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Guest editorial

Geospatial modeling of urban environments

Urban environments are central to human lives and activities. The past century has witnessed a dramatic and continuing trend in urbanization, in which, according to the UN (2007), the percentage of the population that can now be classified as urbanized has increased from approximately 30% in 1950 to over 50% in 2005. In North and Latin America as well as Europe, almost 80% of the total population are urban residents. This phenomenon has excited enormous research interest, particularly in the analysis and modeling of the spatial dynamics of change in urban environments at various levels of spatial and temporal granularity. Recently, the increasing availability of movement data from mobile devices and other location-based services have stimulated new lines of inquiry (Jiang and Yao, 2006) and one of the purposes of this theme issue is to capture some of the breadth of these research investigations in this domain. Seven research papers have been selected from papers presented at the Second International Cartographic Association (ICA) Workshop on Geospatial Analysis and Modeling, held in July 2007 in Athens, GA. The papers represent diverse perspectives geared to providing a better understanding of the social interactions and physical dynamics in urban environments.

The literature reveals considerable work focusing on geographical simulation for exploring the complexity of urban systems. Since the early 1980s geographers have pioneered work employing cellular automata (CA), which simulate incremental changes in the characteristics of atomic urban objects (or spaces) on the basis of transition rules expressed using a form of predicate calculus (eg Batty and Xie, 1994; Clarke and Gaydos, 2003; Couclelis, 1989). Another widely adopted geographic simulation approach, agent-based modeling (ABM) or multiagent simulation (MAS), configures agents to represent humans, agencies, authorities, and other types of decision makers. The behaviors and interactions of agents over the geographic space result in the spatial and temporal dynamics that characterize urban environments. Many applications find advantages in hybrid forms of CA and ABM models that use agents as actors of change while embodying a cellular representation of spaces. For example, Torrens and Benenson (2005) proposed the framework of geographic automata systems that essentially integrate CA and ABM into one system.

Three papers in this theme issue contribute to research on the geographic simulation of urban dynamics. Occelli and Staricco (2009) explore the decision-making processes of individuals' travel behavior by way of geographic simulation. Their multiagent-based system, called CogMob, considers a palette of cognitive strategies which are used in urban mobility. The paper presents interesting findings about how people adopt different cognitive strategies. In contrast to the popular pixel-by-pixel comparison approach to validating ABM simulation models, Kocabas and Dragicevic (2009) present a vector-based validation method for ABMs by using vector GIS and Bayesian networks. The third ABM paper, by Shen, Kawakami, and Kawamura (2009) adopts geographic automata for simulating land-use patterns that are validated using a percolation model. The validated simulation provides a useful tool for 'what-if' scenario analysis in planning and policy making processes.

New lines of cutting-edge research are being fast motivated by the increasing availability of movement data collected using new geospatial technologies. The rapid penetration of wireless communication into peoples' daily life not only has huge impacts on lifestyles and interactions, but also enables new ways in which researchers can study such interactions. For instance, human mobility patterns have been explored intensively using GPS trajectories (eg Gonzalez et al, 2008; Jiang et al, 2008). Two papers in this theme issue present research associated with the Real Time Rome project, which has been developed by the MIT Sensible City Lab using mobile phone usage data collected in Rome. Reades, Calabrese, and Ratti (2009) explore spatiotemporal structures of dynamic interactions of Rome residents and visitors by developing some intriguing eigenvalue analysis of the components of signals that make up urban structure, while Morello and Ratti (2009) focus on the visualization perspective of such patterns revealed by the same data source. The authors present a new technique, namely 3D isovists, to explore visible space from a vantage point in a 3D urban environment.

Spatial and temporal data mining (STDM), as the core component of geographic knowledge discovery, has been widely investigated in response to the increasing availability of the huge and ever-growing amount of geospatial data. The primary objective of STDM boils down to revealing interesting and surprising patterns that otherwise could not be found with traditional data analysis methods (Miller, 2007). Such patterns may present themselves as clusters, classes, associations, rules, and others (Han and Kamber, 2001). Moran's scatterplot has been a popular tool for many years for the investigation of spatial autocorrelation and spatial patterns. In this theme issue, Ahn, Kim, and Lee (2009) extend the tool to what they term a 'Moran Scatterplot Quadrant Sequence' (MSQS), which is used for exploring spatiotemporal patterns. They develop similarity measures and subsequently similarity matrices to measure the 'state sequence' of spatial patterns along the time dimension. In another effort at explaining key change in urban systems, Hwang and Thill (2009) study the complexity of urban housing markets. Recognizing the innate fuzziness and complexity in the cityscape of an urban housing market, they propose the use of a fuzzy clustering method which outperforms its crisp counterparts and is able to paint a more accurate picture of the spatial structure of urban housing markets.

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