Global sensitivity analysis of high-dimensional traffic micro-simulation models: a multi-step approach

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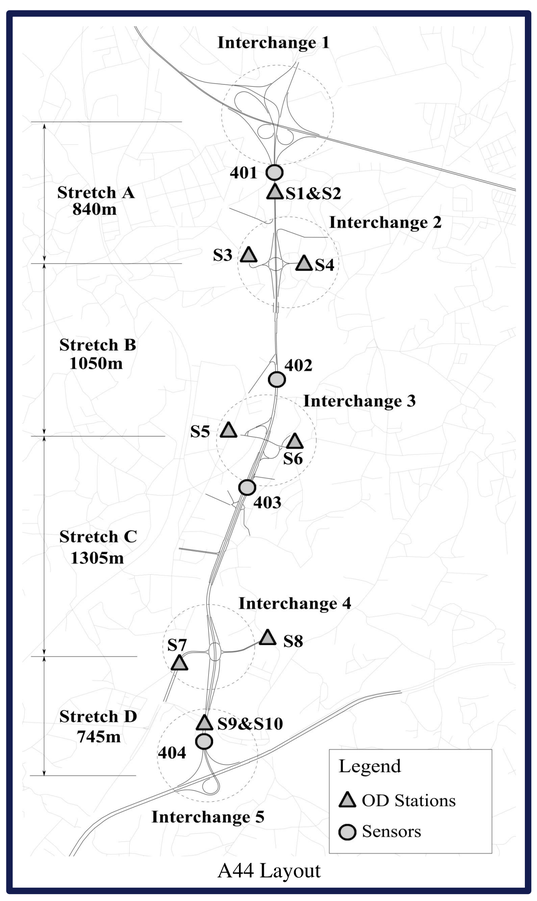


A44 Layout

The calibration and validation of traffic simulation models is a key step in any simulation application. Sensitivity analysis is crucial for a true comprehension of these models behavior, but the main obstacle towards an extensive use of the most sophisticated techniques is jeopardized by the high number of model runs usually required, especially in case of high number of model parameters. We propose a multi-step approach in which a preliminary analysis is carried out on groups of model parameters owning common features (e.g. same sub-model). The the sensitivity analysis of parameters in the most influential groups can be performed. The proposed methodology has been applied to the MITSIM model (101 model parameters) and has allowed uncovering the role played by the different parameters and by the model stochasticity with 80% fewer model evaluations.

Materials and methods

Location & geometric design

The network chosen for this study was the A44 urban motorway in the region of greater Porto, Portugal. It is a dual-carriageway motorway with two 3,50m width lanes, and 2,00m width shoulders in each direction.

Available data

Fixed loop sensor counts and speed aggregated by periods of 5 min were used. Counts and speed at the 8 detection locations resulting from the simulation were compared with the true measures via 3 GoF Measures (RMSE, RMSPE, and U).

MITSIM

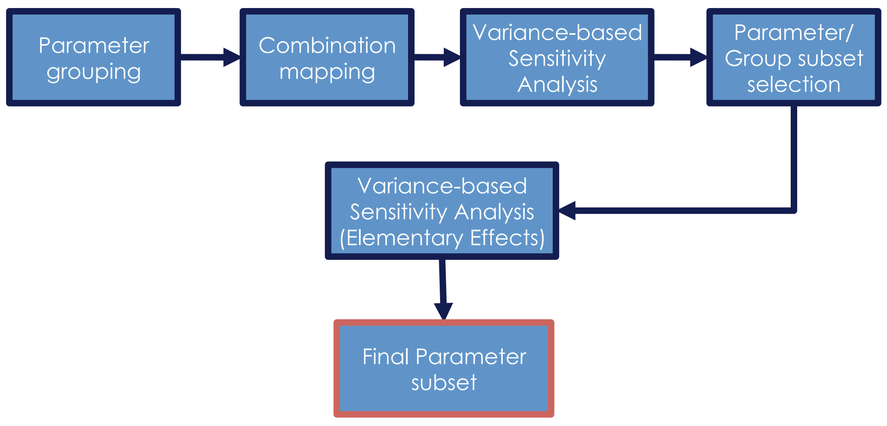
MITSIM integrates four levels of decision-making: target lane, gap acceptance, target gap and acceleration, in a latent decision framework based on the concepts of short-term goal and short-term plan.

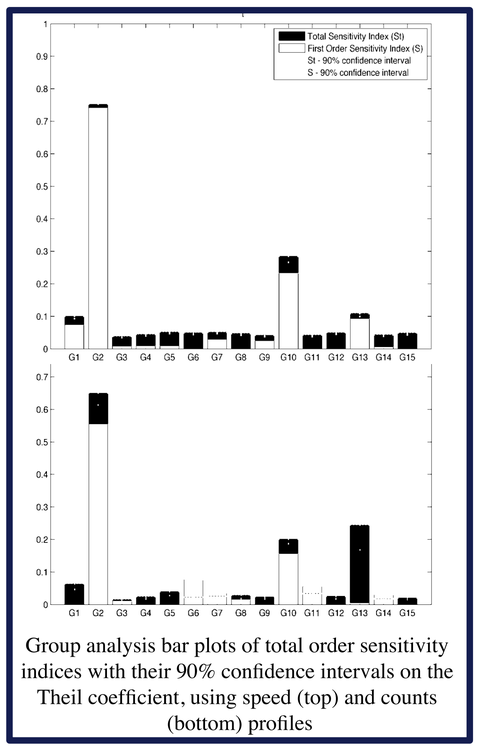
Sensitivity analysis – Group Analysis

The 101 parameters of the MITSIM model were divided in 15 groups corresponding to the 15 different behavioural sub-models. Per each group 1.024 combinations using Sobol's sequences were identified. **Variance-based sensitivity analysis was applied.**

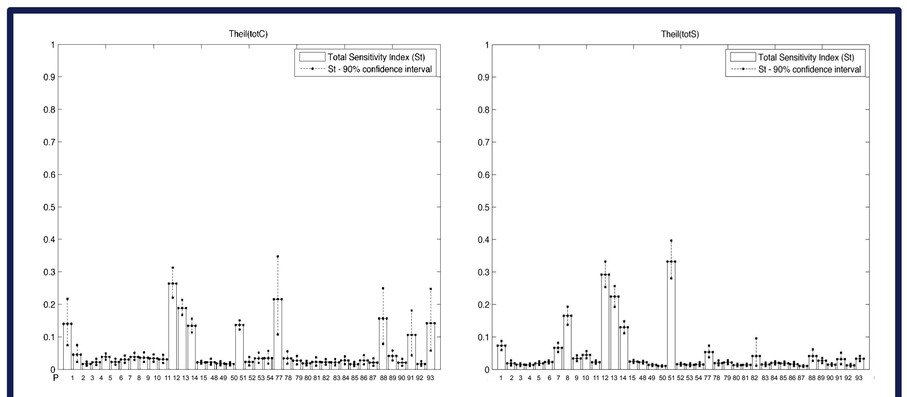
Sensitivity analysis – Elementary effect

34 parameters in total, were considered for this final analysis. All parameters from Group 1 (Reaction Time), Group 2 (Car Following Model), 10 (Driver Heterogeneity Model) and 13 (Lane Utility Model) were used. A consequent reduction of 2/3 in the number of parameters was achieved. A Monte Carlo experiment of size of 512 (18.432 model evaluations) was carried out.





Group analysis bar plots of total order sensitivity indices with their 90% confidence intervals on the Theil coefficient, using speed (top) and counts (bottom) profiles



Elementary Effects bar plots of total order sensitivity indices with their 90% confidence intervals on the Theil inequality coefficient, using counts (left) and speed (right)

Results and discussion

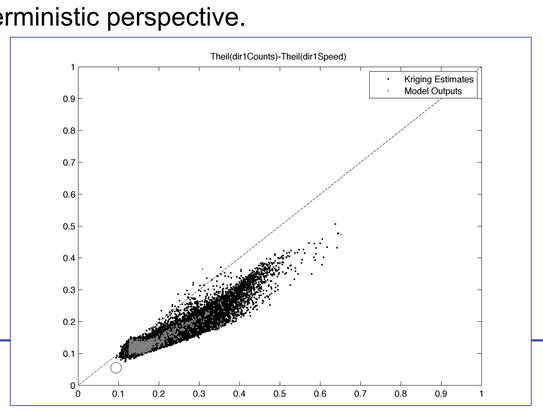
The proposed methodology has been applied to the high-dimensional MITSIM model (101 model parameters) and has allowed uncovering the role played by the different parameters and by the model stochasticity with 80% fewer model evaluations.

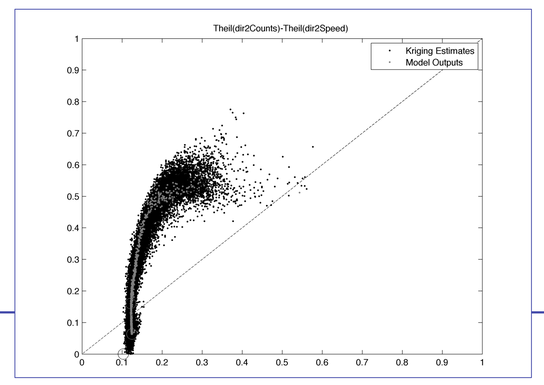
The group analysis allowed individuating the four most important sub-models, namely the reaction time, car-following, the lane utility and the drivers' heterogeneity models. It also allowed choosing among different possible measures of goodness of fit and among different traffic measures those able to better depict traffic dynamics.

The final sensitivity analysis has then been performed with the last 34 model parameters and has allowed individuating a group of **9 parameters accounting for almost the 90% of the output's variance**, with a consequent significant simplification of the subsequent model calibration/estimation phase.

In synthesis, the proposed approach allowed identifying in a quantitative and objective way the most important parameters of the MITSIM model. In addition it has allowed choosing among different possible measures of goodness of fit and among different traffic measures.

The Sensitivity Analysis and the analysis of the uncertainties underlying a traffic simulations has opened up the possibility to review the calibration problem from a statistical rather than from a deterministic perspective.





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