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Generating Intra and Inter-provincial Commercial Vehicle Activity Chains

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Abstract

Modelling large-scale traffic flow systems at a disaggregate level can be data intensive as it requires extensive knowledge about the activities and activity chains of vehicles. This paper focuses on activity chain generation for commercial vehicles. We use a large sample of GPS records to extract a complex network and sample chain characteristics from. The paper makes a valuable contribution in both its methodology, and in its focus on intra and inter-provincial vehicle populations simultaneously. The simulated chains are validated in terms of vehicle kilometrekilometres travelled and its spatiotemporal accuracy, comparing favorably in both.

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Keywords: Commercial vehicle modelling; activity chain; freight; urban

1. Introduction

Commercial vehicles may account for only a small portion of the total vehicle population, but they contribute disproportionately to the traffic conditions, the impact on road quality, and the environment through noise and emissions. On the positive side, they contribute to the economic activity and resulting gross value-add of a region.

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Winter & von Hirschhausen (2006) use a value of time for commercial vehicles that is three times that of private car commuters. Freight is expensive, though, since transportation costs make up a sizable portion of a country's total logistic cost.

Our interest in this paper is on vehicular movement, and not the commodities transported, as is often the focus in freight flow models. Our understanding of how commercial vehicles behave and move around lags our understanding of how people move around. Many of the freight models are adapted from classical four stage models, for example Marker Jr and Goulias (1998) and Al-Deek, Johnson, Mohamed & El-Maghraby (2000), to name but a few. In practice, many modellers add commercial and freight vehicles as mere background noise. Comparing both aggregate and disaggregate freight models, Hensher & Figliozzi (2007) and Samimi, Mohammadian & Kawamura (2009) highlight the gap in our understanding of freight vehicles' behaviour in order to capitalize on the decision-making benefits that disaggregate freight modelling holds. Chow, Yang & Regan (2010) review the value of disaggregate freight models, noting that good freight demand models should have a strong behavioural foundation. To this extent contributions such as Holguin-Veras & Patil (2005), Ruan, Lin & Kawamura (2012) and Schroeder, Zilske, Liedtke & Nagel (2012) have been very valuable.

Disaggregate modelling approaches can provide more accurate and richer result sets that are time-dependent and allows for aggregation to any level required for better decision-making. But they are more often than not computationally expensive and data intense. Modelling commercial vehicles more accurately and realistically should result in more accurate predictions of travel time as both Gao, Balmer & Miller (2009) and Fourie (2010) show using agent-based models. When testing infrastructure investment decisions, say the expansion of a portion of the road network, improved travel time prediction allows better evaluation of the direct effects (travel time savings) of the investment. Although agent-based models hold promise of improved disaggregate modelling and decision-support, much work remains.

This paper aims to contribute by taking another step in disaggregate commercial vehicle activity chain modelling. We build on an earlier paper by Joubert, Fourie & Axhausen (2010) who show how large-scale scenarios that include both private car and commercial vehicles can be simulated in an agent-based setting using complete activity chains. These chains were the result of passive GPS logging of large samples, and not the consequence of distribution channels (Ruan, Lin & Kawamura, 2012) or complex contract negotiations (Liedtke, 2009; Schroeder, Zilske, Liedtke & Nagel, 2012), the latter two being much more sophisticated, but often unattainable as a first approach for low and middle-income countries, such as South Africa.

The earlier work by Joubert, Fourie & Axhausen (2010) had two main drawbacks, both which we aim to address in this paper. Firstly, the synthetic population of commercial vehicles only accounted for those agents that remain predominantly inside the study area. Ruan, Lin & Kawamura (2012) call these urban commercial vehicle movements while in the context of this paper we will refer to such chains as intra-provincial. The reason is context-specific as we use Gauteng as study area, the smallest of the nine provinces in South Africa and the economic heart of the country (see Fig. 1). It would not make sense to focus on any one of the five metropolitan and district councils within Gauteng as they have morphed into a megacity with the majority of people and goods movements between the metros. In this paper we extend the earlier work and create separate and unique populations for the intra- and inter-provincial commercial vehicles.

Secondly, Joubert, Fourie & Axhausen (2010) sample the commercial vehicle activity locations from a kernel density estimate and randomly sequence them. Although their travel time and spatiotemporal validation affirm their approach, results reveal that the chains significantly overestimated the vehicle kilometrekilometres travelled (VKT). We will employ complex networks to improve on the activity sequencing. In addressing these issues, our paper makes a methodological and substantive contribution. Methodologically, to the best of our knowledge, it is the first integration of GPS records and complex networks to generate activity chains. We demonstrate the use of a large GPS data set (40,000+ vehicles over a six-month period) to generate full-day activity chains. We start by presenting the data and methodology used to extract the activities and activity chains from GPS data, as well as the resulting complex networks. The generation of the activity chains for both intra- and inter-provincial vehicles are explained, after which the simulated chains are validated. We conclude with suggestions for further development.