Sensitivity Analysis of Transport Modelling and Simulation to Different Demand Scenarios

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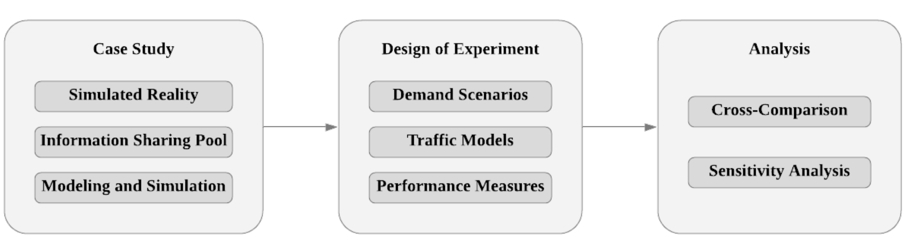
Introduction

Transportation systems have matured into complex systems that demand transport professionals to keep them efficient. These professionals often recur to transport simulation tools to evaluate them. Many simulation tools exist varying in data requirements, methodologies, capabilities, and resolution level. However, there is little guidance on which tool to use. Some studies provide a comprehensive summary of simulation models but rarely direct comparisons. Furthermore, few instances of sensitivity analysis (SA) in transport modeling exist. Some studies investigated the effect of travel demand variability on travel times using microscopic models. Others carried out SA on a mesoscopic model evaluating the parameters' effect on the results. Therefore, it is worth comparing mesoscopic and microscopic simulation models and investigate how sensitive they are to different demand levels

Aims

This thesis aims threefold: First, to develop a systematic approach to compare different simulation models given a common scenario and input data to simulation. Secondly, to perform a sensitivity analysis of the simulation models to different demand levels. Lastly, to evaluate the simulation results based on the theory of the fundamental core models.

Methods and Analysis

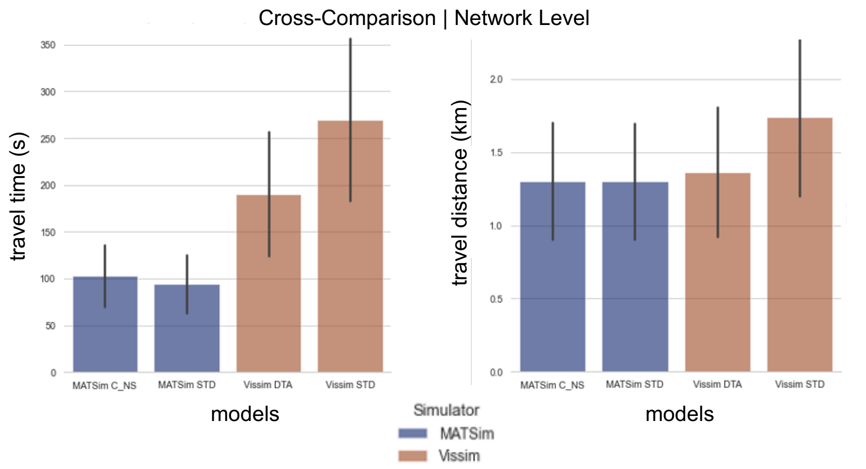


This thesis proposes a systematic approach to compare mesoscopic and microscopic models. The flowchart illustrates the general approach for achieving the aims of this research. The case study has three main steps. In the simulated reality, a microscopic traffic simulation model (Vissim STD) serves as the baseline model and generates a common input data for the base scenario. An information sharing pool stores that synthetic data for the modeling and simulation phase. The traffic simulators pull the required information from the info sharing pool and replicate the base scenario.

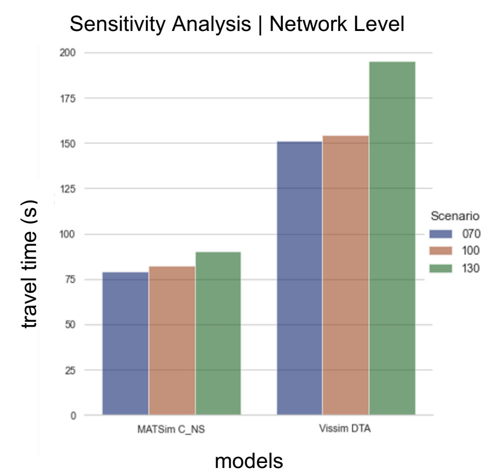
The experiment design encompasses different demand scenarios, choice of performance measurements and traffic models. The demand scenarios are base (100), low (070) and high (130) demand. Next, it defines the traffic models for the analysis. The thesis compares the simulation results of PTV Vissim and MATSim. MATSim STD replicates Vissim STD. Furthermore, alternative models were developed for each simulator. MATSim C NS implements speed and capacity reduction on the throughput of signalized intersections. While the Vissim DTA implements dynamic assignment as route choice strategy. For the performance measures, this study focuses on two statistics: travel time and travel distance.

The analysis starts with the cross-comparison of the traffic models within each scenario. That encompasses statistical visualization techniques, hypothesis testing and correlation methods for a comprehensive quantitative analysis of the simulation results. Next, it applies a sensitivity analysis to investigate the effect of traffic demand variability on travel times.

Results & Evaluation



The bar charts above report the results of two key performance measures (travel time and travel distance) for measurements between all OD pairs. The data represent point-to-point network measurements as aggregated measures (average and standard deviation) over the analysis period, which is two hours of simulation. The MATSim models estimated much lower mean travel time and travel variability when compared to Vissim STD. The Vissim DTA also underestimated the mean travel time and the standard deviation but less than the MATSim models. In terms of travel distance, Vissim STD showed greater values.



This bar chart above represents the sensitivity analysis to different demand scenarios (for Vissim DTA and MATSim C NS, respectively) in travel time measurements between all OD pairs. Note that Vissim produced greater changes in average travel times than MATSim. In Vissim, that change was more significant for the 130% demand.

Conclusions & Recommendations

The mesoscopic models estimated lower average travel time and travel time variability than the microscopic models. The traffic lights and traffic flow models are the main factors for such differences. The microscopic models directly simulate traffic lights, as opposed to the mesoscopic models. Furthermore, the mesoscopic models describe traffic flows as spatial queues, which does not replicate traffic jams close to reality. While the microscopic models rely on driving behavior models such as car-following and lane-changing models. In terms of distance, the models mostly agree. Except for microscopic model with statistic routes that estimated greater values. Note that the route strategy influences the travel time estimates on the microscopic model. Finally, the microscopic model is more sensitive to variation in demand than the mesoscopic model, as expected.