



Special issue on dynamic models serving real-time urban transport operations

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Special issue on dynamic models serving real-time urban transport operations

1. Introduction

This special issue originates from the 20th EURO Working Group on Transportation Meeting (EWGT) held in Budapest in 2017. In the submission phase, almost 400 abstracts were received, from which more than 180 final papers were accepted. The conference program was run in 5 parallel sessions and with more than 220 participants from almost 30 countries. The submitted papers were reviewed by members of the scientific committee, the international program committees and by external experts. From these papers, the ones with specific excellence and relevance were invited to this special issue. Thus, papers of this special issue are addressing the above-listed topics through real-time dynamic models, novel methodological contributions and relevant case studies.

A few papers in the special issue deal with the optimization and control of urban vehicles, such as buses, metros and connected cars aiming to optimize either waiting time of passengers, the fleet size of companies or traffic conditions.

The first paper focuses on the modeling, analysis, performance evaluation and control of urban bus networks characterized by conflicts, synchronization and concurrency using two complementary formalism Petri nets. The aim was to evaluate some metrics within various stations of the bus network, such as arrival, boarding, disembarking and waiting times of each passenger at any network station. Also, the influence of the limited capacity of the buses on passenger travel time was assessed. This was extended with a control approach enabling to determine a compromise between the capacity and number of buses to minimize both waiting time of passengers and transportation company cost.

With reliable and accurate predictions of short-term passenger flow, metro agencies can assign proper trains and crews, optimize schedules and operate efficiently. The second paper presented a hybrid model to forecast short-term passenger flow aggregating SVR-based submodels. The submodels considered not only data from a reconstructed chaos attractor but also periodic historical data. Passenger flow data were used to model implementation and performance evaluation. Results confirm that the proposed EICSVR model was able to significantly improve predictive performance. The accuracy and stability obtained in the empirical study indicated that the proposed model has good development potential for forecasting.

Fleet control cannot be only applied to public transport but also to connected cars due to advances in vehicle technology. Thus, variable speed limit systems can be used to improve traffic conditions by adjusting the speed limits based on the current traffic situation. Connected vehicles can continuously transmit information about their speed and location, which can be used to estimate the current traffic condition at arbitrary locations. The aim of the paper was to allow the application of variable speed limits for

non-recurrent bottleneck mitigation at arbitrary locations, unlike today's systems which require densely placed detectors or are limited to beforehand known bottleneck locations. The proposed system is evaluated by microscopic traffic simulation, and the results indicate that the variable speed limit system managed to improve traffic efficiency in a simulated scenario.

Considering further development of traffic control strategies, an enhanced version of two traffic flow models were presented in the next paper to integrate these models within an urban traffic control framework. The synchronization approach was adopted, and three objective functions were considered and compared: two were mono-criterion and the third was multi-criteria. Simulated annealing and multi-objective simulated annealing were used as a solution algorithm. In terms of traffic flow representation, the approaches analyzed were macroscopic cell-based and mesoscopic link-based, both able to model path choice behaviors and vehicle dispersion phenomena. Furthermore, traffic flow prediction was pursued through a Kalman filter and a rolling horizon approach was adopted as a forecasting framework for the optimization procedure.

More focusing on travel behavior in urban areas, agent-based models can efficiently support transport operations. In this special issue, two papers were selected dealing with the assignment of users to vehicles solving the ride-sharing problem of a single trip and with the creation of optimal activity chains of users including several trips during the day.

Already several companies have successfully applied the classical dial-a-ride method, in which users are assigned to vehicles to minimize the cost function under a set of constraints. As an advanced approach in the first paper, an agent-based model was constructed, where two operating strategies were described: the pick-up strategy was applied at the vehicle level, and then it was applied at global service level with vehicles being shared dynamically and making extra stops to collect travelers with different destinations. At each iteration, the set of possible options depending on itinerary and demand were tested first for already assigned vehicles, then for free vehicles. The option associated with the maximum utility was selected to set the vehicle or service strategy. A case study illustrated the comparison between both strategies and evaluated the efficiency of several service choices.

In order to provide the optimal choice of activity locations and travel time reduction of passengers in a city, in the other paper, a daily activity chain optimization method was elaborated including temporal and spatial flexibility of the activities. In the course of the optimization process, possible alternatives were searched using a modified version of the Traveling Salesman Problem with Time Window method. The method was extended with a genetic algorithm to provide an optimal order of activities as the minimum of the cost function (i.e. travel time). Three transportation modes were considered: car, public transport and combined (public transport with car-sharing). To provide some insight regarding the performance of the optimization algorithm, application-oriented simulations were performed on a real-world transportation network using real travel time information.

If we consider a wider context, traffic control methods could be also used on highways, where different traffic dynamics have to be applied. Two selected papers deal with estimating traffic state in freeway situations and with multi-objective control of metered ramps at ring-road junctions.

In the first paper, a real-time traffic state estimation algorithm was developed, where the evolution of the traffic was defined by a second-order macroscopic model, which computes

for each section of the freeway, the density and the mean speed according to several nonlinear equations. The new method incorporates natural constraints in the state variables, which was applied to the macroscopic model obtaining better results. To validate the proposed method, a simulation over a freeway section was made using two different tools: the macroscopic simulator called METANET and the microscopic simulator called SUMO.

The second paper presented a set-theoretical approach for a multi-objective control design of the local ramp metering problem. Two control objectives were specified: the optimization of traffic performance by the minimization of total time spent, and the emission factor of CO₂, which needed to be minimized, too. As the optimal state for traffic emission lies in the unstable domain of the dynamic system, the control problem was formalized for the multi-objective optimization problem using set-theoretical methods. For this purpose, the nonlinear model METANET was rewritten in a shifted coordinate frame with a parameter-varying, polytopic representation. These sets were used for the design of an interpolated controller that can improve traffic conditions according to the prescribed multi-objective criteria.

The eight papers included in this special issue provide comprehensive coverage of dynamic models serving real-time urban transport operation and present recent advances in the area of transport modeling. The guest editors would like to express their sincere gratitude to the editor-in-chief of the journal for providing an opportunity for this special issue to be published. The guest editors would like to thank all authors and reviewers for their highly appreciated contribution to this special issue.

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