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Handling uncertainty in route choice models: From probabilistic to possibilistic approaches

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Abstract

In order to design effective advanced traffic information systems (ATIS) suitable mathematical models have to be defined to simulate the effects of information on users route choice behaviour and then to incorporate it into traffic assignment models to estimate how traffic demand loads the roads network.

To face this problem it is necessary to deal with uncertainty that plays a crucial role in the users decision-making processes.

To this purpose this paper first analyses how uncertainty affects users' route choice process and how traffic assignment models may take it into account.

In literature route choice behaviour modelling is widely solved within the random utility theory framework but, we show in this paper that such an approach only considers one type of uncertainty. More precisely, the consideration of randomness of traffic by drivers is, for example, hardly ever represented in classical models in spite of its importance in the management of information by drivers.

Starting from the presented analysis a new route choice model is also proposed to represent explicitly the uncertainty lying in users' route choice behaviour. It is based on recent developments in possibility theory which is an alternate way to probability theory in order to represent or measure uncertainty.

Keywords: Traffic assignment; Route choice; Uncertainty; Possibility theory; Expected utility theory; Fuzzy logic

1. Introduction

Traffic managers goals concern with the optimization of roads network performances improving the traffic conditions, reducing the congestion

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as well as the noise and pollutants emissions. Actually, traffic flows are originated by independent drivers who seek their own individual optimum and those drivers can use several different routes, without notifying nor explaining their choice to the road manager.

Thus, before controlling the traffic (towards a "social" optimum), traffic managers have to understand how drivers behave. For this, they use models or representations of this behaviour in order to predict how traffic flows spread out over the roads network. In this paper, we will focus our attention on the drivers route choice process and on the resulting models which are referred to as traffic assignment models.

Till now, such models have almost always supposed that each driver knew the traveling conditions all over the network and was capable of predicting the future traffic conditions so that his/her route choice decision is optimal.

Of course such an assumption is rarely true, but it has been made as a first approximation to enable traffic assignment calculation. Actually, imprecision and uncertainty remain in drivers route choice and it is not necessarily optimal.

Furthermore, for several years, attention has been paid to some emerging which are supposed to reduce congestion by giving information to drivers and, therefore, by diverting several of them from congested areas. In the design and for the a priori evaluation of such systems, traffic assignment models are to be used but such models will have to consider that drivers make their route choice, without knowing the current traffic conditions nor being able to predict their evolution.

In this paper, we propose to analyze the uncertainty lying in the route choice process and, more particularly, how traffic assignment models take it into account. We will see that most classical solutions only deal with part of the problem and that other types of models have to be considered, based on an explicit uncertainty consideration.

Finally, we will propose a new framework for static traffic assignment modeling which is based on some recent developments in the decision theory field and which uses possibility theory, an alternate theory to probability for measuring uncertainty.

The necessary elements of non-classical theories dealing with uncertainty (i.e.: non-probability-based theories) will be briefly reviewed throughout the text.

2. The traffic assignment problem

2.1. Problem reduction

The problem we are interested in can be simplified as follows. Considering an intersection and a flow arriving at a rate q (for example in vehicles/hour) and going to a given destination, what will be the flow q_i using each possible exit route i? Or, in a similar way: what proportion $\gamma_i = q_i/q$ of the entering flow will use each exit? And what would be the impact of any traffic information given to drivers before they choose their route?

Of course, generally, the problem is much more complex. We should consider not only one single isolated intersection and only one destination, but several ones; the different possible routes are not necessarily independent, whereas we will suppose they are; time of arrival in the intersection will not be taken into account and we will suppose traffic is in a stationary state, etc.

But, even if we are not able to predict traffic assignment in a general case, the proposed simplifications makes the result of models understandable and it provides some interesting clues to realize the effects of information on traffic assignment.

2.2. Rationality assumption

We assume that drivers are rational decision makers, they travel for a given purpose (say, work, leisure, etc.) trying to minimize their generalized travel cost.

Such a generalized cost can include a lot of factors such as the travel time, the monetary costs (petrol, tolls, etc.), the travel distance, and so on. But a very large number of drivers are to be considered at the same time (several hundreds of thousands for the morning peak hour in a medium-sized city) so that a multi-criteria analysis would be very complex. Furthermore, we are not