DEVELOPMENT OF A CONTROL MODEL FOR A HEAD ON COLLISION AVOIDANCE SYSTEM

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DEVELOPMENT OF A CONTROL MODEL FOR A HEAD ON COLLISION AVOIDANCE SYSTEM

by

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LIST OF SYMBOLS

m	vehicles mass
ύ	vehicles acceleration
b	damping coefficient
υ	vehicles speed
u	moving forces
t	time
d	distances between vehicles
do	distances opposite vehicles from the references point
dp	Distances passing vehicles from the references point

LIST OF ABBREVIATIONS

VMT	Vehicle Mile Travelled
NCSA	National Centre for Supercomputing Applications
CAS	Collision Avoidance System
MIROS	Malaysian Institute of Road Safety Research
AEB	Autonomous Emergency Braking
FCW	Forward Collision Warning
USM	Universiti Sains Malaysia

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ABSTRACT

The autonomous cars relate to sensor technologies to offer real time information about the environment of the traffic situation. The information that been collected will increase the driving efficiency and respond so that it will offer comfort in the meantime boosts the safety of the driver. This thesis investigates and simulates the creation of a head-on collision control model for a vehicle overtaking a front truck while at the opposite lane a vehicle travelling in the opposite direction. This will show how an autonomous vehicle's algorithm determines whether to pass the front cars or not based on the distances and speeds of the opposing vehicles. The time it takes to overtake the front vehicles is roughly 12 seconds, with a 2 second safety margin. According to the simulation, the system would opt to continue the passing procedure if the time needed for the opposing cars to reach the passing vehicles' distances is greater than 12 seconds, and vice versa if the vehicles decide not to pass the front vehicles.

PEMBANGUNAN MODEL KENDERAAN KAWALAN UNTUK SISTEM PENGHINDARAN PELANGARAN KEPALA BERTEMBUNG

ABSTRAK

Kereta autonomi berkaitan dengan teknologi sensor untuk menawarkan maklumat masa nyata mengenai persekitaran keadaan lalu lintas. Maklumat yang dikumpulkan akan meningkatkan kecekapan memandu dan bertindak balas sehingga memberikan keselesaan sementara itu meningkatkan keselamatan pemandu. Tesis ini menyiasat dan mensimulasikan penciptaan model kawalan perlanggaran secara langsung untuk kenderaan yang menyeberangi trak depan sementara di lorong bertentangan kenderaan bergerak ke arah yang bertentangan. Ini akan menunjukkan bagaimana algoritma kenderaan autonomi menentukan sama ada untuk melepasi kereta depan atau tidak berdasarkan jarak dan kelajuan kenderaan yang bertentangan. Masa yang diperlukan untuk mengatasi kenderaan depan adalah kira-kira 12 saat, dengan margin keselamatan 2 saat. Menurut simulasi, sistem akan memilih untuk melanjutkan prosedur lulus jika waktu yang diperlukan agar mobil lawan dapat mencapai jarak kendaraan yang lewat lebih dari 12 saat, dan sebaliknya jika kendaraan memutuskan untuk tidak melewati kendaraan depan.

CHAPTER 1

INTRODUCTION

1.1 Background

Autonomous vehicles that use the Internet-of-Things idea can improve driving efficiency, traffic safety, and give the driver more time to accomplish other things.[1]. Since at least the 1920s, self-driving automobile tests have been carried out.;[2] In the 1950s, encouraging trials were conducted, and development has continued since then. In the 1980s, Carnegie Mellon University's Navlab developed the first completely self-contained and autonomous vehicles.[3] and ALV projects In 1984, Mercedes-Benz and the Bundeswehr University Munich launched the Eureka Prometheus Project, and in 1987, Mercedes-Benz and the Bundeswehr University Munich launched the Eureka Prometheus Project.[4]. Mercedes-Benz, General Motors, Continental Automotive Systems, Autoliv Inc., Bosch, Nissan, Toyota, Audi, Volvo, Vislab from University of Parma, Oxford University, and Google are just a few of the major corporations and research groups that have created functional autonomous cars since then.[5][6]. Vislab tested BRAiVE, an autonomous vehicle on a mixed traffic route open to the public, in July 2013.[7].

As of 2019, twenty-nine states in the United States have enacted legislation allowing autonomous vehicles. Some UNECE and EU countries, as well as the United Kingdom, have laws and regulations governing automated and fully automated vehicles.[8]: Cities in Belgium, France, Italy, and the United Kingdom are intending to run driverless vehicle transportation systems, and Germany, the Netherlands, and Spain have permitted robotic cars to be tested in traffic.[9][10].

1.2 Overview of head on collision

A collision is any event in which two or more bodies exert forces on each other in a relatively short time. Although the most common use of the word collision refers to incidents in which two or more objects collide with great force, the scientific use of the term implies nothing about the magnitude of the force. In physics, collisions can be classified by the change in the total kinetic energy of the system before and after the collision[11][12]. There seven type of vehicles accident that is head-on, rollover, T-bone, multiple vehicles, sideswipe, side-impact, and single car collision[13]. The reaction of the driver in avoiding the impact is commonly based on the type of accident that they going to face. Passing collisions are one of the most dangerous traffic safety problems. These collisions occur when the driver of the passing vehicle is distracted or does not appropriately assess the passing situation[14]. NCSA predicted that the mortality rate per 100 million vehicle miles travelled (VMT) has increased year over year in the first half of 2020, from 1.06 in 2019 to 1.25 in 2020. (NCSA, 2020). In same study, NCSA also said that in the first six months of 2020, VMT decreased by 264.2 billion miles, or 16.6 percent.[15].

Figure 1: Head on collision situation

Some of the accident that happens is cause by the driver that does not give a proper reaction in the situation before the crash. The split-second decision will determine or even lessen the effect of the crash. The collision avoidance system (CAS) is motorcar safety system that is design to prevent or reduce the probability of collision. The system will used various sensor to detect the parameter that will contribute for the warning system to be activate based on collected data from sensor. Once an impending collision is detected, these systems provide a warning to the driver[16].They may respond automatically without any driver input when a collision is imminent (by braking or steering or both). When both cars are too near to one other, the system can either brake to decrease the vehicle's speed or turn it to prevent collision. However, in the case of an AEB system, FCW will issue a warning to the driver but will not intervene with the cars to avert a collision.[17].

1.3 Problem statement

Based on Malaysian Institute of Road Safety Research (MIROS) the statistic of death cause by vehicle collision in 2020 is 4634 deaths[18]. This cause our country to be having a huge loose in economic perception. The number of vehicle collision are increasing exponentially from years to years. How to reduce the number of traffic accident death have been a huge question in the context of large number of vehicles. Head collision is the most serious issues because it is having the most dangerous situation in a vehicle accident[19]. so, algorithm need to be found in other to create a head collision avoidance system based on the variable that can be apply in this situation.

there are many head on collision system that been developed in till now, but the algorithm only can be apply in a certain situation only. For this thesis, the situation given is to decide whether the car can pass a front vehicle if there is a vehicle moving with certain velocity at the opposite lane. Based on the situation given some current parameters need to be identified that will involve in the car decision making.

1.4 Objective

There are two main objectives of this study.

I. To study the parameter that will be involved in the head on collision decision making for the passing collision warning.

II. Perform a simulation based on the reaction of breaking and turning in MATLAB (Simulink) software to find the safe distance and also the time taken to pass a vehicle in a two lane two side road.

1.5 Scope of project

A head on collision avoidance system with decision making of for the passing a front vehicle is simulated for research purpose. The algorithm that will be used in determined the decision making of the vehicles whether it is safe to passing the front vehicles. The simulation will be focusing the vehicles parameter to decide the safe decision for passing the front truck. The simulation scenario is passing a vehicle in a two-lane two-way road where there is a vehicle that move in certain velocity at the opposite lane.

The simulation of the scenario will be simulated using MATLAB (Simulink) software. In this research paper it also simulates a scenario for vehicles moving and braking for when a static object is in front of the road. The car will be set to a certain velocity in the Simulink and need to break to avoid collision.

CHAPTER 2

LITERATURE REVIEW

2.1 General algorithm

The system is programmed with the driver's characteristics. The system makes two consecutive measurements of the nearest vehicle's location and speed in the nearest lane on the left side, with the time gap between the two measurements equalling the inverse of the detector's frequency. The system determines the acceleration rate of the observed vehicle based on these readings. The algorithm then calculates how long it will take for the opposing car to arrive at the safe location.

The time (tpassing) necessary for the passing vehicle to complete the pass is then calculated using this information, which is equal to the sum of t1 and t2 (the passing vehicle's beginning acceleration) (passing time) The system compares tpassing (the total of topposing and tsm) with tsm representing a 2-second safety buffer, and makes a choice based on the following criteria if tpassing is greater than t0, the "Not safe to pass" message is displayed, and the system repeats the algorithm to find a safe time gap; if tpassing is less than to, the "Safe to pass" message is displayed, and the system repeats the algorithm to find a safe time gap or if tpassing is less than to, the "Safe to pass" message is displayed, and the system repeats the algorithm to find a safe time gap. If the passing distance is less than, the "Safe to Pass" message is displayed, and the driver is permitted to begin the passing operation[20].

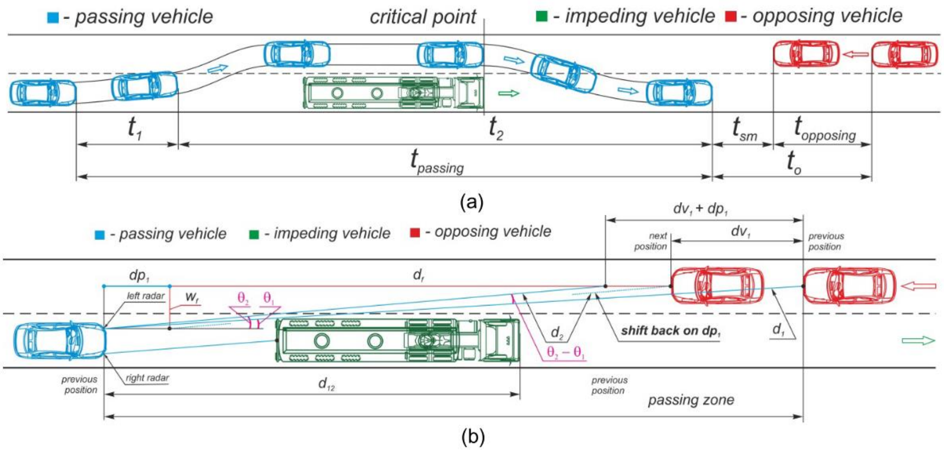

Figure 2: a) time definition b) distance

2.2 Passing vehicles location

The driver's perception-reaction time and initial acceleration (t1), which is the time it takes for the driver to notice the "safe" signal and then respond appropriately (by activating the throttle); and the vehicle's travel time (t2), which is the time it takes for the vehicle to accelerate and clear the path for the approaching vehicle. The time needed for the driver to past the tpassing the sum of t1+t2.

The following formula is used to compute the entire time necessary for the passing vehicle to complete the pass,

tpassing: Tpassing= t1+t2

2.3 Model for automatic steering control.

A linearized model has been shown to be sufficient for investigating automobile steering in typical, i.e., non-emergency scenarios[21]. Assuming modest angles, this permits the Riekert-Schunk single-track model to be used. At the front and back axles, the two front wheels and two rear wheels are combined into a single wheel, and the center of gravity (CG) is positioned in the plane of the road surface. Under the assumption of modest angles, a linear tire model is utilized. within the technical limitations of the tires during regular highway driving conditions the concept of the model.

The linearized 2D model with two internal states, side slip angle ß and yaw rate y, and front wheel steering angle f as an input, for example, may be found in [21] as:

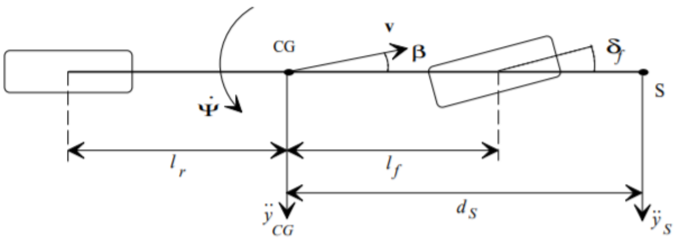

Figure 3: single track model for car steering[22].

Figure 3 shows a block schematic of the closed loop with controller C(s) and ΔyS output feedback.

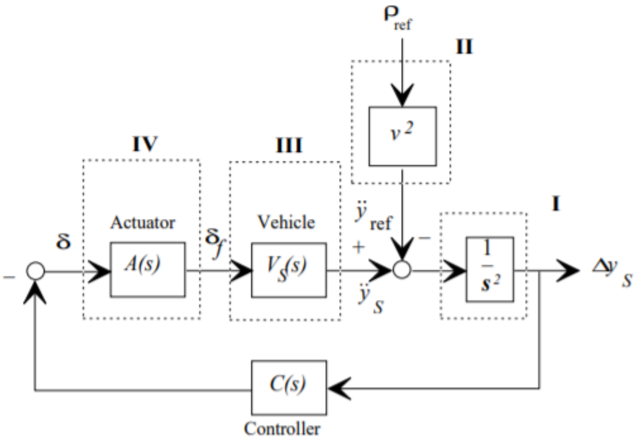

Figure 4:Block diagram for steering angle output[22]

The steering angle block diagram for Simulink are constructed based on figure 3. The block diagram will cause the output angle slowly moving to the reference angle and follow the path of the angle motion[22][23].

2.4 System transfer function

Many current automobiles include automatic cruise control, which is an outstanding example of a feedback control system. The cruise control system's goal is to keep the vehicle speed constant despite external factors like wind or road grade variations. This is done by measuring the vehicle speed, comparing it to the intended or reference speed, and automatically changing the throttle based on a control law [24].

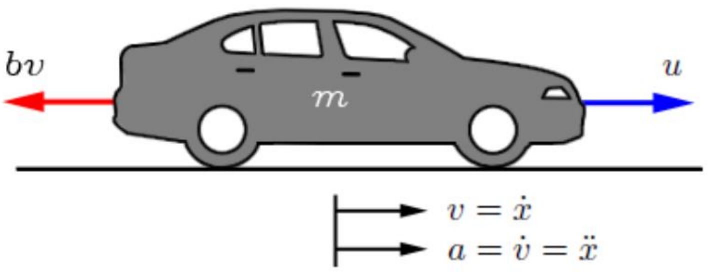

Figure 5:Free body diagram of vehicles dynamic

In this case, we'll look at a simple model of vehicle dynamics, as seen in the free-body figure above. A control force, u, acts on the vehicle, which has mass m. The force created at the road/tire contact is denoted by the letter u. We'll assume that we can manage this force directly in our simplified model, and we'll ignore the dynamics of the engine, tires, and other factors that contribute to the force's generation. Rolling resistance and wind drag resistive forces, bv, are supposed to change linearly with vehicle velocity, v, and operate in the opposite direction of the vehicle's motion[24].

First order mass damper system:

$$m\dot{\upsilon}+b\upsilon=u$$

Because first-order systems only have one energy storage mode, in this example the kinetic energy of the automobile, only one state variable, velocity, is required. As a result, the state-space representation is[25]:

$$\dot{x}= [\dot{\upsilon}]= \left[\frac{-b}{m}\right][\upsilon] + \left[\frac{1}{m}\right][u]$$

Because first-order systems only have one energy storage mode, the kinetic energy of the vehicle in this case, only one state variable, velocity, is required. As a result, the state-space representation has the following form[26]:

$$P(s)= \frac{V(s)}{U(s)} = \frac{1}{ms+b}$$

2.5 Dangerous Targets Recognition and Avoidance Control Strategy

The vehicle safety distance model may be created based on vehicle safety, which assists the driver in maintaining a safe distance between cars. When driving, the sports strategies of the front car and the following vehicle were investigated in this research[27][28]. Figure 6 depicts it. The following vehicle's speed is u1, whereas the front vehicle's speed is u2. The following vehicle's head and the back of the leading vehicle have a safety distance of d. The pursuing vehicle's speed will be lowered to u1'after t seconds, and it will traverse the distance of d1. Simultaneously, the front vehicle's speed will be lowered to u2 ', and it will cover d2. The distance between the two cars will change to d0 at this point, which indicates the minimum safety distance that should be maintained to ensure that the two vehicles are not in danger, and we often set d0 to 25 meters.

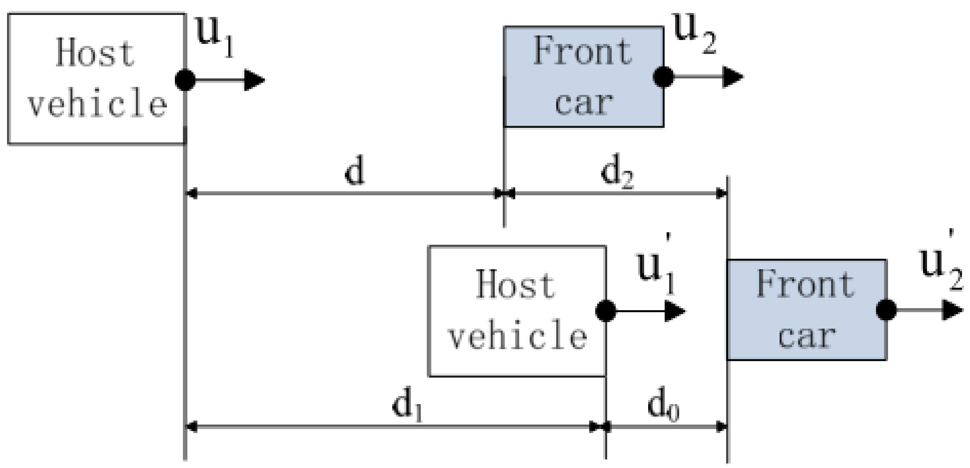

Figure 6: Steering angle block

CHAPTER 3

3.1 MATLAB Simulation Model

In this project, MATLAB/Simulation is used to simulate the vehicle motion for the head on collision system. When MATLAB and Simulink are used together, its combine textual and graphical programming to design a system in a simulation environment. Simulink is a block diagram environment for multidomain simulation, and continuous test and verification of embedded systems. Simulink provide a graphical editor, customizable block libraries, and solvers for modelling and simulating dynamic systems. It is integrated with MATLAB, enabling to incorporate MATLAB algorithms into models and export simulation results to MATLAB for further analysis.

A Simulink model were developed to create the simulation model of the head on collision system based on the position of the car. The simulation of the system will be having a saturation of the signal of the vehicle input so that we can mimic the motion of the real car. A Feedback control is a control mechanism that utilizes measurement information to manipulate a variable to achieve the desired outcome. Head on collision Simulink model, it includes two vehicles, that is vehicle blue and red. Vehicle's red will act as an object while the parameter of vehicles blue will be change it parameter based on simulation expectation.

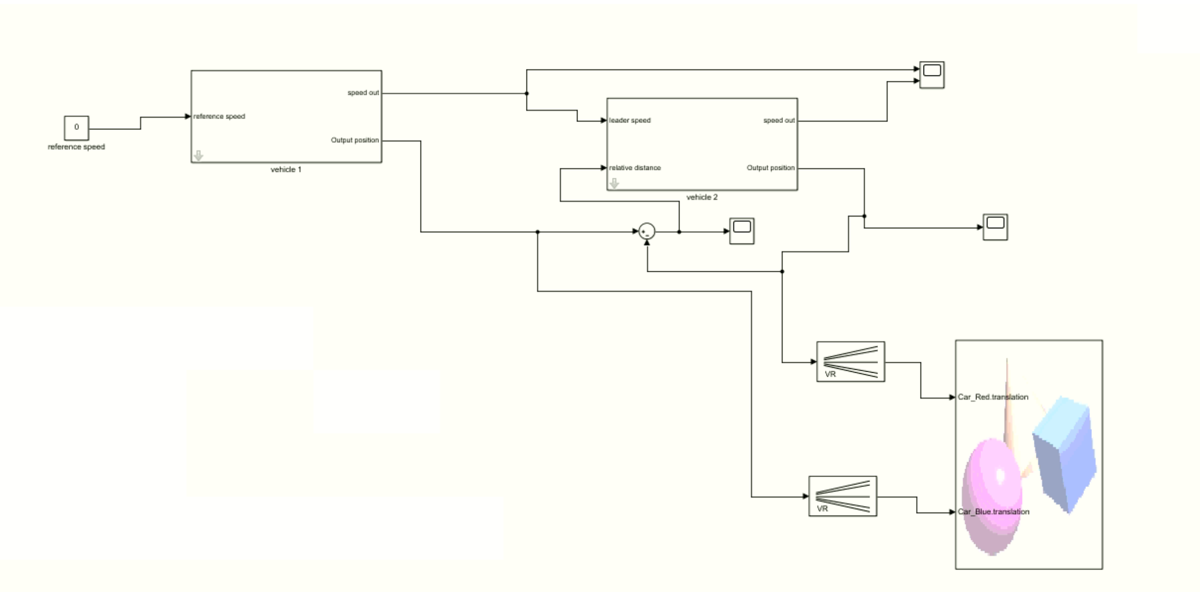

Figure 7: Braking system block diagram

For the input velocity is the velocity for the red car that is the object, and we will set the parameter for the blue car in the block parameter for vehicles 2. Each block vehicles parameter can be set the initial velocity and position for the stating simulation condition.

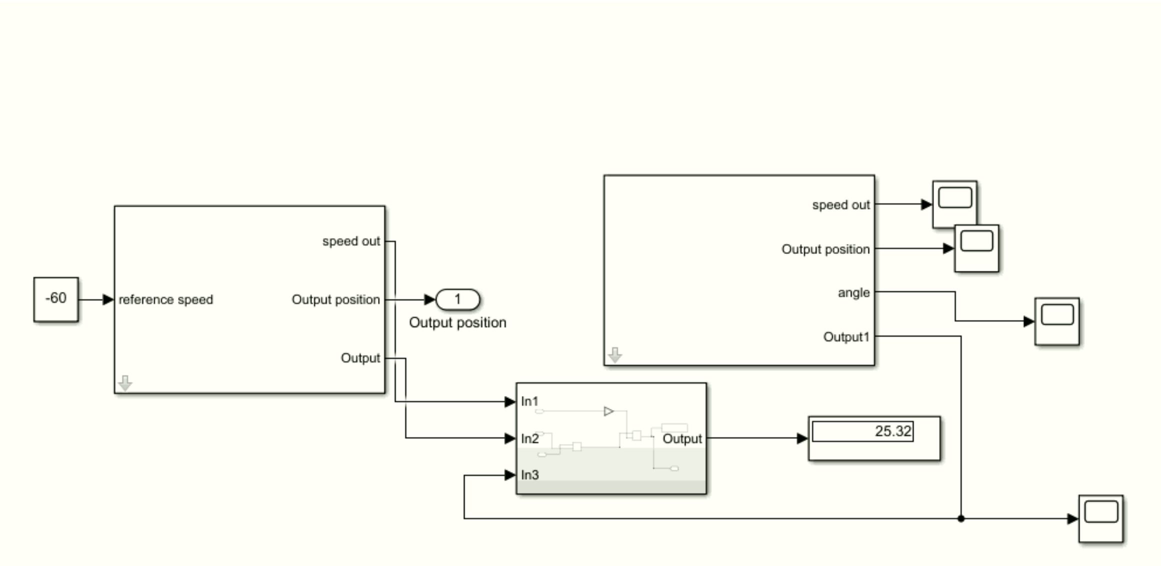

Figure 8: Simulink model for the car passing a truck.

For the truck car passing a truck simulation the scenario is the car need to accelerate to pass a truck with a opposite lane consist of vehicles that travel in certain