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The extensive use of the control systems in cruise of vehicles

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Abstract

Vehicle following and its effects on traffic flow has been an active area of research. Human driving involves reaction times, delays, and human errors that affect traffic flow adversely. One way to eliminate human errors and delays in vehicle following is to replace the human driver with a computer control system and sensors. The purpose of this paper is to develop an autonomous intelligent cruise control (AICC) system for automatic vehicle following, examine its effect on traffic flow, and compare its performance with that of the human driver models. The AICC system developed is not cooperative; i.e., it does not exchange information with other vehicles and yet is not susceptible to oscillations and "slinky" effects. The elimination of the "slinky" effect is achieved by using a safety distance separation rule that is proportional to the vehicle velocity (constant time headway) and by designing the control system appropriately. The performance of the AICC system is found to be superior to that of the human driver models considered. It has a faster and better transient response that leads to a much smoother and faster traffic flow. Computer simulations are used to study the performance of the proposed AICC system and analyze vehicle following in a single lane, without passing, under manual and automatic control. In addition, several emergency situations that include emergency stopping and cut-in cases were simulated. The simulation results demonstrate the effectiveness of the AICC system and its potentially beneficial effects on traffic flow.

Keywords: Intelligent control, remotely operated vehicles, Automatic control, Traffic control, Delay, Computer errors

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Introduction

The cruise control system interacts with the driver, the speed control device (throttle) and the external environment despite various interfaces in order to keep the speed of the car as desired by the driver. These interactions may be one way or both ways. Different kinds of signals may be needed to build this system. The user requests activation of the cruise control. The cruise control system accepts inputs from the sensor and gives a signal to the throttle mechanism for adjustment in the desired position. After the throttle is set, the cruise control system gives the user a feedback that it is now active and set. Various commonly occurring operating scenarios are described in words first, and then translated into an external systems diagram after identifying the main functional blocks. The external systems diagram fulfills all interactions between the functional blocks as stated in the scenarios. Based on the external systems diagram, written requirements, including those for cost and performance trade-offs are generated for the understanding of all stakeholders involved. Then, the first level functional level decomposition is used to analyze the functioning of the main functional block – 'Provide Cruise Control Services'. Then, the physical architecture is explained in its general and instantiated form and interactions are shown using interfaces. Finally, there is a risk analysis done along with an integration and qualification plan.

The study problem

The study problem can be summarized in the following:-

1- Is it possible to develop an autonomous intelligent cruise control (AICC) system for automatic vehicle?

2- What is the impact of developing autonomous intelligent cruise control?

3- How to get benefit from earlier attempts to form (AICC)?

What distinguishes this study from previous studies?

The Previous studies didn't fully address the use of a cruise of vehicle control system. It also did not deal with the problem from a practical side, but the focus was on the theoretical part only, which distinguishes this study from others by focusing the practical aspect of the topic focusing on modern methods in the use of control systems in marine vehicles.

The study contents

1.0 What is cruise control?

The purpose of a cruise control system is to accurately maintain a speed set by the driver without any outside intervention by controlling the throttle-accelerator pedal linkage(Davis et al. n.d.).

The earliest variants of cruise control were actually in use even before the creation of automobiles. The inventor and mechanical engineer James Watt developed a version as early as the 17th century, which allowed steam engines to maintain a constant speed up and down inclines. Cruise control as we know it today was invented in the late 1940s, when the idea of using an electrically-controlled device that could manipulate road speeds and adjust the throttle accordingly was conceived(Tiwari 2016).

2.0 How does it work?

The cruise control system controls the speed of your car the same way you do – by adjusting the throttle (accelerator) position. However, cruise control engages the throttle valve by a cable connected to an actuator, rather than by pressing a pedal. The throttle valve controls the power and speed of the engine by limiting how much air it takes in (since it's an internal combustion engine)(Lee et al. 2013).

The driver can set the cruise control with the cruise switches, which usually consist of ON, OFF, RESUME, SET/ACCEL and COAST. These are commonly located on the steering wheel or on the windshield wiper or turn signal stalk. The SET/ACCEL knob sets the speed of the car. One tap will accelerate it by 1 mph, two by 2 mph and so on. Tapping the knob in the opposite direction will decelerate the vehicle. As a safety feature, the cruise control system will disengage as soon as you hit the brake pedal(Gridharan 2011).

However, with the number of cars on roads increasing more than ever, the functionality of normal cruise control is becoming obsolete. Adaptive cruise control is quickly gaining popularity, and with good reason!

Adaptive Cruise Control is the next big thing in terms of automated speed management in new cars. It is an intelligent form of cruise control that slows down and speeds up automatically to keep pace with the car in front of you.

2.1 Location

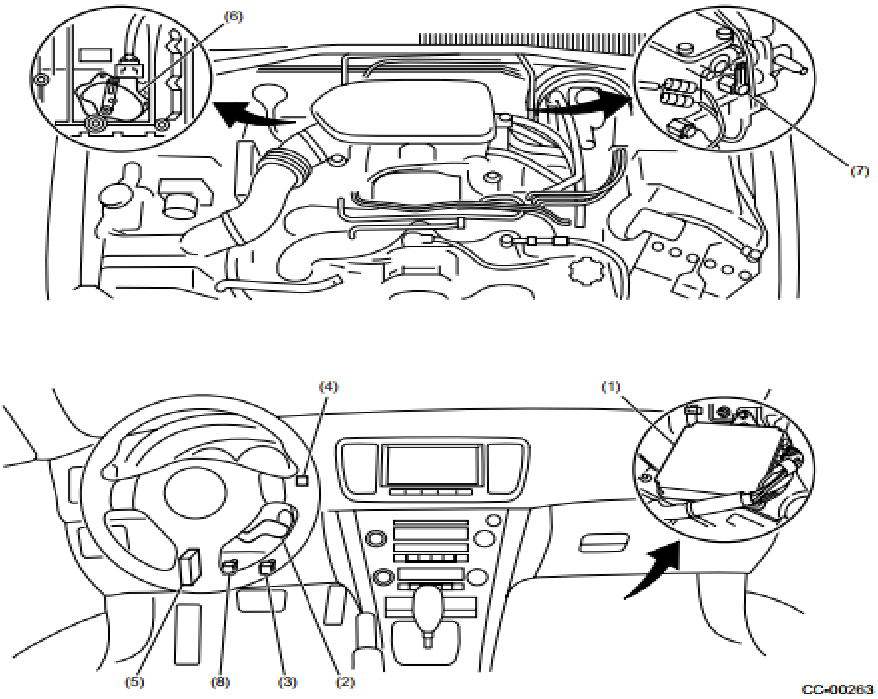

Figure 1.

1- Engine control module (ECM).

2- Cruise control command switch.

3- Stop light and brake switch.

4- Cruise indicator light and cruise set indicator light.

5- Transmission control module.

6- Inhibitor switch.

7- Neutral position switch.

2.2 Control and operation(Buch 2017)

Vehicle speed control	When the actual vehicle speed is higher than the set speed, the throttle valve of the electronic control throttle moves in the closing direction by the amount corresponding to the difference between the two speeds.

	When the actual vehicle speed is lower than the set speed, the throttle valve of the electronic control throttle moves in the opening direction by the amount corresponding to the difference between the two speeds.
Speed set function (SET function)	When the SET/COAST switch is pressed while the vehicle is running at a speed greater than 40 km/h (25 MPH) and the MAIN switch is ON, the cruise control is set at the current vehicle speed (this speed becomes the "memorized speed") and the vehicle maintains this speed thereafter.
Resume control function (RESUME function)	When the RESUME/ACCEL switch is turned ON after the cruise control is temporarily cancelled, the vehicle speed returns to the memorized speed, which was stored just before the cruise control was cancelled. This occurs only when the vehicle is running at a speed greater than 32 km/h (20 MPH). In the following cases, however, the memorized speed is cleared. (1) Ignition switch is turned OFF (2) MAIN switch is turned OFF (3) Abnormality in the system is detected
Deceleration control function (1) (COASTING function)	When the SET/COAST switch is pressed for a prolonged time while the vehicle is governed by the cruise control, the memorized vehicle speed of the cruise control is changed to the vehicle speed value reached at the moment the switch is released after slowing down. However, the cruise control is cancelled when

	the vehicle speed becomes lower than the lower limit of the speed setting range.
Deceleration control function (2) (TAP DOWN function)	When the SET/COAST switch is pressed for a short time while the vehicle is governed by the cruise control, the cruise control subtracts a certain amount from the memorized speed to obtain a new value. However, when the actual vehicle speed largely differs from the memorized speed, the actual speed becomes the new memorized speed of the cruise control.
Acceleration control function (1) (ACCELERATING function)	When the RESUME/ACCEL switch is pressed for a prolonged time while the vehicle is governed by the cruise control, the memorized speed of the cruise control is changed to the vehicle speed value reached at the moment the switch is released after accelerating. However, when the vehicle speed is higher than the upper limit of the speed setting range, the upper limit becomes the memorized speed of the cruise control.
Acceleration control function (2) (TAP UP function)	When the RESUMU/ACCEL switch is pressed for a short time while the vehicle is governed by the cruise control, the cruise control adds a certain amount to the memorized speed to obtain a new value. However, when the actual vehicle speed largely differs from the memorized speed, the cruise control maintains the former memorized speed.

Cruise control cancel function	When any of the following conditions is met, the cruise control is cancelled. (1) Stop light switch ON (brake pedal depressed) (2) Brake switch OFF (brake pedal depressed) (3) Clutch switch ON (clutch pedal depressed) (4) Neutral switch ON (shift lever moved to neutral) (5) CANCEL switch ON (command switch pulled) (6) Ignition switch OFF (7) MAIN switch OFF (8) Transmission gear in 1st or reverse (9) Actual vehicle speed drops below 32 km/h (20 MPH) (10) Abnormality in the system is detected

2.3 Benefits of Cruise Control for the Driver

Cruise control may be intimidating for drivers who have never used it, as when they take their foot off the accelerator and the car doesn't slow down, they feel like they are no longer in control of the car(Buch 2017). Those who are familiar with how cruise control works may find the following benefits:-

1- Cruise control was developed as a comfort and convenience system than a safety system.

2- It allows you to take long road trips with added comfort – driving long distances without putting a strain on your legs through having to hold your foot in a set position for extended periods to manually control the gas pedal and speed.

3- With cruise control activated, the driver can sit back, relax his right leg, and steer the vehicle.

4- For those of us who suffer from the lead-foot syndrome, cruise control ensures that you travel at a smooth and steady speed.

5- Most drivers are fairly inconsistent at maintaining a given speed, instead of creeping up and drifting down as you drive along a road as they manually adjustable relative to the speed limit and road conditions such as hills.

6- Accelerating and braking continuously will use considerably more fuel than maintaining a set speed.

7- Driving with cruise control will help to avoid subconsciously violating speed limits and incurring those unnecessary traffic fines on the open road.

8- It can help with fuel economy during long trips on flat, straight roads and highways.

9- The positives for road safety include a reduction of the mean driving speed, a reduction of the maximum speed, a reduction of speed differences, i.e. increased speed homogeneity and a reduction of the number of very short headway times.

10- As cruise control leads to a decrease in fuel consumption there should also be a decrease of harmful emissions.

3.0 What are the Risks of Using Cruise Control?

With increased comfort, there are however also risks that we need to be aware of! Driver error may lead to vehicle crashes if we use cruise control incorrectly and in the wrong driving conditions. Challenging road conditions may increase the risks for the driver using cruise control(TSUGAWA 2005).

The driver should always be in full control of the movement of his vehicle and an error of judgement on his part cannot be merely blamed on the cruise control feature!

*** Risks can be summarized as follows:-**

1- Cruise control when deployed will attempt to keep the car at a constant speed set by the driver. If the vehicle speed has been set to a 100 km/h speed, the car will automatically enter a corner at 100 km/h. If this is an inappropriate speed for the corner the subsequent braking to reduce speed will, while cornering, affect the balance of the vehicle which may, in turn, induce instability in the vehicle(Allan 2014).

2- This will affect the vehicle handling and if not correctly compensated for by the driver, can in the worst case result in a loss of control of the vehicle.

3- Cruise control may lead to increased lane position variability, delayed braking, and crashing into a stationary queue more frequently.

4- Wet roads significantly affect the grip of the tyre and this, in turn, can make corrective actions by the driver much more difficult to judge.

5- A driver should remain alert while driving - Fatigue and a false sense of security can lead to a lack of attention and an accident.

6- Cruise control should NEVER be used by a driver who is feeling tired or jaded.

7- The lack of need to maintain constant pedal pressure can increase the risk of vehicle accidents caused by highway hypnosis

8- Cruise control can also take your mind off the road (frequently, drivers keep one hand on the wheel while in cruise control, and that's their only contact with the vehicle).

9- With less to concentrate on it's easier to daydream and disconnect from driving safely, which always requires concentration.

10- Another risk is that a driver may not be able to respond as swiftly and effectively to an emergency situation.

11- With cruise control, it takes the driver's foot off the gas pedal and the brake. The driver usually keeps his foot on the floor nearby. If you have to stop suddenly, to avoid a hazard on the road, it will take a few extra Mille-seconds to find the brake pedal, and this time makes a lot of difference in what happens next(Chandramohan 2018).

12- Driving over "rolling" terrain, with gentle up and down portions, can usually be done more economically (using less fuel) by a skilled driver viewing the approaching terrain, by maintaining a relatively constant throttle position and allowing the vehicle to accelerate on the downgrades and decelerate on upgrades, while reducing power when cresting a rise and adding a bit before an upgrade is reached(How to Use Cruise Control: 7 Specific Things You Need to Know Well n.d.).

13- If Advanced Cruise Control is used in busy traffic, and on rural and urban roads other than main roads, there is a potential reduction of the ACC detection capacity.

14- Accidents, merge lanes, exit congestion—all are possible highway hazards that are hard to anticipate, and harder to avoid when you're on cruise control

The results of the study

As with other vehicle components we can expect to see continued improvements and advances in features and technology. Communication between vehicles and between vehicle and roadside is considered the technology that will make a whole new generation of vehicle control systems possible.

Cooperative Advanced Cruise Control with communication between a series of successive ACC-equipped vehicles in the same lane and/or communication with roadside systems will lead to vehicles exchanging information on their position, speed and deceleration. This may benefit road safety as the ACC system can optimize its speed support and drivers can get early warnings of braking or of slow vehicles ahead.

We will continue to assist road users with a better understanding of our vehicles and how we can make informed decisions to improve the safety for all on our roads!!

The suggestions

Further research is needed to improve the understanding on how will AICC affect driver behavior as several assumptions have been on made simulator based on driver so simulation experiments should be conducted for motorway traffic with headway setting, traffic flow levels and traffic composition. We shall work on solutions to the deterioration on the traffic performance that was found in some cases at the higher levels of traffic demand. In addition, non-technological, legal and institutional issues remained should be handled.

The conclusion

the study has confirmed the notion of the earlier studies that AICC systems can contribute to a more stable traffic flow without sacrificing capacity. It appeared in this case that real traffic measurements couldn't be processed without problems. For traffic safety, a decrease was found in the number of shock waves. The study indicate that for larger penetration levels, shorter target headways are necessary.

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