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Ontology-driven Enrichment of Spatial Databases (in the Urban Environment)

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Overview

Introduction

Approaches for pattern recognition (in urban areas)

Ontology-driven enrichment of spatial databases

Formalization example

Discussion & conclusions

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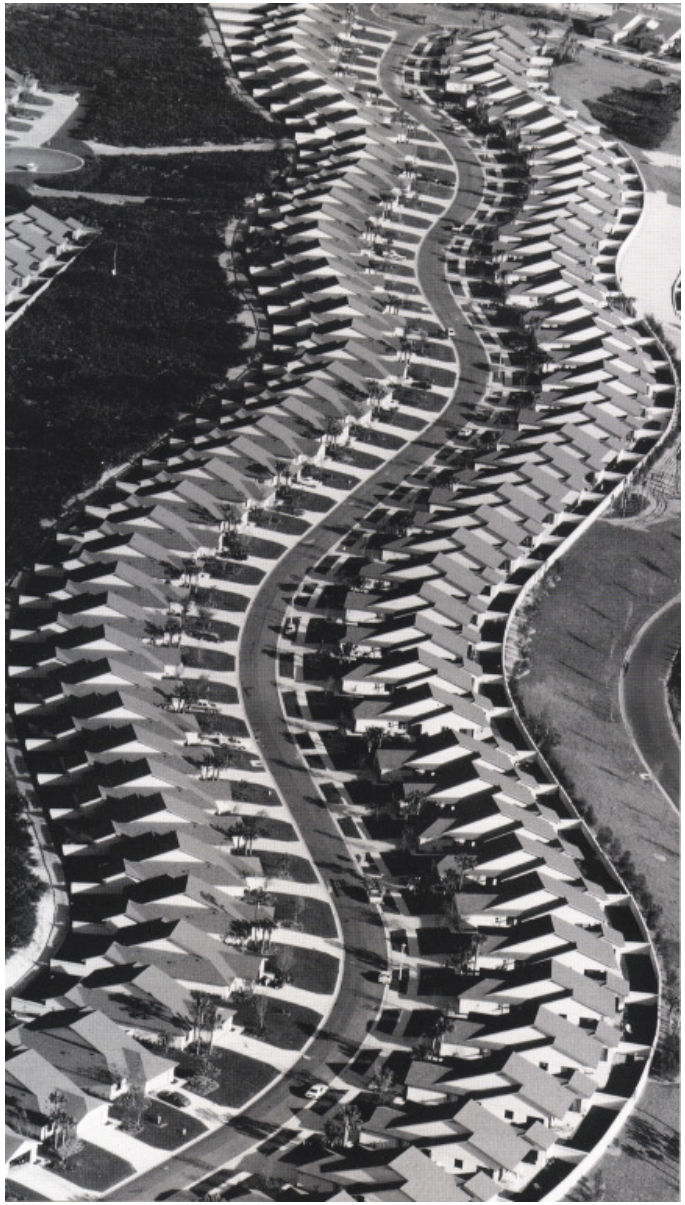
Urban structures?

Grenade-sur-Garonne (France)

Kostof (1992)

Urban structures?



Palm City (Florida)

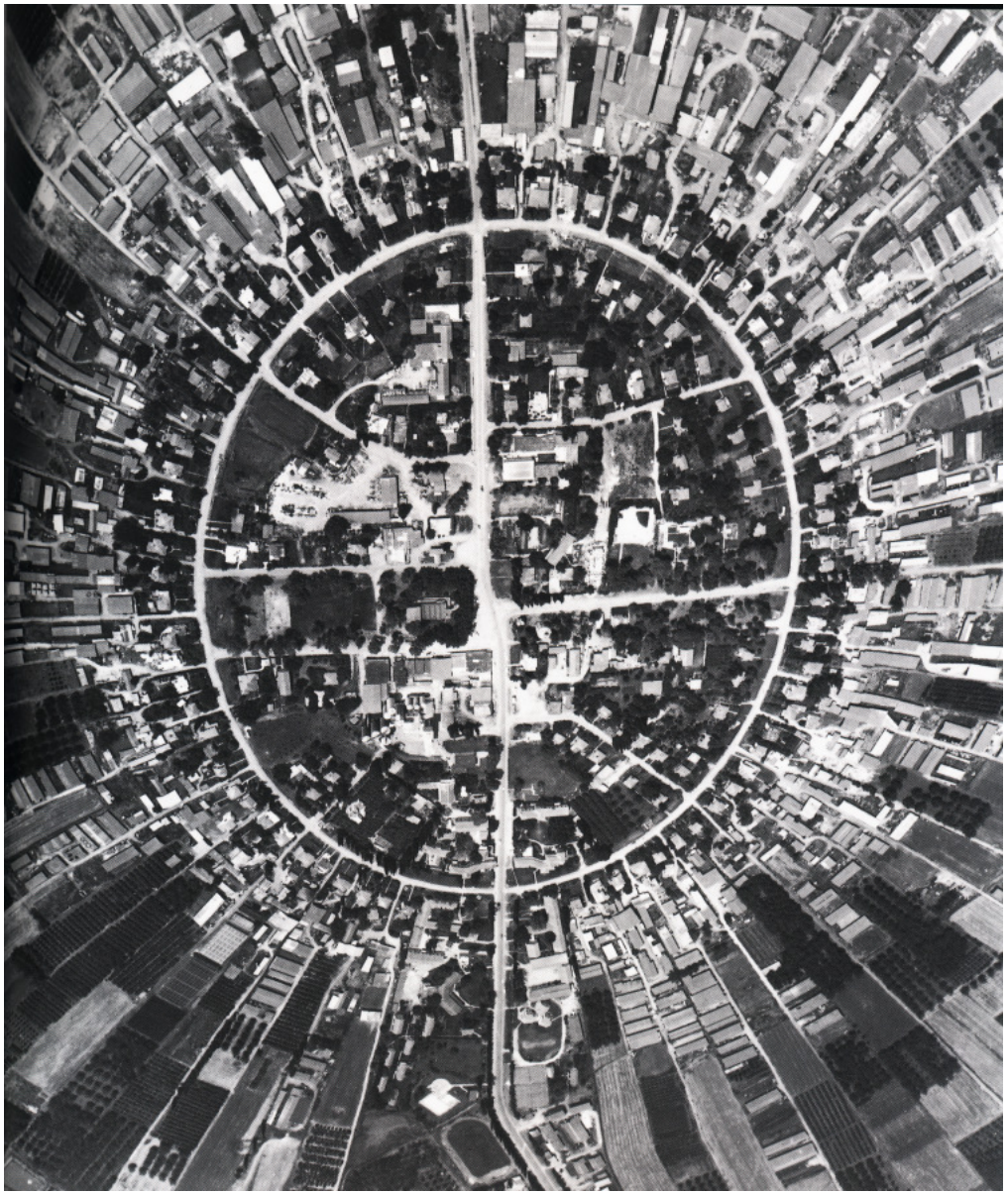
Kostof (1992)

Urban structures?

Paris

Kostof (1992)

Urban structures?



Nahalal (Israel)

Kostof (1992)

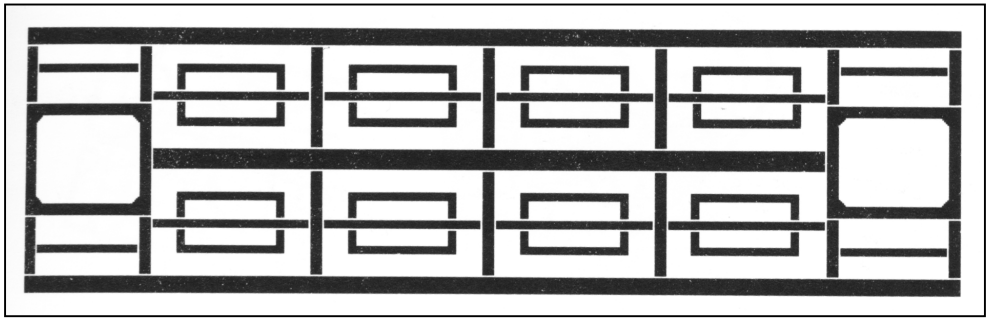
Universität Zürich

Urban structures?

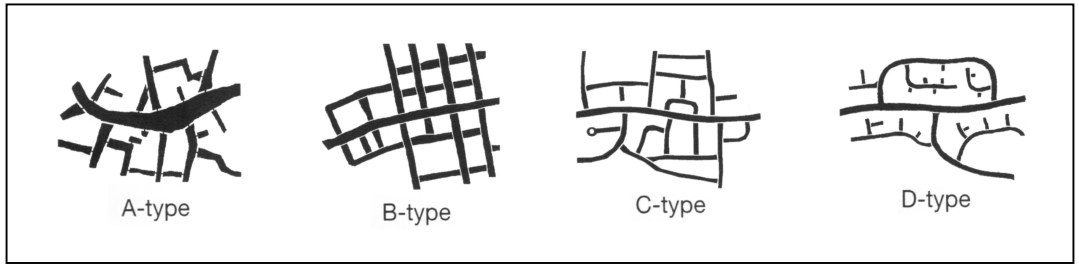
Palmanova (Venetia)

Kostof (1992)

Urban structures?



New Town, Edinburgh



Classification of road structures

Marshall (2005)

Pattern recognition

The notion **pattern** refers to a structure or arrangement, composed of the combination of certain motifs, following a certain scheme (Heinzle 2007).

Applications of pattern recognition of urban structures:

- Automated generalization
- Joining with urban evolution processes
- As a utility for conception and visualization of strategies for urban development
- Interoperability (Geospatial Semantic Web)
- Provision of context information for navigation und mobile information systems
- (…)

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Approaches for urban pattern recognition

- Detection of settlement areas by Boffet (2001), Chaudhry (2004) and Chaudhry (2006).
- Alignments of buildings by Boffet (2001), Christophe & Ruas (2002) and Burghardt & Steiniger (2005).
- Groups of buildings by Regnauld (1998) and Anders et al. (1999).
- Characterization of urban districts & detection of open spaces by Boffet (2001).
- Detection of road patterns by Heinzle (2007).

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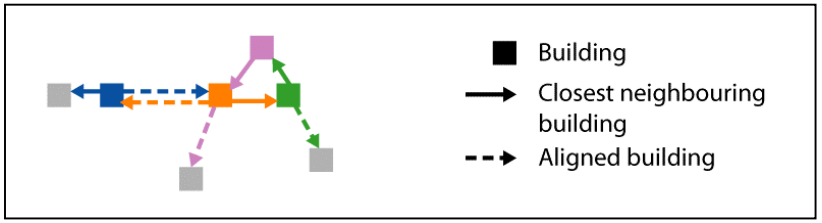
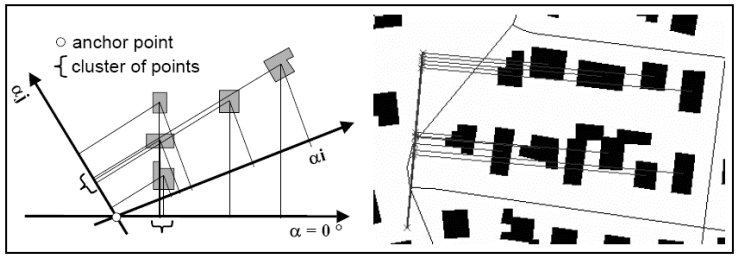


Boffet (2001)



Christophe & Ruas (2002)

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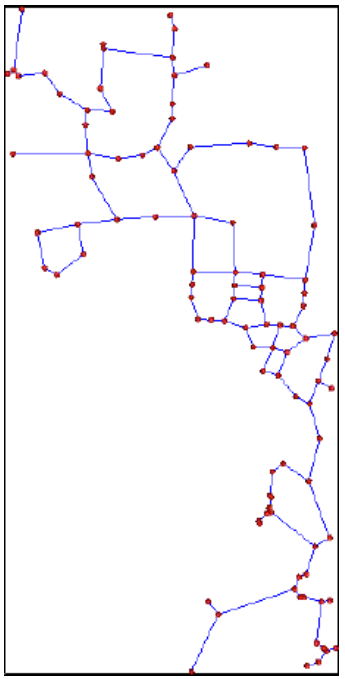
Regnauld (1998): Initial grouping by MST

Anders et al. (1999): Initial grouping by RNG



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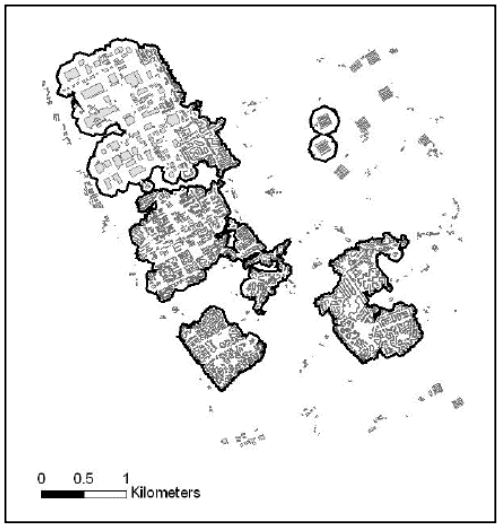
Chaudhry (2004)



Chaudhry (2006) $g_i = \frac{\sqrt{a_i}\sqrt{\sum_{d<=100} a_n}}{d^2}$

Approaches for urban pattern recognition

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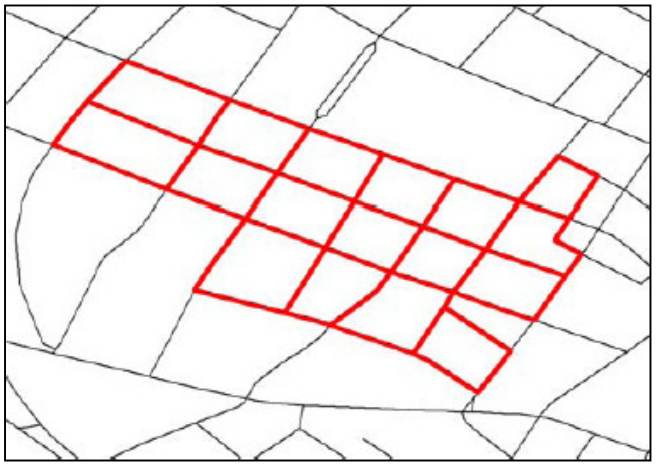
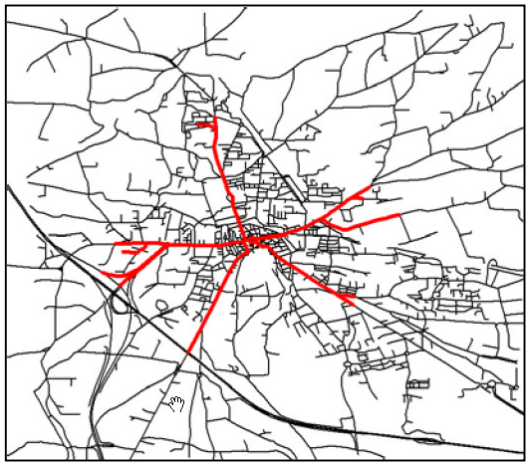
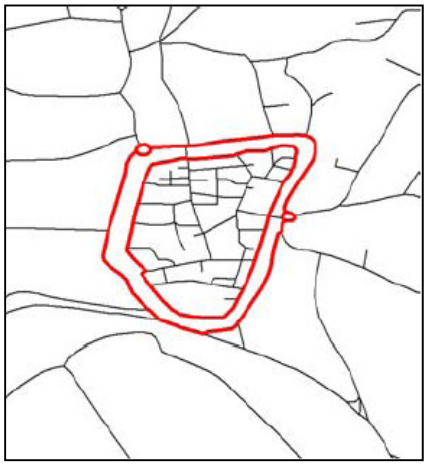


Grid structures



Star structures



Ring structures

Approaches for urban pattern recognition

Urban morphology / design

?

(Micro-/Meso-/Macro-)Structures

Gestalt theory
Algorithms

Geometry
Topology
(Semantic attributes)

Top-down approach for modelling urban structures

Universität Zürich

Urban morphology / design

Ontologies

Formal models of micro-/ meso- & macrostructures

Algorithms

Geometry
Topology
Semantic attributes

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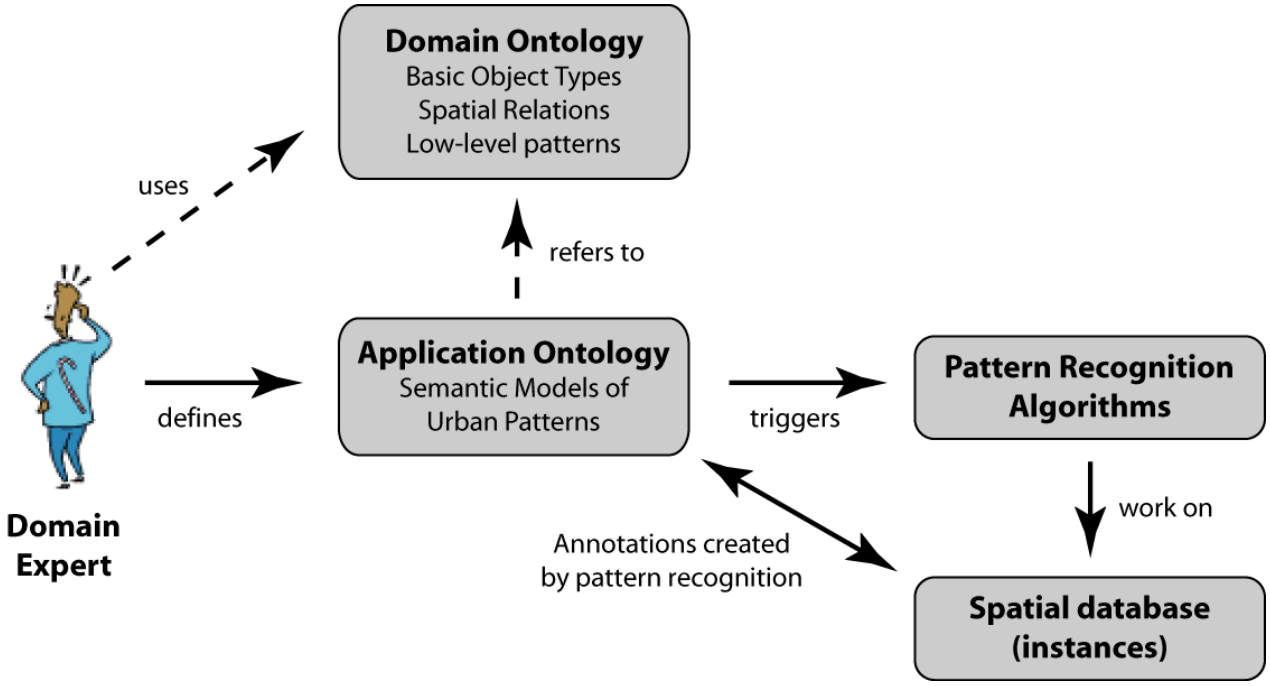
Ontologies

- Ontology = set of terms (concepts) & intented meaning of terms
- Concepts are connected with each other through **relations**
- Classification after degree of universality into
  - **Top Level** Ontologies
    - General kinds of relationships: taxonomy, mereology, topology
    - General kinds of entities: objects / processes
  - **Domain** Ontologies / Task Ontologies
  - **Application** Ontologies / Task Ontologies

Types of relations

- **Taxonomic** relations: Create a hierarchy of concepts
  - *„A residential building is a sub-concept of building„*
- **Partonomic** relations: Define aggregate concepts
  - *„A building complex is composed of buildings“*
- **Roles**: Allow dynamic association of concepts
  - *„For a residential building in 1:10k, Polygon adopts the role SpatialFootPrint“*
  - *„For a residential building in 1:200k, Point adopts the role SpatialFootPrint“*

General approach

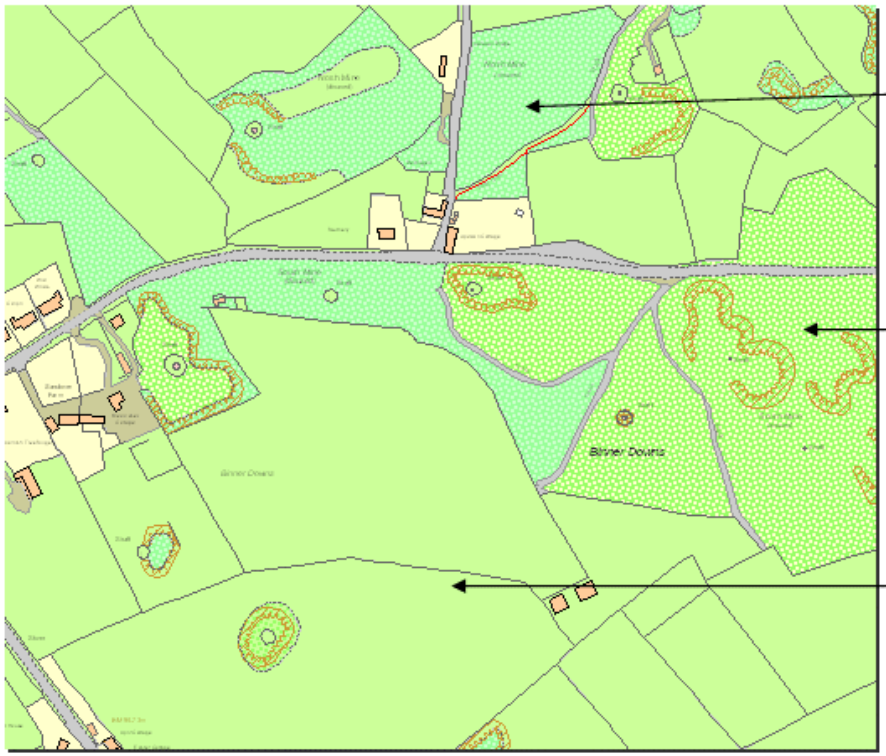


Related work

- Sester (2000): Recognition of parcel, houses in large-scale polygon data using *semantic nets*.
- Klien & Lutz (2006): Translation of ontological descriptions of spatial phenomena into spatial analysis operations
- Thomson (2006): Derivation of land use in OS MasterMap data using ontologies
- Kovacs & Zhou (2007): Ontology-driven recognition of fields in OS MasterMap data

Related work

Ordnance Survey: Ontology-driven approach to detection of fields (1)



Theme:	Land
Descriptive Group:	Natural Environment
Descriptive Term:	Scrub
Make:	Natural

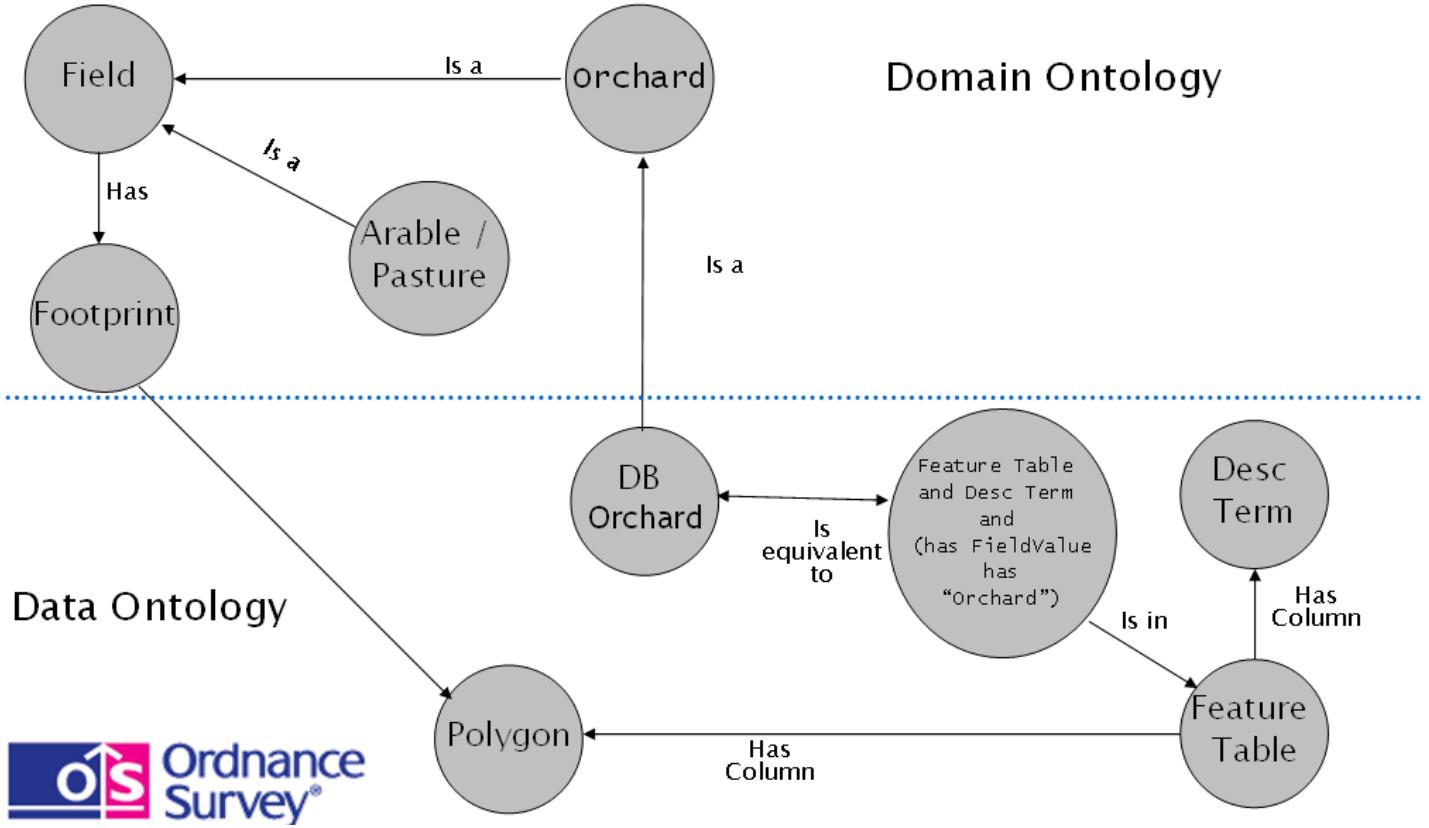
Theme:	Land
Descriptive Group:	Natural Environment
Descriptive Term:	Heath
Make:	Natural

Theme:	Land
Descriptive Group:	General Surface
Descriptive Term:	
Make:	Natural

Kovacs & Zhou (2007)

Related work

Ordnance Survey: Ontology-driven approach to detection of fields (2)



Kovacs & Zhou (2007)

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Example: Perimeter block development

Karlsruhe Weststadt

Example: Perimeter block development

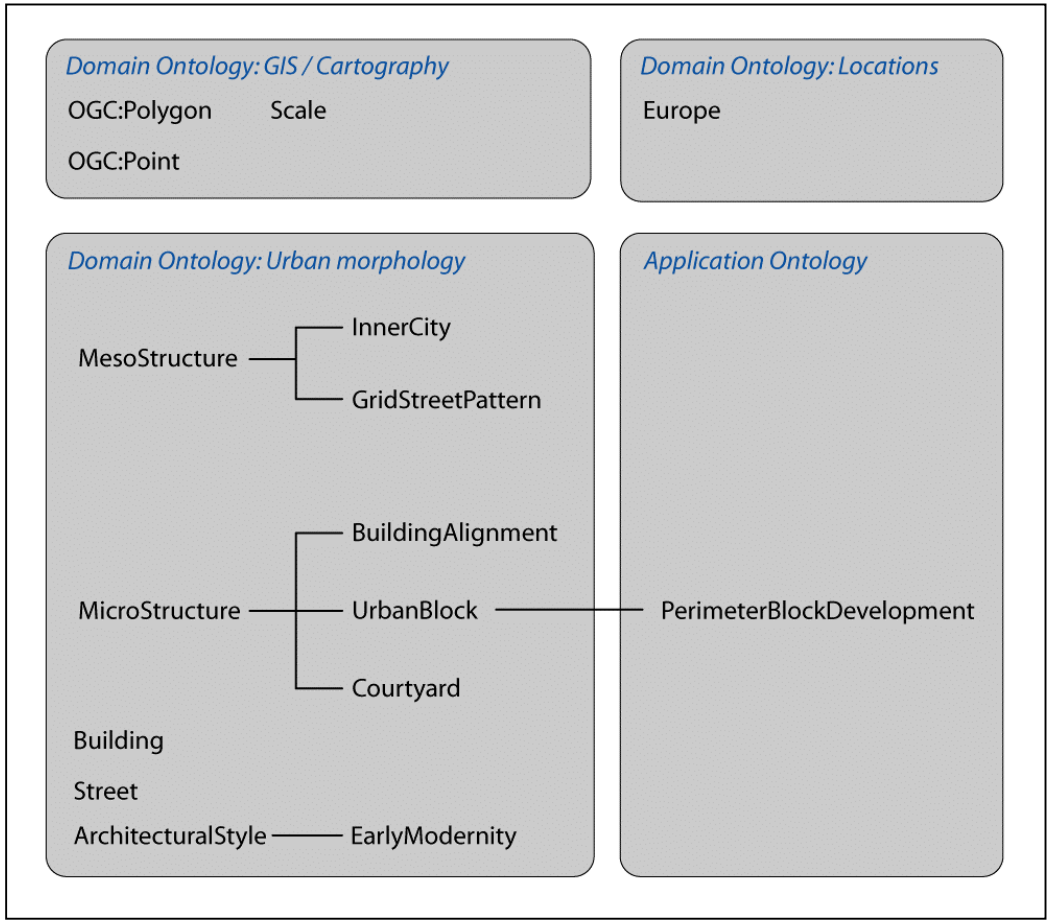
Graz

Example: Perimeter block development

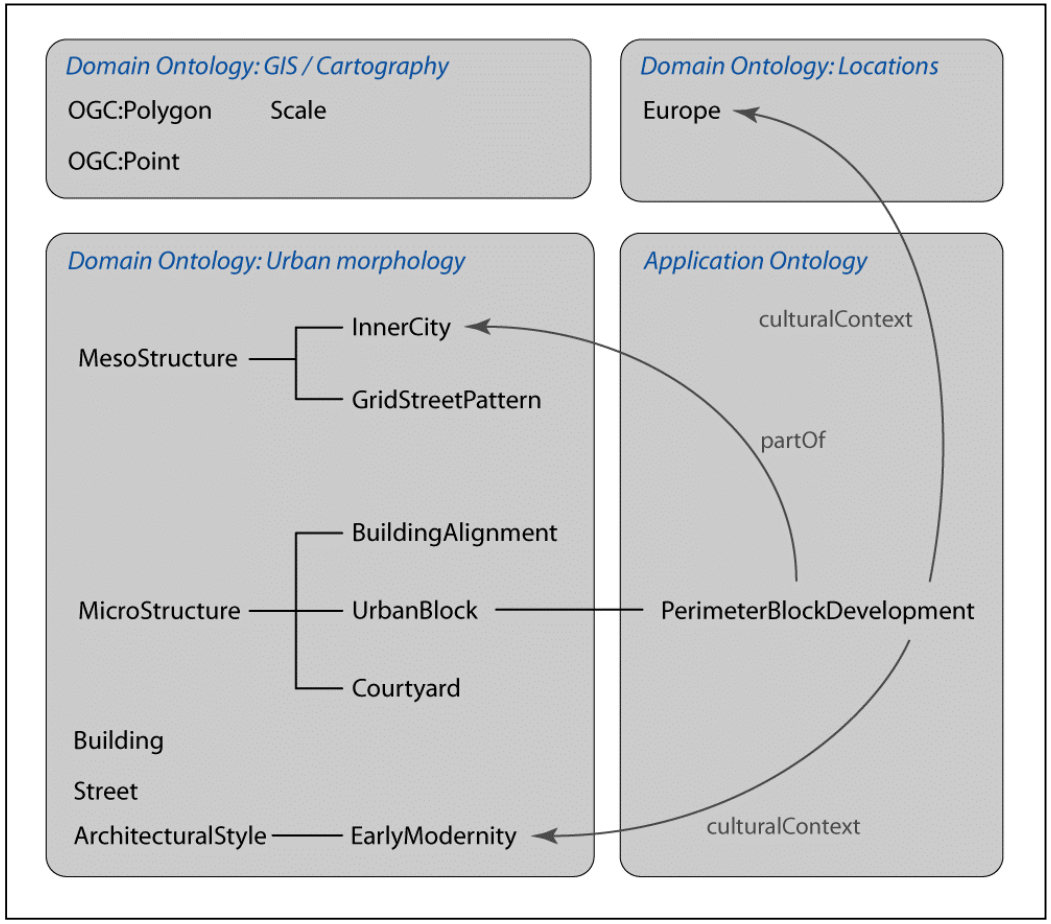
Zurich, general plan of the Canton Zurich 1:2500

Zurich, Swiss national map 1:50.000

Example: Perimeter block development



Example: Perimeter block development



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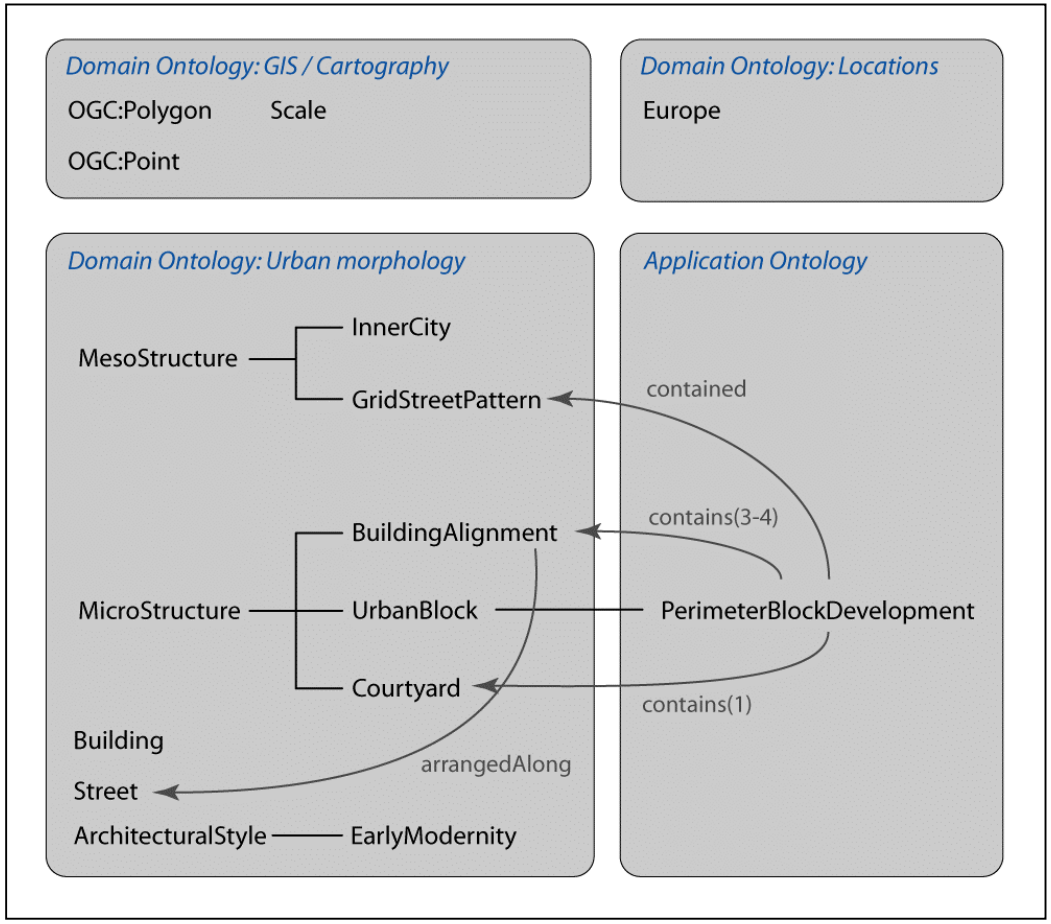

Example: Perimeter block development

- Import into Reasoner which supports *description logics*
- Implementation of spatial query & analysis operations in a GIS (JTS/JUMP) and provision as predicates / functions in the reasoner
- Experiments with Jena Framework (Java Open Source Reasoner)

- Problem: Description logics is poor at dealing with fuzziness

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Discussion

- **Benefits**
  - Properties of patterns are explicitly stated instead of hidden in algorithms.
  - Pattern recognition easily adaptable to different cultures or contexts by adapting pattern specifications.

- **Issues**
  - Connect (lots of) real world data to ontological concepts.
  - Visualization of and interaction with ontology-enriched database.
  - Vagueness of real world data vs. concept definitions in ontologies?

Conclusions

- Top-down approach to modeling and detection of urban structures that complements algorithmical approaches.
- Ontologies are used for modelling. They describe the semantic contexts of concepts and therefore allow a flexible use of ontology-enriched data.
- Issues regarding this kind of use of ontologies have to be adressed.

Thanks for listening!

Questions?