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Uncertainty management in traffic modelling

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In the last century, contributions from engineers, physicists, mathematicians, and behavioural psychologists have lad to a better understanding of driver behaviour and vehicular traffic flow. The focus is the ability to forecast the effect on real systems of different applications ranging from novel driver-assistance systems, to intelligent approaches to optimizing traffic flow, to the precise detection of traffic jams and the short-term forecasting of traffic for dynamic navigation aids.
Increasingly sophisticated models have been therefore developed in the attempt of reproducing the intrinsic complexity of traffic behavior (and that of its components). The challenge and anxiety of providing "certain" answers has however diverted the attention from a basic consideration: "What makes modeling and scientific inquiry in general so painful is uncertainty. Uncertainty is not an accident of the scientific method, but its substance" (Saltelli et al., 2008).
As a matter of fact, (commercially) available traffic simulation models are "fancy"tools of (almost) non-demonstrated utility. In addition, the scientific community is only marginally contributing to identify correct ways to use what is available dealing in a proper manner with the underlying uncertainties of our tools. This is leading to the paradoxical situation in which the outputs of a traffic simulation are likely to be more affected by the assumptions made to define proper distributions for the model inputs than from the model itself.
This deep quandary stems from two main factors: i) traffic dynamics are the results of the combination of several mutually correlated stochastic elements (drivers' behavior, environmental conditions, system performances, etc.), and any observation of the transportation system is just one of the possible occurrence generated by the same inputs.
These elements of intrinsic complexity call for the definition of suitable frameworks for the management of modeling uncertainties. Objective of the present work is to show how Monte Carlo methods can be fruitfully applied to make these frameworks operational.

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