Cruise Control Systems in Automotive Controls

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***Abstract*- In automotive control, conventional cruise control systems have been available in the market for many years. A modern learning technology has a great deal to offer in the practical application of vehicle cruise control. The purpose of a cruise control system is to accurately maintain the driver's desired set speed, without intervention from driver, by actuating the throttle-accelerator pedal linkage. Cruise control is an invaluable feature in American cars. With increasing traffic conventional cruise control is become less useful, but cruise control systems are adapting to this new reality, which leads to the concept of Adaptive Cruise Control (ACC). It maintains a safe distance between the cars. In this paper, the general information about the cruise control systems in the field of vehicle controls is discussed.**

***Index Terms*- cruise control system, adaptive cruise control.**

I. INTRODUCTION

CONVENTIONAL cruise control, which when activated, keeps the speed of the vehicle constant, is an established feature. Adaptive cruise control (ACC), where distance keeping is added to the basic speed control function, has been launched by Jaguar in the supercharged XKR sports car.

Without cruise control, long road trips would be tiring, at least for the drivers. Cruise control is far more common in American cars as compared to other cars, as roads in America are generally bigger & straighter, and also destinations are farther apart. In this paper, we will learn how a conventional cruise control system works, and then we will take a look at adaptive cruise control systems that are under development.

II. BACKGROUND

Cruise control systems are comprised of electronic & mechanical subsystems. Gas pedal and the brakes control the speed of the car. The driver senses the speed and then adjusting the pressure on the gas pedal or the brakes to compensate for variations in the desired speed. The cruise control systems does he same thing with one exception. It only controls the gas pedal. The driver can set the cruise control with the cruise switches, usually ON, OFF, RESUME, SET/ACCEL and COAST. These are located on the steering wheel or on the windshield wiper or turn signal stalk. Fig 1 shows the actual view in the car.

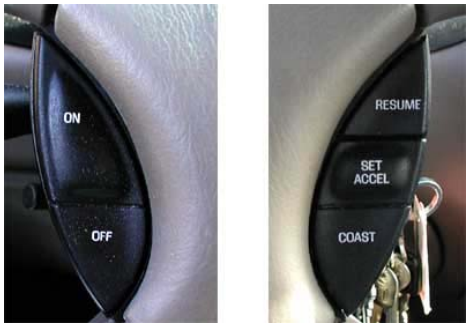

Fig. 1. Cruise Control System Switches on Steering Wheel

The basic function of ON and OFF buttons is to tell the car that you might be hitting another button soon. The OFF button turns the cruise control off. Some systems don't have these buttons. The SET/ACCEL button maintains the speed of car at current driving speed. By holding down this button, it makes the car to accelerate. On most cars, tapping it once will increase speed by 1 mph faster. If the cruise control is disengaged by hitting the brake or clutch pedal, hitting the RESUME will set the car speed back to the previous speed setting. COAST button is used to decelerate the car speed. Some cars with manual transmission has brake & clutch pedal, which disengages the cruise control.

The block diagram in Fig 2 shows the basic cruise control system. Also, Fig 3 shows the working of cruise control system. As shown, the output of block diagram is Throttle, which is a digital value for the engineer throttle setting.

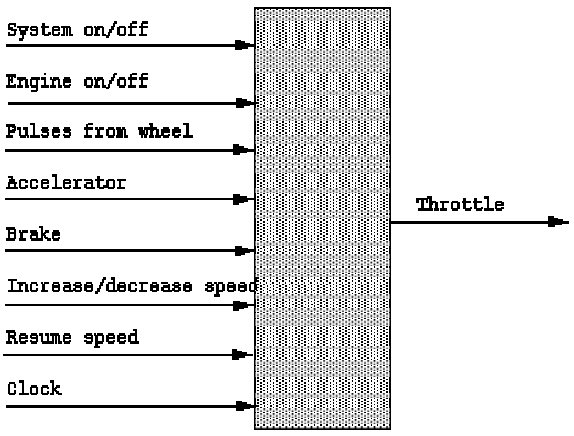

Fig. 2. Block Diagram Representation

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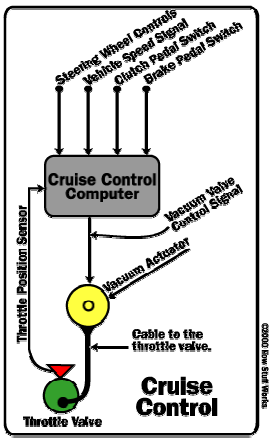

Fig. 3. Working of Cruise Control System

III. DESCRIPTION

Conventional Cruise Control System

In a conventional cruise control system, the driver sets a desired speed and this speed is maintained as a constant by the car once it has been achieved. Conventional cruise control basically provides speed control. This type of cruise control is independent of its environment, for example vehicular traffic in the road or trees etc. The advantage of this system to the driver is that there is decreased workload for the driver in maintaining speed (otherwise he would have to have his leg on the accelerator constantly); physical discomfort is less. Fuel efficiency is improved since there is reduced speed variation. However, the disadvantage of this system is that when the vehicle in the front is traveling at a speed slower than the desired speed, the driver must intervene frequently and adjust the desired speed so that collision does not occur. Alternatively, he must intervene when he wants to increase the speed and overtake the car in the front. This type of cruise control is becoming less meaningful when it comes to passenger cars as the increase in traffic makes it less possible to drive at a set speed.

Adaptive Cruise Control System

The Adaptive Cruise Control (ACC) System is an extension of the Conventional Cruise Control System. It is also known as Intelligent Cruise Control or Autonomous Intelligent Cruise Control (AICC) System. It overcomes the disadvantage of Conventional Cruise Control by incorporating a sensor in it. This system not only keeps the speed constant at a desired value but it adapts the speed according to the vehicular traffic ahead. An appropriate distance is also maintained with the vehicle ahead. Hence, the system can be used in dense traffic with repeated start and stop situations.

The sensor does measurements on vehicles in front of the host vehicle and determines if the vehicle is in the same lane as the host vehicle The ACC system decides depending on which vehicle (usually the closest vehicle on the same lane) it will control the host vehicle and delivers information on the selected vehicle to the speed regulator of the host vehicle. The ACC automatically lowers the speed of the vehicle to match the speed of the vehicle ahead, which subsequently adjusts the distance between the two vehicles. If the preceding vehicle increases its speed later, the ACC system of the host vehicle automatically increases its speed as well.

Sensor System

A sensor is fundamental to ACC. The sensor must be reliable and its performance should be optimum in all types of environmental conditions. The senor must perform well in a wide range of temperatures when its subject to factors such as vibration, corrosive action by petrol, grease, dirt etc. It must also be cost effective.

Radar ACC Vs Lidar ACC

The sensor that is used in ACC system can be either of optical or radar type. A tradeoff is involved in the choice of sensor when designing an ACC. Lidar is less expensive but it performs poorly in rain and snow. The light beam from the lidar is narrower than water droplets or snow flakes which reduces its performance. Also, accumulation of dirt or snow can block the lidar beams. Radar sensors on the other hand can detect a minimum range of 150 meters during bad weather conditions where the driver's range of sight is not more than 10 meters. Hence, radar sensors are preferred in ACC systems.

The first generation of ACC allowed gentle acceleration and deceleration. Here, the driver had to intervene if the system did not comply to the driver's requirements. This system worked the best in highways where speed changes are moderate. The second generation of ACC systems allowed more frequent acceleration and deceleration, which made speed and distance control in heavy traffic easier. But how much ever carefully a control system is designed; it is hard to design a practical model vehicle. The ACC system was designed for providing convenience to the driver; not totally replacing him. The driver must always be present to make decisions in case of emergencies. Recently, additional features such as automatic acceleration/deceleration have been added to AICC. The vehicle switches to a constant distance mode for safety along with the constant speed control. This helps in prevention of collision as obstacle detection is done during determination of "safe distance".

Super Cruise Control System

The next generation of cruise control was the development to the Super Cruise Control System. In SCC system, additional feature of autonomous steering is incorporated in AICC for the vehicle to stay in the road. SCC system prvides lateral control as compared longitudinal control (brake and accelerator control) by AICC. Extensive research is being carried out in this type of cruise control. Neural Network and Computer –vision based techniques have been used. Out of these two methods, the neural network approach realized practical

highway driving. Though neural networks provide a good solution at bends and curves on roads they have been

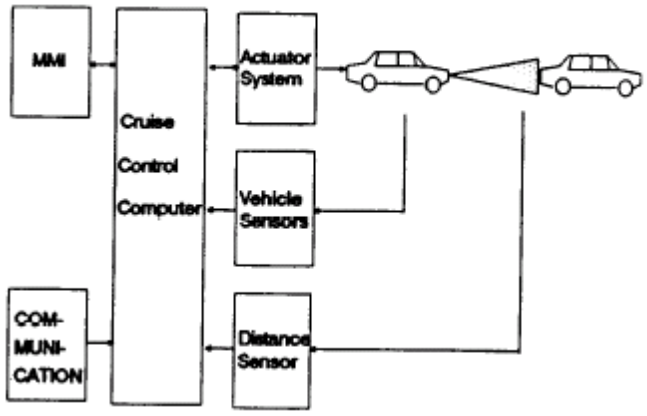

Fig. 4. Control Loop

trained on, in other types of roads they have rely on a generalized algorithm. Neural networks are prone to error even with a lot of training. Human safety might be at stake if these algorithms are not applied carefully. However, these algorithms have good computational power and sufficiently accurate.

IV. FUTURE TRENDS

What's that up ahead?

Air bags and seat belts save tens of thousands of people a year. Supercomputers now let designers create car frames and bodies that protect the people inside by absorbing as much of the energy of a crash as possible. But the ultimate solution, and the only one that will save far more lives, limbs, and money, is to keep cars from smashing into each other in the first place.

Engineers are applying advanced microprocessors, radars, high-speed ICs, and signal-processing chips and algorithms in R&D programs that mark an about-face in the automotive industry: from safety systems that kick in after an accident occurs, attempting to minimize injury and damage, to ones that prevent collisions altogether. Researchers will be soon bring the first cooperative safety systems to market.

Future Technologies to foster include Automatic Pre-Crash Brake Intervention, Collision Avoidance, Adaptive Cruise Control Stop & Go, Curve assistant, Speed limit assistant, Blind spot detection, Lane detection and Automatic braking.

Adaptive cruise control is the first system in a network of sensors. In time you will have a sensor field around the car, which will be used by the vehicle's intelligence. It's the beginning of the microwave era in automotive electronics.

In the next five years, engineers have plans to develop enhanced adaptive cruise control products with collision warning capabilities. These ``stop-and-go'' systems not only will provide limited automatic braking but also will warn drivers--through visual and/or audio signals--that a collision is imminent and that corrective action, such as additional braking or steering clear, must be taken. Installing collision warning systems on heavy trucks in has helped reduce rear-end accidents.

In the next decade, the technology is expected to evolve to collision avoidance systems that can provide emergency braking. Industry analysts predict that the market for adaptive cruise control, collision warning and headway control systems will grow rapidly.

One of the potential advantages of ACC is the foundation that it provides for next generation advancements in lane detection systems that are expected to include cameras. The use of cameras in the vehicle is predicted to help provide for better lane following and collision avoidance by controlling the steering mechanism of the vehicle. This feature is also anticipated to be beneficial in cities and towns with heavy urban stop-and-go traffic by functioning at low stop/start speeds in city traffic. It is expected to have the ability to stop the car completely when sitting in traffic, re-starting and following the car in front when the traffic begins to move again.

Potential Key Benefits of ACC:

- Reduction in accident rate for vehicles fitted with collision avoidance type systems
- Reduction in driver fatigue
- Increase in fuel efficiency due to very gradual speed increase / decrease in traffic
- Interconnection to more advanced future systems

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