Chapter 37
A Short Presentation of LucSim

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Abstract LucSim is a cellular automata (CA) dedicated to geographical analysis and spatial simulation for researchers and advanced planning institutes, providing user-friendly software in order to analyze and simulate land use changes and dynamics. Two complementary models are integrated in the CA: (1) a Markov Chain used to calculate transition matrices from a date to another, and (2) a Decision Tree able to automatically determine a set of transition rules to be applied on land use data. LucSim includes GIS compatibility functions allowing to display ESRI shapefiles and is based on raster georeferenced images saved in TIF format. It was mostly applied on French urban case studies.

Keywords Cellular automata · Markov chains · Transition rules · Decision tree · Urban development

1 Introduction

LucSim is a cellular automata model dedicated to geographical analysis and simulation for researchers and advanced planning institutes. The goal of the project is to provide user-friendly software in order to analyse and simulate land use changes and spatial dynamics (Fig. 1). It is currently being developed at laboratory ThéMA (University Burgundy Franche-Comté and CNRS) from the basis of the CWS/Camdeus project, in collusion with the MobiSim LUTI project, to provide a suit of simulation tools for decision making in urban and land planning.

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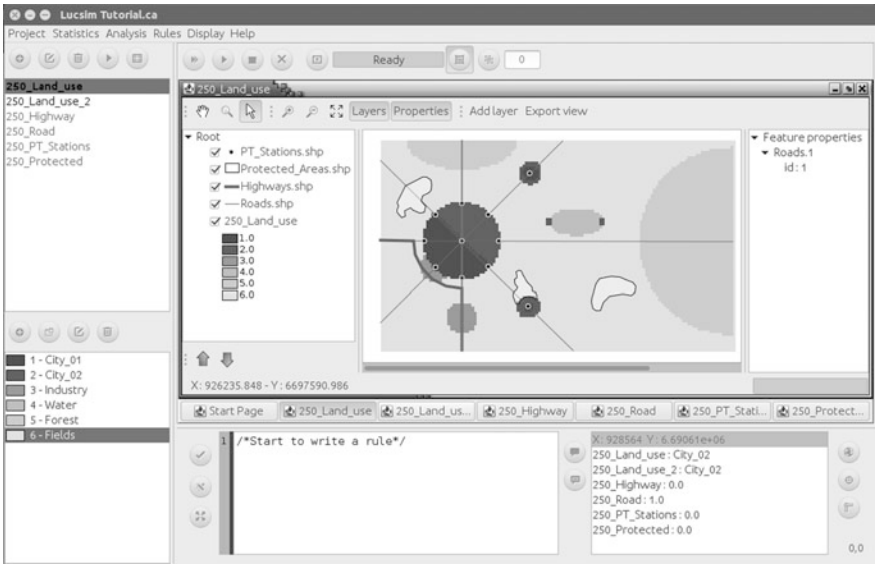

Fig. 1 Screenshot of LucSim tutorial

2 Description of the Methods Implemented in the Model

LucSim relies on the basics of cellular automata, involving grid mapped land-use and transition rules. Its major functionality is based on P. Torrens's definition (Torrens 2000). Technically, the application of a set of transition rules, where the state S of a cell i at step $t + 1$ depends on its state at step t and on its neighbourhood at the same step in a radius O, constitutes the main engine to simulate prospective scenarios of land use change. Land use transition rules can be defined manually, constrained by different techniques or determined automatically.

For rules constraints, two models are integrated in the CA. First, from the land use maps, LucSim is able to calculate transition matrices from a date to another, and to run a markovian process. This Markov chain is useful to calibrate the number of cells that can evolve in the future, and then to improve the temporal dimension of land use change simulation, which is often missing in classical CA tools. Second, LucSim integrates a potential model based on the main principles of spatial interaction. This potential can be used to integrate a specific value to cells and to weight their decreasing influence on the neighbourhood according to their increasing distance. Markov chains and potential modeling can be automatically combined into the CA engine to improve the relevance and the efficiency of the transition rules.

For transition rules automation, LucSim integrates a Decision Tree (DT) process to automatically determine a set of transition rules to be applied an land use data. According to users' parameters and calibration, this DT is based on learning machine and demands to split the initial data in two sub-datasets. The first one is

used for training and the second one for testing the obtained results. Resulting transition rules can immediately be analysed and run through the regular CA process to test hypothesis or forecast future land use changes.

Spatial statistics (neighbourhood analysis) is also an advanced function of the model, allowing to extract specific neighbourhood, to compare sets of land use images, and to assess the relevance of the CA constraints and simulation results.

3 Applications

LucSim was mostly applied on French urban case studies (Belfort, Besançon, Montbéliard, Nantes, Rennes) and on the cross-border regions of Strasbourg-Kehl and Luxembourg.

4 Final Considerations and Technical Summary

As a geographical cellular automata, LucSim includes GIS compatibility functions allowing to display ESRI shapefiles (.shp) and is based on raster georeferenced images saved in TIF format. LucSim must then be connected and feed by GIS and Raster graphics editors. So far as LucSim is strictly defined as a geographical cellular automata (including diachronic land use analysis tools), it does not assume any image creation or modification.

LucSim is a .jar software developed in Java language and necessitates the installation of Java 8 at least to be executed on any system operator (Linux, Mac OS or MS Windows). LucSim can be downloaded here: https://sourcesup.renater.fr/lucsim/.

Reference

Torrens P (2000) How cellular models of urban systems work, Working paper series 28(1) Centre for Advanced Spatial Analysis 68 p