GPS-copilot: real-time location based adaptive cruise control system involving driver health and head distraction analysis

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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. It also warns the driver and/or applies brake support if there is a high risk of a collision. The project aim is to design 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. It is also capable of detecting the speed breakers ahead and controls the vehicle dynamically according to the speed limit set for that part of the road. The system also continuously monitors driver distraction and driver health condition and brings the vehicle under ACC control if the need arises. There are a variety of ways in which drivers can get distracted while driving, for example looking sideways, talking over a mobile phone etc. Driver head movement indicates if he is distracted or not. Our system is capable of sensing this. Another major issue is drivers in city buses or cars who are aged above 40 are at a higher risk of heart attack or similar heart related problems. A heart attack for a city bus driver while driving is fatal not only to him but also for the passengers. Heart rate is a vital symptom for identifying this condition. Our system senses the heart rate of the driver. 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 a 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: *Autonomous vehicles, gps, acc, fuzzy logic, intersection management.*

Introduction

People died in road traffic accidents in the European Union. Some 1.9 million people were injured, some of them severely. The economic damages generated by traffic accidents were estimated at €€ 200 billion, corresponding to approximately 2% of the European Union's Gross National Product. In order to solve this problem, European Commission has taken the challenge of reducing by one half this cipher by the year 2010, mainly applying new information and communication technologies. One of the most dangerous maneuvers is the circulation through road intersections and the various modalities of priority and directions. The research on intelligent vehicles for intersection management is actually a technological challenge, with some groups working in this area worldwide. The philosophy is the integration of vehicle-infrastructure components and functions into cooperative intersection collision avoidance systems using wireless communication technology. Some developments have been carried out as driving aids for augmenting the safety in roadway intersections. In California PATH Program some Intersection-Decision-Support systems have been developed in order to advise the driver in one of the most critical situations: left turn across path with incoming vehicles [1], and some working scenarios to test these systems have been defined [2]. More USA research are described in [3]. In Europe, several projects of the 6th Frame Work Program (FWP) deal with these driving aids. That is the case of Inter safe Project, where an ADAS is under development to detect a potentially dangerous situation in road intersections and to warn the driver [4].

These kind of situations. In the Intelligent Control Systems Laboratory of the Griffith University, in Australia, some autonomous vehicles, Cyber cars, have the capability of performing an automatic route and dealing with basic intersection scenarios [5]. Another full autonomous vehicle driving application is that of the INRIA IMARA group in France. In this case and also using Cyber car vehicles, first steps in automatic intersection management are being carried out, allowing the cooperation of two of these cars in giving the way in intersections, using laser sensors and communications [6].A first simple case of use has been implemented. In this paper we present the approach of the AUTOPIA Program of the Industrial Automation Institute of Spain for automatic driving in roadway intersection, based on GPS and wireless communications. We deal with the two simplest cases, in intersections in which the autonomous vehicle is circulating on a non-priority lane. These two cases of use are: the situation where a car is stopped in a priority lane and the autonomous vehicle circulates through the non-priority one and the situation where both cars are circulating in collision trajectory, with the autonomous going along the non-priority lane. Depending on its speed and position and the speed and position of the vehicle circulating over the priority lane, the autonomous driving system decides whether to stop or to continue the route. Some real experiments have been executed showing the performance of the system.

Automatic Driving Architecture

When designing an architecture that emulates human driving, we have to look at how humans organize the driving task and what operations they perform. According to psychologists, human driving can be divided into three activity levels, depending on the attention, resources and perception that are applied. These are the strategic, tactical and control levels [7]. The strategic level includes planning, for example, choice of the best route to reach a destination. The tactical level comprises the execution of complex maneuvers like stopping, overtaking, giving way, etc. Finally, the control level refers to basic actions to keep the car on the right trajectory: moving the steering wheel, pressing the throttle or brake. These levels are ranked in descending order of complexity. This implies that the higher the complexity the more reasoning is needed and the less reactive the system is. A control system based on human behavior that will support automated operation has to be built around an architecture paradigm. In our case we have chosen Michon [7] model, implemented as a hierarchical architecture, capable of supporting automatic driving and that can be upgraded to deal with other maneuvers that conform to human driving scheme. In our case the strategic planning stage has been taken over by manual user route selection. Then, our architecture is divided into six elements as shown in Fig. 1.

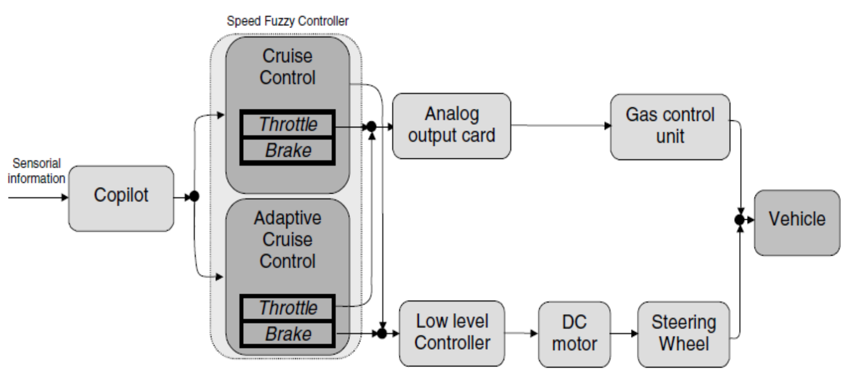

Fig. 1. Automatic speed control architecture

The first module is named copilot and emulates the tactical layer of human driving. It is a decision-making module whose mission resembles the job of a rally driving copilot. It tells the driver when the vehicle is entering a bend or a straight part of the route, when to increase or decrease target speed or when it is necessary to yield, controlling the sequence of operations to be carried out. Usually, the copilot manages the target speed with which the autonomous vehicle has to circulate though a segment of the road.

It has also to select whether this speed control is simple (cruise control) or it is necessary to adapt the speed in order to keep a safety distance from a precedent slower vehicle. In the case of intersection management, copilot aim is to manage the target speed of the vehicle, stopping or reducing its speed in the situations where it is necessary to give the way to another car that circulates in the other road of the intersection. Then it chooses between two kinds of speed behavior controllers: CC and ACC. These controllers represent the control layer of human driving and are modeled using fuzzy logic. This technique applies the knowledge of an expert operator, in this case a human driver, to control the equipment [8]. Another advantage is that complex mathematical models are not needed to manage the equipment. This is a very useful feature where hard nonlinear systems, like vehicle throttle and brake control, are concerned. In other words, by applying fuzzy logic to control the speed of a car, we are modeling driver behavior and not the vehicle itself. The throttle actuator consists of two additional modules: an analog output card that generates a proportional signal of the throttle fuzzy controllers output and the car gas control unit that selects the power effected by the motor according to this signal. The brake management is somehow different. The third architecture module is the low-level controller. Its mission is to receive the target turning angle from the active fuzzy controller and to generate the appropriate control signals for the motor to move the brake. A PID, tuned to manage the DC motor and attached to the brake pedal, forms this low-level controller. The fourth, fifth and sixth architecture modules are formed by the actual DC motor engaged by a pulley to the brake pedal.

First Case of Use

The first scenario that must be solved by our automatic intersection situation manager is shown. The gray car represents the autonomous vehicle and the white one represents a car stopped in the center of an intersection. This is, for example, the case of a car that wants to turn to the left in the intersection or traffic congestion. The automatic driving system controls the speed of the car, using digital cartography as reference. The GPS position also appears in the cartography of the intersection and the coordinates and the width of the cutting road. This information is used to reference the position of other vehicles from our route. Once known the ego-position and the cartography of the involved roads, we can define a “collision area” as the portion of road, on the intersection, where a car on the priority lane can represents an obstacle in the route. It is, in this case, the piece of road where both lanes are overlapped.

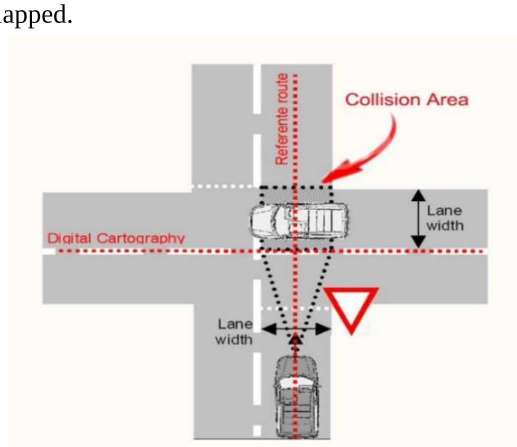

Fig. 2. Graphical representation of the first case of use of the automatic intersection management system

Second Case of Use

Once solved the simplest case of use, we extend it to solve a more complex situation too. In this case, the intersection management system for autonomous vehicles has to deal with this situation when other vehicle approaches the crossroad in colliding trajectory (figure 3), circulating through a priority road (horizontal).

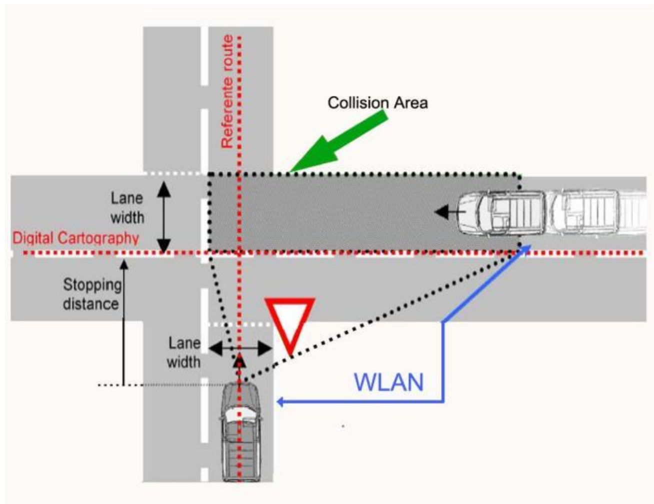

Fig. 3. Graphical representation of the second case of use of the automatic intersection management system

In this case, the gray vehicle is the equipped one that performs a guidance based on GPS. It also considers the cartography of the influence zone, detecting an intersection and a road that cuts its trajectory. Now, we redefine the collision area as the piece of the circulating lane of the priority road that start in the overlapping section up to a preset distance. The control system, also knows the position of the other vehicle transmitted through the WLAN. Then, the yield algorithm is: *IF* the speed of the priority vehicle is not 0 (vehicle not stopped,) *AND* it circulates in colliding route *AND* it is in the collision area, *THEN* stop at a safety distance. *ELSE*, continue route.

Hardware

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 acting 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) sense the front vehicle gap. **Throttle-Brake Sensor: a**nalog output brake pedal and throttle pedal sensing. **DC Motor:** wheel is attached with this motor. **Rotary Encoder:** used to sense the speed of the motor, attached with the motor shaft **Keypad:** used to input the control parameters of the ACC system by the driver ***Software***

Free RTOS: Market leading 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.

Conclusions

Two case of use for automating the intersection maneuver with ongoing traffic has been studied, implemented and tested. With this equipment, it is feasible to add to autonomous vehicles the capability of automatic intersection management. The required data to achieve this maneuver is: real time GPS position of the vehicles on the road, speed of the vehicles of the road, a digital cartography of the driving route, GPS timestamps for message synchronization. In order to continue this work, our aim is to extend the behavior of the control system in yielding maneuvers. In these experiments, only stopping is a considered maneuver in order to respond a yielding. As future work we consider to reduce the circulation speed, optimizing the road occupancy and avoiding time loses in the trajectory following.

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