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Vehicle Collision Avoidance with Adaptive Cruise Control

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ABSTRACT: Adaptive Cruise Control (ACC) is an electronic system that allows the vehicle to slow while approaching another vehicle and accelerate again to the preset speed when traffic is cleared. The proposed system is designed with a GPS equipped ACC system that (apart from performing normal ACC functions) slows down the vehicle intelligently when it enters speed restricted zones such as schools and colleges. The system also continuously monitors driver distraction and driver health conditions and brings the vehicle under ACC control if the need arises. In real-world scenario this system should need to perform the operation within some timing deadline and must be extremely responsive or the result is fatal. Hence the system utilizes the services of an RTOS (Real-Time Operating System). GPS aided ACC with Driver Status Monitoring can be implemented in all types of vehicles where safety will be given first priority and has the potential to become a standard part of any future vehicle.

KEYWORDS: ACC, GPS, FreeRTOS, ARM Cortex-M3, Sonar.

I. INTRODUCTION

Adaptive cruise control is similar to conventional cruise control in that it maintains the vehicle's pre-set speed. However, unlike conventional cruise control, ACC system can automatically adjust speed in order to maintain a proper distance between vehicles in the same

lane. A forward-looking sensor attached to the front of the vehicle is used to detect whetherslower moving vehicles are in the ACC vehicle's path. If a slower moving vehicle is detected, the ACC system will slow the vehicle down and control the clearance, or time gap, between the ACC vehicle and the forward vehicle. If the system detects that the forward vehicle is no longer in the ACC vehicle's path, the ACC system will accelerate the vehicle back to its set cruise control speed. This operation allows the ACC vehicle to autonomously slow down and speed up with traffic and without intervention from the driver.

ACC system is equipped with a GPS module to identify speed restricted zone within the ACC vehicle region and when the ACC system reaches the speed restricted zone, the system automatically reduces the speed below the pre-set cruise speed ensuring safety and once the system moves away from the restricted zone the system automatically reaches the pre-set cruise if there is no slow moving vehicle ahead of the ACC system.

The ACC system ensures safety of the driver by monitoring heart rate and also in order to avoid distraction by a driver, a digital MEMS compass is used. In case of emergency, the system automatically comes to halt

ACC is enabled by pressing an ACC mode switch. It can be deactivated by either pressing ACC off switch or applying accelerator or brake pedal.
This is a real time system which needs to perform multiple operation and hence FreeRTOS, an open source RTOS is used.

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II. BLOCK DIAGRAM

Block diagram of the ACC system prototype is shown in Fig.1.

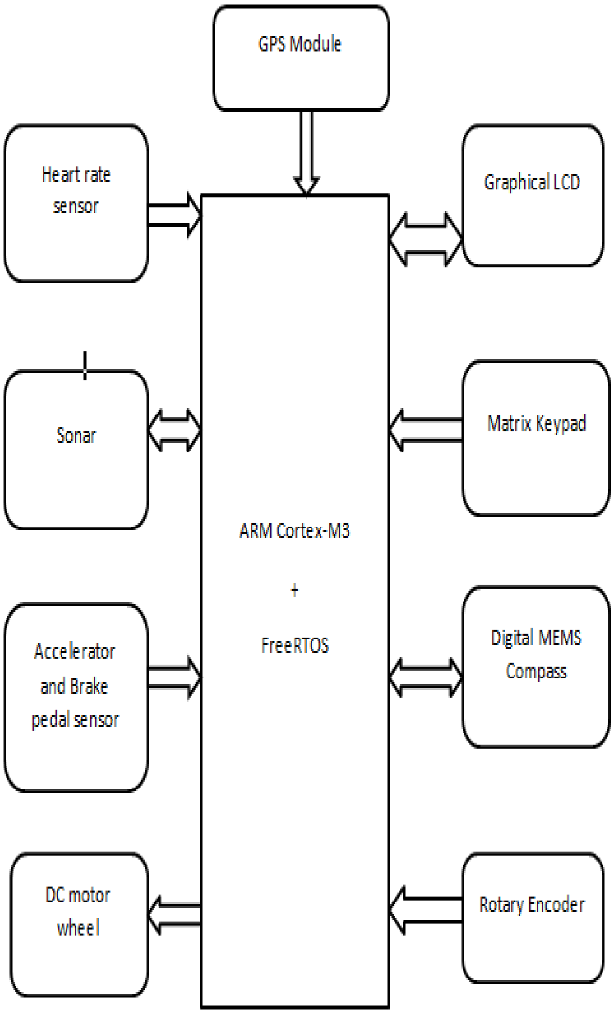

Fig.1 Block diagram of the ACC system prototype

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NECESSITY OF RTOS

A conventional processor can only execute a single task at a time, but by rapidly switching between tasks a multitasking operating system can make it appear as if each task is executing concurrently. The use of a multitasking operating system can simplify the design of what would otherwise be a complex software application. The multitasking and inter-task communications features of the operating system to allow the complex application to be partitioned into a set of smaller and more manageable tasks. It allows inter-task communication. The partitioning can result in easier software testing, work breakdown within teams, and code reuse. Complex timing and sequencing details can be removed from the application code and become the responsibility of the operating system.

RTOS IMPLEMENTED

FreeRTOS is a popularreal-time operating system for embedded devices, being ported to 31 microcontrollers, including ARM Cortex-M3 used in our prototype. FreeRTOS is designed to be small and simple. The kernel itself consists of only three or four C files. To make the code readable, easy to port, and maintainable, it is written mostly in C, but there are a few assembly functions included where needed (mostly in architecture specific scheduler routines).

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FreeRTOS provides methods for multiple threads or tasks, mutexes, semaphores and software timers. A tick-less mode is provided for low power applications. Thread priorities are supported.FreeRTOS implements multiple threads by having the host program call a thread tick method at regular short intervals. The thread tick method switches tasks depending on the priority and a round-robin scheduling scheme. The usual interval is 1/1000 of a second to 1/100 of a second, via. an interrupt from a hardware timer, but this interval is often changed to suit a particular application.

Key features of FreeRTOS are,

- Very small memory footprint, low overhead, and very fast execution.
- Tick-less option for low power applications.
- Equally good for hobbyists who are new to OS, and professional developers working on commercial products.
- Scheduler can be configured for both preemptive and cooperative operations.

III. HARDWARE COMPONENTS

Microcontroller: 32-bit ARM Cortex-M3 microcontroller acts as the brain of the system.
GPS: 66-channel GPS module sends the location data as NMEA packets, interfaced to the microcontroller using UART serial communication.
Display: monochrome Graphics LCD Display acts as the dashboard display for the driver to operate the system.
Heart Rate Sensor: used to sense driver heart beats, output is digital pulses, finger mounted.
Head Tilt Sensor: digital MEMS Compass sensor measures the head tilt angles.
SONAR: ultrasonic distance sensor (dual) senses the front vehicle gap.
Throttle-Brake Sensor: analog output brake pedal and throttle pedal sensing.
DC Motor: wheel is attached to this motor.
Rotary Encoder: used to sense the speed of the motor, attached to the motor shaft.
Matrix Keypad: used to input the control parameters of the ACC system by the driver.

IV. SOFTWARE COMPONENTS

FreeRTOS**:** Open Source Real Time Kernel for Embedded Applications, makes the system responsive and deterministic.
Peripheral Drivers**:** used for thread safe UART, I2C and PWM peripheral handling.
Graphics Display Driver**:** used to handle Graphics LCD in a thread safe manner to display text and plot graph.
NMEA Protocol Decoder**:** used to parse the latitude and longitude position sent by the GPS module.

V. OPERATION MODES

We will discuss modes of operations used in this prototype.
Measuring distance of preceding vehicle.
Using GPS to find the speed restricted zone.
Monitoring driver status.

A. Measuring distance of preceding vehicle

Ultrasonic distance sensor (SONAR) present in the front of the ACC vehicle calculates the distance of the preceding vehicle. TRIGGER pin and ECHO pin of SONAR is connected to the microcontroller.When shortpulse is applied to TRIGGER pin, the transmitter starts sending radio pulses and set ECHO pin from low to high. Radio pulses upon reflecting back from a preceding vehicleset ECHO pin from high to low state. Total transit time from ECHO is used to determine the distance of the preceding vehicle.

If the distance measured from SONAR is less compared to safe distance pre-set by the microcontroller the DC Motor stops. Otherwise, the operation is normal. This operation is performed only when ACC is switched ON using keypad.

B. Using GPS to find the speed restricted zone

GPS modules Tx and Rx is connected to Rx and Tx of the microcontroller. GPS receiver receives the coordinates of the current location in NMEA format. NMEA packets are transmitted to the microcontroller using UART serial communication at TTL level. The baud rate for all communication protocols should be set to the same value.

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Upon receiving the location information, the values are compared with look-up table of all restricted zone which isstored in memory of the microcontroller. If the ACC system reaches the restricted zone, DC motor is made to slow to minimum speed programmed in the microcontroller.

C. Monitoring driver status

Heart rate sensor is used to monitor driver health status. Sensor values are ported into the ADC (Analog Digital Convertor) pin and the digital value are compared with our look-up table value and in case of detection of abnormal value from the sensor the DC motor is made to stop.

To monitor driver distraction, digital MEMS compass is used. Communication is done using I2C protocol. Microcontroller acts as master and MEMS compass acts as a slave.

VI. HARDWARE IMPLEMENTATION

Designing a prototype can project the concept of adaptive Cruise Control. This prototype is capable of detecting vehicle moving in front and also monitors the status of the driver. The interfacing part must be done carefully to avoid impedance mismatching and logic level problems with the target board. The photography of the developed prototype model is shown Figure 2

Fig2. Side view of the prototype

VII. CONCLUSION

In this project, a prototype is designed and implemented using FreeRTOS, a Real Time Operating System and programming is done using the Keil MDK-ARM. The LCD controller has been enabled successfully which gives the status message of the prototype like ACC engaged, Vehicle detected, GPScoordinates and driver health status.

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