

UrbanSim: Interaction and Participation in Integrated Urban Land Use, Transportation, and Environmental Modeling

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1. PROJECT OVERVIEW AND IMPACTS

The process of planning and constructing a new light rail system or freeway, setting an urban growth boundary, changing tax policy, or modifying zoning and land use plans is often politically charged. Our goal in the UrbanSim project is to provide tools for stakeholders to be able to consider different scenarios, and then to evaluate these scenarios by modeling the resulting patterns of urban growth and re-development, of transportation usage, and of environmental impacts, over periods of 20–30 years. UrbanSim, combined with transportation models and macroeconomic inputs, performs simulations of the interactions among urban development, transportation, land use, and environmental impacts. It consists of a set of interacting component models that simulate different actors or processes within the urban environment.

2. RECENT RESEARCH ACTIVITIES

2.1 Opus and UrbanSim 4

One project this past year has been collaboratively developing a new software architecture and framework — Opus, the Open Platform for Urban Simulation — and rewriting UrbanSim in that framework. There were several factors that led us to take this step: a growing consensus among researchers in the urban modeling community that a common, open-source platform would greatly facilitate sharing systems, the desire to make the system code more accessible to domain experts, and some intractable problems with some of our previous component models (which were hard to solve due to the inaccessibility of the source code to domain experts, making rapid experimentation and testing hard).

After preliminary testing and design work that began in January 2005, we began implementing Opus and UrbanSim 4 (the latest version of the system) in March, and now have

a working version of both [4]. The system is written in Python, and makes heavy use of efficient matrix and array manipulation libraries (principally numarray). The implementation of Opus and UrbanSim 4 contains far less code than the previous implementation, yet implements a much more modular and user-extensible system, and runs faster. It also incorporates key functional extensions such as integrated model estimation and visualization.

Opus has been designed in collaboration with groups at the University of Toronto, Technical University of Berlin, and ETH, the Swiss Federal Institute of Technology in Zurich. The Toronto group has also been active in implementing a new open-source travel model in Opus; we plan to use that in our own work, both directly and to do baseline comparisons with an experimental activity-based travel model.

2.2 Statistical Analysis of Uncertainty

Predicting the future is a risky business. There are numerous, complex, and interacting sources of uncertainty in urban simulations of the sort we are developing, including measurement errors, uncertainty regarding exogenous data and other input parameters, and uncertainty arising from the model structure and from the stochastic nature of the simulation. Nevertheless, citizens and governments do have to make decisions, using the best available information. At the same time, we should represent the uncertainty in our conclusions as well as possible, both for truthfulness and as important data to assist in selecting among alternatives.

We are starting a new project to provide a principled statistical analysis of uncertainty in UrbanSim, and to portray these results in a clear and useful way to the users of the system. We are leveraging in this work a promising technique, Bayesian melding, which combines evidence and uncertainty about the inputs and outputs of a computer model to yield distributions of quantities of policy interest. From this can be derived both best estimates and statements of uncertainty about these quantities. This past year we have had some initial success in employing this technique, applying it to calibrate the model using various sources of uncertainty with an application in Eugene-Springfield, Oregon. These results are reported in a journal article recently submitted to *Transportation Research B: Methodology* [3].

To appear in the “Project Highlights” section of the Proceedings of the 7th Annual International Conference on Digital Government Research, May 2006.

2.3 Indicators and Stakeholder Interaction

Another set of activities concerns presenting the results of simulations to different stakeholders, including elected officials, members of neighborhood, business, and advocacy groups, in ways that are clear and that speak to the issues of concern for those stakeholders. Our work in this area is guided by the Value Sensitive Design methodology, an approach to the design of information systems that seeks to account for human values in a principled and comprehensive way throughout the design process.

One project involved carefully documenting and presenting the indicators that portray key results from the simulations. Our design addresses a number of challenges, including responding to the values and interests of diverse stakeholders, and balancing the value of fairness with presenting a diverse set of advocacy positions. We published the results of this work, including empirical evaluations, in the European Computer Supported Cooperative Work conference [1]. Another project has been the development of “Personal Indicators,” which distill the simulation results down in ways that speak to concerns of individual citizens. A preliminary description of this has been accepted for the ACM Computer Human Interaction Conference [2], and will form a section of Janet Davis’s forthcoming Ph.D. dissertation.

2.4 Testing Stochastic Systems

Agile software development methodologies and extensive testing have been a hallmark of our software engineering practices on UrbanSim for some years. However, we have had consistent problems adequately testing stochastic algorithms, which may give different results each time they are run. (And many of the key UrbanSim algorithms are stochastic.) We recently made major progress in this area, developing a set of design patterns for tests of stochastic systems that include distributional tests on the results of running the test repeatedly. This is supported by a sound statistical analysis of how to interpret the results from such tests, and a unit test framework that implements it. These results are currently being written up for publication.

3. COLLABORATIONS

One set of collaborations is with government planning agencies that want to apply UrbanSim to their regions. Our primary effort at present is with Puget Sound Regional Council, the metropolitan planning organization for our own region. We have also collaborated actively with MPOs in Salt Lake City, Eugene, Honolulu, Houston, and Detroit. There have also been research and pilot applications in Amsterdam, Paris, Phoenix, Tel Aviv, and Zurich. The first UrbanSim Users Group meeting in San Antonio, Texas, in January 2005, attracted some 30 participants from MPOs around the country, a number of academic researchers, and one participant from the Netherlands.

Another set of collaborations concerns the development of Opus, the Open Platform for Urban Simulation described in Section 2.1, with an emerging consortium of research teams from Canada, France, Germany, Japan, Switzerland, and the United States. We are also working with researchers at the University of Massachusetts in Amherst on the “UrbanSim Commons,” a web portal to facilitate exchange and collaboration among UrbanSim users.

4. PLANS AND CHALLENGES FOR THE COMING YEAR

We plan to release Opus and UrbanSim 4 early this year. A challenge has been balancing this constant software evolution, driven by the research agenda and problems that we encounter, with the needs of our government partners, who, after all, want a stable, working system that they can use as an ongoing part of their operational procedures. We hope that Opus will provide a workable platform for them, and are putting a great deal of our effort towards that end.

A more risky area of research will our emerging work on statistical analysis and representation of uncertainty using Bayesian melding, which is supported by a new Digital Government grant. As discussed above, our preliminary results are promising — but there are significant challenges and risks, including being able to adequately uncover the uncertainties in the input data and models, and being able to achieve satisfactory performance.

In the area of stakeholder presentation and interaction, we plan to complete the implementation and deployment of a web-based Indicator Browser, which will let interested stakeholders browse through simulation results. The choice and description of indicators can be value-laden and politically sensitive. In response to this, we have been developing Indicator Perspectives, partnering with different groups and agencies to put forth a variety of perspectives on what is most important in the results from UrbanSim, and how it should be interpreted. Our initial partners in this are Northwest Environment Watch, the King County Benchmarks Program, and the Washington Association of Realtors.

Acknowledgments

We would like to thank all of the UrbanSim research team members and collaborators. This research has been funded in part by grants from the National Science Foundation (EIA-0121326 and IIS-0534094), in part by a partnership with the Puget Sound Regional Council, and in part by gifts from IBM and Google.

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