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Guest Editorial

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Applied Urban Modeling: New Types of Spatial Data Provide a Catalyst for New Models

New sources of data originating from new ways of sensing and collecting data are fast emerging as sensors and software are being rapidly embedded into physical and social environments. The data that is being generated usually incorporates time as well as space in much greater locational and temporal precision than anything we have had access to hitherto. This is 'big data', so called because it is often orders of magnitude larger in volume than that collected from conventional 'manual' sources such as the traditional population census and household interview. This is stretching our notion of the system and problems of cities that we might model and it is shortening our attention span, forcing us to concentrate on more immediate problems in both a spatial and temporal sense than what has been the norm in the past.

Our tools for urban planning and design are likely to be transformed by such developments as emerging sources of big data associated with spatial behavior in terms of location and transport interactions are revealing new horizons for urban modeling. Since its inception nearly 50 years ago, urban modeling has had an unapologetically practical and long-term focus on physical interventions in urban land use, accessibility, building location and infrastructure. Its primary purpose was and continues to be to understand the city and then to reshape it to meet long-term goals associated with equity and efficiency – the longevity of urban infrastructure remains an anchor for the need of longer term predictions of the lasting effects of major interventions and cumulative causation over decades. However at the other extreme, much narrower time horizons have been associated with immediate problems and actions in cities which have pushed short-termism to the top of the policy agenda. Suddenly, models are being tasked to inform both short- and long-term issues with respect to urban policy, on matters that pertain to minutes and hours as well as those that pertain to years and decades.

The opportunities for urban modeling to fulfill both such immediate and longer term tasks have become much more significant in the last 20 years: more rounded understanding of human behavior and institutions, an explosion of new data sources, and new means to monitor urban activities (through crowd sourcing for example) are providing the context for using models in more immediate applications. This is particularly the case with respect to transport planning. Moreover, widespread availability of fast computing is heralding a new surge in activity monitoring, research, model-building and policy applications. Slowly but surely our land use and transport models are being adapted to these new tasks.

Almost 20 years ago, Wegener (1994) foresaw some of these new directions for the field of land use and transport modeling, in terms of both the necessity and opportunities for traditional models (which applied static, cross-sectional and aggregate methods) to incorporate different temporal dynamics at increasingly disaggregate spatial scales. A new generation of models such as cellular automata (CA) based models dealing with urban growth followed by more generic agent-based models (ABM) lie in the vanguard of a new concern for temporal

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dynamics which offers the prospect of embracing more immediate and shorter term concerns. Many of these models are more experimental than policy focused (Batty 2008) but recently the development of new forms of hybrid model based on microsimulation particularly associated with the SIMS family of models – UrbanSim and MATSim (http://www.matsim.org/; the latter builds on TRANSIM, see Nagel et al. 1999, Waddell 2002) have the potential to embrace the new data sources, generating new insights into urban behavior, and providing new leads in model simulation.

Whilst the new spatial data appear to be a catalyst for new research directions, a key to their progress is the existence of a variety of milieux in which the urban modelers can better understand one another's preoccupations, methods, data and applications. It is increasingly apparent that the outstanding data and methodological challenges require modelers, who tended to work in isolation in the past, to develop an in-depth understanding across model types and styles regarding possibilities in concert with one another, so that models can be linked to each other and to the policy questions on which they are focused. This was the thinking behind the creation of an annual symposium series on Applied Urban Modeling (AUM) at Cambridge University in 2011 (see http://www.arct.cam.ac.uk/research/applied-urban-modelling-aum) which encourages authors to cooperate in developing new research and in presenting fresh research findings. From this symposium, special issues of journals are organized post symposium based on specific themes. In this special issue, four such research articles are presented, of which three were first presented at the AUM symposium of 2011 and one was specially invited to complement the series. These articles deal largely with the current concern of new large scale data and travel behavior but focus on new methods for dealing with such data as well as on new ways of predicting space-time behaviors.

The first article by Ferreira, Diao and Xu demonstrates how an existing large-scale, location aware administrative data set (in this case the odometer readings from annual safety inspections of individual private passenger vehicles in Metropolitan Boston, Massachusetts) can contribute effectively to the analysis of both medium- to long-term policy implications of greenhouse gas emissions and immediate concerns with near-term urban land use planning alternatives (like "trend growth" vs "smart growth"). Their work links the odometer readings from individual car owners in the recent past to future growth in vehicle miles travelled, at the level of 250 by 250 m grid cells, and highlights the immediacy of its contribution to policy analysis through utilizing the existing administrative dataset and continuous monitoring potential. The quantification of impacts on greenhouse emissions, for instance through the comparison of the alternative planning policies against the State targets, provides evidence for an on-going debate on sustainable urban growth policies (see Echenique et al. 2012) at a geographical resolution hitherto unattainable. The modeling results also clarify both the challenges that the modelers are facing, and the priorities in future data assembly.

Continuing on the theme of car travel, the second article, by Heppenstall, Harland, Ross and Olner, establishes the contribution of a novel hybrid modeling approach that incorporates ABM and spatial interaction modeling through simulating the spatial processes and dynamics in a retail gasoline market. Spatial dynamics is a challenging research area if the modelers wish to retain the theoretical rigor of representing aggregate consumer behavior (such as their price elasticities) whilst simulating complex responses through time and space – a very real need that is critical to the survival of retail businesses that operate on thin profit margins. Their hybrid model incorporates the existing knowledge regarding the aggregate, probabilistic responses of consumers and an ABM for individual gasoline retailers. This allows the spatial competition between individual retailers to be examined at a geographical resolution that is informative to individual retailers for autonomous control over pricing strategies, whilst representing spatial pricing dynamics at a national scale. As a result, they are able to gauge the effects of a rise in oil prices, identifying retailers who are most susceptible to closure over a 10 year period.

The third article, by Anderson, Levinson and Parthasarathi, is focused on improving the model resolution of multimodal transport systems, and developing a new performance measure for assessing a matrix of alternative land use and network scenarios for planning policy purposes. Through an empirical implementation of the model in a large US metropolitan area, they are able to demonstrate the use of their new model in assessing transit and highway network alternatives jointly with land use scenarios. In particular, the performance measure allows them to test the implications of a very broad range of population and job distributions at the city region scale.

The final article by Hagen-Zanker and Jin applies a novel modeling methodology that engages with the emerging microscopic data on travel behavior in model calibration and validation. The method is named adaptive zoning. Unlike traditional zoning (such as by traffic analysis zones or TAZ) where geographic locations are defined by one single universal plan of discrete land parcels for the study area, adaptive zoning establishes a compendium of geographic locations, each of which may represent at a minimum one journey origin or destination only. Those adaptive 'zones' are structured to represent strong spatial interactions in proportionately more detail than weaker ones. In this article they focus on mode choice modeling where the model is required to cover, at the same time, a large study area and fine-grained traveler choices. The findings suggest that adaptive zoning has a significant benefit in enhancing the accuracy of mode choice modeling, in a way that is directly relevant to current policies to encourage active modes across the city-region.

As one would expect, the complex data analyses of all four articles build on new developments in spatial data analysis through GIS platforms. In particular, the GIS tools have enabled the authors to transcend multiple geographical scales from the individual to the city region, and in the process to turn the knowledge on microscopic behavior into policy-cogent findings. Similarly, we are indebted to the editors of *Transactions in GIS* for their willingness to engage with the symposium on applied urban modeling. We hope the articles presented here will expand the dialogue across the related fields, particularly with respect to big data. This dialogue will help shorten time horizons in policy analysis and shed light on how we might best fashion a new generation of planning support tools of which the models and methods contained in these four articles play an integral part.

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