WiP Abstract: Impact of Position Inaccuracy on V2V Intersection Protocols

Seyed (Reza) Azimi, Gaurav Bhatia, Ragunathan(Raj) Rajkumar, Priyantha Mudalige †
Carnegie Mellon Universtiy and General Motors Company †
rezaazimi@cmu.edu, gnb@ece.cmu.edu, raj@ece.cmu.edu, priyantha.mudalige@gm.com

ABSTRACT

We have been investigating vehicle-to-vehicle (V2V) communications as a part of co-operative driving in the context of autonomous driving. In this work, we study the effects of position inaccuracy of commonly-used GPS devices on some of our V2V intersection protocols and suggest required modifications to guarantee their safety and efficiency despite these impairments.

1. V2V INTERSECTION PROTOCOLS

These protocols have been designed to enable co-operative driving among approaching vehicles to ensure their safe passage through the intersection and to increase the throughput at intersections [2]. Vehicles use V2V communications using DSRC to broadcast intersection safety messages to other vehicles [1]. One critical issue for our intersection protocols is the position information accuracy provided by the on-board GPS devices. Position accuracy will affect the protocols since each vehicle depends on its position and the known position of the other vehicles to make safety-critical decisions. All GPS receivers have finite accuracy, with commonly-used inexpensive GPS receivers having errors of up to a few meters.

In our V2V car-following model, each vehicle uses its GPS coordinates, map database and the information received in regular BSM messages to measure its current distance to the vehicle in front of it, and adjusts its speed according to the leader vehicle's velocity to maintain a *safe distance.* Figure 1 shows a screen-shot from our hybrid simulator/emulator AutoSim, in which vehicle B is following vehicle A on its way to the intersection. In this scenario, due to a high position error, vehicle B may not maintain a *safe distance* to its current leader vehicle, leading to a potential collision before entering the intersection.

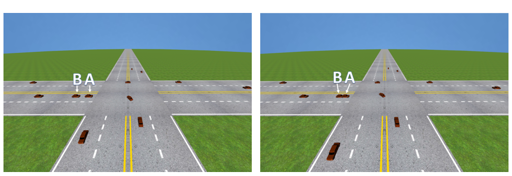

Figure 1: *Snapshots from AutoSim. Collision outside of the intersection area.*

To avoid these collisions outside of the intersection grid, when dealing with high levels of positioning inaccuracy, each vehicle will use an updated *safe distance* parameter based on its GPS positioning error parameter. This increased buffer distance among following vehicles prevents vehicles from getting very close to each other and gives them the capability to slow down without causing an accident when the leader vehicle brakes suddenly.

Since our new intersection protocols explicitly utilizes information relating to a vehicle's progression inside the intersection area. Therefore, a failure in locating a vehicle's current cell information correctly may lead to vehicle collisions inside the intersection grid. However, due to the positioning error, the vehicle might update its *Trajectory Cells List (TCL)* without having completely crossed its previous cell. Figure 2 shows a scenario in which a collision occurs between vehicles A and B. The higher-priority vehicle A is broadcasting an incorrect TCL. As the lower-priority vehicle B receives the updated TCL from vehicle A and calculates that the conflicting cell is now clear, it will progress into that cell. As vehicle A is still occupying the conflicting cell, a potential collision occurs between vehicles A and B.

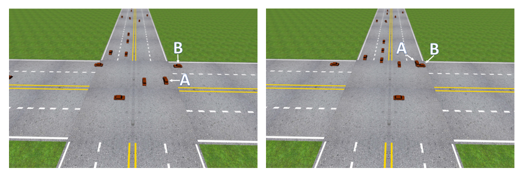

Figure 2: *Snapshots from AutoSim. Collision inside the intersection area.*

To avoid these safety violations, each sender vehicle adds a safety cell to its updated TCL. The TCL now includes the previous cell as well as the current and the next cells of vehicle's trajectory inside the intersection grid. Thus, we add a safety buffer of one intersection cell ahead of and prior to the current cell to assure the safe passage of the vehicle. The size of this safety cell buffer should be a function of the GPS error characteristics and, if the GPS inaccuracy is too high, then collisions can be avoided by increasing the buffer size to more than one cell. The reader may observe correctly that position inaccuracy might also affect the vehicle's ability to correctly determine its lane information. This can be avoided by using local sensing technologies (available on autonomous vehicles) such as cameras and lasers to perform *lane localization.*

Our preliminary simulation results show that by modification in our protocols and the safety parameters, no accidents happen in any tested traffic volumes at the intersection when dealing with high levels of GPS position inaccuracies. However, this guaranteed safety comes with the price of reduced throughput at the intersection. Despite the reduced throughput of modified V2V intersection models, Advanced Maximum Progression-Intersection Protocol (AMP-IP) has 74.16% overall performance improvements over the traffic light model with a 10-second green light time. We will extend our study to ensure that all our proposed intersection protocols support safe traversal through intersections even with imperfect and commonly-used GPS devices.

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2. REFERENCES

[1] Draft sae j2735-200911 dedicated short range (dsrc) message set dictionary.

[2] R.Azimi, G. Bhatia, R. Rajkumar, P. Mudalige. Reliable interesection protocols using vehicular networks, acm/ieee 4th international conference on cyber-physical systems. April 2013.