ISSN 2278 – 0149 www.ijmerr.com
Vol. 3, No. 2, April, 2014

Review Article

REVIEW ON ADAPTIVE CRUISE CONTROL IN AUTOMOBILES

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The concept of assisting driver in the task of longitudinal vehicle control is known as cruise control. Starting from the cruise control devices of the seventies and eighties, now the technology has reached cooperative adaptive cruise control. This paper will address the basic concept of adaptive cruise control and the requirement to realize its improved versions including stop and go adaptive cruise control and cooperative adaptive cruise control. The conventional cruise control was only capable of maintaining a set speed by accelerating or decelerating the vehicle. Adaptive cruise control devices are capable of assisting the driver to keep a safe distance from the preceding vehicle by controlling the engine throttle and brake according to the sensor data about the vehicle. Most of the systems use RADAR as the sensor, a few uses LIDAR also. Controller includes the digital signal processing modules and microcontroller chips specially designed for actuating throttle and brake. The stop and go cruise control is for the slow and congested traffic of the cities where the traffic may be frequently stopped. Co-operative Adaptive Cruise Controls are not yet released but postulations are already there.

Keywords: Cruise Control, Stop and Go Cruise Control, RADAR, Sensors

INTRODUCTION

Every day the media brings us the horrible news on road accidents. A report by Partners of Advanced Transit Highways (PATH) said that the damaged property and other costs may equal 3 % of the world's gross domestic product. The concept of assisting driver in longitudinal vehicle control to avoid collisions has been a major focal point of research at many automobile companies and research organizations. The idea of driver assistance was started with the 'cruise control devices' which first appeared in 1970's in USA. When switched on, this device takes up the task of accelerating or braking to maintain a constant speed. But it could not consider other vehicles on the road.

An 'Adaptive Cruise Control' (ACC) system developed as the next generation assisted the driver to keep a safe distance from the vehicle in front. This system is now available only in some luxury cars like Mercedes S-class, Jaguar and Volvo trucks of the U.S. Department of transportation. Japan's ACAHSR have started developing 'Intelligent Vehicles' that can communicate with each other with the help of a system called 'Co operative Adaptive Cruise Control'. This pa-

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per addresses the concept of Adaptive Cruise Control and its improved versions.

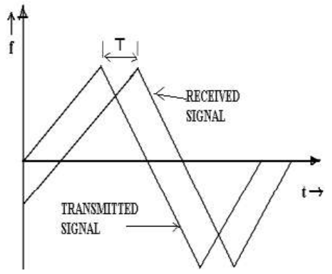
Adaptive cruise control (ACC) is an extension of the cruise control (CC) system, in which the velocity of the vehicle is adjusted according to the behavior of the other moving vehicles ahead, by applying the brake and modulating the throttle to generate the necessary power. The ACC system uses the radar or other sensory devices to measure the distance between vehicles. One limitation of the conventional ACC system is its inability to operate at speeds below 30 km/h (8.33 m/s), however by adding the stop&go function the lower speed range of operation would be included. The new system so-called ACC stop&go is sufficiently versatile and can therefore assist the driver by eliminating the needs for frequent use of accelerator and brake, a useful feature for urban areas and heavy traffic.

Conventional Cruise Control Operation

A typical Conventional Cruise Control maintains a speed set by the driver by adjusting the throttle position. A control unit compares the actual vehicle speed and the desired set speed. If there is a difference between these two values, a signal is sent to a throttle position actuator to adjust the throttle position to bring the vehicle to set speed.

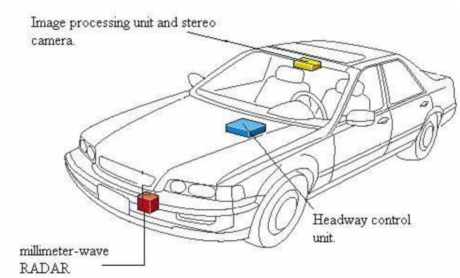
PRINCIPLE OF A.C.C

Figure 1: Working Principle



ACC works by detecting the distance and speed of the vehicles ahead by using either a Lidar system or a Radar system (Payman Shakouri and Andrzej Ordys, 2012); (Neville A Stanton, 2010). The time taken by the transmission and reception is the key of the distance measurement while the shift in frequency of the reflected beam by Doppler Effect is measured to know the speed. According to this, the brake and throttle controls are done to keep the vehicle in a safe position with respect to the other. These systems are characterized by a moderately low level of brake and throttle authority. These are predominantly designed for highway applications with rather homogenous traffic behavior.

Figure 2: Processing Units



The second generation of ACC is the Stop and Go Cruise Control (SACC) (Neville A Stanton, 2010) whose objective is to offer the customer longitudinal support on cruise control at lower speeds down to zero velocity (Willie D Jones, 2001). The SACC can help a driver in situations where all lanes are occupied by vehicles or where it is not possible to set a constant speed or in a frequently stopped and congested traffic (Neville A Stanton, 2010). There is a clear distinction between ACC and SACC with respect to stationary targets. The ACC philosophy is that it will be operated in well structured roads with an orderly traffic flow with speed of vehicles around 40km/hour (Willie D Jones, 2001). While SACC system should be able to deal with stationary targets because within its area of operation the system will encounter such objects very frequently.

TWO TYPES OF A.C.C

- Radar-Based System
  - Three overlapping radar-beams (76-77 kHz)
  - Detects moving object up to 120 m
  - Work in poor weather conditions

Figure 3: Radar-Based System

- Laser-Based System (Lidar)
  - Less expensive and easier to package
  - Light beams are narrower than water droplet and snowflakes.

COMMON TERMS IN A.C.C

- Response time of the driver (t): time needed by the driver to respond safely to any unwanted disturbances (approximately about 2-3 sec)
- Safe distance: the minimum distance between vehicle equipped with ACC to the leading vehicle by which the driver is still able to respond safely in case of emergency braking by the vehicle in front.

Safe distance = Vs * t

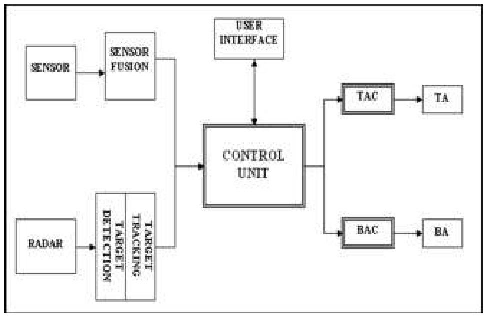
Vs = speed of ACC vehicle

t = 2-3 sec

COMPONENTS OF AN A.C.C SYSTEM

1. A sensor (LIDAR or RADAR) usually kept behind the grill of the vehicle to obtain the information regarding the vehicle ahead. The relevant target data may be velocity, distance, angular position or lateral acceleration.
2. Longitudinal controller which receives the sensor data and process it to generate the commands to the actuators of brakes throttle or gear box using Control Area Network (CAN) of the vehicle

Figure 4: Components of ACC



Sensors

Four Wheel Sensors, Brake Pedal Sensor, Throttle Pedal Sensor, Radar…

Actuators

Brake Actuator, Throttle Actuator.

Controllers

High level & Low level controller.

Communication Medium

SENSOR OPTIONS

Currently four means of object detection are technically feasible and applicable in a vehicle environment (Neville A Stanton, 2010). They are

1. RADAR
2. LIDAR

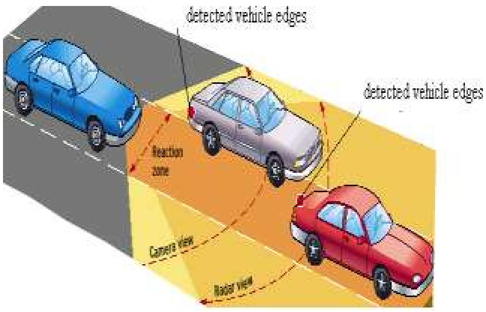
3. VISION SENSORS
4. ULTRASONIC SENSOR

The first ACC system used LIDAR sensor.

WORKING

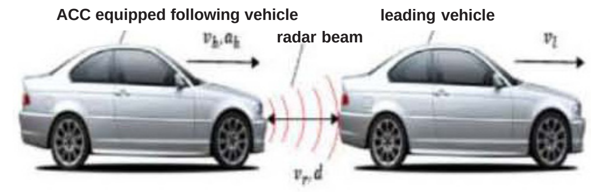
The image processor measures the distances to the objects through triangulation method. This method includes an algorithm based on the detection of the vertical edges and distance. Incorporating both the 16-degree field of view of radar and 40-degree field of view of camera enhances the performance in tight curves (P Venhovens, K Naab and B Adiprasto, 2000).

Figure 5: Detecting a Vehicle



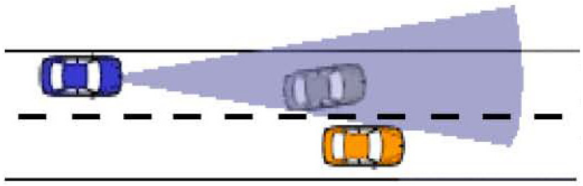
The space of maneuverability is the space required by the driver to maneuver a vehicle. An average driver uses larger sideways acceleration while vehicle speed is low. If the curve radius of a possible trajectory is 'r' for a given velocity 'v' and sideways acceleration 'ay' ,then r= V^2/ ay (Neville A Stanton, 2010). So to get the required 'r' ,when 'v' is low, 'ay' is also to be low correspondingly. The stopping distance is given by, Ds = .5 u /ax + td u, where 'u' is the initial speed 'td' is the time taken by the system to receive and process the sensor data and 'ax' is the acceleration of the vehicle. The figure below shows the detection of edges of the preceding vehicles, the relative speed and safe distance.

Figure 6: Radar System in ACC



FUNCTION

Figure 7: Tracking Method in ACC



- Preset and maintain the car speed
- Measure the distance to the preceding car and the relative speed
- Adjust the car speed accordingly
- Maximum deceleration = 3.5m/s^2
- Change gear automatically
- Function properly in poor weather condition
- Cannot pick up non-moving objects
- Effective in the speed between 30km-180km/h

ADAPTIVE CRUISE CONTROL: OVERVIEW

ACC is an extension of conventional cruise control systems. An ACC system is a driver convenience feature designed to maintain a set following distance from the vehicle ahead. ACC is not a collision warning or avoidance system. An ACC system is designed to assist the driver and is not a fully independent driving system. As with conventional cruise control system manual inputs from the driver, both to accelerator and brake, take priority over the ACC system.

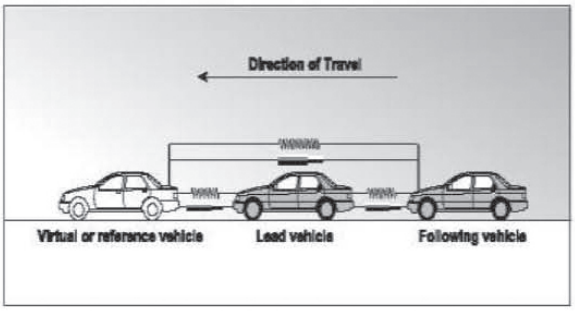
CO-OPERATIVE ADAPTIVE CRUISE CONTROL: [CACC]

Though conventional ACC and SACC are still expensive novelties, the next generation called Cooperative ACC is already being tested. While ACC can respond to the difference between its own behavior and that of the preceding vehicle, the CACC system allows the vehicles to communicate and to work together to avoid collision. (Neville A Stanton, 2010); (P Venhovens, K Naab and B Adiprasto, 2000).

Partners of Advanced Transit Highways (PATH) –a program by Department of Transportation and University of California with companies like Honda conducted an experiment in which three test vehicles used a communication protocol in which the lead car can broadcast information about its speed, acceleration ,braking capacity to the rest of the groups in every 20 ms.

PATH is dedicated to develop systems that allow cars to set up platoons of vehicles in which the cars communicate with each other by exchanging signals using protocols like Bluetooth.

Figure 8: Co-Operative Adaptive Cruise Control



ADVANTAGES AND DISADVANTAGES

Advantages

1. The driver is relieved from the task of careful acceleration, deceleration and braking in congested traffics.
2. A highly responsive traffic system that adjusts itself to avoid accidents can be developed.
3. Since the braking and acceleration are done in a systematic way, the fuel efficiency of the vehicle is increased.

Disadvantages

1. A cheap version is not yet realized.
2. A high market penetration is required if a society of intelligent vehicles is to be formed.
3. Encourages the driver to become careless. It can lead to severe accidents if the system is malfunctioning.
4. The ACC systems evolved till now only enable vehicles to cooperate with the other vehicles but do not respond directly to the traffic signals.

CONCLUSION

The accidents caused by automobiles are injuring lakhs of people every year. The safety measures starting from air bags and seat belts have now reached to ACC, SACC and CACC systems. When technology is placed between the driver and mechanical systems, visual in-car displays can help the driver understand what task the computer controlled system is undertaking. In the case of S&G-ACC, it can help the driver understand which road user the system has detected as an in-path target, and therefore how the vehicle might respond in any given situation.

The researches of Intelligent Vehicles Initiative in USA and the Ertico program of Europe are working on technologies that may ultimately lead to vehicles that are wrapped in a cocoon of sensors with a 360 –degree view of their surroundings. It will probably take decades, but car accidents may eventually become as rare as plane accidents are now, even though the road laws will have to be changed, upto an extent since the non-human part of the vehicle controlling will become predominant. However, more research is in progress to establish a particular algorithm to enable the prediction of the future reference trajectory resulting in further improvement in the performance of the ACC simulation model.

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