WAVE Low Latency Video Streaming for Platooning Safety Real-Time Application

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Safety Real-Time Application

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***Abstract*— The use of Wireless Access in Vehicular Environments (WAVE) technology for exchanging information between vehicles can positively influence the drivers behavior towards safer driving by reducing road accidents and improving driving performance. These exchanged information are more relevant to safety applications if presented as a real-time and high quality video stream. In this paper, we demonstrate the low latency video streaming as a safety application for platoon and reverse parking scenarios. The use of streaming safety application provides an additional tool to the platoon drivers to see the road traffic conditions. It helps the driver to make safer decision and reduce the overtaken risks during a manual overtaking maneuver for instance (i.e platoon output).**

Keywords: WAVE, IEEE802.11p, Video Streaming, Platoon, Reverse Parking.

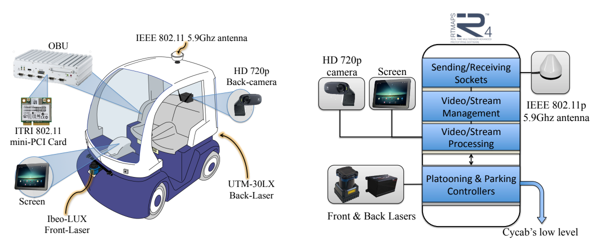
I. Introduction

A large number of the Intelligent Transportation Systems (ITS) multimedia streaming applications are developed for exchanging entertainment data. In contrast, this paper present a demonstration of low latency video streaming for vehicular platooning. For our demonstration, we developed a video streaming safety application for Inter-Vehicular (IV) communications based on the wireless communication standard IEEE802.11p, which dedicated for ITS safety applications.

The developed application provides the platoon members with extended views of the environment, which result in safer platoon merging or manual overtake (leave) processes by continuously multicast streaming from the front camera of the head vehicle, together with the rear camera of the tail member of the platoon.

II. WAVE Video streaming

To allow a real-time display of video streaming for all the platoon members, we use dual multicast communication from the head vehicle (Veh_0) and the tail vehicle in the platoon queue (Veh_n) using two different multicast flows over the same communication channel. Veh_0 is continuously streaming the front view for all platoon members, and is sending instructional and control data to define the ID of Veh_n in order to start the rear camera streaming or the reverse parking process. Meanwhile, a unicast link is dynamically established between Veh_0 and Veh_n to control merging/leaving process and to start the rear camera multicast of Veh_n. To sum up, there will be dual muticasting for two camera streaming and short time unicast on the same channel for merging requests.



(a) Equipped Cycab electric vehicle (b) RTMaps safety application

Fig. 1. Demonstration Cycab vehicle and RTMaps safety application

Each vehicle of the platoon members from 0 to n is able to display the live video streams generated by both Veh_0 and Veh_n on the in-vehicle screen. The Image Rate of the displayed video stream set to be 1000 $Frame/s$. When a new vehicle joins the platoon, a dynamic unicast authentication communication will be established between Veh_0 and Veh_n. The newcomer ID will be defined as the new Veh_n and multicasted by Veh_0 to all members, which will automatically stop the rear camera streaming from Veh_{n-1}.

The proposed demonstration is based on Cycab automated vehicles, equipped as depicted in Fig. 1(a) with an On Board Unit (OBU), 5.9 GHz antenna, front laser Ibeo LUX with four layers, one layer rear Hokuyo laser, rear HD camera and a screen to display streaming, while the head vehicle is equipped with an extra front camera. The OBU integrates an ITRI 802.11p mini-PCI card configured to operate in channel 180 with 10 Mhz of Bandwidth as specified by ETS 202-663 for the European Union frequency allocation, while the Transmission Rate was fixed to 12 $Mbps$ for all tests.

RTMaps 4 [1] was used to develop image processing and socket streaming. Fig. 1(b) shows the safety streaming application processes, starting by acquiring the raw video data of the installed camera. RTMaps will decode these data in real time in order to be delivered to the socket sender which is configured to multicast the stream video over channel 180 and using IPv6 address. Simultaneously, there will be continuous control management process in Veh_0 which will dynamically give vehicle ID's addresses to each vehicle in the platoon. This management process will result in defining the tail vehicle Veh_n which must respond back and start the rear camera multicast streaming. While in the receiver side, the same processes are applied in reversal order to display the streamed view in real time. All the RTMaps processes are real time operations either.

III. Platooning control

A. Reverse parking controller

When the head vehicle arrives to any vehicle already parked and interested to join the platoon, it will establish a unicast link between the both, then, the Veh_0 will give the permission join the platoon. Before starting the reverse parking maneuver, the parked vehicle uses the front and the back lasers to detect the both front and back cars, then calculates respectively the distances X_{Front} and X_{Back}. We specified a secure distance ΔX_{Secu} (about $20\,cm$) to separate the parked vehicle from the front and the back vehicles as shown in Fig. 2.

We propose a bang-bang controller which relies on lasers to detect front and tail vehicles and probably other obstacles. Also, rather than using expensive sensors to determine the vehicle's position such as Real-Time Kinematic GPS, we developed an odometry algorithm based on wheels encoder. Once parked, the odometry algorithm initializes the vehicles position (x, y, ϕ) by $(0, 0, 0)$, and at the end of the reverse parking maneuver the vehicle has to be parallel to its initial position with a reference position $(X_{ref}, Y_{ref}, 0)$, where Y_{ref} is is chosen to let a parallel spacing $(0.5-1m)$ between the ego-vehicle and the parked cars, and X_{ref} is chosen such as an inter vehicle distance (d) of 2 meters is reached as shown in Fig. 2.

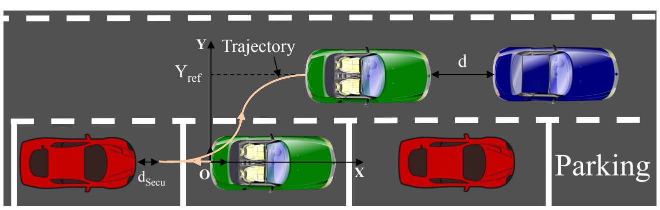


Fig. 2. Reverse Parking and Platooning demonstration scenarios

B. Platooning controller

Once the vehicle finishes the reverse parking maneuver, it detects the tail vehicle of the platoon and initializes the laser tracking algorithm to track this vehicle with a constant inter-vehicle spacing of 2 meters (d). The tracking algorithm calculates the front vehicles position $(X_{rel}, Y_{rel}, \phi_{rel})$ relatively to the ego vehicle. These sensing information are used by a Proportional Integral (PI) longitudinal speed controller and the lateral constant curvature steering controller that we proposed in [2].

C. Obstacle detection

1) Multi object detection and tracking in 5 steps: In the **Data processing** step (1), distances coming from the front and rear laser sensors are converted into (x, y, z) points in

Fig. 3. Three vehicles platoon demonstration supported by video streaming safety application

the local Cartesian coordinate system. They are then sorted depending on their angle to the coordinate system center. In the **Segmentation** step (2), a Cluster-based Recursive Line fitting algorithm is used with parameter $d_1^{'}$ and $d_2^{'}$ for the maximum distances to the closest segment and between two successive segments respectively (see [3]). In the **Clustering** step (3), segments are associated to create objects. Considering our parking application, close obstacles are considered and objects with less than 5 laser impacts are filtered. In the **Classification** step (4), size and shape consideration are used to obtain a raw classification of the object. In the **Tracking** step (5), information about the ego-vehicle dynamics are considered (velocity and steering angle) to improve the tracking of the object in the local Cartesian coordinate system. Object tracking is done in relative coordinates regarding the ego-vehicle using a Constant Velocity Kalman filter and Nearest Neighbor approach for data association.

2) Head vehicle selection: During the reverse parking maneuver, closest front and rear cars are selected to calculate X_{front} and X_{back}. In case a pedestrian or any smaller obstacle is detected around the ego-vehicle, an emergency stop is applied. Then, for the platooning input, the front vehicle is detected as a vehicle, following a car shape, which is the closest obstacle in a corridor surrounding the vehicle path.

IV. Demo description

The discussion of our work will be presented using both documentary video and on table test showing the overall demonstration. The documented video will present our real time streaming safety application for both platoon and reverse parking scenarios, together with detailed illustrations showing three equipped vehicles.

For the concept approval, an on table RTMaps-Based Multicast video streaming will be also performed for the audience, emulating our demonstration for the driver view extension from both tail and head cameras.

References

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