UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF WARNING ALERT SYSTEM FOR MOTORCYCLIST RELATED TO FATIGUE AND DROWSINESS USING ELECTROCARDIOGRAPHY (ECG) SENSOR

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electronic Engineering Technology (Telecommunication) with Honours.

by

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DECLARATION

I hereby, declared this report entitled DEVELOPMENT OF WARNING ALERT SYSTEM FOR MOTORCYCLIST RELATED TO FATIGUE AND DROWSINESS USING ELECTROCARDIOGRAPHY (ECG) SENSOR is the results of my own research except as cited in references.

Signature: ……………………………………………

Author : AZWIN DAMIA BINTI ABDUL HALIM

Date: 15/01/2021

APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Telecommunication) with Honours. The member of the supervisory is as follow:

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Supervisor : NORLEZAH BINTI HASHIM

Signature: ……………………………………………………………

Co-supervisor: DAYANASARI BINTI ABDUL HADI

ABSTRAK

Projek ini adalah mengenai pembanguna sistem amaran untuk penunggang motosikal yang berkaitan dengan keletihan dan mengantuk yang dibina dengan sensor Elektrokardiografi (ECG) dan Arduino UNO. Projek ini dapat memantau aktiviti elektrik jantung penunggang motosikal. Terdapat tiga faktor sebagai penyumbang utama keletihan dan mengantuk. Faktor pertama ialah tekanan tingkah laku yang disebabkan oleh kurang tidurnya waktu. Seterusnya, faktor fizikal dan fisiologi adalah faktor sekunder yang disebabkan oleh kurang bersenam dan kebosanan. Faktor ketiga disebabkan oleh kesihatan perubatan dan neurologi yang dialami oleh penunggang motosikal. Objektif projek ini adalah untuk membangunkan sistem amaran yang berkaitan dengan keletihan dan mengantuk untuk penunggang motosikal dan juga untuk menganalisis prestasi sistem yang dirancang dari segi fungsi. Hasil dari projek ini menunjukkan bahawa jika penunggang motosikal berada dalam keadaan mengantuk, bunyi nada tinggi akan tercetus dari bel. Hasil dari projek ini akan dipantau melalui monitor bersiri dan plotter bersiri dari Arduino IDE.

ABSTRACT

This project is about a development of warning alert system for motorcyclist related to fatigue and drowsiness that is built with Electrocardiography (ECG) sensor and Arduino UNO. This project is able to monitor the heart electrical activity of a motorcyclist. There are three factors as the main contributor to fatigue and drowsiness. The first factor is the stress of behavior that results from lack of time sleep. Next, the physical and physiological factors are secondary factors caused by lack of exercise and boredom. The third factor is caused by medical and neurological health experienced by the motorcyclists. The objective of this project is to develop a warning alert system related to fatigue and drowsiness for motorcyclist and also to analyze the performance of the system designed in terms the functionality. Result from this project show that if the motorcyclist is in a drowsy state, a high pitch sound will trigger from the buzzer. The outcomes from this project will be monitored through the serial monitor and serial plotter of Arduino IDE.

DEDICATION

Special dedication to my beloved parents.

ABDUL HALIM BIN ASHARI

AZIMAH BINTI ABD AZIZ

My family,

(Adibah Durar Binti Abdul Halim, Azib Aiman Bin Abdul Halim and Muhammad Yasin Bin Abdul Halim)

My soft and kind hearted supervisor,

NORLEZAH BINTI HASHIM

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V	-	Voltage
GND	-	Ground
VCC	-	voltage at the common collector

LIST OF ABBREVIATIONS

Arduino IDE	Arduino Integrated Development Environment
BPM	Beats per Minute
DC	Direct Current
EAR	Eye Aspect Ratio
ECG	Electrocardiography
EEG	Electroencephalography
GND	Ground
HF	High Frequency
HRV	Heart Rate Variability
LA	Left Arm
LED	Light Emitting Diode
LH	Low Frequency
PCB	Printed Circuit Board
PPG	Photoplethysmography
PSD	Power Spectral Density
RA	Right Arm
RL	Right Leg
USB	Universal Serial Bus

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter explains in detail the project and the implementation of the project. This first chapter will then cover the background of the project, the problem statement, the objective and the scope of the project.

1.2 Project Background

A major problem in Malaysia is motor vehicle accident, also known as road traffic accident involving cars, motorcycles and public transport. According to the Malaysian Road Safety Institute (MIROS), Malaysia's road accident rate is one of the highest as opposed to other countries in the world.

Fatigue refers to fatigue that results in a decrease in the level of sensitivity to something done. It is also a problem that many motorcycle riders often face when riders do not get enough rest before embarking on the journey. Factors that cause motorcycle fatigue include driving time, sleepiness, working hours, and driver’s behavior and so on. In addition, fatigue and drowsiness are also influenced by performance, such in the workplace, road geometry, road environment and the level of complexity of the tasks that motorcyclists carry.

If the motorcyclist is present with fatigue, it can affect two interrelated situations the impact of riding and the impact of the accident. When tired, riders are more difficult to focus on riding and this is possible increase the risk of accidents.

A drowsiness monitoring system is therefore proposed to resolve this issue. It is utilized to distinguish the heartbeat pace of a motorcyclist with moment input notice of up and coming risk of falling asleep at the worst possible time. The framework should be practical and advantageous.

1.3 Problem Statement

There are three factors as the main contributor to fatigue and drowsiness. The first factor is the stress of behavior that results from lack of time sleep, work activities and so on. Physical and physiological factors are secondary factors caused by lack of exercise, boredom and so on. On the other hand, the third factor is caused by medical and neurological health experienced by the motorcyclists.

Fatigue is additionally connected with physiological changes in brain waves, eye, head, muscle and heart rate. The beginning of exhaustion lessens internal heat level, pulse, circulatory strain, respiratory rate, and adrenaline creation. A person may experience micro-sleep when exhausted. Micro-sleep refers to periods of sleep that last from a few to several seconds. It can be caused by drowsiness caused by sleep disorders like insomnia, obstructive sleep apnea or narcolepsy.

Drowsiness and fatigue is one of the components adding to the decrease sharpness to recognize and react to unexpected scene or event over a longer period, response time, memory, psychomotor coordination, data processing and decision making. Therefore, this project was undertaken to address the problems mentioned above. The system will alert the motorcyclist from falling asleep that might lead an accident from occurring. Therefore, Figure 1.1 shown a statistic based on type of accidents and type of injuries occurred by year. Source is taken from Road Transport Department (RTD) Malaysia and also from The Ministry of Home Affairs (MOHA), and is a ministry of the Government of Malaysia.

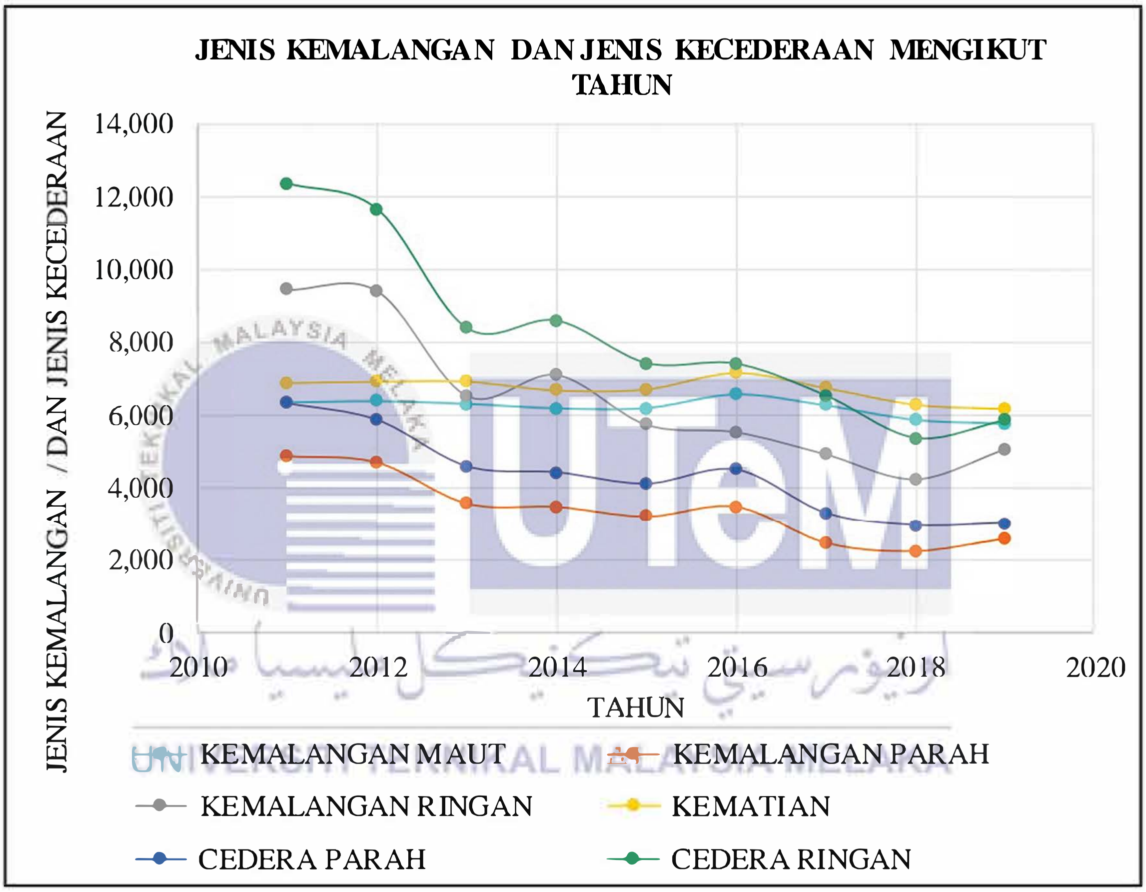

Figure 1.1: A statistic based on type of accidents and type of injuries by year

1.4 Objective

i. To develop a drowsiness detection system for motorcyclist.

ii. To analyze the performance of the system designed in term of its functionality.

1.5 Project Scope

Several scopes must be identified to achieve the objective of the project. The physiological and physical conditions of riders are monitored to detect drowsiness and fatigue in relation to their drowsiness level. The project scope is as follows:

i. The heartbeat rate of the rider will be determined by the Electrocardiography (ECG) sensor.

ii. AD8232 ECG module designed that built with the Arduino UNO Rev3 to extract, strengthen, and refine the use of very weak ECGs that have been mixed in unwanted ways.

iii. ECG electrode lead wire connector which enables the ECG electrode press grip to be improved electrically and mechanically.

The biological data of the system will be displayed through the serial monitor and serial plotter of Arduino IDE, features are extracted and classified to detect rider drowsiness as an output of the system.

1.6 Thesis Outline

The project background, the problem statement of the project, the objectives of the project, the project scope and project outlines are introduced in Chapter 1. The aim of this chapter is to give readers a clear image and a short version of the thesis.

Next, Chapter 2 deals with the project's literature analysis. This chapter discusses and deals with previous research by other scientists. Literature review on existing techniques received and multiple technologies implemented on the previous project on the detection system of drowsiness and fatigue.

Chapter 3 describes the approach and process flow used to simulate and complete the project. In this chapter, the approaches used to simulate the detection system are explained in accordance with the necessary experimental preparation before project implementation.

Chapter 4 presents the analysis and result based on experimental setup. The outcomes acquired were to be discussed and analyzed methodically.

Finally, Chapter 5 concludes the project based on the results achieved and desired objectives. Recommendation on future works or enhancements that can be made for the project are likewise recommended in the part.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will address previous studies and results of other researchers relevant to the project. Detailed discussion has been done and analyzed on the relationships of each works obtained from various authors that are relevant to this project. In view of the strategies utilized in past exploration, the best arrangement was chosen and applied as technique to this project. This chapter comprised of three sections. Firstly, this part will clarify and portray about the past research related to warning alert system. Next, this section will concentrate on the detection of fatigue and drowsiness. Then, this chapter will likewise portray about microcontroller equipment utilized in details and furthermore Electrocardiography (ECG) sensor which will be utilized in this project.

2.2 An Introduction to Warning Alert System

The purpose of alerts and warnings is to give the data needed to inform general society and to carry out the appropriate actions that will contribute to their protection and to provide messages to communities at risk of imminent threats with the goal of increasing the probability that people will take protective measures and reducing the delay in taking those measures.

The Malaysian Institute of Road Safety Research (MIROS) investigated data from road accidents during 2011 and found that mishaps are primarily due because of behavior, carelessness or street foundation (Idris, Hamid and Teik Hua, 2019). The most important problem leading to road accidents is human activity or negligence, which reported 80.6 percent relative to road and surrounding infrastructure (13.2 percent), while vehicle factor is only 6.2 percent. (Statistic by Road Transport Department, Malaysia, Ministry of Transport Malaysia, 2017).

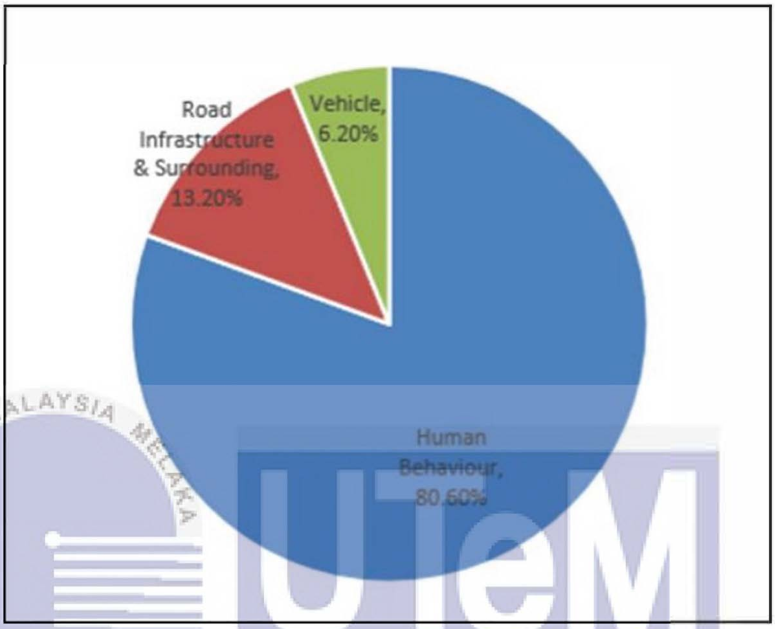

Figure 2.1: Malaysia Institute of Road Safety Research (MIROS) in the year 2017

(Verma, Girdhar and Jha, 2018) said in their exploration that a powerful technique is introduced dependent on eyes state investigation continuously which functions admirably for noisy images as well. The fundamental point is to recognize drowsiness or distraction of driver while driving, both during day and night to alert the driver by trigger and alarm. There were many ways to detect driver drowsiness from driver steering behavior to driver examination (Gromer *et al.*, 2019). Eye tracking, blinking, yeasting or an Electrocardiography (ECG) sensor may be examples. (Gromer *et al.*, 2019) explore the development of an ECG low-cost sensor to diagnose somnolence to gather cardiovascular (HRV) data.

The work covers the development of hardware and software. The device was mounted on a printed PCB to enable an Arduino to use the PCB as an extension shield. The PCB consists of a parallel, twisted ECG channel, which is supplied with two analog outputs for Arduino, which merge the channel to conduct analog – to – digital conversions. The optical ECG signal is moved to an embedded NVidia Computer where encoding, including QRS-complex, heart rate, and HRV detection as well as visualization functionality, takes place.

In extracting important ECG parameters, the resulting compact sensor results in good results. The sensor is used in a wider frame in which facial identification detection is combined with ECG detection in order to improve the quality of identification in unfavorable light or occlusion conditions.

According to (Schmitz *et al.*, 2015), an integrated sensor system that enhances users' safety and extends beyond popular life-styles applications for the continuous monitoring of motorcyclists, which aims to increased use of wearable electronics. The idea is to produce an electronic textile front and garment with integrated ECG electrodes and respiratory sensors as well as file storage, signals and on-board processing electronics.

The ECG and breathing signals will be processed to provide user feedback about user health and also to detect fatigue and activate driver warnings so that crucial conditions can be avoided. Additionally, inertial sensors are used to measure incidents and activate an alarm signal according to the e-Call standard, if necessary. Health records can be given electronically to first responders in case of an incident until they enter the incident site.

Due to a safety functions, determining physiological parameters is vitally important for the system. (Schmitz *et al.*, 2015) elaborates that there are three important ECG signal quality requirements to assess and meet long-term stability, movement-related artifact stability and motorcycle-induced artifact stability. Therefore, silicone electrodes seem a decent alternative to garment electrodes. Front-end textile retains long-term reliability. Many sections of the long-term ECG assessed is fully distortion free.

In recent studies, (Roshni *et al.*, 2020) proposed a non-intrusive real-time drowsiness warning system by monitoring driver's eye condition. The proposed eye-aspect-ratio method is utilized in Raspberry Pi. The system is implemented in Raspberry Pi and uses the eye-aspect ratio. Three techniques are employed for this system to be optimized by re-sizing the frame, using one eye to detect drowsiness and by not processing every frame.

Drowsiness and fatigue, among many other factors, are currently being developed in these accidents and systems that can monitor it. Similar research, (Oviyaa *et al.*, 2020) also supported this claim. This journal has been specifically built to enhance the security of riders. The designed methodology has EEG sensors inside the helmet to detect the driver's drowsy state. The device immediately notify the rider by an alarm when the rider is found to be drowsy. Finally, the engine slows down and stops.

(Dewi Purnamasari and Zul Hazmi, 2018) have proposed a system where they utilized Arduino Nano which makes it simpler to read heartbeat and there are far more sources of documentation that can be used as a source of perspective when composing this program. Arduino Nano is sorted because for this project it does not require numerous pins, so Arduino Nano alone is sufficient to address the issue of pins required.

2.3 An Introduction to Human's Drowsiness and Fatigue

(Verma, Girdhar and Jha, 2018) stated accidents usually occur, and drivers' recklessness is the major cause. This recklessness is caused by driver recklessness or driver drowsiness. Drowsiness is a temporary time or state between a human being's awakening and falling asleep time. Driver drowsiness dozing in the driver's seat, which means resting for a limited quantity of time while the driver is driving a vehicle. Information recommends the use of a dependable driver drowsiness detection system which could warn the driver of an accident (Vicente *et al.*, 2014); and (Warwick *et al.*, 2015). Several researchers tried to determine driver fatigue and drowsiness have been conducted using the following measures: (1) vehicle-based measures; (2) behavioral measures and (3) physiological measures. Past investigations might be alluded from the different writers and furthermore an assortment of sources, for example, articles, books, and papers.

A lot of researches have been carried to predict driver drowsiness based on heart rate variability (HRV) by assessing features such as power spectral density (PSD) from ECG signals (Lee, Kim and Shin, 2017). A study by (Awais, Badruddin and Drieberg, 2017) the Electrocardiography and Electroencephalography (EEG) were proposed as the method of detecting driver drowsiness to improve the detection effectiveness. For a simulator-based driving study, the results differ from a warning and drowsy status from physiological data from 22 human subjects. Building a reliable driver drowsiness detection system is imperative to warn users without frightening them, and is rigorous to change the environment (Jie *et al.*, 2018).

According to (Hendra *et al.*, 2019), drowsiness is a significant cause of road traffic collisions. Recently, driver drowsiness diagnosis depends on bio signal such as

Electrocardiography (ECG) has been under analysis. Alterations during driver's drowsiness, and fatigue can be derived from variation in heart rate (HRV). HRV is derived in ECG from RR interval. This paper presents detection using microcontroller units depending on HRV analysis. ECG signal is acquired by module AD8232 and processed in microcontroller units. They eliminate characteristics from HRV and use the outspread base capacity of the neural network to distinguish among normal and drowsy. Detection of sleepiness with 30s division in the RR interval gives the best yield among others where the exactness of the drowsiness detection is 79.26 percent.

The EEG derived many time and frequency domain characteristics including statistical descriptors of the time domain, intensity measurements and power spectral scales. The ECG-related highlights included heart (HR) and heart (HRV) variation including low-frequency (LF), high-frequency (HF) and LF / HF ratio.

The channel reduction analysis and its effect on detection efficiency is the other major contribution of this paper. The proposed method showed that the combination of EEG and ECG improved the device's efficiency in the separation of warning from drowsing states instead of using them on their own. Their channel reduction study showed that only two electrodes (1 EEG and 1 ECG), meaning an improved efficiency unit viable in comparison with existing systems involving many electrodes, can achieve an adequate degree of accuracy (80%). The findings show that the proposed approach can be a viable alternative to the user-friendly and reliable practical driver drowsiness system.

In order to minimize the risk of an accident, the authors have developed a drowsiness detection system using ECG signal information. ECG signal from a sensor that was then transmitted by hamming window and FFT technology through Bluetooth to android in the calculated Power ratio. According to the paper studied by (Rios-Aguilar *et al.*, 2015), one of the first causal factors for injuries is sleepiness.

A surmised 10 percent to 30 percent of road fatalities are associated with driving fatigue. Numerous tests were conveyed to lessen the possibility of accidents while driving. A portion of these exploratory examinations concentrates on drowsiness or sleepiness of biological responses. New wearable gadgets can monitor heart beat and analyze the physical work of the user using other sensors, for example, Accelerometer and Gyroscope, mounted on a straightforward clock. The primary objective is to use pulsation checks in tandem with advance physical activity to track driver drowsiness or sleepiness to avoid a collision.

In recent studies, (Awais, Badruddin and Drieberg, 2017) clarified that drowsiness in the driver's seat is a central point in street mishaps, prompting numerous deaths, genuine wounds, and money related misfortune. In observational-based research by (Roshni *et al.*, 2020), the results show that the lists of parameters, benefits and limitation are compared with different drowsy driver detection techniques.

Photo plethysmography (PPG) is a basic optical apparatus used to perceive changes in blood volume in peripheral circulation. This is a cheap and non-invasive tool that quantifies the top layer of skin. This approach serves as a guide on our cardiovascular system.

(Dewi Purnamasari and Zul Hazmi, 2018) supported their research by using the Photo plethysmography (PPG) approach and stated that older people normal resting heart rate is 60-100 beats per minute. An irregular rhythm is called bradycardia (<60 adults) and tachycardia (>100 adults) is higher than expected. The difficulty is the point at which the atria and ventricles are out of sync and the pulse should be characterized as a chamber or ventricle. For an example, the ventricular limit in ventricular fibrillation is 300-600 bpm, while the atrial level may indeed be normal (60-100) or snappier (100-150).

In light of (Dewi Purnamasari and Zul Hazmi, 2018) test, the proposed method utilizing Photo plethysmography (PPG) approach is shown to be of acceptable exactness on the grounds that the distinction between the OMRON Automatic Blood Pressure Monitor system is only 3.48 percent. However, this method can be enhanced by using other physiological sensors, along with ECG or by merging with several other techniques, such as image processing, to increase the outcomes of drowsiness detection.

2.4 A Review of Literatures

2.4.1 Detection System of Drowsiness and Fatigue with Arduino

This paper was about developing a drowsiness detection system for motorcyclists by using Arduino. Arduino hardware was used, also in a way functions as a database management. In the same way as the previous work discussed, the aim of this paper was to develop a motorcyclist drowsiness detection system and also to analyze the performance of the system designed in terms of its functionality.

2.4.2 Microcontroller

Arduino and Raspberry primary contrast is that Arduino is a microcontroller board, while Raspberry Pi is smaller than a normal PC. Arduino is Raspberry Pi. Raspberry Pi is a great contrast to Arduino in programming applications, making hardware projects simple.

Arduino comprises hardware and software. The software is an open-source platform linked with the constituent of ASCII text file and programming organization, task and client local area planning and assembling units to fabricate computerized gadgets and intelligent items that can perceive and deal with the genuine articles. Arduino boards can likewise be bought, self-assembled or as custom kits.

The Raspberry Pi is a cheap, credit-card sized device that appends to a PC screen or screen by utilizing a customary mouse and console. It assists individuals with investigating programming and gets the hang of programming in dialects like Scratch and Python. It can also be used for internet surfing and playing high-definition video games, making spreadsheets, and many more.

The proportion of the eye will differ for every human suggested a method which uses a 5-megapixel Raspbian camera that catches the face and eyes of the driver and cycles the pictures to distinguish the driver's fatigue. The Pi and Raspbian camera are used to measure the driver's drowsiness in real time. The utilization of the Haar Cascade Classifier for fatigue is resolved, the eye and the face in particular are measured by the use of forms and the Eye Aspect Ratio (EAR). Eye blindness and head tilting are frequently measured correctly, which helps to signify sleepiness. A loud warning alarms the person driving, waking himf rom his sleep when a vehicle reaches the limit level.

2.4.3 Sensor

The conclusions of this report are important that the ECG and EEG are two important fatigue recognition features and should not be disregarded in any fatigue detection system (Yang, Lin and Bhattacharya, 2010). They also found that the combined success rate was significantly higher than any single metric. Therefore, it is better to detect drowsiness with few false positives, allowing a drowsiness driver to be noticed promptly and preventing road accidents (Sahayadhas, Sundaraj and Murugappan, 2012).

Arduino Nano is an innovation microcontroller board depending on an ATmega328P chip with a petite shape. The characteristic is the same as Arduino Uno.

The notable disadvantage is the lack of a DC power jack and the utilization of a Mini-B USB connector.

According to Table 2.1, Arduino is good for repetitive work for beginner projects and for several tasks; Raspberry Pi can easily handle complex projects. The Electrocardiography (ECG) sensor is a record of the minute electrical pulse generated by the heart during the cardiac cycle. The electrical reflection of the heart activity has a unique characteristic for each individual. ECG is used to show evidence of heart disorders such as heart attacks, irregular heartbeats, or other cardiovascular problems.

EEG tracks the electrical activity of the brain by electrodes mounted on the scalp on a moving strip of paper. EEG is used to diagnose brain disorders, strokes, nervous system problems, and brain tumors.

Table 2.1: The differences between Raspberry Pi and Arduino

No.	Raspberry Pi	Arduino
1	It is a Raspbian OS minicomputer. It can run programs at a time.	Arduino is a PC based microcontroller. It repeatedly runs just one program.
2	It is hard to power with a battery pack.	It can be powered by a battery pack.
3	It requires complex tasks such as the installation of libraries and software for sensors and other interfaces.	It effectively interfaces with sensors and other electronic segments.
4	It is costly	It is cheap
5	Ethernet port and USB Wi-Fi devices, Raspberry Pi can be associated with the web.	It requires outer equipment to interface with the web and this equipment is taken care of with code.
6	It only has an SD card port.	It can provide on board storage.
7	It has 4 USB ports to connect devices	It has only one USB port for the computer.
8	The processor used is from ARM family	Processor used in Arduino is from AVR family Atmega328P
9	It should be shutdown properly, otherwise corruption of the file and software can happen.	It is a plug and play device. If power is connected, the program starts running and simply stops when disconnected.
10	Programming language using python but C, C++, Python, ruby are pre-installed.	Programming language using Arduino, C/C++.

2.5 Journal Comparison of Related Relevant Previous Papers

Table 2.2 shows a comparison between five journals from previous research. There are some similarities of the method and platform used to implement the project.

Table 2.2: Comparison table between five journals from previous research

No.	Author	Title	Technique / Component used	Advantages	Disadvantages
1	Schmitz *et al.*, 2015	Continuous vital monitoring and automated alert message generation for motorbike riders	Electrocardiography (ECG)	The feature enables accurate heart rate measurement results on long motorcycle rides.	In need of good ECG electrodes to keep a good skin contact over multiple hours without frequent moisturiser onto the skin.
2	Chellappa, Joshi and Bharadwaj, 2017	Driver fatigue detection system	External hardware - photoplethysmography (PPG) sensor module, the data processing system (NoSQL database) and the alert module (GPS)	It can trace drowsiness in actual environments and offers a set of warnings based on the detection occurrence.	EEG and ECG data have a more precise chance to produce EEG and ECG data far more precise and also to detect drowsiness.

No.	Author	Title	Technique / Component used	Advantages	Disadvantages
3	Dewi Purnamasari and Zul Hazmi, 2018	Heart Beat Based Drowsiness Detection System for Driver	Photoplethysmogram (PPG), Arduino Nano & Odroid XU4	The use of Arduino Nano additionally makes it simpler to peruse heartbeat as it numerous sources of documentation that can be utilized as a kind of perspective when composing this program. Arduino Nano is sorted on the grounds that for this venture it does not require numerous pins, so Arduino Nano alone is sufficient to address the issue of pins required.	The Odroid analog pin can only be used with C Language while the program was originally created in Python.

No.	Author	Title	Technique / Component used	Advantages	Disadvantages
4	Chellappa *et al.*, 2018	Fatigue detection using Raspberry Pi 3	Raspberry Pi 3, eye blinking & head tilting	Accurate eye detection and faces for every frame help analyze drowsiness level.	The IDLE editor implemented with Python can confuse users. Using an additional IDE involves higher installation process and configuration settings. Functionalities can be very confusing.
5	Gromer *et al.*, 2019	ECG sensor for detection of driver's drowsiness	Arduino UNO; Electrocardiography (ECG)	It provides up to six signals in parallel through several analogue inputs. Arduinos' software remains very straightforward.	The ECG signal has too much noise and artifacts.

2.6 Summary

Collectively, after a thorough dissection of these five journals, the most efficient and reliable method or system can be concluded by the ECG-based method. This is due to the flexibility of the system itself. It is cost-effective, high accuracy verification process and has a quick response rate, which makes it relevant and useful.

CHAPTER 3

METHODOLOGY

3.1 Introduction

Detailed methods and procedures are being discussed to support the objectives after reviewing previous related literature on how the project could be made. It outlines the crucial aspects of the project as this chapter consists of a flowchart that determines the flow of the project, a block diagram that depicts the graphical display on the related connection of the project, components that will be used to build the prototype and also procedures that are needed to ensure that the methodology implementation are in sequential order. The Gantt chart is also provided which helps to plan, coordinate, and track tasks in this project implementation.

Simultaneously, it facilitates understanding of how this project works. The equipment part that been utilized in this undertaking are AD8232 Electrocardiography (ECG) sensor worked with Arduino UNO Rev3, three ECG electrode lead wire connectors, data cable (USB), jumper wires, breadboard and also disposable ECG electrodes pack.

3.2 Software Component

3.2.1 Arduino IDE

Arduino IDE is an official Arduino software. This software is working as a code compilation. It can compile the coding easily even if the person is not familiar with the software. When the code is successfully compiled, then the coding can be uploaded into the physical board. Also known asa sketch, the main code generates a HEX file. It is one of the open - source software that can run on a variety of platforms such as MAC, Windows, Linux, and Java. The Arduino modules that can be used with the software includes Arduino UNO, Arduino Mega, Arduino Nano and many more. Editor and compiler are the main part of this software. The editor is used to write code of the program while the compiler is used to compile the coding before it uploads in the Arduino Module. Arduino IDE software used both high level of C and C++languages.

Figure 3.1 shows the icon of the Arduino IDE software. Meanwhile, Figure 3.2 is the Arduino IDE software interface. Utilize this interface to compose, arrange, and transfer coding to the Arduino board.

Figure 3.1: Arduino IDE Software

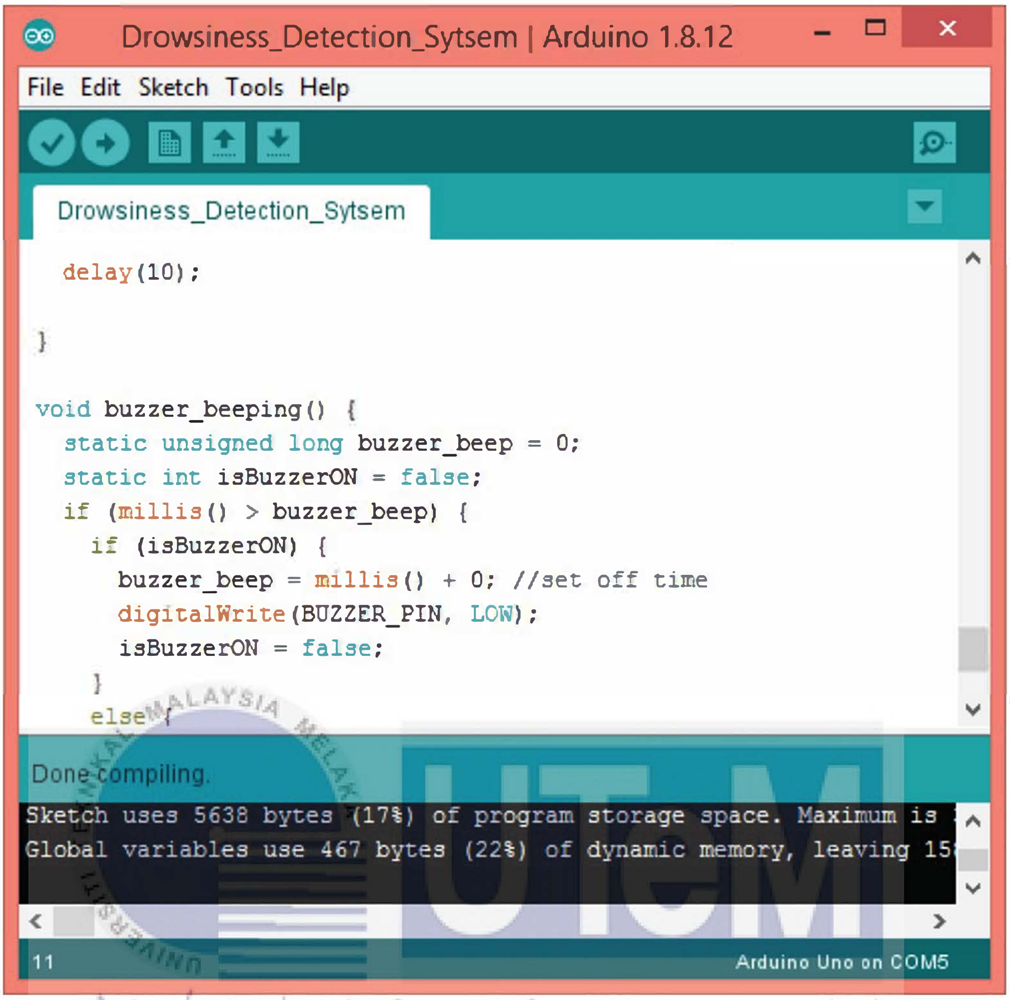

Figure 3.2: Arduino IDE Software Interface

3.3 Hardware Component

3.3.1 List of Materials

The Table 3.1 below shows types of components required to assemble the device.

Table 3.1: List of Materials

No.	Components Name	Description	Quantity
1	Arduino	Arduino UNO Rev3	1
2	ECG sensor	AD8232 ECG module	1
4	ECG electrodes	ECG electrode connector - 3.5 mm	3
5	Disposable ECG Electrodes Pack	-	50
6	Pulse Sensor	-	1
7	Buzzer	Arduino YL-44 Active Buzzer Module	1
8	Connecting wires	Jumper Wires	8
9	Data Cable (USB)	-	1
10	Breadboard	-	1

3.3.2 Arduino UNO Rev3

Microcontroller is a PC processor that incorporates the operation of the focal preparation unit (CPU) of a PC on a single coordinated circuit IC. Arduino software is installed on the computer probably depends on the application so that the program can be transcribed and uploaded. This Arduino software is mainly used for programming C and C++ languages.

Figure 3.3: Arduino UNO Rev3

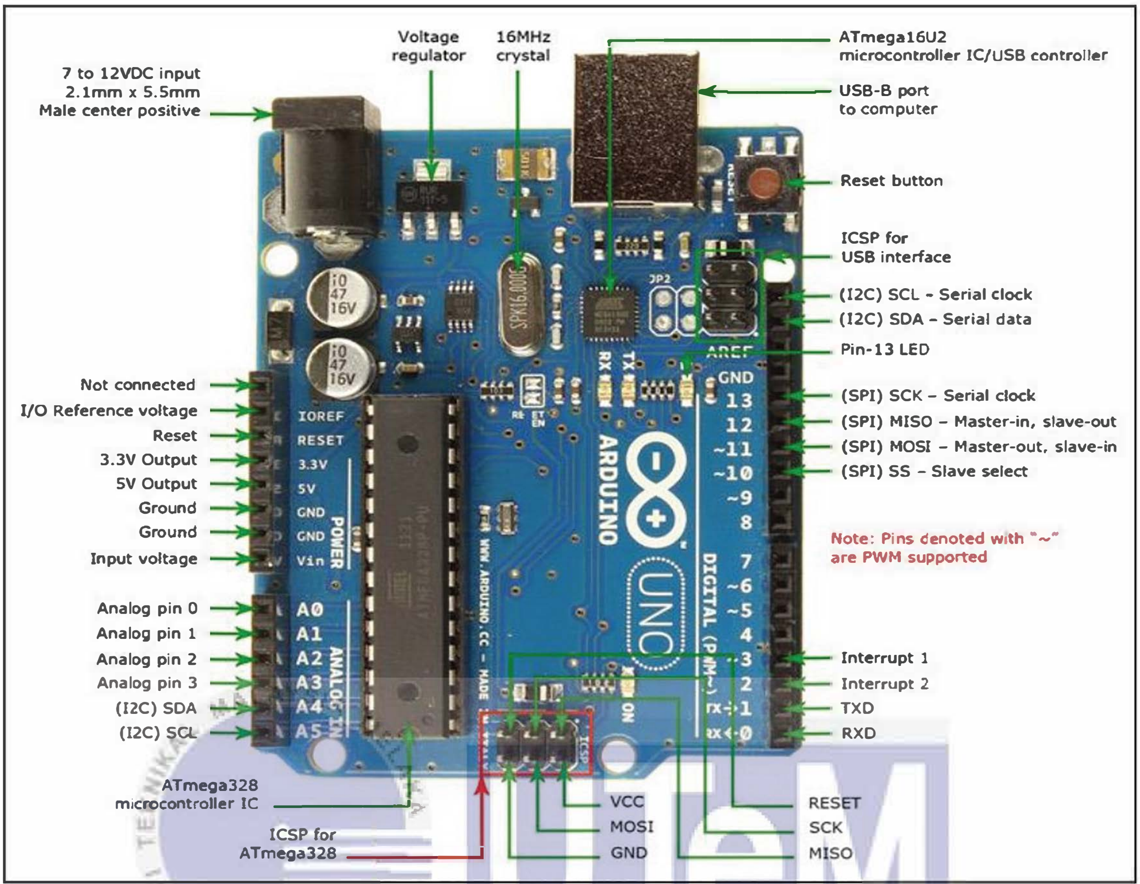

Figure 3.4: Pin configuration of Arduino UNO Rev3

3.3.3 AD8232 ECG Module, Heart Rate Monitor Sensor

The AD8232 is a chip utilized for measuring the heart's electrical movement. The ECG sensor is connected to the individual to gauge electrical exercises of the heart throughout some undefined time frame. The sensor yields can be seen by utilizing the serial monitor or serial plotter with the assistance of a microcontroller. It gathers the information and sends it sequentially to the Arduino UNO Rev3 for additional activities. The ECG is used for the detection of cardiac frequency, heart rhythm and other heart condition information.

This sensor is a financially savvy board used to measure the heart electrical movement. This electrical movement can be viewed as electrocardiography in a simple arrangement. It is made to separate, intensify, and channel little bio-possible signs within the presence of noisy state. Because of the extremely noisy existence of the heart-generated ECG signals, to retrieve the clear signal, an operational amplifier is used.

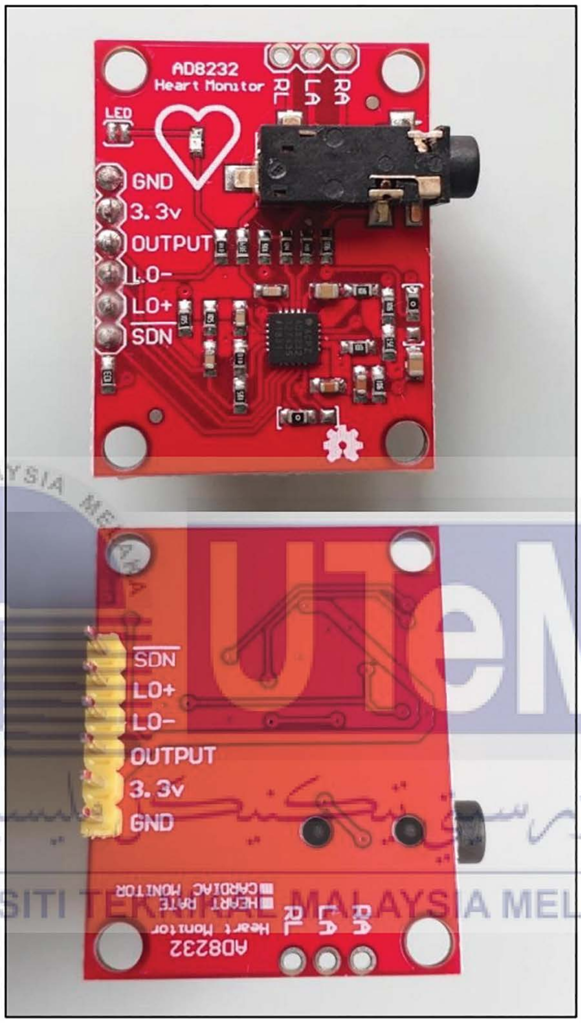

Figure 3.5: AD8232 ECG Module

Figure 3.5 shows the AD8232 ECG module comprising nine pin associations. The essential pins of the AD8232 ECG module comprises SDN, LO+, LO-, OUTPUT, 3.3V, and GND are provided to operate this monitor with an Arduino or other development board. Right Arm (RA), Left Arm (LA), and Right Leg (RL) pins are also provided on this board. Additionally, the LED indicator light pulses at the heartbeat rhythm. However, this module is not a medical device and is not intended to be utilized as analysis or treatment of any conditions.

3.3.4 ECG electrodes

Electrocardiography (ECG) is used to gather electrical signals from the heart. The level of physiological anticipation someone feels can be measured using ECG electrodes. It predominantly records how frequently the heart thumps (heart rate) and how normally it pulsates (heart rhythm).

Figure 3.6: Three ECG electrodes

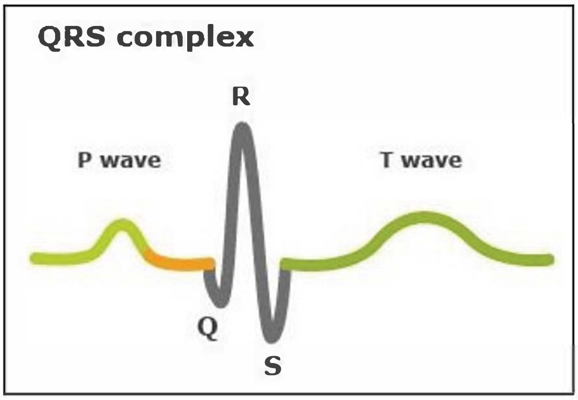

Figure 3.7: Typical ECG waveform pattern

Figure 3.7 explains, the event that the heart is thumping consistently, it will create the ordinary ECG design: The principal top (P wave) shows how the electrical drive (excitation) spreads over the two atria of the heart. The atria contract (press), pumping blood into the ventricles, and then quickly relax. The electrical impulse at that point arrives at the ventricles. This can be found in the Q, R and S waves of the ECG, which is known as the QRS complex. The ventricles contract. Finally, the T wave shows that the electrical impulse has quit spreading, and the ventricles quickly relax again.

3.3.5 Pulse sensor

The pulse sensor provides a digital heartbeat output when a finger is placed on it. This digital output can be connected to a microcontroller to calculate the number of Beats per Minute (BPM). This works by placing a fingertip over the sensor. Blood flow light modulation is applied when the heart pumps a blood pulse through the blood vessels. The essential pins of the pulse sensor are consisted Ground (GND), Power supply +5V (VCC) and also the Analog output (A0).

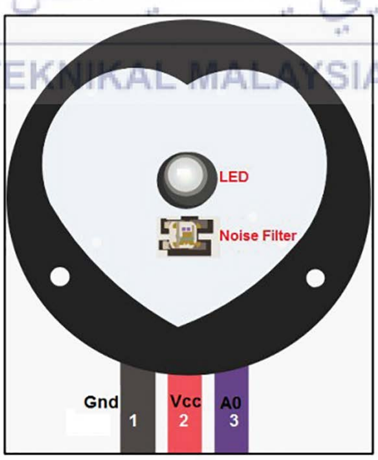

Figure 3.8: Pulse Sensor

3.3.6 Arduino YL-44 Active Buzzer Module

An active buzzer generates the sound itself which it can easily turn it on or off when it is connected to VCC and the ground. Meanwhile, a passive buzzer needs a signal source that provides the sound signal. A passive buzzer module is a device that causes a beeping noise. The YL-44 is a small buzzer that works within the range of frequency of 2 kHz. It is an active buzzer that produces a signal on its own without the need of an additional frequency generator. The only requirement is to set the signal I/O pin to HIGH.

Figure 3.9: Active buzzer module

3.4 Block Diagram of the Project

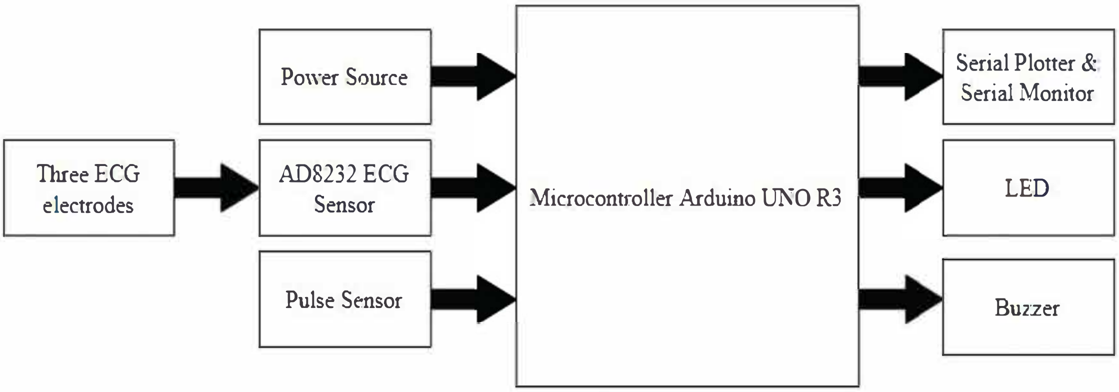

Figure 3.10: Block Diagram of Warning Alert System for Motorcyclists Related To Fatigue and Drowsiness

Based on Figure 3.10, the block diagram represents the basic working concept of the warning alert system for motorcyclists related to fatigue and drowsiness. The power source of the microcontroller of Arduino UNO Rev3 is obtained from the USB adapter which is connected to the PC. Once the connection has been made, the LED light from the microcontroller blinks a few times to indicate that the power is up and there is a connection. Disposable electrodes are then attached directly to the chest to trace any heartbeat activity. These ECG electrodes transform heartbeat to an electrical signal. The AD8232 ECG sensor is very lightweight and durable, slim and exactly designed to measure continuous heartbeat and to provide data of heartbeat. The AD8232 ECG module can channel the sign when there is aggravation and obstruction because of body movement. The recorded signal from AD8232 ECG module is decoded using Arduino UNO Rev3 into analogue data and processed to dsicover the QRS complex peak. After that, the heart rate is calculated in the Arduino UNO Rev3. The data are transmitted to the serial plotter and serial monitor through Arduino IDE software to display the ECG signal. Lastly, if the motorcyclist is in a drowsy state, the LED will light up and the buzzer triggers a high pitch sound to warn the rider.

As a conclusion, after outlining the design concept and the possible outcome of the project, it is certainly achievable in implementing the prototype with the aid of the fundamental working principle based on the flowchart and block diagram. However, it is undeniable that the outcome of the project may vary from the original concept. This method enables the detection of drowsiness without installing any other component in their vehicle. This could be due to various factors such as an instrumental error, programming error, simulation error and others just to name a few. Therefore, it is crucial to be meticulous in analyzing, constructing, designing, implementing and also in the testing phase to ensure that the project is faultless and accurate.

3.5 Project Overview

Figure 3.11 depicts the overall implementation flow of the project. It consists from conducting a thorough research on the project, writing a literature review, hardware and software implementation and all the way to the result outcome.

Table 3.2 and Table 3.3 presented the Gantt chart of Bachelor Degree Project 1 and 2 throughout the process of implementing this project. Last but not least, Figure 3.12 shown the algorithm flowchart of the project implementation.

3.5.1 Project flowchart

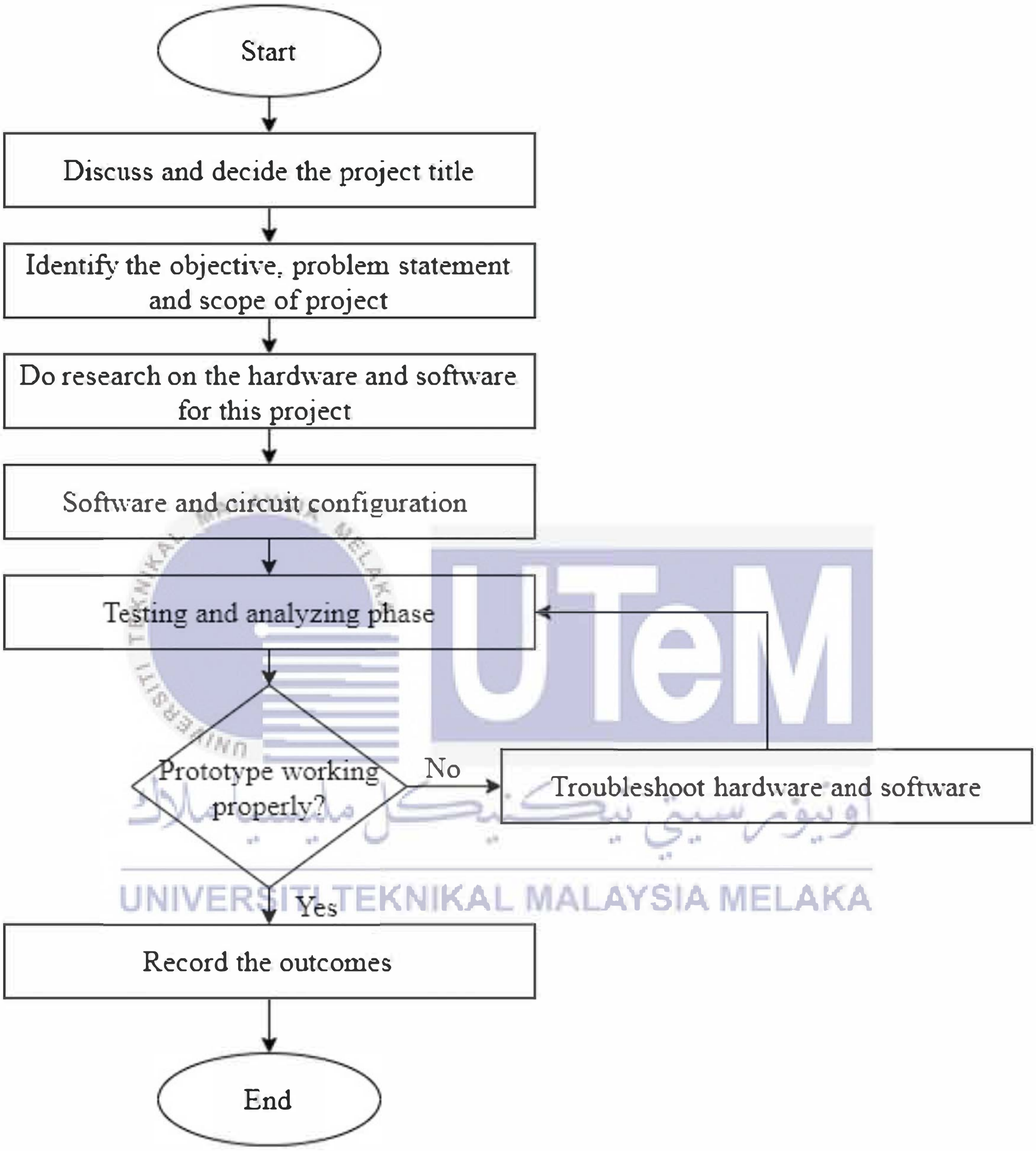

Figure 3.11: Project flowchart

Table 3.2: Gantt chart Bachelor Degree Project 1

No.	Project Activity	Expected / Actual	Week														
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Topic confirmation and discussion with supervisor	Expected															
		Actual															
2	Registration for final year project	Expected															
		Actual															
3	Final year project's briefing by panel	Expected															
		Actual															
4	Study background project	Expected															
		Actual															
5	Prepare for chapter 2: Literature Review	Expected															
		Actual															
6	Prepare for chapter 1: Introduction	Expected															
		Actual															
7	Updated Progress Report to Supervisor	Expected															
		Actual															
8	Prepared for chapter 3: Methodology	Expected															
		Actual															
9	Report Draft Submission	Expected															
		Actual															
10	Prepare for Presentation	Expected															
		Actual															
11	Video Presentation Submission	Expected															
		Actual															
12	PSM Presentation Evaluation	Expected															
		Actual															

Table 3.3: Gantt chart Bachelor Degree Project 2

No.	Project Activity	Expected / Actual	Week														
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Research for information	Expected															
		Actual															
2	Application design and testing	Expected															
		Actual															
3	Collect data	Expected															
		Actual															
4	Analysis data	Expected															
		Actual															
5	Data organizing	Expected															
		Actual															
6	Prepared for chapter 4: Result & Discussion	Expected															
		Actual															
7	Prepared for chapter 5: Conclusion & Recommendation	Expected															
		Actual															
8	Report Draft Submission	Expected															
		Actual															
9	Prepare for Presentation	Expected															
		Actual															
10	Presentation	Expected															
		Actual															
11	Report Submission	Expected															
		Actual															

3.5.2 Algorithm flowchart

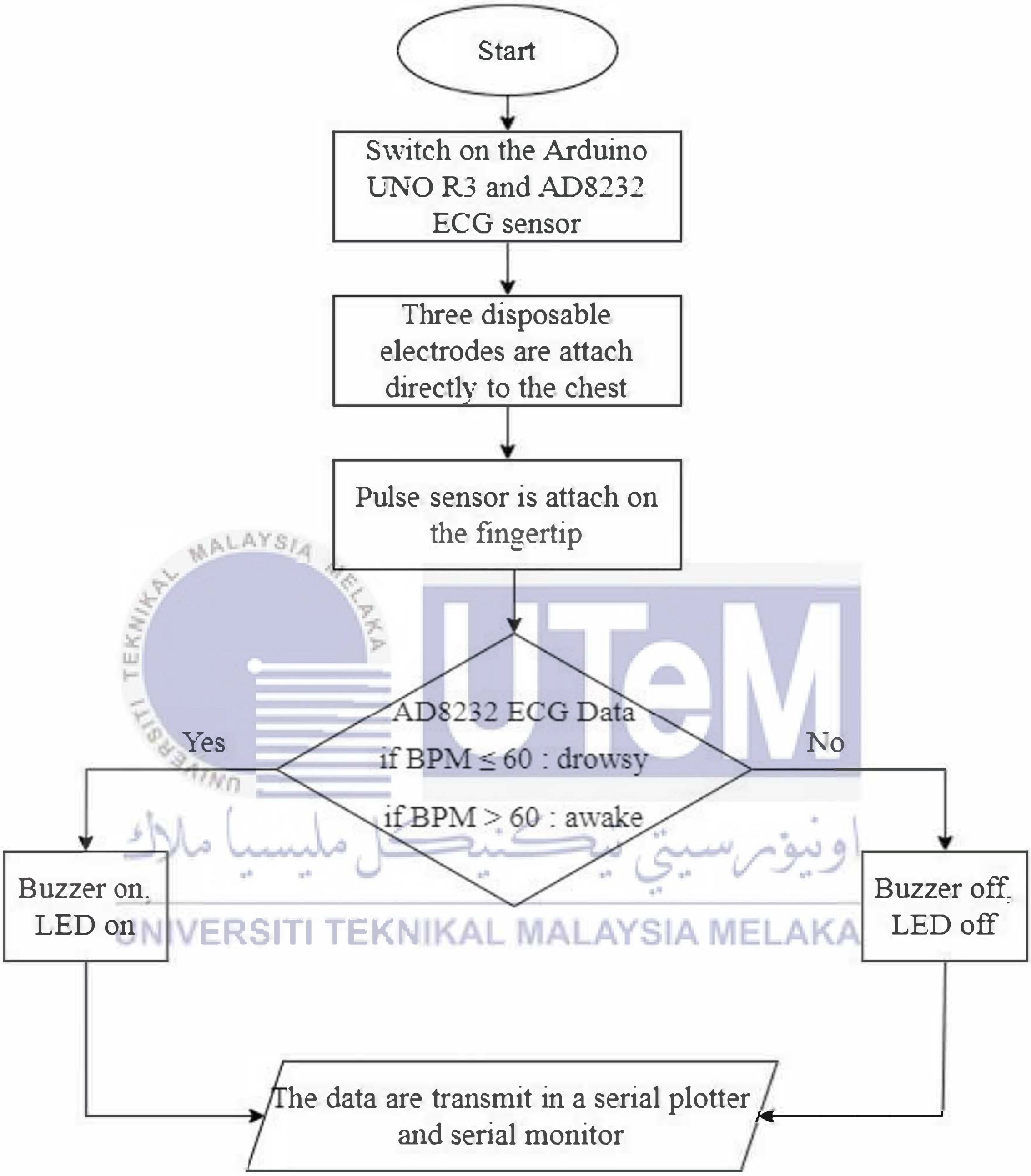

Figure 3.12: Flowchart of warning alert system of drowsiness detection system

Figure 3.12 shows the flowchart of warning alert system of drowsiness detection. The purpose of creating this flowchart is to show the process of drowsiness detection systems working. The process starts after switching on the Arduino UNO Rev3 and the AD8232 ECG module. Then, three disposable electrodes are placed directly on the chest to identify the heart rate electrical activity. The pulse sensor is also used to detect pulse by placing it on the fingertip. The warning alert system is utilized when the readings satisfy the two conditions. If the BPM readings show less than 60BPM, the status will change to drowsy and the buzzer will produce a high pitch sound. Otherwise, if the BPM readings show more than 60BPM, the status will remain awake. Finally, once the data is being transmitted and calculated in Arduino UNO Rev3, the output results will be displayed through the serial monitor and serial plotter in Arduino IDE.

3.6 Summary

This part explained the process and method used to develop the warning alert system for motorcyclists related to fatigue and drowsiness. In addition, the researcher explained the hardware and software used in this project to clearly present the material's vital information. The work progress had been stated clearly in this chapter.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

In this chapter, all of the project results of the experimental studies will be analyzed systematically and will be compared with the graphs and tables followed by observations obtained through the serial monitor and serial plotter of Arduino IDE. The outcomes of the serial monitor and serial plotter of Arduino IDE will be analyzed accordingly. This chapter also determines the project's performance system designed in terms of its functionality. It will conclude and summarize all the information and observation obtained during implementation of the project.

4.2 Hardware Configuration

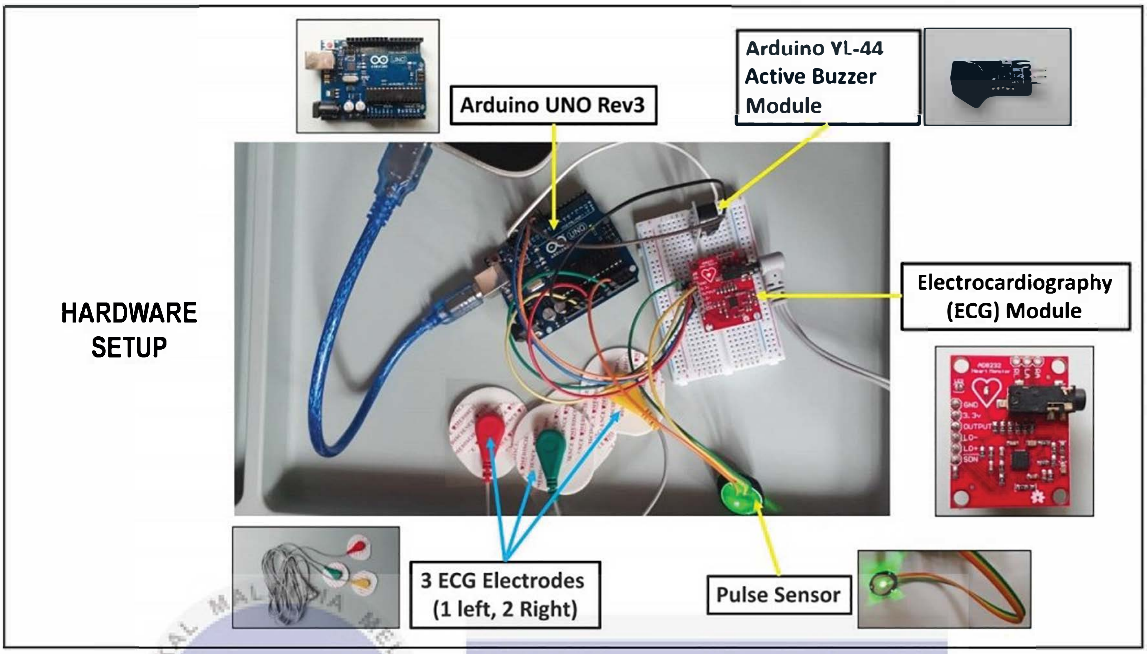

Figure 4.1: Hardware Setup

Three disposable electrodes are attached directly to the chest at certain positions to trace any heartbeat activity. These ECG electrodes transform heartbeat to an electrical signal. The collected signal form of the AD8232 ECG module is converted into analogue data using Arduino UNO Rev3 and transmitted to detect the QRS complex peak. The AD8232 ECG module can filter the signal whenever there is disruption and interruption due to body motion. After that, the heart rate is calculated in the Arduino UNO Rev3. The data are transmitted to the serial plotter and serial monitor through Arduino IDE software to display the pulse and ECG signal. Lastly, the LED will light up and the buzzer triggers a high pitch sound to warn the rider if he/she is in a fatigue and drowsy state.

4.3 Software and Circuit Configuration

This part explained the software and circuit configuration briefly. The software used to draw the circuit configuration is using Fritzing software. The outcomes from this circuit configuration is observed and analyzed through a serial monitor and serial plotter of Arduino IDE.

4.3.1 Connection between Arduino UNO Rev3, AD8232 ECG module, active buzzer module and pulse sensor

Figure 4.2 represents the circuit diagram connection of this project. This circuit diagram consisted of the AD8232 ECG module, active buzzer module, pulse sensor and also Arduino UNO Rev3 board, and was created by using Fritzing software.

In addition, Figure 4.3 represents the schematic diagram of this project. This schematic diagram was also created by using Fritzing software.

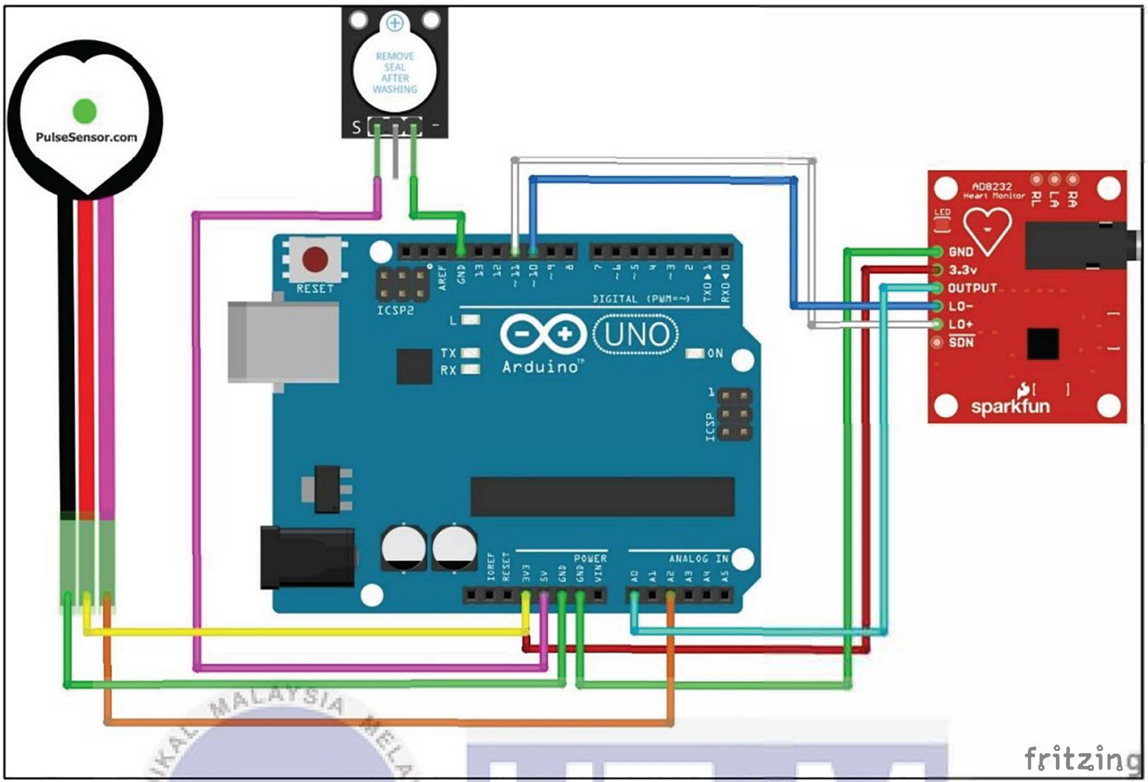

Figure 4.2: Circuit diagram connection by using Fritzing software

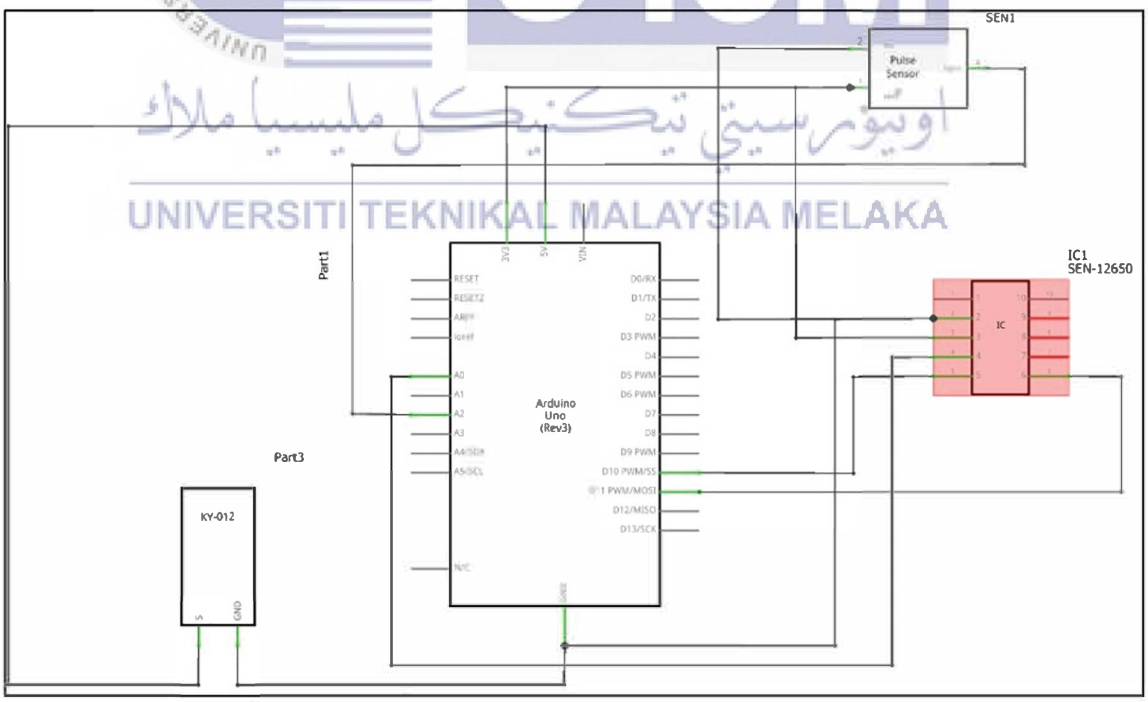

Figure 4.3: Schematic diagram of AD8232 ECG module, active buzzer module and pulse sensor to Arduino board

4.3.2 Pin Configuration between Arduino UNO Rev3, AD8232 ECG module, active buzzer module and pulse sensor

Pin configurations between the Arduino UNO Rev3, AD8232 ECG module, active buzzer module and pulse sensor were tabulated clearly as shown in Table 4.1, Table 4.2 and also Table 4.3 below.

Table 4.1: Pin connection for Arduino UNO Rev3 and AD8232 ECG Module

Arduino UNO	AD8232 ECG Module
3.3V	3.3V
GND	GND
A0	Output
11	LO+
10	LO-
-	SDN

Table 4.2: Pin connection for Arduino UNO Rev3 and pulse sensor

Arduino UNO	Pulse sensor
3.3V	VCC
GND	GND
A2	A0

Table 4.3: Pin connection for Arduino UNO Rev3 and Arduino YL-44 Active Buzzer Module

Arduino UNO	Arduino YL-44 Active Buzzer Module
5V	VCC
9	I/O
GND	GND

4.4 Output from the ECG

In this part of the experiment setup, the drowsiness detection system is implemented using the ECG AD8232 module and Arduino UNO Rev3. There will be a bunch of data analysis that is produced by the serial monitor and serial plotter from Arduino IDE. To analyze the accuracy of QRS complex peak detection method, three boundaries are utilized; they are positive predictive, accuracy and sensitivity (Utomo, Nuryani and Darmanto, 2017). Based on Figure 4.4, the blue line represents ECG signal, the red line represents average to signal, ECG Top and the green light represents the ECG Threshold. The threshold value is calculated automatically.

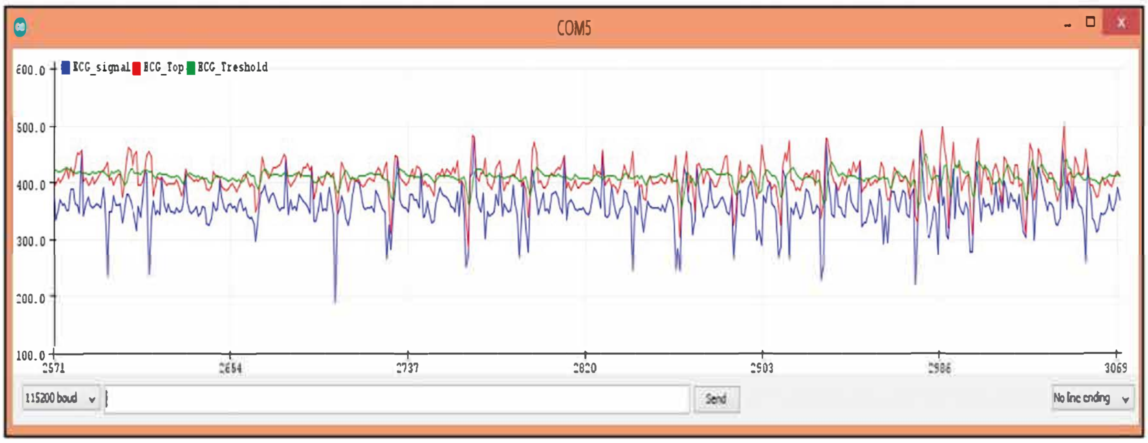

Figure 4.4: Output of ECG threshold value

The ECG signal is obtained by detecting the heartbeat of the human body, as shown in the Figure 4.4 above. In fact, for R-peak detection of the ECG signal, a fixed threshold technique is used. In spite of the fact that a fixed threshold strategy is utilized, it does not generally deliver precise outcomes in the R-peak detection. This calculation of the threshold is what causes R-peak detected.

As per the research paper (Kew and Jeong, 2011), a variable threshold value utilized to beat obstacles and provide more precise R-peak detection accuracy. To execute the threshold level equivalent to 55 percent of the data average, 4 out of 5 R-peak ECGs are detected in the very first place. After all, due to motion artefacts and the signal size shifts, some spike is underneath the threshold level, and henceforth it is unrecognized and produces mistakes. This is done in the signal as its size of the ECG signals changes and motion artefacts, so the threshold value benchmark also shifts. In addition to this project setup, the Arduino code utilizes a hardware timer interrupt to measure the pulse sensor signal at an exact fixed rate (500Hz) to get a generally excellent quality BPM reading.

In the research paper (Utomo, Nuryani and Darmanto, 2017) have clarified about the calculation of QRS complex recognition utilizing the Peak Threshold strategy. An information point (xn) will be considered as a QRS complex pinnacle if the deduction aftereffect of the current information point (xn) and past information point (xn-1); at that point current information point (xn) and its next information point (xn+1), is positive. The determination of the QRS complex in this method can be illustrated in Figure 4.5 and Figure 4.6 below.

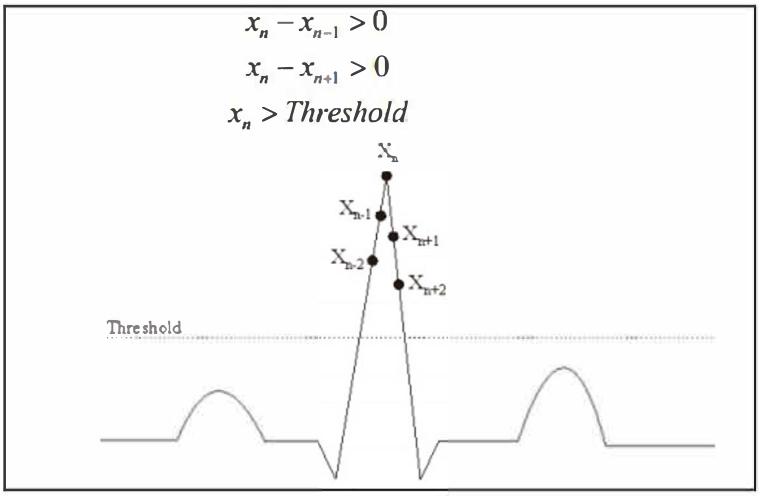

Figure 4.5: Determination of QRS complex peak using the Peak Threshold method (Utomo, Nuryani and Darmanto, 2017)

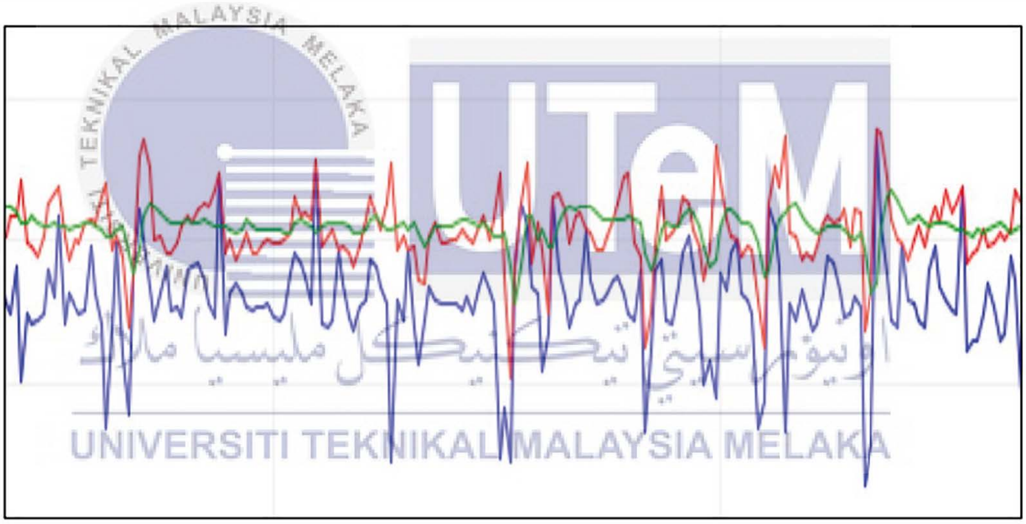

Figure 4.6 ECG signal from serial plotter

The output results of a warning alert system for fatigue and drowsiness that is extracted from the serial monitor as seen in Figure 4.7. The data was taken to see the differences between the calculated value from AD8232 ECG module and also the pulse sensor. Based on the observation (as seen from Figure 4.7), the BPM readings obtained from ECG AD8232 module and pulse sensor are not exactly accurate. This happened due to the noise interference that comes from the ECG sensor and pulse sensor. It can also be seen that the heart beats at 45BPM which results in a drowsy state.

As explained in the algorithm flowchart in Chapter 3, a normal adult heart rate is between 60 to 100 Beats per Minute (BPM). This statement can be supported by (Avram *et al.*, 2019) had done their research and mentioned that 95 percent of real life heart rate was ≤110 in individuals aged 18–45, ≤100 in those aged 45–60 and ≤95 bpm in individuals older than 60 years old.

```
ECG: 88 PULSE: 88 AVG_PULSE: 88 :Status Awake.
ECG: 88 PULSE: 88 AVG_PULSE: 88 :Status Awake.
ECG: 80 PULSE: 80 AVG_PULSE: 80 :Status Awake.
ECG: 80 PULSE: 80 AVG_PULSE: 80 :Status Awake.
ECG: 81 PULSE: 82 AVG_PULSE: 81 :Status Awake.
ECG: 89 PULSE: 110 AVG_PULSE: 99 :Status Awake.
ECG: 92 PULSE: 68 AVG_PULSE: 80 :Status Awake.
ECG: 89 PULSE: 139 AVG_PULSE: 114 :Status Awake.
ECG: 90 PULSE: 90 AVG_PULSE: 90 :Status Awake.
ECG: 90 PULSE: 90 AVG_PULSE: 90 :Status Awake.
ECG: 53 PULSE: 90 AVG_PULSE: 71 :Status Awake.
ECG: 78 PULSE: 80 AVG_PULSE: 79 :Status Awake.
ECG: 45 PULSE: 45 AVG_PULSE: 45 :Status Drowsy.
ECG: 45 PULSE: 45 AVG_PULSE: 45 :Status Drowsy.
ECG: 84 PULSE: 84 AVG_PULSE: 84 :Status Awake.
ECG: 84 PULSE: 84 AVG_PULSE: 84 :Status Awake.
ECG: 83 PULSE: 83 AVG_PULSE: 83 :Status Awake.
ECG: 83 PULSE: 83 AVG_PULSE: 83 :Status Awake.
ECG: 83 PULSE: 82 AVG_PULSE: 82 :Status Awake.
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ECG: 85 PULSE: 84 AVG_PULSE: 84 :Status Awake.
ECG: 84 PULSE: 83 AVG_PULSE: 83 :Status Awake.
ECG: 84 PULSE: 83 AVG_PULSE: 83 :Status Awake.
ECG: 81 PULSE: 82 AVG_PULSE: 81 :Status Awake.
ECG: 81 PULSE: 82 AVG_PULSE: 81 :Status Awake.
ECG: 79 PULSE: 83 AVG_PULSE: 81 :Status Awake.
```


Figure 4.7: Output results from the recordings of ECG, pulse, average pulse and drowsiness status

Refer to the data analysis in the Table 9 and graphs (as seen in Figure 4.8, Figure 4.9 and Figure 4.10) below, it shows that the recording was gathered after lunch or dinner when the person was typically exhausted or sleepy. In this project, the system built has utilized awake and drowsy state data taken from after-lunch or after-dinner recordings. Finally, a collection of 150 sample data were taken in 2 minutes time, which included 8 drowsy, 127 awake and 15 invalid samples. Some limitations from this project is that the AD8232 ECG module designed that built with the Arduino UNO Rev3 is used to extract, strengthen, and refine the weak ECGs that have been mixed in unwanted ways.

Table 4: Output results and status of drowsiness detection

Time(s)	ECG	Pulse	Status
1	80	120	Awake.
2	81	80	Awake.
3	81	80	Awake.
4	82	82	Awake.
5	82	82	Awake.
6	82	82	Awake.
7	80	80	Awake.
8	80	80	Awake.
9	80	80	Awake.
10	132	116	Invalid.
11	132	116	Invalid.
12	82	82	Awake.
13	82	82	Awake.
14	83	85	Awake.
15	88	90	Awake.
16	88	90	Awake.
17	85	85	Awake.
18	85	85	Awake.
19	145	145	Invalid.
20	83	83	Awake.
21	83	83	Awake.
22	119	120	Awake.
23	85	89	Awake.

24	52	52	Drowsy.
25	52	52	Drowsy.
26	53	53	Drowsy.
27	77	77	Awake.
28	75	75	Awake.
29	75	75	Awake.
30	75	75	Awake.
31	75	75	Awake.
32	112	101	Awake.
33	74	74	Awake.
34	77	77	Awake.
35	77	77	Awake.
36	129	164	Invalid.
37	78	77	Awake.
38	78	77	Awake.
39	129	164	Invalid.
40	76	76	Awake.
41	76	76	Awake.
42	124	110	Awake.
43	77	77	Awake.
44	77	77	Awake.
45	126	121	Invalid.
46	80	80	Awake.
47	122	117	Awake.
48	80	121	Awake.
49	81	80	Awake.
50	81	80	Awake.
51	82	82	Awake.
52	82	82	Awake.
53	82	84	Awake.
54	77	76	Awake.
55	77	76	Awake.
56	80	83	Awake.
57	114	111	Awake.
58	74	74	Awake.
59	119	117	Awake.
60	76	76	Awake.
61	81	80	Awake.
62	81	80	Awake.
63	80	82	Awake.
64	82	82	Awake.
65	113	113	Awake.
66	77	77	Awake.

Time (s)	ECG	Pulse	Status
67	74	74	Awake.
68	74	75	Awake.
69	112	112	Awake.
70	112	112	Awake.
71	109	109	Awake.
72	75	75	Awake.
73	127	118	Invalid.
74	77	77	Awake.
75	77	77	Awake.
76	77	77	Awake.
77	82	82	Awake.
78	82	82	Awake.
79	76	76	Awake.
80	76	76	Awake.
81	126	167	Invalid.
82	81	81	Awake.
83	125	163	Invalid.
84	85	85	Awake.
85	86	86	Awake.
86	60	60	Drowsy.
87	60	60	Drowsy.
88	83	83	Awake.
89	83	83	Awake.
90	83	83	Awake.
91	83	83	Awake.
92	83	83	Awake.
93	133	133	Invalid.
94	82	82	Awake.
95	82	82	Awake.
96	79	79	Awake.
97	119	113	Awake.
98	78	120	Awake.
99	83	83	Awake.
100	83	83	Awake.
101	80	126	Awake.
102	80	126	Awake.
103	78	118	Awake.
104	84	84	Awake.
105	83	83	Awake.
106	83	83	Awake.
107	80	80	Awake.
108	80	80	Awake.

Time (s)	ECG	Pulse	Status
109	80	80	Awake.
110	55	55	Drowsy.
111	51	51	Drowsy.
112	51	51	Drowsy.
113	87	87	Awake.
114	83	83	Awake.
115	85	85	Awake.
116	85	85	Awake.
117	82	82	Awake.
118	122	122	Invalid.
119	123	123	Invalid.
120	84	87	Awake.
121	84	83	Awake.
122	84	83	Awake.
123	130	127	Invalid.
124	81	81	Awake.
125	81	81	Awake.
126	81	81	Awake.
127	84	84	Awake.
128	84	84	Awake.
129	89	89	Awake.
130	89	89	Awake.
131	82	81	Awake.
132	82	81	Awake.
133	84	87	Awake.
134	83	83	Awake.
135	83	83	Awake.
136	80	80	Awake.
137	80	80	Awake.
138	80	80	Awake.
139	85	88	Awake.
140	85	85	Awake.
141	122	122	Invalid.
142	79	79	Awake.
143	127	123	Invalid.
144	82	82	Awake.
145	82	83	Awake.
146	82	83	Awake.
147	87	89	Awake.
148	84	84	Awake.
149	87	89	Awake.
150	84	84	Awake.

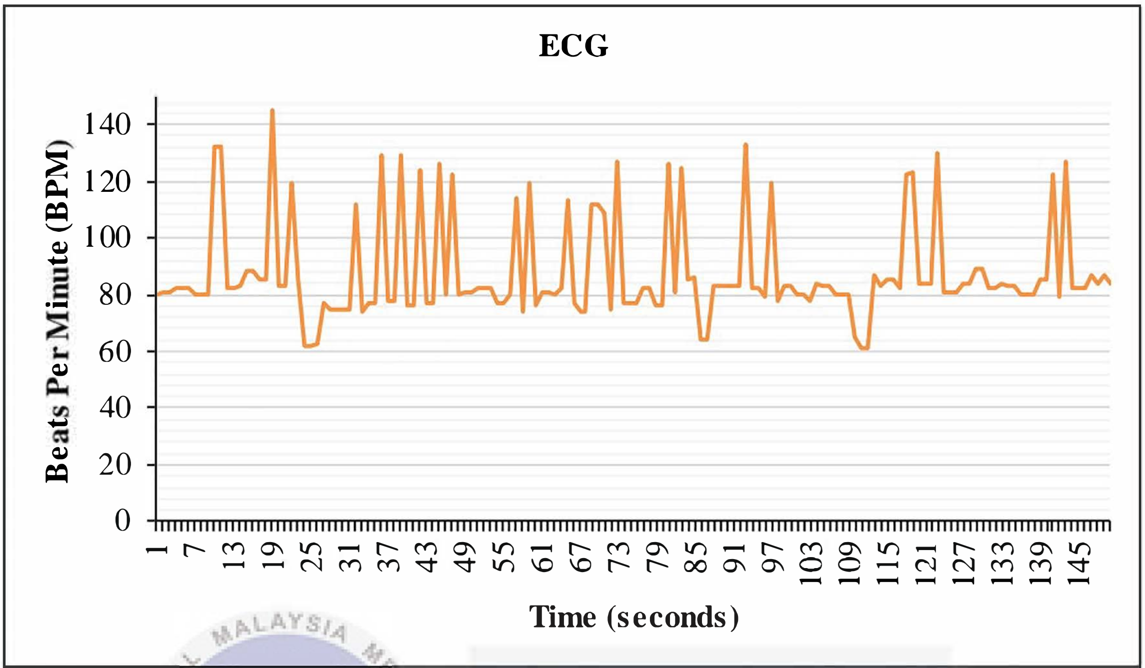

Figure 4.8: The output result of AD8232 ECG module in Beats per Minute (BPM) vs. Time(s)

The graph in Figure 4.8 shows the values of ECG in Beats per Minute (BPM) versus Time (s). Theoretically, a normal heart rate is referring to resting heart. The normal resting heart rate for older children and adults is 60BPM to 100BPM. From this graph, the value that is above 120BPM or below 40BPM is considered invalid value due to movements and noise interference from the human body itself. From this graph, it also explains that the values reach 60BPM meaning that the person is feeling fatigue and drowsy.

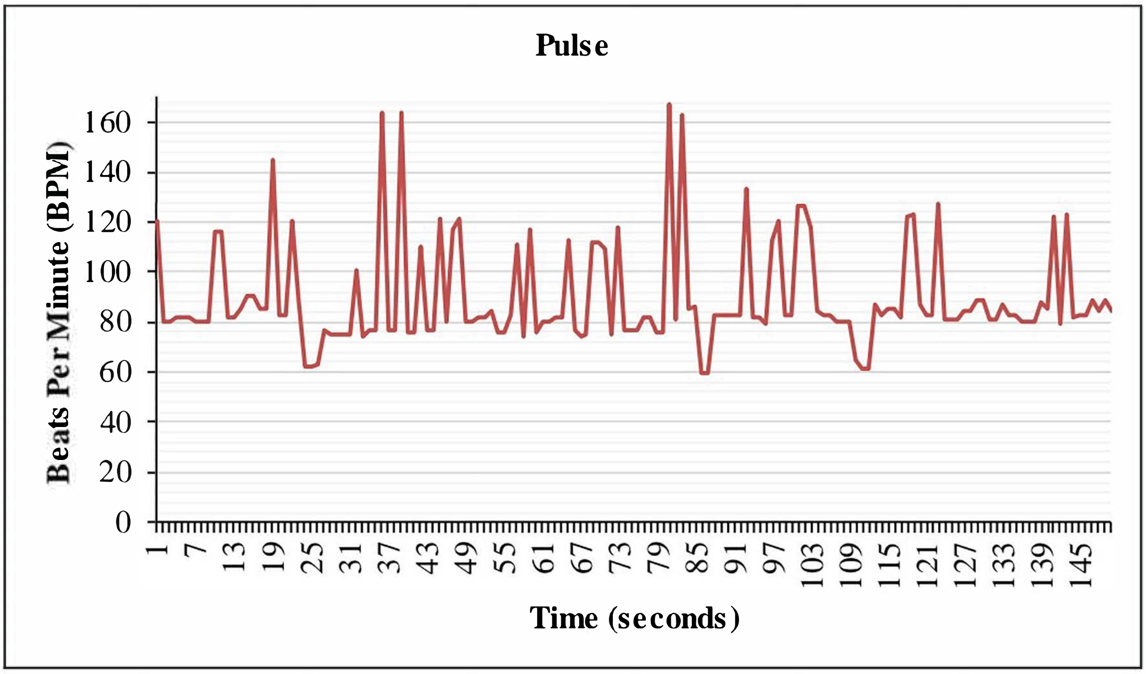

Figure 4.9: The output result of pulse detection in Beats per Minute (BPM) vs. Time (s)

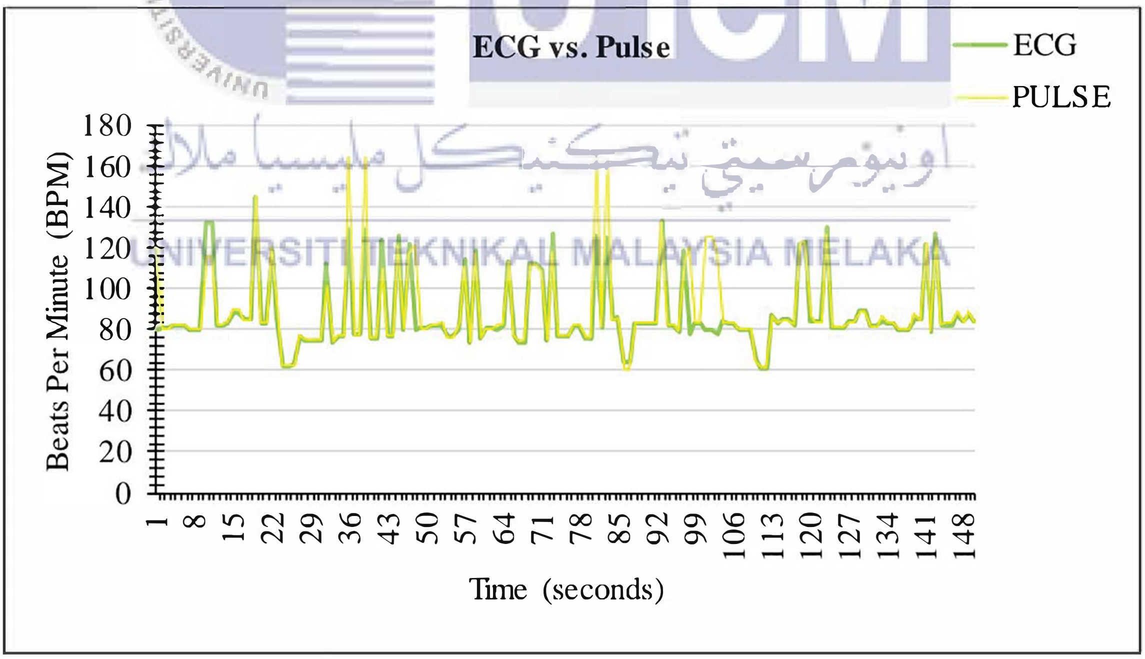

Figure 4.10 Intersection between the outputs from ECG and pulse

The graph in Figure 4.9 shows the values of pulse in Beats per Minute (BPM) versus Time (s). The intersection of these two graphs are shown in Figure 4.10. From the observations, the green line is the output from the ECG module and the yellow line is the output from the pulse sensor. It can be seen that the BPM readings of pulse are slightly higher than the readings of ECG signal. The recorded signal from AD8232 ECG module is decoded using Arduino UNO Rev3 into analogue data and processed to find the QRS complex peak which produced a more accurate heart rate compared to the pulse. In order to get accurate results, the person must not move too much as it will increase the sensitivity of the ECG electrodes and also the pulse sensor.

4.5 Summary

The AD8232 ECG sensor used in this project implementation works as detecting the heart electrical activity. The Arduino UNO Rev3 will transmit and calculate the received signal from ECG to produce readings in Beats per Minute (BPM) and also to produce ECG graphs. Serial monitor and serial monitor in Arduino IDE is used to display the recorded values and signals. From the system, the drowsy state of the motorcyclist can also be determined. The buzzer may help the motorcyclists to stay awake while riding as well as increase their safety.

CHAPTER 5

CONCLUSION AND FUTURE WORK

5.1 Introduction

This chapter is the conclusion that can be drawn to ensure the achieved goals. By doing all sorts of testing analysis before, it is possible to observe all the tests and results. There will also be analysis of the potential work to ensure that the plan can be adapted in the future.

5.2 Conclusion

This project has an important usage for motorcyclists. The goal of this project is to monitor the heart electrical activity of a motorcyclist. Besides that, the goal of this project is to create an alerting system for the motorcyclist to prevent him/her from falling asleep on the wheel which may lead to an accident from occurring.

In this project, the AD8232 ECG sensor is used to measure continuous heartbeat. It can channel the signal when there is disturbance and interference because of body movement. The Arduino UNO Rev3 plays an important role in this project. The recorded signal from AD8232 ECG module is decoded utilizing Arduino UNO Rev3 into analogue data and handled to discover the QRS complex peak which delivered a more exact pulse contrasted with the heartbeat. After that, the heart rate is calculated in the Arduino UNO Rev3. The data are then transmitted to the serial plotter and serial monitor through Arduino IDE software to display the ECG signal. The analysis performance and design testing are performed to prove the capability of the AD8232 ECG sensor to detect the heart electrical activity. Subsequently, the configuration of a warning alert system with an active buzzer is done to achieve the goal of developing an alert system for motorcyclists that is related to fatigue and drowsiness. This project emphasized the alerting system due to the flexibility of the system itself. This project used a low power usage, cost-effective and has a quick response rate, which makes it relevant and useful. Finally, for future research and development, the drowsiness detection system will be focused on programming, integrating and testing the system design. As a conclusion, the objectives of this project have been achieved successfully.

5.3 Future Work

Currently, the design of this system is not complex or wearable. It is hard to implement on motorcyclist's body. The future work that can be suggested to do in order to improvise this project is to use a better sensor that reduces the noise interference when the motorcyclist is in motion.

5.4 Recommendations practice to prevent drowsiness and fatigue

Fatigue in motorcycling has been to a great extent overlooked by road safety practitioners and governments. Currently, researchers do not have adequate data expected to draw reliable reach dependable determinations with respect to the extent of the impacts of variables that may add to cruiser exhaustion or ensuing accidents. Thus, more information on the marvel is expected to permit countermeasures to be created. It is an endeavor to integrate all motorcycle specific fatigue factors notwithstanding the known elements that add to fatigue in all road users.

In future studies, an investigation ought to be led on different sorts of physiological estimates accessible in keen groups, for example, skin temperature and galvanic skin reaction, for more robustness of drowsiness detection models. It would likewise be intriguing to utilize the models with other vehicle-based or conduct based measures.

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APPENDIX

Appendix 1 Arduino IDE command lines for drowsiness detection system

Drowsiness_Detection_Sytsem §

```
#include <TimerOne.h>
#include "pulseClass.h"

#define serialPlotter // kalau nak guna serial plotter
//#define serialMonitor //kalau nak guna serial monitor

#define ECG_PIN     A0
#define PULSE_PIN   A2
#define LED_PIN     13
#define BUZZER_PIN  9

pulseClass ECG;
pulseClass pulse;

int isDrowsy = false;

void pulseRun() {
  ECG.run();
  pulse.run();
}

void setup() {
  // put your setup code here, to run once:
  Serial.begin(115200);

  ECG.setup(ECG_PIN);
  pulse.setup(PULSE_PIN);

  Serial.println("\n\n Initiate pulseSensor.");
```


Drowsiness_Detection_Sytsem §

```
  Serial.println("\n\n Initiate pulseSensor.");
  Serial.println(ECG.setup(A0));

  Timer1.initialize(10000); //interrupt every 10ms
  Timer1.attachInterrupt(pulseRun);

  pinMode(LED_PIN, OUTPUT);
  digitalWrite(LED_PIN, LOW);
  pinMode(BUZZER_PIN, OUTPUT);
  digitalWrite(BUZZER_PIN, LOW);
}

void loop() {

  //simulation purpose
  if (Serial.available() > 0) {
    char inChar = Serial.read();
    switch (inChar) {
      case 'a':
        ECG.setSimulation(Serial.parseInt());
        break;
      case 'b':
        pulse.setSimulation(Serial.parseInt());
        break;
    }
  }

  //buzzer task
```

Drowsiness_Detection_Sytsem

```
  //buzzer task
  if (isDrowsy) {
    digitalWrite(LED_PIN, HIGH);    //led on
    tone(BUZZER_PIN, 1000, 500);//(PIN,PITCH,time)
  } else {
    digitalWrite(BUZZER_PIN, LOW);  //buzzer off
    digitalWrite(LED_PIN, LOW);     //led off
  }

#ifdef serialMonitor
  if (ECG.isUpdated() || pulse.isUpdated()) {

    int BPM1 = ECG.getBPM();
    int BPM2 = pulse.getBPM();

    int BPM = (BPM1 + BPM2) / 2;

    Serial.print(" ECG: ");
    Serial.print(BPM1);

    Serial.print(" PULSE: ");
    Serial.print(BPM2);

    Serial.print(" AVG_PULSE: ");
    Serial.print(BPM);

    if (BPM > 60 && BPM < 120) {
      Serial.print(" :Status Awake.");
      isDrowsy = false;
```

Drowsiness_Detection_Sytsem §

```
  Serial.print(" ECG_Treshold:");
  Serial.print(ECG.threshold());
//  Serial.print(" Pulse_Signal:");
//  Serial.print(pulse.signal());
//  Serial.print(" Pulse_Top:");
//  Serial.print(pulse.top());
//  Serial.print(" Pulse_Treshold:");
//  Serial.print(pulse.threshold());
  Serial.println();
#endif

  delay(600);
}
void buzzer_beeping() {
  static unsigned long buzzer_beep = 0;
  static int isBuzzerON = false;
  if (millis() > buzzer_beep) {
    if (isBuzzerON) {
      buzzer_beep = millis() + 0; //set off time
      digitalWrite(BUZZER_PIN, LOW);
      isBuzzerON = false;
    }
    else {
      buzzer_beep = millis() + 1000; //set on time
      digitalWrite(BUZZER_PIN, HIGH);
      isBuzzerON = true;
    }
  }
}
```