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JUDUL: Experimental Analysis of Drowsiness Detection System Based On Grasping Steering Behaviour

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EXPERIMENTAL ANALYSIS OF DROWSINESS DETECTION SYSTEM
BASED ON GRASPING STEERING BAHAVIOR

MOHAMAD YUSRI BIN MOHAMAD ZIN

Report submitted in fulfilment of the requirements
for the award of the degree of
Bachelor of Manufacturing Engineering

FACULTY OF MANUFACTURING ENGINEERING
UNIVERSITI MALAYSIA PAHANG

JUNE 2013

SUPERVISOR'S DECLARATION

We hereby declare that we have checked this project and in our opinion this project is satisfactory in terms of scope and quality for the award of the degree Bachelor of Manufacturing Engineering.

Signature : …………………………………………..

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Date : JUNE 2013

STUDENT'S DECLARATION

I Mohamad Yusri Bin Mohamad zin declared that this dissertation entitled *"Experimental Analysis of Drowsiness Detection System Based On Grasping Steering Behaviour"* is the result of my own research except as cited in the references. The dissertation has not been accepted for any degree and is not currently submitted in candidature of any other degree.

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To my beloved family

Mohamad Zin Bin Ahmad

Siti Haidah Bte Nina Mohammed

Habsah Bte Amin

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ABSTRACT

This project presents a sensor arrangement that is suitable for measuring grip force and hand position on the steering wheel. This sensor can be used in automotive safety systems designed to detect a drowsy driver, which is the important thing to avoid road accidents. Our approach is to design a sensor network based on the way the driver grips, each sensor equipped with the ability to detect the driver's grip force, A proof-of-concept demonstration of the sensor was created, composed of 12units force sensitive resistor (FSR). This project also presents the results of grip force men and women drivers by using drive simulators at a speed of 60km / h. Four drivers (male and female) took part in this project. Grip force was measured using a force sensitive resistor mounted systems around the steering wheel. The results showed that men's grip force is much higher than female drivers and also can detect sleepy driver, when reach the drowsy level, the buzzer will be activated and will alert the driver. Drowsiness detection system using a force sensitive resistor is a useful method for determining and monitoring the power grip while driving and detecting driver drowsiness level of the driver.

ABSTRAK

Projek ini membentangkan susunan sensor yang amat sesuai untuk mengukur daya gengaman dan kedudukan tangan pada stereng. Sensor ini boleh digunakan dalam sistem keselamatan kenderaan yang bertujuan untuk mengesan pemandu yang mengantuk, untuk mengelakkan kemalangan jalan raya. Pendekatan kami adalah untuk merekabentuk rangkaian sensor berdasarkan cara gengaman pemandu, setiap sensor dibekalkan dengan keupayaan mengesan daya cengkaman pemandu, Satu bukti-demonstrasi konsep sensor dicipta, terdiri daripada 12units force sensitive resistor(FSR). Projek ini juga membentangkan keputusan cengkaman daya pemandu lelaki dan perempuan memandu simulator pemanduan pada keadaan jalan raya yang baik, pada kelajuan 60km / h. Empat orang pemandu (lelaki dan perempuan) telah mengambil bahagian dalam projek ini. Daya genggaman diukur menggunakan force sensitive resistor sistem yang dipasang di sekeliling stereng. Keputusan menunjukkan daya gengaman lelaki yang jauh lebih tinggi dari pemandu wanita dan juga dapat mengesan tahap mengantuk pemandu, apabila pemandu mencapai tahap mengantuk pengera akan diaktifkan dan akan menyedarkan pemandu. Drowsiness detection system yang menggunakan force sensitive resistor merupakan kaedah yang berguna dalam menentukan dan memantau kuasa genggaman pemandu semasa memandu dan mengesan tahap mengantuk pemandu.

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CHAPTER 1

INTRODUCTION

1.1 PROJECT BACKGROUND

Safe driving is a major concern of societies all over the world. Thousands of people are killed, or seriously injured due to drivers falling asleep at the wheels each year. Driver drowsiness (‘falling asleep at the wheel’) is a major cause of road accidents, accounting for up to 20% of serious accidents on motorways and monotonous road. Therefore it is essential to develop a safety system for drowsiness related road accident prevention.

Many methods have been develop and some of them currently used to detect the driver drowsiness such as measurements of physiological feature like eeg, eyelid movement, gaze and head movements, are considered as a ways for monitoring alertness.

Sleep is divided into two broad types: rapid eye movement (REM) and non-rapid eye movement (NREM or non-REM) sleep, REM sleep was divided into four stages in the Rechtschaffen and Kales (R&K) standardization of 1968. Rapid eye movement sleep (REM sleep) is a normal stage of sleep characterized by the rapid and random movement of the eyes. This drowsiness occurs in stage one of NREM sleep.

According to the 2007 AASM standards, NREM consists of three stages. There is relatively little dreaming in NREM. **Stage N1** refers to the transition of the brain from alpha waves having a frequency of 8–13 Hz (common in the awake state) to theta waves having a frequency of 4–7 Hz. This stage is sometimes referred to as somnolence or drowsy sleep. Sudden twitches and hypnic jerks, also known as positivemyoclonus, may be associated with the onset of sleep during N1. Some people may also experience hypnagogic hallucinations during this stage. During N1, the subject loses some muscle tone and most conscious awareness of the external environment.

Stage N2 is characterized by sleep spindles ranging from 11 to 16 Hz (most commonly 12–14 Hz) and K-complexes. During this stage, muscular activity as measured by EMG decreases, and conscious awareness of the external environment disappears. This stage occupies 45–55% of total sleep in adults.

Stage N3 (deep or slow-wave sleep) is characterized by the presence of a minimum of 20% delta waves ranging from 0.5–2 Hz and having a peak-to-peak amplitude >75 μV. (EEG standards define delta waves to be from 0 to 4 Hz, but sleep standards in both the original R&K, as well as the new 2007 AASM guidelines have a range of 0.5–2 Hz.) This is the stage in which parasomnias such as night terrors, nocturnal enuresis, sleepwalking, and somniloquy occur. Many illustrations and descriptions still show a stage N3 with 20–50% delta waves and a stage N4 with greater than 50% delta waves; these have been combined as stage N3. From that we can said that drowsiness occurs in stage one of NREM sleep which is the beginning stage of sleep.

The drowsiness can be divided in two category firstly imaging processing and secondly physiological signal defection. In this research I choose the second method that used physiological signal defection.

The purpose of this research is to build one system that can be used to detecting force from the driver through their hand that hold to the steering. This force can be detected by using force sensitive resistor (FSR) that implement on car steering. [1]

1.2 PROJECT SYNOPSIS

The new system has been introduced, to make sure the accident which occurred by driver drowsiness can be reduce from time to time. This force sensitive resistor is defining an analytical device for the detection of an analyte that combines a biological component with a physicochemical detector. This sensor can detect the force from the driver hand and we can know whether the driver sleepy or not, from that if the driver grip force was loose the data will sent to the system and warned a driver, force sensitive resistor ensure that the grip force can be detected.

1.3 PROBLEMS STATEMENTS

The problem that I face to complete this research was I need to study the behaviour of male and female driver hold the steering in Malaysia during day, between ages 20- 30 years old. This project more towards male driver because of male always travel far and drive in a long period of time, because of that accident always occurs among male driver compare to woman.

Then I need to define where is the best place to implement a sensor at steering that can easily detect the grip force of drivers.

Other than that I need to take a sample two male and female driver in Malaysia to do an experiment about their grip force, from that I can know the grip force when driver experience the drowsiness.

1.4 PROJECT OBJECTIVES

The purpose of this study basically required students to reduce drowsiness among driver in Malaysia. Hence, objective of this project are:

I. To implement a sensor at steering based on the behaviour of drivers based on grasping steering wheel behaviour to detect driver drowsiness.
II. To study grip force when driver experience drowsiness.

1.5 SCOPE OF STUDY

In order to complete this project required precise scope of work and proper plan need to be followed before it would achieve the objective. The scopes of study are:

I. Initial study journal that related about driver drowsiness detection system and behaviour of driver when hold the steering.
II. Study of driver drowsiness causes.
III. Build one system that can alert the diver when driver start sleepy.
IV. Find different grip force between man and woman
V. Implement the system on car steering.

1.6 PROJECT SCHEDULE

Project schedule were attach at appendix A.

CHAPTER 2

LITERETURE REVIEW

2.1 INTRODUCTION

Rational systems that can reduce the main causes of accident occur while driving. Basically the number of deaths due to car accidents has been increased year by year because of drowsiness problem, the implementation of this system at vehicle can reduce this problems. This system using a force sensitive resistor (FSR) to detect grip force, if the grip force was low the alarm in this system make a sound beep and the driver's know he drive in a danger.

2.2 DROWSINESS

Drowsiness refers to feeling abnormally sleepy during the day. People who are drowsy may fall asleep in inappropriate situations or at inappropriate times. This drowsiness occurs in the first stage of sleep. [13]

2.3 DRIVER

Driving is the controlled operation and movement of a land vehicle, such as a car, truck or bus. That used steering control the vehicle whether move to the right or move to the left. [14]

2.3.1 Type of grasping steering wheel

Figure 2.1: Using two hand above the steering wheel

Figure 2.2: Using two hand below the steering wheel

Figure 2.3: One hand above and another below the steering wheel

Figure 2.4: Using one hand below the steering wheel

Figure 2.5: Using one hand above the steering wheel

2.4 ANALYZE OF BEHAVIOR OF DRIVER ON GRASPING STEERING

Understanding human driving behaviour is a key recipe to find better solution to eliminate or at least decrease the problem. One of the important aspects in the research of human driving behaviour is to identify and classify the normal and abnormal behaviour.

European Automobile Manufacturers Association (ACEA) in their vehicle safety model showed that crash unavoidable period come after dangerous period which is caused by abnormal driving behaviour. This explains that accident is happen when the behaviour of the driver has deviated from the expected standard of performance.

Several researches also studied about the driver's handling behaviour. Eksioglu investigated the relationship between driver gender, driving speed, road condition and characteristics of grip force. He conducted the experiments with 13 subject drivers, and concludes the grasping force differences for in gender without influence from driving environments by the analysis results. However, the measurement point for grasping force was fixed in one point on the steering wheel. [4]

Kodiara investigated the grasping feeling of driver in the experiment for meandering driving with lateral direction force measurement. And the importance for grasping feeling on the steering wheel in the evaluation for driver satisfaction had cleared. [3]

Tanaka analysis the steering wheel operation by estimation for human hand impedance properties using mechanical linkage model, from their result, the grasping point on the steering wheel have significance to reduce the driver's operational load and a driver will change the upper and lower position on steering wheel according to the driving environment in order to improve their operational force. [6]

In a vehicle driving situation, there are some contact sensing methodologies using the driver's necessary behaviour for vehicle driving. Steering wheel operation is one such important behaviour for vehicle driving which involves grasping the steering wheel. From this viewpoint, we have investigated the characteristics of steering wheel operation with several subject drivers. [1]

2.5 CASE STUDY 1: DEVELOPMENT OF A SENSOR SYSTEM FOR GRASP BEHAVIOR ON A STEERING WHEEL

Now we look at another simple case study related to drowsiness detection system. Takashi IMAMURA et al. show their analysis results show that in more than 70[%] of cases, the reasons for accidents are cognitive and judgemental errors of the car driver. These matters are one of the big problems in our daily life, and therefore a number of researchers and companies are attempting to develop new technology which can minimize these kinds of accidents. [1]

Recently, several micro-chip sensors which can detect the pH of a person's sweat or the blood flow through a person's skin have been developed. They have the possibility to achieve more precise and more stress-free human sensing if the sensor arrangement is designed correctly for stable detection. In a vehicle driving situation, there are some contact sensing methodologies using the driver's necessary behaviour for vehicle driving. Steering wheel operation is one such important behaviour for vehicle driving which involves grasping the steering wheel. From this viewpoint, we have investigated the characteristics of steering wheel operation with several subject drivers. Based on the knowledge gained through experiments, a multiple-pressure sensor system implemented on the steering wheel is proposed in their research. [1]

2.5.1 Proposed Sensor System and Its Design

In this section, a sensor system which can detect the grasping behaviour of a driver on the steering wheel is proposed. An overview of the construction of the system and design strategies is also described. [3]

2.5.1.1 Purpose of the Sensor System

Grasping or handling behaviour of a driver on the steering wheel is one of the characteristics of driving a car. Generally, it is said that a human's behaviour of their hands includes several symbolic gestures related to their emotions or situations.

Moreover, when people drive a car, they usually operate the steering wheel with their bare hands. This makes it possible to apply several biological sensors. On the other hand, sensors which need contact with human skin usually suffer from sensor noise if they are highly sensitive for biological sensing.

Therefore, sensor selection or sensing strategy becomes more important when a multiple sensor array is used. From this viewpoint, the proposed sensor system is designed to detect the grasp position by pressure to determine the suitable position of human skin for biological sensing. [1]

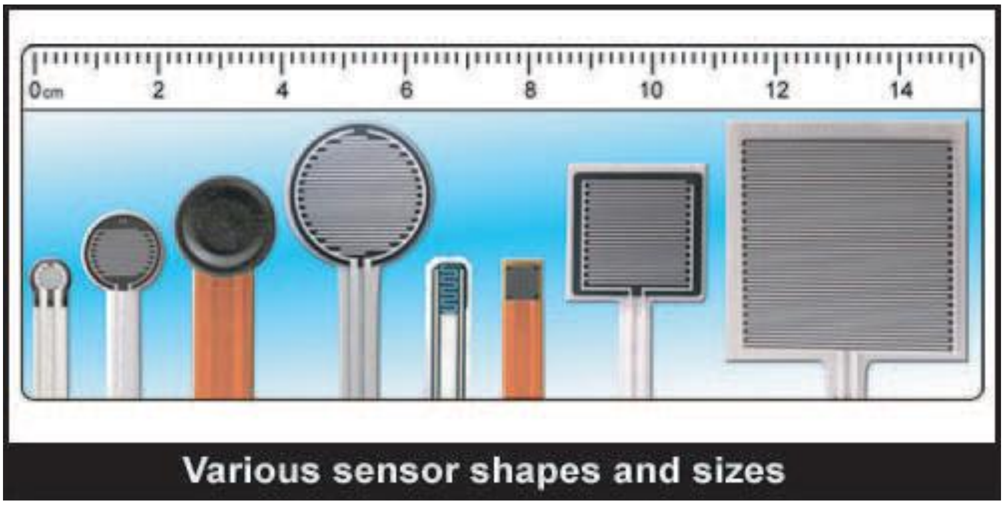

Figure 2.6: Photograph of sensor probe shapes provided in their research (Sources: Takashi IMAMURA et al, October 2009)

Figure 2.6 shows the shape of the sensor probe used in this system. SENSOR PRODUCT INC. provides several kinds or shapes of micro force sensors, and for the proposed system a sensor which is 5[mm] square in size was chosen to be installed inside the steering wheel. Each sensor acquires the pressure force on each sensor probe and is collected by a single unit, which then transmits all of the pressure data to a PC via USB2.0 every 50[msecs].

2.6 CASE STUDY 2: DITRIBUTED SENSOR FOR STEERING WHEEL GRIP FORCE MEASUREMENT IN DRIVER FATIQUE DETECTION

Federico Baronti et al, was introduce a low-cost and simple distributed force sensor that is particularly suitable for measuring grip force and hand position on a steering wheel. The sensor can be used in automotive active safety systems that aim at detecting driver's fatigue, which is a major issue to prevent road accidents. The key point of their approach is to design a chain of sensor units, each of them provided with some intelligence and general purpose capabilities, so that it can serve as platform for integrating different kinds of sensors into the steering wheel. [2]

2.6.1 Steering Wheel Distributed Sensor

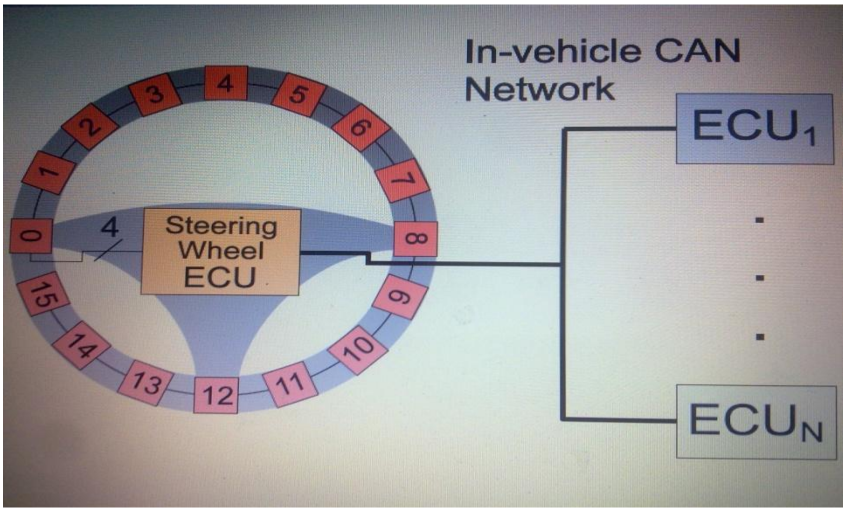

Figure 2.7: Steering wheel distributed sensor.
(Sources: Federico Baronti et al, May 2009)

The key point of our approach is to integrate a distributed sensor network into the steering wheel, as sketched in Figure 2.7.Each unit of the distributed sensor network embeds a tiny microcontroller, which is in charge of reading the actual sensing element and transmitting the local data over the sensor chain.

In addition, it is possible to cascade an almost arbitrary number of units through a simple interface made up of 4 wires, which comprise power supply, clock, and a bidirectional data signal. This solution offers significant advantages as compared to having a set of dumb sensing elements along with a centralised acquisition module, as proposed in [2], in which 17 groups of 3 sensors (polyvinylidene fluoride film, piezoresistive, and temperature sensors) are used.

Obviously, adopting a distributed sensor network approach, the wire harness of the overall sensor and its integration into the steering wheel is dramatically simplified [2]. Moreover, the small additional cost due to the presence of a microcontroller in each unit is comparable with the cost of the analogue multiplexer required in the centralised approach [2], whose complexity also increases with the number of units utilised.

Figure 2.7 shows a possible application scenario of the distributed sensor network, in which 16 units are cascaded, so that a good spatial resolution is obtained. In the considered scenario, the first element of the sensor chain is connected to the nearest CAN (Controller Area Network) node, i.e., the Steering Wheel ECU. We notice that the In-Vehicle CAN network seems to be the ideal infrastructure for sharing data relevant to driver's fatigue detection, which can be performed by either the Steering Wheel ECU, or another ECU specifically devoted to active safety. In this way, some valuable data, such as steering angle and torque, which are already available from the Servo Steering ECU, can be exploited by detection algorithms without the need of additional hardware.[2]

As far as the sensor network management is concerned, each unit owns a unique address, which is assigned to it during the configuration phase. The Steering Wheel ECU can retrieve the data related to a given unit by issuing the reading command together with the unit address. It is also possible to broadcast a command, which does not require a reply, using a general address, so that the command is handled by all the units at the same time. This is useful for triggering the acquisition of the sensing elements by all the units simultaneously. In addition, the broadband address can be used during the configuration phase to set the address of the unit that is selected forcing the reading of its sensing element to a particular value, outside the range of values that are measured during the operating phase.[2]

2.6.2 Implementation and Test

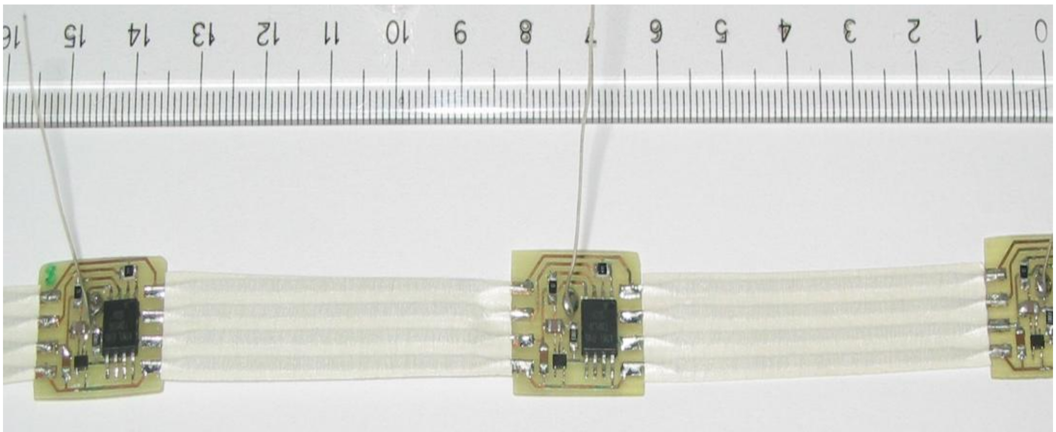

Figure 2.8: Photograph of the sensor chain.

(Sources: Federico Baronti et al, May 2009)

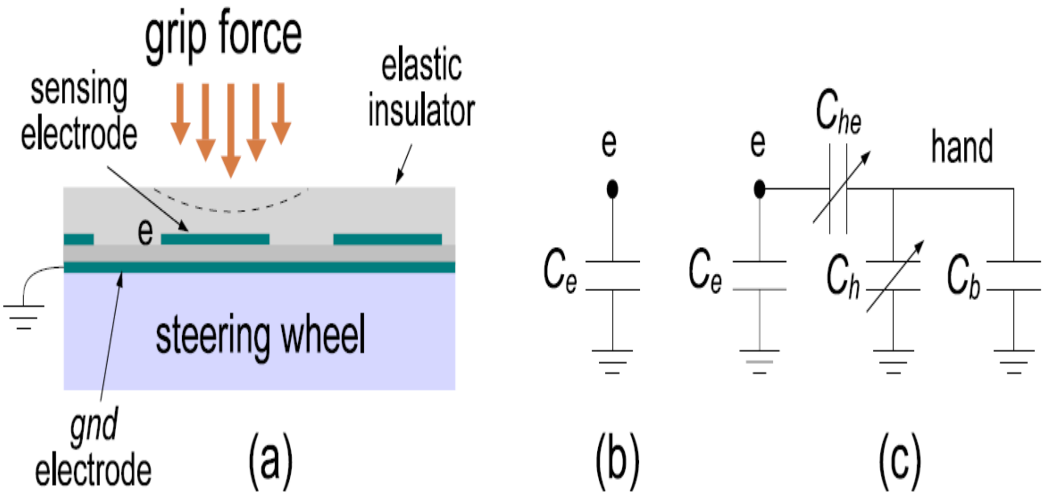

Figure 2.9: (a) Capacitive sensing element. (b) And (c) Electrical models in the absence and presence of the driver's hand respectively.

(Sources: Federico Baronti et al, May 2009)

The sensor unit board has been realised and 16 units have been chained together. A photograph of a portion of the sensor chain is reported in Figure 2.8, which shows that each unit is connected only to its neighbouring ones. The PCB area of a single unit is 20x14 mm2 and the spacing between consecutive units is around 75 mm. The sensor chain has been assembled on a commercial steering wheel (with a 380 mm diameter) adopting for the sensing electrodes the structure sketched in Figure 2.9, which has been specifically designed for this work. In the absence of driver's hands, the only capacitance added to C0 is the capacitance Ce between sensing and gnd electrodes. On the contrary, the presence of the driver's hand introduces three additional capacitors, i.e., Che between hand and sensing electrode, Ch between hand and gnd electrode, and Cb that is the driver capacitance towards gnd. The values of the first two capacitors depend on the grip force, so that the frequency of the oscillator is related to the presence of the hand and to its grip force to the steering wheel. The on-board components R and C0, as well as the integration window of the frequency meter, can be tailored to the above electrode parameters to increase sensor sensitivity.[2]

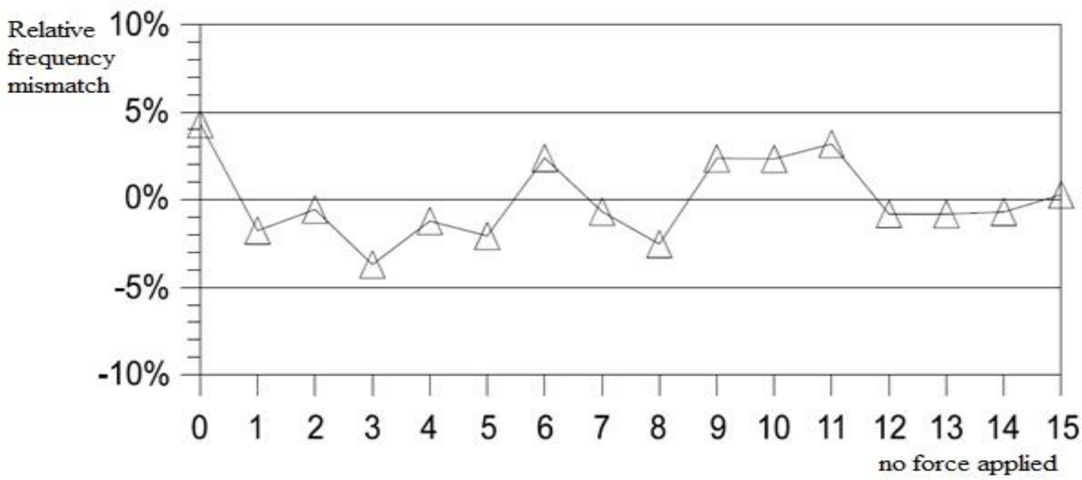

Figure 2.10: Relative frequency mismatch of the 16 units when no force is applied. (Sources: Federico Baronti et al, May 2009)

The implemented distributed sensor has been tested connecting it to a PC through an interface board that generates the 1 MHz clock and acts as a bridge between the sensor chain and the PC serial port. Before assembling the chain on the steering wheel, each unit has been configured with a unique address. As that phase can be carried out by broadcast commands only, the selection of the unit being configured is achieved by connecting its sensing electrode to ground, so that it is the only unit in the chain with the oscillator stopped. Then, only the microcontroller that reads a frequency equal to zero will accept the configuration command and set its address. Once the chain has been configured and assembled on the steering wheel, the performance of the sensor has been evaluated querying the sensor readings from a LabVIEW application running on the PC with 10 Hz rate. First of all, no force was applied to characterise the uniformity of the chain and the results are reported in Figure 2.5, which shows a good repeatability from unit to unit. Then, the response of the sensor to a grip force was investigated. It was found that the frequency reading of the unit corresponding to the steering wheel sector where the hand is positioned decreases as expected and up to 40% when the maximum force is applied. This is a very encouraging result and proves that the proposed sensor can be used to monitor grip force in driver's fatigue detection systems.[9]

2.7 CASE STUDY 3: WIRELESS SENSOR EMBEDDED STEERING WHEEL FOR REAL TIME MONITORING OF DRIVER FATIQUE DETECTION

Betsy Thomas Electronics et al, study said that the system architecture for real-time, non-obstructive, automatic detection and alarming for driver drowsiness. Data/sensor fusion technology incorporated with the system monitors the driver drowsiness including fatigue and cardiac problems. Alertness of the driver is monitored by analyzing the heart rate by a non-invasive method. The system reads the pulse rate of the driver through multimodal physiological sensor unit embedded on steering wheel. Formulated data processing algorithm incorporated with the system measures the heart rate of the individual and invokes an emergency alarm, if it falls below a specified threshold value. A second level of alarm is issued to the concerned authorities and rescue forces, if the heart rate variation is found to be consistent. The second level of warning incorporates alert messages constituting vehicle identification number and GPS coordinates. One of the novel ideas incorporated is the development of multiple sensors embedded in the steering wheel and unique heart rate calculation algorithm. The system is capable of measuring the heart rate and dynamically alerts the driver or the rescue team about the driver drowsiness, to avert accidents. At the end of this paper, an analysis on the various methods for failure analysis and prevention is also provided. [3]

2.7.1 Intelligent Steering Wheel Distributed Sensor

This paper is to integrate sensors in the steering wheel without causing any inconvenience to the driver. Intelligent Steering Wheel Distributed Sensor Network (ISDSN) consists of multiple sensors embedded on the steering wheel. The pulse sensors encircled on the steering wheel captures the pulse rate of the driver. The main advantage of this sensor is that the IR emitter and detector are arranged in a small single package and this tiny sensor package is encircled in the steering wheel cover. The arrangement of the sensor network in the steering wheel is depicted in Figure 2.11.The sensor network makes no inconvenience to the driver since it is closely packed inside the steering wheel cover and only the sensor portion is exposed outside and a direct contact is enough to measure the heart beat using this system. [4]

Figure 2.11: Sensor embedded steering wheel
(Sources: Betsy Thomas Electronics et al, April 2008)

When the driver places the palm on the steering wheel, the light from the sensor is obstructed and the reflected light from the palm is registered. The light reflected back is taken for subsequent data analysis and processing to determine the heart rate variability. The light reflected back depends on the blood volume changes through the blood vessels.

The ISDSN detection system consists of four modules namely, IR sensor assembly, filtering and amplification module, data conversion module, data aggregation and processing module as shown in Figure 2.12. A sensors embedded steering wheel model is depicted in the figure and the notations 1, 2, 3...N are the sensor assembly fixed in the steering wheel cover. Each sensor assembly is a tiny set of signal conditioning circuit that can easily been accommodated in the steering wheel cover. The signal conditioning circuitry comprises of a filter and an amplifier. The primary section of the entire assembly is the sensor unit alone.

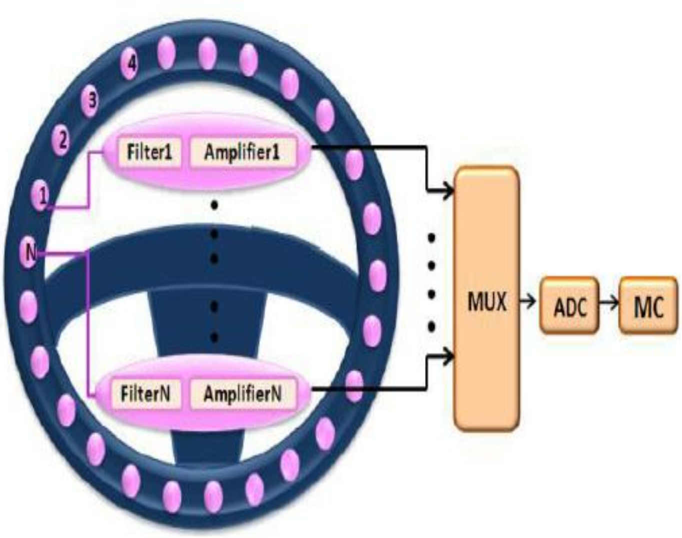

Figure 2.12: ISDSN Detection system

(Sources: Betsy Thomas Electronics et al, April 2008)

The reflective IR sensor array used for drowsiness detection comprises of IR emitters and phototransistor detectors. Infrared light is absorbed well in blood and weakly absorbed in tissue. When the palm is placed on the sensor the light passes through the skin and the light that is reflected back on account of blood passage is captured by the detector. The light reflected back has intensity variation that occurs as the blood volume changes in the tissue and these results in voltage variations. This voltage level variation determines the heart rate. [5]

2.7.2 Wireless Sensor Network

The architecture for the proposed wireless sensor network system, to detect driver drowsiness, includes an intelligent steering-wheel distributed sensor network (ISDSN), a sensor data storage (SDS), a data analysis and feedback module (DAFM), and remote reporting centre (RRC). The proposed system design is given in the block diagram below. The wireless sensor system will gather signals from multiple sensors placed on the steering wheel, provides real time monitoring and feedback, data analysis and reporting driver performance to remote centre. Each module has different functionalities to detect driver drowsiness.

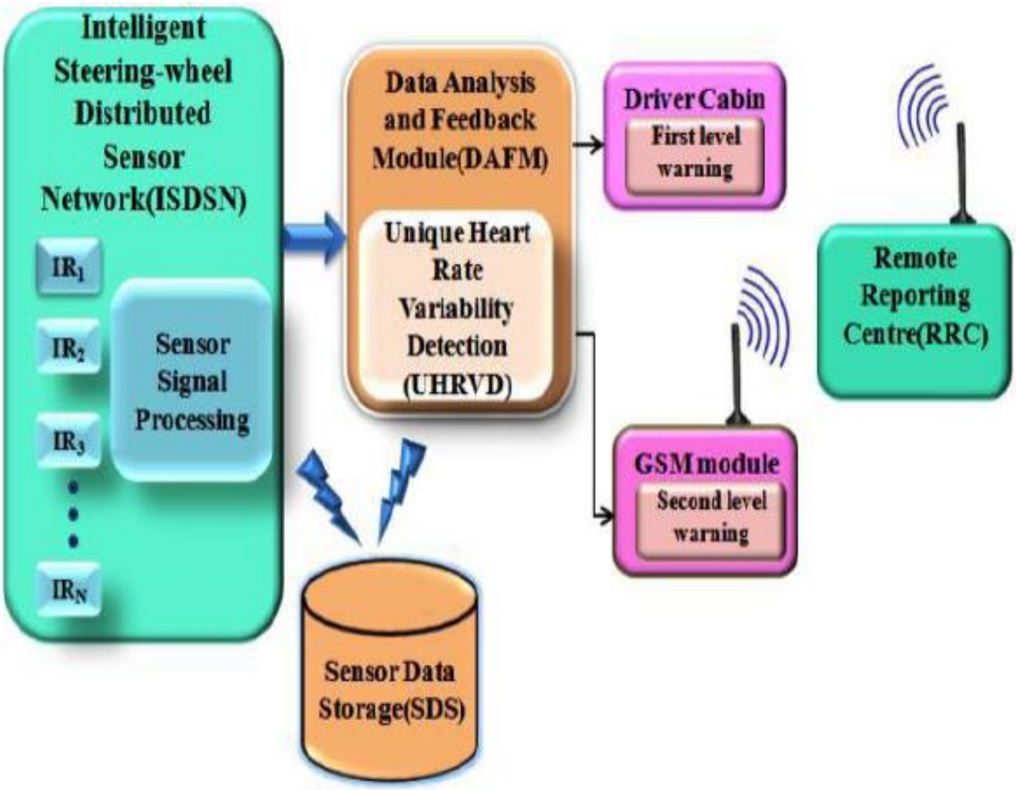

Figure 2.13: Block diagram

(Sources: Betsy Thomas Electronics et al, April 2008)

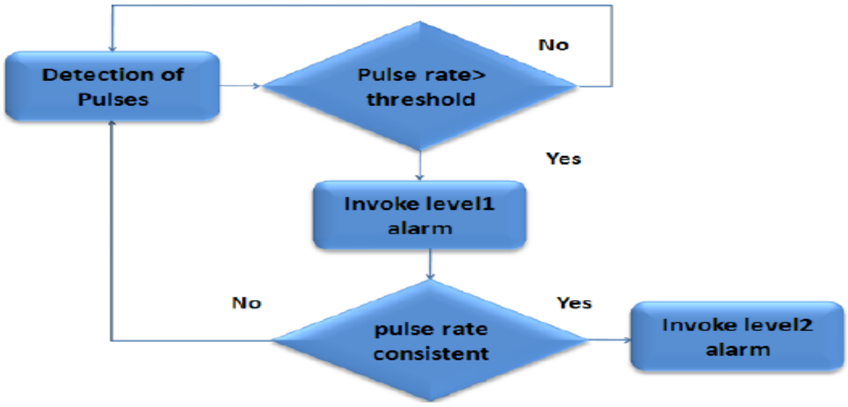

Figure 2.14: Flow diagram of the system

(Sources: Betsy Thomas Electronics et al, April 2008)

2.7.3 Result

The prototype of driver drowsiness detection system using IR reflective sensors was developed and tested using LabVIEW software. The simulation result of pulse rate variation is given in the graph below. The pulse signal obtained from the hand by placing the palm on the IR reflective sensors is captured as given below in Figure 2.15.

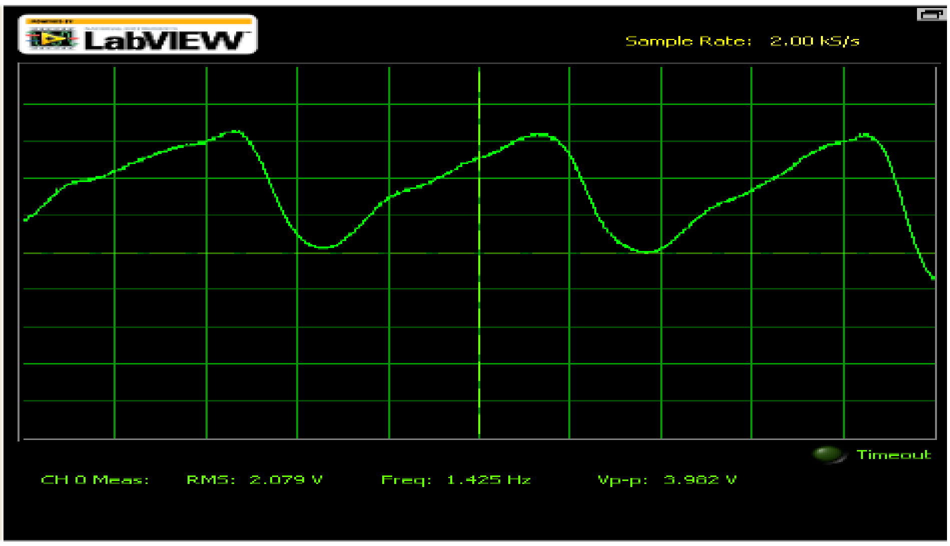

Figure 2.15: Pulse rate variation from ISDSN

(Sources: Betsy Thomas Electronics et al, April 2008)

Here the feature point is repeated at intervals. Each signal peak in the feature point gives the heart beat pulse received by the detector. The light transmitted from the emitter will be reflected back with little absorption when the heart pumps blood through the blood vessels. When the blood pumping withdraws, the light will be passed through the palm hence no signal is obtained. The high and low peak shown in the graph indicates this level. Consecutive signal peaks were analyzed and checked the variation with actual set threshold value since the peak and interval between the pulses determines the heart rate variability. The software developed takes the pulse value and calculates the amplitude and the interval in each feature point that is repeated at intervals. [5]

2.7.4 Failure Analysis and Prevention

Failure of any one of the components present in the Intelligent Steering-wheel Distributed Sensor Network can lead to accidents and hence this has to be prevented. For this, it is essential to provide crucial failure information about each component. Failure Modes and Effects Analysis (FMEA) includes the various types of analyses including prior engineering knowledge and experience which are commonly used to determine the potential modes of failures a product might encounter during its lifetime. A function-failure method is used to design the product with solutions for functions that eliminate or reduce the potential of a failure mode. In particular, methods to understand and predict the potential failure modes are viewed as essential for fault monitoring and failure prevention. This method explores the relationship between failure modes and functionality of components.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This invention relates to a system for a drowsy driver. Each year numerous automotive accidents and fatalities occur as a result of sleepy individuals falling asleep while driving. It has been observed that these drivers exhibit certain physiological patterns that are predictable and detectible.

First step to start this invention must understand the way of driver grasping steering wheel by using the video that I have been made and using the survey towards twenty randomly male respondent.

Secondly using Force Sensitive Resistor (FSR)**,** this device was use to get grip force from driver to detect whether drowsy or not. Then used National instrument (NI) board to do a programming to convert the grip force from driver and convert to graft output.

Lastly this invention used an alarm system to alert the driver if the grip force reaches drowsy level.

3.2 DEVELOPMENT OF DROWSINEES DETECTION SYSTEM

The classic “head bobbing” motion, where the driver’s head drops and then quickly pulls back upward is one of the patterns that is often exhibited when an individual is becoming drowsy while seated in an upright position. Additionally, a lower grip force may also indicate the presence of drowsy driver.

Several known drowsiness detection systems used CCD cameras or other optical sensors to detect an image of the driver’s face in order to analyze eyelid movements for signs of drowsiness. Optical sensors may become covered or blocked by dirt and debris and therefore lose their ability to function effectively. Furthermore they may be ineffective when the driver is wearing eyeglasses or sunglasses.

Furthermore, some systems attempt to detect a drowsy driver by monitoring only the steering pattern of the driver. In certain conditions, this system may incorrectly determine the driver drowsiness level. For example, new driver often exhibit erratic steering pattern while learning how to drive. Also, drivers of off-road vehicles may also display abnormal and erratic steering patterns while trying to navigate rough terrain. A drowsiness detection system based solely on steering patterns may falsely identify these drivers as drowsy.

Other systems attempt to monitor the driver’s heart rate using devices and apparatuses that must be fastened to the driver’s body. These include wrist straps, collars, handbag, glasses and other device. These systems may cause discomfort and may be bothersome to the driver, and therefore may place the driver at increased risk. Additionally, there is no guarantee that the driver will wear any of these devices. These systems are only effective in cases where the driver choose to war the device.

It is therefore desirable to provide an effective system capable of determining the driver’s risk of falling asleep by implementation a sensors at steering wheel that can easily detect the impulse from the driver’s through their hand, this device don’t have any risk because it not be bothersome to the driver.

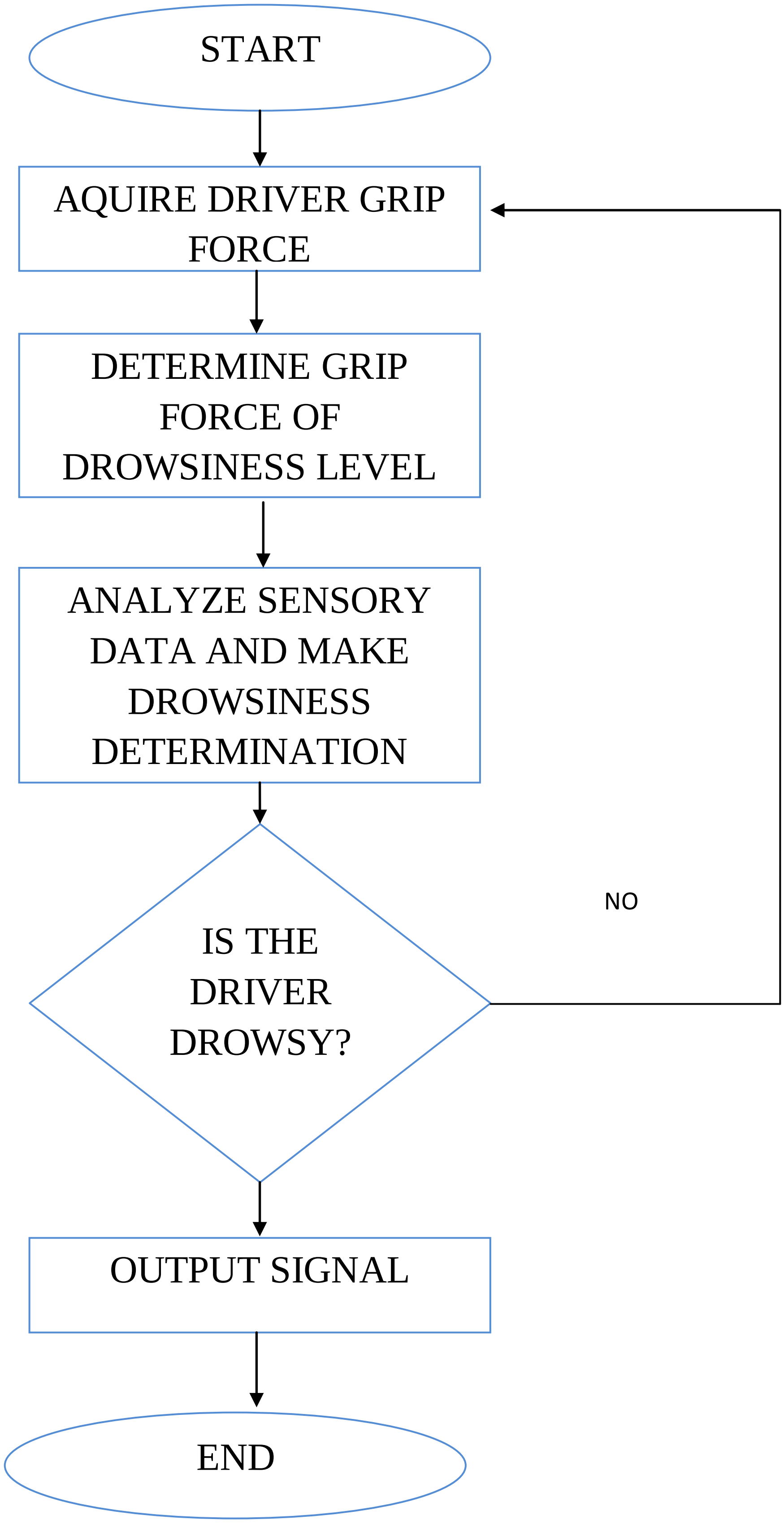

Figure 3.1: Project flow chart

3.3 STUDIES ON DRIVER BEHAVIOR

3.3.1 Make a video

From a video that I have made, when a driver drives a car I want to understand about behaviour of human while driving a car, I more specific about how the driver grasping a steering wheel. There are so many way that driver use to grasp a steering wheel, as an example in a highway the driver always use two hand to grasping the steering because of car moving faster, different from drive at resident area their always use one hand because of the car moving slowly, from my experience as a driver, the driver become more sleepy when drive at highway because the road straight and lack of car and they always use highway for travel in long period of time, because of that the driver's can easily experience drowsiness.

I more specific to male drivers because of man usually drives a car for travelling for a long distance, different from female driver that usually drive at resident area.

Besides that, day or night also the causes of drowsiness to happen, I more specific drive during a day, because of driver always to go work. Such as truck driver, taxi driver and many more.

Figure 3.2: Start driving

Figure 3.3: After half hour driving

Figure 3.4: After forty minutes driving

Figure 3.5: After one hour driving

Figure 3.6: Corner to right

Figure 3.7: Corner to left

Example of way grasping steering wheel from video

3.3.2 Survey

This survey have been done towards 20 randomly respondents. This survey functioned as the medium that help me to understand the behaviour of male drivers among 20-30 years old during a day.

Besides that, this survey also can help me to make a conclusion what is the best way grasping steering wheel. Then, I can know how many percent of driver in Malaysia experience the drowsy while driving and the cause of drowsiness happen. Example of survey form were attach at appendix B

3.4 TRACK LANE

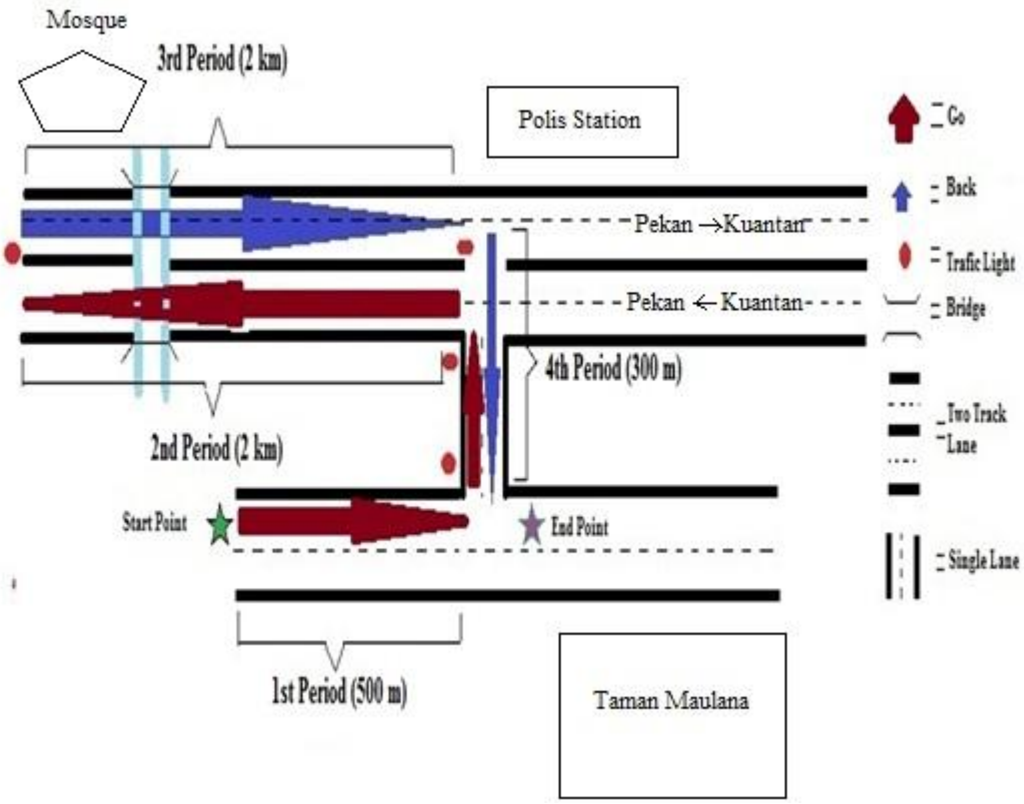

Figure 3.8: Track Lane

In this project all driver used a same track lane to see the differences of the way they use to grasping steering wheel. The track lane that used nearing Pekan, Pahang, Malaysia. The distance that we travelled approximately 5 KM for each driver and have four traffics signal.

Other than that all driver usually used this track lane to get to town. This track also normal road that used by villagers and full with car, all drivers must have good driving experience from that we can see how they control the car safely

The snap shot from video were done at first, second, third and fourth period at track lane. For first period after 250m from starting point, for second period after 1000m from second traffic signal, for third period at also after 1000m after third traffic signal and for last period after 150m after last traffic signal.

3.5 DRIVING SIMULATION

In this project we have Driving Simulation methodologies applied to training and research in the field of road transport has been proven to be both cost-effective and efficient. Simulation aims to give the driver an opportunity to immerse him/herself in his habitual workplace

The truck simulator as showed in figure 3.9 consists of a real car steering embedded with 12 FSR sensors, an instructor station and a system of screens that cover 180 degrees of vision. A set of 1 screen with re-configurable positions cover a large area showing all angles of vision of drivers. The simulator has 2 scenarios (straight lane and cornering) with more than 40km of roads it allows driving in at same time of day.

Figure 3.9: Driving simulator

3.6 DRIVER CRITERIA

In this project exactly have six driver four male drivers and two female drivers. All drivers that have chosen should have these criteria such as fatty or slim age between 20 – 30 years old.

Table 3.1: Driver Criteria

Gender	Driver	Weight (kg)	Height (m)
Male	A	100	1.60
	B	97	1.55
	C	56	1.53
	D	60	1.58
Female	E	60	1.43
	F	48	1.40

All driver are arranged from A – F, for male driver we have driver A – D and for female driver E and F. For male driver, driver A weight 100 kg, driver B 97 kg, driver C 56 kg and for last male driver, driver D 60 kg, and for female, drive E 60 kg and driver F 48 kg.

All drivers have different weight for fatty driver weight range between 80 kg to 100 kg for male and between 60 kg to 80 kg for female driver, for slim driver weight range between 50 kg to 80 kg for male driver and 40 kg to 60 kg for female driver. Driver height not important because their height about same.

This driving simulator about 30 minutes of driving period from start to end point, at minutes 21 at driving simulator we have cornering road that make the driver shock and their grip force become stronger again.

3.7 GRIP FORCE MEASUREMENT

3.7.1 Force Sensitive Resistor (FSR)

` In my research I use this force sensitive resistor (FSR) to read the grip force from drivers hand by using reactive resistor that implement to car steering.

Force Sensing Resistors (FSR) is a polymer thick film (PTF) device which exhibits a decrease in resistance with an increase in the force applied to the active surface. Its force sensitivity is optimized for use in human touch control of electronic devices. FSRs are not a load cell or strain gauge, though they have similar properties. FSRs are not suitable for precision measurements.

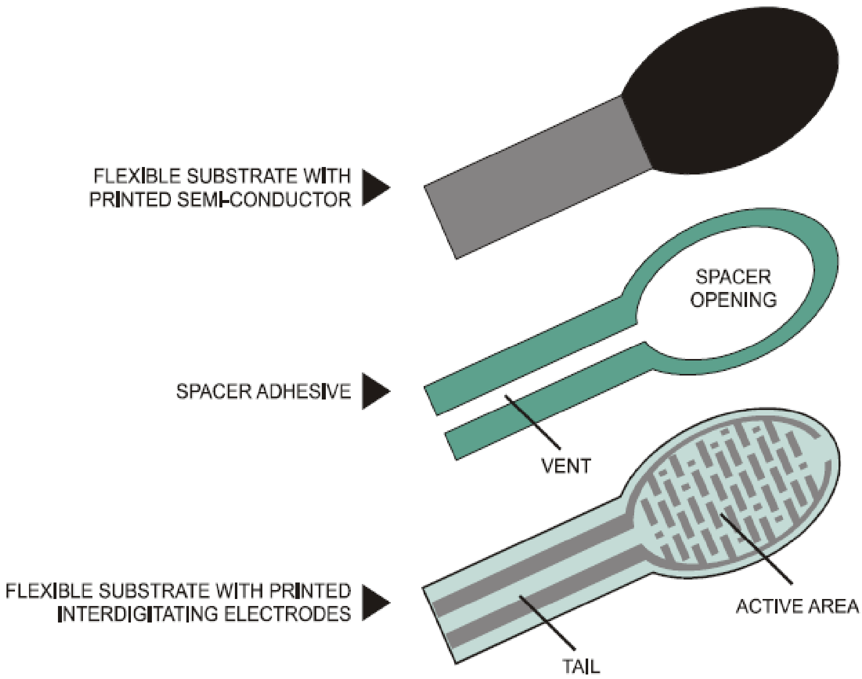

Figure 3.10: FSR Construction

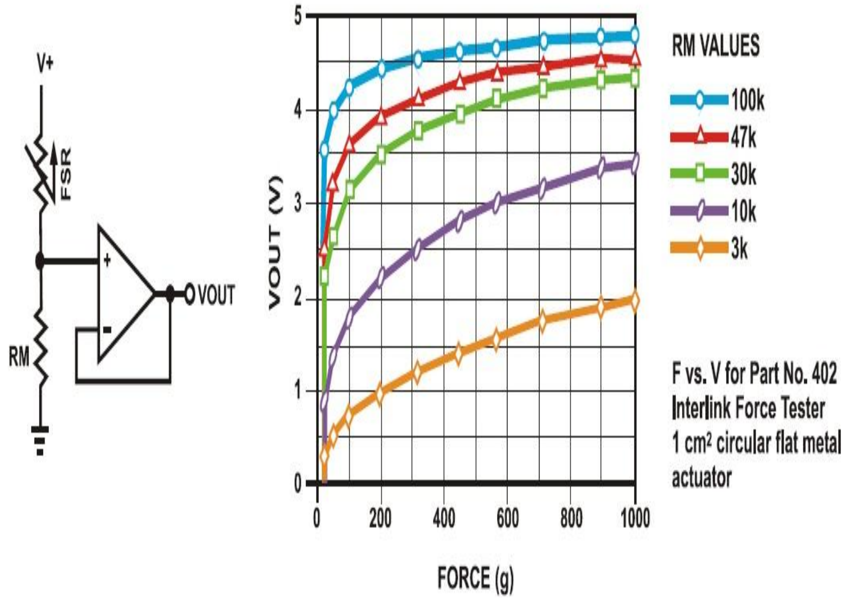

Figure 3.11: FSR Voltage Divider

For a simple force-to-voltage conversion, the FSR device is tied to a measuring resistor in a voltage divider configuration. The output is described by the equation:

$$VOUT = (V+) / [1 + RFSR/RM]. \qquad (3.1)$$

In the shown configuration, the output voltage increases with increasing force. If RFSR and RM are swapped, the output swing will decrease with increasing force. These two output forms are mirror images about the line VOUT = (V+) / 2

The measuring resistor, RM, is chosen to maximize the desired force sensitivity range and to limit current. The current through the FSR should be limited to less than 1 mA/square cm of applied force. Suggested opamps for single sided supply designs are LM358 and LM324. FET input devices such as LF355 and TL082 are also good. The low bias currents of these op-amps reduce the error due to the source impedance of the voltage divider. A family of FORCE vs. VOUT curves is shown on the graph above for a standard FSR in a voltage divider configuration with various RM resistors.

3.7.2 Sensor Characteristics

The sensor values were already calibrated before installation inside the steering wheel. However, in the manufacturing process, the outside leather has to be tightened to avoid slackness between the core of steering wheel and leather, and this tightening applies a constant pressure force on the sensor probe as a bias value.

In this system, detection of the changes of a driver's grasping force is main importance, and consequently the sensor value can be used as a relative value even though it contains a bias value. The evaluation results as show in next subsection that the sensor can detected grasping behaviour in which the driver put his hand on a point, then moved his hand to another point and then back to first point. Furthermore the experiments confirm that the system has enough sensitivity in force detection and time resolution.

3.7.3 Mechanical Problem of the System

A serious problem of the proposed system is the wiring for the sensor cables. In this system there are 13 sensors inside the steering wheel, and the sensor cables occupy the wiring space where the tip of the sensor probe is small. The most inconvenient aspect of the steering wheel is that the cables constrain its movable range.

3.7.4 National instrument (NI) board

In this research I used NI board to do a programming to get an output from the ECG that read the heart rate of the driver. This board will combine with alarm system that can alert the driver when the heart rate of driver achieved the drowsy level.

Figure 3.12: National Instrument board

3.7.5 LabVIEW Software

This software were use to do a programming to National instrument (NI) board to convert data from ECG to the output. Then connect this board to alarm system that used to alert the driver.

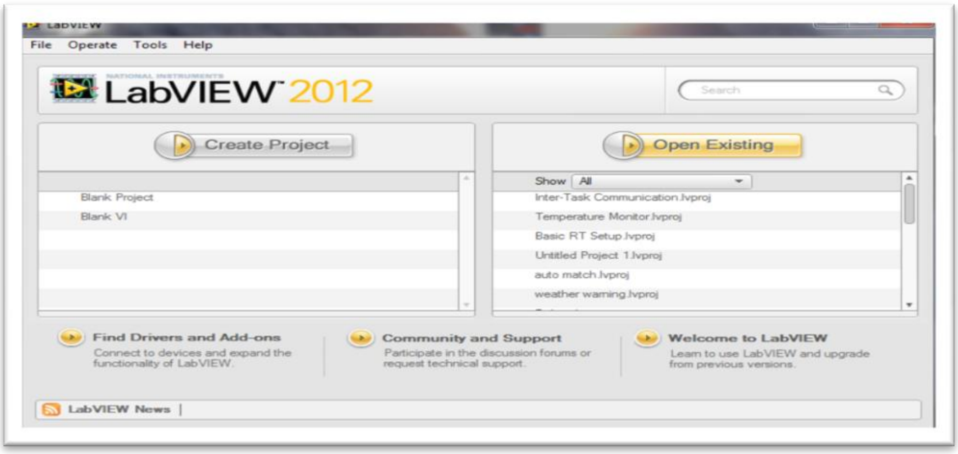

Figure 3.13: LabVIEW software

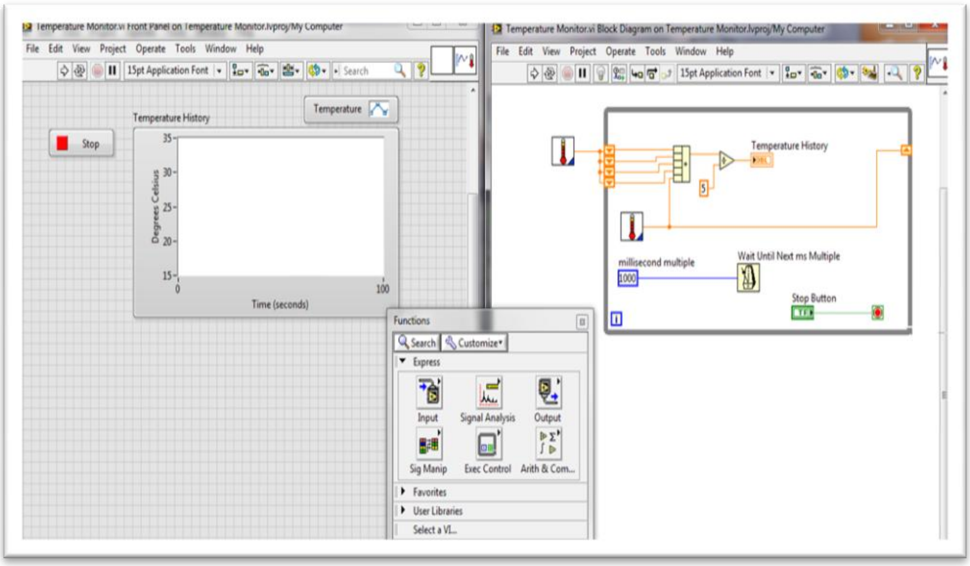

Figure 3.14: Programming

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

In this chapter we can see the result of arrangement of sensors at car steering wheel, this arrangement of sensor based on the steering wheel grasping behaviour by the driver.

Other than that we can also study the different grip force between fatty and slim driver and also how these criteria can affect the different of their grip force. If their grip forces under drowsy level the system automatically activate and alert the driver by beep sound.

4.2 IMPLEMENTATION OF SENSOR

The implementation of the sensors to the steering wheel was conducted based on the considerations above in chapter 3. In this section, an evaluation of the sensor system through fundamental experiments using the sensor system is performed.

Twelve sensors was embedded at steering wheel to easily detect grip force from driver hand, based on their behaviour the higher probability was the driver using both hand left and right above steering wheel so at more sensors embedded at this area.

4.3 SURVEY RESULT

Table 4.1: Survey towards 20 respondence

Way	Grasping Behavior	Result (Per Person)
1		8
2		3
3		3
4		2
5		4

This survey done towards twenty randomly respondence, to understand most likely way of grasping steering wheel by driver in Malaysia. The highest result is by using both hands above at right and left steering wheel, respondence choose number one because they feel more comfortable and more cautious drive by using both hands.

4.4 BEHAVIOUR OF DRIVERS

4.4.1 Grasping Behaviour for Sensor Arrangement

Table 4.2, 4.3, 4.4, and 4.5 shows results for grasping style of driver's hands in this project. They were picked up from the movie as the majority style in each period of driving course and at 4 kinds of trial. These results show that the grabbing style has individual characteristics strongly in each person. Other than that, there are almost no differences between trial number 1-2 and 4 because of the driving situation has time constrain and it makes driver's stress.

Moreover, it was clarified that all of the drivers were not aware of their grasping style through this project. And they also could not found their own grabbing style from the sample photographs. From these results, the grasping steering wheel is one of unconscious behaviour of driver, and it has the possibility to estimate their internal state by observing for their grabbing styles. In order to investigate more precise grasping behaviour, integrated steering wheel with pressure sensors based on their grasping styles for sensor project.

From this project we can see that all drivers have their own way of grasping steering wheel that based on their comfort. Driving in the rural area has different grasping style from urban area. Usually at rural area their driving carefully because of single track lane and full with car on the road different from urban area that have double track line and lack of car.

Table 4.2: Behaviour of Driver A

Driver A	1st Period	2nd Period	3rd Period	4th Period	Traffic Signals
1st Trial					
2nd Trial					
3rd Trial					
4th Trial					

Driver A, age 23 years old, weight 100 kg, height 160 cm, and physical condition fatty. As we can see at the first trial and second trial don't have any difference between the grasping style, we can look that he grasps the steering wheel with full of confident and tight form the first period until the last period, when have a traffic signal he turn the steering wheel using two hand.

At two and fourth period at the third trial we can see that he start loose hand from the steering wheel, this is because the driving situation has time constrain and it makes driver's boring.

From the last trial we can see he loose his hand from steering wheel from period two until the last period but still cornering using two hand because of he still have good confident level but start fell stress while driving.

Table 4.3: Behaviour of Driver B

Driver B	1^{st} Period	2^{nd} Period	3^{rd} Period	4^{th} Period	Traffic Signals
1^{st} Trial					
2^{nd} Trial					
3^{rd} Trial					
4^{th} Trial					

Driver B, age 27 years old, weight 97 kg, height 155 cm, and physical condition fatty. As we can see at the first trial we can look that he grasps the steering wheel with full of confident and tight form the first period until the last period, then at a traffic signal he turn the steering wheel using two hand.

When the second trial was start he start loose his hand from steering wheel from period one until the last period, he not grasp the steering wheel but just put his hand at the centre of the steering wheel and cornering using only one hand.

At the third trial he grasps at the bottom of steering wheel at the first period. While at the second and third period he again grasp at upper of steering wheel look like normal but when arrive at fourth period he again only used one hand to grasp steering wheel.

At the last period he start look very drowsy and cannot drive efficiently, he use so many way of grasping steering wheel at first period grasp at the bottom of steering wheel at second period upper of steering wheel at third period just only one hand to grasp and at last period using both hand but one above and one bottom of steering wheel.

Table 4.4: Behaviour of Driver C

Driver C	1st Period	2nd Period	3rd Period	4th Period	Traffic Signals
1st Trial					\ 
2nd Trial					
3rd Trial					
4th Trial					

Driver C, age 23 years old weight 56 kg, height 153 cm, and physical condition slim. As we can see at the first trial and second trial, we can look that he grasps the steering wheel with full of confident and tight form the first period until the third period, but at the last period he try used only one hand, then at a traffic signal he turn the steering wheel using both hand.

At the third trial he grasps the steering wheel like in first and second trial. While at the third period he again grasp at bottom of steering wheel with one hand like usual., but when arrive at traffic signal he again used both hand to grasp steering wheel.

At the last period he looks very confident to drive because of same track lane. He only used one hand to grasp steering wheel at first, third and last period and at second period using both hand to be more confident to handle the car.

From all the trial that done towards him, we can conclude that he more comfortable and more confident drive a car using one hand than using both hand to grasp steering wheel.

Table 4.5: Behaviour of Driver D

Driver D	1st Period	2nd Period	3rd Period	4th Period	Traffic Signals
1st Trial					
2nd Trial					
3rd Trial					
4th Trial					

Driver D, age 23 years old weight 60 kg, height 158 cm, and physical condition slim. As we can see at the first trial and second trial don't have any difference between the grasping style, we can look that he grasps the steering wheel with full of confident and tight form the first period until the last period, when have a traffic signal he turn the steering wheel using two hand.

At first, second and fourth period at the third trial we can see that he start loose hand from the steering wheel but still used both hand one upper and one bottom of steering wheel, this is because the driving situation has time constrain and it makes driver's boring.

From the last trial we can see he loose his hand from steering wheel from period two until the last period but still cornering using two hand because of he still have good confident level but start fell stress while driving.

Table 4.6: Behaviour of Driver A, B, C, and D

Driver	1st Period	2nd Period	3rd Period	4th Period	Traffic Signals
A					
B					
C					
D					

From Table 4.6 it showed the differences grasping steering behaviour from drivers A, B, C, and D. There is not much different grasping steering behaviour between all drivers.

Driver A and B, from figure showed that they more comfortable by using both hand to grasping steering wheel, maybe it related to their fatty criteria, from that they feel more confident to control a car.

Driver C and D, from figure showed their confident level to high so they more comfortable using one hand to grasp steering wheel, maybe it also effected by their slim criteria.

4.4.2 Grasping Behaviour when Driver Experience Drowsiness

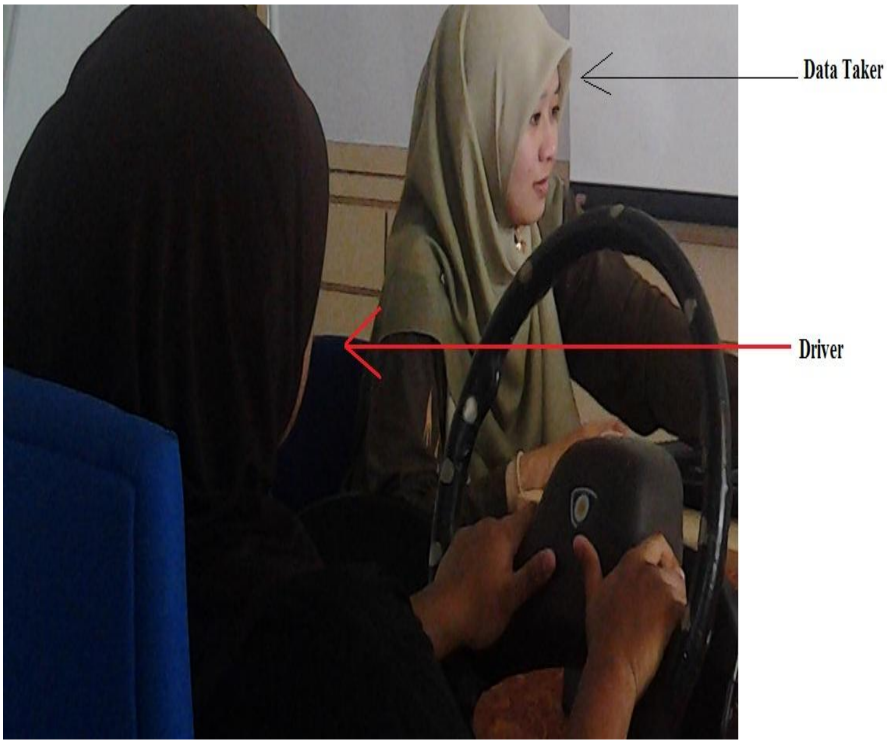

Figure 4.1: Driver E (fatty)

Figure 4.2: Driver A (fatty)

Figure 4.3: Driver F (slim)

Figure 4.4: Driver C (slim)

Figure 4.1, 4.2, 4.3 and 4.4 above showed all four drivers that has been test using driving simulator, all driver experience drowsiness while driving, but not at same time, as example first female driver feel drowsy after 15 minutes driving started and for second female faster than first driver, after 13 minutes driving started.

Beside that all driver have different grasping behaviour when they experience drowsy. For male driver they more comfortable by using both hand above steering wheel when experience drowsiness, different from female driver more comfortable by using one or both hand but at centre of steering wheel.

4.5) Graphical Result

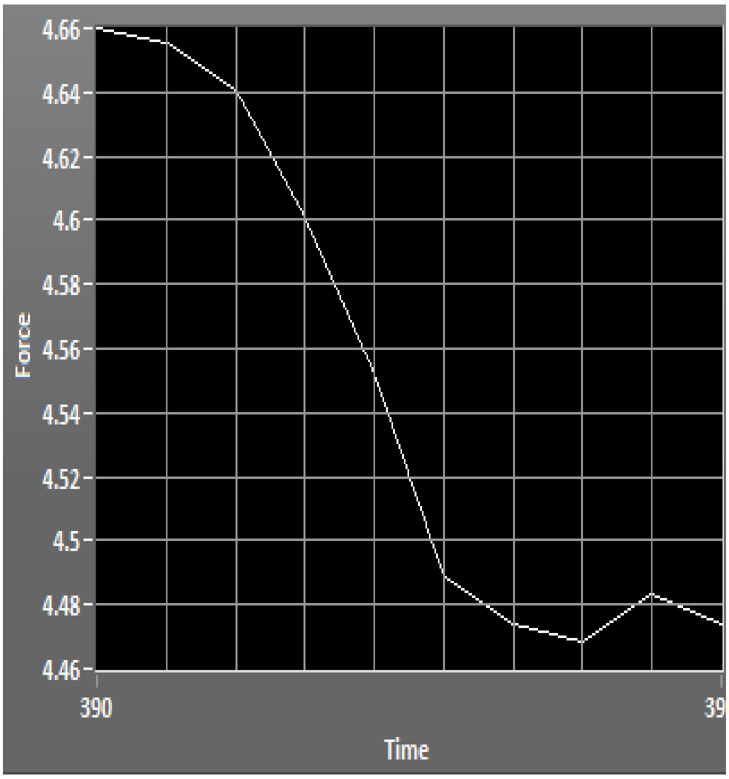

Figure 4.5: Graph from labView Software

The prototype of driver drowsiness detection system using FSR sensors was developed and tested using Labview software. The simulation result of pulse rate variation is given in the graph above. The pulse signal obtained from the hand by placing the palm on the FSR sensors is captured as given above in Figure 4.11 all driver have different grip force and different behaviour. From this graph we should convert time by using this formula

$$\text{Frequency} = 1 / \text{time} \qquad (4.1)$$

This project used 5 Hz of frequency so from that we can get the time range of this graph

$$\text{Time} = 1 / 5$$

$$= 0.2 \text{ second}$$

From the graph above the time are 390 from that we can convert time into minute

$$390 \times 0.2 \text{ second} \div 60 \text{ second}$$

$$= 1 \text{ minute and } 30 \text{ second}$$

Table 4.7: Driver grip force

Time (M)	Male (slim)	Male (fatty)	Female (slim)	Female (fatty)
1	4.6	4.66	3.8	4
2	4.54	4.64	3.65	4.22
3	4.55	4.6	3.9	4.38
4	4.56	4.56	3.94	4.14
5	4.54	4.66	3.92	3.98
6	4.53	4.58	3.8	4.25
7	4.55	4.43	3.84	4.24
8	4.53	2.46	3.7	4.18
9	4	2.22	3.65	3.86
10	2.53	2	2.4	3
11	1.22	2.56	2	3.44
12	1	2.38	1.83	2.55
13	0.98	2	1.84	2.38
14	0.5	1.71	1.87	2.4
15	0.66	1.69	1.89	2.46
16	0.7	1.74	1.88	2.5
17	0.62	1.75	1.86	2.48
18	0.7	1.78	1.83	2.52
19	0.65	1.83	1.87	2.5
20	4.59	4.79	4.1	4.7
21	4.66	4.76	4	4.65
22	4.44	4.75	4.3	4.5
23	4.57	4.73	4.2	4.35
24	4.62	4.71	4.3	4.2
25	2.88	3	2.37	2
26	1.98	2.95	2.41	1.85
27	0.86	2.75	2.42	1.9
28	0.35	2.7	2.45	1.5
29	0.55	2.9	2.46	1.6
30	0.75	2.5	2.5	1.8

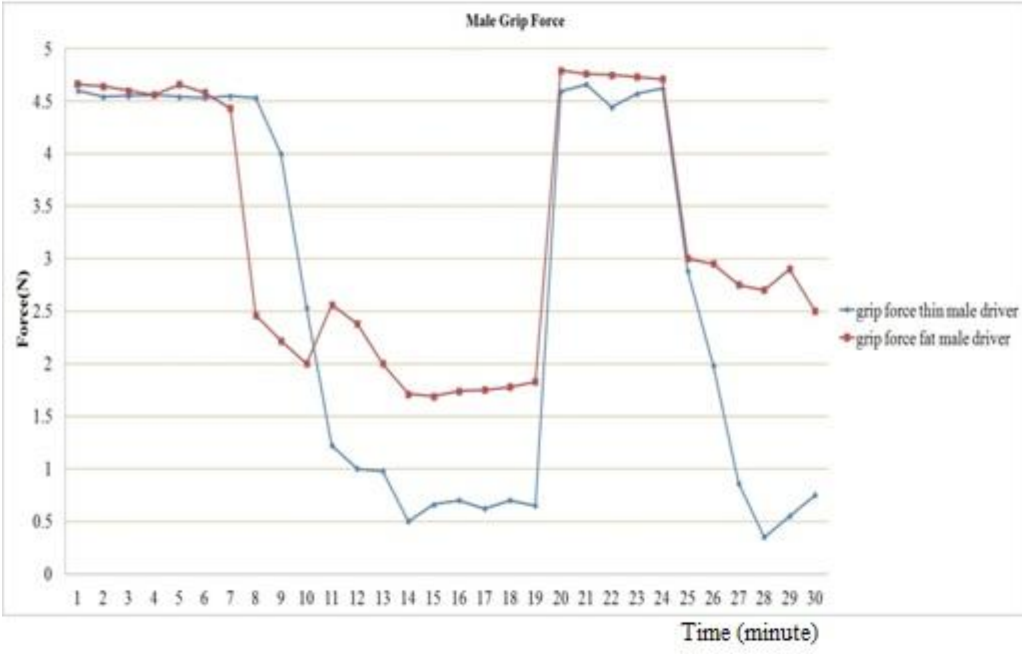

Figure 4.6: Male grip force

From Figure 4.6 above we can see different between fatty male driver grip force and slim male driver grip force, at starting point fatty driver give more pressure than slim driver, but their grip force not significantly different, for fatty driver 4.66 N and for slim driver 4.6 N.

After 8 minutes drive from starting point fatty driver start feeling drowsy, while for slim driver he start feel drowsy at minute 9 after start but his grip force still stronger not like fatty driver his grip force suddenly down below 2.5 N, but at minute 11 slim driver has very low grip force approached 1 N.

While cornering us need more grip force to pull or push steering wheel, from graph it showed at minute 21 when cornering grip force from fatty driver stronger than slim driver. Fatty person usually have bigger hand than slim driver that why fatty driver have higher grip force than slim driver.

After cornering their grip force become lower again because of experience drowsiness again.

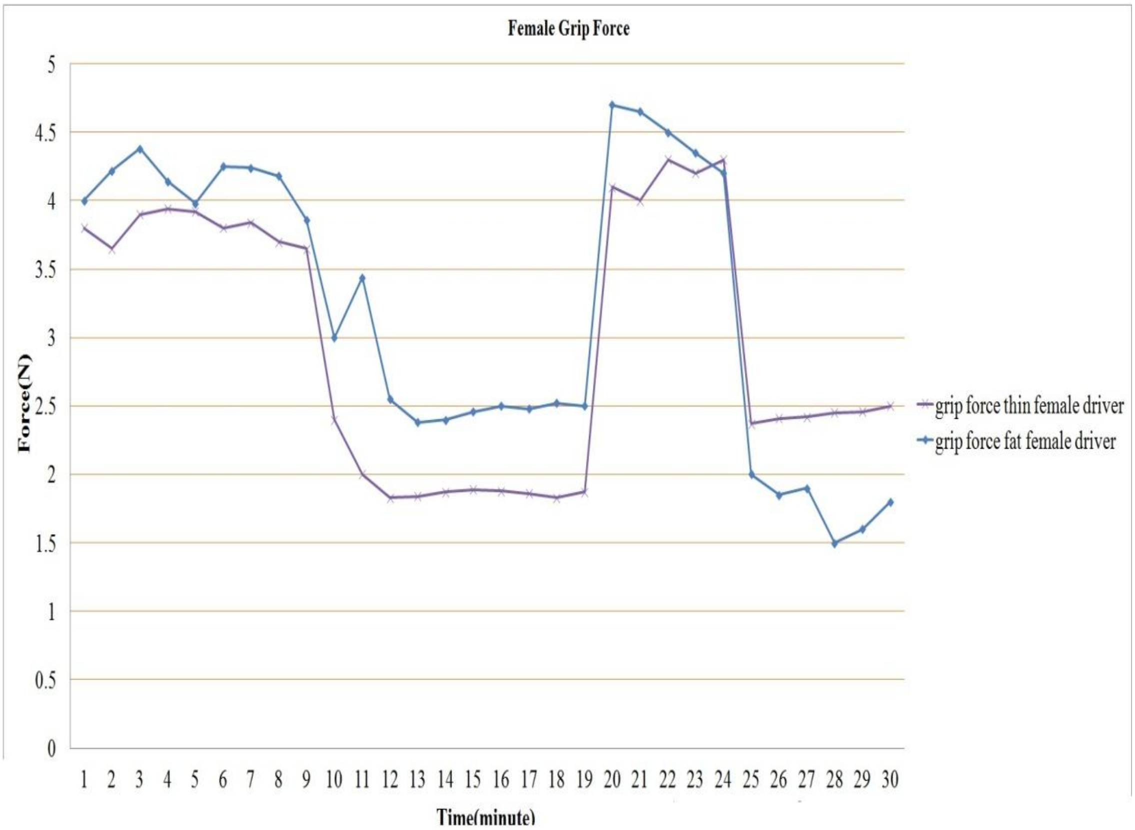

Figure 4.7: Female grip force

From Figure 4.7 above we can see different between fatty female driver grip force and slim female driver grip force, at starting point fatty driver give more pressure than slim driver, but their grip force not significantly different, for fatty driver 4 N and for slim driver 3.8 N.

After 10 minutes drive from starting point both driver start feeling drowsy, but slim driver her grip force suddenly down below 2.5 N, different from fatty driver feel drowsy but her grip force still stronger than slim driver.

While cornering drivers need more grip force to pull or push steering wheel, from graph it showed at minute 21 when cornering grip force from fatty driver stronger than slim driver. Fatty person usually have bigger hand than slim driver that why fatty driver have higher grip force than slim driver.

After cornering their grip force become lower again because of experience drowsiness again, but this time slim driver grip force become lower than fatty driver because of slim driver slow to become drowsy again after cornering compare to fatty driver

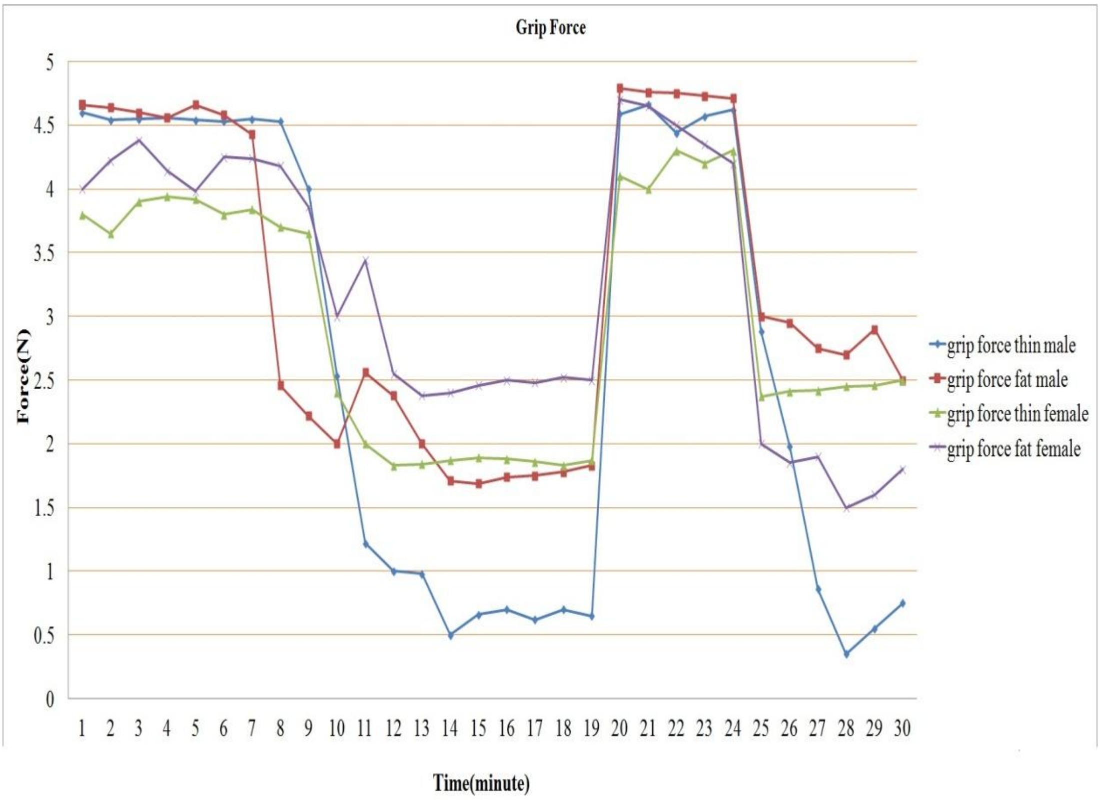

Figure 4.8: Grip force of the driver A, B, E and F

From Figure 4.8 above it showed result of all four drivers that have been test using driving simulator. We can see grip force different between male driver and female driver. Grip force from male driver stronger than female driver in a normal condition but when they experience drowsiness their grip force becomes lower than female driver.

At starting point all drivers still in good condition, and feel drowsy after few minutes' drive driving simulator, for fat male driver, he become drowsy faster than others driver, eight minute after start driving this because fat people easily become sleepy than slim people.

Beside that, from this graph we can see that fatty driver from both genders have stronger grip force versus slim driver, maybe they have bigger hand size and their grip force also bigger.

From this graph above we can conclude that not so many differences between male and female driver grip force, but when female driver experience drowsiness their grip force still stronger than male driver because of female driver more careful and cautious than male driver, and the drowsy level of the driver in Malaysia age between 20 – 30 years old whether slim or fatty driver fix at 2.5 N

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

In Chapter 1, the problem statement has been developed and the scope of study also been developing in order to achieve the objective. The aim of this project is to find the behaviour of driver in Malaysia based on the way on grasping steering wheel, to build one system that can alert drive if they experience drowsiness while driving

In Chapter 2, literature review was crucial because it is necessary to get the exposure and information about the project scope and objective. At first and the most important things in conducting this project is to understand about how many way the most use by driver to grasp steering wheel. Second is to understand about the grip force level while experience drowsy and normal grip force. In order to get the best place for sensor arrangement in steering wheel need to used some driver to do an experiment. This information important for arrangement of sensor at steering wheel took place in chapter 4.

In Chapter 3, the scope of study is to understand human behaviour based on grasping steering wheel. The aim is to find the best sensor arrangement that can detect whatever kind of grasping steering wheel even though normal or abnormal way of grasping steering wheel. Snap shot from video that have been made towards four different drivers with four times trial were take to get more accurate grasping style. Other than that, survey that has been made towards twenty randomly respondence also helps to get the most usual way that used to grasps steering wheel while driving a car.

In Chapter 4, the main focus is to understanding the behaviour of driver based on grasping steering wheel when experience drowsy while driving. The most challenging part is to arrange twelve sensors at steering wheel that connected parallel to each other and to make sure the sensor not disturb the driver while driving and not affected driver skin by biological sense from sensor itself. What more important things are to make sure all sensors can detect grip force from driver hand and give an output result that show in graphical way by using LabView Software.

Other than that, the sensors arrangement at steering wheel based o human grasping steering wheel behaviour and also we can know the drowsy level of driver while driving is 2.5 N. When the drowsy level detect the buzzer will be automatically activate and warn a driver from drive in drowsy condition.

5.2 LIMITATIONS AND RECOMMENDATION

This drowsiness detection system still need more improvement from time by time, this is because still got some limitation from this system. To make improvement towards this project we need long period of time to do more detail about this project that can help alert all driver in Malaysia when experience drowsy while driving

First limitation of this system that only can detect grip force from youth, range from twenty to thirty years old, this because in my area difficult to find adult to do an experiment towards them. Recommendation of this system in the future can detect grip force from all drivers without age exception, that means youth or adult still can use this system.

Second limitations of this system are that only can use in a day not at night because we don’t have enough time to complete the programming data. Recommendation of this limitation completes all the programming and can use this system whether in day or night.

Third limitation of this project is used a drug to make them feel sleepy, the drug taken half an hour before driving simulator started. My recommendation of this limitation is to make the driver falling sleepy by itself by making a drive simulator in long period of time more than one hour.

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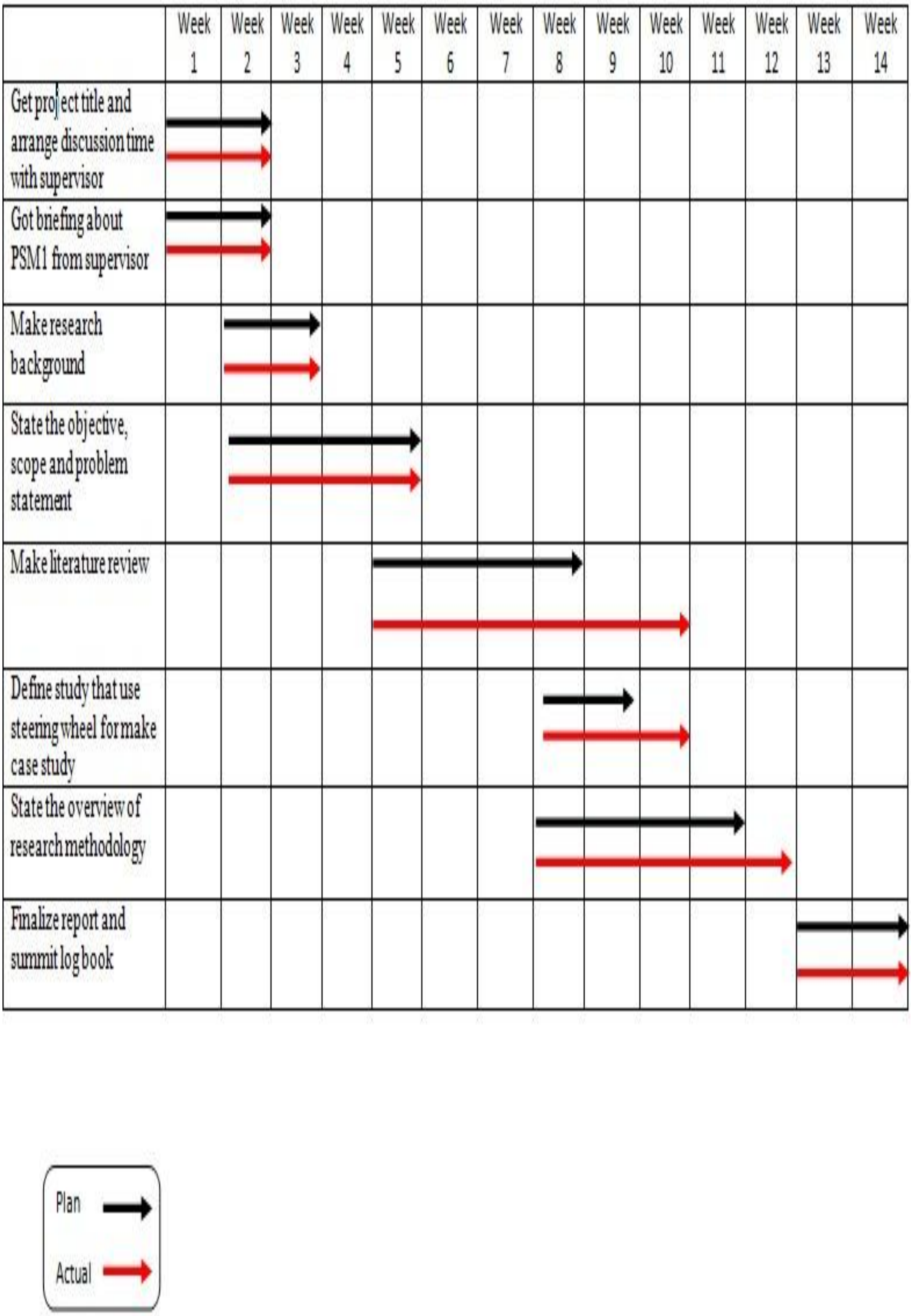
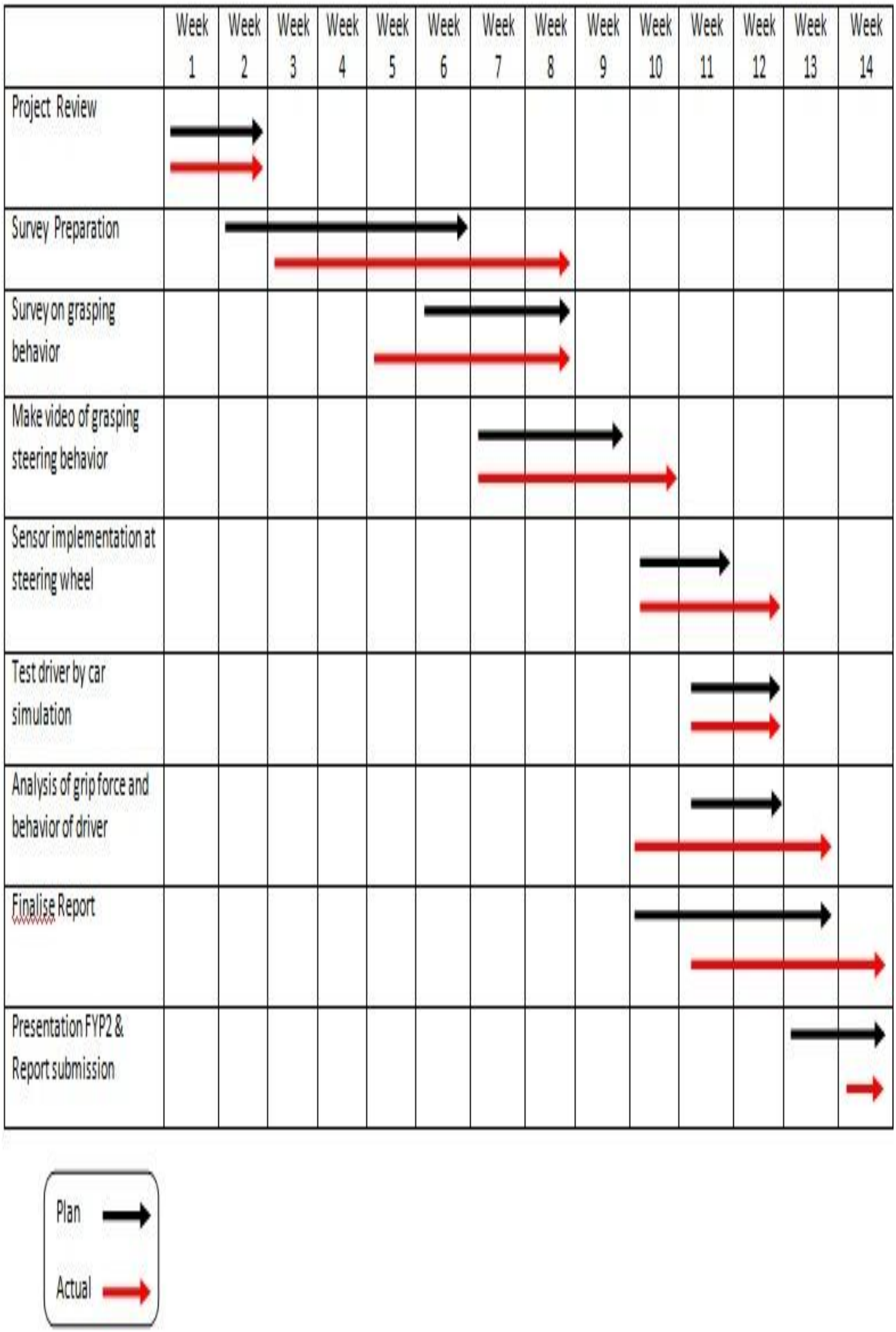
Appendix A

Appendix A1 (Gantt chart for FYP1)



Appendix A2 (Gantt chart for FYP2)



Appendix B

SURVEY OF THE WAY OF GRASPING STEERING WHEEL

AGE: ....years old

GENDER: MALE ☐

FEMALE ☐

Would you rate level of like or dislike the way of grasping steering wheel?

	Like	Somewhat like	Average	Somewhat dislike	Dislike
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐