Simulating urban dynamics from the bottom up: the City Simulation Lab

E.N. Speelman
Laboratory of Geo-information Science & Remote Science
Wageningen, the Netherlands
erika.speelman@wur.nl

A. Ligtenberg
Laboratory of Geo-information Science & Remote Sensing
Wageningen, the Netherlands
arend.ligtenberg@wur.nl

Abstract

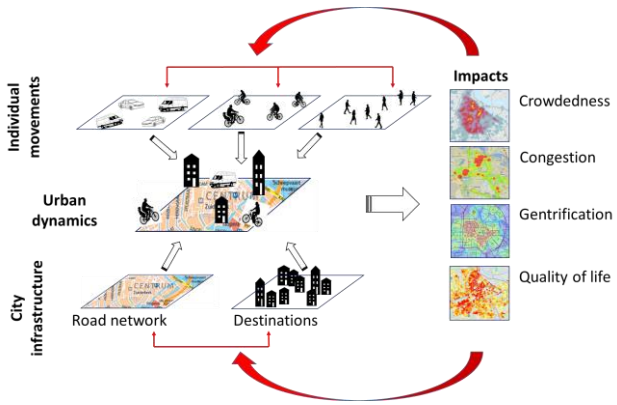
Cities are inherently multi-functional. They play an important role in providing a comfortable living environment to its inhabitants, while at the same time they are home to businesses and attract many visitors. Combining high-level multi-functionality is increasingly challenging in particular with the expected urban growth. This urges us to develop new methods to better understand urban dynamics and to allow us to reconsider the design and possible policy interventions that facilitate cities to strengthen their multi-functionality. In this project, we develop and implement the innovative Participatory Urban Modelling (PUM) framework. This framework combines theory-based agent-based modelling, with participatory gaming and simulation to explore and discuss urban spatial-temporal patterns and possible policy interventions together with stakeholders. The case study in which we implement the framework is tourism in the historic city of Amsterdam. Similar to several other European cities, the increasing number of people visiting the historic city centre of Amsterdam is starting to result in conflicts between the city's various functions. By employing the Participatory Urban Modelling (PUM) framework here, we explore the framework's efficacy while at the same time contributing to potential solutions through realistic, relevant simulation models.
Keywords: Urban Dynamics, Decision-making theories, Agent-based modelling, Spatial–temporal patterns, Participatory research

1 Introduction

It is expected that in 2030 about 5 billion people will live in cities as compared to the 3.6 billion now (UN, 2014). This massive growth challenges the liveability of urban environments. Designing sustainable cities attractive to tourists, industry and commercial organizations as well as pleasant to live in, requires a thorough understanding of urban dynamics and the role of individual and collective human decision-making within this.

Cities like other complex adaptive systems commonly develop in an open-ended and often unexpected way with neighbourhoods and urban populations in constant development. Conflicting use-patterns impact urban quality indicators resulting in specific spatial-temporal patterns and (potential) conflicts among city users (figure 1). Currently, tools to improve our understanding of these complex processes remain limited and even more so our capacity to anticipate these complex developments.

Figure 1: Conceptual overview of the interacting elements and processes in the city simulator.



2 Objective

Against this background the objective of the City Simulation Lab is formulated as:

- To develop a Participatory Urban Modelling (PUM) framework for the development, validation and calibration of participatory urban simulation models
- To develop a City Simulator toolbox consisting of multiple agent-based models of urban systems
- To increase current understanding of complex urban processes leading to specific spatial-temporal patterns from the (spatial) interactions of distinct agents
- To improve the capacity to anticipate complex urban dynamics through interactive participatory workshops

3 Methods

3.1 Case: Tourism expansion in Amsterdam

Amsterdam has seen a steep 40% increase in tourists in just five years, with currently 17 million people visiting the city on annual basis (Amsterdam City Index, 2018). This strong increase impacts the liveability of the city and causes conflicts among different users of the city.

3.2 Participatory Urban Modelling (PUM)

Addressing issues and exploring alternative solutions in urban systems is strongly dependent on the perspectives of the multitude of stakeholders involved. In order to explore the current issues and relevant potential alternative solutions it is essential to take these different perspectives into account.

Therefore, we developed the Participatory Urban Modelling (PUM) framework which aims for participatory development, validation and calibration of participatory urban simulation models. Within this cyclic process of the framework,

researchers and stakeholders actively collaborate in the development of the City Simulator toolbox through (figure 2).

The framework is based around a series of agent-based urban models jointly referred to as the City Simulator toolbox (figure 2). These models represent various urban spatial dynamics such as cyclists and pedestrian movement. Agent-based models are generally based on "simple" decision rules at agent level. However, by simulating the interactions among agents and between agents are their environment, surprising spatial patterns can occur. These patterns can be analysed and be better understood by understanding the rules of individual agents.

Agent decision-making is based on a broad framework of behavioural theories. The agent rules will qualitatively validated one-on-one Human Agent validation (HAV) sessions in which humans will make decisions like those taken by the agents in the model while interacting with agents in the model under the same conditions as the agents interact with each other. In addition, empirical data from counting's, surveys and tracking tools will be used to validate the simulated spatial movements of the agents.

The relevance of the toolbox and the associated models within will be assured through interactive Participatory Urban Gaming (PUG) workshops. In these workshops, stakeholders collectively define the issues as hand and reflect on the models developed in the toolbox. After model validation, stakeholders will jointly define potential (policy) alternatives to address the issues. Together they will explore the impacts on quality indicators and spatial conflicts through interacting through a combination of serious games and agent-based models from within the toolbox.

Figure 2: Schematic overview of the Participatory Urban Modelling (PUM) framework and the three interlinked activities within the framework (*top*) and illustrations of the three activities (*bottom*).

3.3 Expected outcome

The expected outcome of the City Simulation Lab are:

- A series of relevant and validated agent-based models within the City Simulator toolbox capable of exploring (policy) scenarios
- An improved understanding of complex urban dynamics and tourism expansion in Amsterdam through the validated outcome of the developed agent-based models

References

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