Safe Crossroads via Vehicle to Vehicle Communication

The use of wireless vehicle to vehicle communication to ensure a safe autonomous driving through crossroads.

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***Abstract* — Driving through crossroads is one of the most dangerous maneuvers. The European community goal of reducing the vehicle accident rate will require a reduction of accidents in crossroads. This paper presents a method of cooperation among vehicles getting into crossroads in order to avoid accidents.**

Keywords – Automatic Driving; Crossroads; Vehicle to Vehicle Communication; Accident Reduction.

I. INTRODUCTION

The safety mechanism for automatic driving in a crossroad must be highly reliable and accurate. This paper is going to introduce a method that allows automatic driving in crossroads. This method tries to emphasize in the safety issues instead of trying to optimize the traffic congestions in the crossroads. The experimental results were obtained in our experimental zone and also in the Cybercars2 project final demonstration at Place du Verdun in La Rochelle, France.

A. Problem description

The problem to solve is how to merge two flows of cars in a one way crossing. This is a simplified case of study, but can be considered as a starting point for a further research. When a vehicle arrives to a crossing there is always the possibility of an accident, either because of a driving error or because of a misperception of the environment. In this paper we attempt a method to increase the knowledge available to the cars, so accidents can be avoided. This implies cooperation among vehicles and between vehicles and infrastructure. Even if the presentation is about automated driving it is obvious that it can also become an Advance Driven Assistance System to help the drivers.

B. Matter of concern and problem difficulties

There are a lot of problems to solve the automatic driving in crossroads. Most of them come from the communications step. Once the car have all the information needed to take a decision is relatively easy to take a robust decision that allows all the cars to travel safely.

Even with a well tested communications technology, there are a lot of problems that can happen in a real car, real world application. In most of our cities there are important buildings that are protected from terrorist attacks, and to do so, there are some radio interferences. The buildings also shade the satellite signals and make signal reflections. The wire connections suffer the vibrations of onboard equipment and sometimes broke. And so on…

But, in order to achieve a full autonomous driving, it's needed to solve all the basic maneuvers. The adaptative cruise control [1], the overtaking [2], the pedestrian detection [4], and some other maneuvers and techniques have been studied previously. Our research group still works on almost all the issues. And the solution of all the possible scenarios is far from being solved. However, the benefits for achieving autonomous driving cars or the ADAS obtained in the way to do so are well known and are not going to be discussed here.

II. AUTOMATIC DRIVING THROUGH CROSSROADS

A. Path following

The first step in order to achieve automatic driving is to be able to follow a path. In this project it is performed by storing a map describing a trajectory and using a GPS to monitor the actual position of the vehicle. The comparison of these data permits identify the distance between the actual position and the target one thus permitting to act upon the car controls in order to correct the actual trajectory [3].

B. Vehicle to Vehicle communications

This work is about vehicle cooperation. We think the solution of the problems of traffic need the cooperation among vehicles. In this work the vehicles share information to permit other vehicles to cooperate. Every vehicle will broadcast its own position, as well as its velocity and some more data so other vehicles can take their own decisions.

C. *Infraestructure to Vehicle communications*

This work is about vehicle cooperation, but it is not enough. We think the infrastructure is to be part of the solution communicating with the cars. Some information the infrastructure has might be necessary for the orderly driving in the crossroad, for example a command to stop because of an accident blocking circulation. We are actually proposing that the information messages that imply a modification of the driving behavior (because an accident, rain, etc…) in road be actually sent to the cars directly.

D. *Maps*

The vehicles have to know in advance the trajectory so the crossroads positions can be determined. This is achieved through a map containing the information about the driving area, be it a nation, or, more likely, a thematic park. In this way the analysis of the map permit the identification of the next crossroad in the path, what on its turn permits to identify which messages from other vehicles have to be analyzed in order to determine the course of action in the crossroad.

E. *Decision Taking*

After the number of vehicles coming into the crossroads has been determined, the decision taking algorithm will permit to adopt a decision on whether to stop or to proceed, and in this case whether to maintain the speed or to reduce it. This algorithm can be as simple as stopping if there is some vehicle coming from the right side into the crossroad. Or as complicate as to introduce rights of way and determination of time other vehicles will take to get into the crossroad in order to adapt the speed and not to have to stop. In this paper we only deal with stopping if a car comes from the right side.

F. *Experiments*

The experiments that have been carried out were done in La Rochelle as a part of the Cybercars 2 final demonstration. Two vehicles start moving in a one way eight shaped loop (8). The starting positions and speeds have been selected to ensure that both vehicles will arrive to the cross section of the loop at the same time but arriving from different directions. The vehicle which has a car coming from his right has to stop and let the other car to continue and cross the intersection.

To be able to perform this maneuver each car needs the position and speed of the other car. The accuracy and reliability of that information is really important for the safety of the maneuver, so some other information is added to the communication package. A timestamp has been added to ensure that the information is not too old. And the DGPS quality is also added to the comm. package to be able to stop the experiment if the accuracy of the DGPS position measurements goes down.

In addition to this in-code safety measures, some light displays have been added to be able to check if the communications still alive, and to inform of the intersection state. So the passenger will be able to know if the intersection is occupied by other car and also if his car is going to stop before the intersection entrance to let the car coming from the right pass.

III. Conclusions

Automating driving is far for being in the near future, but we consider it will eventually come. The experiment described in this paper show that it is possible to control driving automatically by sharing information among vehicles.

References

[1] J. E. Naranjo, C. González, R. García, T. de Pedro, “ACC+Stop&Go maneuvers with throttle and brake fuzzy control” in IEEE Transactions on Intelligent Transportation Systems, Jun. 2006, Volume 7, Number 2, pp.213–225.

[2] J. E. Naranjo, C. González, R. García, T. de Pedro, “Lane-Change Fuzzy Control in Autonomous Vehicles for the Overtaking Maneuver” in IEEE Transactions on Intelligent Transportation Systems, September 2008, Volume 9, Number 3, ISSN 1524-9050, pp.438–450.

[3] J. E. Naranjo, C. González, R. García, T. de Pedro, R. Haber “Power-steering control architecture for automatic driving” in IEEE Transactions on Intelligent Transportation Systems, Dec. 2005, Volume 6, Number 4, pp.406–415.

[4] M. A. Sotelo, F. J. Rodriguez, L. Magdalena. “VIRTUOUS: Vision based road transportation for unmaned operation on urban like scenarios” in IEEE Transactions on Intelligent Transportation Systems, Jun. 2004, Volume 5, Number 2, pp.69–83.