CELL COMPLEXES TOPOLOGICAL LINKS FOR BUILDINGS IN CITYGML

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Introduction

Topological Information
- Describe connectivity information between buildings (Krämer & Huhnt, 2009)
- Comprehensive connectivity information is required to support 3D exploratory analyses (Isikdag et al., 2013; Moser et al., 2010; Ellul, 2007)

CityGML
- XML links or “XLink” mechanism relates explicitly stored objects (Kolbe, 2009)
- No maintenance of relationships between 0D, 1D, and 2D primitives (Ghawana & Zlatanova, 2012)
- Neighbouring buildings often modelled using separate (“invisible”) surfaces to facilitate efficient and consistent visualisation (Gröger et al., 2005)

Cell Complexes Topological Links
- Clear storage of topological information in a topological data structure is preferable for extraction of connectivity information (Boguslawski et al., 2011)
- Traverse via decomposed lower dimension primitives such as 0D points, 1D lines and 2D surfaces to make up a 3D object while preserving connectivity information
Methodology

Extraction of geometrical properties

Generate topological links based on the extracted properties
CityGML Datasets

Dataset A: Two connected buildings

Dataset B: Two disjointed buildings

*The CityGML datasets used in this study were obtained freely from Nordrhein-Westfalen Open Data*
Extraction of Geometric Properties

Dataset A:
• 2 Buildings
• 15 Surfaces
• 16 Nodes

Dataset B:
• 2 Buildings
• 18 Surfaces
• 20 Nodes
Generating Topological Links

Start

Input extracted geometrical properties text file

Check:
- $\alpha_0$ link → Are nodes connected?
- $\alpha_1$ link → Are lines connected?
- $\alpha_2$ link → Are surfaces traversable?
- $\alpha_3$ link → Are buildings connected?

Generate and store links:
- $\alpha_0$ link → Link connected nodes to form lines
- $\alpha_1$ link → Link connected lines to form surfaces
- $\alpha_2$ link → Link surfaces to form buildings
- $\alpha_3$ link → Link connected buildings

End
Results (1D $\alpha_0$ links)

**$\alpha_0$ Links for Dataset A**

- 16 nodes $\rightarrow$ 57 $\alpha_0$ links

**$\alpha_0$ Links for Dataset B**

- 20 nodes $\rightarrow$ 67 $\alpha_0$ links
Results (2D $\alpha_1$ links)

$\alpha_1$ Links for Dataset A

57 $\alpha_0$ links $\rightarrow$ 15 $\alpha_1$ links

$\alpha_1$ Links for Dataset B

67 $\alpha_0$ links $\rightarrow$ 18 $\alpha_1$ links
Results (3D $\alpha_2$ links)

$\alpha_2$ Links for Dataset A

15 $\alpha_1$ links $\rightarrow$ 2 $\alpha_2$ links

$\alpha_2$ Links for Dataset B

18 $\alpha_1$ links $\rightarrow$ 2 $\alpha_2$ links
Results ($\alpha_3$ links)

$\alpha_3$ Links for Dataset A

2 $\alpha_2$ links $\rightarrow$ 2 $\alpha_3$ links

$\alpha_3$ Links for Dataset B

No connected buildings

The $\alpha_3$ links describe the connection between the buildings of Dataset A which could not be referenced in CityGML due to being connected via an “invisible” face.
Conclusion

Dataset A: 2 connected buildings
Dataset B: 2 disjointed buildings

Cell Complexes
Topological Links

4 Topological Links

$\alpha_0$ link: 0D nodes to 1D lines
$\alpha_1$ link: 1D lines to 2D surfaces
$\alpha_2$ link: 2D surfaces to 3D volumes
$\alpha_3$ link: connections between 3D volumes

Decrease in number of links

Dataset A: 57 $\alpha_0$ links to 2 $\alpha_2$ links
Dataset B: 67 $\alpha_0$ links to 2 $\alpha_2$ links

Preserve topological properties

Simple and compact
One $\alpha_2$ link per building
Describe how surfaces are connected (via an “invisible” face)
Allows navigation through topological links
Future Research

– $n$-dimensional case study
– 3D Smart Cities
– BIM
– Urban Pollutions (multi-dimensional)
– Visual Positioning System (VPS) Integration (local positioning)
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