Embedding Real Vehicles in SUMO for Large-Scale ITS Scenario Emulation

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***Abstract*—We present a platform for embedding, in real-time, real vehicles into SUMO (Simulation of Urban MObility). The purpose of the platform is to provide a half-way mark between emulating large-scale traffic scenarios purely with simulators, and demonstrating prototype technologies in the real world with small fleets of field-test vehicles, in the pursuit of evaluating experimental large-scale intelligent transportation systems (ITS).**

I. Introduction

The inadequacy of many of our current transport systems, when it comes to coping with factors such as rising volumes of traffic and environmental pollution, together with rapid advancements in information and communications technology (ICT), has sparked much investment in developing smarter transportation systems. Projects such as EcoGem (Cooperative Advanced Driver Assistance System for Green Cars), funded in the context of the European Green Cars Initiative, aim to integrate technology and intelligence into vehicles and the physical transportation infrastructure in order to provide increased efficiency, safety, and capacity on our roads, and improve the general road travelling experience.

The question is how to test and evaluate intelligent transportation systems (ITS) when they are in the experimental stage? This often proves challenging given that intelligent transportation systems are frequently intended to eventually be deployed in large urban areas and major cities. Access to fleets of thousands of vehicles equipped with the prototype technologies and communications abilities necessary for testing is usually impractical. Simulators may be used to emulate large scale, but cannot accommodate for all of the complexities, uncertainties, technical issues, and driver attitudes and responses that might arise in the real world [1]. On the other hand, small, real-world test fleets of 1–20 vehicles demonstrate proof of concept, but cannot accurately predict the outcomes of ITS in the context of much larger fleet sizes and city-wide scenarios.

In this short note, we consider the idea of merging large-scale traffic simulation and the proof of concept capability provided by real-world vehicles. In particular, we present a prototype platform for embedding, in real-time, real vehicles into SUMO (Simulation of Urban MObility). Our tool provides opportunities for demonstrating intelligent transportation methodologies on real vehicles that simultaneously interact with large-scale, simulated traffic scenarios. We discuss the potential of our platform in the context of a number of ITS applications.

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II. Motivation

The advantage of the proposed platform is that it allows test drivers of real vehicles to experience being in a large-scale connected vehicle scenario, given that in actuality, only a small number of real, field-test vehicles may be in use, and the rest are simulated. As opposed to evaluating experimental large-scale ITS using a traffic simulator alone, the platform allows for real driver responses to the advice and directions given by the simulator to be observed and fed back to the simulator, in real-time, so that the simulator may process inputs otherwise possibly not predicted. Factors, such as how often a driver would like to receive behavioural recommendations, or how likely a driver is to obey a series of recommendations, can be explored. The platform also adds an element of safety to testing in that field demonstrations can be performed on empty roads or test tracks while scenarios such as wide-spread traffic congestion and accidents are simulated.

The following list outlines a number of ITS applications that could benefit from enhanced demonstration using our platform. The list is, of course, by no means exhaustive, and there are certainly scenarios in which testing with the platform does not make sense.

a) Intelligent Speed Advisory Systems: these include systems that attempt to detect approaching traffic bottlenecks, such as roadwork zones or traffic jams, and provide drivers with resultant updates on recommended travelling speeds; for instance, see [2]. The goal is to reduce road chaos; ensure that vehicles travel at safe speeds and at safe distances from the vehicles ahead of them as they approach, enter and leave the bottleneck; and to increase the overall throughput of traffic in the congested zone. One benefit of testing this kind of system with our platform is that a traffic bottleneck can be emulated on demand in the simulator while proof-of-concept of the system is being demonstrated in a real vehicle. Driver comfort and compliancy with the frequency of incoming speed recommendations can also be assessed.

b) Local Obstacle Avoidance via Re-Routing: the objective here is to intelligently reroute traffic around a local obstacle, e.g. a traffic accident or congestion [3]. Again, a benefit of testing an intelligent system of this kind with our platform is that a road obstacle can be emulated on demand in the simulator while proof-of-concept of the system is being demonstrated in a real vehicle. Further similarity between a real road obstacle and a simulated one exists when, in each case, the driver cannot visually see the oncoming obstacle because it is, for example, around a corner or too far ahead. Yet, at this early stage of approaching the obstacle, the driver may be expected to reroute, and the platform allows for the assessment of driver comfort with these early reroutes.

c) Pollution Control: systems such as twinLIN [4] offer advanced vehicle engine control based on environmental information. Our platform allows one to simulate regional vehicle emissions and air quality while, through the use of additional devices, such as the automated mechanical switch described in [4], imposing mandatory changes to the engine mode of a real vehicle while a driver travels. The impact on the driver of these mandatory engine mode changes can be examined.

Other available hybrid platforms developed by the research community include GrooveNet [5]. GrooveNet is tailored towards exploring protocol design of vehicle-to-vehicle networks, and is not built on SUMO.

III. PROTOTYPE PLATFORM

We now describe the structural components of the platform, and aspects of a demonstration that we performed to test the setup, as follows.

a) Large-Scale Traffic Simulator: SUMO [6] is an open source, microscopic road traffic simulation package primarily being developed at the Institute of Transportation Systems at the German Aerospace Centre (DLR). SUMO is designed to handle large road networks, and comes with a "remote control" interface, TraCI (short for Traffic Control Interface), that allows one to adapt the simulation online. For our demonstration, running SUMO (version 0.16.0) on a Dell Inspiron 7520 laptop (Intel Core i7-3612QM processor and 8GB RAM) with Windows 7 Home Premium operating system sufficed.

b) Real Vehicle: our field-test vehicle was a 2008 Toyota Prius 1.5 5DR Hybrid Synergy Drive. The road network that we generated in SUMO, and the road network that we drove the real vehicle around on, were topographically the same. A virtual vehicle representing the Toyota Prius (i.e. an avatar of the real vehicle) was created in SUMO. This was partially achieved by assigning physical characteristics to the virtual vehicle that were approximately the same as those of the real Toyota Prius. Further details on defining vehicle types and routes in SUMO are available in the user documentation found on the SUMO website [6].

c) Road Network: to generate our road network in SUMO, we imported a map of the National University of Ireland Maynooth (NUIM) north campus from OpenStreetMap.

d) Smartphone: in the Prius, we carried a Samsung Galaxy S III mini (model no. GT-I8190N) running the Android Jelly Bean operating system (version 4.1.2). The purpose of the smartphone was to relay periodic sensor information from the car's onboard computer to the office laptop running SUMO; and to receive messages from SUMO and display them on the smartphone user interface for the driver.

e) A Python Script: we wrote a script in Python 2.7.3 that was run on the office laptop with SUMO and was comprised of two parts: a main part that acted as a client to SUMO, adapting a simulation of a traffic scenario online (via TraCI); and a subprocess part that acted as a server, listening for incoming calls from the smartphone and then handling the data transfer between the smartphone and SUMO.

f) OBD-II Adaptor: the hardware device that we used to connect the Prius' onboard computer to the Samsung smartphone was Kiwi Bluetooth by PLX Devices.[1] A variety of existing smartphone applications are compatible for use with this hardware device. We decided upon Torque Pro[2] given that an Android Interface Definition Language (AIDL) application programming interface (API) is included for third party plug-in applications, which we made use of, as follows.

g) SumoEmbed: SumoEmbed is the name of a plug-in application that we designed for Torque Pro. For the purpose of a demonstration of our prototype platform, we designed the user interface so that it displays, while sending to SUMO over a TCP internet connection, the real vehicle's current speed. In addition, it displays messages that it receives from SUMO. We elected to demonstrate the speed advisory system described in [2]. For this demonstration, the messages received from SUMO and displayed on the smartphone user interface included the detected traffic scenario, recommended vehicle speed, and distance to the next vehicle. Further details on this demonstration are available in [7].

IV. CONCLUSION

A future goal is to make SumoEmbed location aware and perform map-matching on the computer running SUMO.

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