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Review IJACSE

Review of Adaptive Cruise Control System

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Abstract

New technologies are constantly being created in the modern era of the automotive industry to increase driver comfort and safety. The vehicle industry is focused on creating new designs that prioritize comfort and safety to overcome this problem. The technology which helps the automotive industry is the Adaptive Cruise Control system (ACC). The ACC system is an electronic device that assists drivers to keep a guarded distance from the upcoming vehicle by automatically adjusting the vehicle's speed. It works on sensors and radars which are the heart of the system. The implementation of this system can significantly reduce the risk of accidents caused by the driver's inability to keep a safe space from the moving car ahead. The use of this technology provides a basis for additional studies concerning automotive safety and automation. In this review work, we have explored the different technologies and mechanisms associated with ACC and their performance metrics have also been put there of.

Keywords: Adaptive cruise control (ACC), sensors, radars, metrics, FLCs

INTRODUCTION

In the modern era of the automobile industry, new technologies are continuously being developed to improve safety and comfort for drivers. Unfortunately, road accidents remain a serious concern, with statistics from India in 2021 showing a total of 4,12,432 accidents, resulting in 1,53,972 deaths and injuries to 3,84,448 people. Most of these accidents, around 67%, are caused by human error, distraction, poor judgment, or lack of situational awareness. To address this issue, the automobile industry is working on developing new designs that prioritize safety and comfort. Researchers, manufacturers, governments, and customers worldwide are collaborating to create the ACC system and solve the various challenges it presents, including social, traffic, and human issues.

Human issues include concerns related to the ACC system's impact on driver behavior and user acceptability, as well as the challenges presented by human-machine interaction. Traffic issues involve the stability, capacity, and safety of the traffic flow, while social issues relate to how the ACC system interacts with society, such as its impact on the environment, marketing, and the law. As the penetration of the ACC system increases, efforts must be made to address these challenges. This includes improving traffic capacity, enhancing traffic flow stability, and reducing fuel consumption [1–4]. By working together and implementing new technologies, the automobile industry can continue to make driving safer and more comfortable for all.

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ADAPTIVE CRUISE CONTROL (ACC) SYSTEM

Flowchart of ACC

ACC is an advanced system that assists drivers in maintaining a secure distance and altering the

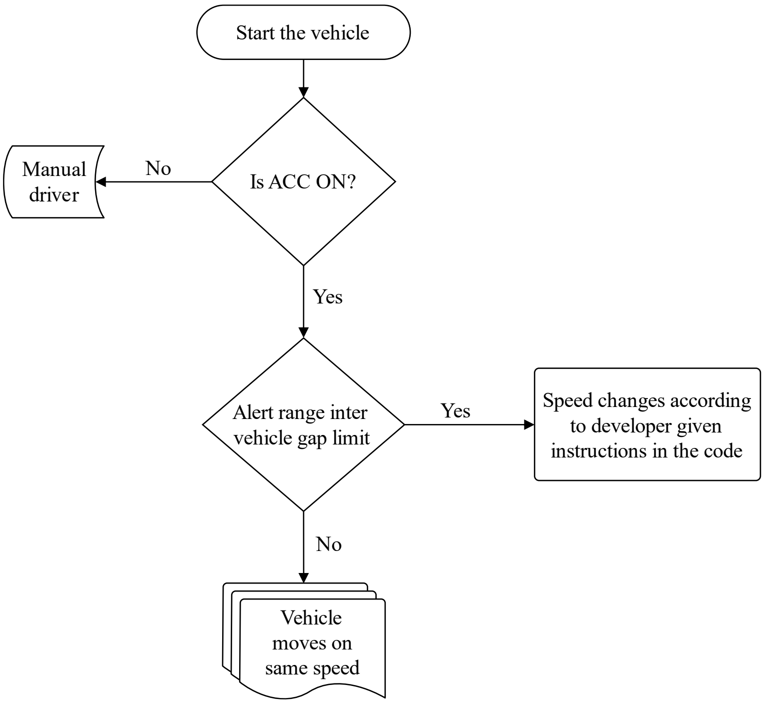

Figure 1. Schematic of ACC.

vehicle's acceleration based on the front vehicle as shown in Figure 1. The system uses sensors like radar or lidar to detect the speed, and distance of the preceding vehicle and adjust the host vehicle's speed accordingly.

Different Types of ACC

Fuzzy Logic Cruise Control System

Figure 2 demonstrates the schematic of a fuzzy logic cruise control system (FLC). It can be designed for any type of vehicle transmission system, whether it is a semi-automatic, automatic, or manual transmission [5, 6]. FLCs have the capability of handling uncertain and imprecise data which makes them useful in situations where traditional control methods may not be effective. This fuzzy logic system can be used in cruise control applications wherein the inputs include vehicle speed, desired speed, and the rate of change of the desired speed. The FLC calculates the throttle opening required to maintain the desired speed and outputs a control signal that adjusts the throttle position accordingly. FLCs have the advantage of being able to handle non-linear systems like the engine and transmission of a vehicle and can adapt to changing conditions while learning from previous experiences.

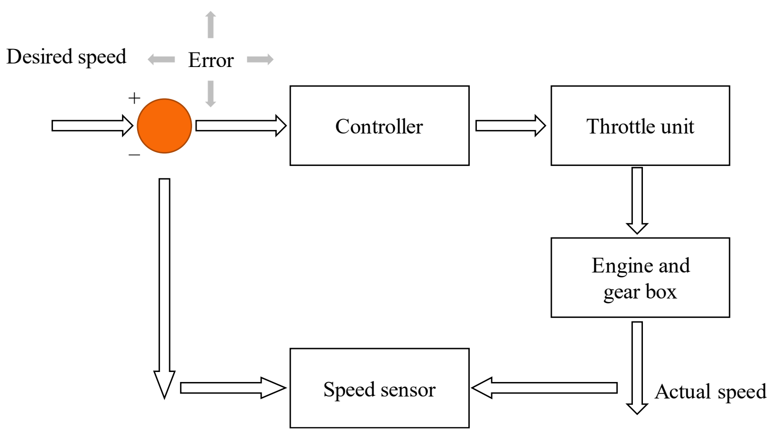

Figure 2. Fuzzy logic cruise control system.

However, the design and tuning of FLCs can be more complicated than traditional control systems, resulting in a more complex system that may be difficult to understand. Therefore, the suitability of using FLCs in cruise control applications depends on a case-to-case basis.

Figure 2. explains the Fuzzy logic cruise control system, it is a closed-loop control system that regulates the speed of a vehicle. The system adjusts the engine and gearbox based on the initial speed setting, which is determined by the position of the throttle. To measure the actual speed, a speed sensor is used as part of the feedback mechanism. The controller receives the error signal, which represents the difference between the desired speed and the actual speed, as input. The controller then generates a signal that modifies the throttle angle to correct the error [7]. By changing the throttle's opening range, the controller adjusts the engine's speed, allowing the cruise controller to maintain the vehicle's speed by comparing the feedback speed sensor's reading with the desired speed.

Potential Field-based Hierarchical Automatic Cruise Control System

Figure 3 displays the schematic diagram of the potential field-based hierarchical system ACC. It is a type of control system that is suitable for semi-autonomous electric vehicles. It uses a hierarchical control architecture to adjust the vehicle's speed according to changing traffic conditions and to maintain a safe distance from other vehicles. The top level of the control architecture is responsible for generating a virtual force field around the vehicle. The potential field generator considers the speed and distance of other vehicles and applies a repulsive or attractive force if they are too close or too far away. At the lower level of the control architecture, an adaptive cruise control system utilizes the virtual force field generated by the potential field generator to regulate the vehicle's speed. The system maintains a safe distance from other moving vehicles, while still maintaining the desired speed. One of the advantages of this potential field-based hierarchical adaptive cruise control system is its ability to adapt to changing traffic conditions, including speed limit changes or sudden stops by other vehicles [8]. It can also help reduce driver workload and improve safety in semi-autonomous vehicles. However, implementing this control system may require complex algorithms and significant computational resources to generate and maintain the virtual force field.

In Figure 3, the electronic control unit consists of radar, a camera, and GPS. In this area, it collects external data such as road conditions, objects ahead, and speed sensors. Then the collected data will be analyzed and accordingly, the decision will be sent to the driving system, steering system, and battery management system. These whole processed signals will be sent to motor drivers to operate the wheel motors.

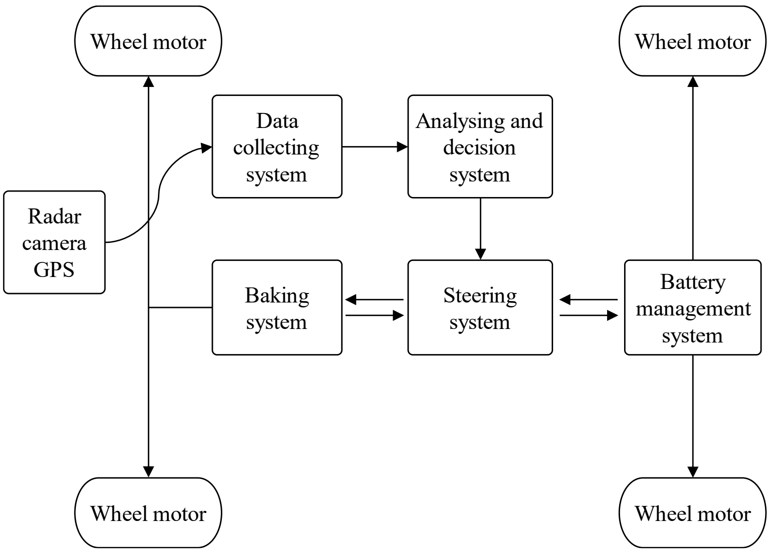

Figure 3. Potential field-based hierarchical automatic cruise control system.

Predictive Cruise Control System (PCC)

A predictive Cruise Control System (PCC) is a sophisticated control system that uses a combination of sensors and algorithms to predict traffic and road conditions ahead of the vehicle and optimize the vehicle's speed and acceleration accordingly. It is relatively stable on any type of road condition. This technology has been studied and implemented in various types of vehicles, including fully electric vehicles, and has the potential to optimize energy consumption and increase driving range. PCC for fully electric vehicles uses a variety of sensors, including cameras, radars, and LiDARs, to collect data about the road and traffic ahead. This data is then processed by advanced algorithms that can predict traffic flow, congestion, and other road conditions, and adjust the vehicle's speed and acceleration accordingly. The primary advantage of PCC in fully electric vehicles is its ability to minimize energy usage and reduce the need for frequent stops and starts by predicting road conditions, and traffic, and adjusting the vehicle's speed and acceleration accordingly. This can help improve energy-saving, increase driving range, and reduce emissions. Overall, PCC has the potential to enhance driving safety by providing drivers with more accurate and timely information about road conditions. Several major automakers are currently developing and refining this technology, and it is expected to become more widely available in the coming years.

Figure 4 explains the predictive cruise control system by taking the host vehicle and the preceding vehicle. In the host vehicle, the controller manages the wheels, and it also manages the braking torque and transmission process through the motor which is run by the battery.

Advanced Driver Assistance System

Figure 5 is the diagram of Advanced Driver Assistance Systems (ADAS). It is an area that is currently being researched and developed within the automotive industry. It comprises a range of technologies designed to aid drivers in driving and enhance road safety. Ongoing research areas in ADAS include autonomous driving, where efforts are being directed toward creating fully automated vehicles. Such systems can operate vehicles without human intervention by utilizing advanced sensors, algorithms, and computing systems to interpret their surroundings and make decisions based on this information. Object detection and recognition are also important components of ADAS systems, with researchers striving to improve the precision and dependability of these systems, particularly in challenging environments like low light or inclement weather conditions. Intelligent cruise control systems utilize sensors and data to modify a vehicle's speed and to keep a precise distance from other vehicles on the road. Research in this area aims to enhance the precision and reliability of these systems while also developing new functionalities such as automated lane changing. Collision avoidance systems utilize sensors and data to detect and warn drivers about potential collisions with other vehicles, pedestrians, or objects on the road and focus on developing more advanced collision avoidance systems that can take action to avoid collisions, such as automatic braking or swerving. Finally, the human-machine interface is an increasingly crucial element as ADAS systems become more sophisticated. The parameters of ADAS are unavailable because it is a newly launched technology and parameters are yet to be known in coming years.

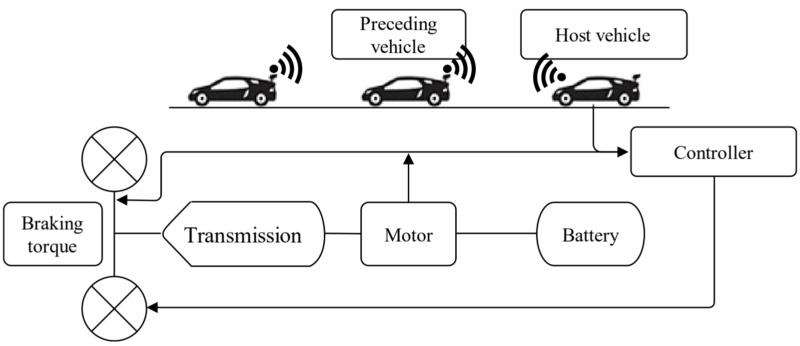

Figure 4. PCC diagram.

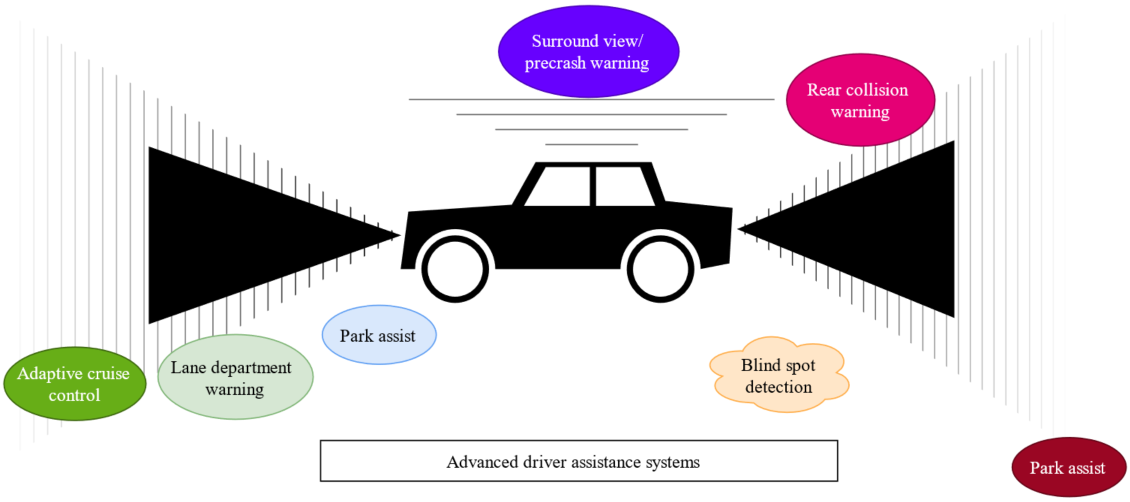

Figure 5. ADAS diagram.

Table 1. Comparison between different cruise control system.

Performance metric	Fuzzy logic cruise control system	Potential field-based hierarchical control system	Predictive cruise control system
Basic functionality	Adjust the speed of the vehicle	Adjust the speed of the vehicle hinge on potential field theory.	Predicts future speed and adjusts
Technology used	Fuzzy logic	Potential field theory	Predictive algorithm
Input variables	Speed, distance to the vehicle ahead	Speed, distance, acceleration of other vehicles.	Road gradient, speed limit, traffic
Output Variables	Acceleration	Acceleration	Acceleration
Application	Used in many vehicles today	Mostly used in high performance vehicles	Used in luxury and high-performance vehicles
Accuracy	High	High	High
Responsiveness	Medium	High	High
Adaptability	High	Medium	High
Robustness	Medium	High	High
Computational requirements	Low	High	Medium

Figure 5 displays the working areas of a vehicle that had ADAS technology. It consists of lane departure warning that helps in the unnecessary crossing of the lane on highways. Blind spots are dangerous areas for the driver to find side vehicles; to overcome that, Blind spot detection is also included in ADAS. Park assist is for smoothness assistance in parking areas to park the vehicle.

Table 1 concludes that the selection of a cruise control system will rely on the requirements and limitations of the application. It is crucial to remember that each of these systems has unique characteristics. When it comes to computational requirements, robustness, and communication requirements, the potential field-based hierarchical control system is the best.

CONCLUSION

To improve the accuracy and reliability of the current ACC system, researchers can explore the use of multiple sensors such as radar, lidar, and cameras. Additionally, the integration of artificial intelligence (AI) in the system can help learn the driver's behavior and preferences and improve decision-making in complex situations. Another research area could explore the use of cooperative ACC, which involves communication between vehicles on the road to coordinate speed and reduce accidents. The human-machine interface of the ACC system is another area for research, as the design and layout can affect the driver's trust and acceptance of the system. Integrating the ACC system with other advanced technologies, such as automatic emergency braking, departure caution, and forward collision warning can result in a more comprehensive safety system. Ongoing research can fully realize the potential of the ACC system to enhance automotive safety and reduce accidents.

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REFERENCES

1. Dawood YS, Mahmood AK, Ibrahim MA. Comparison of PID, GA and fuzzy logic controllers for cruise control systems. Int J Comput Digit Syst. 2018; 7(05): 311–319.
2. Huang Y, Ding H, Zhang Y, Wang H, Cao D, Xu N, Hu C. A motion planning and tracking framework for autonomous vehicles based on artificial potential field elaborated resistance network approach. IEEE Trans Ind Electron. 2020 Feb; 67(2): 1376–1386. IEEE Xplore. https://ieeexplore.ieee.org/document/8643096.
3. Van Keulen T, Naus G, De Jager B, Van De Molengraft R, Steinbuch M, Aneke E. Predictive cruise control in hybrid electric vehicles. World Electr Veh J. 2009; 3(3): 494–504. ISSN: 2032–6653.
4. Vahidi A, Eskandarian A. Research advances in intelligent collision avoidance and adaptive cruise control. IEEE Trans Intell Transp Syst. 2003 Sep; 4(3): 143–153. IEEE Xplore, https://ieeexplore.ieee.org/document/1255576.
5. Milanes V, Shladover SE, Spring J, Nowakowski C, Kawazoe H, Nakamura M. Cooperative adaptive cruise control in real traffic situations. IEEE Trans Intell Transp Syst. 2014 Feb; 15(1): 296–305. IEEE Xplore, https://ieeexplore.ieee.org/document/6588305
6. Hwisoo Eom, Sang Hun Lee. Human-Automation Interaction Design for Adaptive Cruise Control Systems of Ground Vehicles. Sensors. 2015; 15(6): 13916–13944. https://doi.org/10.3390/s150613916
7. Dey KC, Yan L, Wang X, Wang Y, Shen H, Chowdhury M, Soundararaj V, *et al*. A review of communication, driver characteristics, and controls aspects of cooperative adaptive cruise control (CACC). IEEE Trans Intell Transp Syst. 2015; 17(2): 491–509. IEEE Xplore. https://ieeexplore.ieee.org/document/7314936.
8. Okuda R, Kajiwara Y, Terashima K. A survey of technical trend of ADAS and autonomous driving. In Technical Papers of 2014 IEEE International Symposium on VLSI Design, Automation and Test. 2014 Apr; 1–4. IEEE Xplore, https://ieeexplore.ieee.org/document/6839646.

