Simulating urban expansion through Cellular Automata model on different neighborhood size

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Abstract:

The aim of this study is to simulating urban expansion through Cellular Automata model on different neighborhood size in Erbil city, Kurdistan region, IRAQ. The different type of Cellular Automata model is utilized to simulate land use/cover change based on different neighborhood size to 1985 and to predict the pattern of urban extent in 2050. A FCA interface as first method guided cellular automata approach. The CA - Markov land-cover change model was second method that has been successfully applied for simulating Erbil expansion. Based on geographical entity many restrictions existing in standard CA are released in VecGCA.

Keywords: GIS, Urban Expansion, FCA, CA- Markov, VecGCA, Erbil City

1. Introduction:

Cities play a crucial role in our lives, providing habitats for over half of the world's population. However, understanding such systems is extremely complex as they are composed of many parts, with many dynamically changing parameters and large numbers of discrete actors interacting within space (Batty, 2005). There are various types of models in the environmental sciences, and surely there is no unique opinion about the essence of an environmental model (Almeida et al, 2008)

The complexity and dynamics of urban systems make the applicable practice of urban modeling very difficult (Yan Lu, 2009). Today, processing temporal satellite images obtained from remote sensing technology are very useful tools for evaluation and modeling land –use/cover changes in the world. Cellular automata (CA) with simple mathematical systems have very complicated system (Lanes et al, 2010). The integration of GIS and CA shows tremendous capability in simulating Spatio - temporal dynamic process in geography world. But standard CA has some restrictions in cellular shape, spatial resolution, precision, quantity, neighbor and rule which restrict the CA's abilities of simulating real world and other applications (Moreno et al, 2008). Taking the IRAQ country, Kurdistan Region, Erbil Metropolitan Area (EMA) as a study area, Fuzzy Cellular Automata, CA- Markov and Vector – based Geographical Cellular Automata in Geospatial Information System (GIS) has been successfully applied. Four Landsat, TM and ETM+ images (1985, 1990, 2000 and 2010) with specific time interval, socio-economic and environmental variables were used as inputs while urban and non-urban areas were considered as outputs for all models.

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2. Materials and Methods:

Erbil City is located in the north of Iraq. Erbil Province borders Turkey to the north and Iran to the east. Erbil composes with both Dahuk and Sulaymaniyah, the area run by the Kurdistan Regional Government (KRG). The City of Erbil is the capital of both Erbil Province and the KRG (OCHA and UNAMI, 2009). The different type of Cellular Automata model is utilized to simulate land use/cover change based on different neighborhood size to 1985 and to predict the pattern of urban extent in 2050.

In Fuzzy Cellular Automata a fuzzy inference guided cellular automata approach. Semantic or linguistic knowledge on Land use change is expressed as fuzzy rules, based on which fuzzy inference is applied to determine the urban development potential for each pixel (Al-Ahmadi et al, 2008). According to the plan of Erbil, parameters such as distance from transport networks, distance from residential areas, distance from the green spaces, urban density, and elevation used to urban growth simulation(Al-Amadi et al, 2008). To simulation the best model we used three pixels size of urban ETM+ images (10 * 10 m, 30 *30 m and 50* 50 meters). According to The Moore neighborhood types in three sizes 8, 24 and 48 cells in three neighborhoods of small, medium and large scale urban development models were used for implementation. Overall accuracy and kappa coefficient was designed to evaluate the accuracy of model in various time intervals. The investigation determined that the best simulation model can be achieved in a small neighborhood with 10m pixels. In Fuzzy Cellular Automata (FCA) method to simulated and predicted urban expansion pattern, using many parameters such as reliability of data and expertise to understand.

The CA - Markov land-cover change model was second method that has been successfully applied for simulating Erbil expansion. The Markov model is a theory based on the process of the formation of Markov random process systems for the prediction and optimal control theory method (Samat, 2009). Markov chain method analyses a pair of land cover images and outputs a transition probability matrix, a transition area matrix, and a set of conditional probability images. The transition probability matrix shows the probability that one land use class will change to the others. The transition area matrix tells the number of pixels that are expected to change from one class to the others over the specified period (Wang et al, 2010).

The conditional probability images illustrate the probability that each land cover type would be found after a specific time passes. The Markov chain analysis was used to compute transition probabilities based on the LANDSAT satellite images. Some of its characteristics (fixed driving factors, neighborhood filter rules, etc.) may complicate its application and lower the quality of reconstructions (Wang et al, 2010). The best results were achieved when moderate changes were considered. The quality of reconstructions was poorest when periods or classes with exceptionally high or low variability of land-use were considered. The application of historical and archeological data for calibration and validation of reconstructions is desirable if realistic reconstructions of the development of the cultural landscape are expected.

In this method the problem was about low resolution (30m) property of Landsat images which makes the classification difficult. Moreover beside the properties of the Landsat image the study area which includes many heterogeneous areas make the classification with Landsat images difficult. The overall accuracy for the classification was around 75% and according to Pontius (2000) the minimum requirement of the accuracy in classification should be around 80 % to explain the LULC categories. But for this study because of the resolution of the images and the heterogeneity of the study area we continue the study with the overall 78.5 % accuracy.

Typically a CA model is a close system, which means no information, or energy or mass is exchanging with its outside world while it is not the case in an urban context (Moreno et al, 2007). The VecGCA method was third method that was tested with experimental data in controlled conditions to determine the ability of different neighborhood size in simulation model. The results indicate that the nature of modeled objects and interactions Geometrical objects displaying independent of their location and size of neighbouring cells. The dependency algorithm Program, the effect of buffer size on the results, the number of classes and the complex nature of vector analysis to analysis of raster are very important.

3. References:

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