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Data Collection for Traffic and Drivers' Behaviour Studies: a large-scale survey

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Abstract

Studies of driving behaviour are of great help for different tasks in transportation engineering. These include data collection both for statistical analysis and for identification of driving models and estimation of modelling parameters (calibration). The data and models may be applied to different areas: i) road safety analysis; ii) microscopic models for traffic simulation, forecast and control; iii) control logics aimed at ADAS (Advanced Driving Assistance Systems). In this paper we present a large survey based on the naturalistic (on-the-road) observation of driving behaviour with a view to obtaining microscopic data for single vehicles on long road segments and for long time periods. Data are collected by means of an instrumented vehicle (IV), equipped with GPS, radar, cameras and other sensors. The behaviour of more than 100 drivers was observed by using the IV in *active mode*, that is by observing the kinematics imposed on the vehicle by the driver, as well as the kinematics with respect to neighbouring vehicles. Sensors were also mounted backwards on the IV, allowing the behaviour of the driver behind to be observed in *passive mode*. As the vehicle behind changes, the next is observed and within a short period of time the behaviour of several drivers can be examined, without the observed driver being aware. The paper presents the experiment by describing the road context, aims and experimental procedure. Statistics and initial insights are also presented based on the large amount of data collected (more than 8000 km of observed trajectories and 120 hours of driving in active mode). As an example of how to use the data directly, apart from calibration of driving behaviour models, indexes based on aggregate measures of safety are computed, presented and discussed.

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Keywords: Driving Behaviour; Data collection; Accident Analysis; Road safety; Microscopic; Advanced Driving Assistance Systems; Intelligent Transportation Systems; Instrumented Vehicle.

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1. Introduction

Identification of driving behaviour represents a fundamental requirement for traffic studies and generates benefits especially in three main fields: road safety analysis; microscopic traffic simulation; intelligent transportation systems (ITS).

Road safety analysis aims to understand the causes of accidents and take measures to prevent them from occurring. Safety can be determined according to different approaches. One is based on statistical considerations and concerns identification of so-called *hotspots* (Montella, 2010). Another approach uses *accident scenarios* and is based on statistical inference (Fleury and Brenac, 2001); recurrent conditions are investigated in observed accidents in order to identify prototype unsafe scenarios related to various aspects, such as the road geometry, road section, vehicle characteristics, the pavement and the weather. A third approach, adopted in this paper, is based on the analysis of driving behaviour, computing the so-called *surrogate safety measures* (Tarko, 2009). All approaches require a non-negligible amount of data, often related to car-following conditions, rear-endings being one of the most frequent causes of injuries (excluding accidents that involve vulnerable road users).

Identification of driving behaviour is also a key task for microscopic traffic models, developed to improve the detail of traffic flow studies by explicitly representing the interaction between the single components of a traffic stream. The choices of each vehicle, in terms of spacing with respect to the vehicle(s) ahead, lane changing, gap acceptance, etc., are identified by analytical models. A review of some of these models can be found in Toledo (2007). A major task for microscopic traffic models is their calibration, given that a large number of parameters have to be estimated for each of the modelling components, including car-following.

ITS are advanced applications that embody decision-making and/or operational intelligence in order to provide innovative services. These applications allow both safer and more efficient use of the road by travellers and enhanced traffic management. In the field of ITS, Advanced Driver Assistance Systems (ADAS) represent a real opportunity to both improve road safety and support efficient transportation systems. Not only do ADAS directly influence the interaction among vehicles and thus affect traffic flows and characteristics., but they also control the driving task directly, reducing drivers' errors and shortening reaction times. The development of such systems is not straightforward and many issues have to be addressed, not only from a technological point of view. For instance, it is crucial to be sure that any proposed system considers driver expectation and behaviour and ensures there is a minimal mismatch between the system behaviour and the driver's normal behaviour, thus increasing driver acceptance (Simonelli et al., 2009; Bifulco et al., 2013a). Indeed, an ideal ADAS needs to be based on a good understanding of driver behaviour, particularly in car-following which still represents one of the main fields of application for solutions like ACC (Adaptive Cruise Control) and AEB (Advanced Emergency Braking).

This paper presents the data-collection activities carried out within the Italian research project DRIVEIN^2 (DRIVEr monitoring: technologies, methodologies, and IN-vehicle INnovative systems). The project involves eight partners and focuses on defining methodologies, technologies and solutions to capture driving behaviours, with special emphasis on road-safety solutions. The DRIVE IN^2 project (Bifulco et al., 2012a) falls within the field of ADAS and, among others, aims to implement a Driver-In-the-Loop (DIL) laboratory based on a multidisciplinary approach which involves knowledge of automotive solutions, transportation engineering and traffic psychology. The project relies on driving data collected by means of both an instrumented vehicle (IV) used for naturalistic (on-the-road) observations and a driving simulator (DS). How the IV is equipped and how it is employed in our experimental framework is described in Bifulco et al. (2012b). The reciprocal validation of DS and IV is an on-going task, with first results recently submitted (Bifulco et al., 2013b).

In this paper, after a review of current advances in microscopic data collection (section 2), the experiment is described in detail (section 3). An application of the collected data to road safety analysis is presented in section 4. Finally, the results are discussed and conclusions are drawn.