Manipulating higher dimensional spatial information

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What do we mean?

- Manipulation (creation, analysis, 2D/3D output)
- Higher-dimensional (> 3D)
- Information (structured objects)
- Geometry + topology
Examples

2D
Examples 2D
Examples 2D
Examples  Move to 3D
Examples

Move to 3D
Examples

Move to 3D
Examples  Move to 3D
Other possibilities

Scale

Meijers and van Oosterom (2011)
Other possibilities

Extruded data
Other possibilities

Extruded data
Other possibilities

Extruded data
Other possibilities

Extruded data
4D data sources
woensdag 0:00:00 18-8-2010 Day=1 Week=1
dinsdag 11:31:12 24-8-2010 Day=7 Week=1
dinsdag 3:50:24 7-9-2010 Day=21 Week=3
dinsdag 15:07:12 14-9-2010 Day=28 Week=4
dinsdag 19:55:12 21-9-2010 Day=35 Week=5
dinsdag 20:24:00 28-9-2010 Day=42 Week=6
maandag 0:00:00 11-10-2010 Day=55 Week=8
Why higher dimensional information?

- Full topology, i.e. all links exist
- Analyse using queries along all dimensions
- Consistency of data
- Genericity, i.e. add anything that makes sense as a dimension

- n-d data models
- n-d data structures
- n-d algorithms
Why higher dimensional information?

Functional

• Full topology, i.e. all links exist

• Analyse using queries along all dimensions

• Consistency of data

• Genericity, i.e. add anything that makes sense as a dimension

Technical

• n-d data models

• n-d data structures

• n-d algorithms
Why higher dimensional information?

**Functional**
- Mathematically strong models that work on any type of data and can be extended

**Technical**
- Ongoing research on higher dimensional models, structures and algorithms
Why higher dimensional information?

**Functional**

• Mathematically strong models that work on any data and can be extended

**Technical**

• Ongoing research on higher dimensional models, structures and algorithms
What is a dimension?

Point

$(x_0, x_1, \ldots)$
What is a dimension? Half-edge

incident vertex

next halfedge

opposite halfedge

halfedge

previous halfedge

incident facet

Kettner (1998)
Dimension

Topological/combinatorial vs. embedding/geometry
Dimension

Topological/combinatorial vs. embedding/geometry

Geometric modellers vs. computational geometers
Dimension of an object

- The dimension of an object is given by the **minimum** dimension of a combinatorial model that is able to store it.

- The dimension of a set of spatial objects is given by the **minimum** dimension of a combinatorial model that is able to store all of these objects, and the topological relationships between them.

Kettner (1998)
Dimension of the space

• The dimension of the space is given by the minimum number of linearly independent axes in which the objects are embedded.

• In $\mathbb{R}^d$, it is $d$. 

$(x_0, x_1, \ldots)$
Dimension reduction

Why?
Dimension reduction

Why?
Dimension reduction

Extracting *meaningful* 2D/3D (intuitively understandable) data
Intersection

\[ A \]

\[ B \]

intersection(\(A, B\))
Intersection

• General case

• Computationally expensive: at least $O(n^{d-1})$

• Very hard to implement!
  
  • Robustness/numerical errors

  • Depends on underlying data structure
Introducing slicing

• Start simple and build towards more complex cases

• A specific case of intersection:

  • a higher dimensional object, generally consisting of a spatially indexed and large data set

  • is intersected with another lower-dimensional object, which is often simple, half-open, box-shaped, and parallel to an axis
Slicing 3D to 2D

\[ x_3 = c \]

\[ A \cap B \]

\[ x_3 = c \]
Slicing 4D to 3D
5D project

+ 3D space
+ Scale
+ Time

= 5D modelling
Current and future work

• Algorithms to construct n-d datasets
• Exploiting the full power of additional informations
• Work toward more complex cases
Thank you.

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