Shift in Paradigm Needed for Urban Spatial-Temporal Analysis and Modeling

Panel Contribution to the PERN Cyberseminar on Urban Spatial Expansion by John Hasse, Department of Geography, Rowan University, Email: hasse @rowan.edu

PERN Coordinator's note: In this statement John Hasse suggests a shift from traditional raster and vector approaches to modeling urban growth to cellular automata models based on the most fundamental building block of urban areas, building units. He also addresses the data requirements for such models, which are more easily met in developed than developing countries. This statement addresses the need identified in the Redman & Jones background paper for new urban models that relate the complexity of economic, social and environmental factors (Research Domain I.D), and the need for new approaches to collecting consistently defined data over wide geographic areas on urban form, size and population (Research Domain II.B).

Over the last three decades there has been extraordinary research progress in the spatial analysis and modeling of the human urbanization process. The sister technologies of remote sensing and geographic information systems (GIS) have been foundational tools of urban research since their infancy in the 1960's. Techniques and methodologies for utilizing remote sensing and GIS technologies for urban analysis have also evolved and developed in tandem with the advances made in their technological capabilities. Over the past few years a number of research journals and conferences have focused specifically on modeling urban process, techniques and methods summarizing the state of the art in urban geospatial research. A variety of approaches to current trends in urban research have been highlighted as well as methodological advances such as the use of neural networks, automated pattern recognition and hyperspectral analysis to name a few.

However, while the progress of urban research has been remarkable, there still remains a number of technical challenges and limitations that have yet to be adequately handled within this line of research such as the meaningful integration of remote sensing data with socioeconomic/demographic data as well as the spatial/temporal landscape modeling of urban process. Furthermore, the utility of the information provided by the current state-of-the-art urban analysis to meaningfully inform sound policy making has arguably lagged well behind the advances in the technologies and techniques. What do we really know about fundamental patterns and processes underlying urbanization? How well do we really understand the impacts and efficiencies of various spatial forms of urbanization? How do we meaningfully analyze and compare urbanization processes from one neighborhood to the next, let alone from one city to another, when there are vast differences in the cultural and physical landscape matrixes in which each city exists?

We are challenged to have urban analysis and modeling provide a better understanding of the environmental, social and health-related implications of various patterns of urbanization so that the information leads to substantial improvements in policy and management. Urban researchers need to produce better information that is more valuable to and usable in the planning office, health ministry and environmental regulatory agency, than is currently occurring.

Quantifying Urban Form at its Atomic Level

One direction of research that holds promise for moving beyond the research and policy limitations of many current urban modeling approaches is redesigning the urban model so that it more robustly and eloquently represents the underlying patterns and processes of urbanization.

To date, urban analysis has relied on the two main spatial modeling GIS data platforms of raster and vector. Raster-based modeling approaches have been widely utilized for remote sensing/environmental/land use/land cover lines of analysis while vector-based models have been more widely utilized for socio/demographic approaches to urban analysis. While each platform has its advantages and disadvantages for modeling urban structure, there are nevertheless still many limitations with current raster/vector urban analytical approaches related to problematic issues of appropriate data scaling, modeling urban temporal change, ecological fallacy/ MAUP, among many others. It can just be clunky to represent many aspects of urban process in either a raster or vector data platform. In order to move beyond these limitations urban geospatial modeling may need to reconceptualize the way it represents urban phenomena by reducing urban structure down to the smallest building blocks.

To do this we must shift our approach to urban modeling away from trying to fit the urban process into raster cells or polygons. Instead we must first begin with the urban process itself and then ask how to best model that within a state-of-the-art geospatial digital environment. If the human urbanization process consists of the nexus between the physical built environment and social process, we must ask the question of what is the appropriate fundamental unit or smallest 'cell' by which the urbanization process functions. Is it the neighborhood, the census block, or the zip code area? These are often the spatial units by which demographic data are made available to researchers. Is the smallest fundamental urban spatial unit the individual person living within the city, the family, or the household? These are often the units by which demographic data are collected but by which are protected from public disclosure for issues of privacy.

It can be argued that *building units* emerge as the logical atom or smallest cell of urban spatial structure. By modeling urban spatial structure as elemental building units that exist at a particular time and location in space, building units become the 'urban atomic components' or 'urban cells' that can then be organized and combined into a nested hierarchy of functional entities at the appropriate scale of the phenomenon of interest. Continuing the analogy of urban form as living organism, neighborhoods can be seen as a collection of building unit *cells* grouped into discrete functional areas or the *organs* of the urban organism. Neighborhoods linked together through transportation and infrastructure networks become the functional urban *systems* and the city itself combines the various neighborhoods and systems into the complete functioning (or sometimes dysfunctioning) urban *organism*.

While the analogy of urban process as atomic structure or biological organism can only go so far, many research advances can potentially be made by modeling the urban process within just such an atomic/hierarchal framework. Individual components of the atomic urban data model can be modular and object-oriented so that each building unit can "know" its own location, statistical summaries of the people living/employed in the building, the land area occupied and the building floor area, available social and health-related data, etc. Object-oriented building units could know their own date of creation and thus be incorporated into temporal modeling of urbanization. Building units could also know their proximity to sources of environmental contamination as well as their proximity to crime scenes, accidents, and a potentially limitless amount of socioeconomic data. Urban data collected, organized and analyzed at the urban atomic level of the building unit allows for robust analytical approaches to reveal patterns, correlations and functional relationships between the full arrays of collected data items utilizing various statistical analytical methods.

Developing such an atomic model of urbanization with so much information collected for each building unit sounds daunting and perhaps attainable only after years of expensive data development. However, much of the data and capabilities already exist. Geocoding of addresses makes the locating of building units with a known street address easily accomplished. County tax records describing property parcels and dwellings are accessible public information and regional phone directories including address are already widely available via the internet. Private industry has already developed vast databases of information that include easily geocodable address information. In some European countries the postal service agency collects and updates delivery address locations four times a year making access to current building location data remarkably up to date. On the other hand, in developing countries and particularly in impoverished areas, building unit locations as well as socioeconomic and environmental data may be more difficult to acquire and compile thus making it more difficult to provide comparisons and other useful information. Nevertheless, data collection and development in these developing areas can potentially leapfrog ahead of currently available methods by taking advantage of GPS technology, on-screen delineations of building locations through new generations of remotely sensed imagery as well as other technical advances. Analysis and comparison of cities utilizing an urban atomic data modeling approach would allow better understanding of the differences between urban process in developed and developing countries as well as provide potentially more useful information to land managers and stakeholders. Even when limited additional socioeconomic data exist, the spatial location of building units alone can provide a wealth of information on the spatial patterns of urbanization and associated factors and consequences.

Conclusion

Urbanization is a major factor in anthropogenic environmental impact and intricately interrelated to socioeconomic conditions within the regions in which it occurs and yet we still know relatively little about the socioeconomic/ecological processes, patterns and impacts underlying the urbanization process. While there has been substantial progress in recent decades, to date there still remains significant limitations to current approaches of urban analysis and modeling that has restricted scholarly characterizations of urban form and process as well as hindered meaningful urban comparisons between cities. Furthermore, current approaches to urban analysis and modeling have been limited in providing policy makers and land management stakeholders with substantially useful information.

This short position paper proposes a possible direction for future research in urban analysis that can move beyond some of these limitations by developing an urban atomization research approach. In order to make progress on such a line of research an agenda should be developed to support and foster urban atomization research between different institutions in different parts of the world. Initial work has begun in exploring urban atomization modeling (See Hasse 2004, Hasse and Lathrop 2003,) but this is only a beginning for what has the potential to be an important shift in paradigm for urban spatial-temporal modeling and analysis. The author welcomes feedback and collaboration in progressing this line of research.

References

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