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Influence of driver characteristics on emissions and fuel consumption

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Abstract

Fuel consumption and atmospheric pollution emissions of vehicles depend on driving conditions, the characteristics of the driver and the car. The influence of driving style on the environmental aspects of a car journey has been investigated. Driver characteristics were determined by a Driver Behaviour Questionnaire and observed acceleration and deceleration behaviour. That results in four types of drivers with similar characteristics within a type group. We measured 56 trajectories of 28 drivers using GPS devices. The measurements were done on a route of 8.4 km in an urban environment in Chengdu (PR China). From the trajectories, the emissions and fuel consumption were determined with the Comprehensive Modal Emissions Model. The results were related to the traffic control along the journey resulting in fuel consumption and emissions per stop and per second idling. There are significant differences in saturation flow, emissions and fuel consumption between different driver types. Cautious, novice drivers have the lowest emission and fuel consumption and give the lowest saturation flow and have the lowest cruise speed; experienced smooth driving drivers give a high saturation flow while keeping fuel consumption and emissions also low. Aggressive experienced drivers have a high saturation flow and fuel consumption / emissions. Therefore, microscopic traffic models that simulate emissions and fuel consumption should take the differences between driver types into account.

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1. Introduction

The determination of fuel consumption and air pollution emissions (shortly: emissions) of road traffic is important for policy making and the management of the driving conditions on the roads.

It is well known that different people behave differently when they drive their car. The performance of a novice driver is different from an experienced driver. Impatient and aggressive driving is characterized by a fast reaction to a changing driving situation, strong accelerations and braking and short headways to a car in front. The applied accelerations and speeds during a trip determine emissions and fuel consumption (e.g. Nam et al. 2003).

In previous research, Li et al. (2015) analysed different characteristics of drivers (acceleration at different speeds, self-assessment by a questionnaire etc.). Based on factor analysis of 23 personal characteristics they identified four types of drivers. These driver types are given in the following description:

1. Aggressive, macho and unsteady
2. Conservative, careful, novice
3. Professional, smooth going
4. Experienced, speeding.

Drivers with different types behave differently, which has an influence on the fuel consumption and emission of their car.

In urban road networks the traffic control and road characteristics determine for a great deal the driving, deceleration and acceleration of cars. Brundell-Freij and Ericsson (2005) showed that 9 factors are dominant for the fuel consumption and emissions, among which the stopped time, speed changes and the time driven with high accelerations and high engine speed. These factors are especially influenced by traffic control and by the characteristic of the drivers. While Brundell-Freij and Ericsson and Nam et al. (2003) determined the characteristics of the drivers that participated in their research ex-post based on their driving performance and a few personal characteristics, we have determined the classification ex-ante based on 23 personal characteristics.

Traffic control can be optimized to reduce fuel consumption, which is normally done by reducing the number of stops. However, the way drivers react on traffic lights is different: some slow down gradually, others use their brakes just on a short distance from the stop line. The acceleration can be smooth or aggressively. Those all have influence on the emissions and fuel consumption. Therefore, the most important factors related to the emissions and fuel consumption for urban trips are the driving pattern as related to the driver type and the traffic conditions. In the research reported in this article we want to show that the ex-ante characterization of drivers is a useful instrument to analyse different driving behaviour and to show that different driver types need different traffic control.

The following section gives a short introduction on the models that can be used to estimate emissions and fuel consumption from trajectories. In order to analyse the influence of the driving behaviour and personal characteristics we measured how 28 drivers in Chengdu (the capital of Sichuan province of China) were driving along a track in an urban environment. This survey is described in the section 3. We have analysed the driving behaviour and the relation with the driver type. That is described in section 4. Finally in section 5 we analysed the traffic control on a part of the test route and investigated whether the optimized traffic control depends on the driver type.

2. Modelling emissions and fuel consumption

In order to get grip on the influence of traffic characteristics on emissions and fuel consumption several models have been developed for the emissions of individual motor vehicles. The U.S. Environmental Protection Agency (2003) developed the MOBILE6 model based on measurements of emissions and fuel consumption of cars in laboratory situations driving the standard driving cycles (Barlow et al. 2009). Later, Portable Emissions Monitoring Systems (PEMs) have been used to obtain data on emissions in specific situations like sudden accelerations (Frey et al. 2006). In 2006 the Comprehensive Modal Emission Model (CMEM) has become available, which contains a database of various motor vehicles. This model not only gives emissions and fuel consumption in different driving conditions, but also simulates the effect of the age of a motor vehicle, the state of maintenance, ambient air