Scenario Planning and Visualization

Webinar 8 of an 8-part TMIP Webinar series on land use forecasting methods.

Land Use Forecasting Webinar Series

1. The Evolving State of the Practice
2. Land Use Theory and Data
3. Scenario Planning and Visioning (I-PLACE3S)
4. Spatial Input-Output Frameworks (PECAS)
5. Dynamic Microsimulation (UrbanSim)
6. Modeling Real Estate Demand
7. Modeling Real Estate Supply
8. Scenario Planning and Visualization
1. Urban Visualization
2. Bridging the Gap Between Urban Simulation, Visualization and Geometric Modeling
3. Application: UrbanVision
Urban Visualization

• Visualizations of land use forecasting results
  - Used by regional planning agencies to evaluate
    • Alternative transportation investments
    • Land use regulations
    • Environmental protection policies

• Visualizations of land use forecasts
  - Interest several groups of population with different levels of expertise in handling data
    • Policy makers
    • The public
    • Modelers running the simulation
Urban Visualization

• Traditional urban visualization techniques
  - Focused on handling large urban simulation datasets
  - Making their analysis more intuitive to urban planners
• In the following, we outline a few representative techniques

Urban Visualization

• Traditional urban visualization techniques
  - Choropleth maps:
    Areas shaded in proportion to the values of the displayed variables
  - (standard GIS representation)

Example simulation output:
Map-based indicator display for Puget Sound
(Total land value per acre, 2000)
From UrbanSim Application in Seattle, WA
Urban Visualization

• Traditional urban visualization techniques
  - Cartograms: Distort a map by **resizing** its regions according to the values of the displayed variable, but keeping the map recognizable


Urban Visualization

• **Legible Cities**
  Chang, Wessel, Kosara, Sauda, Ribarsky
• TVCG 2007
Urban Visualization

• Goal: Visualize an urban model in a focus-dependent, multi-resolution fashion, while retaining the legibility of the city

Original Model  45% polygons  18% polygons

Urban Visualization

• Integrate 3D model view and data view
  - Relationships between the geospatial information of the urban model and the related urban data can be more intuitively identified
Urban Visualization

• Geographically Weighted Visualization
  Dykes, Brunsdon
• TVCG 2007

Visually encode information about geographic and statistical proximity and variation through
- geographically weighted (GW)-choropleth maps
- multivariate GW-boxplots
- GW-shading and scalograms

New graphic types reveal information about GW statistics at several scales concurrently
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Visualization of Land Use Model Results

- Vanegas, Aliaga, Benes, Waddell, TVCG 2009

Video
Visualization of Simulated Urban Spaces

- Infer an urban layout
  - Images (aerial view) + Structure (streets, parcels)
from the values of a set of simulation variables at any given time step

Visualization of Simulated Urban Spaces

- Approach
  - Spatially match socioeconomic data set with input aerial images and structure of the urban space
Visualization of Simulated Urban Spaces

• Approach
  - Create new structure that matches a set of attributes inferred from the simulation variables
  - New blank lots are created

Visualization of Simulated Urban Spaces

• Approach
  - Aerial view imagery is "borrowed" from existing lots of the city with similar socioeconomic attributes as the new blank lot
Visualization of Simulated Urban Spaces

• Example result
Bridging the gap between urban simulation, visualization and modeling

• **Interactive Geometric Simulation of 4D Cities**
  Weber, Müller, Wonka, Gross

• Eurographics 2009

Interactive Geometric Simulation of 4D Cities

• Problem:
  - How to model cities that are changing over time?
  - How to use the urban simulation data to infer the geometry of the city (roads, lots, buildings)?
Interactive Geometric Simulation of 4D Cities

- Traffic simulation for street generation

Interactive Geometric Simulation of 4D Cities

- Land use simulation
  - Optimization of a land use value function
  
  \[
  luv = \lambda_{global} \cdot luv_{global} + \lambda_{local} \frac{\sum_{i} \text{lot}[i].area \cdot \text{lot}[i].luv}{\sum_{i} \text{lot}[i].area}
  \]

  - Global and Local land use goals
Interactive Geometric Simulation of 4D Cities

- Validation

Video

1900
Bridging the gap between urban simulation, visualization and modeling

- Interactive Design of Urban Spaces using Geometrical and Behavioral Modeling
  Vanegas, Aliaga, Benes, Waddell
- SIGGRAPH Asia 2009

Interactive Design of Urban Spaces using Geometrical and Behavioral Modeling

- Interactive Design of Urban Spaces using Geometrical and Behavioral Modeling

[Diagram of socioeconomic and geometric factors]
Interactive Design of Urban Spaces using Geometrical and Behavioral Modeling

• System
  - Consists of N variables defined over a spatial domain
  - Each variable sampled over a 2D spatial grid $G$ of size $W \times H$
  - $v_k(i,j)$ denotes the value of $k$-th variable at grid cell $(i,j)$

Interactive Design of Urban Spaces using Geometrical and Behavioral Modeling

• Operations
  - Location and de-location of behavioral variables using location choice and mobility algorithms
Interactive Design of Urban Spaces using Geometrical and Behavioral Modeling

- Arterials and Streets
  - Seeds
  - Expansion of Arterials
  - Expansion of Streets

Interactive Design of Urban Spaces using Geometrical and Behavioral Modeling

Grid

Radial

Tortuosity
Interactive Design of Urban Spaces using Geometrical and Behavioral Modeling

• Validation of urban behavioral+geometric simulation model
Procedural Buildings, Parcels and Cities

- Buildings Video
- Parcels Video
- Cities Video

Interactive Design of Urban Spaces using Geometrical and Behavioral Modeling
1. Urban Visualization
2. Bridging the Gap Between Urban Simulation, Visualization and Geometric Modeling
3. Application: UrbanVision
Stakeholders Create Scenarios Using Place Types

Stakeholders assign place types to map: must match target population and employment

Source: SACOG

Fusion: Visioning, Modeling, Visualization

• Take the best elements of modeling and scenario planning and hybridize
• Use scenario planning to engage community in creating a preferred Vision
• Use disaggregate land use models to Analyze scenarios
• Use 3D visualization and indicators to Visualize scenarios
• This is the aim of the UrbanVision platform
The UrbanVision Project

- Funded by Metropolitan Transportation Commission, NSF, and the University of California (MRPI)
  - MTC Plan Bay Area, a Sustainable Communities Strategies Planning Process
  - Involves visioning, modeling, and visualization for community engagement
- Collaborative Project between UC Berkeley and Purdue University
- Summary:
  - Develop an extension to UrbanSim
  - Add 3D geometric modeling and rendering
  - Add flexible indicator and accessibility framework
  - Add scenario editing/creation interface

UrbanVision Design Elements and Use Cases

- **Use Case 1**: Visualize completed scenarios
  - Generate 3D buildings and streetscapes consistent with scenario
  - Support interactive exploration of 3D rendering, including comparison of scenarios
  - Generate animated visualization of traffic and pedestrians consistent with scenario
  - Generate indicators consistent with scenario
- **Use Case 2**: Generate detail for a zone-level scenario
  - Given initial vision-based scenario at a zone level, fill-in details
  - Use zoning editor to set zoning and overlays for scenario at a parcel level
  - Generate buildings within building envelopes, up to zone-level targets
  - Allocate target population and employment
- **Use Case 3**: Create, Model, and Visualize scenarios, generate preferred scenario
  - Use UrbanSim and new developer model + zoning editor + 3D Visualization
UrbanVision System Design

Data Sources

- Digital terrain models
- Digital orthophotos
- Street Network
  - openstreetmap.org
- Parcels
- Building attributes
- Google buildings where available and of good quality
- Zoning
- General Plans
- Planned Developments
- Business establishments
- Synthesized population
- Planning boundaries
Connecting Urban Geometry, Computing Accessibilities

San Francisco Bay Area Case Study

- Full street network - 463K street edges
- Full parcel set - 2.1M parcels
- Data stored as households, businesses, buildings
The “buffer query”

- Variables in location choice models
- Variables in travel model generators/attractors
- Real estate comparables
- Micro-accessibility measures for walkability

Parcel - Street Network Linkage

- Given a variable associated with a parcel, connect it to the street network and aggregate
Types of Data

<table>
<thead>
<tr>
<th>Parcels</th>
<th>Buildings</th>
<th>Households</th>
<th>Persons</th>
<th>Jobs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parcel id</td>
<td>Building id</td>
<td>Household id</td>
<td>Person id</td>
<td>Job id</td>
</tr>
<tr>
<td>Zones, cities, zip code, etc.</td>
<td>Parcel id</td>
<td>Building id</td>
<td>Household id / Job id (if worker)</td>
<td>Building id</td>
</tr>
<tr>
<td>1.18 million parcels</td>
<td>1.0 million buildings</td>
<td>1.28 million households</td>
<td>3.2 million people</td>
<td>1.85 million jobs</td>
</tr>
</tbody>
</table>

Heatmap #1: Non-residential Sqft
Accessibility Engine:
High-performance Accessibility Queries

- On a Bay Area all-streets network has 456K links, 355K Nodes, computing a Walk Score (our implementation), accumulating approximately 15 different Points of Interest for each node, takes less than 3 seconds.
- On a national all-streets network with approximately 12 million nodes, queries such as the number of intersections within 1/3 kilometer runs in 15 seconds (total, for all nodes in the national network)
- Point-to-Point Accessibilities (minimum path) queries are extremely fast:
  - Bay Area sized network: ~ 20-40 microseconds per query
  - Continental sized network: ~ 100 microseconds per query
- This Accessibility Engine is being developed into an API for use in models and other ad-hoc queries

Building Types in UrbanVision
Used for Proforma Real Estate Modeling and for Procedural Modeling of 3D Buildings

14 base types, total of 64 sub-types, used for both real estate modeling (pro-formas), and procedural modeling and rendering
Procedurally-Generated Buildings

Video

Developer Model
Uses Geometry & Accessibility Engines

Spec Development Model
- Identify Sites
- Determine Feasibility
  - Optimize proforma NPVs of auto-generated, physically feasible and entitled development proposals
- Generate Outputs
  - Provide information to parcel and building databases

Fee Development Model
- User Specified Events
  - Accepts inputs from cities, counties, and others regarding redevelopment projects and other projects made possible by public subsidy rather than market demand
Simulating Developer Site Selection Process
Filtering on Spatial Criteria (what is adjacent and nearby)
Considering Alternative Development Configurations for Redevelopment and Subdivision
Considering Alternative Development Configurations for Redevelopment and Subdivision
Doing Market Analysis

Assessing Building Envelope from General Plan and Zoning

- Buildable Envelope
- Parcel Boundary
- Office
- Parking
- Retail
And Simulating the Proforma Analysis to Maximize Profit based on Alternative Densities and Uses

![Developer / Investor Profit Graph](image)

UrbanVision: Visualization Interface

[Video](#)
UrbanVision: Visualization Interface - Street View

UrbanVision: Indicator Workspace
UrbanVision: Zoning Editor Interface

Video

UrbanVision: Travel Model Network Matching

Video
Summary and Next Steps

- Developed an integrated UrbanVision platform for
  - **Visioning**: engaging communities in designing their future
  - **Modeling**: analyzing alternative land use and transportation policy/design scenarios
  - **Visualizing**: 3D representation of alternative scenarios, with indicators
- Developed efficient pedestrian-scale accessibility and urban design calculator
- Implementing a realistic real estate development simulator
- Tightly coupling: UrbanSim+Activity-Based Travel Model+UrbanVision
- Will launch in public workshops in the Bay Area in January 2012
- **Immersive Cities Lab** at UC Berkeley

Questions and Discussion

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