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A personalized adaptive cruise control system based on driving style recognition and model predictive control

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Abstract: A customised adaptive cruise control (ACC) system based on model predictive control (MPC) and driving style identification to accommodate various driving styles while ensuring car-following, comfort, and fuel-efficiency performances. A series of real-world vehicle experiments are carried out to gather the driving data of 66 randomly selected drivers in order to determine the controller parameters that correspond to various driving styles. The experimental data is then clustered using an unsupervised machine learning technique. A driving style classifier is created using supervised machine learning on the basis of this information, and it can be used to identify drivers' driving styles online. The control issue with the customised ACC system is thus defined as a multi-objective optimisation issue that may be resolved using the MPC approach. The simulation findings demonstrate that the suggested personalised ACC system can provide varying performances and cater to the needs of various driving styles.

I. INTRODUCTION

Personalized A highway-safe cruise control system has been created. When travelling on broad, straight roads with distant destinations, this technique is helpful. The traditional cruise control is less effective when traffic congestion increases. To address this issue, the adaptive cruise control (ACC) technology was created. One method of control, velocity control, is offered by traditional cruise control for a car. In contrast, ACC offers two control modes: velocity control and distance control. Because it serves as a longitudinal control pilot, ACC lessens the stress of driving in congested traffic. ACC can function similarly to traditional cruise control in that it maintains the vehicle's predetermined speed. Contrary to cruise control, however, ACC has the ability to automatically change speed in order to maintain a safe distance between an object and the ACC-equipped vehicle. This is accomplished by measuring the relative separation between the host car and a vehicle in front using laser or radar.

One of the technologies that works in congested traffic to maintain the distance behind the obstacle vehicle is low-speed ACC. Sometimes this kind of ACC system is referred to as "stop-and-go ACC." Early iterations might merely include a "stop and wait" feature, which means that when necessary, drivers would have to start moving again. Manufacturers are reluctant to give such a system to automatically operate in complex low-speed conditions where there may be bicycles and people, which is the reason for this. In order to stop and start the vehicle's motion, the typical low-speed ACC system operates at a very low speed (about 5 km/hr). In 2004, low-speed ACC was launched on the Japanese market.

II. OBJECTIVES

- ★ To enhance the driving experience by customising the ACC system to each driver's driving preferences and styles.
- ★ To make the car safer by correctly anticipating and reacting to potential on-road dangers.
- ★ To cut down on fuel use by tailoring the vehicle's acceleration and speed patterns based on current traffic circumstances and driver behaviour.
- ★ To increase the car's overall efficiency by reducing pointless braking and acceleration.
- ★ To use testing and evaluation in the real world to show the proposed system's viability and efficacy.

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III. METHODOLOGY

The system must first identify the driver's driving style online in order to create a customised ACC that accommodates various driving patterns. Three sorts of driving styles—conservative, moderate, and aggressive—are defined in this essay. When it functions, the ACC controller will automatically change to a mode that corresponds to the driving style. Fig. 4.1 depicts the design flow for the classifier and recognition of driving styles. First, a series of experiments must be planned to gather actual driving data that can depict the driving style in order to accurately identify the driver's style online. The drivers in the tests must then be efficiently clustered according to various driving styles using the analysis of driving data. For the creation of a classifier that categorises driving styles and a customised ACC controller, the clustering results are used as the training set. Finally, a driving style classifier is created and integrated into the upper- controller's front end so that, when the system is in operation, the driving style of the present driver may be identified online.

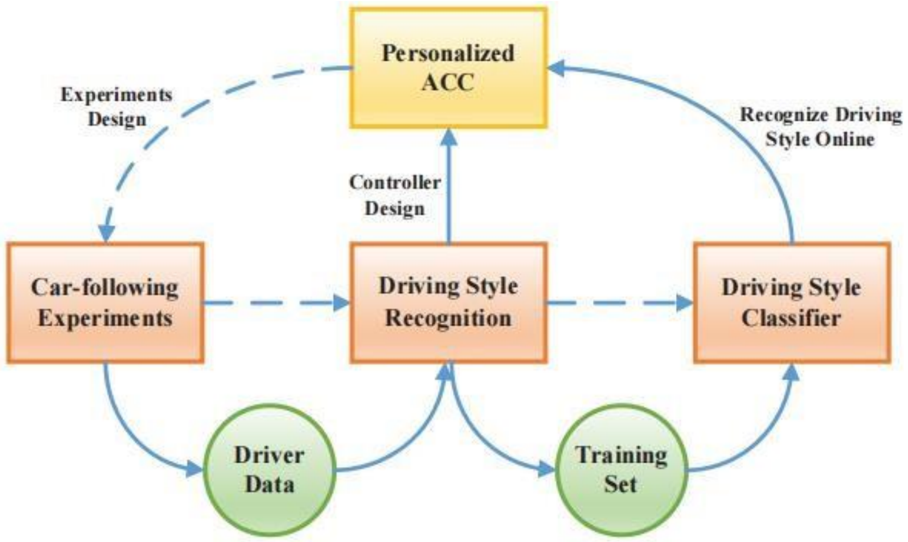

Figure 1: style recognition and classifier design flow chartDriving.

IV. HARDWARE AND SOFTWAREREQUIREMENTS

 LIDAR

This approach was employed in the initial Toyota acc system. By calculating the beat frequency difference between the reflection of a Frequency Modulated Continuous Light Wave (FMCW) A system that measured up to 100 metres was created by a company called Vorad Technologies. The light signal was produced by a high frequency modulated, low power laser diode. The majority of today's acc systems are built with 77GHz RADAR sensors. The great benefit of RADAR systems is that they can measure relative velocity directly, and their performance is unaffected by heavy rain and fog. Although these weather conditions limit its employment within a 30 to 40 metre range, LIDAR systems are inexpensive and offer good angular resolution.

★ RADAR

An electromagnetic system called RADAR is used to find and locate things that reflect light, such as aircraft, ships, spacecraft, or moving vehicles. It works by sending energy into space and detecting the echo signal reflected from a target. The reflected energy not only indicates the target's presence, but it also provides additional information about the target when compared to the transmitted signal. The "Pulse Doppler RADAR," currently in use, employs the "Doppler effect" to calculate the target's velocity.

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★ Pulse Doppler Radar

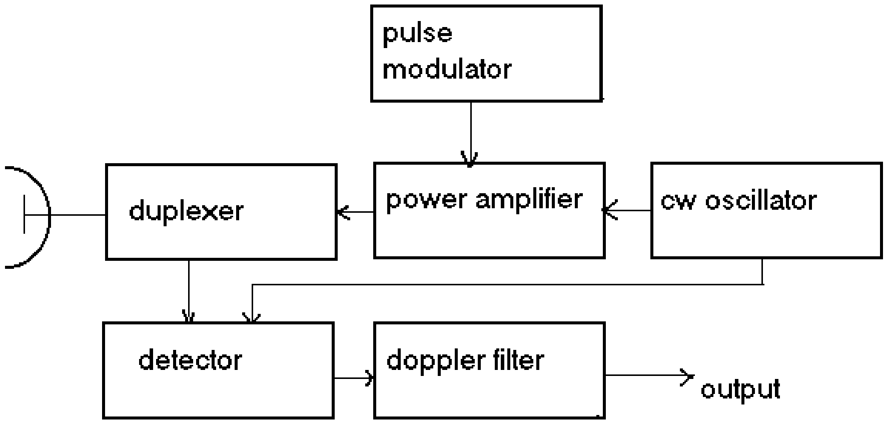


Figure 5: Pulse Doppler Radar

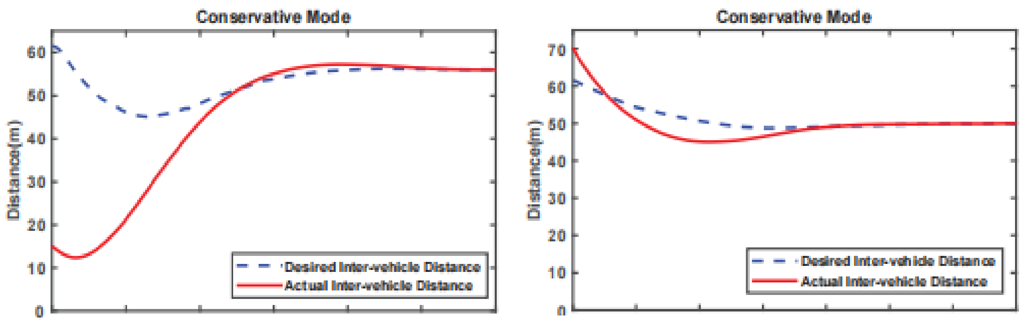
The signal to be transmitted is generated by a continuous wave oscillator and is pulse-modulated and power-amped. The single antenna can be quickly switched from transmitter to receiver and back with the use of a switching mechanism called a "duplexer." The duplexer is a TR-switch, a gas- discharge device.

The mechanism malfunctions as a result of the transmitter's high-power pulse, protecting the receiver. The duplexer directs the echo signal to the receiver upon reception. The Doppler filter eliminates the noise and produces the frequency shift, or "fd," while the detector demodulates the incoming signal.

★ FUSION SENSOR

Through their PATH programme, Fujitsu Ten Ltd. and Honda have unveiled a new sensor system that combines millimetre wave radar with a stereo camera with 640x480 pixels and a 40- degree field of view. Together, these two components enable you to distinguish the car from immobile objects. While the stereo camera is continuously taking pictures of everything in its field of view, the RADAR is focusing on the car'srear bumper.

V. RESULTS



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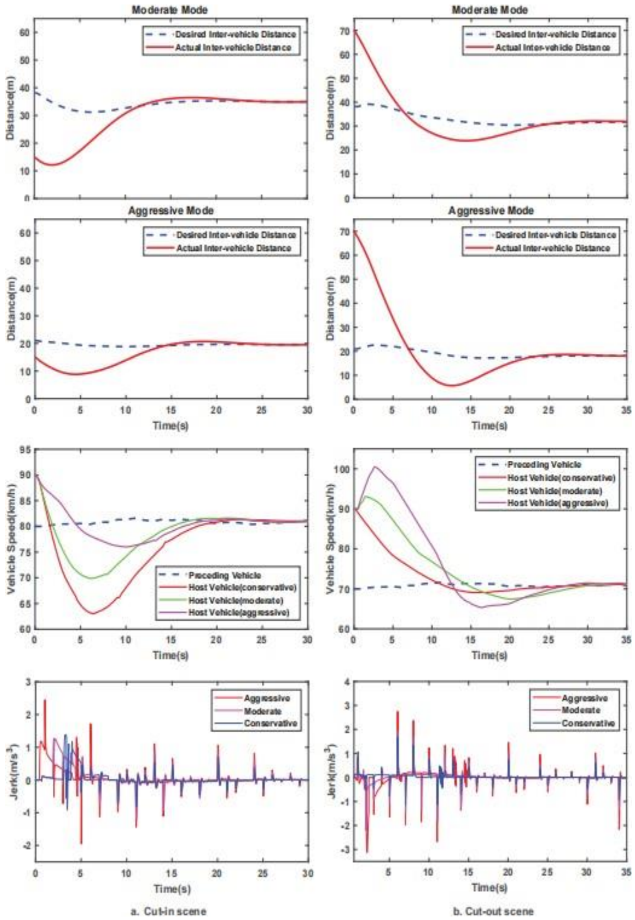

Figure: Comparison of different driving styles in cut-in andcut-out scenes

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