A prototype for ontology driven on-demand mapping of urban traffic accidents

Nick Gould
Manchester Metropolitan University
nicholas.m.gould@stu.mmu.ac.uk
nickgould@live.co.uk
Project context

NMA map production
- Highly automated
- Fixed target scales
- Familiar features
- Sophisticated software
- Experts

On-demand mapping
- Unfamiliar data
- Automatic generalisation
- Integrate not overlay
- Non-expert

Google Maps
- Multiple scales
- Base maps
- User data overlays
- No integration
- Non-expert
Use case: mapping road accidents
Respecting relations
Digital Generalisation

Philosophical Objectives (Why to generalise)

- Theoretical elements
  - reducing complexity
  - reducing complexity
  - maintaining spatial accuracy
  - maintaining attribute accuracy
  - maintaining aesthetic quality
  - maintaining a logical hierarchy
  - consistently applying rules

- Application-specific elements
  - map purpose and intended scale
  - appropriateness of scale
  - retention of clarity

- Computational elements
  - cost effective algorithms
  - maximum data reduction
  - minimum memory/disk requirements

Cartometric Evaluation (When to generalise)

- Geometric Conditions
  - congestion
  - coalescence
  - conflict
  - complication
  - inconsistency
  - imperceptibility

- Spatial and holistic measures
  - density measures
    - distribution measures
    - length & sinuosity measures
    - shape measures
    - distance measures
    - Gestalt measures
    - abstract measures

Spatial and Attribute transformations (How to generalise)

- Spatial transformations
  - simplification
  - smoothing
  - aggregation
  - amalgamation
  - merging
  - collapse
  - refinement
  - exaggeration
  - enhancement
  - displacement

- Attribute Transformations
  - classification
  - symbolisation

- Transformation controls
  - generalisation operator selection
  - algorithm selection
  - parameter selection

Describe these concepts in an ontology

McMaster & Shea, 1992
• Can the concepts of cartographic generalisation be formalised in an ontology with sufficient detail to allow the process to be automated?
Ontological concepts: general

- `Operation`
  - `implements`
  - `Transformation Algorithm`
  - `Algorithm`
  - `measures`
  - `Measure Algorithm`

- `Symptom`
  - `hasSymptom`
  - `hasEffect`
  - `relieves`
  - `Remedy`

- `Problem FeatureCollection`
  - `FeatureCollection`

- "is a" relationship
- Property relationship
System overview

- Why, When, How
- Represents
- Implements
- Uses

Ontology

Mapping Engine
System architecture

Protégé editor → Ontology (OWL file) → Source data (Shape files) → Copy of Ontology → OWL Java API → Mapping Engine → Measure Algorithms → Transformation Algorithms → GeoTools → Results (Shape files)

On-demand mapping system

Java application

Source data (Shape files)
The ontology identifies transformation (generalisation) algorithm... but...
... how to automatically provide parameter values for the algorithm?
Transformation algorithm: pruning

Total length = 335413m
DegreeOfGeneralisation = 9
Target length = 33541m

Current length = 34410m
Road network and accidents at 1:30K
Conditions: accidents

High road accident density
Identified by measure algorithm
Conditions: roads

High (cross)road density
Identified by measure algorithm
Workflow

A

Amalgamate accidents

Collapse roads

Prune roads

B
Pruned road network and amalgamated accidents at 1:30K
• Road sections that provide context have been pruned
• Semantics – what is a road accident?
  – Punctual event
  – Takes place on a road
• Expressed as spatial relation

- contained by
- adjacent
- intersects
- intersects
Modelling spatial relations

intersects

intersects

IntersectMeasure
Algorithm

measuredBy

SpatialRelation

Intersects

“Is A” relationship

AccidentIntersects
Road

hasThematicFeatureType

Accident
FeatureType

Road
FeatureType

hasSupportFeatureType

AreaGeometry

AreaGeometry

LineGeometry

hasThematicGeometry

hasSupportGeometry

Goal: store knowledge in the ontology and not the algorithm
Workflow – accidents only

For a particular condition at a particular scale

* Non-deterministic workflow
* Apply optimisation method?
* Refine the ontology...?
Refining the ontology  
Describing the impact of operations

- Can impact be linked to user requirements?
Conclusion

• Difficulties building workflow with ontologies
• Role for ontologies in on-demand mapping?
• Support for agent-based systems?
  – Provide shared knowledge base
  – Make implicit ontologies explicit
Future work? - Web Ontology Services for generalisation
Thank you!

• Thanks to:
  – OSGB
  – Nico Regnauld
  – William Mackaness
  – Transport for Greater Manchester