ISSN: 0974-5823 Vol. 7 No. 5 May, 2022

International Journal of Mechanical Engineering

Module for Traffic Free Transportation System in Hatch Back Cars with Proportional Integral Derivative Control

Mekete Asmare Huluka[1], Muralidhar Singh M[2], Ramesh Kumar P[3] , Chockalingam.T[4], Shumye Birhan Mule[5], Dillip Narayan Sahu[6]

[1,4,5]Lecturer, Electrical and Computer Engineering, University of Gondar, Institute of Technology, Gondar, Ethiopia.

[2]Senior Assistant Professor, Department of Mechanical Engineering, Madanapalle Institute of Technology & Science, Andhra Pradesh, India.

[3]Assistant Professor, Department of Agriculture, Karunya Institute of technology and Sciences, Coimbatore, Tamil Nadu, India.

[6]Lecturer, Department of MCA, School of Computer Science, Gangadhar Meher University (GMU), Sambalpur, Odisha, India.

Abstract

The safety of the driver and the safety of the vehicle are the most crucial considerations when it comes to automotive driving. Safe following distance between cars is a new idea established with the goal of reducing traffic congestion by regulating the amount of space (distance) and speed available to drivers. Adaptive Cruise Control (ACC) is a popular feature in cars because it helps drivers drive more comfortably and safely. Jerk, spatiotemporal issues, road elevations, as well as nonlinear power train dynamics can't be successfully addressed by the ACC system. Hatchback segment automobiles are equipped with an excellent safety system and a collision avoidance technology known as PID controller based Collision Avoidance (PID-CA) module. PID-CA module successfully detects and avoids traffic crashes on the road in a major way in all environmental circumstances, according to the suggested design. Developing a real-time transportation system using the suggested PID-CA module increases vehicle manufacturing technology's level of dependability and security. Adopting the suggested PID-CA module in Hatchback category automobiles increases driver safety while also decreasing operating costs.

Keywords: Adaptive Cruise Control, PID controller, Hatchback, Collision Avoidance System, RADAR.

1. Introduction

Stormy weather, bad road conditions, traffic congestion, and driver weariness have all contributed to an increase in traffic accidents in recent years. In the majority of collisions, the driver's delayed reaction to the circumstance causes the accident, as shown by traffic accident data. Thus, the quick reaction is produced by deploying Collision Avoidance System (CAS) in the car driving system. By employing a Proportional Integral Derivative (PID) controller in conjunction with RADAR-based Vehicle Collision Avoidance (RADAR-VCA), the previous chapter successfully identified the leading vehicle in front of the host vehicle and maintained the safe following distance to avoid traffic congestion.

Cars are equipped with the Proportional Integral Derivative (PID) controller-based Collision Avoidance (PID-CA) module in order to create a real-time traffic-free environment and ensure driver safety by automatically safeguarding vehicles from accidents. Collision Avoidance System (CAS) is included into the proposed PID-CA module for the road transportation system, which successfully protects the cars from crashing. The CAS helps drivers stay safer on the road by reducing the likelihood of an accident. As part of the proposed PID-CA module, the Antilock Braking System (ABS) and Electronic Stability Program (ESP) are integrated into the CAS (ESP). Most intelligent vehicles are equipped with CAS, a proactive accident mitigation system, which is often referred to as CAS. The Proportional Integral Derivative (PID) is the control system used by the automotive industry for all processes. CAS is also applied with an Engine Control Unit (ECU) to prevent collisions and mishaps, as well as to monitor and control the vehicle's speed.

2. Literature Review

Pedestrian and bicyclist accidents have risen as a result of the ever-increasing advancements in automotive technology. There are times when collisions between cars and objects, as well as the consideration of emergency avoidance difficulties, might result in a traffic accident. High-speed emergency avoidance is given more attention. The driver usually uses the emergency brake parking or the bypass passage to avoid crashes if the cars are travelling at their maximum speed. One of the basic prerequisites for vehicle active safety is the ability of drivers to safely operate their vehicles on their own. Modern intelligent transportation systems place a high value on maintaining traffic safety. It is also possible to use cooperative collision avoidance, in which two or more cars work together to avoid collisions in a certain traffic situation. For vehicle autonomous driving, a variety of Adaptive Cruise

Control and Collision Avoidance (ACC) methods were developed. Drivers' well-being was taken into consideration while designing the control systems. The use of hard braking and lane change strategies helps to avoid rear-end collisions, although ACC still has certain performance issues. Consequently, a number of studies have been carried out to improve the ACC's ability to prevent collisions.

In [3] an Adaptive Cruise Control (ACC) approach based on Supervised Adaptive Dynamic Programming (SADP) The SADP algorithm is designed to deal with stochastic demands in dynamic programming. In order to allow the host car to direct in both highway and urban situations, an ACC system was created. In both circumstances, the ACC system was activated so that the host car could be driven autonomously to a chosen speed or a certain distance from the target vehicle. When it comes to creating a well-organized controller, standard Adaptive Dynamic Programming (ADP) was used. The model of recommending a location for alleviating training restrictions was constructed using a SADP algorithm. To address the complete spectrum of ACC difficulties, the SADP algorithm offers a well-organized control solution. Using the SADP method proved ineffective in reducing speed error.

In [4] Adaptive Cruise Control was given a formal method by the authors (ACC). There were two different ways to make control software. Each of these two methods produced a controller that was correct in its design, and they both rely on fixed-point assessments of certain set-valued mappings for their effectiveness. One of the control methods used continuous state space assessments, whereas the other used a finite-state abstraction. This was the first time that a low-dimensional model was used to synthesise controllers. By converting textual ambiguity into exact mathematical requirements, a thorough design control process removed any likelihood of ambiguity. Systematic design and testing of the models and conditions were carried out using a closed loop approach. The fuel usage was not taken into account by ACC.

In [5] As a way to improve both efficiency and safety, the authors created the Ecological Adaptive Cruise Controller (Eco-ACC). The Eco-ACC system was put to use in order to save as much energy as possible while still ensuring the safety of the vehicle. Plug-in Hybrid Electric Vehicles' top speeds might be adjusted using the controller and an onboard sensor (PHEVs). The vehicle's speed was then managed using a Nonlinear Model Predictive Control (NMPC) technique. The authenticity of the model was established by a high-fidelity autonomy-dependent model that was based on a robust and well-organized control-oriented model. In addition, NMPC improved the overall energy output. Cars were not kept at a safe distance from each other when NMPC was used to prevent a collision.

In [6] An AIT intelligent vehicle's adaptive cruise control system has been detailed in detail by the author. Several modifications were made to the vehicle's throttle and brake systems. As part of a drive-by-wire system, an external DC motor with a position control method was used to modify a cable coming from the accelerator pedal. A dc servo motor was used to modify the braking mechanism such that the brake pedal remained open. The velocity control mode was implemented using a proportional and derivative control approach with error correction. A fuzzy logic approach for distance control has also been developed. The fuzzy controller received inputs from a laser range finder in the form of distance error and relative velocity. A lack of attention was paid to the issue of speed.

In [7] An adaptive cruise control system with a longitudinal controller for following a previous vehicle has been described by the author in detail. As part of the test, an adaptive cruise control system was installed on the test car to help it detect a preceding vehicle. By maintaining its accelerator and brake, the following car was able to keep a safe distance from the previous vehicle. Laser scanner data on the front of a following vehicle was used to determine the distance inaccuracies caused by previous vehicle distances. The Electronic Regulate Unit (ECU) receives data from the Acceleration Position Sensor (APS) to control the vehicle's speed (ECU). The use of a longitudinal controller enhanced the computational complexity of the system.

In [8] To prevent rear-end collisions, the author created a hierarchical stop-and-go cruise control system (S&G). The safety distance may be estimated using a vehicle dynamics model that takes headway approach into account. After that, a fuzzy PID control standard was used to construct an upper and a lower controller. The host vehicle might be directed by the S&G system to keep a safe distance behind a leading vehicle whose speed was being modified. The S&G technology improved the vehicle's active safety, reducing the driver's tiredness. S&G systems do not handle the issue of maintaining traffic in a variety of conditions utilising safety measures.

In [9] The author demonstrated a vehicle-integrated Intelligent Safety System's interface-related activities (ISS). A Tire Pressure Monitoring System (TPMS) and an Airbag Deployment Decision System (ADDS) were part of the ISS (TPMS). After then, a working prototype including hardware components was created. Crash recognition and weight sensing were integrated with image processing and other safety subsystems to help make intelligent judgments about airbag deployment. The in-vehicle use of the integrated safety system allowed it to monitor tyre pressure and temperature. Using interface-relevant activities did not enhance traffic forecasts.

In [10] An intelligent vehicle's safety and comfort may be improved with an Advanced Emergency Braking System (AEBS), according to the authors. Model Predictive Algorithm and a vision-based model of longitudinal vehicle dynamics were created to handle the nonlinearities in automobile dynamics. Finally, a hierarchical control structure was put in place to decouple and synchronise the system. Using a coordinated cost function, collision risk was reduced and fuel economy was increased. Finally, a multi-objective optimization control with non-linear model predictive control for efficient tracking was developed. Non-singular Fast Terminal Sliding Mode (NFTSM) control theory was also used to design an electronic brake controller that tracks the goal in a set time. Using AEBS reduced the likelihood of an accident and improved both driving comfort and fuel efficiency. AEBS was unable to improve the effectiveness of collision avoidance.

3. Proposed System

Traffic crashes and accidents are caused by a driver's lack of attention or exhaustion in a normal driving system. Driver assistance systems are becoming more common as transportation networks expand at an exponential rate, in part to help drivers escape traffic jams. By using an Adaptive Cruise Control (ACC) technology, drivers may enjoy a more secure ride. Safe following distance is maintained by analysing a previous vehicle's distance and speed, which may be determined by the use of the ACC system. As a result, the preceding vehicle's speed and the distance between the host vehicle and preceding vehicle are used to effectively manage the host vehicle's speed. The avoidance of vehicle collisions is made possible by the speed and distance management in the vehicle's driving system, and this in turn makes driving more efficient. A PID controller based Collision Avoidance (PID-CA) module is used in the vehicle driving system to reduce traffic congestion and accidents on the road with the deployment of CAS in order to get superior outcomes.

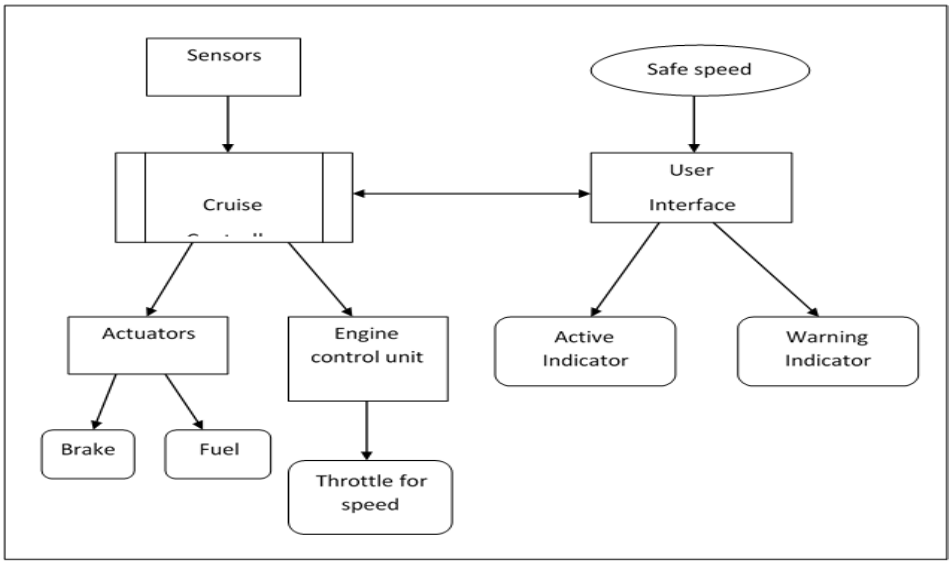


Figure.1. Conceptual block diagram of proposed PID controller based Collision Avoidance module

The suggested PID-CA module, as illustrated in Figure 1, provides a safe and collision-free transportation system. The proposed PID-CA module monitors the traffic ahead on the road to calculate the distance between the host and the preceding vehicle and the speed of the preceding vehicle. As soon as the sensor detects a slowing vehicle, the suggested PID-CA module instantly applies the brakes to prevent the car from colliding with it. As a result, the vehicle's speed may be managed, and a safe separation between cars is maintained. As a result of this, if the warning sign is set to "ON," then the vehicle's speed is regulated by the user interface. The host vehicle's speed is controlled through tuning based on manual driving data. There are threshold levels for warning index and inverse TTC that are determined depending on a driver's manual data and driving condition. The engine control unit receives an acceleration or deceleration signal based on the estimated value. Maximum allowable speed is used to manage PID-CA module on an open road in the proposed system. If there is no obstruction in the route of the vehicle, it will maintain the predetermined speed. PID controllers reduce the host vehicle's speed to prevent a collision when the sensor module detects the leading vehicle. The next sections detail the proposed PID-CA module's approach for achieving a collision-free driving system.

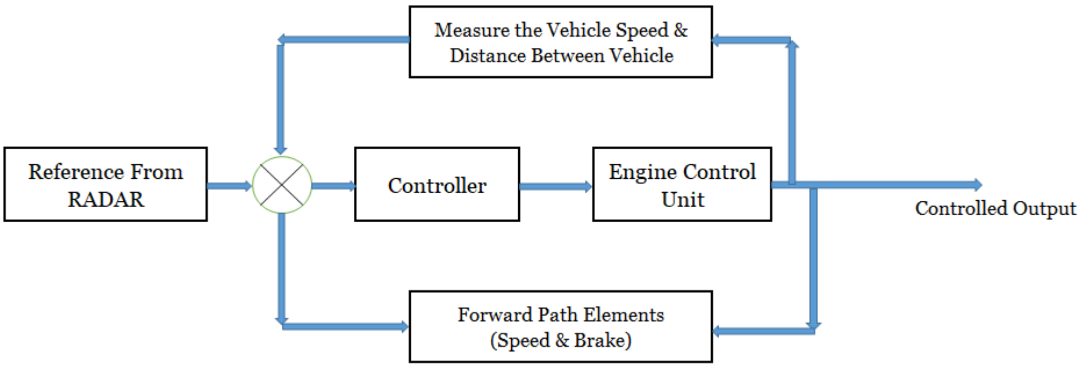


Figure.2. RADAR based closed loop control system

RADAR-based closed loop control systems are used in automobile driving systems for vehicle collision avoidance systems, as illustrated in Figure.2. That is why the closed loop control system uses RADAR to maintain a safe gap between cars on the road. The sensor module feeds back a receiving signal that tells us how far away we should keep things to keep everyone safe. Any impediment on the road is detected by the sensor module receiver and sent to the PID controller. An electronic (vehicle) stability method is shown in Figure 3.

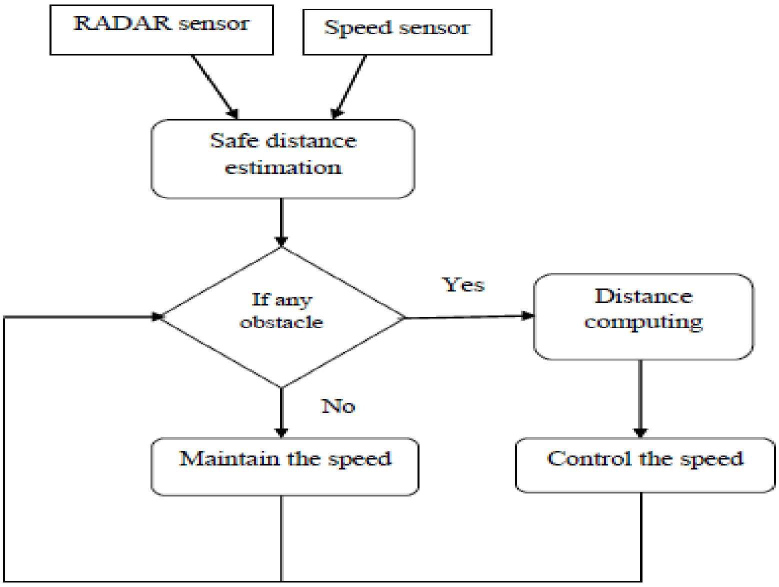


Figure.3. Overall process of Electronic (vehicle) stability algorithm

In the suggested PID-CA module, the speed control procedure is shown in Figure.4 to prevent traffic collisions. Wheel-mounted radar and laser sensors are initially installed on the host vehicle. They are used to gather information about the car in front of them on the road. Using the vehicle stability algorithm, a safe distance may then be established for the driver.

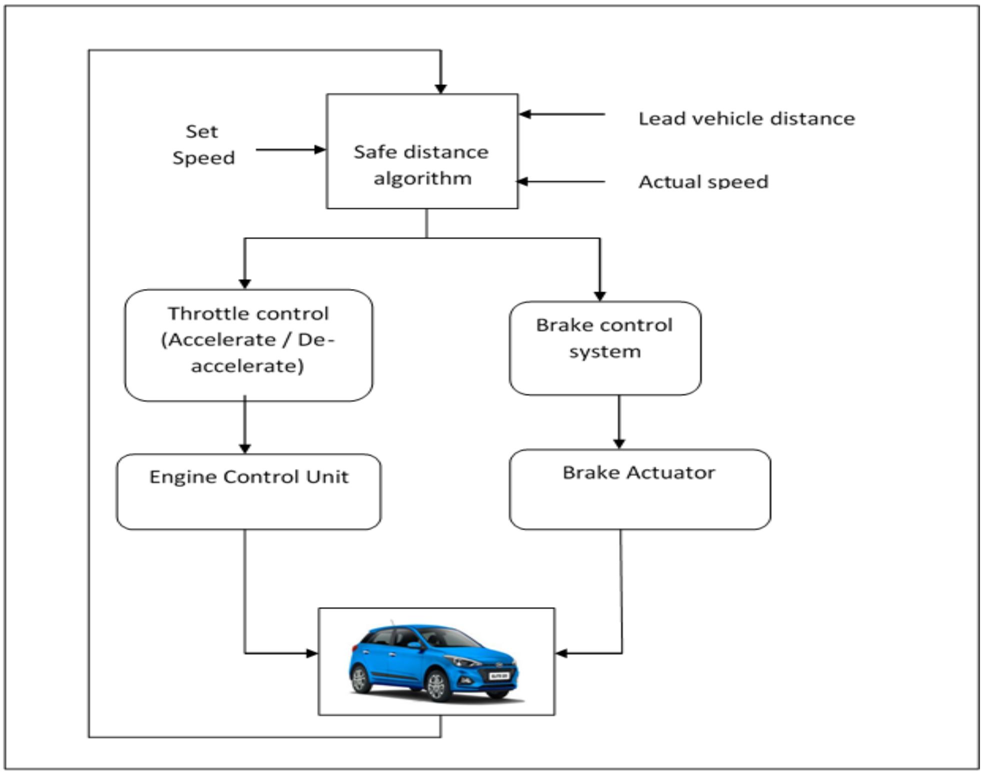


Figure.4. Speed control process in proposed PID-CA module

As a result, the host vehicle runs at the predetermined speed when there are no barriers in front of it. In addition, if a preceding vehicle (obstacles) is present in front of the host vehicle, the host vehicle's real speed is reduced to 50% of the set speed. Speed and gap between hosts and preceding vehicles are maintained in crucial ways as a result of this. The vehicle stability algorithm guides the engine control unit to activate the vehicle towards the predetermined speed after the clearance of the previous cars. By using the suggested PID-CA module's vehicle stability algorithm, the engine control unit is able to alleviate traffic congestion and consequently reduce the likelihood of traffic accidents.

Radar sensors mounted on moving vehicles provide data to the PID control module of the PID-CA module under consideration. Using the sensor module, the host vehicle is able to identify the objects in front of it on the road and modify its speed accordingly in order to prevent crashes. The suggested PID-CA module improves the performance responsiveness to traffic conditions significantly in the driving system it is included into. Brakes may be pre-charged for more forceful or emergency braking when a driver's reaction is delayed by a planned PID-CA module. As a result, there will be no rear-end collisions.

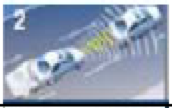
Risks		
	Risk Avoidance: Traffic Guidance	
	Increased Risk: Brake Preparation	
	High Risk: Driver Warning/Accident mitigation	
	Crash inevitable: Accident preparation	

Figure.5. Various Phases in Collision Avoidance Systems

Figure 5 depicts the several stages of the collision avoidance system. The purpose of Traffic Guidance is to advise the motorist of the current traffic conditions on the route. Preparation for the brakes improves the vehicle's stopping power. The motorist is guided to avoid a collision by means of a warning system. The occupant protection and vehicle speed are prepared in accident prevention. As a result, a safe and secure transportation system is achieved by the suggested PID-CA module.

4. Results and Discussion

Matlab Simulink is used to create the PID controller based Collision Avoidance (PID-CA) module to reduce the error rate for distance, speed and fuel consumption. Simulated outputs for different speeds are generated using MATLAB to demonstrate the stability algorithm's performance at various vehicle speeds. These figures show the simulation results at various set speeds. The required speed is shown by a circle on each graph.

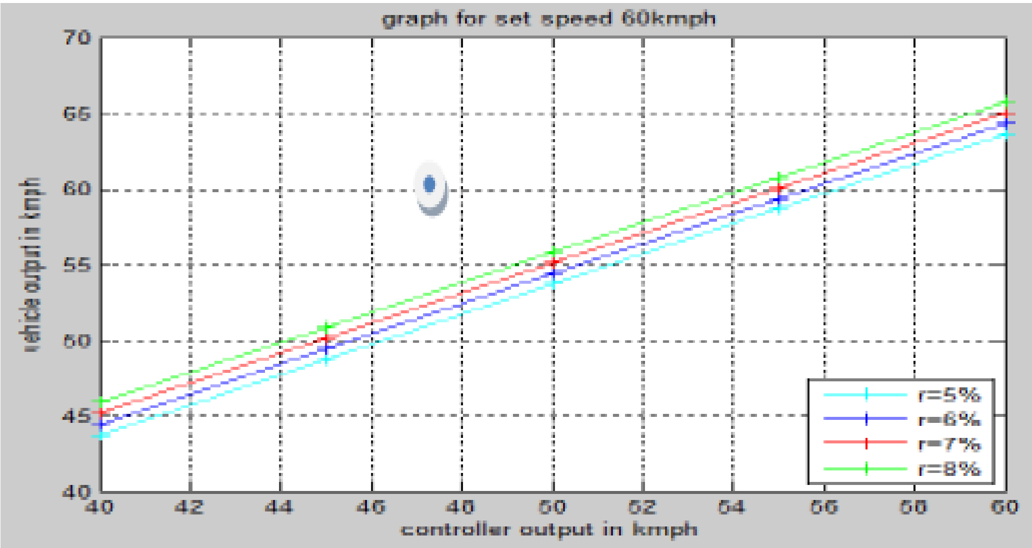


Figure.6. Plot of Controller output vs Vehicle output for Set Speed of 60 KMPH

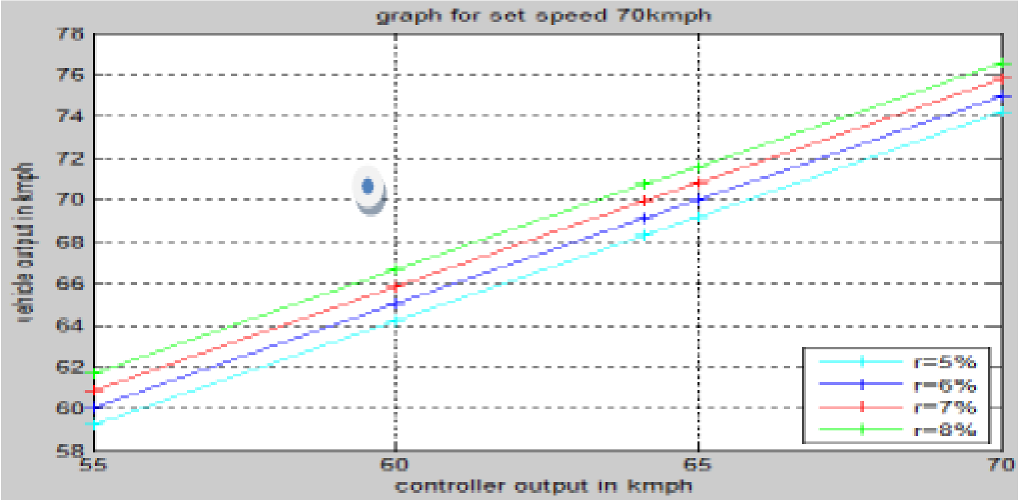


Figure.7. Plot of Controller output vs Vehicle Output for Set Speed of 70 KMPH

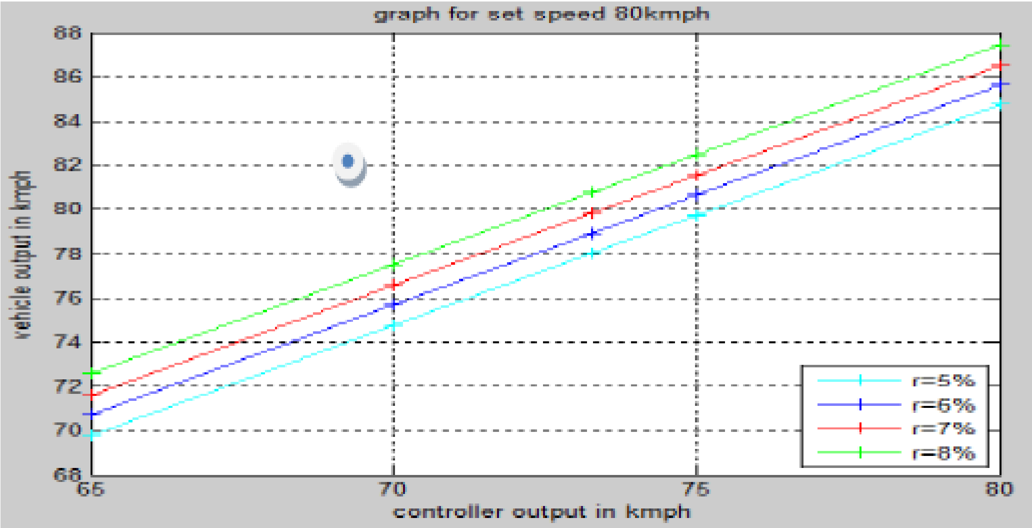


Figure.8. Plot of Controller output vs Vehicle output for Set Speed of 80 KMPH

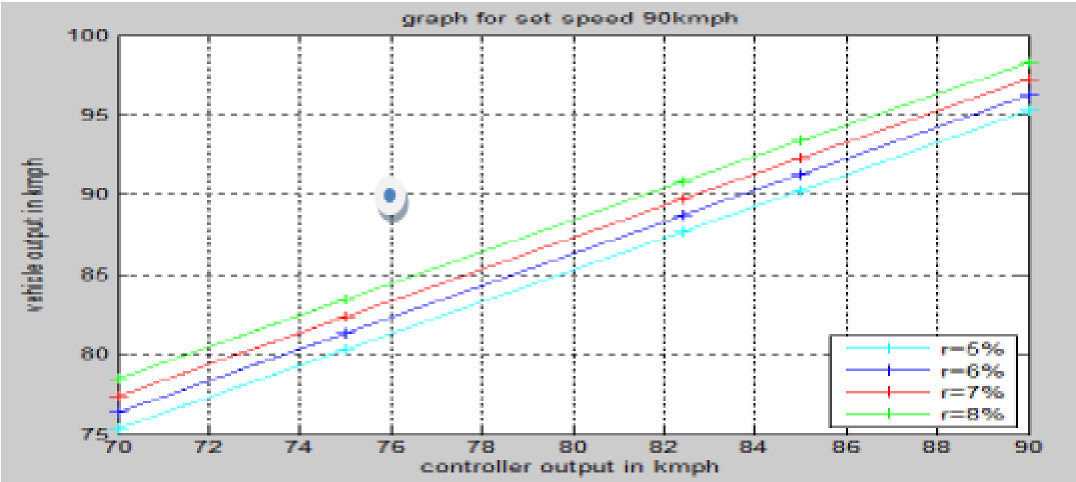


Figure.9. Plot of Controller output vs Vehicle output for Set Speed of 90 KMPH

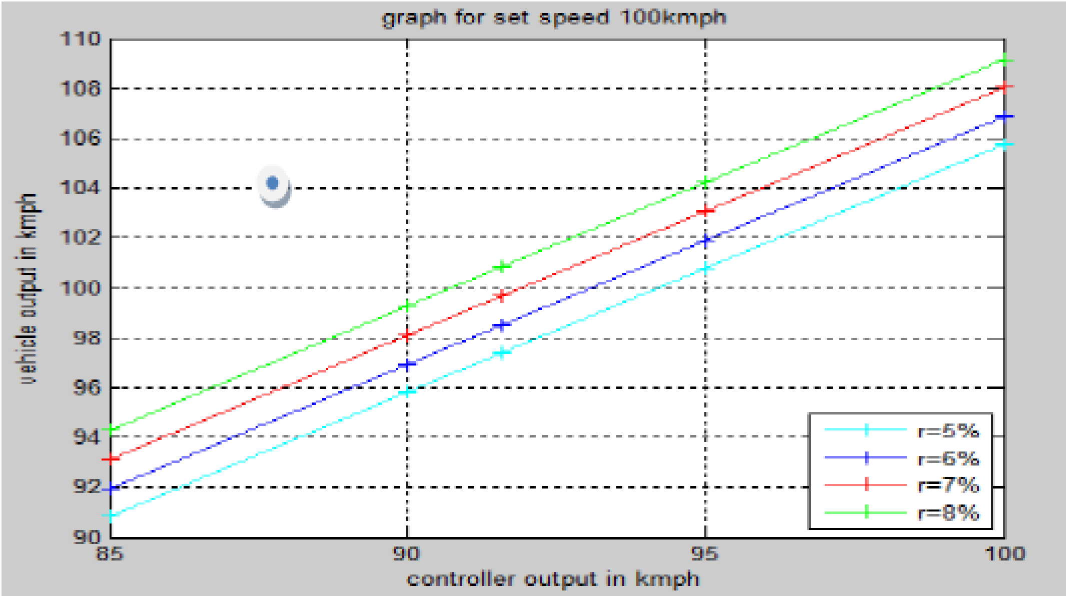


Figure.10. Plot of Controller output vs Vehicle output for Set Speed of 100 KMPH

According to figures 6 to 10, the vehicle output is dependent on controller input. The vehicle's speed fluctuates and stays the same with an observed inaccuracy rate of 7 percent. When the error rate exceeds or falls below the threshold of 7 percent, the vehicle becomes unstable. With an error rate of 7 percent, the engine control unit (ECU) is able to keep the vehicle's speed stable by limiting its rate of error. Figures show that, for all specified speeds between 60 and 100 kilometres per hour, the automobile speed is the same at a rate of 7% inaccuracy. To keep the remaining mistake rate low, the vehicle speed is slowed down. Programming in the ECU and speed command ensures that the automobile is driven safely. Fuel flow is normalised by the ECU if the driver has specified its speed value in the Engine Control Unit.

5. Conclusion

PID controller based Collision Avoidance (PID-CA) module, an effective safety system and collision avoidance system, is presented to lessen the collisions of Hatchback segment automobiles with other vehicles. When operating in any kind of environment, the suggested PID-CA module ensures driver safety by rapidly identifying and preventing traffic collisions. Vehicle manufacturing technology may be improved by the development of the suggested PID-CA module in real-time transportation systems. In Hatchback category automobiles, the installation of the suggested PID-CA module enables a safe driving system and is economical for drivers.

References

1. G. Meiring and H. Myburgh, “A review of intelligent driving style analysis systems and related artificial intelligence algorithms,” *Sensors*, vol. 15, no. 12, pp. 30653–30682, 2015.
2. V. C. Magana and M. Munoz-Organero, “Toward safer Highways: Predicting Driver Stress in Varying Conditions on Habitual Routes,” *IEEE Vehicular Technology Magazine*, vol. 12, no. 4, pp. 69–76, 2017.
3. M. Oastler, *Vehicle weights explained |tare, kerb, GVM, payload and trailer figures - Car Advice |CarsGuide*, Cox Automotive, COX AUSTRALIA MEDIA SOLUTIONS PTY LTD, 2015, December 2017.
4. J. Richardson, S. Jones, A. Brown, E. O', N. A. Brien, and D. Hajializadeh, “On the use of bridge weigh-in-motion for overweight truck enforcement,” *International Journal of Heavy Vehicle Systems*, vol. 21, no. 2, p. 83, 2014.
5. J. Gajda, P. Burnos, and R. Sroka, “Accuracy assessment of weigh-in-motion systems for vehicle’s direct enforcement,” *IEEE Intelligent Transportation Systems Magazine*, vol. 10, no. 1, pp. 88–94, 2018.
6. W. Weidner, F. W. G. Transchel, and R. Weidner, “Classification of scale-sensitive telematic observables for riskindividual pricing,” *European Actuarial Journal*, vol. 6, no. 1, pp. 3–24, 2016.
7. S. Kirushnath and B. Kabaso, “Weigh-in-motion using machine learning and telematics,” in *2018 2nd International Conference on Telematics and Future Generation Networks (TAFGEN)*, pp. 115–120, Kuching, Malaysia, July 2018.
8. J. Labarrere, “What is WIM and history,” *ISWIM - International Society for Weigh in Motion*, ISWIM International Society for Weigh in Motion, 2017, December 2017.
9. I. L. Al-Qadi, H. Wang, Y. Ouyang, K. Grimmelsman, and J. E. Purdy, *LTBP Program’s Literature Review on Weigh-In-Motion Systems (No. FHWA-HRT-16-024)*, Federal Highway Administration. Office of Infrastructure Research and Development, USA, 2016.
10. R. Shah, Y. Sharma, B. Mathew, V. Kateshiya, and J. Parmar, “Review paper on overloading effect,” *International Journal of Advanced Scientific Research and Management*, vol. 1, no. 4, pp. 131–134, 2016.

11. T. R. McKay, C. Salvaggio, J. W. Faulring et al., “Passive detection of vehicle loading,” in *Visual Information Processing and Communication III*, Burlingame, California, USA, 2012.
12. D. Braun, E. Reiter, and A. Siddharthan, “Creating textual driver feedback from telemetric data,” in *Proceedings of the 15th European Workshop on Natural Language Generation (ENLG)*, pp. 156–165, Brighton, UK, 2015.
13. R. Vaiana, T. Iuele, V. Astarita et al., “Driving behavior and traffic safety: an acceleration-based safety evaluation procedure for smartphones,” *Modern Applied Science*, vol. 8, no. 1, pp. 88–96, 2014.
14. D. I. Tselentis, G. Yannis, and E. I. Vlahogianni, “Innovative motor insurance schemes: a review of current practices and emerging challenges,” *Accident Analysis & Prevention*, vol. 98, pp. 139–148, 2017.
15. E. I. Vlahogianni and E. N. Barmpounakis, “Driving analytics using smartphones: algorithms, comparisons and challenges,” *Transportation Research Part C: Emerging Technologies*, vol. 79, pp. 196–206, 2017.