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Assessing the importance of vehicle type for the implementation of eco-routing systems

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Abstract

Nowadays, several methods to promote a more sustainable distribution of traffic flows are available. In response to rising energy costs and increased environmental concerns, eco-friendly route choices can be provided individually by means of smart navigation tools that allow several vehicle routing options designed to minimize air pollutant emissions and fuel consumption. Simultaneously, the use of intelligent road pricing systems and the use of variable message signs can change the route choice process of drivers (and thus network equilibrium), by varying the perceived attributes of competing routes. However, so far too little attention has been paid to the fact that the eco-friendliness of various routes may change, depending on vehicle characteristics which may cause problems on the efficiency of these systems. This issue has been empirically addressed in this research, using a database of more than 13,330 km of GPS data in six different Origin-Destination (OD) pairs and 9 different routes. Simultaneously, two different approaches for estimating (CO_2, HC, CO, NO_X) emissions were tested: a) second-by-second vehicle dynamics, using the Vehicle Specific Power (VSP) instantaneous model; and b) route average speed using the EMEP/EEA methodology. The results show that depending on the characteristics of the routes associated with a certain OD pair, the eco-friendly route may differ according to the vehicle model and the emissions estimation method. Innovative approaches to provide accurate emissions and eco-routing information are needed.

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Keywords: Eco-routing, emissions modelling, vehicle characteristics, VSP, EMEP/EEA

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1. Introduction

In spite of recent technological advances, transportation sector is still producing major impacts on the economy and environment. Indeed, the success in decreasing transportation emissions has been lower than desirable due to several factors such as the urban sprawl and several obstacles to the market penetration of cleaner technologies. As a result, the "Europe 2020" strategy has underlined the relevance of improving the efficiency in the transportation networks through the better use of the existing infrastructures. Different measures to promote a sustainable use of existing infrastructures may comprise behavioral changes in the operation of vehicles (eco-driving) as well as the selection of routes with lower emissions impacts. Section 2 shows that extensive research has been carried out on the potential of eco-routing systems for reducing emissions. So far, however, there has been little discussion about 1) if eco-routes are regularly the same among different vehicle types and ii) if different methodologies for calculating emissions may originate different eco-friendliness route ratings. Using an extensive database of GPS data, this paper attempts to contribute by examining these issues in different routes connecting three (Origin/Destination) (OD) pairs with very different characteristics.

2. Literature review

Previous literature has highlighted the potential and applicability of a correct route choice as a tool for reducing emissions. Usually the impact of the route of choice in terms of emissions is done using different types of models. Several case studies (Benedek and Rilett, 1998; Guo et al., 2013; Zhang et al., 2010) applied emissions models based on average speed to estimate the emission impacts of eco-routing strategies. Other authors applied instantaneous emissions models to evaluate the impact of route choice in terms of emissions and fuel consumption (Ahn and Rakha, 2013; Bandeira et al., 2013; Barth et al., 2007; Ericsson et al., 2006; Frey et al., 2008; Guo et al., 2013; Gwo Hshiung and Chien-Ho, 1993; Minett et al., 2011; Rilett and Benedek, 1994; Zhang et al., 2010). Instantaneous emission models (such as VSP, CMEM, VT-micro) clearly include congestion in the modelling process, but for average speed models (such as COPERT), this could not be determined directly (Smit et al., 2008). Based on a comparative study performed in a motorway and in an arterial road, Ahn & Rakha (2008) pointed out that use of instantaneous emission models is the most appropriate method to assess different operational traffic scenarios. However, Green et al, (2009) pointed out that there is insufficient understanding of the uncertainties in both types of models as well as the main factors affecting the quality of information.

Currently the majority of pre-trip information (e.g. via *Google maps, Bing maps, ViaMichelin*) and on board information devices (e.g. *TomTom, Garmin*) about an environmentally friendly route is generally provided for a generic vehicle (or with basic information about the type of fuel). This information is typically based on link based average factors which allow the estimation of fuel consumption or dioxide of carbon (CO_2) emissions for different paths. However, there is a lack of knowledge about whether the eco-friendly route choice would be different for different vehicles models. Moreover, other local pollutants, such as hydrocarbons (HC), carbon monoxide (CO), nitrogen oxides (NO_X) and particulate matter (PM), have a strong direct impact on human health and usually are not considered in this type of analysis. Different authors have pointed out that frequently the optimal speed profile to reduce energy consumption cannot be considered ecologically optimal due to increases in other pollutants such as CO and HC emissions (Bandeira et al., 2013; Mensing et al., 2014). A number of researchers have reported the importance of considering the vehicle type on implementing eco-routing systems. Using GPS date and PEMS Frey et al., (2008) have shown that both intra-and inter vehicle variability are significant sources of overall variation in emission rates. Ahn & Rakha (2008) have also demonstrated that the fleet composition should be cautiously examined before executing emissions-optimized assignments which is in line with (Nie and Li, 2013) who have numerically demonstrated that vehicle characteristics influence path choice in eco-routing.

In the context of the AERIS research project, an interface between a vehicle's on-board diagnostic bus, data stream and an on-board energy/emissions model to estimate fuel use has been assessed (Barth and Boriboonsomsin, 2012). The authors have demonstrated that once calibrated, this system can provide accurate instantaneous environmental information of a specific vehicle to a traffic management centre. This information can be applied to adjust different specific Intelligent Transportation Systems (ITS) of the road network such as dynamical signal phase, ramp meters or variable speed limits. However, even considering the recent advances in computational speed, the direct use of instantaneous emissions models may not be a feasible solution to estimate