MODELLING AND CONTROL OF THROTTLE AND BRAKE CONTROL SYSTEM USING PID CONTROLLER

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DECLARATION

I declare that this project entitled **"Modelling and Control Of Throttle And Brake Control System Using PID Controller"** is the result of my research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in the candidature of any other degree.

Signature	:	
Name	:	Abdul Hayee Bin Ab Malik
Date	:	28 January 2022

APPROVAL

I hereby declare that I have checked this thesis, and, in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours.

Signature	:	
Supervisor Name	:	Ts. Khairul Amri Bin Tofrowaih
Date	:	28 January 2022

DEDICATION

At the first dedicating this work to Almighty ALLAH, without His mercy and sympathy, I was not able to accomplish this work. I am also dedicated to my supervisor, Ts. Khairul Amri Bin Tofrowaih because giving me this opportunity, experience and knowledge in my life to complete this meaningful research. My special dedication to my beloved late brother Muhammad Shukri Bin Ab Malik that have become as my inspiration, my obligations and my strength to further studies in the automotive field and to complete this project. My sincere appreciation also to my family members and colleagues for all the encouragement, spirituals and moral support that had been given to me all the time.

ABSTRACT

Various control intervention thresholds have been introduced to the automotive industries as it can reduce the possibility of road crash occurrences. This project's aims are to derive transfer function of acceleration and braking of vehicle MATLAB model using system identification method and compare the rise time, settling time, and overshoot of original input source with tuned signal by varying responses time and transient behaviour in PID controller tuner. Road slope is one of the factors that influence road crash occurrences, and it is essential to have good configuration of throttle and brake system. A system identification method used to obtain transfer function from default model where a PID controller can be tuned from the transfer function then applied in the full model. Various input and output variable used to train a transfer function and validate in the system identification toolbox in MATLAB to get the best-fit transfer function according to the default responses. The response of tuned controller model will be analysed and compared towards the default controller model. The model of the tuned PID controller for step input managed to satisfy the desired response compared with the drive cycle source, it does not manage to satisfy the desired response.

ABSTRAK

Pelbagai ambang intervensi kawalan telah diperkenalkan kepada industri automotif kerana ia dapat mengurangkan kemungkinan kejadian kemalangan jalan raya. Matlamat projek ini adalah untuk mendapatkan fungsi pemindahan pecutan dan brek model MATLAB kenderaan menggunakan kaedah pengenalan sistem dan membandingkan masa kenaikan, masa penyelesaian, dan overshoot sumber input asal dengan isyarat ditala oleh masa tindak balas yang berbeza-beza dan tingkah laku sementara dalam penala pengawal PID. Cerun jalan raya adalah salah satu faktor yang mempengaruhi kejadian kemalangan jalan raya, dan penting untuk mempunyai konfigurasi pendikit dan sistem brek yang baik. Kaedah pengenalan sistem yang digunakan untuk mendapatkan fungsi pemindahan dari model lalai di mana pengawal PID boleh ditala dari fungsi pemindahan kemudian digunakan dalam model penuh. Pelbagai pemboleh ubah input dan output yang digunakan untuk melatih fungsi pemindahan dan mengesahkan dalam kotak alat pengenalan sistem dalam MATLAB untuk mendapatkan fungsi pemindahan yang paling sesuai mengikut respons lalai. Tindak balas model pengawal yang ditala akan dianalisis dan dibandingkan dengan model pengawal lalai. Model pengawal PID yang ditala untuk input langkah berjaya memenuhi tindak balas yang dikehendaki berbanding dengan sumber kitaran pemacu, ia tidak berjaya memenuhi tindak balas yang dikehendaki.

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LIST OF ABBREVIATIONS

ADAS	-	Advance Driver-Assistance System
ARIMA	-	Autoregressive Integrated Moving Average
DSD	-	Decision Sight Distance
ESC	-	Electronic Stability Control
ESC	-	Electronic Stability Control
GIS	-	Geographical Information System
GPS	-	Global Positioning System
ISD	-	Intersection Sight Distance
JKR	-	Road Safety Department of Malaysia
LOS	-	Level of Service
MIROS	-	Malaysia Institute of Road Safety
MOT	-	Ministry of Transport Malaysia
MPC	-	Model Predictive Controller
MP-DTC	-	Model Predictive Direct Torque Controller
NCAP	-	New Car Assessment Programme
NEDC	-	New European Driving Cycle
PHEV	-	Plug-In Hybrid Electric Vehicle
PID	-	Proportional, Integral, Derivative
PSD	-	Passing Sight Distance
RMP	-	Royal Malaysian Police
SSD	-	Stopping Sight Distance
TCS	-	Traction Control System
TCS	-	Traction Control System
UTeM	-	Universiti Teknikal Malaysia Melaka
WHO	-	World Health Organization
WHO	-	World Health Organization
2DOF	-	Two Degree of Freedom

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CHAPTER 1

INTRODUCTION

1.1 Background Study

The road network is an essential aspect for a developing country because every country tends to pursue their development and modernisation in every inch of its region. To ensure they can achieve their mission and vision, connecting rural areas with cities is crucial to makeover since development primarily connects to every city and rural area. It requires roadway development across a wide range of mountainous topography areas. A suitable road network is vital to make sure it is safe to be used.

Malaysia has two main road networks: federal roads and state roads that link up the entire country. Federal roads link up state capitals and those that lead to entry points and exit from the country. It is classified as highways, main highways, regional road structure, and minor roads that give access to government buildings. State roads are also another type of road network. It consists of main roads, secondary roads, minor roads, residential roads, and local streets. These types of the network are then classified into three topography groups, where the topography refers to road geometry elements such as arrangements, slopes, eyesight distance, and cross-section. These three groups of topography are flat, rolling, and mountainous. Firstly, flat ground means that sight distances are identifiable, and average pass inclinations of the earth often below 3% on flat terrain. Geological grades continuously climb over or drop underneath the road grade. In a rolling ground, the cross slopes on the ground range from 3 to 25%. Finally, mountainous ground refers to a topographical state in which longitudinal and transverse variations throughout the height of the earth adjacent to a route as well as highway were abrupt and unexpected, and in which benching and sidehill extraction is commonly used to achieve appropriate horizontal and vertical alignment. In steep hills, ground surface cross-slopes are frequently more than 25% (JKR, 2000).

Road slope or road grade is the ratio which the roadway goes up and down concerning the horizontal across its course referred to the gradients of the roadway, another phrase, the longitudinal slope delivered to the trail's formation-level across its path (Sautya, 2017). The slopes are the mountain's grade or slant. A sloped driveway denotes a significant inclination, while a moderate slope denotes a minor incline (DeYoung, 2018). The roadway's slope is described as the roadway's elevation as it ascends and descends along its course. Road slope always referred to the hilly area or mountainous area since these types of terrain mostly have the highest road grade level and become the steepest road. Mountainous areas have always been a dangerous area to drive since it has a higher road slope or road grade than other types of terrain. According to (L. Li et al., 2013), mountain roads are high-risk sites for car crashes due to their complicated geographical circumstances and road geometry. Additionally, a study claimed that bad curve layout, the presence of guide rails, limited margin drop-offs, limited visibility at bend or valley crossings, and improper lighting placement are the primary factors impacting crashes in a hilly environment (Fatma et al., 2020).

According to the New Car Assessment Programme (NCAP), to ensure more comfortable and safe travel, particularly on challenging terrain, every car must include an adequate vehicle safety system. To guarantee the ride quality in a dangerous state while reducing crash risk during routine driving, control intervention thresholds must be deliberately constructed using travelling data and ambient factors (Lutz et al., 2017). The best approximation is yet another level of car electronic stability control (ESC). The automobile traction control system (TCS) has been an active vehicle security system that integrates a tire slip ratio program to enhance traction performance and steering wheel ride quality, particularly on slippery roads. An active control system is required that assists the operator in maintaining control of their vehicle during a tricky scenario. Numerous control methods can be applied to TCS, including the threshold control, proportional-integral-derivative (PID) control, sliding-mode control, and fuzzy control (Austin & Morrey, 2000),(Koker et al., 2006). Although the threshold control process is simple, it takes multiple dynamic analysis to obtain fair values for various road conditions (Wang et al., 2010). The fuzzy control method proposed by some researcher has been proved to meet the requirements of vehicle safety and comfort, and it has been proposed that the fuzzy PID control algorithm is applied to the vehicle speed control system (Preindl & Bolognani, 2013), (Choi et al., 2013). The fuzzy control scheme has also been used to manage the moving wheel's slip ratio, but it requires numerous assessments to determine the precise controls (M. Bauer & Tomizuka, n.d.). The benefit of PID controllers above other systems is that they do not require a specific computational formula. Nonetheless, obtaining the process variables necessary to get a satisfying result is not straightforward. Considerable changes in the friction between the tire and the roadway may lead to substantial control faults in the PID controllers (Ameddah & Benmokrane, 2010)

PID controller is one kind of device with a feedback control loop to regulate all the process variables where it controls different process variables like pressure, flow, temperature, and speed in industrial application. The PID controller is one of the foremost common sorts of controllers. The PID controller has gotten wide application in various objective and design systems of programmed control of the working parameters of tools, making it easy to provide signal generation (Ajwad et al., 2015). Approximately 90–95 per cent of controllers in use today employ the PID algorithm. This extremely popular is the comprehension of construction and manufacturing processes, the ease of operation, the appropriateness for tackling the majority of actual problems, and the economics (Doroshenko, 2017). However, some difficulties arise because of the complexity of the operation, such as in numerous PID controllers. The differential element is disabled only because it is difficult to set up perfectly.

1.2 Problem Statement

Road accidents rapidly increase over the years due to the massive amounts of vehicles on the road because of the great competition among the automotive industry worldwide. The World Health Organization (WHO) predicts that road traffic injuries will climb from ninth place in 2004 to fifth place in 2030 as one of the leading causes of death worldwide (WHO, 2009). Human mistake, activity, vehicle and street conditions, and the nearby environment have been decided as a critical point that affects driving habits, which can, in turn, contribute to a car accident. In Malaysia, the authorised-based by the Royal Malaysian Police (RMP) research-based by the Malaysian Institute of Road Safety Research (MIROS) conduct and evaluate the accidents statistic every year. MIROS was set up to control and improve road security in Malaysia. It acts as the most coordinator in creating youthful minds and teaching individuals almost road safety.

The severity of crashes in hilly areas or mountainous areas is higher than in flat areas or level areas due to the topological condition that requires high concentration and perfect vehicle's condition. Mountainous road engineering work requires considerable technological capacities and resources to build safer roads; however, these are not always available, making it challenging to maintain desirable roadway geometric features that ensure the safety of the road users (Yun et al., 2013). Violent driving, speed up and braking, will wastes energy considerably (Kamal et al., 2011). Moreover, topographical features and road environments are closely linked with driving performance, as driving along high and steep mountain grades is often challenging. Continuous braking along downgrades may make brake pads hot, cause them to lose their grip, and eventually lead to brake function loss (Rusli, 2017). Once again, it was demonstrated that diverse road features, such as middle fences, margins and lane widths, level and perpendicular turns, the frequency of entry points, and pedestrian conditions, all play an important role in the frequency and intensity of road traffic accidents (Musa et al., 2020).

According to the Ministry of Transportation Malaysia, accidents tend to increase gradually, according to Figure 1. The number of road accidents in Malaysia for the last ten years shown in Figure 1, where 414,421 cases in 2010 kept increasing to 489,606 cases in 2015 and peaked at 567,516 cases in 2019. In the meantime, the death toll has decreased steadily ever since it crested at 7,152 during 2016 then reached a ten-year low of 6,167 in 2019. (Figure 2).

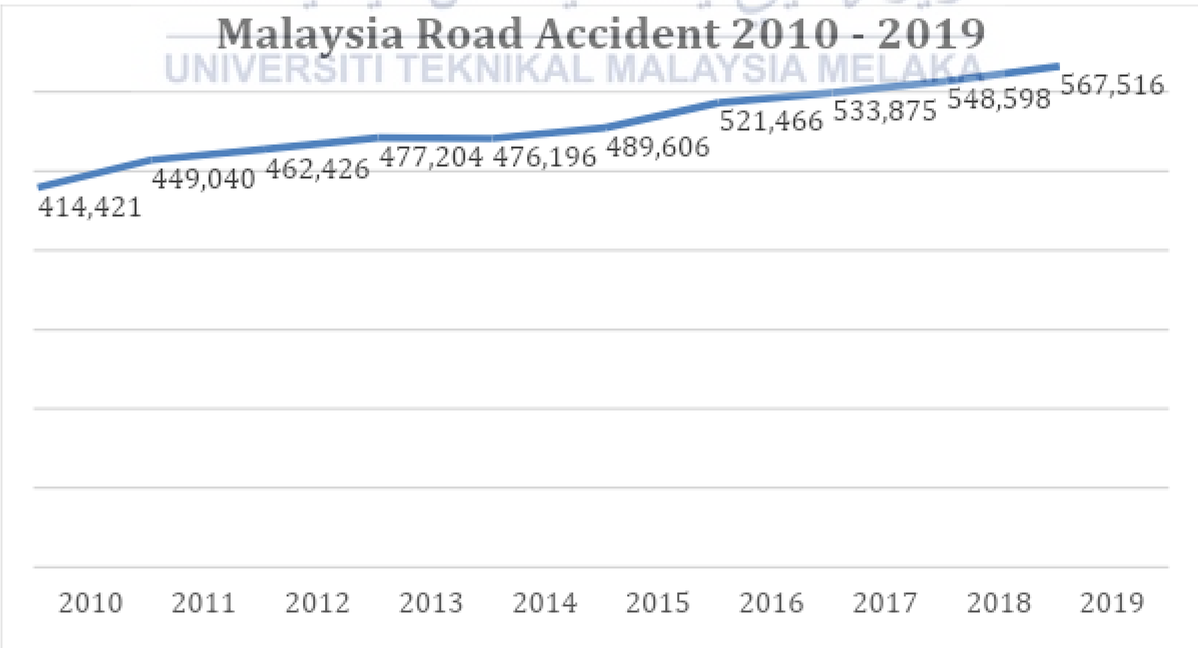

Figure 1.1 Malaysia Road Accident 2010 - 2019

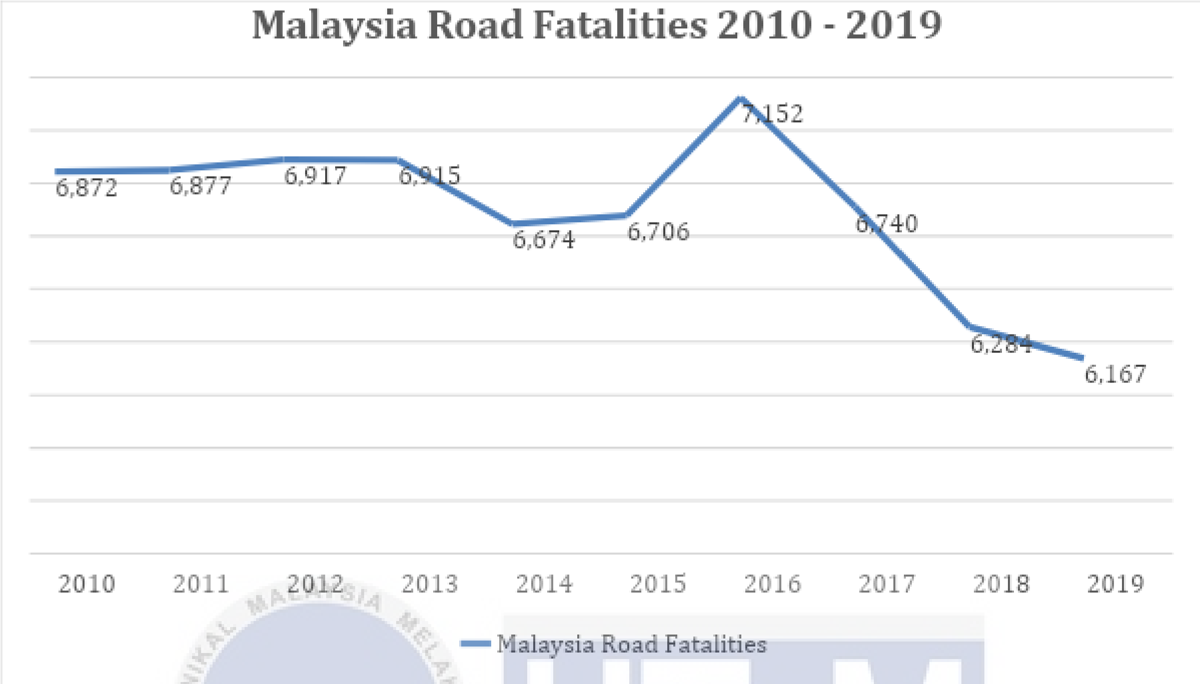

Figure 1.2 Malaysia Road Fatalities 2010 - 2019

Table 1.1 Total fatalities cases to state roads by the state year 2013-2017

State/ Year	2013	2014	2015	2016	2017	Total
Perlis	72	61	65	67	37	302
Kedah	517	525	530	572	327	2,471
Pulau Pinang	381	378	360	411	240	2,773
Perak	770	750	726	789	429	3,464
Selangor	1,019	1,068	1,028	1,140	627	4,882
Wilayah Persekutuan	243	238	256	232	132	1,101
Negeri Sembilan	396	379	355	414	214	1,758
Melaka	258	236	256	247	120	1,117
Johor	1,128	1,018	1,040	1,135	596	4,917
Pahang	592	539	532	539	293	2,495
Kelantan	378	354	426	453	260	1,871
Terengganu	320	276	307	342	191	1,436
Sabah	420	420	392	379	211	1,822
Sarawak	421	432	433	432	236	1,954
Total	6,915	6,674	6,706	7,152	3,913	31,360

Based on the death data from road accidents provided by the Road Safety Department of Malaysia (JKR), Ministry of Transport Malaysia. The data taken are obtained from the Road Accident Statistics Book. The fatalities cases on the state road for five years from 2013 to 2017 was stated in Table 1.1. The highest number of fatal cases recorded in Johor were 4,917 cases recorded in the five years the followed by Selangor, 4,882 cases recorded. The lowest cases recorded was in Perlis were 302 cases during the five years compared to Johor and Selangor. It was a massive difference for these three states. Johor recorded the highest