Applications of internet of things for monitoring drivers- a comprehensive study

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Article Info

ABSTRACT

Driving is a complex task that involves interacting adequately with the vehicle and the environmental changes simultaneously. Drivers' health is an essential factor in determining performance outcomes and enhancing road safety. It is a known reality that drivers with sudden health complications are most likely to be involved in road accidents and suffer several injuries. Besides that, drunk driving is another aspect of a significant public health issue, where drivers under the influence of alcohol show a clear vision loss and vehicle control. The internet of things (IoT) is a trendsetting advancement in which all sensor data can be collected in the cloud. In this paper, an active monitoring tool is developed to record the driver's heart rate if these readings reach vital values while on the move. Additionally, the tool monitors the driver's alcohol concentration, and if it rises beyond a certain threshold, an alarm is sent to the designated emergency contact. The tool has been tested and has been found to work satisfactorily.

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1. INTRODUCTION

The internet of things (IoT) directly links thousands of cutting-edge technologies such as sensors, processors, nodes, switches, and networks. These physical devices communicate and interact wirelessly. Interconnected devices exchange information and data without user interaction [1], [2]. The widespread rollout of IoT in manufacturing industries was first observed to incorporate flexibility and reduced production costs. Ultimately, its applicability has evolved into more commercial and general use [3]-[4]. Nevertheless, the possibilities that IoT brings to the automotive industry are truly enormous. There are different kinds of use cases IoT has advanced for the way people relate with their vehicles. These are summarised in Figure 1 [5].

The fundamental notion of the IoT can significantly improve the standard of living and safety of drivers on the road. According to recent research published by the World Health Organization (WHO), a percentage of road accidents are caused by sudden health abnormalities that develop while driving under certain circumstances [6]. Additionally, there has been an increase in drunk driving, resulting in numerous deaths and damage to many on-side properties [7]. According to the ministry of transport, while road safety statistics have improved over the past two years, there are even more opportunities to reduce fatalities and severe injuries on the roads [8], [9]. On another note, the authorities also warned that technology is only the start, as it is necessary to cultivate the right mentality to act on the collected data [10].

IoT is a combination of the two terms that are Internet and things. The first term is the internet; the internet is defined as a network that offers a wide range of information and connectivity connecting thousands

of users to specific typical internet protocols [11]. Various sectors and departments are connected via the Internet through multiple technologies to maintain communication and transfer relevant information. Several technologies such as computers, mobile phones, and business organisations connect to the internet [12]. The second term is things; things are those objects that become intelligent by putting in a technological device [13]. Thus, integrating IoT and vehicles can provide an assistance system that can monitor driver health abnormalities or alcohol levels to prevent crashes while driving on the road [14]-[16]. The following section will address health abnormalities and alcohol in greater detail.
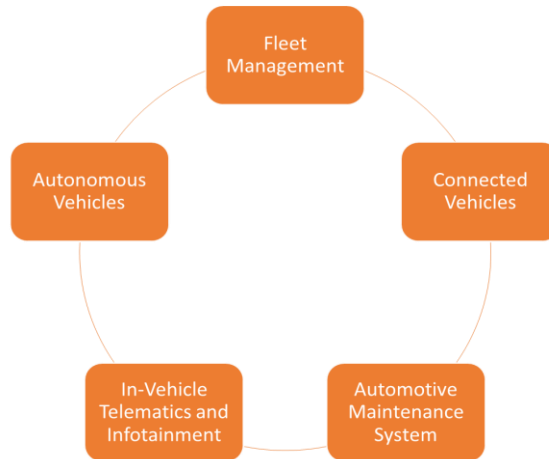

Figure 1. Different IoT use case for vehicles [5]

Health abnormalities are described as a condition or behaviour that is not usual or different from what is considered normal [17]. An example of health abnormalities is heart episodes. Heart episodes can take place at any time, including while driving on the road [18]-[20]. One in four deaths is related to heart disease, making it a fraction of the cause of death [21]. Common heart diseases include coronary heart disease (CAD), which can weaken the heart and cause heart failure [18]. Furthermore, an irregular heartbeat, also known as arrhythmia, with atrial fibrillation (AFib) is another frequent cause of heart failure [22]. For instance, some cases related to sudden heart failure or seizures while driving has resulted in severe injuries to road users in Malaysia. Figure 2 briefly shows the chronology of specific use cases. Several research studies have also uncovered a framework that monitors heart rate, as shown in Table 1.
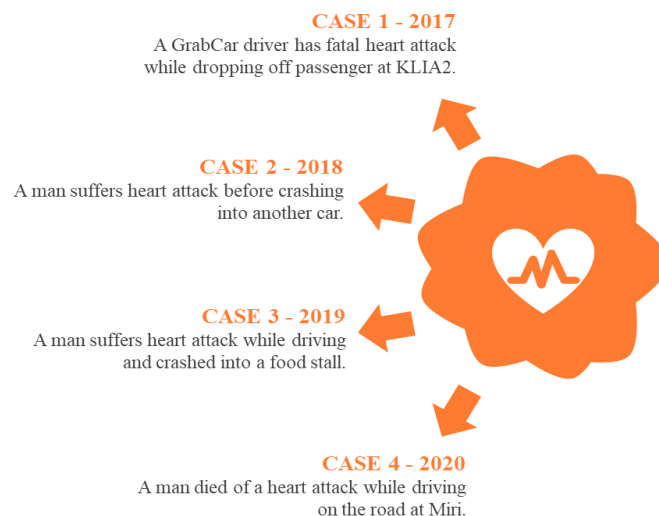

CASE 1 - 2017
A GrabCar driver has fatal heart attack while dropping off passenger at KLIA2.

CASE 2 - 2018
A man suffers heart attack before crashing into another car.

CASE 3 - 2019
A man suffers heart attack while driving and crashed into a food stall.

CASE 4 - 2020
A man died of a heart attack while driving on the road at Miri.

Figure 2. Use cases of heart attack while driving in Malaysia [23]-[26]

Table 1. Previous studies on health state monitoring

Authors	Contributions
Cherif *et al.* (2020) [27]	This article describes a smart system that can remotely monitor a driver's health status in real time. The authors aim to produce an intelligent and connected steering wheel that detects physiological signals and alerts the driver. The monitoring of heart rate and its variations was the primary focus of the study. During certain conditions, the driver will receive an alert, and the information will be forwarded to the healthcare professional in the event of an emergency.
Chowdhury *et al.* (2019) [28]	This paper aims to describe a wearable real-time heart attack monitoring and warning system for drivers. The authors aim for the accurate detection of symptoms of heart attack events. The system continuously monitors the driver's ECG, and if there are any pre-symptoms, the driver is informed to pull over to the side. An alert is sent to the medical service team with the driver's location in such a context.
Leicht *et al.* (2018) [29]	This article describes capacitive ECG monitoring in cardiac patients in simulated driving situations. The authors seek to compare the value of a classic galvanic reference ECG (rECG) to a capacitively coupled electrocardiogram (cECG) in patients. rECG and cECG data were instinctively assessed by two cardiologists in terms of artefacts, available data for differential diagnosis, signal quality, ECG time intervals, and ECG structures visibility.
Khan and Cho (2017) [30]	This paper describes the use of infrared UWB for breath and human heart rate monitoring. The authors aim to extract respiratory and cardiac frequencies from the reflective signal of the human body. The measurement process incorporates an auto-correlation technique to detect random body movements. Based on the experiment, the result shows more outliers in the conventional algorithm's measured values than the proposed algorithm.
Sun and Yu (2014) [31]	This article addresses a non-intrusive biopotential measuring method for health monitoring and driver drowsiness detection. The study was brought out to monitor biopotential signals without interacting directly with intact skin remotely. The measurement is based on delicate sensors and electronic designs. As a result of this experiment, the system detected EEG or ECG signals without skin contact.

Driving with blood alcohol content (BAC) is sometimes referred to as driving under the influence of alcohol (DUI) or impaired driving (ID) [32], [33]. Any amount of alcohol in an individual's bloodstream can affect their ability to drive. The effects of alcohol consumption vary greatly, which means that a person is at risk of causing an accident or injury on the road [34], [35]. On average, alcohol-related accidents are the highest in the majority of Asian countries [36]. For example, a few cases are associated with the risk of alcohol accidents in Malaysia, including the person causing severe injury and even death to other road users. Figure 3 briefly shows the sequence of events of specific use cases. Several research projects have also identified a framework for monitoring alcohol levels in drivers, as shown in Table 2.

CASE 1 - 2017
A man rammed into another car under the influence of alcohol

CASE 2 - 2018
A woman under the influence of alcohol rammed into another car at Tawau.

CASE 3 - 2019
A man driving under the influence of alcohol slammed into a roadside kuih stall.

CASE 4 - 2020
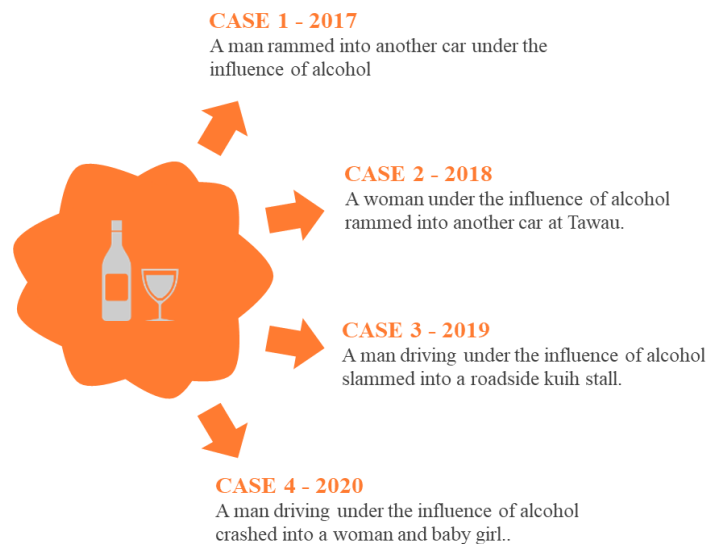A man driving under the influence of alcohol crashed into a woman and baby girl..

Figure 3. Use cases of alcohol consumption while driving in Malaysia [37]-[40]

Thus, this paper presents a tool that monitors the heart rate and detects the alcohol concentration of drivers while on the move. If the readings reach a vital level in the state, the emergency contact will be notified, and the readings will also be sent to the cloud for further analysis. This paper is organised as follows; Section 2 elaborates on its importance for monitoring drivers specifically in terms of health abnormalities and alcohol. The framework of the proposed work is shown in section 3. In section 4, the testing outcomes are presented. In the last section, the conclusion and future direction are highlighted.

Table 2. Previous studies on alcohol level detection

Authors	Contributions
Shukla *et al.* (2020) [41]	This paper describes an automatic engine locking system due to alcohol detection. The authors aim to design a continuous monitoring tool of alcohol concentration. The prototype includes several sensors and hardware modules that monitor constantly. If the attention is above the threshold value, a message is sent to the smartphone of the current vehicle location.
Mandal *et al.* (2020) [42]	This article describes a system for detecting alcohol and checking the safety belt. The authors seek to develop a system to ensure that drivers wear seatbelts and are alcohol-free before driving. The development includes connectivity of the processing unit as well as sensors. This experiment demonstrated that the prototype could determine the state of the seat belt and the concentration of alcohol.
Montalvo *et al.* (2019) [43]	This research proposes a multivariate technique for detecting alcohol in drivers equipped with artificial vision and sensors. The authors aim to detect excessive drinking in drivers to reduce road accidents. Variable measurement includes the use of sensitive sensors and synthetic vision. The criteria implemented to acquire the user's data were correct, as they enabled the user's alcohol consumption to be satisfactorily determined.
Wakana *et al.* (2018) [44]	This article discusses a portable alcohol detection device that is capable of respiratory recognition. The authors choose to create a portable device that detects alcohol in the breath using a non-contact breath detector. The device comprises a casing with input for breathing, a USB connection for connecting a smartphone, and a PCB. During the experiment, the equipment was able to identify saturated water vapour and human breath metabolite.
Sandeep *et al.* (2017) [45]	This paper describes an IoT-based drunken driving/fatigue detection and prevention model. The author aims to use IoT to protect drivers from road accidents due to fatigue and drunk driving. The system was developed to comprise dedicated sensors and hardware modules. If there is a detection of alcohol consumption or fatigue, an alarm is triggered along with an automatic ignition turn-off.

2. METHOD

The main idea behind this work is to develop a kind of tool to monitor the driver's heart rate and alcohol concentration while on the road. The main component used for the design of this project is arduino UNO, MQ3 sensor, impulse sensor, GSM module, buzzer, and LEDs. The working principle is shown in Figure 4, while the flowchart diagram is shown in Figure 5.
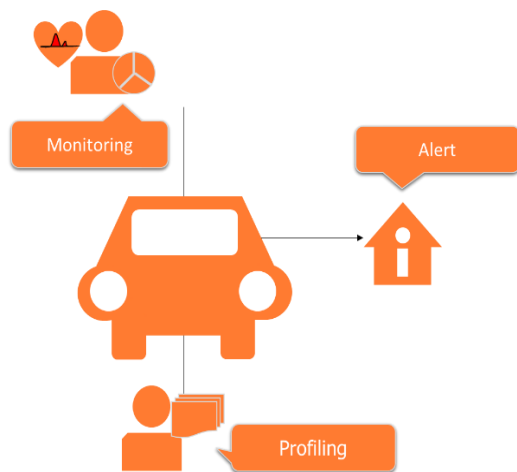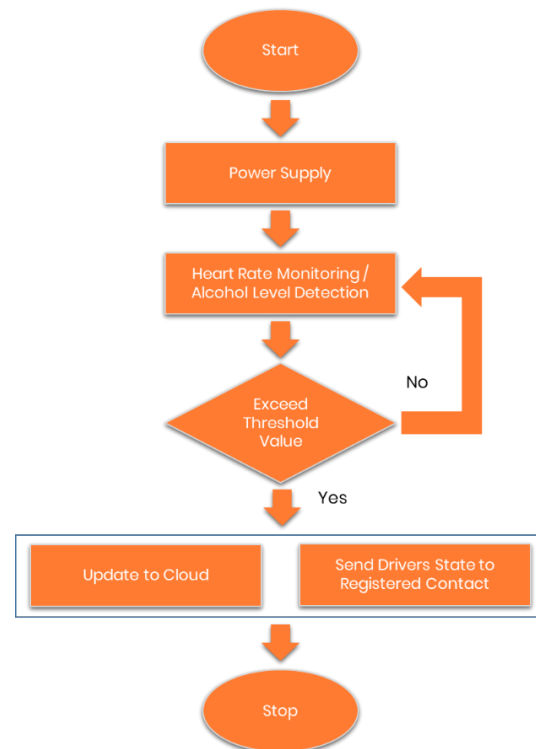

Figure 4. Working principle

Figure 5. Flowchart

Figure 6 shows the breadboard diagram of the prototype development. Components such as microcontrollers and sensors are more easily seen on a breadboard diagram, which helps design the prototype. This may ensure that the required goals are met and the desired outcomes are achieved. The components connected by connectors are shown in Figure 6.
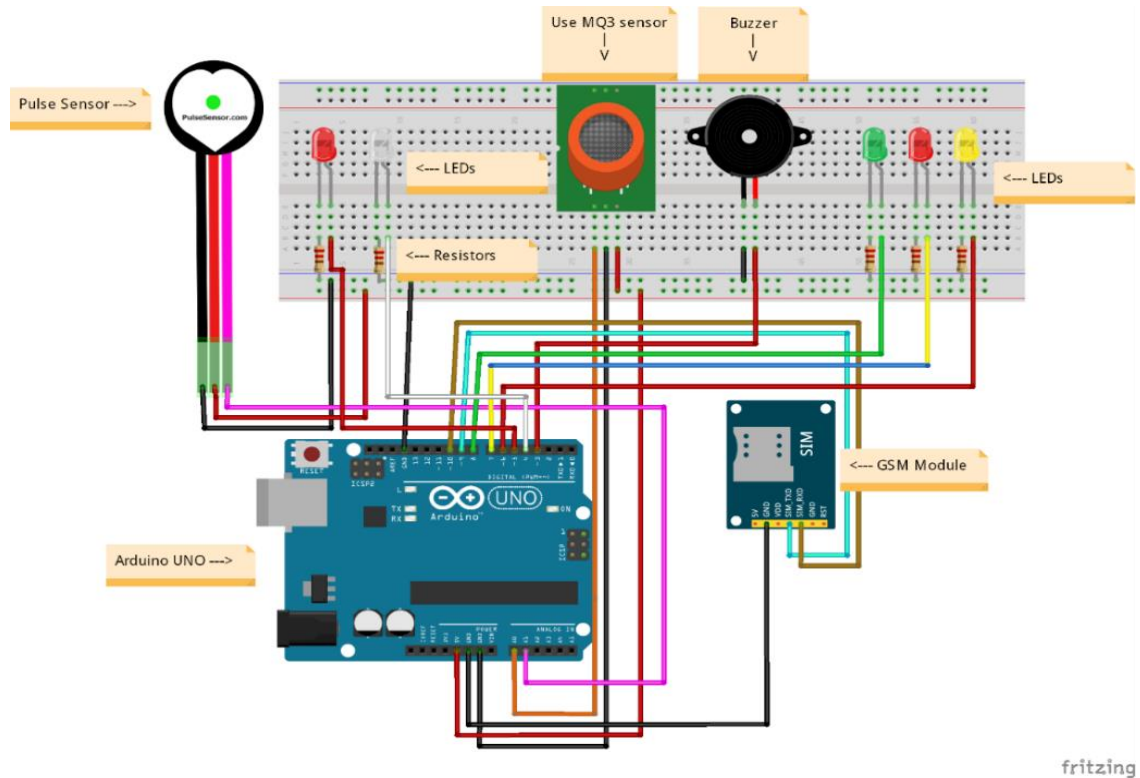
Figure 6. Breadboard diagram

3.   RESULT AND DISCUSSION

The prototype comprises an arduino UNO microcontroller connected to the arduino IDE, which uploads and executes the programmes required to operate it. Putting one's finger on the pulse sensor is the initial step in this procedure. The tool is equipped with two LEDs, one of which emits red light and the other of which emits white light (placed inside the box). The red light switches on in the context of the heart rate are abnormal, while the white light constantly flashes to indicate the heart rate. On the other hand, the tool detects alcohol, placed near the steering to detect the concentration. The tool has three additional LEDs, where the green light is normal, blue light is slightly concentrated, and yellow is heavily concentrated. If the yellow light is constantly present, the information is sent to the emergency contact person and recorded in the cloud for profiling. The prototype itself is illustrated in Figure 7, which includes car steering and sensor positioning. Figures 8 and 9 demonstrate the outcome of heart rate monitoring and alcohol concentration detection, respectively.

Figure 7. Prototype

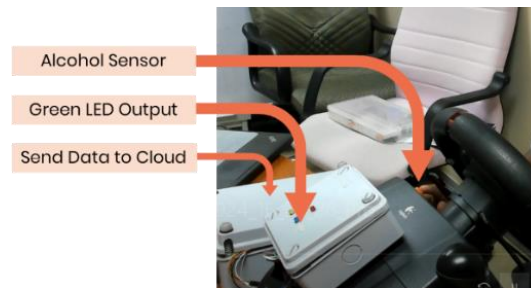Figure 8. Heart rate testing condition

Figure 9. Alcohol testing condition

Although sensors deployed were cost-effective, it does nevertheless produce an adequeate output. Following the completion of the testing, the proposed prototype was found to be capable of monitoring the heart rate of any individual while also detecting the presence of alcohol in a laboratory-controlled environment. Table 3 depicts the total time required by the prototype to perform the whole measurement and sensing procedure.

Table 3. Prototype time required to complete the procedure

Procedure	Time Taken
Monitoring of Heart Rate with Pulse Sensor	1 to 3 seconds
Detection Alcohol Concentration with MQ3 Sensor	1 to 3 seconds

4. CONCLUSION

The internet of things (IoT) makes transformative changes possible, and there is no doubt that the automotive industry is changing rapidly. This paper presents the conceptual approach of IoT for monitoring drivers regarding health abnormalities (heart rate) and alcohol concentration (level). Based on the test, the prototype developed can monitor the heart rate and detect alcohol concentration. An LED indication has demonstrated the heart rate and alcohol concentration output. If the threshold value is exceeded in this instance, the buzzer will sound, and the information will be transmitted to the cloud. The prototype is currently being tested in a monitored laboratory. As for the future direction where the developed prototype is packaged to be tested in the vehicle. This could identify the factors of any influence upon the readings.

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