UrbanSim: Integrated Land Use, Transportation, and Environmental Modelling

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Land Use/Transportation Interactions

• Patterns of land use and transportation are critical in determining economic vitality, livability, and sustainability of urban areas
• Land use and transportation interact with each other and with the environment.
• Example: Suppose you were a Puget Sound resident in the early 1960s. Three alternative transportation plans are proposed.  
  • a freeway-oriented system  
  • a rail-oriented system  
  • do nothing

Puget Sound Freeway Plans from early 60s

Puget Sound Example continued

We might want to ask questions such as:  
• What will the region look like in the year 2000 under these different scenarios?  
• How will people and goods move around?  
• What will be the density and character of development?  
• How much open space will there be?  
• What will be the environmental impacts on air and water quality?
Applications to Date

- Eugene/Springfield, Oregon (including historical validation — started with 1980 data and predicted state in 1995)
- Salt Lake City
- Honolulu
- now working on Puget Sound (substantially larger area than the others)

Software Status

- Written in the Java programming language (about 200,000 lines, plus 100,000 more lines of Java that is automatically generated)
- Software is under the GNU Public License (so it's free, and freely redistributable)
- We have made an initial release of the system, with several hundred downloads

Software Architecture – Overview

- UrbanSim is composed of interacting models that simulate particular aspects of the urban environment
  - Demographics (people moving in and out of the area, births and deaths)
  - Residential location choice
  - Business location choice
  - Transportation
  - ...

System Architecture Diagram

Spatial Representation

- Geographic information is of the essence!
- UrbanSim currently represents a region using a 2-dimensional grid.
  - Analogy: Game of Life grid
  - Each grid cell is 150 meters square
- Grid cell attributes include:
  - Building type, square feet
  - Number of residents
  - Number of employees (for businesses)
  - etc

Hawaii -- Housing Density
Hawaii -- Grid Cells

Time
- As with most simulations, UrbanSim keeps track of simulated time
- There is a global variable `currentYear`
  - Analogy: “stepCount” in Game of Life
- Typical simulation is run for 20 years
- Most models run once each simulated year

Temporal Representation

The Model Coordinator
- Handles initialization of models
- Coordinates execution of all models
- Notifies models of updates
  - For example, the Land Developer model might build some new houses.
  - The Model Coordinator notifies the Residential Location Choice model that new housing is available.

Business Location Model

Nested Logit Structure
\[
P(h) = e^{\sum e^{V_{lh}}} \quad \text{Marginal Choice of Building Type}
\]
\[
P_l^l = \ln \sum e^{V_{lh}} \quad \text{Logsum}
\]
\[
P_l(l) = \frac{e^{V_{lh}}}{\sum e^{V_{lh}}} \quad \text{Conditional Choice of Location}
\]
### Latent Demand

\[
D(l, b, t) = \sum_i P(l, b | i) M_i R_b + \sum_j E_j - (AV(l, b, t) + TV(l, b, t))
\]

- **\(P(l, b | i)\)** is the probability that a mover of type \(i\) will choose building type \(b\) in location \(l\) in year \(t\).
- **\(M_i\)** is the total number of movers of type \(i\) in year \(t\).
- **\(R_b\)** is the utilization rate for building type \(b\) (for \(res=1\), for non-res=sqft/emp for \(b\)).
- **\(E_j\)** is the total quantity of occupied space in building type \(b\), location \(l\) in year \(t\).
- **\(AV(l, b, t)\)** is the total actual vacancy (from prev year) in building type \(b\), location \(l\), and year \(t\).
- **\(TV(l, b, t)\)** is the tentative vacancy (movers subtracted) in building type \(b\), location \(l\), and year \(t\).

### Market Price Adjustment

\[
P_{lb} = P_{lb-1} \left[ \frac{D(l, b, t)}{(1-a)S(l, b, t)} \right]^{1/2}
\]

- **\(P_{lb}\)** is the land price of building type \(b\) in location \(l\) in year \(t\).
- **\(P_{lb-1}\)** is the previous year closing land price for the same building and location.
- **\(D(l, b, t)\)** is the total demand in the current year for space in the building type and location.
- **\(S(l, b, t)\)** is the current year total supply of space of building type \(b\) in location \(l\).
- **\(a\)** is a scaling parameter for the price adjustment, initially set to 1.