Simulation of e-bike and e-scooter trips using MATSim.

Eleni Antoniou[1], Panagiotis G. Tzouras[1]*, Lambros Mitropoulos[1], Christos Karolemeas[1] and Konstantinos Kepaptsoglou[1]

[1]Laboratory of Transportation Engineering, School of Rural, Surveying and Geoinformatics Engineering, National Technical University of Athens, Iroon Politechneiou 9, Athens, 15780, Greece.

* Corresponding author: ptzouras@mail.ntua.gr

Extended abstract

Problem description: Micromobility services have grown exponentially in many cities of the world within the last 10 years aiming to become an integral part of future transport systems. Micromobility modes are flexible transport modes with mass no more than 350 kg and a design speed of no higher than 45 km/h, which can provide quick access from/to public transport terminals (Yanocha and Allan, 2019; OECD/ITF, 2020). Powered bicycles (or e-bikes) and standing or seated scooters (or e-scooters) are among the considered micromobility modes, according to the taxonomy of SAE International (2019). Nevertheless, several adverse impacts are presented in the literature for e-scooters, related to increased road accidents, reduced road capacity due to complex road user interactions and discomfort while riding in urban roads (Cao *et al.*, 2021). Recent studies attempted to further explore and discuss travel patterns of micromobility by surveying user analysis (Glenn *et al.*, 2020; Sanders, Branion-Calles and Nelson, 2020; Nikiforiadis *et al.*, 2021) and analyzing trajectories using spatial analysis techniques (McKenzie, 2019; Caspi, Smart and Noland, 2020; Hosseinzadeh *et al.*, 2021; Luo *et al.*, 2021). Although, these approaches identified some interesting trends, they failed to predict the future impacts of micromobility and its overall contribution to sustainable urban mobility. Definitely, the dual riding behavior especially of e-scooter users is a significant barrier in modeling micromobility modes and predicting future impacts. Indeed, according to Tuncer et al (2020), e-scooters are capable to switch from vehicles' roadway to pedestrians' sidewalk. This issue creates a complicated multi-scale simulation problem that has not been addressed completely at network scale.

Research objective: Agent-based models (ABMs), like MATSim, have been utilized to predict the impacts of innovative shared mobility services at network scale, e.g., shared autonomous vehicles (Bischoff and Maciejewski, 2016; Bösch, 2018), electric taxis (Bischoff and Maciejewski, 2014), etc. These services are quite similar to micromobility. Therefore, ABMs seem to be an interesting solution in simulating these innovative modes in large scale networks. The objective of this study refers to the development of a routing model based on which e-bike and e-scooter trips can be simulated physically using MATSim. This developed model aims to comprise a major component of a large-scale ABM simulation scenario of micromobility services for Athens, Greece.

Approach: This study follows a similar approach with Ziemke et al. (2019), who introduced infrastructure parameters in scoring functions to model bicycle traffic. Yet, in the developed model, we hypothesize that perceived safety is a determinant factor of the utility function of micromobility models. It is an approach to integrate safety factors in MATSim framework for the first time. Therefore, this framework is further extended, so that perceived safety scores can be estimated per link and per time-step based on the traffic conditions. The differences in travel behavior of e-bike and e-scooter riders are considered and discussed by integrating different parameters (i.e., weights) per mode. Perceived safety scores per mode are influenced by road design (i.e., existence of bike lane, sidewalk width, number of traffic lanes and surface condition) and the existence of different non-moving (e.g., obstacles in the sidewalk) and moving (i.e., vehicles or pedestrians) objects appearing in the urban road environment each time step (Livingston *et al.*, 2018; Tzouras *et al.*, 2021). We calibrate the scoring functions of

MATSim based on the outputs of a rating experiment, in which respondents rated perceived safety of riding an e-bike or an e-scooter in different road environments and under different traffic conditions. A small-scale scenario in Athens, Greece is utilized to test whether this new routing model may provide reasonable simulation results. The transferability of these tools in large-scale scenarios is further discussed in order to provide practical recommendations for future applications.

Keywords: MATSim, routing problem, perceived safety, e-scooter, e-bike

References

Bischoff, J. and Maciejewski, M. (2014) 'Agent-based Simulation of Electric Taxicab Fleets', *Transportation Research Procedia*, 4, pp. 191–198. doi: 10.1016/j.trpro.2014.11.015.

Bischoff, J. and Maciejewski, M. (2016) 'Simulation of City-wide Replacement of Private Cars with Autonomous Taxis in Berlin', *Procedia Computer Science*, 83, pp. 237–244. doi: 10.1016/j.procs.2016.04.121.

Bösch, P. M. (2018) *Autonomous Vehicles - The next Revolution in Mobility*. ETH Zurich. doi: 10.3929/ethz-a-010782581.

Cao, Z. *et al.* (2021) 'E-scooter sharing to serve short-distance transit trips: A Singapore case', *Transportation Research Part A: Policy and Practice*, 147, pp. 177–196. doi: 10.1016/j.tra.2021.03.004.

Caspi, O., Smart, M. J. and Noland, R. B. (2020) 'Spatial associations of dockless shared e-scooter usage', *Transportation Research Part D: Transport and Environment*, 86. doi: 10.1016/j.trd.2020.102396.

Glenn, J. *et al.* (2020) 'Considering the potential health impacts of electric scooters: An analysis of user reported behaviors in provo, Utah', *International Journal of Environmental Research and Public Health*, 17(17), pp. 1–15. doi: 10.3390/ijerph17176344.

Hosseinzadeh, A. *et al.* (2021) 'Spatial analysis of shared e-scooter trips', *Journal of Transport Geography*, 92. doi: 10.1016/j.jtrangeo.2021.103016.

Livingston, C. *et al.* (2018) 'The influence of the route environment on the route choice of bicyclists: A preliminary study', *hEART 2019 - 8th Symposium of the European Association for Research in Transportation*. doi: 10.3929/ethz-b-000376513.

Luo, H. *et al.* (2021) 'Are shared electric scooters competing with buses? a case study in Indianapolis', *Transportation Research Part D: Transport and Environment*, 97(June), p. 102877. doi: 10.1016/j.trd.2021.102877.

McKenzie, G. (2019) 'Spatiotemporal comparative analysis of scooter-share and bike-share usage patterns in Washington, D.C.', *Journal of Transport Geography*, 78, pp. 19–28. doi: 10.1016/j.jtrangeo.2019.05.007.

Nikiforiadis, A. *et al.* (2021) 'Analysis of attitudes and engagement of shared e-scooter users', *Transportation Research Part D: Transport and Environment*, 94(March), p. 102790. doi: 10.1016/j.trd.2021.102790.

OECD/ITF (2020) 'Safe Micromobility: Corporate Partnership Board Report', p. 98. Available at: https://www.itf-oecd.org/safe-micromobility.

SAE International (2019) *Taxonomy and Classification of Powered Micromobility Vehicles*. Available at: https://saemobilus.sae.org/content/j3194_201911.

Sanders, R. L., Branion-Calles, M. and Nelson, T. A. (2020) 'To scoot or not to scoot: Findings from a recent survey about the benefits and barriers of using E-scooters for riders and non-riders', *Transportation Research Part A: Policy and Practice*, 139(June), pp. 217–227. doi: 10.1016/j.tra.2020.07.009.

Tuncer, S. *et al.* (2020) 'Notes on the practices and appearances of e-scooter users in public space', *Journal of Transport Geography*, 85(March), p. 102702. doi: 10.1016/j.jtrangeo.2020.102702.

Tzouras, P. G. *et al.* (2021) 'A Concept Agent-Based Simulation Model to Evaluate the Impacts of a Shared Space Network', *Procedia Computer Science*, 184(C), pp. 680–685.

Yanocha, D. and Allan, M. (2019) *The Electric Assist: Leveraging E-bikes and E-scooters for More Livable Cities*. Available at: https://www.itdp.org/publication/electric-assist/.

Ziemke, D., Metzler, S. and Nagel, K. (2019) 'Bicycle traffic and its interaction with motorized traffic in an agent-based transport simulation framework', *Future Generation Computer Systems*, 97(June 2018), pp. 30–40. doi: 10.1016/j.future.2018.11.005.