Assisting Drivers During Overtaking Using Car-2-Car Communication and Multi-Agent Systems

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***Abstract*—A warning system for assisting drivers during overtaking maneuvers is proposed. The system relies on Car-2-Car communication technologies and multi-agent systems. A protocol for safety overtaking is proposed based on ACL communicative acts. The mathematical model for safety overtaking used Kalman filter to minimize localization error.**

***Index Terms*—Safety overtaking, Car-2-Car communication, VANETS, multi-agent systems**

I. Introduction

Smart vehicles currently share with Internet of Things the first rank regarding expectations, as demonstrated by the Gartners Hype (http://www.gartner.com/newsroom/id/3114217). Smart vehicles represent the major change in the 2015 Hype Cycle for Emerging Technologies, as this technology has shifted from pre-peak to peak of the Hype Cycle. The main rationale is that all major automotive companies are putting smart vehicles on their near-term road-maps. At the EU level, European Commission (EC) is getting involved and promoting several Field Operational Test, while European Telecommunications Standards Institute (ETSI) has finally standardized higher layer networking protocols.

The main bottleneck is that C2X technology has just solved low level aspects with respect to ad-hoc networks or regulatory norms and standards, with much work remained at the application layer. In this paper, advances in multi-agent systems (communication protocols, speech acts) are exploited to deploy cooperative, communication based active safety application.

The remaining of this paper is structured as follows: Section II formalises the mathematical model for vehicle overtaking. Section III details the communication protocol and the experiments run based on multi-agent systems. Discussion appears section inIV, while section V concludes the paper.

II. Cooperative safety overtaking

This section formalises the mathematical model for overtaking and the approach for minimizing localisation error of the vehicles envolved in overtaking.

A. 2^+ *Overtaking Model*

In the 2^+ overtaking, multiple vehicles which have to be overtaken in a single maneuver. The overtaking car will have to travel a longer distance on the opposite road before returning to the original lane. A novel model for the 2^+ overtaking maneuver is introduced in this section. The model is an extension of the mathematical model described in [2].

The situation in which one or more vehicles are in front on the overtaking vehicle, on the same lane, and an arbitrary number of vehicles can be present on the opposite lane is considered here. The model assumes that the overtaking vehicle may start the maneuver at an arbitrary distance from the car in front. In Fig. 1, the car c_1 is the overtaking vehicle, as it is signaling its intension by signaling left. The three dots between c_2 and c_3 signify that an arbitrary number of vehicles may exist there. The left signal message is beaconed to the other agents in the vanet.

We consider the physical lengths of the cars to be important as vehicle lengths can vary significantly, depending on their type. Average personal automobiles usually have a length from 2 to 4 meters but the maximum length of a truck can exceed 25 meters. We denote them with h_i for vehicle c_i. This information is obtained through Car-2-Car communication.

To calculate the safety level of an overtake, velocity and position of four vehicles are required: the overtaking vehicle c_1, the closest vehicle c_2 and farthest vehicle c_3 from the same lane as the overtaker and the closest vehicle c_4 from the opposite lane.

Let $|c_i|$ be the velocity of the vehicle c_i, while $|c_i|_x$ and $|c_i|_y$ be the velocity components on x and y-axis, respectively. We denote with $d_{ij}[\tau_k]$ the distance between vehicles c_i and c_j at time τ_k. Here, τ_k represents the time interval since the overtaking maneuver started. We assume the distance between c_i and c_j is estimated at time t_0 when the overtaking maneuver starts based on vanets communication. This distance can be calculated using equation (1).

$$d_{ij}[\tau_k] = d_{ij}[\tau_0] + (\tau_k \cdot ||c_i| - |c_j||) \tag{1}$$

There are two steps for assessing the safety of the maneuver. Firstly, we need to calculate the required time to overtake tto. Secondly, the time to collision ttc should be estimated. tto consists of the time required for lane-change and the time spent on the opposite lane. When starting to change the lane, vehicle c_1 will make an angle θ with the road lane. Vector decomposition [2] is used to calculate the velocity components on x and y-axis of vehicle c_1, using equations (2) and (3).

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