User-Directed Generalisation of Roads and Buildings for Multi-scale Cartography

Edith Punt and David Watkins
Generalisation Goals for Esri

- Esri aims to provide a suite tools to help users generalise cartographic data for print or web display
- To be commercially viable, the tools must
  - be robust, efficient, flexible, and easy-to-use
  - work at a variety of scales, and
  - adapt to a spectrum of map specifications and requirements
  - consider multiple themes contextually
- ArcGIS version 10 introduces new tools to generalise roads and buildings
An Optimization Approach

- The ArcGIS solution uses an optimised approach where each task is made up of constraints, reflexes, and actions
  - **Constraint:** “building cannot be closer than x from another”
  - **Reflex:** “a building cannot be moved onto a road.”
  - **Actions:** “move building away”, “move building back”, “mask building”

- An underlying optimiser kernel seeks to improve the satisfaction of constraints by applying actions
  - Compromises made to maintain satisfaction of all constraints

- Simulated annealing—where a greater degree of change and tolerance of unsatisfactory states is allowed early in the process—prevents the system from getting caught in local minima of progressively poor results
Leveraging the Geoprocessing Framework

- The Geoprocessing framework is an established component of ArcGIS used to transform data.
- Geoprocessing employs a functional decomposition approach where each workflow task is a discrete operation, represented by a separate tool.
- Each tool is user-driven through variable parameters.
- Users build custom workflows by specifying parameters and arranging tasks in appropriate sequences.
- Modeling and scripting components of the framework provide automation and sharing.
Thin Road Network tool

- Removes less significant roads, retains pattern and connectivity
  - Balanced by road classification
  - Retain specific features by locking

- Visibility controlled by a field, easy to modify
  - Use multiple fields for multiple scales in one dataset
Merge Divided Roads tool

- Create a single highway feature from dual lanes
- Create a single road from a boulevard
- Merge only equal-class roads together
- Retain displacement for propagation to nearby features
Resolve Road Conflicts tool

- Adjust roads to show visual separation
  - multi-lane highways, boulevards, dead-ends, roundabouts
- Less significant roads moved to accommodate more significant roads
- Retain displacement for propagation to nearby features
Propagate Displacement tool

- Conflict resolution may introduce spatial discrepancy
  - Adjust adjacent features to reestablish relationships
- Use displacement output from other tools
  - Merge Divided Roads tool
  - Resolve Road Conflicts tool
Resolve Building Conflicts tool

- Separate buildings from each other and from barriers
  - Retain relative density and pattern
  - Enforce minimum building size
  - Adjust visibility, size, and spacing
  - Manage distance and orientation from barrier features
Web-Mapping Application: Hamilton County, Indiana

- A workflow leveraging these tools was created to produce a multi-scale Web map service to verify results
  - Compare processed results to simple selection
  - provides a superior alternative, with room for improvement

- ~ 9k scale: No generalisation needed; data captured at ~2k
- ~ 18k scale: Building footprints simplified, roads thinned, parallel roads separated, displacement propagated to buildings, building conflicts resolved, buildings oriented to roads
- ~ 36k scale: Same workflow as 18k, but parameters modified
- ~ 72k scale: Buildings aggregated to built up area, roads thinned and merged, conflicts resolved on remaining roads
Future Research

• Research is currently underway to extend the generalisation solution in ArcGIS
  - Improve details of the results, like ramps
  - Scale the tools to work on a nationwide or even a global dataset contextually
  - Create a building to built up area aggregation tool
  - Upgrade previously released generalization tools to work contextually
  - Address new themes, particularly hydrology and physiography