ROBUST VEHICLE SPEED LIMITER

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I dearly dedicate this work to my beloved Mother, Hajia Binta Faruk Muhd; and Father, Alhaji Faruk Muhammad Yanganau.

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ABSTRACT

Over speeding is still a generic practice on many roads and this contributes to a substantial number of crashes. Even though speed limits are set and penalties are imposed for disobeying these limits, and in some countries the implementation of some intelligent speed assistance systems had been made, some road users just do not care. The reckless, ignorant and self-centered drivers who disobey speed limits do not only pose danger to themselves, but also to other road users. The aim of this research is to develop a robust vehicle speed limiter, particularly considering four-wheel-drive (4WD) through-the-road hybrid electric vehicle (TtR HEV). The objective of the research therefore is to design a robust controller that adapts to various external disturbances. Thus to understand the behavior and to improve the behavior of dynamic 4WD electric vehicle its mathematical model is obtained, and accordingly simulated using a computer aided software, analyzed in frequency domain and then the controller is designed based on the specifications obtained. Upon implementation of this system the speed limiter will make these HEVs to move at the speed limit pre-fixed for the particular highway.

ABSTRAK

Amalan memandu melebihi had laju yang dibenarkan masih menjadi kebiasaan di kebanyakan jalan raya dan ini menyumbang kepada sebilangan besar kemalangan yang berlaku. Walaupun had laju telah ditetapkan dan penalti dikenakan kepada pesalah yang melanggar had laju ini, serta di kebanyakan negara, sistem bantuan kelajuan pintar telah digunapakai, namun sesetengah pengguna jalan raya tidak mengambil peduli akan hal ini. Sikap pemandu yang memandu melulu, jahil dan mementingkan diri sendiri dengan melanggar had laju ini bukan sahaja membahayakan diri sendiri tetapi juga kepada pengguna jalan raya yang lain. Kajian ini adalah bertujuan untuk membangunkan sebuah penghad kelajuan kenderaan yang mantap dengan mempertimbangkan pacuan empat roda (4WD) berdasarkan profil jalan raya kenderaan elektrik hibrid (TtR HEV). Objektif kajian ini adalah untuk mereka bentuk sebuah pengawal yang mantap yang mampu menyesuaikan diri dengan pelbagai gangguan luaran. Oleh itu, model matematik diperolehi bagi memahami dan memperbaiki kelakuan dinamik kenderaan elektrik pacuan empat roda (4WD) dan simulasi dilakukan dengan bantuan perisian komputer, dianalisis dalam domain frekuensi dan selepas itu, pengawal direka berdasarkan spesifikasi yang diperolehi. Setelah pelaksanaan sistem ini, penghad kelajuan akan membuatkan kenderaan elektrik hibrid (HEVs) ini bergerak pada had laju yang ditetapkan untuk lebuh raya tertentu.

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LIST OF ABBREVIATIONS

4WD	- Four-Wheel-Drive
EV	- Electric Vehicle
HEV	- Hybrid Electric Vehicle
TtR	- Through-the-Road
IWMs	- In-Wheel-Motors
ICE	- Internal Combustion Engine
ISA	- Intelligent Speed Adaptation
ADAS	- Advanced Driver Assistance System
N-PID	- Nonlinear Proportional Integral Derivative
CC	- Cruise Control
ACC	- Adaptive Cruise Control
CWS	- Curve Warning Systems
GPS	- Global Positioning System
GIS	- Geographical Information system
SOC	- State of Charge
RBS	- Regenerative Braking System
SDC	- Smart Display and Speed Control
SI	- Spark Ignition
PI	- Proportional-Integral
PD	- Proportional-Derivative
PID	- Proportional-Integral-Derivative
FLC	- Fuzzy Logic Controller

CHAPTER 1

INTRODUCTION

1.1 Introduction

Speed refers to a measure of the rate of motion. It is a distance travelled per unit time spent travelling. Over speeding is quite a common routine in Europe, Asia and many other countries. Typically, 50% of drivers go beyond the speed limit [1]. The faster one drives, the higher the risk for a crash to occur, consequently the more severe the injury in case of a crash. Recent studies shows that one third of the number of fatal or serious accidents are associated with excessive or inappropriate speed [2], as well as changes in the roadway (like the presence of road-work or unexpected obstacles). Hence a relatively great safety benefits could be earned from reducing driving speeds, by the traffic authorities, automotive industry and transport research groups.

Therefore advent of intelligent speed adaptation (ISA) comes in handy, also known as intelligent speed assistance/authority/alerting [3] is described as any system/technology that relentlessly monitors the speed at which a vehicle is and the corresponding area speed limit. This system implements an action when the vehicle is detected to have exceeded the speed limit. This action is usually performed through an advisory system, where the driver is cautioned or through an interference system where the driving systems of the vehicle are controlled automatically to reduce the vehicle's speed. Intelligent speed adaptation either uses information of the road which the vehicle travels on, to verify or validated the speed of the vehicle. The information is normally obtained through use of a digital maps integrated roadway coordinates as well as data on the speed zoning for that roadway at that location, through general speed zoning information for a defined geographical area (e.g., an urban area which has a single defined speed limit), or through feature recognition technology that detects and interprets speed limit signage using digital signal processing [4]. Therefore the purpose of ISA and Robust speed limitation is to assist the driver in keeping to the lawful speed limit at all times. This may be when passing through different speed zones or when road winding is high or even in an unfavorable weather condition and particularly useful when drivers are in unfamiliar regions or when they pass through areas where variable speed limits are used.

1.2 Background

There are a number of traditional and well-proved measures to improve speed limit compliance and reduce driving speeds, which consist of inventions like advanced driver assistance systems (ADAS), which are acoustic, visual signals produced by the vehicle itself to communicate to the driver the possibility of a collision, in car speed assistance, intelligent speed adaptation controllers [5]. A major example of driver assistance systems is the cruise control (CC), this technology have the ability to maintain a preset speed by the driver and its advancement, the adaptive cruise control (ACC), which basically an upgraded version of the CC that maintain safe distance between vehicles. Curve warning systems (CWS) were further developed to complement the ACC, the CWS use a combination of global positioning system (GPS) and digital maps obtained from a Geographical Information System (GIS), to calculate threat levels for a driver approaching a curve too quickly. Likewise, intelligent speed assistance (ISA) systems warn the driver when the vehicle's velocity is inappropriate, using GPS in combination with a digital road map containing information about the speed limits[5]. However useful, these systems lack robustness in terms of over speeding thus safety will be highly achieved with the use of more intelligent automatic driving controls and a developing number of sensors both on the road groundwork and the vehicle itself [6].

Intelligent speed adaptation is evolving rapidly and becoming more diverse; with HEVs springing up ISA can comfortably be fitted in this aspect to optimize maximum control. Therefore the need for a robust controller which will do the job, the basic principle behind the HEVs is simple. These vehicles are equipped with an internal combustion engine and a separate in-wheel motors in the rear tires which are equipped with more functional components that are performed by the internal combustion engine. The amount of power generated by these in-wheel motors can vary depending on the manufacturer and the size of the motor depending on the size of the vehicles, the number of the motors in the vehicle can also be adjusted to meet the supply power of the car, but normally two are sufficient for general purpose vehicles. The in-wheel active suspension system is an electrically operated system that can react in a mere 3/1,000ths of a second to automatically correct pitching and rolling motions [7],some in-wheel motor designs offer what is called the regenerative braking meaning the system captures some of its own kinetic energy while braking and sends it back to charge the battery presently some hybrids such as the Toyota Prius have already incorporate this regenerative braking technology, which provides the automobiles with a longer driving range [8]. One of the advantages of this system is high efficiency in power transfer because the power goes straight from the motor to the wheel which is not the case for internal combustion engine. Also in a vehicle equipped with in-wheel electric motors, there's plenty of torque available almost instantly. Electric motors produce a high amount of torque, and since that force is transmitted directly to the wheel, very little is lost in the transfer [9].

1.3 Statement of the problem

Intelligent automation instrumentation is becoming dominant in many aspects of modern technology. Consequently Intelligent Speed adaptation systems came into existence, for minimizing accident caused due to over speeding and high speed relative cases. Quite a number of technologies exist out there but lack real efficiency and precision E.g. Driver assistance systems (ADAS), Cruise control (CC), Adaptive cruise control (ACC) and so on. Therefore the need arises for a more robust speed limiter that adapts to high level of uncertainties.

1.4 Aim

This research is aimed at designing a robust vehicle speed restrictor or limiter for hybrid electric vehicles.

1.5 Objectives

The research is based on the objective;

1. To develop a controller that limits the speed and gives a degree of robustness for a through the road hybrid electric vehicle

1.6 Scope and Limitation

This research focuses on through-the-road (TtR) hybrid electric vehicles (HEV) in relation to speed limitation. These TtR HEVs are equipped with an internal combustion engine (ICE) under the hood of the vehicle powering the front wheels, and in-wheel electric motors located in the hub of the rear wheels. The rear wheels contain not only the braking components, but also all of the functionality performed by the engine (ICE), such as transmission, clutch, suspension and other related parts. Therefore using the mathematical models of the internal combustion engine (ICE), in-wheel motor (IWM) and vehicle dynamics of the HEV a design for a speed controller with a computer aided program is proposed.

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