Title: City-scale Traffic Simulation: Calibration and Performance

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Abstract:

Stimulated by the increased complexity in city-scale traffic systems, the fast-increasing computational power of parallel & distributed platforms, and new technologies to collect data, researchers and practitioners have shown interests in city-scale traffic simulations, to support decision making in city-scale transport planning and city-scale traffic management. However, a successful deployment of a city-scale traffic simulation is not trivial. There are several challenges. We focus on two main challenges: the calibration of city-scale traffic simulations and the performance of city-scale traffic simulations. The key problem in the calibration of city-scale traffic simulations is the lack of an effective and efficient methodology to calibrate unknown variables in city-scale traffic simulations. The key problem in the performance of city-scale traffic simulations is the lack of a systematic methodology to optimize the performance of city-scale traffic simulations.

In the calibration of city-scale traffic simulations, this thesis proposes an enhanced calibration algorithm, named "W-SPSA". It is motivated by an observation that the state-of-the-art calibration algorithm (SPSA) deteriorates when the scale of the problem became larger, in terms of the network size and the length of the simulation period. The reason for this deterioration lies in the systematic error in the method to estimate the gradient in the SPSA algorithm. In order to solve the systematic error, a 2-D weight matrix is incorporated in W-SPSA. The 2-D weight matrix represents the correlations between unknown variables and measurements. The idea is successfully demonstrated to calibrate 373,646 time-dependent OD flows in one day in Project DynaMIT on Singapore Expressway Network.

In the performance of city-scale traffic simulations, this thesis proposes a three-step performance optimization methodology to improve the computational complexity and scalability of city-scale traffic simulations. These three steps are framework optimization, serial bottleneck optimization, and scalability optimization. Following the three-step methodology, this thesis illustrates: 1) an Entry Time based Supply Framework (ETSF), 2) an efficient two-dimensional spatial index (Sim-Tree), and 3) a framework to execute city-
scale traffic simulations on the CPU/GPU Platform. The three-step methodology is demonstrated to support the simulation of the Singapore expressway road network from 7:00AM to 8:00AM with in total 106,386 vehicles. The execution time is improved from 6690.2ms to 894.0ms. The three-step performance optimization methodology is suitable to be used as a guideline to optimize the performance of both existing and ongoing city-scale traffic simulations.