PhD thesis Proposal
Modelling and Estimation for Large Scale Multimodal Mobility Networks
2023-2026

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Keywords:
Large scale networks, multimodal mobility, estimation theory.

Starting date of the PhD:
October 2023 (for 3 years)

Profile:
The candidate should have a solid background in estimation theory or signal processing and good computer skills in Matlab and/or Python.

Location:
GIPSA-Lab, Grenoble University East Campus, Grenoble, France.

How to apply:
Applications should be declared as soon as possible. The position may be closed as soon as a competent candidate has applied. Please include the CV, and marks.

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Motivation of PhD

Our society is more and more conscious of the contribution of current mobility modes to the climate crisis. This is why innovative low-carbon mobility solutions are being promoted by decision-makers and increasingly adopted by citizens. It is, for instance, expected that Electric Vehicles (EVs) will account for 70% of sold vehicles by 2030. The EU Commission, with its Fit 55 plan, even envisions a ban on the sale of new petrol and diesel cars as early as 2035. Meanwhile, adoption of micromobility modes is increasing significantly. Micromobility is an umbrella term used to describe the category of transportation using non-conventional battery-powered vehicles aimed at shrinking the physical and environmental footprint required for quickly moving people over relatively short distances. With micromobility, urban transportation modes have diversified very quickly. The challenge for cities encompasses organization and planning of public space and promotion of active mobility for health purpose given the passivity of some micromobility modes (e-scooters in particular). The co-existence of these modes in shared spaces cause various kinds of inconvenience for other users (people in wheelchairs, walking with a baby in a stroller, or elderly people) and alters the perception of safety which can lead vulnerable people to be more sedentary. Beyond the perception, it is attested that the number of accidents due to e-scooters is constantly increasing. It is therefore crucial to monitor the use of these micromobility modes by collecting information in a dynamic and non-intrusive way and then make recommendations for safer shared spaces and physical activity.

Proposed work during PhD

Three main tasks are envisioned for this thesis:

a)- City-wide mobility model: This task aims at developing a dynamic network model for multimodal mobility over a city. For this purpose, our starting point will be the recent works by the team which developed a large-scale mobility model to characterize the daily movement of people in an urban network. This model is based on the modeling of people's mobility between their place of residence and 5 categories of destinations (work, schools, etc.). It generates a graph with nodes (origins and destinations) and also their interconnections through the origin-destination matrix that characterizes: directions, weights and temporal profile of the connections between nodes. The model simulates the movement of people at an aggregate level (no distinction of individuals, no information on the routes connecting origin and destination), Pratap et al. 2022. It has been used to control epidemics propagation while preserving the territory productivity, Niazi et al. 2021.

For monitoring multi-modal mobility, we will divide the city in cells. Each cell will define a node of the mobility networks. Each node will have several states representing the number of users for each mobility mode. Transition can be done from one mode to another. Therefore, there will be a dynamic for mobility mode in each node. Each node will interact with its neighbors. Two nodes will be adjacent if there is at least one mode from which people can jump from one node to another. The graph is expected to be large and dense with weights related to mobility between nodes. The originality of this task rests in the finer grain of the proposed description and the accurate distinction between the possible transportation modes, including cars, public transportation and micromobility.

b)- From discrete to continuous: Here we will develop a dynamic continuous counterpart to the discrete city-wide network of the previous task by using graphons (Ruiz et al, 2021) and/or continuation (Nikitin et al. 2021). The city-wide network from the previous task is equipped with dynamics for the evolution of the shares of the mobility modes. We expect that these dynamics will feature diffusion and transport terms: therefore, the dynamics belong to a class that we are able to treat by continuation and graphon methods (or a combination of both). While the apparent geographical interpretation is conductive to continuation methods, public transportation (such as tramways in the Grenoble case study) effectively introduces long-range connections and counters the inherent sparsity of the micromobility diffusion.

c)- Network estimation: The aim is to develop techniques for state estimation for providing a cartography of transportation modes usage. The estimation problem here consists in: (i) the estimation of connection weights (probabilities) in the context of dynamic network models; (ii) estimate the states of the nodes or aggregated states in order to provide a cartography of co-existence of transportation modes. Connection weights will be treated as functional data. The question here is therefore to estimate the tensor of weights (or connection probabilities; tensor here means multiway array from partial measurements provided by people using mobility modes detectors (Taia-Alaoui et al. 2022) or other sensors like loop detectors for vehicles and bicycles (the latter are available in the city of Grenoble and our team has acquired experience with dealing with similar data in building the GTL and GTL-Villle platforms). This task will include methods for dynamic network completion using graphon approximation, which will be acutely needed to cope with partial observations. These methods will be based on related methods proposed for collaborative filtering, such as (Shah and Lee, 2018). Furthermore, we will develop techniques to detect (despite noisy and possibly patchy data) potential conflict zones, where conflict and safety issues originate from high rates of penetration of micromobility modes such as e-scooter (Dozza et al. 2022).

References

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