ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

IVT Institut für Verkehrsplanung und Transportsysteme
Institute for Transport Planning and Systems

Sensitivity Analysis of a Microscopic Traffic Model

Qiao Ge, Monica Menendez

Introduction

Microscopic traffic simulators are widely used nowadays. However, they typically have a very large number of input parameters, which makes the model calibration rather difficult and time consuming. In order to overcome these difficulties, the Sensitivity Analysis (SA) is essentially required as a preliminary step for the model calibration. Through SA the modeler can obtain a better knowledge about the relationship between the model inputs and outputs, and hence focus only on the most important parameters for further calibration.

Methodology

The SA method developed in our research is based on the *Elementary Effects* (EE) method. The EE is derived by varying one parameter while keeping all others fixed in each calculation step. The EE for the *i*-th parameter is defined as:

$$EE_i = \frac{Y(x_1,\dots,x_{i-1},x_i+\Delta,\dots,x_k) - Y(x_1,\dots,x_{i-1},x_i,\dots,x_k)}{\Delta}$$

where Y is the model output for k independent parameters X_1 to X_k, and Δ is the variation of the *i*-th parameter. By randomly producing m EE in the input space for any parameter, the sensitivity of the model to that parameter can be evaluated. The computational cost of the basic EE method is $2mk$. This cost can be reduced by sampling with trajectories. A trajectory is a set of k input parameters plus one randomly generated start point in the input space. Along a trajectory each input is increased or decreased by a constant step size (see Fig. 1). By randomly sampling m trajectories, the computational cost is reduced to $m(k+1)$.

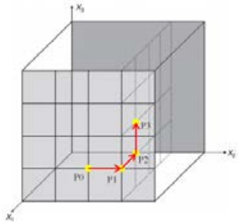

Figure 1. Example of trajectory with 3 input parameters.

The cost can be further reduced by only sampling a set of r ($r \ll m$) Optimized Trajectories (OT) covering as much as possible the input space (see Fig. 2). The difficulty here lies in the selection of OTs. This could be very time consuming when the model is complex and has a lot of inputs.

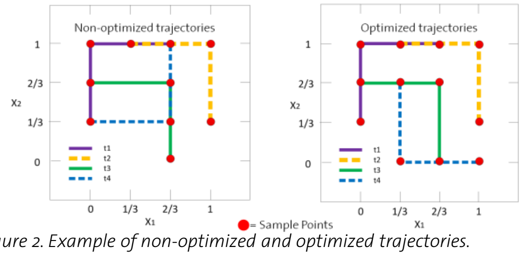

Figure 2. Example of non-optimized and optimized trajectories.

We developed the quasi-OT approach to solve this problem: instead of picking the r OTs directly from the m trajectories, we first eliminate the worst one, then the second worst one, etc. ... until when there are only r trajectories left.

Application and Results

The quasi-OT approach based EE method was applied in the sensitivity analysis for the calibration of a VISSIM model for the city of Zürich. The spatial scope of the network being modelled was quite large (see Fig. 3). It encompassed the inner city of Zürich (a complex urban layout with narrow streets, hills, mixed transportation modes, a large amount of pedestrians, etc.). The complexity of the network resulted computational costs of over 30 minutes for each simulation run.

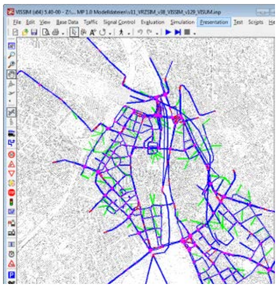

Figure 3. VISSIM network in the study area.

From the total 192 VISSIM parameters, 14 parameters were selected for the SA according to the traffic conditions and characteristics in the Zürich inner-city, previous research and studies, common sense, and our own experience. By using the quasi-OT based EE method, the time cost of SA was reduced from 77 days to only 2 days (see Fig. 4). Results from this project showed that this approach is efficient for dealing with the SA of complex models like VISSIM.

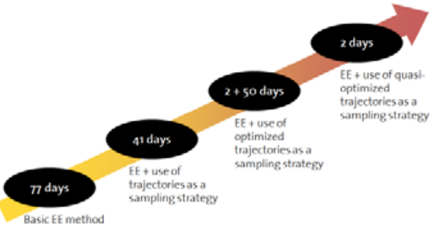

Figure 4. Computational cost of SA by using different methods.

The 14 parameters were sorted by their sensitivity indexes (see Fig. 5). This index represents the sensitivity of the model output to variations in the inputs. The SA showed that the model was very sensitive to parameters 1, 2 and 3 (car- following model), parameter 11 (lane-changing model) and parameter 13 (lane model). Based on these results, those five parameters were selected for the subsequent calibration.

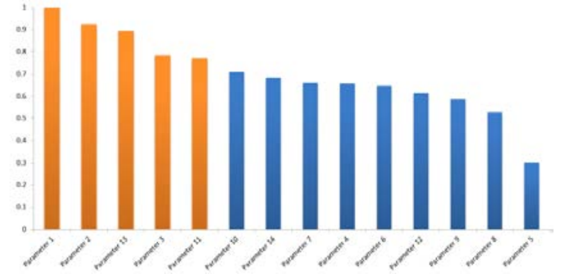

Figure 5. Sensitivity indexes of parameters (sorted from highest to lowest). The parameter with the highest sensitivity is assigned an index of 1.

Traffic Engineering Group (SVT)

IVT
ETH Hönggerberg
CH - 8093 Zürich

Tel. +41 44 633 31 05
E-mail info@ivt.baug.ethz.ch
Web http://www.ivt.ethz.ch