SimMobility & Aimsun Workshop

13:30 – 18:00 Thursday 20th June 2024

Otakaari 1, Espoo, Finland

The workshop will cover topics relevant to modelling the demand and supply of new technologies using data-driven and simulation-based tools as well as demand and congestion management. The different research topics to be presented use the state-of-the-art SimMobility and Aimsun tools.

13:30-13:35	**Welcome and Agenda introduction** – Dr. Bat-hen Nahmias- Biran (Tel-Aviv University) & Prof. Claudio Roncoli (Aalto University)
13:35-13:45	**Opening remarks** – Prof. Moshe Ben-Akiva, MIT
13:45-14:55	**Demand and congestion management**
13:45-14:00	The role of microsimulation to support the management of congestion at big events: the case study of Allianz Arena in Germany
14:00-14:15	Evaluating congestion pricing schemes using passenger and freight microsimulation in SimMobility
14:15-14:30	SimDanmark: An activity-based simulation for Denmark
14:30-14:45	Assessing the impacts of tradable credit schemes through agent-based simulation
14:45-14:55	Questions
14:55-15:15	**Break**
15:15-16:20	**Machine learning approaches to enhance simulation-based tools**
15:15-15:30	Enhancing bike-sharing system operation through supervised machine learning and smart data management
15:30-15:45	Bayesian Optimization of tradable credit schemes through agent-based simulation
15:45-16:00	(Meta-)SimMobility: Research directions towards wide scalability and generalisation
16:00-16:15	Synthetic population generation using Generative Adversarial Networks: A case study in Denmark
16:15-16:25	Questions
16:25-16:45	**Break**
16:45-17:45	**Modelling new technologies using state of the art tools**
16:45-17:00	Sustainable automated mobility-on-demand strategies in dense urban areas: A case study of the Tel Aviv metropolis in 2040

17:00-17:15	Performance matters: Assessing the lost potential demand of an on-demand AV service
17:15-17:30	Sustainable last-mile logistics: a joint optimization-simulation framework for multi-purpose cargo-bike fleet scheduling
17:30-17:45	Quantifying the environmental impact of autonomous vehicles in urban settings
17:45-18:00	Questions
18:00	**Close of workshop**

Abstracts

First session: Demand and congestion management

The role of microsimulation to support the management of congestion at big events: the case study of Allianz Arena in Germany

Juan Angarita, Aimsun (representing the GEMINI project, https://www.geminiproject.eu)

Traffic congestion is a phenomenon that has multiple economic, social, and environmental issues. In some particular contexts, like sporting events at great venues, congestion amplifies its impacts in the aforementioned dimensions, especially when cars are a predominant means of transport. Therefore, designing and deploying traffic management strategies is crucial to deal with congestion and its associated externalities. This work focused on using traffic simulation to model and test the impact of traffic management measures on congestion. To this end, we use microsimulation and historical parking occupancy data to evaluate the impact of lane separation policies, which allow us to reduce travel times before and after games. Therefore, this approach seeks to solve transportation issues in very high-traffic density scenarios.

Evaluating congestion pricing schemes using passenger and freight microsimulation in SimMobility

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We examine the impacts of several congestion pricing schemes on both passenger transport and freight in an integrated manner using SimMobility. Through simulations of a prototypical North American city, we find that a distance-based pricing scheme yields larger welfare gains than an area-

based scheme, although the gains are a modest fraction of toll revenues (around 30%). In the absence of revenue recycling or redistribution, distance-based and cordon-based schemes are found to be particularly regressive. On average, lower income individuals lose as a result of the scheme, whereas higher income individuals gain. A similar trend is observed in the context of shippers -- small establishments having lower shipment values lose on average whereas larger establishments with higher shipment values gain. We perform a detailed spatial analysis of distributional outcomes, and examine the impacts on network performance, activity generation, mode and departure time choices, and logistics operations.

SimDanmark: An activity-based simulation for Denmark

Lorena T. Lahoz[1], Mayara M. Monteiro[1], Ravi Seshadri[1], Carlos Lima Azevedo[1]

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This presentation focuses on the modelling and implementation effort of the activity-based model in SimMobility for Denmark. We will present the data and estimation challenges in the estimation of the national model, along with the implementation of the latest development in SimMobility pre-day applied to the Danish case. The models are estimated for using the three years of the Danish Travel Survey, implemented in SimMobility and used in simulation together with a synthetic population generated with machine learning. Simulation results will be presented and future extensions that should be accounted when moving from regional to the national context will also be discussed.

Assessing the impacts of tradable credit schemes through agent-based simulation

Renming Liu[1], Ravi Seshadri[1], Yu Jiang[1], Moshe Ben-Akiva[2], and Carlos Lima Azevedo[1]

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[2]Civil and Environmental Engineering Department, Massachusetts Institute of Technology

Tradable credit schemes (TCS) are gaining traction in transportation research as a viable alternative to congestion pricing, offering revenue neutrality and equity benefits. However, current research often employs simplistic approaches, lacking in comprehensive modeling of demand, supply, and market dynamics. We propose an integrated simulation framework within SimMobility, featuring an extended TCS design and a nuanced simulation of market interactions. Our approach encompasses individual trading behaviors and complex TCS market dynamics, enabling flexible testing of future TCS designs. Using a pre-day activity-based model and multimodal traffic simulator, we demonstrate the platform's efficacy in analyzing TCS impacts on congestion mitigation and welfare enhancement in a prototypical city. This framework provides insights into market and mobility properties, advancing understanding of TCS implementations.

Second session: Machine learning approaches to enhance simulation-based tools

Enhancing bike-sharing system operation through supervised machine learning and smart data management

Athina Tympakianaki, Juan Angarita, Aimsun (representing the SPINE project, https://www.spine-project.eu)

A bike-sharing system is a key element in increasing the use of alternative modes of transport that, in the end, allows car use to be disincentivized. In this sense, the quality of this micro-mobility service is a priority to enhance its adoption by citizens. This work focused on using machine learning approaches to predict bike-sharing bikes demand and know the occupancy of stations in advance. The latter is done by analyzing and mining historical data of the system, represented by point-to-point travel requests disaggregated by days and bike users. In this way, we can extract predictions and travel patterns to simulate the system's operation and test balancing strategies, which increase the system's quality, measured as bike availability to supply user demands through all the system's stations. Thus, our ultimate aim is to enhance the decision-making process of bike-sharing operators when managing bike-sharing systems in urban environments.

Bayesian Optimization of tradable credit schemes through agent-based simulation

Dimitrios Argyros[1], Renming Liu[1], Ravi Seshadri[1], Filipe Rodrigues[1], and Carlos Lima Azevedo[1]

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Tradable credit schemes (TCS) for mobility are still far from practice, but technology and algorithms for its design and operation are now becoming a central research topic within our research community. Algorithms to support the decision making in TCS design and operation are still missing, especially considering the complex demand-credit market-supply dynamics in heterogenous traveller settings. In this study, we integrate an agent- and activity-driven mobility simulator with a Bayesian Optimization (BO) framework aimed at determining optimal TCS tariffs within a daily mobility and transportation network system. Building upon previous research involving a BO-framework tailored for road pricing, we extend this methodology to the realm of TCS, employing a departure-time and route-choice sensitive demand model within a detailed mesoscopic network encapsulated within the agent-based model SimMobility. Through the utilization of simulation capabilities inherent in SimMobility, the impacts of the identified policy measures are comprehensively analyzed, shedding light on their efficacy and potential implications.

(Meta-)SimMobility: Research directions towards wide scalability and generalisation

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Large-scale simulation models like SimMobility face the critical challenge of computational complexity. This complexity significantly hampers calibration and model exploration, such as scenario discovery, due to the extensive time required for each simulation run. Traditionally, two approaches have been employed to mitigate this issue: model simplification through spatial and/or temporal aggregation and scope reduction by focusing on specific segments of the transport network or population subsets. Alternatively, analytical or statistical model approximations, known as metamodels, have been utilized. Recently, Machine Learning (ML)-based metamodels have gained popularity for their potential to streamline simulations. However, these models often struggle with out-of-distribution scenarios, failing to accurately represent the original simulation under new conditions, such as policy interventions. This presentation introduces recent advancements in causal metamodeling, an approach that integrates ML-based metamodeling with domain-specific knowledge to produce simulation approximations that not only remain true to the original model but also operate with significantly enhanced speed. Drawing on the recently started APEX project, I will outline the foundational concepts, share preliminary findings, and explore the challenges and opportunities this research presents. Through causal metamodeling, we aim to significantly improve the scalability and generalization capabilities of large-scale models like SimMobility, opening new avenues for comprehensive and efficient scenario analysis.

Synthetic population generation using Generative Adversarial Networks: A case study in Denmark

Sigridur Thora Halldorsdottir[1], Luis Gideon Pieschel[1], Lorena T. Lahoz[1], Francisco Pereira[1] and Carlos Lima Azevedo[1]

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This work addresses the challenges in input genreation for large scale agent-based urban simulation, namely in synthetic population generation. Using Generative Adversarial Networks (GANs), the study conducts a comparative evaluation of various GAN architectures for generating synthetic populations for SimMobility. Specifically, Wasserstein GAN, Directed Acyclic Tabular GAN, and Conditional Input DATGAN are analyzed. By leveraging extracted marginal distributions of the Danish population, representative populations are generated. However, model selection significantly impacts training time and adaptability. Notably, the ciDATGAN model emerges as the most promising approach, aligning with the requirements of the SimMobility framework.

Third session: Modelling new technologies using state of the art tools

Sustainable automated mobility-on-demand strategies in dense urban areas: A case study of the Tel Aviv metropolis in 2040

Bat-Hen Nahmias-Biran [1,2], Gabriel Dadashev[1] and Yedidya Levi[1]

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The emergence of automated mobility-on-demand (AMoD) services in urban regions has underscored crucial issues concerning the sustainable advancement of urban mobility. In this work we developed and calibrated a prototype city representing a futuristic Tel Aviv metropolitan area for the year 2040. This metropolis is characterized by a high level of development coupled with significant mass transit availability and usage. Using the combined SimMobility–Aimsun framework, we investigated the effects of AMoD services in this model transit-oriented city. The goal was to understand which strategies would lead to the most sustainable outcomes in this type of metropolis. Our findings suggest that AMoD contributes to higher congestion levels and increased passenger VKT. However, when AmoD is integrated with public transit systems or introduced alongside measures to reduce household car ownership, it helps alleviate the VKT impact. None of the AMoD strategies analyzed in our study reduce the congestion effects of AMoD and all strategies cannibalize active mobility compared to the base case.

Performance matters - Assessing the lost potential demand of an on-demand AV service

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Automated vehicles are key to unlock a more widespread on-demand service, increasing accessibility also in peripheral areas. Still, while wide attention has been dedicated to behavioural attitudes towards these services or to their effects on the network, few works focus on how the performance of these services may affect the overall demand in return. People may be willing to use an automated taxi, but may be less willing to wait certain waiting times. In this study, we analyse through an activity-based model (SimMobility MT) and a traffic assignment one how the effects of network congestion and fleet size constraints may cause a certain portion of the demand to shift to traditional modes of transport rather than exploit the automated on-demand system. By doing so, we provide a methodological approach to better frame absorbed and lost demand, thus improving the accuracy of business cases for the service provider.

Sustainable last-mile logistics: a joint optimization-simulation framework for multi-purpose cargo-bike fleet scheduling

Lampros Yfantis, Aimsun (representing Horizon Europe, GREEN-LOG Project)

This presentation elaborates on the collaborative work that has been and is currently being conducted within the Horizon Europe GREEN-LOG project by the Athens University of Economics and Business and Aimsun. The work investigates sustainable operations for last-mile logistics via multi-purpose cargo fleets. The operation type being investigated is the concurrent scheduling and utilization of different types of cargo bikes, which can be used concurrently either for parcel pick-up and deliveries or/and for movable micro-consolidation points (e.g., movable lockers). A joint

sequential optimization-simulation solution framework is adopted and described for solving the day-to-day scheduling problem. Early results from an application for the city Oxford, UK are presented, and future next steps are discussed.

Quantifying the environmental impact of autonomous vehicles in urban settings

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This presentation delves into a collaborative endeavour between the Joint Research Centre (JRC) of the European Commission and the CCAM partnership, focusing on the environmental implications of vehicle automation. Through the integration of the Simmobility activity-based demand model for Santander, Spain, with the Aimsun network model, our analysis spans autonomous services like robotaxis, public transport shuttles, and frequent automated buses. Beyond direct emissions, the study extends to the vehicles' operational energy demands, encapsulating computational power and connectivity. Significantly, the project explores the impact of various urban policies, including Urban Vehicle Access Regulations (UVARs), diverse pricing strategies, and a hypothetical scenario prohibiting private vehicles in the city. A critical aspect of our investigation is understanding the environmental rebound effect associated with the increased comfort AVs offer. This approach aims to provide insights into sustainable urban mobility, evaluating how advancements in vehicle automation interact with urban policy and its environmental outcomes.