Chapter 4
Urban Development Modelling: A Survey

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ABSTRACT

Modelling and simulating cities evolution has been lately the focus of scientific studies, in the urban field, as it represents a mean for effectively managing and planning land-development. Consequently, the development of urban models has known a remarkable growth. This model boom was a key driver behind many studies aiming at providing comprehensive reviews of existing urban models through classifying them based on various characteristics. In this context, this chapter reviews the different classification studies, proposes a classification of a set of most popular models based on their modelling-task, strategy, and data, then assume and argue how these three elements can majorly affect the modelling-approach choice-making. Indeed, its overall goal is to deliver a sort of "white paper" aiming at assisting researchers in their seeking for the most adequate modelling-approach for their urban modelling-task specifications.

INTRODUCTION

Spurred mainly by economic development and revolutions in transport, communication, and information, uncontrolled and unplanned urban growth or urban change is accompanied by various and serious problems. These include, amongst others, pollution, energy inefficiency, reduction in well-being, inflated infrastructure and public service costs, encroachment on valuable agriculture land, biodiversity loss, local and regional climate change, etc. (Lambin et al., 2001). One of the worth citing examples is the degradation of wildlife habitat in India (Yadav, Kapoor, & Sarma, 2012), mainly due to human encroachment in terms of agriculture land and build-up area, and their anthropogenic activities.

Faced to all these severe negative consequences, a need for efficient analysis, comprehension, and anticipation of urban change, specifically land-use/cover change (LUCC), and its possible impacts on

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human environment has arisen. In fact, this knowledge is crucial to maintain sustainable land development and suitable life conditions for citizens, which represent universally shared objectives.

Urban change which as most of other real world phenomena represents the outcome of temporal processes. A process is defined as a set of events such as land use and land cover changes. These types of change are deeply related to the concept of spatio-temporal evolution as they take the modelled systems (urban phenomena) and their constituent objects from a state to another one valid for a specific spatial and temporal frame. Many efforts have been done in representing and modelling the temporal component in urban change phenomena, from different perspectives: the representation of time in itself (linear, branch, cyclical), time measurement in the context of databases, and temporal relationships between events (chronological order). Many example of work emphasising on the temporal dimension when dealing with analysing urban growth, have been presented. For instance, in (Lyons, Roelfsema, & Phinn, 2013) the authors used timeseries images stacking for a per pixel analysis over time to determine inter and intra-annual temporal trajectories showing the dynamics of seagrass cover in the area of Moreton Bay over time. Although time is often conceptualized as linear continuum on linear scale, this conceptualization is insufficient when dealing with real life phenomena which may branch into different scenarios or have a cyclical temporal pattern. In the context of databases, many challenges in dealing with embedded temporal information have arisen. They are mainly related to the representation of events in time (discrete, continuous), and the frequency of observation of phenomena (time resolution) which represents an influential elements of the analysis and understanding of urban growth dynamic. In fact this latter is non-linear, stochastic or even chaotic in the longer term which results in the fact that patterns, processes and behaviours of urban growth are temporally varied. Another important interest is devoted to temporal relationships among the different events (before, after, overlap). These relationships are important in following the urban growth dynamic over time and therefore analyse it and understand it.

In the last few decades, modelling and simulating cities urban development have drawn a great attention, and thus, a quite number of models have been proposed. This model boom was a key driver behind many studies aiming at providing comprehensive reviews of existing urban models through classifying them based on various characteristics. Although we recognise the importance of modelling temporal dimension in urban change phenomena, the authors of this paper concentrated on the spatial aspect of modelling.

As matter of fact, the overall goal of the present chapter is to propose a sort of handbook to guide researchers in their seeking for adequate methods for their urban modelling problem specifications. In this light, the authors conducted the present study on a set of thirty well-known urban change models existing in the literature with the objectives of not simply surveying them or just conveying to readers how they have been set up and what are their limits and strengths . Instead, this chapter attempt to dive into the details of each of the addressed urban models so as to unveil any underlying links between three important characterizing elements that this work proposes to consider. After that, and based on the preceding steps, directives on the choice making of the adequate modelling approach are derived.

BACKGROUND

Due to the exponential increase in the development of models, plurality of works attempting at providing comprehensive studies of them and their characteristics have been proposed. They proceeded, mainly, by creating categories then classifying models according to these categories in order to recognize, dif-