on the DLP projector was collected from real driver tests and that's part of it, which conveyed positive feedback.

In future work, sound control system (Alexa) will be recommended to explore vehicle automation that is controlled through voice commands via the echo, and send SMS messages instead of using email, control of the system using eye pupils will be also important. Finally, the new system collects all data output from the different features to make a large dataset used in a comparable algorithm of deep learning

ACKNOWLEDGMENTS

We appreciate the help from engineer Hassan Gamal Mohamed's technical aspects for the completion of this research paper.

Funding:

This research has not received any type of funding.

Conflicts of Interest:

The authors declare that there is no conflict of interest.

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