

## Design and implementation of an Intelligent Mobility Solution with Adaptive Cruise Control

Zhang Aiping, Ji Aiyingji,

Department of Obstetrics and Gynecology, Zhengzhou Hospital of Traditional Chinese Medicine,  
Zhengzhou

Department of Digestion, The First Affiliated Hospital of Henan University of Traditional Chinese  
Medicine, Zhengzhou China,

### Abstract

The primary aim for vehicle automation research is to enhance driver comfort. As the number of cars on the road continues to rise, traffic congestion is reaching new heights. Driving in an urban environment may be a gruelling experience. A lifesaver for motorists whose survival depends on their ability to move across town will be an effective traffic management system. Driver assistance systems that monitor the vehicle's speed were first introduced with the introduction of the cruise control (CC) [1]. Additional radars [11] and cameras were added to the original CC system, resulting in the more advanced Adaptive Cruise Control (ACC) [1]. When the automobile is in difficult-to-maneuver situations, even the control system itself may take over control of the vehicle. A new kind of control system was introduced when the ACC was upgraded to Cooperative Adaptive Cruise Control (CACC). String Stability and GPS [15] for precise movement have enhanced vehicle density while reducing road accidents dramatically thanks to the platoon concept and its associated inter-vehicle communication system. The paper sheds light on CACC from the perspective of ACC.

**Keywords: ACC, CACC, Vehicle Following, Vehicle-Vehicle Communication**

### I. INTRODUCTION

It's exhausting to be behind the wheel when there's a lot of traffic. In order to react swiftly to unexpected conditions, the driver must be focused at all times.

Driving may be made more enjoyable with the use of Adaptive Cruise Control (or ACC). It is possible for ACC to alleviate the stress of driving by adjusting the vehicle's speed to match the flow of traffic. [1] The driver specifies the desired speed and the

distance to be maintained from the car ahead of them. [1] It is possible to adjust this distance based on the driving circumstances and personal style. A radar sensor with a long range is used to keep tabs on traffic conditions directly in front of the vehicle



**Fig. 1: Long Range Radar [8]**

When a vehicle's sensor system sends out radar waves, they are reflected back by the objects in front of it. Using this information, the ACC can identify vehicles ahead and determine factors such as distance, direction, and speed relative to the item in front. ACC maintains the set desired speed when the road ahead is clear. There is an Electronic Stability Program (ESP) [1] and engine control or brake system interaction that guarantees that the established safety distance is maintained in the event of an approaching vehicle. [1]

As soon as the road ahead is clear, the vehicle's ACC system accelerates automatically to the driver-specified speed. For example, ACC supports both harmonic and discordant traffic flow on the roadways. Even if the ACC is on, the driver is still responsible for keeping an

eye on the distance and speed of the car in front of him or her at all times. The drivers have the priority to turn-off or override the ACC function at any moment. Drivers driving cross-country highways or on freeways may benefit from the assistance of the standard ACC, which can be used at speeds up to 200mph. At speeds below 30 kilometres per hour, the ACC's stop and go version is also operational. Even at low speeds, the system is able to maintain a specified distance from the preceding vehicle and can even bring the car to a full stop. The ACC car will automatically drive ahead if the vehicle in front does so within a short period of time. To return to ACC mode after a period of inactivity, the driver merely has to apply a little amount of throttle. To those drivers who spend most of their time on congested roadways, "ACC stop and go" [1] is a godsend. One long-range radar sensor can be used to implement both ACC versions. By incorporating more video or radar sensor technologies into the vehicle, ACC functionalities may be further improved and enhanced.. Increased dynamics while moving forward from a stop are made possible by increasing the ACC speed range from 200kmph to 250kmph. [1]

As ACC continues to evolve, Cooperative Adaptive Cruise Control is the next step (CACC). An inter-vehicle communication system is used as an add-on to the Cruise Control system in order to increase the maximum speed and decrease traffic congestion. This document describes the process of moving from ACC to CACC.

Fig. 2: Driver assistance systems [1]

## II. LITERATURE REVIEW

Autonomous driving is becoming an integral aspect of car technology. For automotive drivers, artificial intelligence using neural networks is assuming the role of intelligent driving. To avert calamities, there are instances where human intellect must outperform artificial intelligence's computer power. Many types of autonomous manoeuvring have been created to aid the driver in avoiding weariness as a result of long distance driving. HIL (Hardware in the Loop) [2] is the first of its type as a control for a fleet of automobiles. Following a successful test of platooning cars for Cooperative Adaptive Cruise Control (CACC), wireless technology has now advanced to a sufficient level. There were always issues when an algorithm was performed between cars in a lane because of the decentralised nature of the technique. For example, each car in the fleet is able to talk to one another. After some time, this is now a dynamically-connected network system. Because of this, developing an asymptotic network control system is a time-consuming endeavour for developers. The development of an algorithm with String Stability [2] is currently being pursued. The dynamics of traffic will differ based on the location, such as highways and urban centres. As the algorithm is designed, the CACC-equipped cars will react accordingly. Not only does this strategy not work because of the varying road conditions, but it also doesn't work because of the variable vehicle densities at different sites. Depending on the age and

aggressiveness of the driver, the reaction time might range from 0.8 seconds to 1 second. To compensate for this disparity, a flexible strategy is essential. [3] FAST (flexible agent-based simulator of traffic) [3] is a simulator model to study the Adaptability of CACC-equipped cars in varied traffic situations. Different road conditions with changeable traffic are part of this object-oriented microsimulation running on a Java platform. In this they employed a dedicated lane known as HOV (high-occupancy vehicle) for cars equipped with CACC. As a consequence, traffic flow increased significantly while congestion was reduced to a minimum. [3]

If your car is equipped with adaptive cruise control (ACC), you may select a speed and the vehicle will maintain that speed and modify automatically based on the vehicle ahead of you. In the event of cars equipped with CACC, the speed and spacing between the vehicles are determined by the vehicle in front, and the platoon will be updated with the vehicle characteristics and other traffic factors to ensure a safe and efficient movement with the least possible congestion. The goal of algorithm development is to get the output of a closed loop system to a zero error level. In cruise control systems and adaptive cruise control systems, PID controllers [13] are often used. The two controls vary in that they rely on different types of settings and operate in different ways.

Traffic flow must be taken into account while driving ACC-equipped vehicles.

Slide mode is used to do this. An extra S variable will be introduced such that the feedback loop's output is always zero error probability and does so with the least amount of time delay possible. This allows the vehicle to respond quickly and adapt to changing conditions. [4]It's not a simple process to develop cruise control controllers. During acceleration and braking, the vehicle's dynamics will be different. Depending on the car's gearbox, the throttle response will be different. In the field of vehicle automation, the idea of a hybrid controller that can change its mode of operation quickly and easily in response to changing conditions is gaining traction. The FOC (fractional-order control) [5] modified version of the ordinary PID controller has acquired prominence in the design of CACC because it can transition between controllers based on dynamics.

### **ACC IN BRIEF**

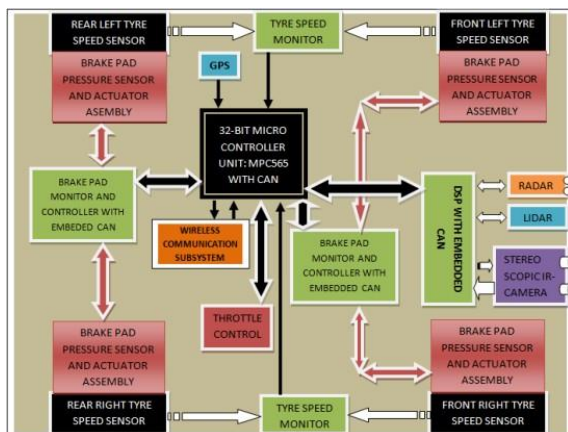
III.CACC has two subsystems: ACC and CACC. The ACC in the CACC system controls the vehicle's braking system as well as the steering angle and yaw rate sensors, which allow it to determine the vehicle's current lane and recognise road bends. The second CACC subsystem, the communication subsystem, is responsible for transferring data among the pool's cars. In addition to the RADAR sensor, the ACC subsystem has a LIDAR [12], stereoscopic camera, tyre speed sensor, and brake pad monitor sensor. The RADAR sensor measures the vehicle's speed and distance. As long as the computed distance between two cars is higher than the intended one, one of them

will be sped up to make up for lost time, and as long as the calculated distance is smaller, one of them will be slowed down by decreasing throttle, lowering gear, or even applying brakes. The maximum deceleration potential of the brake system (full braking) is limited to roughly 25% in order to minimise unexpected jerks and to provide a comfortable journey.

IV. There will be noise in the RADAR signals that are received, and as a result, there is a considerable risk of signal loss. Rain, sleet, and slush can have an impact on radar performance. It becomes more difficult to keep track of what's going on since the reflected signal from the previous car must be processed and filtered. Stereo vision cameras and their image processing capability are employed here as a support for RADAR. This aids with lane maintenance and identifies the precise vehicle with which manoeuvring is required for a safe trip through road bends. In metropolitan locations, where stop-and-go traffic is the norm, the CACC function will be very useful. When stuck in traffic, technology has improved to the point where it is now possible to entirely halt the automobile in order to save gasoline. When traffic starts moving again, the system restarts the vehicle and follows the automobile in front. As a result, the driver's weariness will be reduced by using this form of control action. Active braking may be necessary to prevent a collision in certain traffic scenarios.

### **V.HARDWARE ARCHITECTURE OF CACC**

Figure 3 depicts the CACC hardware architecture. A stereoscopic camera, RADAR, and LIDAR make up the front end. A digital signal processor (DSP) manages the navigation units, which can process data in real time. There are tachometers attached to each tyre that measure the speed of the vehicle in real-time. via the CAN Bus [10], the 32-bit MCU [14] receives the signal from the DSP and tyre speed controller. System and sensor data may be exchanged via the CAN Bus, a serial protocol. Up to 1Mbps can be transmitted and received over a single or dual-wire networked data bus when using CAN. In figure-3, the CAN bus is shown by a black arrow. The system must update the brake pad information on a frequent basis in order to have total control over the vehicle's movement. In the event of an emergency, the ACC can calculate the amount of time it will take to decelerate and come to a complete stop from the predetermined speed. As a result, a CAN bus connects the brake pad controller to the MCU.



**Fig. 3:** Cooperative Adaptive Cruise Control (CACC) Hardware Layout.

VI. The distinction between ACC and CACC is that communication mechanisms are present. There will be a GPS system for satellite navigation. Vehicle-to-vehicle communication is handled by a separate wireless system. The protocol utilised for string stability in the HIL system will be improved for vehicle usage, as there is no central unit.

## VII. WORKING OF CACC

Automated driver assistance systems (CACCs) are designed to help alleviate driver fatigue during long drives. The ACC and OTA (On the Air) [17] wireless communication systems in CACC may function together as a group or as ACC on its own to communicate with the rest of the system. Figure-4 depicts the CACC workflow diagram. The fluidic performance of a vehicle equipped with the CACC system is dependent on three parameters from the preceding vehicle: distance, speed, and position. Long-range radars are used to determine the distance and speed of the vehicle in front of the driver. The Doppler shift effect can be used to determine if the preceding vehicle is accelerating or decelerating based on the time difference between the transmitted and reflected signals at the radar sensor. The previous vehicle's relative angle must be determined in order to ascertain the vehicle's location (relative position). With the use of a 3-beam radar, the ratio of signal amplitudes of the broadcast and received signals can be calculated, and this may be used to establish a car's location in relation to other vehicles.

The CACC system log will be updated as a result of the sensors in the vehicle subsystem monitoring the various system parameters. In addition, the ACC system's subsidiaries are screened for compliance. After the feature is activated in the car, the initialization process will be completed in 2 seconds. At first, the system will function as a stand-alone ACC. Having modulated the vehicle's manoeuvrability using the ACC in accordance with the pre-set speed restriction to the ACC console in the driver cabin, the vehicle prepares its communication subsystem for platooning so that CACC may be activated. Platooning requests are sent with their GPS locations and pre-set vehicle speeds. CACC-equipped cars in close proximity to the platoon may now join the pool and synchronise themselves with the vehicle in front of the platoon. The operation will be continued to any limit. Using the accelerator pedal, the driver can overdrive at any time and the system will activate once the driver stops accelerating.

Fig. 4: CACC work-flow diagram

VIII. Drivers in CACC can only control the ACC, which keeps tabs on the vehicle's performance metrics and makes adjustments to provide a stress-free travel. The platooning method is handled by a wireless communication subsystem that is not under the control of the driver. To initiate platooning, the first vehicle must be ACC-stabilized; otherwise, it may join a pool with CACC controls. At any point, the driver has the option to accept or refuse a platoon. If there are any objects present, the ACC will wait for a response from the driver. The ACC will begin the braking

operation if the driver does not reply within the determined safe time, and the acoustic notice will be heard in the cabin. Accident-avoidance technology alerts the driver if the vehicle's brake actuation is insufficient to stop it from colliding with another object. An item is removed from the path of travel, and the ACC automatically accelerates to its pre-set speed.

IX. For a CACC system the complete flow diagram is valid for its functioning. The add on in this situation is the following cars will be informed with the leading vehicle's location, velocity, and acceleration so that the following vehicle's ACC may optimise the settings in its plant(car) for a safe journey in platoon. Assign each vehicle's location, velocity and acceleration  $I = 0 - n$  to  $z_i$ ,  $v_i$  and  $a_i$ ;  $I = 1$  is the lead vehicle and the rest are following. Vehicles that are too close together pile up, and this results in incorrect parameter computations.

## X. CONCLUSION

There is still a long way to go in the development of vehicle intelligence. Although it isn't a replacement for human intellect, it may be used as an aid in some situations. Human intelligence will only be able to avert a collision with a plant in certain scenarios on the road. So the technology must be viewed merely as an assisting system. Due to the inherent limitations of wireless technology, there is the potential for data loss, packet corruption, and platooning delays. Even if the vehicle is equipped with CACC, the

driver should still be aware of their surroundings.

## REFERENCES

[1]<http://www.bosch-mobility-solutions.com/>

[2]Four people from Italy: [2] Giovanni Fiengo; [2] Manuela Tufo; [2] Stefania Santini; University of Palermo, Palermo, Italy: 22nd Mediterranean Conference on Control and Automation (MED), 2014, 22nd Mediterranean Conference on Control and Automation (MED). The week of June 16-19, 2014. The city of Palermo in Sicily

[3 Shannon Bowling, Georges M. Arnaout Cooperative Adaptive Cruise Control Deployment Strategy to Improve Traffic Dynamics. Automation and Computing 11(1), February 2014; pages 10-18 in print.

[4]Sliding-Mode-Control-Based Adaptive Cruise Controller [4] by Behnam Ganji; Abbas Z. Kouzani; Sui Yang Khoo; and Mojdeh Nasir, 2014 IEEE International Conference on Control & Automation (ICCA) June 18-20, 2014 in Taichung, Taiwan.

[5]Experimental Application of Hybrid Fractional-Order Adaptive Cruise Control at Low Speed IEEE Transactions on Control Systems Technology, Vol. 22, No. 6, November 2014.

(6) Vicente Milanés, Steven E. Shladover, John Spring, Christopher Nowakowski, Hiroshi Kawazoe, and Masahide Nakamura. [6]. IEEE Transactions on Intelligent Transportation Systems, Vol.

15, No. 1, February 2014, "Cooperative Adaptive Cruise Control in Real Traffic Situations"

[6]<http://forum.a8parts.co.uk/attachment.php?attachmentid=4812&d=1348136382>  
Car Cruise Control System by Karen Lie at Calvin College, page 8 of 10. [9] A sampled-data cooperative adaptive cruise control system for vehicles with sensor failures, IEEE Transactions on Intelligent Transportation Systems, Vol. 15, No. 6, December 2014, by Ge Guo and Wei Yue, IEEE members.