ABM simulation focused on urban mobility

Antonio González Cuevas, Remo Suppi

Universitat Autònoma de Barcelona, Dept. de Arquitectura de Computadores y Sistemas Operativos, 08193, Cerdanyola (Barcelona), España
{toni.gonzalezcuevas@gmail.com, remo.suppi@uab.cat}

Abstract. The objectives of this research is to solve, through high-performance simulation, different mobility problems in cities with mixed traffic (public and private transport, emergencies, bicycles, scooters). To achieve these objectives, the research is oriented to develop new ABM models (Agent Based Models), integrated with Geographic Information Systems (GIS) in order to provide answers to different situations and mobility scenarios in big cities. We want to analyze different episodes and strategies (real or possible) to solve questions based on 'What if?' with variables such as mixed traffic, bicycles exclusive lanes, reduction of private vehicles lanes, among others. This work shows the first phase of ongoing research focused on the city of Barcelona, but the proposed methodology and models can be quickly extended to other cities. For this, we work with data captured in real traffic analysis processed with vehicle recognition algorithms based on AI (artificial intelligence) and the results are used as the basis for the ABM model based on GIS. The simulation is carried out by integrating initial real data with those generated by the simulation in order to analyze the mobility and their interactions.

Keywords: Agent Based Modeling, urban mobility simulation, real-time data, high performance computing.

1 Introduction

Simulation models aim to analyze different aspects of reality, capturing capabilities and behavior. These models allow knowing possible real scenarios but before they occur. Methods to analyze real scenarios are common in different disciplines for training and decision making, but these methods can be very complex or very costly (are used, for example, in evacuation of buildings, terrorist alerts, floods, etc.).

One of the important problems of the simulation is that, habitually, the models are proposed for a set of initial conditions but these models are disconnected from reality when the simulation advances. To solve this problem, large amounts of simulations must be carried out to analyze the different possible scenarios. In urban environments and traffic simulations, other alternatives are possible, such as having real data to 'reorient' the simulation to generate different analyzes and extract knowledge. [1, 3, 4]

For example, a use case could be simulating one of the streets with the highest traffic density at Barcelona, using real data and 'causing', through simulation, a multiple accident to analyze the situation on this street and its surroundings. With this information, it would be possible to determine the origin and best route for the

emergency teams based on the minimum arrival time at the accident place in a collapsed environment with a very high density of vehicles.

For this, it is necessary to have reliable real data that can be injected into the simulator and to develop methodology and models that, focused on a context of mobility in cities, allow us to draw conclusions and knowledge using simulations. This type of model will allow the generation of decision support tools based on data, not only for critical situations, but also in the forecasting of complex urban mobility models such as, for example, 'what is the impact of adding a bicycle lane on a high density street? If the maximum speed is reduced by 40%, how does it affect mobility? or 'the mixed traffic (cars, public transport, motorcycles, bicycles, skateboards) is possible on high density way?. [3,6]

This research proposes to provide answers to these situations using high-performance simulation based on agents, considering real data to analyze mobility flows and interactions between different types of vehicles, as well as the conditions and consequences of these interactions. The strategy to generate open simulations (no only for a specific city only) is to use GIS systems to adapt the environment to the simulation framework. With this, the ABM simulation + GIS environment + real data will allow us to respond to different real situations and scenarios in a city or complex mobility environments to analyze different episodes and strategies (real or fictitious).

2 Objectives and methodology

The main objective of this project is based on the development and validation of urban mobility maps using agent-based simulation models. The requirements are: infrastructure by GIS-based models, mixed and priority traffic, effective validation on real data, Decision-Making-Support (DMS)-oriented, ABM-based design that can be migrated to Cloud and HPC environments when higher performance is required.

For this, the following design aspects have been considered: GIS model centered on Barcelona, incremental design (phases), multi-lane support, regulated traffic (traffic lights), vehicles of different types with adjustable parameters (initially: category, maximum speed, density and priority). In second term, the incorporation of priority vehicles, integration with Open-Data (traffic, congestion points, greatest accident rate points, etc.), scalability at the city level /region, migration to HPC for large city models will be considered.

An incremental phased development has been used as a methodology. This methodology will allow consolidating the objectives centered on 4 major tasks: 1) collection and extraction of real data, 2) integration of GIS data in agent-based simulation environments, 3) simple mobility models based on real data on GIS infrastructure, 4) multilane models with mixed traffic centered on an urban road with a high density of controlled traffic and its surroundings.

3 Current & future developments

Task 1: Collection and extraction of real data.

For this task, a framework based on artificial intelligence was developed for the recognition of vehicles from a real video of the road of interest and its surroundings. This environment allows us to identify the different vehicles on the road, obtaining the number of vehicles of each lane, direction, speed and distance. The initial work has been developed based on the DeepSORT and YOLOv5 [2] libraries with a first analysis focused on cars on a high density Barcelona street (Gran Vía de les Corts Catalanes) to obtain data on speed distributions and distances between cars. The following figure shows the developed data collection and recognition environment.

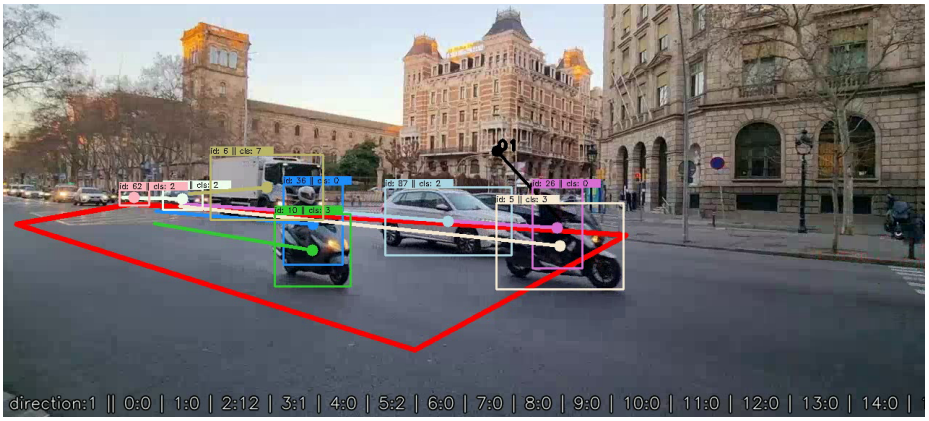

Fig. 1. Identification of vehicles in Gran Vía de les Corts Catalanes street (Barcelona).

These data will be used to define the preliminary ABM simulation model.

Task 2: integration of GIS data in agent-based simulation environment.

The development of this task focuses on integrating a GIS map on an agent-based simulation environment in order to draw the GIS streets within the simulation environment. As ABM simulation environment, NetLogo [7] has been selected since it supports GIS extensions [8] and the models can be migrated to an HPC environment without problems. Figure 2 shows the integration of the map of Barcelona in the simulation environment where the roads (blue lines) are active part of the simulation framework (gray lines are visualized as background image).

Task 3: simple mobility models based on real data on GIS infrastructure.

With the data and GIS integration developed in the previous tasks, a first preliminary simulation model based on ABM has been developed with the following characteristics: multi-agent environment (cars) based on NetLogo, uniform speed distribution based on real data, constant vehicle density, single lane (with contention), speed management. The figure 3 shows the visualization of the Netlogo environment with the cars and the different parameters. As preliminary results, average minimum

speeds is near to 20 km/h and average maximum speeds is 52 km/h are obtained similar to real data used.

Fig. 2. GIS model integrated in Netlogo

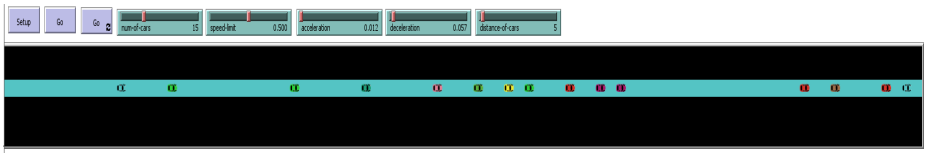

Fig. 3. visualization of single line simulation in NetLogo

In this first simple simulation, has been possible to verify that in order to obtain fluid traffic, the intensity of the traffic is the main factor and how the acceleration/deceleration factors have a direct impact on the levels of retention generated. As a next step in the investigation is the complete simulation model to include the different requirements proposed in the objectives.

4 Conclusions.

This line of research is an ambitious project that aims to integrate real data with agent-based simulation and GIS maps. Considering the complexity of some aspects of the problem, a development by phases has been chosen. The current results of the project are visualized as: capture and identification of the parameters of the streets to be analyzed, the integration of a GIS environment with an agent-based simulation environment and a preliminary simple agent-based simulation model. From the simulated model, the first preliminary results have been obtained that validate the real data, where factors such as traffic intensity, speed and as well as vehicle acceleration and deceleration are critical elements in city traffic.

Acknowledgments: This research has been supported by the Agencia Estatal de Investigacion (AEI), Spain and the Fondo Europeo de Desarrollo Regional (FEDER) UE, under contract PID2020-112496GB-I00 and partially funded by the Fundacion Escuelas Universitarias Gimbernat (EUG).

References

1 Ki Yong Lee, YoonJae Shin, YeonJeong Choe, SeonJeong Kim, Young-Kyoon Suh, Jeong Hwan Sa, and Kum Won Cho. Design and implementation of a data-driven simulation service system. EDB'16, 77–80, USA, 2016.

2 YoloV5 https://github.com/ultralytics/yolov5 https://github.com/ZQPei/deep_sort_pytorch

3 Vallati, M.; Magazzeni, D.; De Schutter, B.; Chrpa, L.; McCluskey, T.L. Efficient Macroscopic Urban Traffic Models for Reducing Congestion: A PDDL + Planning Approach. In Proceedings of the Thirtieth AAAI Conference on Artificial Intelligence (AAAI-16), pp. 3188–3194, USA. 2016.

4 Maggi, E., Vallino, E.. Understanding urban mobility and the impact of public policies: The role of the agent-based models. Research in Transportation Economics. 55, pp 50-59. 2016.

5 A. Gaudiani, E. Luque, P. García, M. Re, M. Naiouf, and A. De Giusti. Computing, a powerful tool for improving the parameters simulation quality in flood prediction. Procedia Computer Science, 29, pp 299-309, International Conference on Computational Science. 2014.

6 Hu X. Dynamic data-driven simulation: Connecting real-time data with simulation. In Yilmaz L., editor, Concepts and Methodologies for Modeling and Simulation. Simulation Foundations, Methods and Applications. Springer, 2015

7 Wilensky, U. Netlogo. User Manual. https://ccl.northwestern.edu/netlogo/docs/. Center for Connected Learning and Computer-Based Modeling, Northwestern University, Evanston, IL. 2022.

8 NetLogo Gis Extension. https://ccl.northwestern.edu/netlogo/docs/gis.html. 2022.