Urban Generator

intro input data simulation results
SLEUTH model

[Slope, Land cover, Exclusion, Urbanization, Transportation, and Hillshade]

Cellular automaton based urban growth model

*developed by Keith C. Clarke, University of California, Santa Barbara

The model

• is initialized with four type of input data
• applies growth rules controlled by five growth coefficients
• can be calibrated to correspond recent development by using historical cross section data (input data)
  > individual growth coefficients for the area
• basic simulation unit is a growth cycle
SLEUTH operational principle

Initial Conditions

- START_* coefficient values
- for (all MC) {seed++}
- Excluded

Generate Simulations

- Slope
- Land Cover
- Urban
- Transportation
- Hillshade

Conclude Simulations

- $S_1M_{C_1}$
- $S_2M_{C_2}$
- $S_nM_{C_n}$
Self modification

The model includes the following self modification procedure:

**Rapid Growth**
Greater than "critical" number of hectares/year
- DIFFUSION is multiplied by a constant > 1.0
- SPREAD is multiplied by a constant > 1.0
- BREED is multiplied by a constant > 1.0

**Normal Growth**
Between Rapid and Little or No Growth
- If average slope > 10%, increase SPREAD
- ROAD_GRAVITY increases by percent road
- SLOPE_RESISTANCE increases by 0.2 * percent urban

**Little or No Growth**
Annual growth rate is less than a critical value
- DIFFUSION is multiplied by a constant < 1.0
- SPREAD is multiplied by a constant < 1.0
- BREED is multiplied by a constant < 1.0
Input Data

- slope
- excluded
- transportation

(binary/gray scale gif files)

urban

(hillshade) background

(landcover) for deltatron module
Growth Coefficients

Diffusion
Breed
Spread
Slope
Road Gravity

Coefficient values effect how the growth rules are applied. These values are calibrated by comparing simulated land cover change with a historical data of the area.
Growth Rules

Spontaneous Growth  (*diffusion, slope*)
Growth Rules

New Spreading Center Growth \((breed, slope)\)
Growth Rules

Edge Growth  \((\text{spread, slope})\)
Growth Rules

Road–Influenced Growth  \((\text{breed, road gravity, diffusion})\)
Calibration

1. Test phase
   - Model inputs
   - Error
   - Correct

2. Calibration phase
   - Coarse Calibration
   - Fine Calibration
   - Final Calibration
   - Deriving Calibration
   - Prediction phase
   - Error
   - Correct

3. Prediction phase
   - Error
   - Correct

END
TUT contribution

• Applicability of Finnish GIS data bases
• Comparison of ’free’ & ’controlled’ growth land use policy scenarios
• Testing changes in ’total potential of growth’ of excluded layer
• Experimenting different representations of transportation networks
Case Helsinki

- Calibrations with different input data
  
  Urban area: 5 historical cross sections

Excluded:

  'controlled’ / 'free’ growth
  normalized / unnormalized

Transportation:

  main roads as lines (binary)
  accessibility surface (grayscale)
  railroads + stations r=600m (binary)
  main roads + railroads + stations (binary)

- Predictions → 2050
### Case Helsinki – Input Data

|------------|------|--------|------|--------|------|

Urban areas were defined on the basis of Finnish grid format census data:
- sum of floor area in 250x250m cells
- number buildings in 250x250m cells

Areas with quite low density were selected as 'urbanized areas' in order to catch the sprawl-like development.
Case Helsinki – Input Data

Excluded

'controlled growth'

'free growth'

unnormalized

normalized
Case Helsinki – Input Data

Excluded 1 – Controlled Growth

1965 1985 2005

Regional plans describing probability of growth.
## Case Helsinki – Input Data

**Excluded 1 – Controlled Growth**

<table>
<thead>
<tr>
<th>Area</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central functions</td>
<td>100</td>
</tr>
<tr>
<td>Housing/ Industrial areas</td>
<td>80</td>
</tr>
<tr>
<td>Undefined/ special areas</td>
<td>60</td>
</tr>
<tr>
<td>Recreation areas</td>
<td>40</td>
</tr>
<tr>
<td>Protected areas</td>
<td>20</td>
</tr>
<tr>
<td>Water Systems</td>
<td>0</td>
</tr>
</tbody>
</table>
Case Helsinki – Input Data

Excluded 2 – 'Free' Growth / unnormalized

Probability of urbanization is equal everywhere – except areas of water systems.
Case Helsinki – Input Data

Excluded 2 – ’Free’ growth

Unnormalized

Normalized (50 % of MAX)

Total potential of growth

= sum of probabilities of cells to be urbanized
Case Helsinki – Input Data

Transportation

Main roads as lines

Railroads + stations

Accessibility of road network

Main roads + railroads
Case Helsinki – Input Data

Transportation
- binary step based accessibility analysis of road network.

Accessibility (connectivity) analysis transformed to grayscale surface.
Case Helsinki – Input Data

Slope

Slopes were generated from topographical database.
Simulation Predictions

Prediction maps: Probability of a cell to be urbanized.

The simulations were carried out with all input data combinations.
Simulation area of Helsinki region
Prediction – Helsinki

2011

Input
Prediction – Turku

2011

Input
Predictions Helsinki 2040

'Controlled' Growth

- Accessibility
- Roads as lines
- Railroads + stations
- Main roads + railroads

'Free' Growth
Predictions Helsinki 2050

'Controlled' Growth
- railroads + stations

'Free' Growth
- accessibility
- roads as lines
- railroads + stations
- main roads + railroads
Predictions

With different ’excluded’ inputs

Hki 022
Hki 030
Hki 029

In all three cases transportation layer: accessibility.
Predictions

Comparison of unnormalized and normalized case

HKI 10 unnormalized

HKI 18 normalized

Transportation: Roads as lines.

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Predictions

'Free' growth as 'excluded' input

Helsinki

Protected areas have only small probability to be urbanized also in the case of 'free' growth.
Predictions

Accessibility as 'transportation' input

Case Helsinki

Case Turku

2040

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Predictions

With different 'transportation' inputs / Case Turku

2050

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Some Conclusions

• Total potential of growth in ‘excluded’ layer impacts to amount of growth as expected and should be taken into account when creating scenarios.

• Representation of transportation network influenced significantly to form and focus of growth.

• Strength of the SLEUTH model is highly visual results.

• Future work: tools for analyses of prediction images.
Thank you!