GEOSIMULATION AND SPATIAL ANALYSIS

Linking Cellular Automata and Neural Networks to Forecast Land Use/Cover Change

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The geosimulation is an emergent field of inquiry that advocates the use of computational intensive methods of spatial analysis as the ones that appeal to heuristic search, neural nets and cellular automata. This work presents a method to simulate the land use/cover evolution in a rural/urban fringe reality, linking neural networks and cellular automata (CA) in a GIS environment. The simulation of such alterations appealing solely to cellular automata is not convenient, because these models, in its more conventional form, comprise limitations in the definition of the space parameters and the transition rules. In this work a neural net is used to survey the importance degree that each prediction variable (probability) has in the geographic constraints. These variables are gotten with resource to GIS.

KEYWORDS

Cellular Automata, Neural Networks, Land Use/Cover Change.

ABSTRACT

The geographic space representation in a GIS environment is usually static. Hence, a focus with raised relevance in the geosimulation is the elaboration of models that combine the structural elements of the space (geographic objects) with the processes that modify it (human actions and the form they process along time).These models aim at to free the analyst of the static space vision, induce by traditional cartography and to explain the dynamic component as an essential part of the geographic space.

This motivation leads to the use of cellular automata as a method to simulate the urban and regional growth. The cellular automata (CA) extend this analogy in a way that provides the visualization of a set of cells (pixels) in interaction, being each one of them a computer (automation). By this means, the cellular automata can be understood as a dynamic and relatively simple space system, in which the state of each cell of the matrix depends on the previous state of the cells enclosed inside a defined neighbourhood, in accordance with a set of transition rules. This work presents a method to simulate the land use\cover for year 2015 in an urban/rural fringe reality (Almada Municipality), linking neural nets and cellular automata in a GIS environment.

The choice of this municipality is due to diverse factors of great importance, such as: is near the capital (Lisbon); enjoys of increased accessibility since the construction of the Tagus bridge; as the possibility of urban expansion and rare natural potentialities and, between 1967 and 1986, the territory attended to a unmeasured urban pressure, resulting in a irreversible ground occupation in areas of strong physical restrictions. Between 1960 and 1991 (dates corresponding to the population census) its population did not stop to grow, even that in differentiated rhythms. The job dependence is a reality that the pendular movements between Lisbon and Almada corroborate, its beaches had been emerge as an alternative to the Estoril line ones and the second residence assumes a strong importance.

Despite its advantages (e.g. to have in consideration the context) the CA lay problems in the transition rules definition and in the model structure definition. These are normally dependents of the application in cause, therefore even there's diverse CA models similar in its generic nature they differ substantially in form. These variations result from the existence of different forms of defining the transition rules and the models structures. These models can also include constraints in order to generate idealized urban forms (Li and Yeh, 2000) and, options and planning objectives to produce alternative scenarios (Wu and Webster, 2000). Thus, they have been proposed structures and substantially different transition rules to answer the same objectives and specifications. The choice quandary of the appropriate model is always present in the sense that a wide ranging fan of options exists.

Another problem of the CA models, and perhaps the greater, is the weight determination of each factor. In the past, these models were only used to simulate the urban growth in the perspective of the rural-urban transition. The simulation of this type of growth, that only deals with binary states - urban or not, is relatively easy, but CA models become extremely more complex when multiple uses are introduced, as residential, commercial and industrial. When dealing with diverse land use/cover uses in competition between them for the territory (i.e. expansion space), the number of weight factors particularly increases and the models become more complex. Numerous parameters exist that need to be determined so that the simulation reflects an urban system and the role of possible models to use is enormous.

The simulation involving multiple land use/cover implies the use of several spatial variables. The contribution of each one of these to the simulation is quantified by the weight (i.e. balance factor that is associated to it). The value of these parameters has a great effect (weight) in the simulation results, resulting that different combinations lead total different urban forms. One way to carry on this type of calibration, but at the same time shortening the processing period is through the use of neuronal networks.

The applied model is based on three sequential steps: i) application of space rules that relate the forecast variable with the land use/cover transformation in each location; ii) integration of all the information levels using neural nets and iii) create a secular data series that allows to foresee futures uses.

This article demonstrates that neural nets can conveniently be incorporated within cellular automata models, in order to simulate the evolution of multiple land uses/covers. This method can break away from some of the difficulties imposed by the traditional CA models, in complex urban systems simulation and multiple land use/cover changes, through the significant reduction of the necessary time to define the variables weights, the transition rules of the model structures. GIS allows the straightforward attainment of training data, permitting model calibrating and to get, with easiness, the parameters value. This approach has as main advantages is ability to deal with incomplete and erroneous input data and the fact that the generated forecast surface is clearly not linear, which opens a clearly high role of probabilities relatively to the surfaces produced by the linear regression models. In a large extent of the geographic phenomena the variables are correlated and the traditional methods, as the multi-criterion analysis techniques, are inadequate to evaluate the proper variables weight. In the neural net based CA model, the spatial variables do not have necessarily to be independent ones of the others.

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