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Do cooperative systems make drivers' car-following behavior safer?

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ABSTRACT

The main goal of in-vehicle technologies and co-operative services is to reduce congestion and increase traffic safety. This is achieved by alerting drivers on risky traffic conditions ahead of them and by exchanging traffic and safety related information for the particular road segment with nearby vehicles. Road capacity, level of service, safety, and air pollution are impacted to a large extent by car-following behavior of drivers. Car-following behavior is an essential component of micro-simulation models. This paper investigates the impact of an infrastructure-to-vehicle (I2V) co-operative system on drivers' car-following behavior. Test drivers in this experiment drove an instrumented vehicle with and without the system. Collected trajectory data of the subject vehicle and the vehicle in front, as well as socio-demographic characteristics of the test drivers were used to estimate car-following models capturing their driving behavior with and without the I2V system. The results show that the co-operative system harmonized the behavior of drivers and reduced the range of acceleration and deceleration differences among them. The observed impact of the system was largest on the older group of drivers.

1. Introduction

Efforts to develop systems that assist drivers in their primary and secondary driving tasks, including intelligent co-operative systems are increasing, and is expected that the number of vehicles equipped with these systems will keep growing in the future. Therefore, understanding the interaction of drivers with these systems, their impact on their driving behavior, and the direction of impact is important.

There are two broad categories of cooperative systems, one based on Vehicle-to-Vehicle (V2V) wireless communication, and the other on Vehicle-to-Infrastructure (V2I and I2V) wireless communication. Cooperative systems focus on increasing the ability of drivers to interact with their environment and respond to situations that develop. Therefore, it is expected that through better situational awareness, traffic conditions and road safety will improve (Kompfner, 2010). The evaluation of cooperative systems, in terms of their functionality, and contribution to traffic and safety conditions, once they are deployed, is a complex task. Detailed observations of vehicle and driver behavior are needed. Collecting such data from a real world environment might put the test driver and the surrounding vehicles in risky situations. Therefore, driving simulator experiments and very limited field tests are used at the beginning for the collection of the required data (McDonald, 2004). However, the direct measurement of the impact of cooperative systems on the overall traffic conditions and the number of collisions under these conditions is difficult (even in field tests). This is mainly because controlled field tests take place

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for relatively short time period, the number of test vehicles is limited, and it is difficult to monitor vehicles which are not equipped with the system.

Furthermore, an important question related to the evaluation of co-operative systems is the impact on traffic conditions at various levels of system penetration. Development of car-following models that capture the behavior of drivers with equipped vehicles is useful in that regard, as traffic simulation models can incorporate the corresponding behavior and be used for the evaluation. Car-following models are essential in microscopic traffic simulation and impact their fidelity (Koutsopoulos and Farah, 2012). In addition, drivers' car-following behavior significantly impacts traffic conditions, safety, and air pollution.

The objective of this paper is two folds: (1) to evaluate the impact of co-operative systems on drivers' car-following behavior using data from real experiment. A comparison between the two estimated models, driving with and without the system, is expected to shed light on the question whether the use of such systems contributes to the traffic conditions and traffic safety and (2) to incorporate, probably for the first time, the impact of certain demographic characteristics as explanatory variables in the estimated car following model. Hence, the impact of these factors can be explicitly assessed.

2. System evaluation

Evaluation of co-operative systems has received considerable attention in the literature. Fig. 1 illustrates an evaluation framework that encompasses both data sources and availability and the corresponding evaluation approach. In particular, the framework is appropriate (and consistent) with current conditions, where experiments (both in the field and with driver simulators) are limited (with respect to the number of equipped vehicles that can simultaneously participate).

Usually, when testing new systems, data is first collected in virtual environments such as using a driver simulator. A virtual environment has several important advantages. It provides a safe and controlled environment, which is critical especially when testing the impact of a new system on driver behavior. Moreover, it provides the possibility to simulate risky situations, the ability to control the factors that could affect driver behavior (traffic, weather, etc.), and to repeat the same

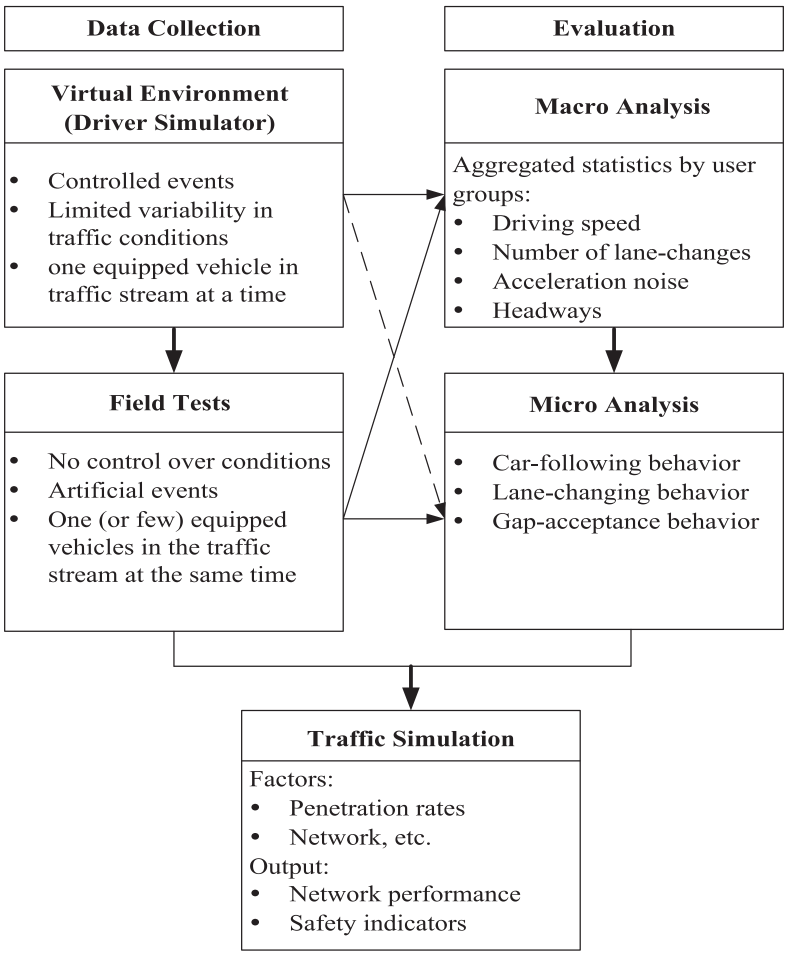

Fig. 1. System evaluation framework.