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Adaptive Cruise Control (ACC)

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Abstract - *The goal of this paper is to optimize Adaptive Cruise Control (ACC) for the EFFIQUE-ADAS vehicle for Team Stallion Effi-cycle. EFFIQUE-ADAS is a four-wheeled electric single-seat vehicle with state-of-the-art drive assistance systems. Adaptive Cruise Control (ACC) is a sophisticated driver assistance system that operates to improve driving comfort and safety by automatically adjusting the speed of a vehicle to keep a safe distance from the leading vehicle. Adaptive cruise control system is an ADAS level 1 technology, which is a very important component of the Safety of vehicles and accident prevention. There are other technologies too, i.e., blind spot detection and collision avoidance. The Optimization process is strictly followed according to the SAE-NIS Effi-cycle 2024 rulebook so as to be overall compliant with the restrictions and guidelines throughout the entire process.*

Key Words: ADAS, Intelligent vehicle system, Collision Avoidance, Adaptive Cruise Control, Autonomous Vehicles.

1. INTRODUCTION

Adaptive Cruise Control refers to automobile speed control for vehicles that adjusts the speed of a vehicle automatically. Adaptive cruise control is achieved by monitoring a series of sensors inside and outside your vehicle to track the other cars moving on the road. These sensors can inform the vehicle when it is coming towards you and alert your system that you should decelerate or respond to a shift in the situation. The concept of driver assistance first came to the United States in the 1970s in the form of the 'Cruise Control Device.' As long as the device is used, it carries out the function of accelerating or braking in order to maintain the vehicle at constant speed. It was not capable, however, of taking the other cars moving on the path into account. As part of the next generation, an 'Adaptive Cruise Control'(ACC) technology assisted the driver with the process of maintaining a safety distance from the leading car. The ACC must interact with a series of other systems, including brake, harness, and other sensors. The difficult part for the successful manufacturing of ACC is to incorporate a new component to the automobile industry that is capable of detecting different parameters, such as distance, relative speed, etc, of other vehicles. For this, the components mainly used to detect such parameters are lidar and radar. Delphi Delco Electronic Systems (DDES) offers ACC products of two forms, i.e, radar and lidar

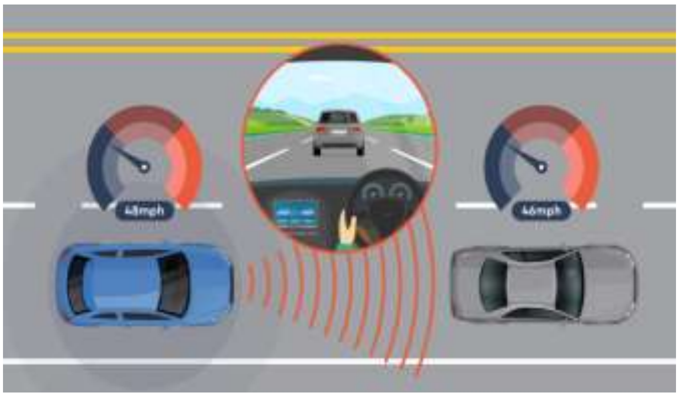

Fig1.ACC with Stop & Go function

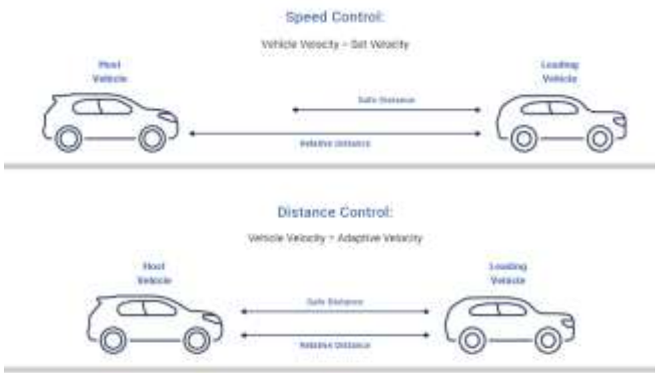

Fig2. Working modes of adaptive cruise control.

Radar application and intelligent control system developments made the development of many other forms of cruise control possible. For regular vehicles, a cruise control system can offer economical driving, but that is not always the goal; it is more of a driving safety and convenience option. Electric vehicles, though, still suffer from the problem of range anxiety, and some studies have shown that optimal driving can still extend the range of the vehicle. Therefore, many advanced forms of cruise control were developed, including efficient cruise control, predictive cruise control, optimized cruise control, and more, where, along with safe driving distance, traffic light status is also considered in order to predict braking.

Adaptive cruise control has two control loops: the first is the normal speed control, e.g., in cruise control; the control block keeps the host vehicle at the set speed value. However, the second control loop is a distance control, and this includes road scanning and, if there is a leading vehicle, the set speed is modulated in order to keep a safe distance between the host vehicle and the detected leading vehicle. To detect the leading vehicles and road obstacles, adaptive cruise control requires radar or laser sensors to scan the road. When there is no vehicle or obstacle in front of the host car, then adaptive cruise control

is in speed mode alone, while in normal cruise control, the vehicle is traveling at the speed value chosen by the user.
When a leading vehicle is detected, the inter-vehicle distance is computed and compared with the safe distance value. When the inter-vehicle distance is larger than the safe distance value at which the host vehicle is running at the set speed value, the adaptive cruise control system is in the speed mode. When the intervehicle distance is smaller than the safe distance value, then the host vehicle speed is regulated to ensure a safe distance between the vehicles, hence the adaptive cruise control is in the safe distance mode.
Figure 1 shows how the Adaptive Cruise Control is very useful and very convenient in "stop and start" traffic conditions. The Stop & Go feature will reduce your speed and bring the vehicle to a standstill if the vehicle in front of you stops in front of your vehicle, and then drive the vehicle automatically if the stop is shorter than two/three seconds. Figure 2 shows the two modes of operation of an ACC system.

2. EV Propulsion System with ACC

There is no throttle control, throttle position sensor, or throttle valve for old vehicles. The engine is replaced with an electric machine, and the motor acceleration is regulated through the motor control block through the inverter. Therefore, for an EV, the output of the ACC block is fed to the motor control block—an indirect field-oriented control block in this case.
Similar to the ICE vehicle, the accelerator ratio in the setting of the ACC block serves as the reference for the field-oriented control block, and the motor speed feedback signal generates the corresponding PWM driving signals for the inverter to drive the electric machine operating mode (motor or generator) and commanded speed. Figure 3 is a block diagram of an EV with an ACC system.

3. METHODOLOGY

3.1 Block diagram for ACC.

A simple ACC system consists of 3 main components as indicated by Fig. 4 below, i.e, Brake controlling, distance detection, and Speed controlling. The block diagram below will be used to implement the ACC. The figure represents a control system of an automatic brake and throttle control system, presumably for an automobile. The controller sends signals to relays, which control a DC motor for the brake pedal and a throttle unit for speed. A LiDAR sensor gives input to the controller, enabling it to detect obstacles or variation in distance. The controller processes this input and controls braking or throttle commands accordingly, increasing automated driving capability.

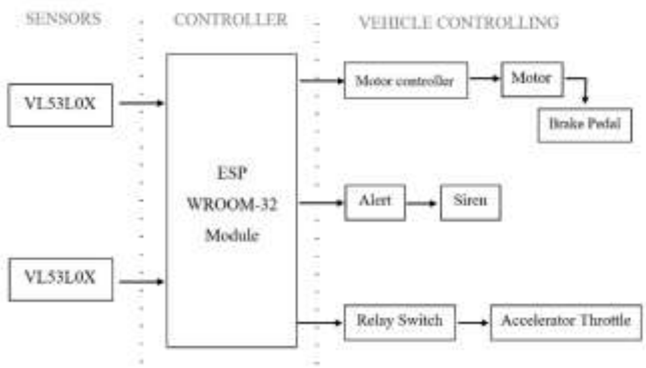

Fig4. Block Diagram of Adaptive Cruise Control System

3.1 ESP-WROOM-32 Module

ESP-WROOM-32 is a low-power, highly integrated module that features a dual-core processor and Wi-Fi and Bluetooth. It is widely utilized in wearable electronics, automation, and Internet of Things (IoT) devices because of its strength in wireless connectivity and flexibility.
Key Features:

- Dual-core 32-bit processor
- Integrated 2.4 GHz Wi-Fi and Bluetooth
- Multiple peripherals and GPIOs

Fig5.ESP-WROOM-32 Module

3.2 VL53LOX

The VL53L0X is an infrared laser distance sensor that utilizes Time-of-Flight technology to measure the distance to a target that is independent of its reflectance. It is based on ST's Flight Sense™ technology and provides more accurate and stable measurements than traditional IR proximity sensors.

Fig6.VL53LOX

3.3 Motor Controller

The L298N motor driver module is a low-cost, small-sized, and universal module in robotics and embedded systems projects. It enables microcontrollers to control the speed and direction of rotation of two DC motors or a single stepper motor using Pulse Width Modulation signals.

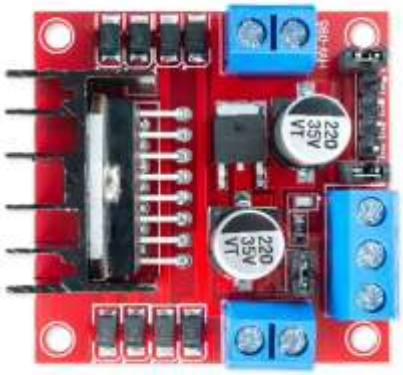

Fig7. Motor controller L298N

3.4 DC 555 motor with gearbox

The DC555 12V motor is a brushed DC motor with medium speed and torque balance.

A 100 RPM gearbox DC 555 motor is utilized for applications with high torque and low speed for projects where high torque and low speed are needed.

This is a very typical pairing for robotics and automation applications.

Operating Voltage

6V – 18V (Optimally at 12V)

Fig8.DC 555 motor with gearbox

3.5 Relay Switch

A relay switch is an electromechanical switch electrically driven by an electromagnet that mechanically toggles a group of contacts. It allows low-power circuits (like microcontrollers) to control high-power devices like motors, lights, or appliances.

Fig9. Relay Switch

3.6 Siren

In an automotive Adaptive cruise control system, a siren is a warning audio signal for notifying the driver, approaching pedestrians, or other vehicles when an imminent collision is near. The system typically uses sensors like infrared, LIDAR to identify objects on the vehicle's path. The sensors send information to a microcontroller, e.g., an ESP32, which in turn processes the information in real-time.

Fig10. Siren

4. CONCLUSIONS

Adaptive Cruise Control (ACC) is a revolutionary technology that significantly enhances driving comfort and safety. With the help of sophisticated sensors, such as radar, LIDAR, and cameras, ACC tracks the distance to the front vehicle in real-time and adjusts the speed of the vehicle to maintain a suitable following distance. This real-time adjustment of traffic dynamics minimizes the risk of rear-end collisions, a frequent phenomenon in conventional driving conditions. ACC's ability to minimize drivers' workload through automatic speed regulation also helps to minimize driver fatigue and stress, particularly during long journeys or in congested traffic. This not only offers a smoother drive but also results in greater driver attentiveness and reducing the risk of accidents caused by human error. ACC is also a significant step towards future autonomous driving. It is also completely compatible with other advanced driver assistance systems, paving the way for more sophisticated automated driving solutions. As the technology matures, we can look forward to further improvements in sensor precision, decision-making algorithms, and system reliability, making ACC an absolute requirement on modern vehicles.

Fig10. Implementation

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