New England University Transportation Cen
77 Massachusetts Avenue, E40-
Cambridge, MA 02
617.253.0
utc.mit.

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Urban transportation optimization: a multi-model simulation-based optimization approach

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Principal Investigator:	Carolina Osorio	**Co-Principal Investigator:**	
Title:	Assistant Professor	**Title:**	
University:	MIT	**University:**	
Email:	osorioc@mit.edu	**Email:**	
Phone:	+1 617 452 3063	**Phone:**	

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Consider a subnetwork within a larger urban network (e.g., an arterial within a city, a city within a region) where local changes to the supply of the subnetwork are being considered (e.g., changes in the network design or in the traffic control). Transportation agencies often resort to the use of traffic simulators in order to evaluate the impacts of these changes both locally (i.e., within the subnetwork) as well as globally (i.e. at the larger-scale). Transportation agencies often have multiple simulators that cover the subnetwork of interest. Nonetheless, these multiple simulators may differ in their modeling assumptions (e.g., macroscopic versus microscopic), in their reliability (e.g., quality of their calibration) as well as in their modeling scale (e.g., city-scale model versus regional model). Transportation experts will consider the pro's and con's of each model, and will ultimately choose one model to rely on in order to determine and study in detail the subnetwork changes. The choice of a model is not an easy task. A larger-scale model may, for instance, capture more accurately the local-global interactions; yet may do so at a greater computational cost.
This project proposed a simulation-based optimization (SO) framework that allows for the combined use of multiple simulation models. It aims to achieve a suitable trade-off between obtaining accurate local performance estimates and the associated computational costs. The SO method is suitable to address continuous and generally constrained transportation problems, where the objective function is estimated via simulation, whereas the constraints are available in closed-form and are differentiable.

The methodologies developed build upon state of the art simulation-based optimization techniques. The technique combines information from various traffic simulators: both large-scale and small-scale. The combination takes advantage of the detail of the large-scale simulation models and of the low computational overhead associated with the small-scale simulation models. Their combined use leads to an attractive trade-off between accuracy and computational overhead.

The time-dependent extension of the model allows for dynamic traffic control problems, such as signal coordination problems and real-time traffic control problems, to be addressed more efficiently.

The developed methodologies have been used to study large-scale urban traffic signal control problems. In particular, a case study of the Swiss city of Lausanne was carried out. Results show that significant computational run-time savings are achieved by using the proposed algorithm.

The efficient traffic management strategies resulting from this approach will mitigate congestion in urban areas by enabling us to derive more benefits from existing transportation infrastructure. The same strategy could also be used to identify energyefficient traffic management strategies that will improve the livability of urban communities.

We applied simulation-based optimization techniques to a rail yard optimization problem, and won the second prize at the INFORMS RAS 2013 competition. Starting off with a rule-based simulation model of the rail yard, we were able to optimize the operations of the yard by tuning the rules using simulation based optimization.

Presentations

Osorio, C. and Selvam, K. L. Using large scale traffic simulation models to inform the design of vehicle sharing networks. INFORMS Annual Meeting, October 7, 2013, Minneapolis, MN, USA

Osorio, C. and Chong. L. A simulation-based optimization algorithm for dynamic urban transportation problems. INFORMS Annual Meeting, October 8, 2013, Minneapolis, MN, USA

Posters

Osorio, C. and Selvam, K. Solving urban transportation problems by combining the use of multiple traffic simulation models. Transportation Research Board 93rd Annual Meeting, Washington D.C., January 2014

Chong, L. Computationally efficient optimization method for traffic signal problems. Transportation Research Board 93rd Annual Meeting, Washington D.C., January 2014