PhD position: Agent-based simulation for interactive urban planning

Building models to anticipate the impacts of urban developments on the quality of life and mobility at a neighborhood scale.

Keywords : Multi-agent simulation, urban planning, simulation of mobilities

Context and motivations

Toulouse Métropole is one of the most dynamic metropolitan areas in Europe structured around 114 municipalities welcoming more than 1 million inhabitants in 2018 and consisting of a main urban area with Toulouse and its 472,000 inhabitants but also including peri-urban and rural areas. The Toulouse area is marked by a phenomenon of pronounced urban sprawl resulting in significant congestion of the metropolitan road networks. The phenomenon of urban sprawl also leads to a need to make travel more fluid with peri-urban and rural areas. In this context, the ambition of the VILAGIL project is to provide new solutions to these congestion problems by anticipating and accelerating the conditions for the arrival of new operators managed within the framework of collaborative governance. Indeed, the integration of new mobility services associating private partners constitutes an opportunity for the community to respond immediately to the objectives of:

- Decongest the territory
- Promote mobility for all
- Decarbonize the territory
- Make Toulouse a territory of excellence, a showcase for new mobility

In this context, the Urban Planning action of VILAGIL aims to set up a simulation platform taking into account a multitude of available data to offer residents new services, particularly in connection with mobility, but also to provide planners with tools to simulate mobility behaviors according to their choices for urban development on a neighborhood scale. The objective is to provide support for reflection, argumentation and operation concerning the establishment and then operation of new living areas and the visualization of the state of the various impacted networks (energy, transport, bicycle terminals, pedestrian routes, etc.).

Multi-agent simulation

Multi-agent simulation is a relevant analysis and forecasting tool, often used by decision-makers to study and understand a wide variety of collective phenomena such as: energy consumption or mobility at the scale of a city, building evacuation in case of

a fire or the development of crime at an urban scale, etc. In this context, several levels of observation can be considered, in particular:

- **The microscopic level** made up of autonomous entities located in the virtual world (modeling an urban environment). These entities have intrinsic properties and constraints (operating rules, position in the environment, etc.), objectives to be achieved (local goals, destination, etc.) and interact in their environment according to predefined rules (cooperation, competition, etc. .).
- **The macroscopic level** which is built from the interactions of entities at the microscopic level, each having their own specific behavior and which imposes constraints (pollution, traffic density, etc.) or opportunities (installation of public services, shops, etc.) on the microscopic scale.

The main interest of these systems is their ability to bring out complex behaviors at the macroscopic level from simple rules at the microscopic level. They are also well suited for modeling open systems thanks to their self-organizing capacity. Without going into details, each agent has parameters governing their behavior. By self-adjusting its parameters, the agent adapts its behavior in reaction to external events and allows the emergence of new collective behaviors. The decentralized nature of these systems makes the link between these two levels of observation difficult to establish while it would be interesting to understand among these parameters which influence the overall behavior of the system.

Research project

This thesis work is part of the Urban Planning action of the VILAGIL project. It aims to design, implement and validate the multi-agent model on the GAMA platform to simulate the impact of different neighborhood development choices on the quality of life of the inhabitants, on criteria linked to urban planning (mobility, energy, services…) and on the neighbourhood surroundings, in particular in terms of road traffic and congestion.

The work will be divided into three phases:

1. The first phase consists of the implementation of a multimodal mobility model where the decisions of agents' activities adapt to the constraints (physical and social) arising from their environment. This environment is dynamic and modified either exogenously (scenarios or introduction of new elements) or endogenously (typically the behavior of other agents). Depending on their own behavior, their goals and what they perceive from the environment, each agent adapts their behavior leading to the emergence of complex collective phenomena. The state of the art will in particular make it possible to identify, evaluate and adapt the different existing models and theories, by exploring different concepts such as

the theory of situated action and affordance. The proposed model will be calibrated and evaluated on mobility data.

2. The second phase concerns the analysis of the impact of the choice of facilities modifying the agents' environment on a set of indicators defined with the partners of the VILAGIL project (such as the quality of life in the neighborhoods). Thus, from scenarios defined with the project partners, it will be a question of understanding how individuals adapt their behavior to these changes and their impact on the system. This study should identify at the microscopic level the weighted influence of these parameters on indicators for the management of change and thus guide the choices of urban planners.
3. The third phase deals with the interdependence between the microscopic level (the first phase) and the macroscopic level (the second phase). If this coupling can be carried out in a (semi) automated way, we will be able to lead proposals for change in the environment, with an urban planning that can be better understood and controlled.

Required profile

Initial training in Computer Science, the student must have knowledge of multi-agent systems in general and multi-agent simulation (GAMA or at least Netlogo) in particular, GIS and good bases in statistics. He will have to demonstrate a certain interest in urban modeling and simulation.

The doctoral student will be supervised by Prof. Frédéric Amblard, Dr. Benoît Gaudou, Dr. Elsy Kaddoum and Dr. Nicolas Verstaevel from the SMAC team at IRIT. He will also interact strongly with the other teams involved in the urban planning action of the VILAGIL project.
The thesis is financed by the VILAGIL project. The PhD candidate will benefit from a 3-year doctoral fellowship work contract providing him/her about 1,400 euros net funding per month.

Applications (https://forms.gle/JWUp2KHGLorsmxu57) should include CV, motivation letter, school reports and the name of at least two professors we can contact for recommandation.
Applications will be examined on a rolling basis until may 31st 2021.

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