Modelling and enriching multi-scale trajectories for soft mobility analysis in urban areas

This Ph.D. proposal is focused on soft mobility and is part of the PEPR MOBIDEC and its target project Mob Sci-Factory. The last has the ambition to identify open-access mobility data, propose methods and tools to manage and analyse mobility data, and finally propose a decision-making platform to share data, tools and code for mobility decarbonization.

General context

Urban areas face different challenges, such as traffic congestion, air pollution, and public health. Moreover, COVID-19 pandemic showed how quickly human mobility can rapidly change and increase the development of new mobility services (e.g., bikes, scooters). Soft mobility, which is more and more developed in big metropolitan areas, is related to different types of mobility such as walking, cycling, public transportation, micro mobility using electric scooters, and it emerges as a promising approach for mobility decarbonization. Indeed, by prioritizing soft mobility initiatives, cities can mitigate the negative impacts of transportation on the environment and health while improving the well-being of residents. However, soft mobility policies also raise challenges, such as infrastructure investment in scarce places, safety, cultural and behavioral changes, sustained and equity policies (e.g. take into account all bilities). Moreover, due to the rapid change in human mobility behaviour, government agencies and local stakeholders need access to fine-grained spatiotemporal soft mobility data, as well as methods and tools to analyse them and characterise human behavior, typical activities and spatio-temporal patterns. But, that's far from being the case today. This thesis aims at filling this gap.

In fact, nowadays, mobility data exist in different forms. For example, transport operators release their mobility data in open access (e.g., Vélib, bicycles counters), crowdsourced GNSS data produced by citizens are shared on different platforms (e.g., Strava, IGNRando, OutdoorVision, city walking tours vidéos), contextual information such as air quality data (e.g., AirPARIFF, sensors community, air citizen), points of Interest (e.g. ,OpenStreetMap, Overture), weather data is freely available, to name only a few of them.

In this context, we hypothesize that combining the existing mobility data within a unified view offers a strong potential to understand, improve and promote soft mobility in urban areas. However, providing such a unified model is a very complex task.

Research objectives

From a research perspective, different approaches exist to model spatio-temporal trajectories such as those segmenting the trajectory into stops and moves (Spaccapietra, et al., 2008) or more recently, those that propose to describe a trajectory using a multiple aspects view (Cayèré et al., 2021, Melo et al. 2019, EL Hafyani et al., 2022). These models allow linking the spatio-temporal trajectory with different characteristics (e.g., weather, air pollution exposure, landmarks).

The first objective is to combine the two types of models by proposing an integrated uniform model and to instantiate it with real data. The second objective is to address stakeholders' needs by enhancing the reusability of the model for specific analysis scenarios, where the analytical dimensions may vary thematically or exhibit different scales or qualities. Flexibility will also ensure the usability of the proposed approach when new types of data are available. Finally, the third objective is to provide methods and algorithms to enrich soft mobility trajectories, allowing various multi-dimensional analysis (e.g., individual exposure to pollution, impact of public policies on the evolution of soft mobility).

To achieve these goals, we have identified the following research axes:

1) Propose a flexible data model to describe spatio-temporal trajectories with intrinsic (e.g. stops, moves, types of moves) and extrinsic (e.g., pollution exposure, obstacles, point of interest, disability elements) characteristics. Consider the dimension of users' profiles according to their observed soft mobility patterns.
2) Develop machine learning algorithms to identify and distinguish sustainable and soft modes of transportation from existing trajectories (e.g. walking, scooters, buses).
3) Implement the model within a system and instantiate it on case studies defining different scenarios (e.g. pollution exposure, safety, impact, enrich road segments with soft mobility data) using real data.

There are several challenges that need to be addressed when dealing with mobility data integration, such as spatiotemporal, thematic, and semantic heterogeneity; different data quality and spatio-temporal scales, as well as diverse potential uses of the model. Moreover, combining spatial presence (e.g., count of users in a place), origine-destination flows, and moving object data (e.g., scarce trajectories from one area to another) is challenging due to their inherently different formats, sources, and representativeness, which should be taken into account in this research work.

This research will be fully open data and open science compliant, i.e., models, data, algorithms, and code will be shared to enhance reproducibility and re-use by research and stakeholders communities.

Profile and skills: The candidate should hold a Master's degree in computer science or geomatics. For a computer science master's, a sensitivity to the field of geographic information and spatial-temporal analysis would be highly appreciated. Strong programming skills are necessary (e.g. Python). Good interpersonal skills, motivation for research and teamwork, initiative, writing skills, and proficiency in English are required.

Supervision and Hosting: The PHD is a collaboration between LASTIG laboratory from University Gustave Eiffel - IGN and DAVID laboratory from University Paris-Saclay under the supervision of Ana-Maria Raimond (DR) and Karine Zeitouni (Professor). It will be conducted at the LASTIG (73 avenue de Paris, Saint-Mandé 94165). The doctoral contract, is for a three years period, may or may not include teaching tasks, depending on the candidate's profile and preference. The PhD candidate will be working with a group of researchers, collaborating specifically with a post-doc on trajectory visualization and an engineer on trajectory data mining.

Application Procedure: Send **before May 12 2024** a **pdf file** composed by your CV, a letter of motivation, transcripts from the last two academic years, and preferably at least one letter of recommendation by using IGN website and following this link .

Références

1. Spaccapietra, Stefano & Parent, Christine & Macedo, Jose & Porto, Fabio & Vangenot, Christelle. (2008). A Conceptual View on Trajectories. Data & Knowledge Engineering. 65. 126-146. 10.1016/j.datak.2007.10.008.
2. Cayèré C. et al., 2021, Multi-Level and Multiple Aspect Semantic Trajectory Model: Application to the Tourism Domain, ISPRS International Journal of Geo-Information, 10.3390/ijgi10090592, 10, 9, (592).
3. Mello R. d. S., Bogorny V., Alvares L. O., Santana L. H. Z., Ferrero C. A., Frozza A. A. et al., 2019. MASTER: A multiple aspect view on trajectories. Transactions in GIS, p. tgis.12526.
4..El Hafyani, H., Zeitouni, K., Taher, Y., Yeh, L., & Ktaish, A. (2022). A Multidimensional Trajectory Model in the Context of Mobile Crowd Sensing. In *Smart Trajectories* (pp. 153-176). CRC Press.