Lecture 5 : Relation modelling and MRDB

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Outline

1. Triangulations
2. Reactive data structures
3. Relation modelling within MRDB
4. Literature
TRIANGULATIONS
Voronoi polygon - a polygon whose interior consists of all points in the plane which are closer to a particular lattice point than to any other.

All Voronoi polygons of a point set build the Voronoi diagram.

Construction:
- From the bisectors of adjacent points
- Each vertex of the Voronoi diagram is obtained as the intersection of exactly three bisectors

Alternative names:
- Thiessen polygons or Dirichlet tessellation
the Delaunay triangulation (DT) refers to a network of several points on a triangle mesh

the Delaunay triangulation is the dual structure of the Voronoi diagram
  - within the DT two points will be connected in case the corresponding Voronoi polygons have a common line
selected properties

- DT satisfies the circle criterion - no point is inside the circumcircle of any triangle
- maximize the minimum angle of all the angles of the triangles in the triangulation
- any other triangulation generates at least one triangle with an sharp angle

Figure left: the circle criterion is not considered, because point D is situated within the circumcircle of triangle (∆ABC)

Figure right: the triangles (∆ ABD, ∆ BCD) satisfy the circle criterion → Delaunay triangulation
construct Delaunay triangulation for the following set of points and the Voronoi polygon around point A.
construct Delaunay triangulation for the following set of points and the Voronoi polygon around point A
Constraint Delaunay triangulation is carried out not only on a set of points, but also on pre-defined edges.

Applications
- in digital terrain models (e.g. terrain edges or roads)
- building generalisation
Constraint Delaunay triangulation

Bader, 2001
Example of digital terrain model with Constrained Delaunay triangulation

Source: Institute for Geodesy and Geoinformation, University Bonn
Constraint Delaunay triangulation

Example of digital terrain model with Constrained Delaunay triangulation

Source: Institute for Geodesy and Geoinformation, University Bonn
textured terrain model

Constraint Delaunay triangulation with consideration of road axes
Applications of Voronoi, DT and CDT

generalization of terrain model by eliminating triangle edges below a sharpness threshold

derivation of a new contour line based on CDT of existing contour lines and terrain points (Li et al. 1999)
Further applications of Voronoi, DT and CDT

- extraction of middle axes (skeleton) of polygons or linear objects
- cluster detection
- determining neighbouring objects (non-metric) by searching through related triangles
Applications of Voronoi, DT and CDT

- middle axis and weighted middle axis as merging boundary (Jones et al. 1995)
- direct merge
- snap merge
- new allocation of eroded area
- skeleton based on Constrained Delaunay triangulation (Haunert & Sester, 2008)
- (Bader & Weibel, 1997)
REACTIVE DATA STRUCTURES

- BLG-tree: Binary Line Generalization (Oosterom, 1991)
- tGAP-tree: topological Generalized Area (Oosterom, 2005)
- reactive conflict graph (Petzold, 2003)
Binary Line Generalization (BLG-tree)

BLG-tree (Oosterom, 1991) based on Douglas-Peucker algorithm for line simplification.

The use of hierarchical data structure allows the scale-dependent representation of linear objects with varying degrees of detail in real time (on-the-fly).
topological Generalized Area Partitioning (tGAP-tree)

van Oosterom (2005)
Reactive conflict graph

data structure for the storage of potential conflicts during automated label placement (Petzold, 2003)

structure:

- **nodes** $\iff$ labelled **objects**
- **edges** $\iff$ potential **conflicts**

potential conflicts are scale dependent

- scale interval [lower boundary, upper boundary]

2 phases

- pre-processing: creation of reactive conflict graph
- interaction phase: usage of data structure
Reactive conflict graph: example

Source: Petzold (2003)
Reactive conflict graph: example

Source: Petzold (2003)
Köln - Bad Godesberg
[1:2.247.001, 1:681.000]
Köln - Leverkusen
[1:1.307.001, 1:274.000]
Bonn - Bad Godesberg
[1:2.247.001, 1:100.000]
Bonn - Leverkusen
[1:1.307.001, 1:274.000]
Köln - Leverkusen
[1:1.307.001, 1:274.000]
Köln - Bad Godesberg
[1:2.247.001, 1:681.000]
• 3 dimensions:
  - two spatial dimensions
  - third dimension (z-axis): scale

• request:
  - map extent
  - scale

• result:
  - static conflict graph adapted on scale
RELATION MODELLING WITHIN MRDB
Relation modelling within MRDB
Multiple representation

Why does different representation exist respective redundant storage of data?

- no information about the existence of already collected data
- different requirements of application, both in terms of semantic and technical aspects
  - phenomena can be described as an independent objects or through attributes as part of higher class objects (e.g. railway with 3 tracks)
  - information can be coded differently (different coordinate systems)
  - modelling differences (e.g. river can be modelled as area object or as line object; city as polygon or point, ...)

ICA COMMISSION ON GENERALISATION AND MULTIPLE REPRESENTATION
2 July 2011 - Paris
Definition Multiple Representation Databases

The term “multiple representation database” refers to a database structure in which several representation of the same geographic entity or phenomenon, … are stored as different objects in database and linked. (Sarjakoski, 2007)

Advantages and usage of a MRDB
- supports effective data management, avoids storage of duplicated data sets
- quality checks and quality improvement of data sets (consistency)
- basis for automated, incremental updates
- supports spatial analysis
- extended usage scenarios in digital and mobile cartography (e.g. adaptive zooming)
at the NMAs different representation are related to traditional map series

at the NMAs different representation are related to traditional map series

Source: Landeskarte der Schweiz, swisstopo
MRDB in car navigation

Type of relations modelled within MRDB is still an ongoing research topic. Current approaches distinguish three types of relations:

1. Vertical relations
2. Horizontal relations
3. Temporal / update relations
Definition - Vertical relations (VR) connect objects, which represent the same real world phenomena at different resolutions or Level of Detail (LoD) on a defined time stamp.

Taking the assumption, that details and objects will be preserved or removed at smaller scales → a modelling of 1:1, n:1 and 1:0 relations would be sufficient.

In the simplest case a connection through primary key and foreign key could be realised without introducing an explicit relation.

Working with real data shows, that it is necessary also to model n:m-relations.

Thus explicit modelling of vertical relations as concrete instances becomes essential.

Useful extension

Additional meta information about applied generalisation operators can be stored as attributes of the vertical relations.
Vertical relations

- selection
- simplification / smoothing
- aggregation
- enlargement
- displacement
- typification
- hierarchical data structures

Source:
options for linking remove objects between different level of detail (LOD)

no linkages

alternative to Hampe (2007)
1:0 vertical relation

connection with neighbouring object of the same object class (e.g. outgoing side street)

connection with object they go up (e.g. outgoing street to settlement area)

Characteristics

- an essential part of MRDB
- store meta-information of generalisation operators and parameters
- support automated update
- improves data quality by comparing consistency
- provides analysis functionality across all resolutions
Relation attributes, meta information

VERTICAL-RELATION / INTER-RESOLUTION-RELATION:

id: 0
origin: ID: 20; GenObjectClass: "geb-goldkueste3"
target: ID: 52; GenObjectClass: "geb-goldkueste3"
genSequence:
  --id: 0
  --consideredObjs:
  --genOperation:
    -----id: 0
    -----genOperator:
      =======id: 30
      =======name:typification
      =======description:Typification Generalisation
      =======parameterDescription: [ 
      =======-Number of remaining objects; 10
      =======-Percentage of remaining objects; 60
      =======-Minimal distance between remain. Obj.; 10.0
      =======-consider number; false
      =======-consider percentage; true
      =======-consider minimal distance; false
      =======-]
      ----parameter: 10; 50; 10.0; false; true; false
  --resolutionRelation: 0
Vertical relations

Example

Resolution

Resolution

Res1

Res2
Definition - Horizontal relations (HR) represent groupings of objects within the same resolution or level of detail this way an additional characterisation of objects through their neighbourhoods (geometric, semantic), also referred to as context modelling the degree of horizontal relations can vary between 1 ... n, depending on the number of participating objects a special case is the degree 1, e.g. if only one object is contained within a partition the number of horizontal relations is not limited – the decision for an explicit modelling depends on – application and use of HR – effort to produce the HR on-the-fly
context modelling
context modelling

examples
context modelling

examples

• partonomic relations
context modelling

examples

• partonomic relations
• neighbourhood relations
context modelling

Examples

- partonomic relations
- neighbourhood relations
- structural relations
context modelling

examples
• partonomic relations
• neighbourhood relations
• structural relations
• semantic relations
Derivation of horizontal relations – example of detecting building alignments

- focus on buildings situated near linear objects
- pre-selection with buffer operation
- evaluation of homogeneity based on similarity measures (size, shape, orientation, neighbourhood)
Homogeneity of building alignments

1. Calculation of individual measures for each building
2. Calculation of variations within one group, e.g. maximum deviation from the mean
   \[ \sigma_{\text{max}}(A) = \max(A_{\text{max}} - A_{\text{mean}}, A_{\text{mean}} - A_{\text{min}}) \]
3. Comparison of deviations between different groups
Homogeneity of building alignments
Original Vec25 without generalisation
Automated typification for digital topographic map 1:50k (DTK50)
Automated typification for digital topographic map 1:50k (DTK50) with horizontal relations
Horizontal relations

Original Vec25 without generalisation
Generalisation example

without explicit modelled alignments base on horizontal relation

with
Where next

- we have to make tools for the creation of triangulations, auxiliary data structures and explicit relations more accessible
- further research on the usage of vertical relations required
  - e.g. for incremental updates
- utilisation of horizontal relations for the modelling of context
  - implementation through generalisation operators required
    → generalisation of object groups
  - utilisation within the agent framework through meso agents
- interplay between multi representation databases with fixed scales and vario scale data structures
  - usage of vario scale data structures for continuous zooming
References


References


Welcome to the WPS Portal of the TU Dresden

About this side
Written by Martin Zielinschi
Monday, 20 June 2011 12:13

The WPS Portal of the TU Dresden provides developers and users of web processing services, which generalize vector data, a collection of service descriptions and the possibility to make use of the services. The service descriptions should be the base of further development. To make use of the services one have to install the open source software OpenJUMP as well as the installation of a plug-in to connect the client with the server.

How to install and use the services
To use the processing services one have to install the open source GIS-software “OpenJUMP”. Connecting OpenJUMP with the services is done by installing the service plug-ins into the local OpenJUMP folder. Actually two plug-ins are available. The wpsplugin contains OGC conform web processing services. The webopenplugin consist of more services than the first one mentioned does, but they are still in a stage of development and therefore not OGC conform.

Some annotation to OpenJUMP
OpenJUMP supports different kinds of file formats and data types which can be handled by the processing services. This article lists these formats and types and describes them briefly. Furthermore, some important annotations you may be interested in can be found here.
several degrees of data integration can be distinguished

integration of meta data:
- standardised catalogue will help with selection of appropriate data set

integration of semantic:
- an integrated schema will be defined, which unifies the semantic of the different representations
- additional rules has to be derived to enable an automated transfer according to the integrated schema

complete integration:
- through semantic integration only the schemata are combined within a common data model, objects which represent the same real world phenomena are not connected
- with complete integration these objects will be identified and connected through explicit relations (links) within the database

Relation modelling in MRDB

Horizontal relations

$\text{Res}_1$  \hspace{1cm} $\text{Res}_2$  \hspace{1cm} Time

$t_1$  \hspace{1cm} $t_2$

Update relations

Vertical relations
Applications of Voronoi, DT and CDT

collapse of a polygon to a skeleton through centers of triangle circumcircles

collapse of a ribbon-shaped object to a skeleton through the centers of triangle edges connecting opposite sides

graphic exaggeration of a concave polygon based on displacement vector of triangle nodes

direct merge

snap merge
Applications of Voronoi, DT and CDT

middle axis and weighted middle axis as merging boundary

(Jones et al., 1995) (Bader & Weibel, 1997)

adopt merge of natural objects

new allocation of eroded area

displacement buffer around an arbitrary object
Applications of Voronoi, DT and CDT

Derivation of a new contour line based on CDT of existing contour lines and terrain points.

Generalization of terrain model by eliminating triangle edges below a sharpness threshold.