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Adaptive Cruise Control System with Collision Detection and Break Support

Riddhi Naik¹

Student, Department of Electronics and Telecommunication Engineering, Pimpri Chinchwad College of Engineering,

Pune, India¹

ABSTRACT: In this Research, an Adaptive Cruise control system is developed to support an intelligent vehicle assistance. The project consists of an embedded system to demonstrate the behaviour of the vehicle when an obstacle gets detected. The performance is observed using various test cases with varying values of velocity and the distance of an obstacle form the vehicle. Cruise control system has been developed to assist the driver for driving in long distance on highway. At congested traffic, the conventional cruise control system becomes less useful. Adaptive cruise control (ACC) system is developed to cope up with this situation. The conventional cruise control has one mode of control, that is velocity control. On the other hand, ACC has two modes of control, velocity and distance control. ACC assists driver in the congested traffic by acting as a longitudinal control pilot.

The Intelligent Vehicle Initiative (IVI) provides vehicle-based tools that could assist drivers in reacting both more rapidly and effectively to a range of external stimuli. Intelligent or adaptive cruise control systems (ICC or ACC), for example, attempt to assist drivers in better maintaining a safe headway under normal driving conditions. In addition, automatic braking systems may provide additional safety benefits by assisting drivers to respond more quickly to unexpected events.

KEYWORDS: Adaptive Cruise Control, Automotive Electronics, Collison Detection, Ultrasonic Sensor

I. INTRODUCTION

Proportion-Integration-Differentiation type control, sliding mode control and linear quadratic optimal control performed well in improving the safety and comfort. In order to satisfy the requirements of human drivers, intelligent control laws are employed to construct ACC systems. Fuzzy control based on the skilled driver was applied to the ACC system to achieve a humanlike driving categorized driving situation into safe, warning and dangerous modes using warning index and the time-to- collision, then the different control strategy was adopted depending on these modes and hence a same performance as manual-driving was obtained. Model predictive control was used to design the ACC system in with the objectives of comfort, fuel-economy, safety and car-following.

As driving habits change among drivers and over time in the ACC system, an intelligent ACC system should adapt to different driving habits. Otherwise a driver would intervene even in situations that ACC is able to manage, typically when it could not meet the driver's expectations. As so, an ACC system which takes the individual driving habit into consideration would contribute to its attraction and put into commercial production. All the above-mentioned ACC systems were designed according to the common driving habit model, so that it is difficult for them to be put into application. The online learning method is thought as a good solution to such problem and much work has been done.

Adaptive cruise control (ACC) systems are extensions of standard cruise control (SCC) systems. Whereas an SCC system provides a vehicle with one mode of longitudinal control (speed control), an ACC system provides a vehicle with two modes of longitudinal control (speed control and headway control). Headway control refers to the procedure through which a vehicle first establishes and then maintains as specified distance between itself and the immediately preceding vehicle. A vehicle equipped with an ACC system (an ACC vehicle) uses an onboard radar that measures the range and range rate between itself and the preceding vehicle to enable headway control. An ACC system uses its two modes of longitudinal control as follows. If there is no preceding vehicle, then the ACC system enables its



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speed-control mode and regulates the vehicle speed at a driver defined setting. However, if the ACC vehicle is traveling using its speed-control mode and encounters a new, or target, vehicle traveling with a slower speed, then the ACC system must enable its headway-control mode to avoid a collision with the target vehicle.

In this project, we have developed ARM 7 based embedded model, which works to demonstrate the conditions for an Adaptive Cruise Control System.

II. RELATED WORK

This project consists of a handheld range finding device using ultrasonic transducer and an ARM7 microcontroller. A two-line LCD display is used to display the measurements. There is a 40-kHz transmitter and receiver. The 40 kHz-transmission signal is generated via a square wave outputted from the ARM7. The microcontroller is then used to calculate the time of flight (TOF) for the sound wave that is bounced off of distant objects. The return signal is amplified using two op-amp amplifiers. There are three potentiometers that need to be calibrated for correct operation. One controls the contrast of the LCD display. Another control the amplification of the third stage of the amplifier system. The third controls the voltage offset that connects to the base of a NPN switching transistor. The measurement range of the device is one to ten feet. Further distances can be measured, but due to circuit noise erroneous measurements can be obtained for longer distances. The absolute maximum range that can be measured is about twenty feet.



The Block Diagram in Fig 2.2. shows the arrangement of the system components and the flow of overall instructions. LPC2148 receives the inputs from RF decoder which is controlled by the user. Which in result gives out the instructions for the DC motors.



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Fig. 2.3

The block diagram shown in fig 2.2 and 2.3 shows the overall flow of the embedded module developed to work as an adaptive cruise control system. The ARM7 drives the transmitter and the LCD display. When the send key is depressed a 40kHz pulse is transmitted from the device.

1. Operating Principles:

The ARM7 is the heart of the device. The ARM7 drives the transmitter and the LCD display. When the send key is depressed a 40kHz pulse is transmitted from the device. While the ARM7 is listening for a response from the receiver it counts the times that it goes through a loop. Once the signal is received this count is used to calculate the distance from the far object using the value for the speed of light through air. The count value is a measure of the time of flight (TOF). Once the distance is calculated it is displayed on the LCD screen.

2. LCD Interface:

The LCD is driven by the ARM7 via a 4bit interface. Pins D0-D3 on the ARM7 connects to the 4bit mode data pins on the display. The Enable and RS pins on the display are connected to the ARM7. The contrast is connected to a 10-kOhm potentiometer that is connected between VCC and GND. This adjusted to set the correct display contrast. Power and ground is also connected directly to the display device. On power, up the ARM7 initializes the display and sets it for 4bit operation. A welcome message is then displayed. After a measurement is made or the mask value is changed display code routines are called to print these response messages on the display.

3. Transmitter and Receiver Circuit:

The 40 kHz transmitter is connecting directly to pins RA0 and RA1 on the ARM7. The ARM7 oscillates at a frequency of 40 kHz between high and low on RA0 and low and high on RA1. This produces a 40 kHz square wave with a peak to peak voltage of about 10 volts. This signal is transmitted for approximately 130us per measurement.

A 40 kHz receiver is connected between ground and the input of one half of a LM358 op-amp (single source dual op-amp). The signal from the receiver goes through three stages of amplification. The first two stages amplify the signal 100 times, effectively providing 10,000 times amplification. The third stage of amplification is an adjustable gain amplifier. The input resistance is a variable resistor that ranges between 1-kOhm and 47-kOhm. The feedback resistor is a 50-kOhm resistor. This provides an additional amplification between 1 and 50 times. The final output from the amplifier circuit is connected directly to the base of the NPN switching transistor. Also connected to the base of the switching transistor is a voltage offset provided by a 10-kOhm potentiometer connected between VCC and Ground. This provides the extra push that the signal needs to reach the switching region of the transistor. The signal provides spikes that add to the offset voltage and switch the transistor into the on state.



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4. Ultrasonic Sensor:



Fig 2.4 Ultrasonic Sensor – HCSR04

You can get ultrasonic transducers optimized for 25 kHz, 32 kHz, 40 kHz or wide bandwidth transducers. This project uses a 40 kHz transducer but it will still work with the others if you make simple changes to the software (where it generates the 40kz signal). The receiver and generator circuits will work as they are. If you use a different transducer you must change the software to generate the correct frequency for the transducer as they only work at their specific operating frequency. The 40kz signal is easily generated by the microcontroller but detection requires a sensitive amplifier. I have used a three-transistor amplifier for the receiver.

5. Distance Calculation:

A measurement is initiated via the send button. When first depressed the 40kHz pulse is sent out through the transmitter. After the ARM7 has completed the transmission pulse the receiver stage is entered. The receiver stage waits a certain amount of time before checking for signal reception. The receiver stage of the code waits for a specified amount of time based on the mask value. This wait period is to ensure that the receiver does not register the transmission signal as the return signal and also to ignore the return signal bounced back from small obstructions that are between the device and the object that a measurement is being made to. If the mask is set to zero then the minimum default wait period is performed. This period of time is the time it takes for the transmitted signal to travel 1 ft and to return. Given the speed of sound, 1125 ft/s, and an actual distance of 2 ft this wait time is approximately 1.8ms. If the mask is greater than 0 then the wait period is the time that it takes for sound to travel 2 meters times the mask. This serves to make the mask value the approximate distance in meters below which a return signal will be ignored. This time period is approximately 5.8ms.

After the wait period has elapsed the ARM7 clears any interrupt flags and begins looking for an interrupt triggered by the reception of the signal. The ARM7 goes through a loop checking for the return signal and if it is not detected then a counter is incremented. This loop is repeated until either the counter is full or the signal is received. If the counter becomes full then the value of 0 meters is displayed. Otherwise the calculation phase is entered.

After the signal is received the calculation phase is entered. Each counter value of 562 equates to 1 meter. The distance waited based on the mask value and the distance calculated from the counter value are added together. The feet and inch distance are then calculated from the distance in meters. The two values are then displayed on the LCD.

This robot is a RF controlled robot. This can be moved forward and reverse direction using geared motors of 60RPM. Also, this robot can take sharp turnings towards left and right directions. This project uses ARM7 MCU as its controller. The RF modules used here are STT-433 MHz Transmitter, STR-433 MHz Receiver, HT12E RF Encoder and HT12D RF Decoder. The three switches are interfaced to the RF transmitter through RF Encoder. The encoder continuously reads the status of the switches, passes the data to the RF transmitter and the transmitter transmits the data.



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6. WORKFLOW:



Figure 2.5 Illustrates the overall working module of the ACC developed to observe the behaviour of the vehicle with intelligent driver assistance. After the signal is received the calculation phase is entered. Each counter value of 562 equates to 1 meter. The distance waited based on the mask value and the distance calculated from the counter value are added together. The feet and inch distance are then calculated from the distance in meters. The two values are then displayed on the LCD.

7. Circuit Diagram



Fig. 2.6 Circuit Diagram



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8. Software

8.1 Design Simulation software used: -Proteus 7.9 sp1: Proteus 7.9 is a simulation software for various designs with microcontroller. It is mainly popular because of availability of almost all microcontrollers in it. So, it is a handy tool to test programs and embedded designs. We can simulate your programming of microcontroller in Proteus 8 Simulation Software.Figure 2.4 shows the circuit diagram of the microcontroller based embedded module.

8.2 KeilMDK Version 5 :Keil MDK Version 5 is the latest release of our complete software development environment for a wide range of ARM, Cortex-M, and Cortex-R based microcontroller devices. MDK includes the μ Vision IDE/Debugger, ARM C/C++ Compiler, and essential middleware components.

9. testing strategies and test procedures

9.1. power supply testing: -

With the specified components in design we built the DC regulated power supply circuit on bread board. By using Digital multimeter we measured the voltage across each stage of power supply.



Fig 2.7 testing of power supply power supply

9.2. Sensor testing:

In order to measure the distance between vehicle and obstacle we are using an ultrasonic module HCsr-04.to test whether the sensor is working properly or not we mounted the sensor on breadboard and gave the input square wave of 1 kHz at the trigger pin of module. We observed the echo pin output on CRO monitor while varying the distance of an obstacle from sensor.





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Fig 2.9

10. Troubleshooting

While testing the power supply, due to the low power of the load resistor it got burnt and in solution for it a high-power resistor(50hm,5W) was replaced in its place.

While testing the sensor, output wave was getting stuck at a specific value when obstacle goes beyond certain distance. For this problem we varied the input clock wave frequency from 1 kHz to 100 Hz.and specified range was properly measured by sensor.

11. Result

In power supply testing, we got output of filter capacitor stage as +9.5-volt dc and final output at the load as +4.97 volt regulated dc voltage Which is approximately equal to the required output voltage.

. We tested the HC-SR04 ultrasonic module and verified that it can measure the variable distance continuously with some small amount of time delay and can measure the distance in range of 4 cm to 400 cm.

III. CONCLUSION

In this paper we have collectively studied all the issues which occurs while implementing ACC system and different research done to solve those issues. When used for sensing functions, the ultrasonic method has unique advantages over conventional sensors: Discrete distances to moving objects can be detected and measured. It is Less affected by target materials and surfaces, and not affected by color. Solid-state units have virtually unlimited, maintenance free life. Can detect small objects over long operating distances. It has good resistance to external disturbances such as vibration, infrared radiation, ambient noise, and EMI radiation. It gives comparatively Spontaneous output.

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