Interactive Urban Models

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Visual computing to support urban design will involve a synthesis of geometric modeling, geographic information systems (GIS), and interactive multimedia. Increasingly, CAD is a suitable point of departure for such work. Using such media, this study explores newly practical steps toward a body of media arts expressly for the design, analysis, and communication of urban form.

Disciplinary Context

Urban design lies somewhere in between architecture and planning; so should its tools. Urban design mediates between architecture, which otherwise has been losing its influence on civic space, and planning, whose numerically-based policies otherwise have undesirable side effects on city form. It is gaining in importance because of popular concern the environment, something which implicates architects and turns the focus to what happens between the buildings. It has complex needs for to combining spatial, visual, and numerical representations and for conducting analysis, design, and public presentation. Thus urban design has been slow to get started, but may eventually outpace its related disciplines, in the use of computing.

Research in this area will likely incorporate more diverse visual factors than have the symbolic manipulations typical of earlier academic work computer-aided design. Opportunities for university-professional interaction will make especially good sense for long-term public projects for which the marketplace has fewer effective study mechanisms. As public participation in design demands better electronic, visual display of quantitative information, and as media arts literacy spreads, some sort of interchange will be increasingly vital from the university perspective. This is appropriate, for narratives on complex bodies of data have always been the concern of the university.

Any new work in interactive urban models takes place against a well-established background of spatial data analysis in planning. Quite early on, planners were among the first to make intensive use of computing. Complex numerical models to support policy decision making were practical long before the simplest computer graphics. Until recently, the dominant applications have been in social demographics, economic forecasting, infrastructure evaluation, and environmental impact studies. Specific computer-aided studies of urban form have been few.

But soon, and to the extent that it makes responsible use of new developments in visual computing, urban design will increase its capacity as a discipline.

Toolkit

Right now there is a confluence of three pertinent software domains: geometric modeling, geographic information systems, and interactive multimedia [figure 1]. Together, these may prove at least as valuable as computer-aided design and drafting (CADD) systems did earlier for architecture or statistics did for planning. Consider these in turn.

Geometric modeling is increasingly a core competency in design education. Geometric modeling of course extends of euclidean measure and construction into three dimensions. It hierarchically structures three-dimensional documentation. It has the potential to improve communication with related presentations, such as images, analyses, or fabrication methods. Ordinary geometric modelers such as AutoCAD are increasingly practical for building large scale urban models, especially if specific considerations are made: (1) extruded plan polygons represent building form; (2) attributes, with finite sets of possible values, establish classification schemes; (3) external references subdivide very large models into manageable units; (4) named views are collected to be arranged in animation or hypermedia programs.
Small-scale geographic information systems (GIS) are the next component. Quite recently, computing has become practical in public agencies for spatial documentation uses such as utilities, legal records, and usage classification, and in environmental firms for spatial analysis and design, such as impact assessment and site selection. Increased popular concern for effective environmental management should continue to accelerate development. Moreover, emerging CAD-based GIS technologies are making spatial data tools more accessible to designers. Formerly, GIS work required exporting plans and attributes to separate systems, whether large (Arc-Info) or small (Mac-Gis). CAD-based work often accomplished its tabulations using more rudimentary programs such as spreadsheets. Now, there is occurring a fundamental advance on GIS extensions of CAD systems because recently-introduced CAD extension languages are capable of maintaining structured data types. For example Arc-CAD, written in ADS, provides a combination of plan topology, spatially-linked attributes, and tabular relations in a form much more convenient to the AutoCAD user.

Finally, recent developments in interactive multimedia enable many new modes of inquiry and display, appropriate for communicating design to professionals and public alike. These technologies include: (1) hypermedia programs, chiefly Hypercard; (2) other means for connecting, such as object linking and embedding; (3) image databases; (4) sequencing programs, where object, camera, and lighting motions are keyed to a timecode, such as Adobe Premiere; (5) convenient variable-rate playback systems, such as Quicktime. What all of these share is a narrative structure for making larger amounts of information intelligible. Very convincing displays of rich amounts of information about selected urban sites, and of specific opportunities for increasing the payback on intensive geometric modeling, have been demonstrated regularly from the first moviemap of Aspen to the latest virtual museum of Vicenza.

Admittedly, integrating these media will remain imperfect process, for a single, governing model is neither attainable nor appropriate. But for the various multi-actor representations we need, various ad-hoc linkages are becoming more practical. Figure 2 describes several possible levels.
Pedagogical Intent

Consider a scenario for the study of interactive urban models. The immediate goal is to demonstrate practical possibilities for applying the emerging repertoire of standard computer applications to urban design and documentation. The long-term goal is to develop a support framework for the studio. Because urban design decision making is especially information-intensive, using interactive documentation should enhance the studio processes. Network-supported data gathering inside or outside the studio discipline will become more practical. Information usage in the studio will also help to justify the site research necessary in any case for continuing these exploratory studies.

The electronic representation used for such work will not be so monolithic as an architectural model. The forms themselves will be more numerous, less detailed. Annotation will be more important, because nonvisual information will be useful for generating, locating, or sorting particular geometries. Essential views will be more numerous, and will occur in both sequences and networks. Different sorts of views may be combined, e.g. model perspectives and scanned photographs. One should note that interactive urban models are not just three-dimensional maps; anything about spatial distributions should have consequences to form. Neither are they complex models of individual buildings; only when detailed massing and facades inform considerations of open space will those be brought in. Nor do they emphasize terrain models, even if some of those are required.

Finally the content for the scenario must be rich. For a large enough topic, better public domain data will be available, the departure from manual methods will be better-justified, and more technical issues will come to light.

Organization of the Study

This particular study chose Industrial South Boston as its site (figure 3). The area from Fort Point Channel to the Reserved Channel and to 2nd Street is an interesting juncture of downtown, industrial, and residential neighborhoods. It is in transition due to the increasing touristic value of the waterfront and to the construction of the Massachusetts Turnpike.
extension [figure 4]. Thus the site came with a wealth of data. Public studies, by the Boston Redevelopment Authority and the Economic Development Industrial Corporation provided effective summaries. Site mapping was partly available in digital format, due to the extensive public works occurring.

We proceeded with three-dimensional modeling as the home medium. Students took parcels off the available base map and modeled buildings according to available data, chiefly height surveys and Sanborn maps. These models were generated exclusively from polylines. A macro program was used to turn each polygon into a three-dimensional surface object. The students also attached several attributes to the polygons. The attribute fields were standardized. The resulting models were then reassembled over the network using an external reference process [figure 5] that permits continual updates to any of the separate pieces.

Using this base, we then conducted series of practice exercises demonstrating rudimentary linkage to related on-hand media. The simplest of these was one-way export for tabulating the hundreds of attributes. The second was a connection to a simple GIS capable of two-way links between maps and tables. The third was export of images to form a browsable network of views using Hypercard [figure 6]. The fourth was a simple-camera animation, for which the path was limited to a single street, so that changes in direction and breadth of view, rather than position, would be emphasized.

Following these exercises, we then turned to more detailed investigation of individual topics. One team focused on formal modeling, without linkage to other media. It demonstrated the use of layering and block structure for organizing the large numbers of objects of low complexity characteristic to this work [figure 7]. Given that a repertoire of repeating forms is essential to urban design, a second team looked at typologies. Because typologies generally involve syntax and articulation which go beyond the simpler rapid prototyping for which CAD systems are designed, this work required more explicit intent in use of the modeler. For clarity of convention, the team transposed the usual Lynchian elements to 3D [figure 8].

Another team concentrated on spatial data and therefore on the link to GIS technology. They began with rudimentary explorations using batch translations to MapInfo via DXF. This program lacked sufficient
Figure 5: Exploded view of assembled external reference to sectors of study area

Figure 6: View web in Hypercard. Left: introductory card. Right: typical card
capacity for our large model. Intensive focus on links to relational databases and map was put off until Arc-CAD became available. More recent exploration with the latter program have demonstrated street themes and vicinity buffers. [Figure 9 displays results of cumulative display queries. Figure 10 shows a database design. We expect to dwell more intensively on these topics in the coming year.

Two more teams combined the model with images: the first conducted a pictorial analysis, the second a motion analysis. Images exported from the model to Hypercard were linked not only to each other as in the earlier exercise, but also to photographs and video clips. Key plans reflected orientation of individual shots or sequences [Figure 11], and per-perspective views from the model were matched to similar still views of the site. Diagrams sometimes provided additional access structures. Combinations of media were especially effective. Figure 12 shows an interface for site analysis. Figure 13 shows a combination of views for site documentation, including key axonometric, current pictorial view, cross-sectional diagram, and animated motion through a given point.

Technical Issues

The main question concerns the appropriateness of three dimensionally modeling areas large enough to be just as appropriately approached as mapping problems. This work arbitarily chose to assess its uses and limitations of the 3D model as the point of departure. For many studies of spatial distributions, such as land use, ownership, zoning, etc., there is little need for any such three-dimensional representation, and much more need for plan topology. But for others where volumetric factors such as building heights, building types, shadows, or viewsheds are concerned—often exactly what divides urban designers from planners—there is stronger motive to use a geometric models in combination with a maps. Which of these to use as a base depends on intent. Where different coverages are to be studied and area analysis is critical, GIS is the preferable base. In this case, crude building forms can be extruded from polygon features and their height attributes. Where more complex visual elements such as rooflines or facade modulations are needed, or where macro programs need to interpret both forms and attributes, geometric modeling is the preferable base. Here, attributes may be exported to tabulation programs as necessary. As an example of a macro program, consider a build-out tool which reads setback and

<table>
<thead>
<tr>
<th>Theme</th>
<th>Topology</th>
<th>Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parcels</td>
<td>Polygon</td>
<td>Address</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NumFloors</td>
</tr>
<tr>
<td></td>
<td></td>
<td>YearBuilt</td>
</tr>
<tr>
<td>Footprints</td>
<td>Polygon</td>
<td>Owner</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hbuildings</td>
</tr>
<tr>
<td></td>
<td></td>
<td>InFov/HOW</td>
</tr>
<tr>
<td>Streets</td>
<td>Line</td>
<td>Name</td>
</tr>
<tr>
<td>Attraction</td>
<td>Point</td>
<td>Name</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NumVisitors</td>
</tr>
<tr>
<td>Waterfront</td>
<td>Line</td>
<td>(none)</td>
</tr>
</tbody>
</table>

Figure 9: Reports on a line theme. (Congress Street)

Figure 10: Example of a simple GIS database design
Figure 11: Maps and diagrams accessed by hierarchical classifications of urban elements

Figure 12: Image collection
Figure 13: Indexed multimedia: synthetic animation still, sampled photo, key axonometric, and sectional diagram.

Figure 14: Transparenyly rendered model of allowable buildouts.
allowable floor area ration attributes and offsets and extrudes a form from each parcel polygon [figure 14].

Polygons have many possible uses [figure 15]. If a an arbitrarily complex form can be linked to the same polygon used for spatial data access and area topologies, then the issue is not which kind of program to use but how much can be represented without information overload. Geometric modelers have been limited to the use of layers and hierarchical assemblies for control over the selection and display of elements. Defining themes, validating topology, and defining attribute tables adds a lot of overhead.

There are other difficulties. Multiple attributes attached to geometric elements are not always translatable to records in a GIS relational database. The assembly hierarchies and external references that geometric modelers use are incompatible with the coverage layers that GIS programs use. These many structures also become confusing when used together as multimedia links. Attaching pictures and clips adds large storage requirements. Moreover, multimedia is not just a matter of reporting. How does eventual narrative intent affect the modeling and annotation process beforehand?

**Recommendations**

The best approaches to this work will be many. There is no reason to expect a single integration schema to emerge. Upon closer inspection, the convergence of media illustrated at the outset looks much more complex [figure 16].

Many may say that one main question is how much to link to a polygon, to which the easiest answer is to just annotate forms with a single pointer, to which any number of attributes can be related elsewhere. This pointer may also be used in cross-reference to locations in hypermedia view webs or animated view sequences.

But turn the question in another direction: how to apply thematic mapping techniques to the display of complex geometric form? Ideally, other structured queries should be applicable, and models should be able to behave as volumetrically indexed databases. But this, too, is a direction for interactive media.

Numerical measures should become more interactive, too. The larger the scale of a project, the harder to ignore economic and infrastructural issues, thus the
Figure 16: Initial diagram revised. Integration schema as if the plan polygon were at the center of things

give a presentation from a database and then give people a package to take home? What are the respective roles of narrative and navigation?

In all these regards, at a more general level, we are dealing with the issue of database design. What is the granularity of the model, i.e., the number of pointers and the scale and type of forms to which they are to be attached? What are the structure, and default valuation of associated nongeometric records? How much more work goes into building such a database after geometric modeling is complete?

Future Studies

If design representations generally become much more translatable, once in digital format, we should indeed obtain new syntheses. Here are a few possibilities:

- Large, thematic models of formal contexts will be more practical.
- Maps or models might move. They could also become indices for photo and video collections.
- Dynamic simulations should support various visual studies: growth (or decay), of infrastructure, evolving uses, and the like.
- Design improvisations should be more easily measurable while in progress.
- Visual interfaces to statistical analysis should make large bodies of quantitative data more intelligible for design support.

By far the most important development issue, however, is not the technology but the data. For urban models, this is likely to mean getting information from public agencies and private consultants (who may or may not have it to the desired depth and format), and then sharing it more accessibly among studio participants. We must generally assume a more collaborative and information-intensive design process and open our attitudes about design communication. The desirability of these changes may seem self-evident, but the reality has been evasive, especially in the schools. Before we test our hypotheses about new syntheses of representations, we need to re-emphasize decision making and communication themselves.
Acknowledgements

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References


Notes

1 At least those cited here and proceedings of URISA or GIS/LIS
2 This we be accomplished using a closed polyline with nonzero thickness and a polyface top, and automated using a macro
3 City/View and the Union Station Study to cite a couple coming out of MIT, for instance. Virtual museum in progress: Mitchell, et al.
4 Sanborn maps show heights and construction dates, among other things. For this site, maps made as long ago as 1890 were available.
5 Capacity limitations prevented this process from always using the entire site, however, so students worked with their individual sectors.
6 Although now we lack the time to build a large database. Just a small area was studied.
7 This was created as a part of a media arts workshop and doctoral dissertation by Renya Onasick.
8 As quantitative reporting on visual manipulation, this would be complementary to the visual display of quantitative information, which may remain more the domain of planners.