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Developing an Agent-Based Model to Simulate Urban Land-Use Expansion (Case Study: Qazvin)

F. Hosseinali, A. A. Alesheikh, F. Nourian
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Extended abstract

1-Introduction

Urban land-use expansion is a challenging issue in developing countries. Increases in population as well as the immigration from the villages to the cities are the two major factors for that phenomenon. Those factors have reduced the influence of efforts that try to limit the cities' boundaries. Thus, spatial planners always look for the models that simulate the expansion of urban land-uses and enable them to prevent unbalanced expansions of cities and guide the developments to the desired areas.

Several models have been developed and evaluated for simulating urban land-use expansions.

Despite the variety of the models, most of them have focused on simulating urban land-use expansions just around a city. Thus, the regional models that consider wider area are of primary importance.

2- Theoretical bases

In this study a new agent-based model has been developed and implemented to simulate urban land-use expansion in Qazvin and Alborz regions of Qazvin state which have an area of 1620 square kilometers. In this model, land-use developers have been treated as agents that move in the landscape explicitly and assess the state of parcels for development. So, the environment of the model is raster. The agents are developed into five groups which have different aims. The agents may fall in competition to develop the same parcels. Moreover, due to the spatial essence of the problem, GIS were used to prepare the

Author (s)

F. Hosseinali (✉)
PhD Student of GIS, K.N.Toosi University of Technology, Tehran, Iran
e-mail: frdhal@gmail.com
A. A. Alesheikh
Associate Professor of GIS, K.N.Toosi University of Technology, Tehran, Iran
F. Nourian
Associate Professor of Urban Planning, University of Tehran, Tehran, Iran

environment of agents' movement and search and to aggregate and analyze the results.

Two main steps can be recognized in this model: the Searching step and the Development step:

Searching step: The agents are created and distributed in the districts. The selection of districts is probabilistic and is based on the primary probability of selection, assumed for districts. When agents go to the districts, at first they move randomly to the neighborhood of pre-developed areas. Wherever the agent starts its activities, it assesses and saves the state of its current parcel and also its eight adjacent parcels. Next, the agent moves to its best neighbor parcel, or if more than one parcel achieves the same score, it chooses one of them randomly. If the agent movement is finished or it is not able to move to a neighbor parcel, the agent changes the search region in the district and jumps to another position in the same district. Moreover, the agents can search a specific number of districts in the same way. Thus, at the end of each Searching step, each agent records the situation of several visited parcels and sorts them in descending order.

Developing step: When all agents finish the search, the Developing step starts, and agents choose the top scoring parcels in their sorted list to develop. In the conflict cases, a competition determines the winner and the loser(s).

3– Discussion

In this research, the agents play the role of land-use developers which assess the land parcels and develop the desired ones. Thus, the agents should have an important characteristic which is called bounded rationality. This means that the knowledge of each agent about its environment is limited. In this model, the agents search a definite number of parcels and they are divided into five categories. With these two mentioned characteristics, the developers are treated as the agents with bounded rationality.

The model has several parameters which should be set before running. The parameters were set in two ways. Some of them like the weights of the input layers were set by experts. To set the others, several sets of parameters were considered and the model ran with each set. Therefore, the best set of parameters which caused the best result of the model was found.

To evaluate the model, data of year 2005 were used as the input and data of year 2010 were used for checking the results. By calibrating the model, the most desired configuration of the model was found and the results were close to the reality as the Kappa index raised up to 78.17 percent. These results show that the precision of the model to simulate land-use developments is good. Thus, the model is able to detect the area that faced rapid urban land-use expansions.

4– Conclusion

This paper presented the concepts and specifications of an agent-based model for the simulation of urban land-use sprawl in a Geographical Information Systems (GIS) environment. The multi-agent system of

residential development implemented in this paper demonstrated the ability of agent-based models to simulate urban land-use development. Furthermore, the results affirmed that linking GIS with ABM can enhance the capabilities of a simulation / modeling system for spatial problem purposes. A newly developed method for searching landscapes, selecting parcels and having competitions among agents, bring us better ways to simulate the behavior of land-use developers.

5– Suggestions

While the application of simulations to study human-landscape interactions is burgeoning, developing a comprehensive and empirically based framework for linking the social, biophysical and geographic disciplines across space and time remains for further research. Furthermore, developing the agents to make more complex decisions, as well as, establishing a framework for direct linking of the agents are suggested for future researches.

Keywords: Agent-based modeling, urban land-use expansion, competition, GIS

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