Structuring Geographic Information to support Semantic and Visual ‘zoom’

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Theme

• Computational techniques to support multi-scale viewing and analysis of Geographic Information

• Map centric $\rightarrow$ Database centric view
Outline

• The power of the map
• Cartography - From an Art to a Science?
• Multiscale Mapping
• Semantic Reference Systems
• Conclusion
  – Geography – the borrower of science
Expanding tropics – a threat to billions?

Scientists shocked by dramatic growth of Earth's tropical belt and warn of grave consequences.
NICOLAI COPEI INCI

net, in quo terram cum orbe lunari tanquam epicyclo contineri diximus. Quinque loco Venus nono mente reducitur. Sextum denique locum Mercurius tenet, octoginta dierum spacio circu-

Schema huius primum divisio Sphaearum.
Alfred Wegener

Paris, 20 November 1869

The number of men present at any given time is represented by the width of the grey line; one mm. indicates ten thousand men. Figures are also written besides the lines. Grey designates men moving into Russia; black, for those leaving. Sources for the data are the works of messrs. Thiers, Segur, Fazensac, Chambray and the unpublished diary of Jacob, who became an Army Pharmacist on 28 October. In order to visualize the army’s losses more clearly, I have drawn this as if the units under prince Jerome and Marshall Davoust (temporarily separated from the main body to go to Minsk and Mikiów, which then joined up with the main army again) had stayed with the army throughout.

Figure 58. Minard’s map of Napoleon’s Russian campaign.

This graphic has been translated from French to English and modified to most effectively display the temperature data.
Modelling cartographic design (tailored interface) 

Modelling multiple geographical scales 

Automation 

Understanding changing contexts of use 

Technology Driven.....
Design & Meaning
Semiotics: 1969, Kolácny
Importance of
1) scale;
2) prototypical views
...to semiotics/ sign systems:

Put your arm down when you think you know what it is?
Multiple views of the world...
Multiple representations

Low level of Detail

High level of Detail

1:250,000

1:50,000

1:25,000

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MRDB – requires very rich models of Geographic Space

- Topological modelling
- Neighbourhoods: Tessellations of space: Voronoi
- Modelling networks: graph theory
- Statistical techniques: clustering techniques
- Classification methodologies: Taxonomies and Partonomies (Mereology)
Objects and Relationship

• Partonomic Relationships ‘part of’
Taxonomic Classification

- Aggregation *within* a superclass
Partonomic Classification

- Aggregation of *different* classes
Container Boundaries

- Container Boundaries that ‘fit’ with our conceptual understanding of the world:
  - (pebbles → Islands)
  - Houes → Settlement
  - Tree stands → Forest
  - Hills → Ranges
Automatic creation of partonomic information

Source Objects

Database Enrichment

Aggregation

(a) Trees
Building
Vegetation
Water
Land Cover
Motorway
A road
B road
Local Street

(b) Forest container Boundary

Settlement container Boundary

(c) Forest
Settlement
Motorway
A road
B road
General Land Cover
Settlement Container Boundary

- Source Database
  - Select: Building Objects
    - Model Density
      - Expansion and Aggregation
        - Derive: Settlement Container Boundary
Settlement Container Boundary
Settlement Container Boundary

- Modelling ‘Citiness’

\[ c_j = \sum_{i=1}^{n} d_i^2 \]

\[ c_j = \sqrt{a_j} \sqrt{\sum_{i=1}^{n} a_i} \]

50 closest buildings
Settlement Container Boundary

\[ e_a = k \cdot c \]

Provided

\[ e_a \leq k \]

- a. Buildings (Grey Scaled by \( c \))
- b. Expand proportional to \( c \)
- c. Aggregation
- d. Hole Removal & Elimination

lectures in computational thinking
Settlement Container Boundary
Connecting geographies

- Semantic zoom.....Visual zoom....

‘These partonomic structures provide a ‘conceptual skeleton’ linking appearance and function.’

Tversky
Meaningful database queries

- Spatial Analysis
- Spatial Joins
- Feature Intersection
- Where
- b.
- c.
- East Calder'
Utility

Higher Level of Abstraction

Meaning

London

Hyde Park  Tower Bridge  The London eye  Big Ben  Tames River  Trafalgar Square
Thematic mapping

Extension of Target Data Model

A hilly settlement area in Edinburgh.
A Vision....

CAPTURE
Remote sensing technologies

AUTOMATIC
CHANGE DETECTION
Pattern recognition / information science

UPDATE & VERSIONING
Database technologies

Multiple Representation Data Base

MAP GENERALISATION
Model generalisation Cartographic generalisation

MAPS
(series production, web services, mobile environments)
Geography – the borrower of science

- Cartography - geography
- Semiotics, communication theory – linguistics
- Mereology (partonomies), ontologies – philosophy
- Pattern recognition, scale space – robotics
- Models of space – mathematics & computer science
- Reasoning about space – psychology
- Models of Interaction – informatics
- …. Truly interdisciplinary nature….
Conclusion

• Different: Map as a system of Relationships
• Weave: model ↔ visual form
• Geography – the borrower of science
• Technology – changing science of cartography
• Not subsumed by scientific visualisation and VR, but *complimentary to*...
Questions