

ICT PHD

Research project for a PhD curriculum in ICT – Computer Engineering and Science

Tutor: Laura Po

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() Foreign Co-tutor:**

Proposed Title of the research:

Graph Data Science and Digital Twin for Urban Mobility Analysis and Planning

Keywords: (5)

Graph Analytics

Large Knowledge Graphs

Machine Learning

Intelligent Transportation System (ITS)

Semantic Trajectories

Research objectives: --(max 10 rows)

Smart mobility is the main driver for implementing sustainable urban mobility. When it comes to urban mobility, the importance of the network and its spatial structure is fundamental.

Graphs are 'unifying abstractions' that can leverage interconnectedness to represent, explore, predict, and explain real- and digital-world phenomena.

The aim of the proposal is to explore the effectiveness of using graph networks in the study of mobility, to study urban mobility patterns by integrating graph modeling, machine learning models, and visual analysis with user trajectory data, and to implement intermodal routing.

In recent years, several researches reported that urban transportation dynamics can be discovered and optimized by applying graph analysis algorithms.

The first objective is to create and store an urban graph that integrates real traffic flows and all mobility-related information (such as information on public transport, mobility operators, parking, bicycle docks, taxi slots, and so on).

The urban graph network can be represented not only as a complex single graph but rather as multilevel graph that represents different transport means through different levels or also by a graph partitioned in urban-level graphs and street-level graphs.

The second objective is to conduct analysis on the urban graph network.

Graph centrality measures, including page rank and betweenness centrality, are then computed to characterize the time-varying importance of different urban regions. The importance of streets to discover and assess city traffic patterns can be investigated.

Moreover, the graph model provides a better insight into the spatial structure of the transportation network for a better understanding of the interactions between neighborhoods, to identify the infrastructure needs, to better integrate different transport modes, and to find leakages in the mobility services.

The third objective is to visualize the interconnections between different transport modes and the

best trajectory between the neighborhoods of the city.

Since mobility data have a spatio-temporal dimension, different techniques to visualize and interpolate this kind of data will be studied.

Lastly, since intermodal routing can contribute to significantly reducing the costs and delays of journey compared to unimodal routing. Experiments on the selection of different modes and services to determine suitable paths throughout a given intermodal network will be explored. Moreover, reducing costs of the intermodal services acts also as a potential driver for modal shift.

Proposed research activity -- (max 10 rows)

The proposal includes the study and the implementation of techniques for

- Data series management: sensors data collection, analysis, and outlier detection
- Data integration: mobility data, geographical data, crowd-sourced data, sensor data.
- Graph modeling: development of a multi-modal graph network
- Traffic flow estimation, prediction and re-routing

The main activities will include:

- Survey and Analysis of the different graph models
- Analysis of the existing best practices, standards and services for intermodal traffic management
- Use of big data, digital twin and HPC technologies to store data and to elaborate statistics and simulations on scalable datasets
- Development of an urban mobility model
- Development of a tool for the effective display of mobility data

Other activities that might be included are:

- Check of the density levels to detect traffic congestion for routing and re-routing of vehicles
- Spatio-temporal and graph-based analysis of citizen's mobility patterns, multimodal urban mobility habits
- Transportation mode recognition from GPS trajectories using deep learning algorithms

Supporting research projects (and Department)

[Under evaluation] European project submitted to EIT Urban Mobility

[Under evaluation] European project submitted to Horizon Europe under the call HORIZON-CL5-2022-D6-02-05

Possible connections with research groups, companies, universities.

Eindhoven University of Technology, Netherlands (Prof. Frauke Behrendt)

Technical University of Madrid, Spain (Prof. Oscar Corcho)

Universidade de Santiago de Compostela, Spain (Prof. José Ramón Ríos Viqueira)

Universidad de Zaragoza, Spain (Prof. Raquel Trillo Lado)

CEFRIEL, Italy (Dott. Marco Comerio)

Fundación Centro Tecnológico de Supercomputación de Galicia, Spain (Dr. Ignacio López Cabido)

(*) optional

(**) optional/to be completed on the second year