REGRESSION ANALYSIS OF HEART RATE FOR DRIVING FATIGUE USING RESPONSE SURFACE METHODOLOGY (RSM)

MUHAMMAD ASYRAF BIN MOHAMMAD ZEN

B051810021

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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This report is submitted by the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for a Bachelor Degree in Manufacturing Engineering

by

MUHAMMAD ASYRAF BIN MOHAMMAD ZEN
B051810021
960625-10-5311

FACULTY OF MANUFACTURING ENGINEERING
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_____
Alamat Tetap:
No. 2499 Lorong Kenanga,
Batu 17 ¾ Kampung Damai, Kuang,
48050 Rawang, Selangor.
Tarikh: 25/7/2022

_____
Cop Rasmi:
PROF. MADYA DR. SERI RAHAYU BINTI KAMAT
Fakulti Kejuruteraan Pembuatan
Universiti Teknikal Malaysia Melaka

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DATE: 25/7/2022

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirement for Degree of Manufacturing Engineering (Hons). The member of the supervisory committee is as follow:

....

(ASSOCIATE PROFESSOR DR. SERI RAHAYU BINTI KAMAT)

PROF. MADYA DR. SERI RAHAYU BINTI KAMAT
Fakulti Kejuruteraan Pembuatan
Universiti Teknikal Malaysia Melaka

ABSTRAK

Di zaman yang serba canggih ini, kenderaan adalah sesuatu yang sangat berguna untuk masyarakat dunia. Sama ada menaiki kenderaan awam mahupun kenderaan persendirian. Hal ini kerana, kenderaan dapat menjimatkan masa dan tenaga seseorang untuk menuju ke destinasi yang ingin dituju. Tidak dinafikan kenderaan mempunyai banyak manfaat dan kelebihan untuk masayarakat, tetapi tidak lupa juga dengan risiko yang boleh merbahayakan keselamatan dan nyawa seseorang jika berlaku kemalangan. Terdapat banyak faktor yang menyebabkan kemalangan. Antaranya adalah keletihan pemandu yang menjadi punca kepada kehilangan tumpuan ketika memandu dan seterusnya menyebabkan pemandu gagal membuat keputusan yang tepat apabila berlaku kecemasan. Ergonomik kognitif, kadang-kadang disebut sebagai kejuruteraan factor manusia dikenal pasti sebagai punca keletihan pemandu di kalangan pemandu di Malaysia. Tujuan penyelidian ini dijalankan adalah untuk membangunkan satu model regrasi berdasarkan kepada faktor-faktor ergonomik kognitif yang menyumbang kepada keletihan dan menyebabkan kehilangan fokus dan gagal membuat keputusan yang tepat. Model yang dibangunkan dapat menghubungkan antara parameter input dan keputusan yang akan dihasilkan.

ABSTRACT

In this modern era, vehicles are something that is very useful for the world community. Whether riding a public vehicle or a private vehicle. This is because, the vehicle can save a person's time and energy to go to the desired destination. There is no doubt that vehicles have many benefits and advantages for society, but do not forget also the risks that can endanger the safety and life of a person in the event of an accident. There are many factors that cause accidents. Among them is driver fatigue which is the cause of loss of focus while driving and in turn causes the driver to fail to make the right decision when an emergency occurs. Cognitive ergonomics, sometimes referred to as human factor engineering has been identified as a cause of driver fatigue among drivers in Malaysia. The purpose of this research conducted was to develop a regression model based on cognitive ergonomic factors that contribute to fatigue that cause loss of focus and failure to make accurate decisions. The model developed can link between the input parameters and the results to be produced.
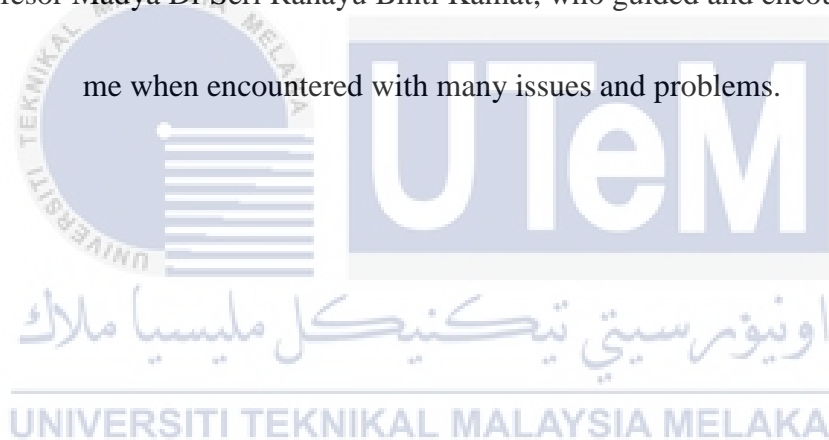
DEDICATION

A special dedication to the Almighty God who made this project a success despite

having to face a lot of challenges and problem, and to my beloved parents who are

my encouraging source. Also, thanks to my generous supervisor,

Profesor Madya Dr Seri Rahayu Binti Kamat, who guided and encouraged

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TABLE OF CONTENTS

LIST OF FIGURE

LIST OF TABLE

CHAPTER 1

INTRODUCTION

This chapter contain of background that explain about information of this project. This chapter also explain about objective that shows about the purposes of this project, problem statement that leads to carry out this experiment. Next, the scope will show about the research scope for number of respondents, respondent weight categories, timing, and gender of the respondent for this experiment.

1.1 Background of Study

In this era of modernization, vehicle is one of the most important for human being because it can help human to travel from one place to another place. According to statistics released by the Ministry of Transport Malaysia (MOT), a total of 32,378,174 total motor vehicles were registered in Malaysia in 2020(MOT, 2020). Meanwhile, the increasing number of vehicles also can increase the number of drivers licensed. By the Jabatan Pengangkutan Jalanraya (JPJ) with an increase of 2.86 percent which is 15,810,413 compared to 15,371,130 in 2019. Table 1.1 shows the number of vehicles in Malaysia increasing.

Type of Vehicles	Amount in 2019	Amount in 2020	Increase in %
Motorcycle	14,332,226	14,891,585	3.98%
Car	14,695,664	15,240,536	3.71%
Bus	62,966	63,389	0.67%
Taxi	92,011	90,994	-1.11%
Rental car	28,123	30,091	7.00%
Goods vehicle	1,295,486	1,325,680	2.33%
Other's vehicle	718,296	735,899	2.45%
Total	**31,214,772**	**32,378,174**	**3.73%**

Table 1.1: Cumulative number of vehicles by type in Malaysia in 2019-2020

This proves that there are many drivers in Malaysia. This also means number of accidents in Malaysia also can increase. We are living in the century of action for road safety, which implies that the topic of road safety is serious and that the entire globe is fighting to find a solution to the problem of traffic accidents. Every year, more than 1.2 million people die on the world's roads, making road traffic injuries the top cause of death worldwide.(Davidović et al., 2018) Based on the statistic by Ministry of Transport Malaysia (MOT), the number of road accident in Malaysia keep increasing during 2010-2019 (Figure 1.2). In 2014, the ASEAN Transport Minister had appointed MIROS as the ASEAN Road Safety Centre. The center's purpose is to promote and disseminate information on ASEAN road safety concerns, including legislation, standards, data management, and public awareness and education.. In two years, the number of fatalities has been decreasing from 7,152 in 2016 and showed the lowest number at 6,167 in 2019 during 2010-2019 period (Figure 1.3).
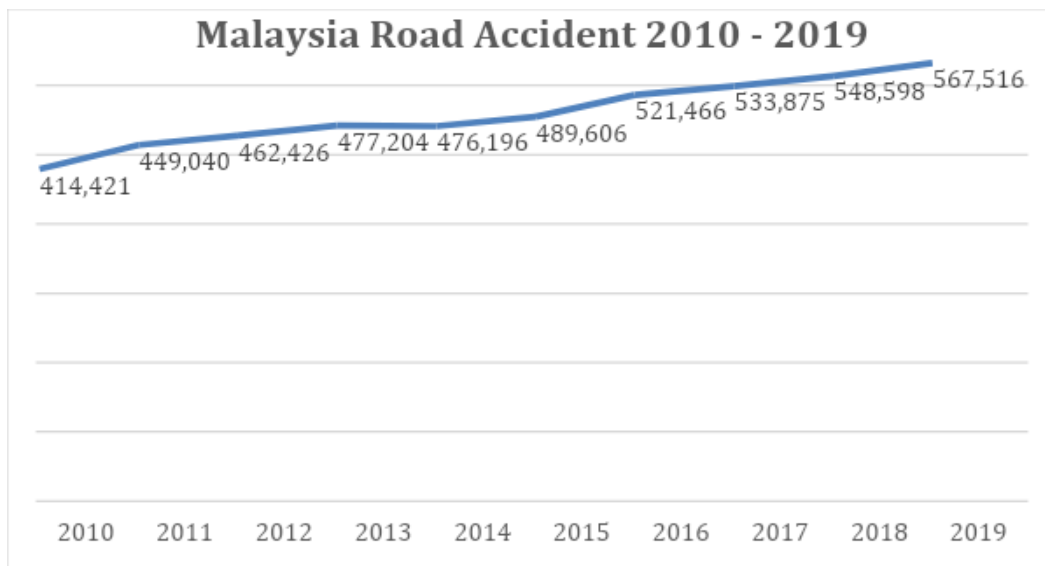
Figure 3.2: Malaysia Road Accident 2010 – 2019

Years	Percentage
2010-2011	+8.35%
2011-2012	+2.98%
2012-2013	+3.2%
2013-2014	-0.21%
2014-2015	+2.82%
2015-2016	+6.51%
2016-2017	+2.38%
2017-2018	+2.75%
2018-2019	+3.45%

Table 1.2: Malaysia Road Accident percentage 2010-2019
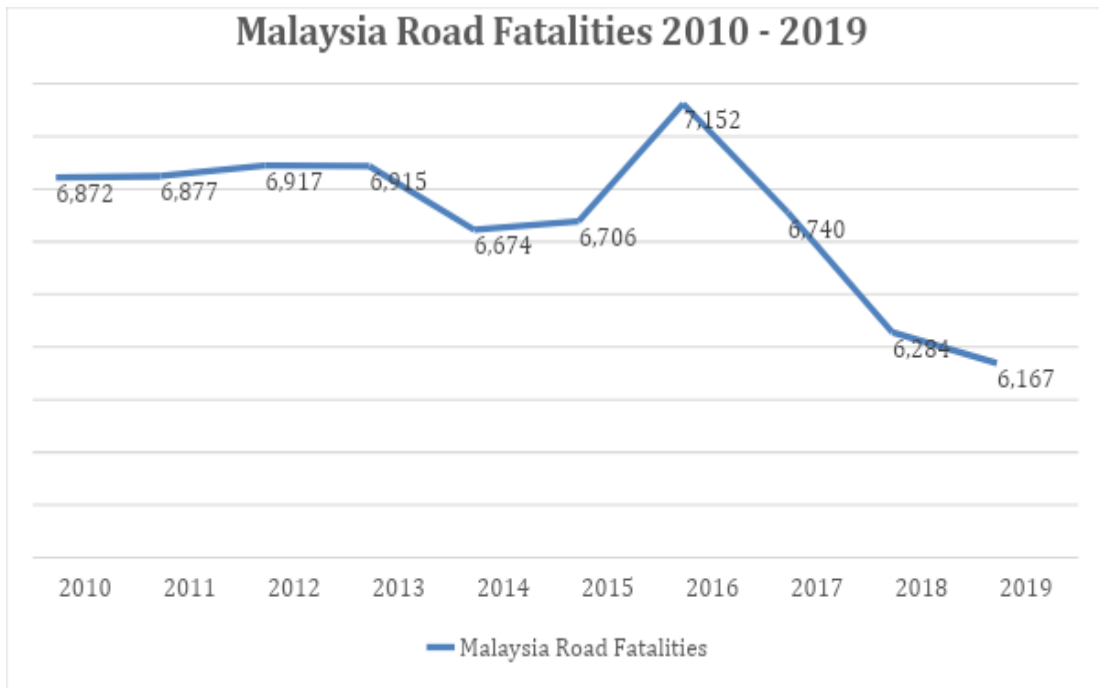
Figure 1.3: Malaysia Road Fatalities 2010 - 2019

Years	Percentage
2010-2011	+0.07%
2011-2012	+0.58%
2012-2013	-0.03%
2013-2014	-3.49%
2014-2015	+0.48%
2015-2016	+6.65%
2016-2017	-5.76%
2017-2018	-6.77%
2018-2019	-1.86%

Table 1.3: Malaysia Road Fatalities percentage 2010 - 2019

There are many factors that cause to road accident. The factors include vehicle condition road structure, weather, and human factor itself. In fact, more than 500,000 of Malaysians died because of accident on road and mostly road accident cases came from driver's behaviour, road condition, equipment failure and infrastructure. The topic surrounding road accidents is growing extra; every year over five millions of people in the world a violent death and a quarter of these are traffic accident victims (WHO, 2015) However, improvements in automotive technology in terms of the safety have reached a high level. Road design and signage have also been upgraded, where multiple blackspots have been found and studies to minimise the causes of road accidents have been performed. However, it was found that the number of accident rates keep increasing time

by time. 70% of road fatalities occur in developing nations, where the population is less developed, killing 1.17 million people a year. Pedestrian are responsible for the 65 percent of those murdered on the road, 35 percent are pedestrians under the age of twenty-five. Every year, an estimated 23–34 million people are killed or seriously injured as a result of road accidents.(Khairul Amri Kamarudin et al., 2018)

Based on previous research, focus on the relationship between fatigue and driving performance. Attention to the performance of drivers in the transportation of oil and gas is very important. This would lead to more safety on the road. (Al-Mekhlafi et al., 2020). For this research focus on decision making and focus while driving. There are two types of situations when someone drive on road whether the driver already familiar to taking that route or first time to going through that route. Both situations have different focus level when go through that route. If the driver usually used that road, the driver already knows the condition of the road and that will give opportunity to the driver to focus on certain place. This also can give the driver to make right decision making. So, the driver will drive at high speed because already know where the obstacle or bad road condition. While the driver for the first time using that road will be more focus when go through that route because the driver unfamiliar with that road. This driving activity involve the brain and the muscle to control the can using arms and legs. Brain can function properly with enough amount of glucose and oxygen level. After using brain too much without rest, oxygen that supply to brain and muscle will decreased. Consequently, this can make the driver fatigue and will affected the driver focus and decision making that can lead to accident.

Fatigue is an extreme tiredness that will happen to those who do not get enough rest after working for a very long period. Ideally, seven to eight hours is a sufficient duration to an adult to get enough rest after an intense working hour.(RoSPA, 2001) After leaving workplace, most people will drive their own car to go home. In the worst condition, the drivers that have fatigue after going through the working hours will be nodding off or have micro sleep cannot control the car. Accidents caused by fatigued drivers have a higher fatality rate and more environmental damage than those caused by alert drivers. Driver fatigue has been linked to car accidents ((Sikander & Anwar, 2019)). This can impact the reaction time and decision making thus will increase the chances of accident to occur.

1.2 Objective

1) To investigate the driving fatigue based on heart rate with different condition of the road (uphill/downhill and straight road).

2) To analyze the data of the heart rate that cause driving stress with different condition of the road (uphill/ downhill and straight road).

3) To develop and validate the regression models using Design Expert System based on the heart rate with different condition of the road (uphill/downhill and straight road).

1.3 Scope

The scope for this research is focus on the overweight or obesity drivers which has Body Mass Index (BMI) more than 24.9 and less than 29.9. All the respondent for this research is men only. This research has been done in the Ergonomic lab in Faculty of Manufacturing, UTeM by using the driver simulator. The respondent will use the driver simulator to feels the real experience of driving a car. The simulation will include different type of road which is winding & up/down hills. Meanwhile, the respondent will use output parameter to detect the brainwave of the respondent while drive the simulator. This research also focusses on decision making and focus while driving. The respondent also will use Perodua Bezza for real driving experience.

CHAPTER 2
LITERATURE REVIEW

The purpose of literature reviews it to obtain understanding and details of the existing research conducted by other researcher around the world to a certain topic or area of study based and to present the idea in the form of the written report.

2.1 Driving Fatigue

A state of extreme tiredness caused on by an insufficient amount of rest after a long period of work. Adults require seven to eight hours of sleep every night in order to fully recover from a long day at work. Having a sleep problem is a condition in which the body is unable to manage its own sleep patterns. Fatigued drivers may fall asleep at the wheel and lose control of the car in a worst-case situation. Responding and making decisions can be slowed down, increasing the risk of an accident. If a driver falls asleep for just four seconds while traveling at a speed of 100 km/h the car will have gone 111 meters without a driver in control (Royal Commission, 2015).

According to previous study, physiological signs such as heart rate are reliable markers of driver fatigue. When fatigue causes a stress reaction in organs, the cardiovascular nervous system will adapt properly. Long distance driving is a major cause of fatigue related accidents on freeways and other large roads. Long distance driving causes severe decrease the driver attentiveness and performance, which might threaten transportation safety. (Ting, P. H et al, 2008). Driver fatigue has been identified as a major cause of serious accidents which leads to reduced driving performance efficiency (Nailul Munna Abang Abdullah et al, 2011) Hence, early detection of driver fatigue is very important in order to reduce the number of accidents. Driver fatigue may be identified by detecting the heart rate of the driver

with a wearable device or by extracting face characteristics from the driver using an RGB camera. Nevertheless, a wearable device is inconvenient and uncomfortable for the driver, and the detection accuracy of an RGB camera may be impacted by light, spectacles, and head tilt. (Du et al, 2021).

Table 2.1: Driving Fatigue from previous research

Author	Title	Findings
Guanglong Du, Tao Li, Chunquan Li , Peter X. Liu , and Di Li (2020)	Vision-Based Fatigue Driving Recognition Method Integrating Heart Rate and Facial Features	Early detection of driver fatigue is very important in order to reduce the number of accidents. Driving fatigue can be detected by measuring drivers' heart rate with a wearable device or extracting their facial features with an RGB camera. However, a wearable device causes inconvenience and discomfort to the driver, and an RGB camera's detection accuracy may be affected by light, glasses, and head orientation
Ruben Buendia, Fabio Forcolin, Johan Karlsson (2019)	Deriving heart rate variability indices from cardiac monitoring—An indicator of driver sleepiness	Driver fatigue is considered to be a major contributor to road traffic crashes. Cardiac monitoring and heart rate variability (HRV) analysis is a candidate method for early and accurate detection of driver sleepiness.

2.2 Pulse Oximeter

A pulse oximeter is a device that is often placed on the tip of the index finger. In order to determine the oxygen saturation level and pulse rate of the blood, it makes use of laser beams. The oxygen saturation level provides information on the amount of oxygen that is carried by the blood. It is a straightforward examination that does not cause any discomfort in order to evaluate the efficiency with which oxygen is being transported to your extremities, such as your arms and legs.

Figure 2.2a: Example of new model Finger Pulse Oximeter

Figure 2.2b: Example of old model of Finger Pulse Oximeter

Oxygen is essential to the continued functioning of all biological processes, systems, and organs. If cells do not receive sufficient oxygen, they will begin to malfunction and will eventually die. Cell death can lead to organ failure, which shows itself physically as a wide variety of symptoms. The body transports oxygen to the organs by filtering it through the lungs. The lungs then distribute oxygen into the blood via hemoglobin proteins in red blood cells. These proteins provide oxygen to the rest of the body. Pulse oximetry can be used to assess the degree to which hemoglobin proteins are saturated with oxygen. The oxygen saturation test is a popular test that is used to determine the amount of oxygen that is reaching the organs. The amount of oxygen in the air should be at a saturation level of between 95 and 100 percent. Oxygen partial pressures that are lower than 90 percent of the capacity of the atmosphere. If the source level is too low, there is a possibility that a medical emergency

will arise. Some medical professionals use pulse oximetry to determine whether or not it is safe for their patients to engage in physical activity, while others may suggest that their patients wear a pulse oximeter while they are working out in order to ensure that their patients' safety. The use of pulse oximetry in combination with a stress test is another option that is open to doctor.

Table 2.2: Pulse Oximeter used in previous research

Authors	Title	Findings
Jing, D., Zhang, S., & Guo, Z. (2020).	Fatigue driving detection method for low-voltage and hypoxia plateau area: A physiological characteristic analysis approach	Fatigue driving is one of the main reasons for fatal crashes and highway accidents for drivers. Driving fatigue detection method based on monitoring psychological indicators is an effective method to avoid traffic accidents. The driver's heart rate (HR) and blood oxygen saturation (SpO2) data were obtained in low-voltage and hypoxia plateau area by driving fatigue test, that is, field driving fatigue test and drug intervention fatigue driving test.
Barua, T., Jahan, E., & Salma, U. (2020).	an overview on heart rate monitoring and pulse oximeter system	This device is able to produce highly reliable test results for both heart rate and SpO2 level. Our designed device has the advantage that it can be used by nonprofessional people at home to measure the heart rate and SPO2 level easily and safely.

2.3 Concept of the Cognitive Factor

2.3.1 Decision making

Decision making is a process to make choice for something that have many option by identifying a decision, gathering information, and assessing alternative resolutions. Organized information and alternative definitions provided by a step-by-step decision-making approach can help someone make more deliberate and considered decisions. There are numerous aspects that play a role in a person's decision-making process. An individual's age and socioeconomic level are also important determinants. A belief in personal relevance is also a significant influence in the decision-making process. They all play a role in the decision-making process and in the decisions that are ultimately made.

Nowadays, there are many drivers on roadway. Due to the fact that they are distracted by a variety of factors both inside and outside their vehicle, today's drivers are more prone to make poor judgments while driving.

Table 2.3.1: previous study for decision making that affected driving performance

Authors	Title	Findings
(Terai et al., 2015)	An experimental study on the difference in drivers' decision-making behavior during manual and supported driving	Driver decision-making qualities are different while driving with manual or automated control, according to this study. When utilising driving assistance systems, people were more careful when making lane change judgments, but their sensitivity to danger circumstances may have decreased as a result.
(X. Wang et al., n.d.)	Driver's Behavior and Decision-Making Optimization Model in Mixed Traffic Environment	According to this article, When a driver is making a decision in a complicated mixed traffic environment, he or she is actually analysing a lot of information from outside sources, like the outside environment, his or her own information (like speed, temperament, driving characteristics, and task), and information from inside the vehicle.

2.3.2 Focusing

There are more and more things that can keep drivers from paying full attention to the road. Distracted driving is becoming more and more of a problem. It can happen when driver drunk or tired, eat, or use a device while driving. When people text while they drive, it is very common. It's easy to lose focus on the road while commuting or travelling. Bring your focus back to your surroundings if it wanders. Driver fatigue causes loss of focus.

Table 2.3.2: focusing affected driving performance based on other research

Author	Title	Findings
(Regan, 2003)	Driver distraction	According to estimates, inattentive or distracted driving is a contributing factor in around one-quarter of all vehicle accidents in the United States.