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A micro-simulation model system of departure time using a perception updating model under travel time uncertainty

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Abstract

Existing microscopic traffic models have often neglected departure time change as a possible response to congestion. In addition, they lack a formal model of how travellers base their daily travel decisions on the accumulated experience gathered from repetitively travelling through the transport network. This paper proposes an approach to account for these shortcomings. A micro-simulation approach is applied, in which individuals base their consecutive departure time decisions on a mental model. The mental model is the outcome of a continuous process of perception updating according to principles of reinforcement learning. Individuals' daily travel decisions are linked to the traffic simulator SIAS-PARAMICS to create a simulation system in which both individual decision-making and system performance (and interactions between these two levels) are adequately represented. The model is applied in a case study that supports the feasibility of this approach.

Keywords: Micro-simulation; Congestion; Departure time choice; Learning and adaptation

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1. Introduction

Congestion is a major problem in urban areas throughout the world, causing both economic and environmental damage. Congestion occurs when the demand for travel exceeds the capacity of the existing road infrastructure at a certain location and at a certain time. Policies that are typically applied in urban areas to resolve (or at least reduce) congestion problems are often aimed at increasing the capacity of the road infrastructure, by adding additional lanes or by optimising control systems (ramp metering, coordinated traffic signalling). In any case, the additional capacity is added to a complex traffic system, which is close to (or has already exceeded) system capacity. As a consequence, the behaviour of the system in response to minor changes in traffic demand or road capacity may be highly non-linear.

A suitable way of describing systems in such states is the use of micro-simulation models. Micro-simulation models describe the behaviour of individual decision makers, but also the interaction between the system level and the individual, e.g. due to limitations in the capacity of the system. Micro-simulation models are increasingly regarded as particularly suitable for modelling non-linearities in systems' behaviour under critical situations (see Nagel and Raney, in press). In particular, the emergence of system-level phenomena such as congestion is more easily modelled in a bottom-up fashion. An additional advantage of micro-simulation models is that the behaviour of individual actors can be specified in accordance with behavioural principles, found in physiology, psychology or economic science, that go beyond the utility maximising assumptions used in analytical models. For example, existing analytical traffic allocation models assume that travellers have perfect information of travel times in the network, which is an unrealistic assumption. Applying learning-based algorithms may lead to different and probably more realistic assignments (Nakayama et al., 1999).

A drawback of micro-simulation models has long been their computational requirements, but this argument has lost its power in the light of improved computer technology. As a result, the last decade has shown the release of a considerable number of microscopic traffic simulators (e.g. Nagel and Raney, in press) that are often available as commercial software packages. Nowadays, microscopic traffic simulation is often used in many practical situations (e.g. Mahmassani and Jayakrishnan, 1991; Anderson and Souleyrette, 2002; Klügl and Bazzan, in press; Rossetti and Liu, in press).

Notwithstanding the usefulness of microscopic traffic simulators for applied traffic forecasting, their scope is often limited to route choice in a transport network, assuming an OD-matrix with fixed departure time profiles for each OD pair. This does not seem justified in settings with high congestion levels. Many publications (e.g. Jou et al., 1997; Mahmassani and Liu, 1999; Kroes et al., 1996) emphasize the importance of departure time choice as a potential response to congestion. Ignoring departure time as a response to policies aimed at the reduction of congestion (which is common practice in applied micro-simulation modelling) may therefore lead to biased results. In particular, it can be argued that individuals will try to maximize their trip utility by both minimizing travel time and arriving as close as possible in the vicinity of their preferred arrival time. In congested settings, this implies trade offs between travel time and arrival time, involving both route and departure time switches. Ignoring departure time switches and so-called schedule delays (diversions from someone's preferred arrival time), will lead to wrong assessments of generalized travel costs (see de Palma and Marchal (2002) for a more elaborate discussion).