5D Data Modelling

27-4-2012

Project leader: Jantien Stoter

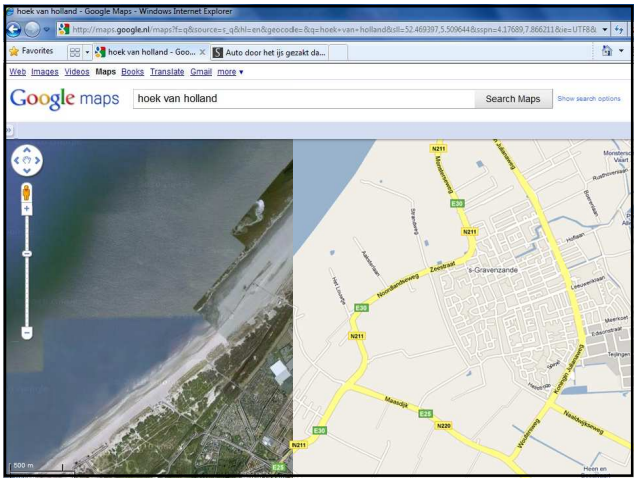
TUDelft Challenge the future

Introduction to the research team

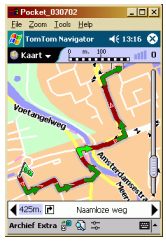
Name researcher	Position	Fte 5D/Vario
Hugo Ledoux	WP	0.4/0
Martijn Meijers	PD	0.25/0.75
Ken Arroyo Ohori	PhD	1.0/0
Vacancy Vario-scale	PhD	0/1.0
Vacancy 5D (3D+scale)	PhD	1.0/0
Peter van Oosterom	WP	0.08/1
Jantien Stoter	WP	0.35
Linda van den Brink	PhD	
Several MSc students		

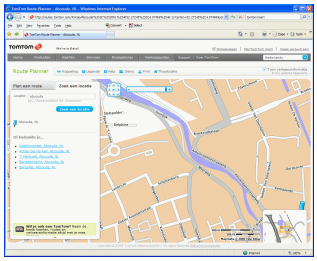
Innovative integration

- Space, Scale, Time ⟶ 5D data modelling



Problems of separate maintenance of spatial data





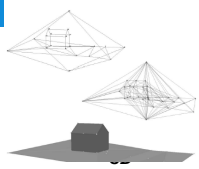
Navigation in 2002 **Navigation in 2010**

Navigeren in 2002 **Navigeren in 2010**

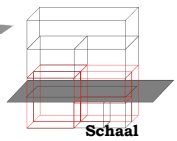
Auto door het ijs gezakt dankzij navigatie-systeem Fregatwerf 49

Zoetermeer - Maandagavond is 69-jarige man uit Wassenaar met zijn auto te water geraakt op de Fregatwerf in Zoetermeer. Tijdens de autorit heeft het navigatiesysteem de man een een boothelling opgestuurd waar normaal

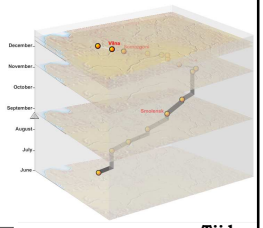
Previous research: separate treatment of 3D, Scale and Time



(Penninga, 2007)



Schaal
(Vermeij, 2003)

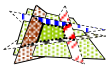


Tijd
(Kraak, 2006)

Method: Apply mathematical theories on multi-dimensional data modelling

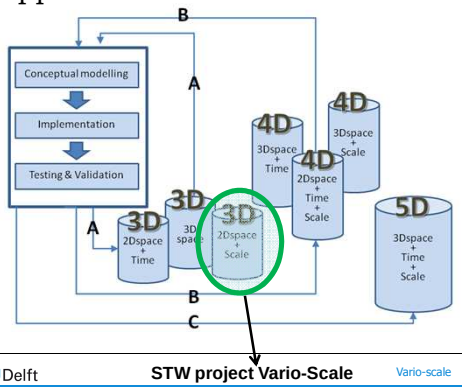
- Multidimensional polyhedra
  - GISt, TU Delft: Arens, Stoter (2004)

- Regular Polytopes
  - GISt, TU Delft: Thompson (2007)



- Simplical Homology
  - GISt, TU Delft: Penninga (2008)

Approach: 3 iterations

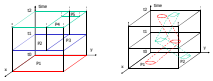


STW project Vario-Scale

Examples of intermediate models

- 3D

- 2D+time



- 2D+scale: see later presentations.....

- 4D hypercube for integrating scale in 3D city models

What did we do from June 2011?

1. nD mathematical modelling
2. nD modelling in GIS
3. Application requirements for nD modelling

Progress and milestones: nD mathematical modelling

- Literature study on related work on nD modelling in Computer Graphics, also selection of appropriate mathematical models *(Ken)*
- Prototype implementation of selected nD data structure (i.e. G-maps) for use in GIS *(Ken)*
- Data structures for efficient storage of 3D triangulations in a DBMS *(Hugo)*

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Progress and milestones: nD modelling in GIS (1/2)

- ***General***
  - Requirements to make the "simple" mathematical models work on complex GIS objects *(Ken, Hugo, Jantien)*
  - Literature study on 2D and 3D Modelling in GIS, Spatio-temporal Modelling, Multi-scale Modelling *(Ken)*
- ***2D+scale*** *(Martijn, Peter):*
  - Prototype implementation: Obtaining topology for a large dataset (work in progress)
  - Prototype implementation: Displacement based on Least Squares for limited set of objects
  - Vario-scale as 3D model, based on decomposition in simplexes
- ***3D+scale*** *(Hugo, Jantien):*
  - Problem definition for the 3D+scale concept in city models

Progress and milestones: nD modelling in GIS (2/2)

- ***3D space:***
  - Extrusion of topological consistent buildings *(Martijn/Hugo)*
  - Integration 2D information model and CityGML *(Linda, Jantien)*
  - Automated generation of 3D TOP10NL: specific cases *(Hugo/Jantien)*
  - Validation of 3D solids *(Hugo)*
  - Loading non topological data formats into G-maps and correctly generating its topology *(Ken)*
  - Generation simple primitives from G-maps for visualisation purposes *(Ken)*
  - Prototype implementation of 3D data viewer easily extensible to higher dimensions *(Ken)*

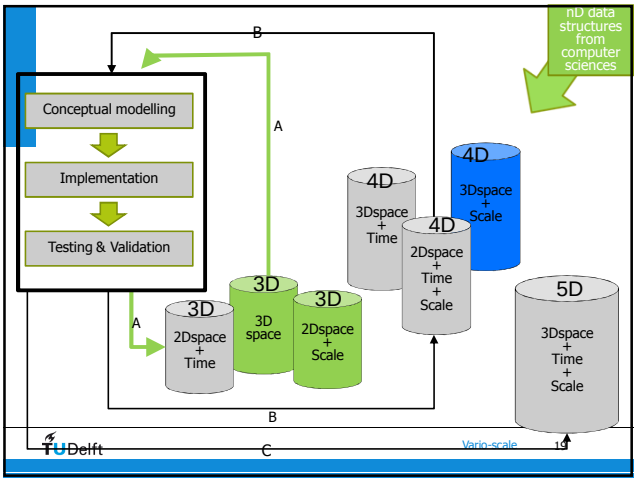
Progress and milestones: Application requirements for nD modelling

- ***General*** *(all)*
  - Identification of most relevant domains (Mobile use of geo-information, 3D/4D Cadastre, 2D topographic maps and scale)
- ***3D Cadastre and time:***
  - Develop information models for this domain *(Peter)*
  - What is the definition of a valid 3D parcel (closed/bounded, planar/curved boundaries, etc.) *(Peter)*
  - Time as separate attribute or integrated with space (4D space-time partition) *(Peter)*
- ***2D Topographic data and scale:***
  - Exploration of requirements, study constrained tGAP approach
  - Study integration DLM-DCM *(Martijn, Peter, Jantien)*
  - Automated generalisation of topographic data *(Jantien)*

Main conclusions

- nD approach for geo-information modelling looks promising
- G-maps implemented for simple objects and needs to be extended to support complicated GIS objects
- nD approach for geo-information requires to make dimensional aspects of geo-information explicit. A first step has been done in the IMGeo ADE of CityGML.

OUR PLANS



Plans (6-8 months) 1/2

- Implementation of slicing G-maps implementation
- Studying other nD data structures and data models
- Studying feasibility of implementation the data structures in DBMS
- Investigating concept of validity in higher-dimension
- Scoping the PhD on 3D+scale model

Plans (6-8 months) 2/2

- Apply nD data structure to real data:
  - Extend G-maps implementation to support complex geometries
  - Fill G-maps structure with 3D+time data
  - Implement TOP10NL in vario-scale
  - Study vario-scale implementation for cartographic generalisation, eventually as preprocessing for cartographic generalisation

Vario-scale Geo-information

- Proposal submitted: 11 February 2010
- Proposal awarded: 31 January 2011 (STW newsletter)
- Project started: 1 July 2011

1. Multi-scale (multi-representation, MRDB state of the art)
2. Vario-scale (tGAP → 3D prisms, on-going TUD research)
3. True vario-scale (smooth tGAP → new concept 'born' January 2011)

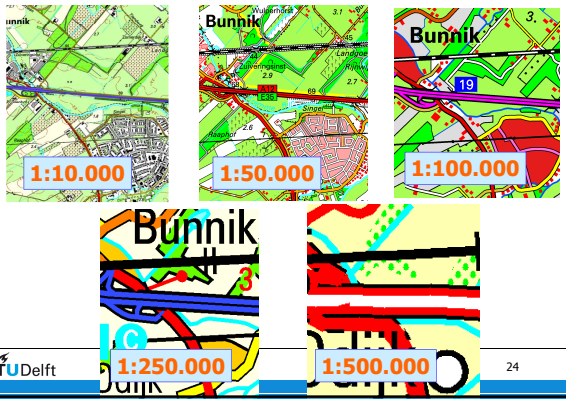
Semantic modeling and vario-scale geo-information

Two steps, two parts in presentation

1. Multi-scale modelling (and attention to DLM-DCM)
2. Vario-scale modelling

Peter van Oosterom
Keynote presentation at SeCoGIS 2011,
1 November 2011, Brussels
5th International Workshop on
Semantic and Conceptual Issues in GIS

Context of the research



Applying DLM and DCM concepts in a multi-scale data environment

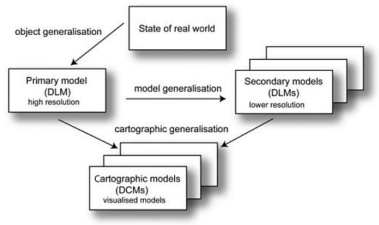
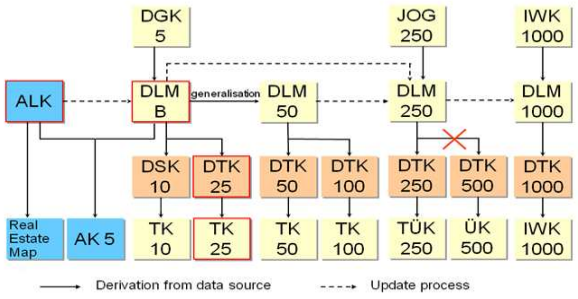


Fig. 2.3. The ATKIS model (after Grünreich, 1985). Printed by permission.

Joint work with Martijn Meijers (TU Delft) Jantien Stoter (TU Delft/Kadaster)
Dietmar Grünreich (BKG, Germany), Menno-Jan Kraak (ITC, Univ Twente)

GDI 2010: Generalization and Data Integration, 20-22 June 2010, Boulder USA

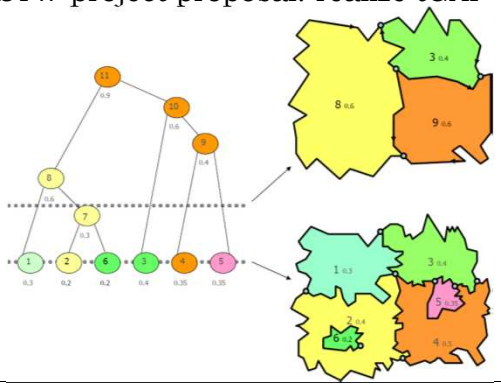
Applied in Germany



Vario-scale as ultimate solution?

- Still the 'multi-scale (adapted) DLM only' has some drawbacks → why redundant store same feature at multiple scales?
- Vario-scale is option, that avoids redundancy and also offers in-between scales (e.g. to support smooth-zoom) → tGAP
- However, improvements needed (and possible):
  1. Road collapses to line (kind of multi-rep)
  2. Certain concepts do not exits at largest scale but can only be introduced and medium/smaller scales (roundabout)
  3. Certain types of changes (again difficult to compute with simple structure; typify, displace,…), add second representation

STW project proposal: realize tGAP



Originally planned steps

- Compare MRDB – tGAP solutions
- Progressive transfer tGAP server – client
- User's perspective (to drive tGAP creation)

- Supporting updates (dynamic structure)
- Managing large datasets (divide-and-conquer Field-tree based)
- Formalization

- Thematic semantics
- Different generalization operation for different themes
- Better quality population tGAP structure (constraint tGAP)

Planning

- Staff
  - 1 AIO (4 years) → 3 candidates selected
  - 1 Postdoc (3 years) → Martijn Meijers started 1 July 2011
  - Supervision
- ESRI and 1Spatial contribute by providing licences to software (value € 110,000)
- Changes
  - Team-up with 5D geo-information project
  - Concept of true vario-scale (after submission of proposal)