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A Human-centered Test-bed for Mixed Traffic of Autonomous and Non-autonomous Vehicles

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Abstract

A vehicular ad hoc network (VANET) is a vehicular-wireless network enabling vehicle-to-vehicle (V2V) communications and vehicle to infrastructure (V2I) communications. VANET has been under the international spotlight because various applications can be developed by leveraging those wireless communications to avoid vehicular collisions or to save energies. Most of VANET applications have been developed for the operations of non-autonomous vehicles (NAVs). However, due to the recent advanced autonomous vehicle (AV) technologies, human factors affecting the interaction between NAVs and AVs need to be studied. In this paper, we introduce our test-bed for that human factor research. Such a test-bed, various scenarios with V2V communications are possible for human factor experiments. Those scenarios include, a warning message for a vehicular collision can be chosen to be turned on or off, and a proper intersection control protocol without traffic signals can be chosen depending on the existence of NAVs.

Keywords: Connected vehicle test-bed, autonomous vehicle, human factor, and VANET applications.

1. Introduction

A vehicular ad hoc network (VANET) is a type of the Mobile ad hoc network (MANET) and is created by cars with wireless communication technology using a dedicated short-range communication (DSRC) [1]. In VANET, Vehicle can communicate with other vehicles by vehicle-to-vehicle communication (V2V) or communicate with roadside unit (RSU) by vehicle to infrastructure communication (V2I). These types of communications allow a driver to get a wide range of information and enable to develop a large number of applications. The AV technology based on VANET is promising to enhance drivers' safety, to control congestions, to save energy, and to use roads efficiently. Accordingly, Google has been developing technologies for AVs and tested the driving of AVs on public roads in California [5]. Both Audi and Toyota unveiled their AV visions and research programs at the international Consumer Electronics Show in 2013. Nissan also has participated in the AV business by announcing a plan to sell AVs by 2020. VANET applications are classified by either comport/entertainment applications or safety applications depending on their purposes [2]. Also safety applications can further be categorized such as intersection collision avoidance, public safety, sign extension, vehicle diagnostics and maintenance, and information from other vehicles [3]. The applications mentioned above are mainly for NAVs. According to the survey on vehicular networking [4], technologies in the USA, Japan, and Europe have been developed mainly for NAVs, not for AVs. This paper introduces our test-bed with V2I communications and V2V communications, which will be used for human factor research in developing applications for both AVs and NAVs.

2. Human-centered Test-bed

As shown in Fig. 1, our test-bed consists of an open-source driving simulator called OpenDS, a driving device called CDS and a traffic Simulator called AutoSim. The CDS (developed by INNOSIMULATION) handles road-vehicle interface to control the car like steering wheel, acceleration pedal, brake pedal, gearbox, and etc. OpenDS (developed by EU-project, GetHomeSafe) is designed for industrial research and development, and scientific experiment in the field of automobile. The OpenDS renders a realistic driving environment by incorporating physical properties of car engines and roads. It can also create polished 3D driving environments as well as dynamic driving tasks. Hence, in our test-bed, a subject for an experiment can control the car through the CDS interface, and can have a realistic driving experience. AutoSim (developed by Carnegie Mellon University) is a hybrid emulator-simulator for vehicular communications and interactions. It facilitates protocol designing and in-vehicle application developing while using real street-map-based topography. The surrounding vehicles in the view of driver in OpenDS are created by AutoSim. We conducted a number of simulations using V2V communications with following properties: unavoidable vehicle collision scenarios between attacker AV and NAV at an intersection, avoidable vehicle collisions with warning signals and instructions, intersection controls (AMP-IP and MP-IP in [6]) using AVs without traffic signals and traffic accidents, and intersection controls without traffic signals between NAV and AV.

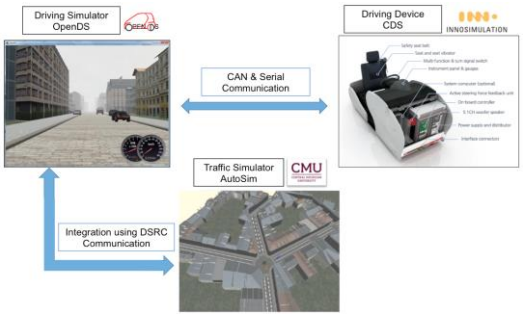

Figure 1 A Human-centered Test-bed

3. Conclusions

It would take some time to migrate from NAVs to AVs. For this reason, it is necessary to study human factors in the interactions between NAVs and AVs for this transition time. Our cyber-transportation test-bed will serve well for the human factor research. For future works, we plan to develop an application to prevent an aggressive driver from misusing AV technologies, and realistic intersection control protocol for both AVs and NAVs with no traffic signal. We also plan to develop a solution that efficiently makes a balance between travel time and safety according to the level of aggressiveness assigned for AV.

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