



**ifgi**

Institute for Geoinformatics  
University of Münster



**musil**

The MUSIL logo, which includes a stylized grey arrow pointing right and the word "musil" in blue lowercase letters.

# What does it take to interoperate?

**Semantic interoperability revisited  
in terms of human digital communication**

Simon Scheider

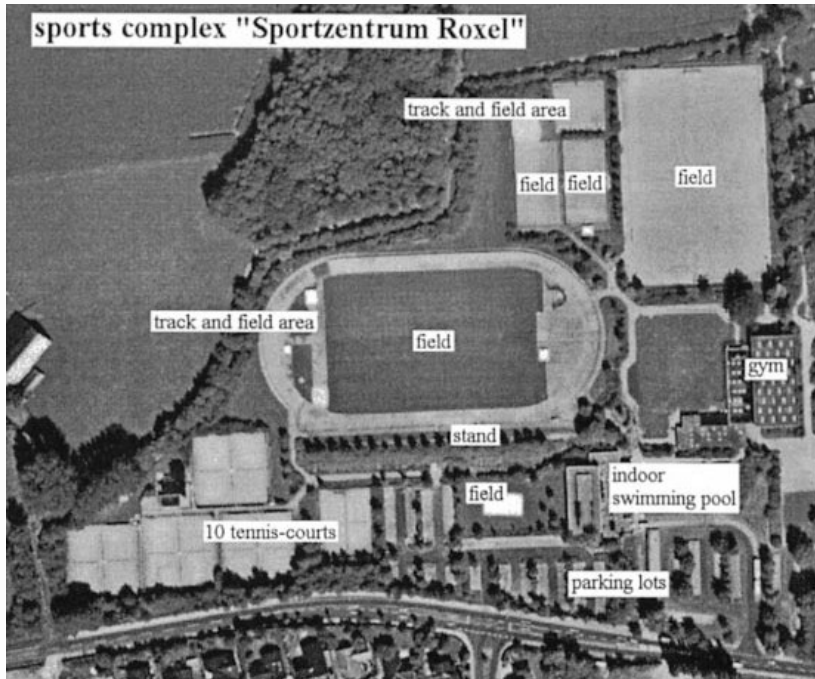
Münster Semantic Interoperability Lab (MUSIL)

EarthScienceOntolog:

Panel Session-03 - Thu 2012-10-11

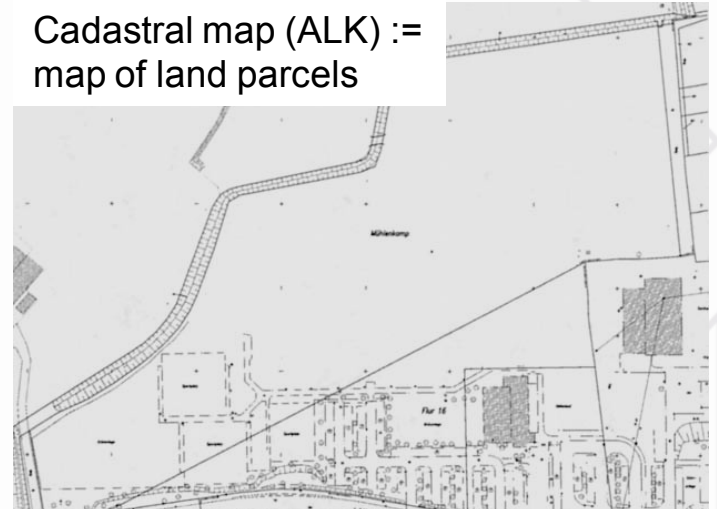


# Illustration 1: How to map a sports ground



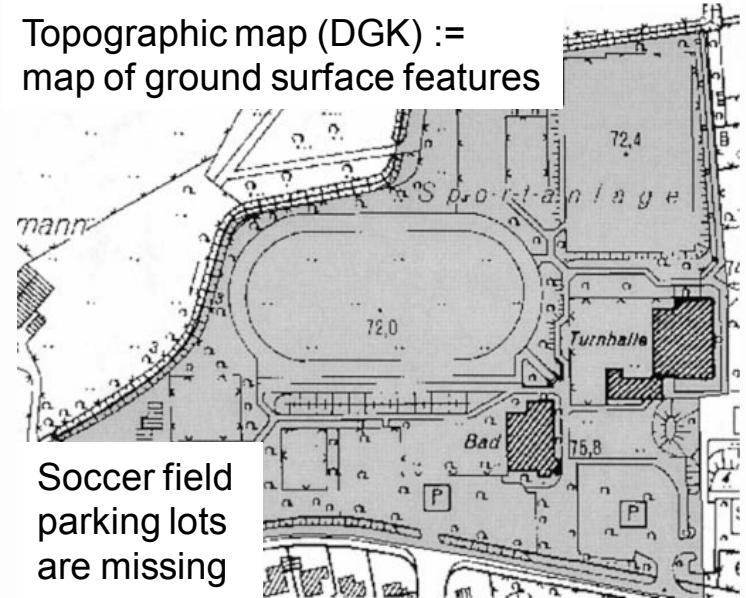
Taken from Harvey et al. 1999

Cadastral map (ALK) :=  
map of land parcels



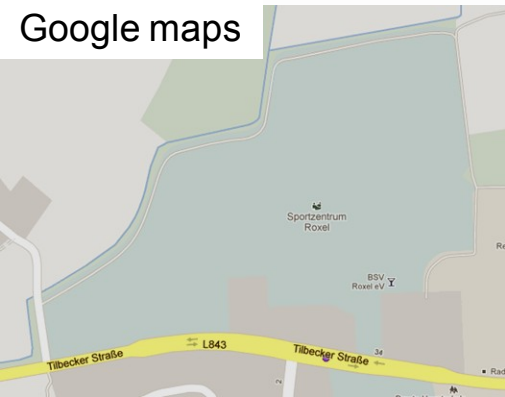
Track and soccer field missing

Topographic map (DGK) :=  
map of ground surface features



Soccer field  
parking lots  
are missing

Google maps

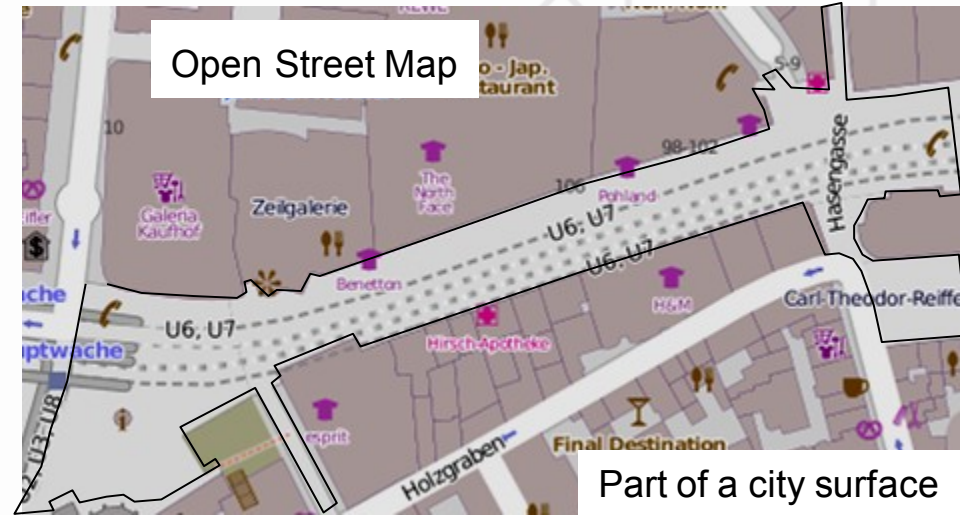
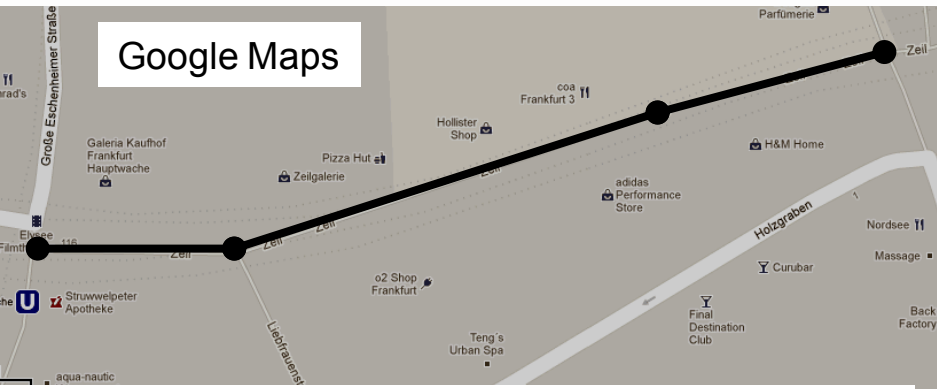


# Illustration 2: How to represent Frankfurt Zeil



Frankfurt Zeil is a famous pedestrian shopping area in Frankfurt a. Main

Is it a road object with motor traffic restrictions? Or a public place? Or a non-identifiable part of the city surface?



Type of a road object without motor traffic (embedded road graph)

Part of a city surface

# The challenge of interoperability in a nutshell

name1



name2



Source: A. Kleon

From multi term --  
single perspective

- The problem cannot be reduced to labeling, i.e., to establishing standard terms for given concepts
- Conceptualizations vary considerably, that is, each dataset comes with an intrinsic perspective, and for good reasons
- To the extent that things and their categories in one perspective do not exist in another one
- Sometimes, terms may not even be comparable across perspectives

name1



name2



"Is this a meadow, a field,  
or a vacant lot?"

... to multi term --  
multi perspective

# Paradigms of semantic interoperability and corresponding strategies

Paradigm	Main idea	Heterogeneity strategy	Means to semantic interoperability	Critical assumption
<b>Holistic standardization</b>	Term-meaning standardization	Heterogeneity resolution	Ability to subscribe to a standard	Term-meaning can be standardized
<b>Top-level ontology alignment</b>	Alignment with core standard	Heterogeneity avoidance	Ability to align with core standards	Core term-meaning can be standardized
<b>Pluralist peer-to-peer translation</b>	Term similarity and translation	Heterogeneity mitigation	Ability to translate between similar terms	Term-meanings are comparable and mappable
<b>Semantic imitation</b>				
<b>Bottom-up construction</b>	Term-meaning generation	Heterogeneity articulation	Ability to understand semantic differences	Term-meanings can be reconstructed
<b>Human-machine-human communication</b>	Term-meaning communication	Heterogeneity articulation	Ability to act on information	Term-meanings can be communicated

# Interoperability as communication problem

Sharing meanings is a result of human communication. It requires understanding **acts of reference**.

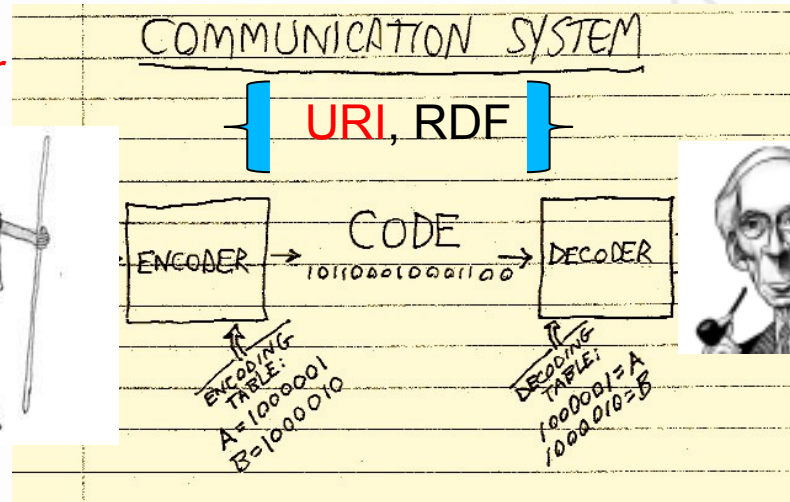
Human - machine - human

Domain of experience of encoder

Act of reference of encoder

Act of interpretation of decoder

Domain of experience of decoder



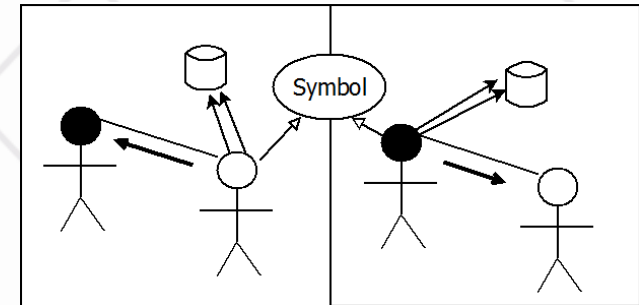
“The problem is not that machines cannot communicate, but that humans misunderstand each other when communicating via machines”

**Reference gets lost since it is generated outside the machine**

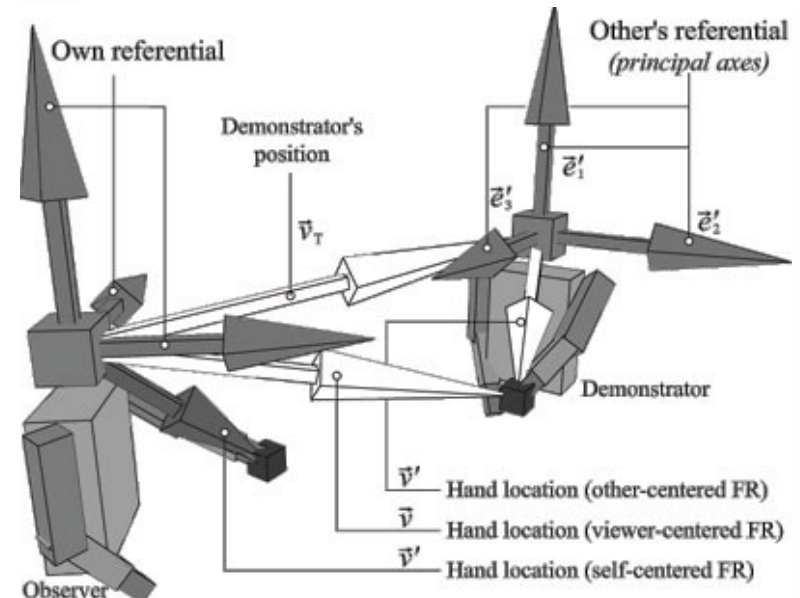
# Sharing meaning requires recomputing it in terms of shared operations

Theses (c.f. Scheider 2012):

- Meaning is something that observers do (speech act that joins human attention on a reproducible phenomenon)
- Sharing meaning requires „**imitation**“: Regenerating it in terms of shared operations (perceptual, technical, and constructive)
- Conventional reference formalisms can be **grounded in such operations**  
 $\cong$  Semantic Reference Systems  
 (Kuhn 2003)

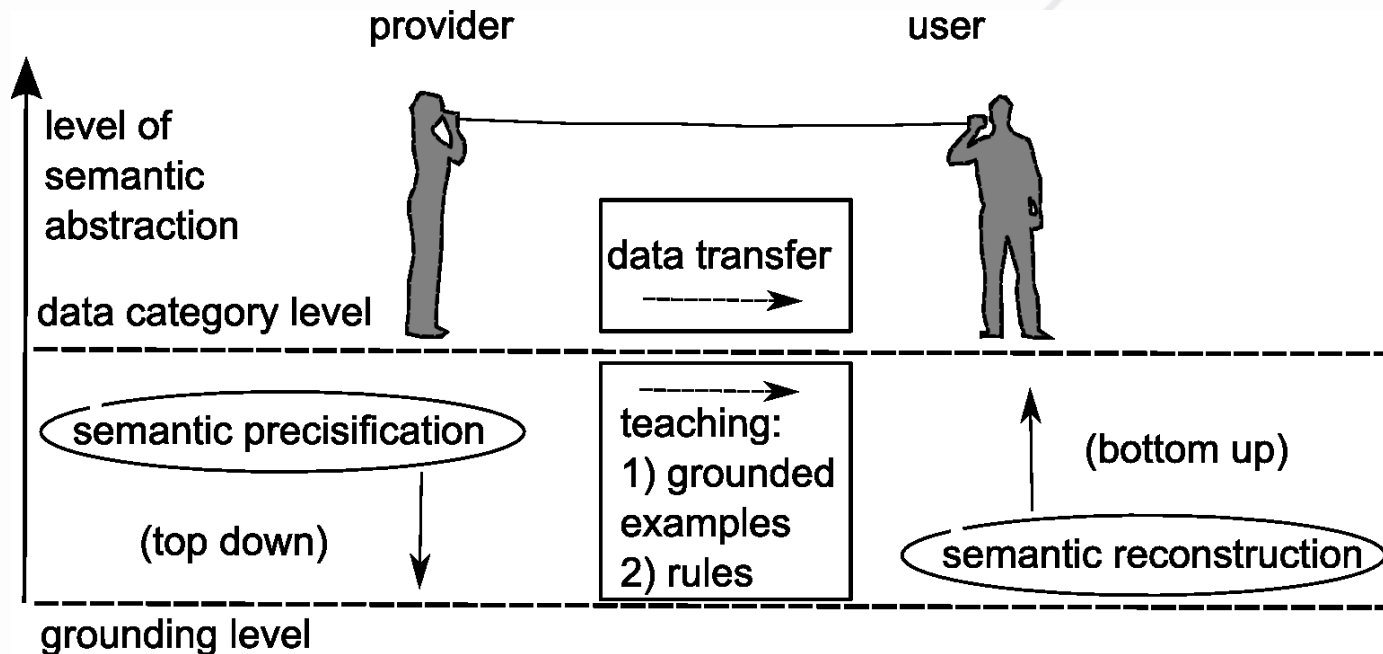


Joining attention (Tomasello 1999)



Imitation of „**holding sth. in front**“ by robots (Sauter and Billard 2005)

# Interoperability as result of semantic imitation



- The provider supplies data and takes on the role of a teacher.
- The user tries to imitate the provider by **reconstructing data categories** in terms of a grounding level
- The task of the provider is to **teach data categories** with respect to a grounding level (by examples and rules)
- The game is evaluated by **classification quality** (precision and recall) of examples



# Semantic imitation tools: the big picture

Logic inspired examples:

*Logical syntax  
Inference calculus  
Intuitionistic calculus*

*Formation algorithm  
Resolution algorithm  
Tableau algorithm*

*Variable instantiation  
Quantifier instantiation*

**synthetic tools  
(downhill)**

constructive calculus  
(set of rules)

Construction procedure

Instantiation/  
Simulation procedure

*Logical primitive  
Nonlogical primitive  
Axiom*

primitive concepts/  
"slots"

construction patterns

concepts of interest

*Definiendum  
Theorem*

data

*Ground sentences  
A-Box*

**analytic tools  
(uphill)**

*Definiens  
Logical formulae  
Proof*

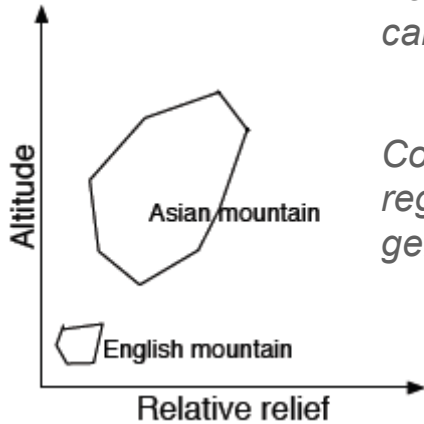
Learning Procedure

*Syntax parsers  
Inductive logic programming*



# Semantic imitation tools: example 1

Category construction  
Mountains as regions in conceptual spaces:



Vector calculus

Convex region generator

Mountain categorizer

**synthetic tools (downhill)**

constructive calculus (set of rules)

Construction procedure

Mountain

Instantiation/Simulation procedure

Measurement scales for relief

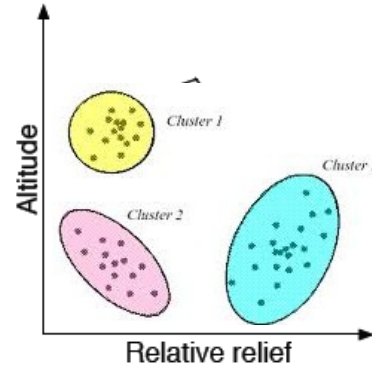
primitive concepts/ "slots"

construction patterns

concepts of interest

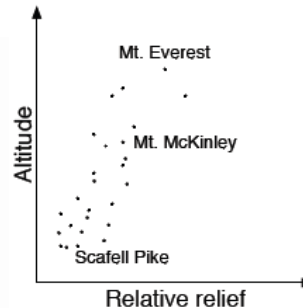
data

**analytic tools (uphill)**



Unsupervised learning (Cluster analysis)

(Adams Janowicz 2011)

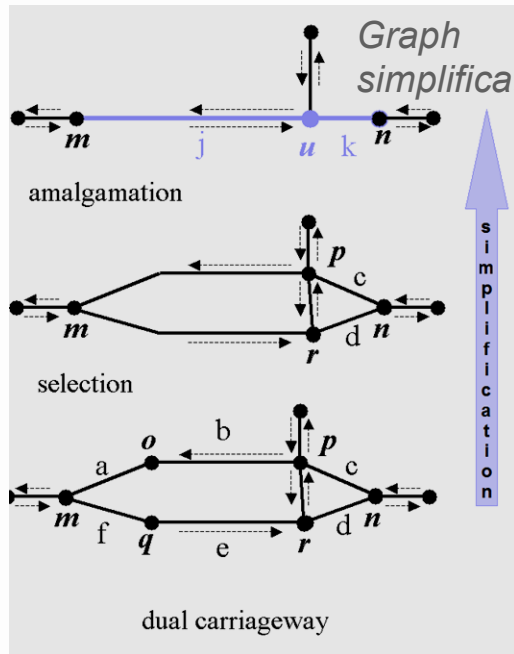


Mountain data

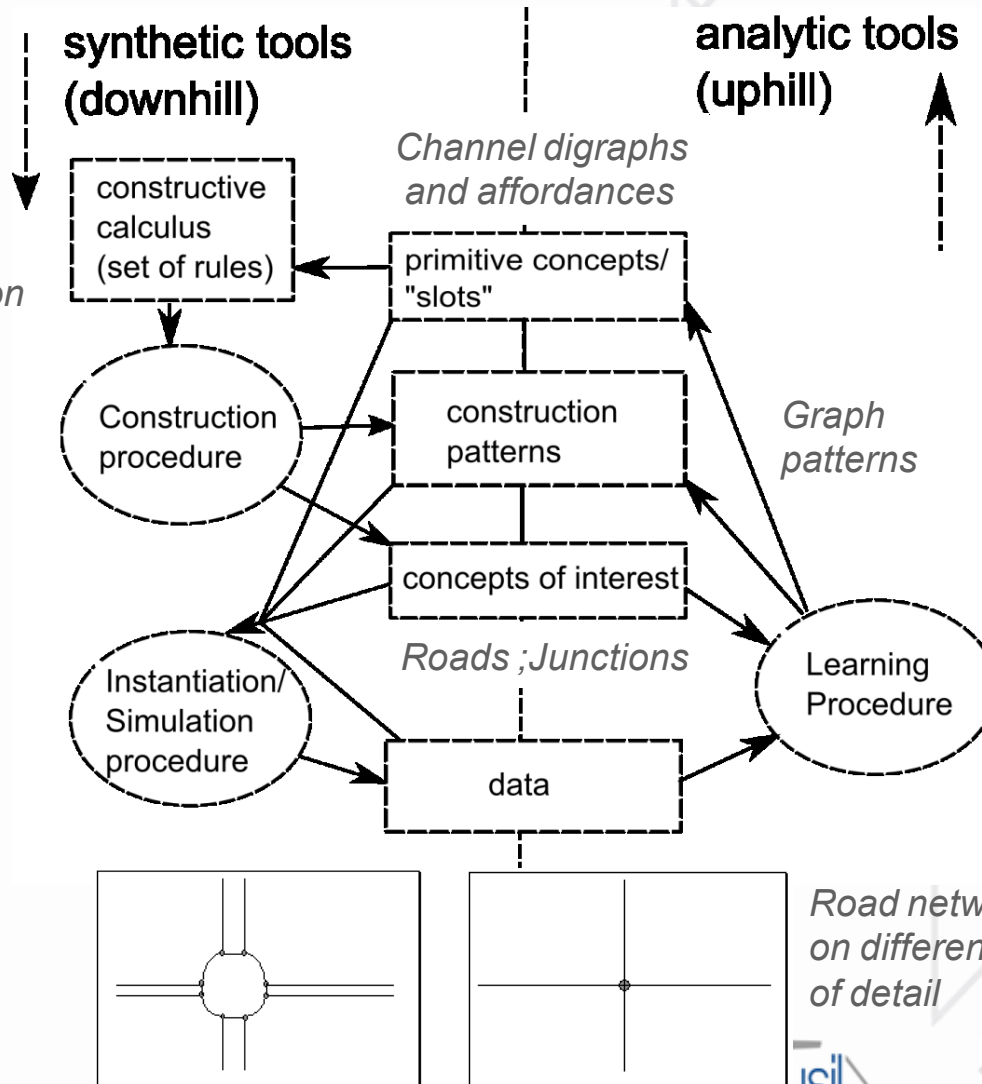


# Semantic imitation tools: example 2

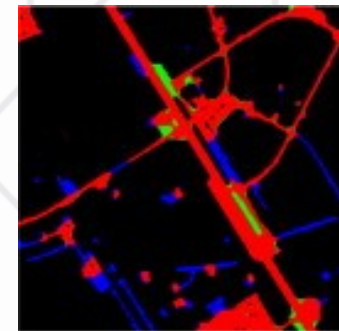
Object construction:  
Roads and junctions as embedded graphs:



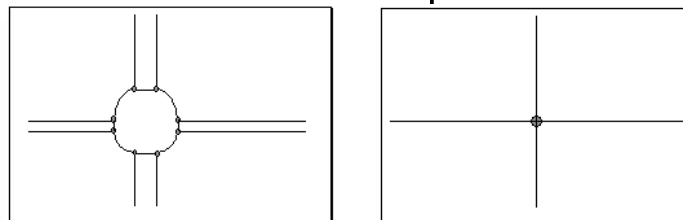
(Scheider Possin 2012)



Delineation of roads



Road network data on different levels of detail





# Thank you!

*Adams , B., and Janowicz K. (2011) Constructing Geo-Ontologies by Reification of Observation Data*

*Harvey F. et al. 1999: Semantic interoperability: a central issue for sharing geographic information*

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*Kuhn, W. (2003) Semantic reference systems. Int. J. Geogr. Inf. Science 17(5) 405-409.*

*Sauser, E. and Billard, A. (2005) Three Dimensional Frames of References Transformations using Recurrent Populations of Neurons. Neurocomputing, 64, 5-24*

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*Scheider S. and Possin J. (2012) Affordance-based individuation of junctions in Open Street Map*

