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Guest Editorial

Simulation in spatial analysis and modeling

GeoComputation is an evolving research field with a primary focus on exploring new modeling paradigms and techniques derived from advances in computation for the goal of enriching geographic analysis of highly complex, and often non-deterministic problems (Longley, 1998). Agent-based models, cellular automata, fuzzy sets, genetic algorithms, and neural networks have attracted attention as useful research tools. In recent years, computational geometry, interactive exploratory data analysis and mining, numerical modeling, and many other research themes have been entering the scope of GeoComputation (Couclelis, 1998; Xie & Ye, 2006). Simulation in spatial analysis and modeling has been one of the key approaches of many researchers of GeoComputation. A dynamic geographic simulation represents the spatiotemporal dynamics of a physical system, a human system, or a coupled human–physical system that incorporates multiple stochastic and dynamic processes with the aim of solving or understanding problems or systems with multiple and often conflicting objectives (Maxwell & Costanza, 1997; Batty, 2005). Solving these multi-objective problems presents a significant challenge and may have to rely on alternative evaluations of optimal solutions (Bennett, Xiao, & Armstrong, 2004). As Page (2003) so cogently argues: "... our models become better, more accurate, if they make assumptions that more closely match the behavior of real people ... " In addition to the model inputs, algorithms, assumptions, and outputs, the human dimension (modeler) is the most important fifth element to keep honesty toward the sensitivity test and to establish credibility in complex modeling and simulation (Clarke, 2005). The diversifications and complexities embedded in geo-simulations become the main theme of this special issue.

This special issue draws together seven papers that were presented at the GeoComputation 2005 conference, held August 1–3, 2005 in Ann Arbor, Michigan and jointly hosted by the School of Natural Resources and Environment at the University of Michigan and the Institute for Geospatial Research and Education at Eastern Michigan University. Xiao et al. reviews recent development in evolutionary algorithms and presents a conceptual framework for multi-objective spatial decision making. This framework supports the generation of alternatives for solving spatial optimization problems using evolutionary algorithms and provides visual tools to evaluate multi-objective spatial decisions. Duh and Brown tackle multi-objective spatial allocation problems by integrating several techniques in an innovative method called Knowledge-Informed Pareto Simulated Annealing. Duh

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and Brown demonstrate that the knowledge-informed approach is more effective than the standard Pareto simulation annealing through a case study of optimizing spatial patterns of two classes of land covers in a hypothetical landscape. Powers et al. applies the optimization algorithm, simulated annealing (SA), to investigate temporal dependence in error propagation in simulating land cover changes. User-defined objective functions are used in SA to create three specific error patterns with the errors located randomly and independently across the study area with a predefined level of spatial autocorrelation at Times 1 and 2, with temporal correlation between Times 1 and 2, and with a correlation between the classification boundaries at Time 1 and a predefined level of spatial correlation at Time 2. Powers et al. point out that temporal dependence of errors has a significant effect on our ability to detect pattern changes and associated errors and there exist complex interactions between patterns of change and patterns of error. It is imperative to quantify and model spatial and temporal dependencies in order to understand error propagations in detecting land cover changes.

Two papers focus primarily on simulating or representing objects in constant change. Prager explores how environmental objects serve to contextualize parametric estimations of spatiotemporal uncertainties associated with moving objects. Geographic objects surrounding a moving object are formalized as uncertainty surfaces in a way that buildings are quantified as hindrance probabilities while roads as enabling scores. Prager demonstrates that this ontological approach of environmental contextualization achieves increased accuracy of describing trajectories of moving objects and could be integrated in spatiotemporal database design. Kim and Cova propose and test the tweening grammars for making more effective and efficient interpolations between two snapshots of changing geographic phenomena such as wildfires. Kim and Cova develop a hybrid approach using a semi-automated correspondence rule and medial axis transformation, and successfully illustrate this approach in a case study of tweening the Southeastern California Prix Fire in 2003.

The paper by Torrens and Nara elaborates a hybridized cellular- and agent-automata model for testing hypotheses related to urban gentrification dynamics. Fixed automata are configured over a regular lattice of square cells at the most local scale, while agent (mobile) automata are introduced as Residents to model households. The agent behavior is formulated based on a decision-making regime for households in a competitive market. The model is tested in a formerly deprived area of Salt Lake City that is undergoing dramatic change. Torrens and Nara demonstrate that this hybrid automata model is adequate for hypothesis testing and scenarios evaluation across a wide array of gentrification issues.

Finally, Shortridge presents experimental findings which describe the practical limits of Moran's I under a variety of different proportions of ones to zeros (in a binary raster) and contiguity measures. This paper points out that differences in positive spatial autocorrelation due to contiguity are very trivial, but I values in negatively autocorrelated rasters show vast sensitivity to the contiguity methods.

In summary, these papers provide a valuable spotlight into the emerging field of GeoComputation. The contributing authors have made unique contributions in synthesizing current advances in geo-simulations and spatial decision making, developing new simulation techniques and approaches, designing new frameworks and methods to expand our research ability to the areas that have been less attainable before, and conducting new tests for investigating simulation errors and validating applicability of new or improved models. Moreover, many of these papers show strong signs of interdisciplinary research, which brings positive impact on future growth of GeoComputation. Finally, all of these new developments are taking place in a dynamic research field that is changing dramatically. Many of these papers reflect this nature, presenting results from on-going projects, where there are plenty of rooms for further exploration and work.

We wish to thank the editor of *Computer*, *Environment and Urban Systems* for providing this forum for these papers, the anonymous reviewers for their generous and insightful advices to the authors for producing better quality papers, and the authors themselves for their timely production of the papers and their subsequent revisions.

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