Real Time Location based Enhanced ACC System with 3D RISS-GPS Navigator for accidence avoidance and Tracking

S.K.Darun (student)
Dept of EIE
Bannari Amman Institute Of technology.
ERODE, TAMIL NADU,INDIA
contactdarun@gmail.com

Abstract— *The present technologies provide only assistance in a car for controlling the relative speed and distance between two vehicles in the same lane and permit to drive at a constant given speed in a Highway free of traffic and to maintain a constant distance with the vehicle ahead but not collision avoidance But the proposed system provides enhancements in the present adaptive cruise control system, which in addition to collision detection provides a comprehensive solution to avoid collision without the driver's intervention. Our system with the help of sensors constantly monitors the lane in which it is traveling. The system after detecting a moving vehicle in front (which moves slower than the set cruise speed of our car) will try to switch to the adjacent lane, if unoccupied. This judgment (of whether a lane is occupied or not) is done with the help of proximity sensors attached on either side of the vehicle. In the new lane, the car will accelerate to the set cruise speed and after overtaking the vehicle, it will again switch back to the previously occupied lane, all of which is done without any human (driver) intervention. This paper also proposes a design of MPF-GPS (a continuous and accurate solution integrating low-cost MEMS-based inertial sensors, the vehicle odometer, GPS, and map data from road networks) Despite the traditional inadequate performance of MEMS-based sensors in this problem, the performance is enhanced through a special combination of inertial sensors and odometer that has better performance for land vehicles than traditional solutions*

Keywords— RTOS, ACC, GPS, Particle Filter, Map Matching. Inertial Sensors,

I. INTRODUCTION

A cruise control system accelerates aggressively to the desired speed without overshooting, and then maintains that speed with little deviation no matter how much weight is in the car, or how steep the hill you drive up. The cruise control system controls the speed of the car by adjusting the throttle position, so it needs sensors to tell it the speed and throttle position. It also needs to monitor the controls so it can tell what the desired speed is and when to disengage. With traffic continually increasing, basic cruise control is becoming less useful, but instead of becoming obsolete, cruise control systems are adapting to this new reality -- adaptive cruise control, which will allow your car to follow the car in front of it while continually adjusting speed to maintain a safe distance and overtaking (the car in front) without the driver's intervention But in the proposed system, the car after detecting a moving vehicle (slower than the set cruise speed) will try to switch to the adjacent lane, only if unoccupied which is again sensed by sensors on either side of the vehicle.

This system gathers data from the sensors in real time and processes it using an ARM 9 processor which supports many Real Time Operating Systems like Vxworks, QNX, OSEK, µCos etc and is more suited to hard real time systems because it has a clock speed of 220Mhz and hence, a response time in the order of nanoseconds.

II. ADAPTIVE CRUISE CONTROL

Adaptive Cruise Control (ACC) is an extension of the existing cruise control systems, which in general, maintains vehicle speed through a link in the vehicle's powertrain.

A. Potential Key Benefits of ACC

- Reduction in accident rate for vehicles fitted with collision avoidance type systems.
- Increase in fuel efficiency due to very gradual speed increase / decrease in traffic.
- Interconnection to more advanced future systems

B. Drawbacks in ACC

One of the major drawbacks of the present Adaptive cruise control systems is that when the ACC equipped vehicle detects a slow moving vehicle in its lane, it will indefinitely follow the Vehicle unless the driver intervenes and changes to the adjacent lane and again brings the car to the cruise speed.

III. ENHANCEMENT IN ACC

The existing technologies provide for, only a stop and go adaptive cruise control, which reduces the speed of the vehicle according to the speed of the vehicle in front. But the proposed system provides certain enhancements to the presently available adaptive cruise control system. The proposed system segregates the critical and non- critical tasks unlike the present systems in which both are handled by a single processor. When the ACC equipped vehicle detects a vehicle (in front) in the same lane it is traveling, initially the speed reduces and the sensors on the adjacent sides of the vehicle are engaged to check the adjacent lanes for any traffic movement. If the adjacent lane is unoccupied, the system automatically decides to steer the vehicle to the adjacent lane at an optimum speed without losing the stability of the vehicle and accelerates the car to the set cruise speed. After overtaking, which is decided by the input from the sensors on the adjacent side of the vehicle, it once again steers the car back to the previously occupied lane. The interesting point to note here is that all of this is done in real time without the driver having even to move his finger. This is hard real time system .It needs the programming of RTOS.

IV. 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 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

V. 3D RISS- GPS

The interruptions and degradations in Global Navigation Satellite Systems (GNSS)-based vehicular navigation solutions in dense urban scenarios such as urban canyons and tunnels lead to the fact that these solutions have to be augmented with other systems to achieve continuous and accurate navigation. Although there are several works to enhance GNSS receiver capabilities and applicability on mobile navigators, but still augmentation with other systems is the best way toward achieving more available and more accurate navigation systems. Among the systems that can be integrated with satellite navigation is: Dead reckoning systems, such as inertial navigation systems (INS) and odometry. Despite the advantages of these sensors, they provide inadequate performance in degraded GPS environments such as urban canyons or tunnels because of their complex error characteristics which are stochastic in nature and difficult to model especially in the absence of absolute updates.

So our paper proposes a vehicular navigator based on integrating low-cost MEMS-based inertial sensors, the vehicle odometer, GPS, and map data from road networks. Despite the traditional inadequate performance of MEMS-based sensors in this problem, three methods to enhance the performance are proposed in this work: (i) The use of a three-dimensional (3D) reduced inertial sensor system (RISS) that has better performance for land vehicles than traditional full-inertial Measurement unit (IMU) solutions; (ii) The use of map information from road networks to constrain the positioning solution.

The first enhancement is due to the use of 3D RISS to provide a 3D position, velocity, and attitude (pitch, roll, and azimuth). This 3D RISS consists of a single axis gyroscope aligned with the vertical axis of the vehicle, two horizontal accelerometers aligned with the forward and the transversal axes of the vehicle, and the vehicle odometer. The advantages of the proposed 3D RISS over a full IMU are due to two factors, namely the calculation of pitch and roll from accelerometers instead of the traditionally used horizontal gyroscopes, and the calculation of velocity from odometer derived speed instead of accelerometers. The latter leads to another improvement caused by the projection (using the attitude angles) of the speed (in RISS case) rather than acceleration (in full-IMU case). The integrated 3D RISS/GPS solution has another advantage, which is that the higher performance of the RISS is exploited in overcoming multipath Effects that contaminate the GPS signals in urban canyons.

The second approach to achieve an enhanced solution is the use of map information from the road network to constrain the positioning solution. This extra aid is beneficial during GPS degradation or blockage, to mitigate the drift of the positioning solution. The map information is not just employed as a matching or pull-back step but it is used inside the filter itself, since PF gives more flexibility because there are no restrictions on its model. Thus the integration of the RISS/GPS solution with map matching can be considered a tight integration as opposed to loose integration or the pull-back strategy, which implements a single matching step and uses it as either the new solution or as a single measurement update to the filter. This latter is commonly used in most of the currently available Map matching techniques.

VI.3D REDUCED INERTIAL SENSOR SYSTEM

A navigation solution based on KF for loosely coupled 2D RISS/GPS integration was introduced in with the assumption that the vehicle mostly stays in the horizontal plane, while proposed a Mixture PF for loosely coupled 2D RISS/GPS integration. 2D RISS consists of a single gyroscope vertically aligned with the body frame of the vehicle together with the vehicle odometer. The 3D RISS was first proposed in where Mixture PF was used for 3D RISS/GPS integration. The 3D RISS uses one gyroscope, two accelerometers and the vehicle odometer to compute a 3D position, 3D velocity, and 3D attitude. The accelerometers are aligned with forward and transversal axes of the vehicle body frame; a reliable model for the Earth gravity and an odometer are used to decouple the actual acceleration of the vehicle from the accelerometers readings thus making them appropriate to calculate pitch and roll respectively. This configuration obviates the need of two, relatively costly and error prone gyroscopes. The single gyroscope aligned with the vertical axis of the vehicle body frame is used with the pitch and roll information to obtain an accurate azimuth angle in the horizontal East-North plane which is completely compensated for tilt errors. The forward speed derived from the vehicle odometer or from wheel encoders together with the pitch and azimuth angles is used to calculate the East, North and vertical (Up) velocities. Consequently, the latitude, longitude and the altitude of the vehicle are determined yielding a 3D position of the vehicle. The equations of 3D RISS are presented in, as well as its advantages over using a full-IMU for wheel-based mobile platforms and its advantages over 2D dead reckoning systems.

VII. PROTOTYPE DESIGN

The design of the prototype of the above-proposed system has certain constraints regarding the selection of the Target Board, Drives, Sensors and suitable power supply design. The various requirements of the proposed system and the selection of the required hardware to successfully implement the prototype model will be elaborated

A. Requirements of Target Board

- It must be able to support the incorporation of a real time operating system
- It must have enough peripherals to support the development of the intended system
- It must have support of some of the Real time operating system

- Board support packages (BSP's) for the Target Board must be available from the vendor.

All of the above requirements are met by ATMEL AT91SAM9263 EK-B board, which has an ARM9 processor with a clock speed of 220 MHz. This is the target board that the prototype incorporates and the same board is so much versatile and powerful that it can be incorporated in an actual vehicle with Adaptive Cruise Control. In fact the full potential of this board can only be realized on a fully developed vehicle rather than in this prototype

B. Programming using IAR Embedded Workbench

The IAR Embedded workbench IDE, which allows us to develop and manage complete, embedded application projects. It is basically a development platform with all the features to work on 8-bit, 16-bit and 32- bit micro controllers.

The IDE is the framework where all necessary tools are seamlessly integrated

- The highly optimizing IAR C/C++
- The IAR Assembler
- The versatile IAR ILINK, Linker, including accompanying tools
- A powerful editor
- A project manager
- A command line build utility
- IAR C-SPY Debugger, a state-of-the-art high-level language debugger

C. Interfacing with hardware

The target board contains certain peripherals which are available for user applications other than the serial port, USB device, USB host port, image sensor interface and J-link. The PIO controller (Parallel Input / Output Controller) can be programmed either as input or output port as per user needs. All the I/O lines managed by the PIO Controllers integrate a programmable pull-up resistor of 100 kΩ typical. Programming of this pull-up resistor is performed independently for each I/O line through the PIO Controllers.

VIII. PROGRAMMING IN RTOS

A. Algorithm

The algorithm of the design is explained as follows:

- Include the required header files and Board Support Packages.
- Initialize the addresses of the SD RAM where the images are to be loaded.
- Configure the PIO (Programmable Input/output) pins needed by the application
- Enable the peripheral clock for LCD controller and PIO pins
- Initialize the LCD controller with the board parameters
- Give the supply to motor through the PIO pins – Task 1
- Check for input from the front sensors – Task 2
- If input detected from the front sensor, give appropriate signals to turn the motor – Task 3
- Engage the side sensor to check if the vehicle has been overtaken – Task 4
- If the vehicle has overtaken, bring the ACC vehicle back to the first lane
- Display the status of the vehicle at all times – Task 5

The design is depicted with the state diagram in Figure.1. Programming is done using the IAR Embedded Workbench (v 5.30), which also uses C language for coding. But the coding is very specific for each target board.

VIII. HARDWARE IMPLEMENTATION

Designing a prototype can project the concept of adaptive Cruise Control. This prototype is capable of detecting vehicle moving in front and can over take the vehicle after it is sensed. The prototype design consists of a pair of dc-geared motors, a sensor unit. The whole unit is movable with which it can also carry the target board with itself. 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 Figure4

IX. EXPERIMENTAL RESULTS

The performance of the proposed Mixture PF with 3D RISS/GPS/Map data integration is examined with road test experiments in a land vehicle. The inertial sensors used inside RISS in the presented experiments are from a MEMS-grade IMU. The gyroscopes of this IMU have biases in the range of 2º/sec, the specifications are shown in Table I. The forward speed derived from the vehicle odometer is collected through the on board diagnostics interface using a data logging device. A relatively low-cost single frequency GPS receiver is used in these experiments for integration with RISS. The results are evaluated with respect to a reference solution that utilizes a high-end tactical grade IMU (With Ring Laser gyroscopes) integrated with a high-end dual frequency GPS receiver. This integrated solution provided the reference to validate the proposed method and to examine the performance during different conditions including degraded and completely blocked GPS.

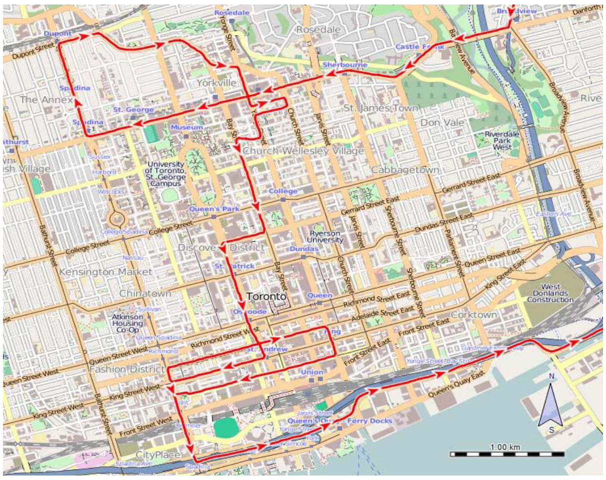

Figure 1: First trajectory in downtown Toronto.

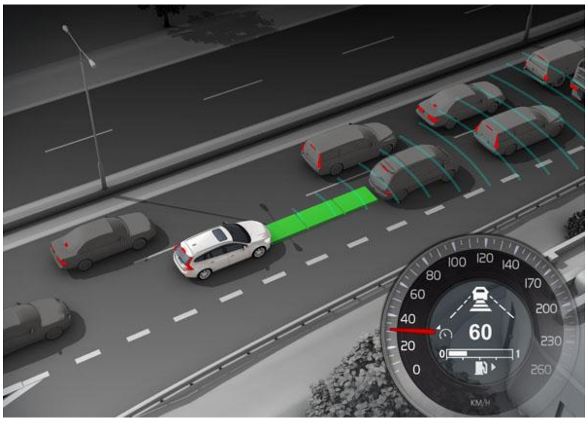

Figure 2: An ACC-3D RISS GPS based System.

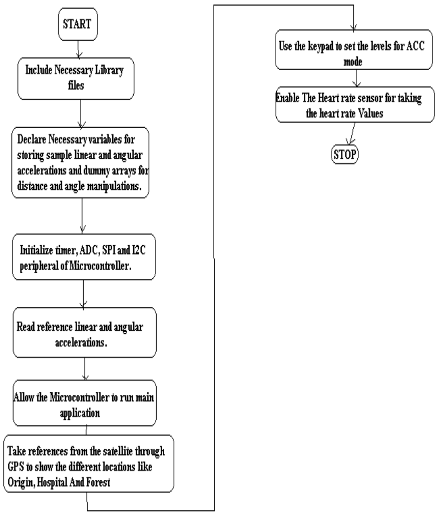

Figure 3: A flow chart of ACC-3D RISS GPS based System.

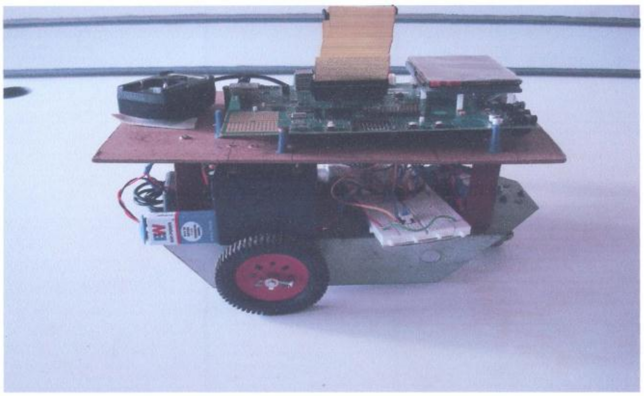

Figure 4. Side view of the prototype

X. CONCLUSION

In this project, a prototype is designed and implemented using µCos – II, a Real Time Operating System and programming is done using the IAR Embedded Workbench. The prototype detects the slow moving obstacle (in front), steers it immediately to the adjacent lane and comes back to the previously occupied lane after overtaking the obstacle. The LCD controller has been enabled successfully which gives the status message of the prototype like ACC engaged, Vehicle detected, overtaking and overtaking completed. In the proposed system only two lanes are considered to demonstrate the collision avoidance system. But in the real world it's not the same case and hence number of complex situations need to be considered to provide a fool-proof collision avoidance system.

This paper presented a low cost navigation device for land vehicles involving a reduced number of MEMS-based inertial sensors augmented with the measurements of the vehicle odometer and integrated with GPS and map data. The integration technique used was a Mixture PF that enables the utilization of nonlinear models, advanced modeling for the inertial sensors stochastic errors, and tight integration of the map data with this integrated navigation system.

Here a DC series motor is used for motion but in the case of vehicles, varying the air-fuel mixture in an Internal Combustion (IC) engine to adjust the speed of the vehicle to the desired level controls the fuel injector. This can be adapted from ACC. While overtaking, more factors need to be considered like Electronic Stability Control (ESC), Anti-lock Braking System (ABS), and Brake Assist etc. to steer the vehicle without it going into a skid.

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