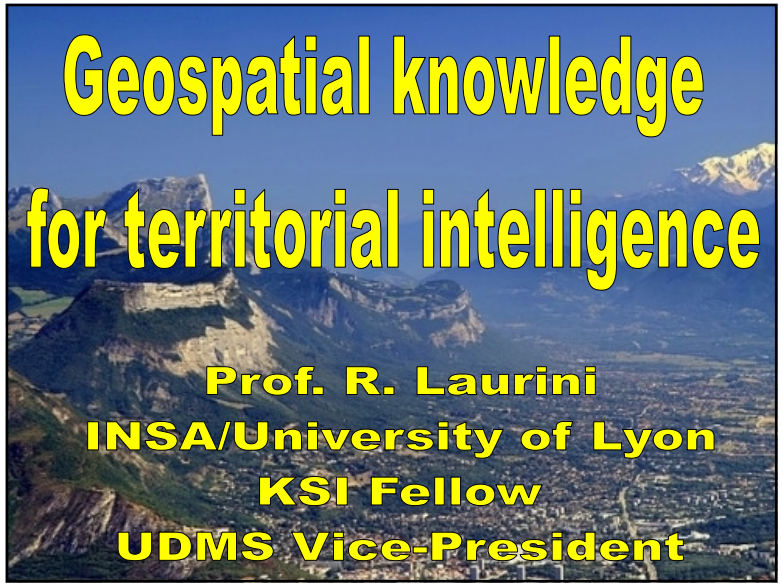


Geospatial Knowledge for Territorial Intelligence

- 1 – Territorial Intelligence
- 2 – Generalities about Geographic Knowledge
- 3 – Generic Geographic knowledge
  - 3.1 – Mutation of topological relations
  - 3.2 – Gazetteers and toponyms/placenames
  - 3.3 – About raster
- 4 – Conclusions

Geographic relations

- In addition to spatial relations
  - Tessellations for administrative objects
  - Networks
  - Ribbon relations
  - Geographic ontologies with Geo Relations
  - Gazetteers

1 – Territorial Intelligence

- Business intelligence applied to territories
  - Cities (➔smart cities)
  - Regions, Countries
- Links with urban, regional and environmental
  - Planning
  - Management
- Objective: Sustainable development

A new family of concepts

- Such as
  - competitive intelligence,
  - strategic economic intelligence,
  - distributed intelligence,
  - social intelligence, or collective,
- emphasizing organized and systematic collection, analysis and dissemination of information for the purpose of development.

Territorial Intelligence

Territorial Intelligence
=
(Territory
+
Collective Human Intelligence
+
Artificial Intelligence)

➔ Sustainable development)

2 – Generalities about GK

- Definitions
  - Feature = geographic entity existing in the real word
  - Geographic object = computer representation of a feature
  - Rule = mathematical inference
- Not only logics, but also space/geometry

AI + Computational Geometry

- Necessity to include
  - Computational geometry
  - Topology
  - Spatial analysis
  - Operation research
  - Linguistics
  - Etc.
- Earth rotundity

Generic and specific knowledge

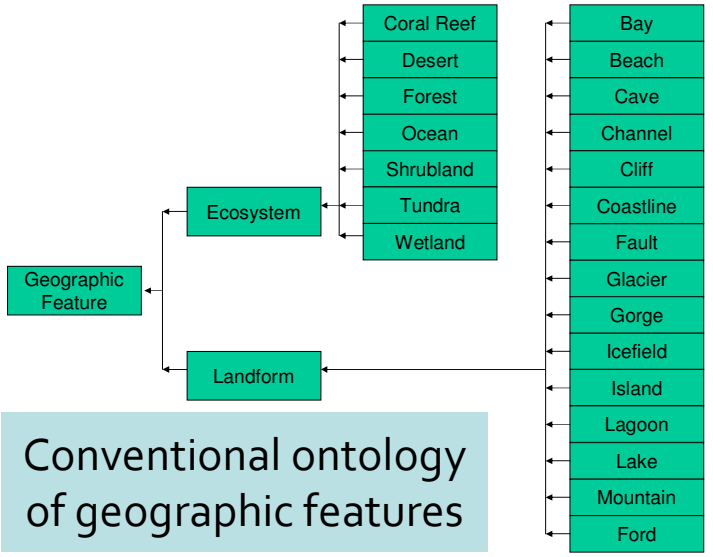
- Specific knowledge
  - Devoted to a particular place in the world
  - F.i. Antarctica, near Equator, etc.
  - Mountains, seashore
- Generic knowledge
  - Valid everywhere
  - Links with acquisition devices
  - Links with maths and linguistics

Application knowledge

- Knowledge rules valid in one domain
  - Urban planning
  - Environmental planning
  - Transportation, logistics
  - Etc.

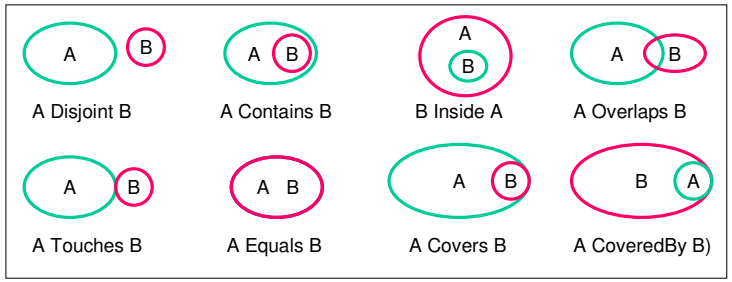
Geographic Ontologies

- Organizations of geo features
- Relations « *is_a* », « *has_a* », « *whole_part* »
- Necessity of spatial relations

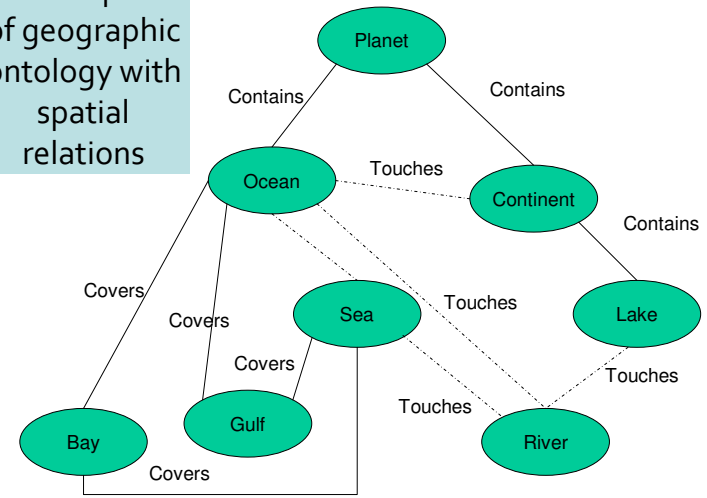


Conventional ontology of geographic features

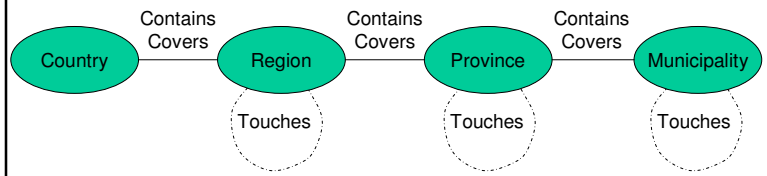
Egenhofer topological relations



Example of geographic ontology with spatial relations



Administrative subdivisions

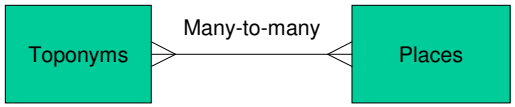


Rapid analysis of toponyms

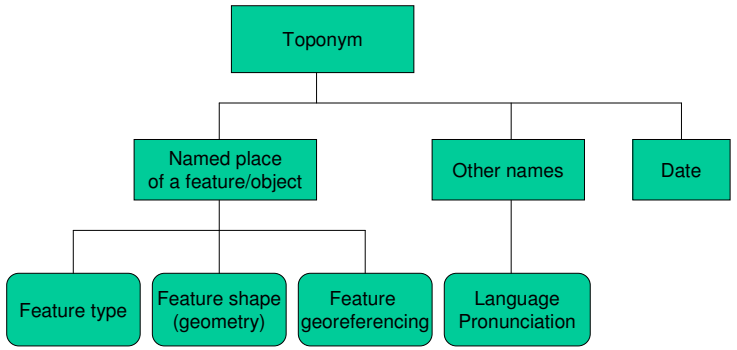
- "Mississippi" can be the name of a river or of a state,
- The city is "Venice", Italy, is also known as "Venezia", "Venise", "Venedig" respectively in Italian, French and German.
- The local name of the Greek city of "Athens" is "Αθήνα" read [a'θina].
- "Istanbul" was known as "Byzantium" and "Constantinople" in the past.
- The modern city of "Rome" is much bigger than in Romulus time.
- The toponym "Milano" can correspond to the city of Milano or the province of Milano.
- Some cities have specific characteristics such as capital of a state; a river can have an estuary in a sea.

Gazetteers

- A dictionary of toponyms/placenames
- A database structure for placenames

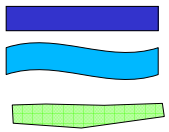


Example of gazetteer

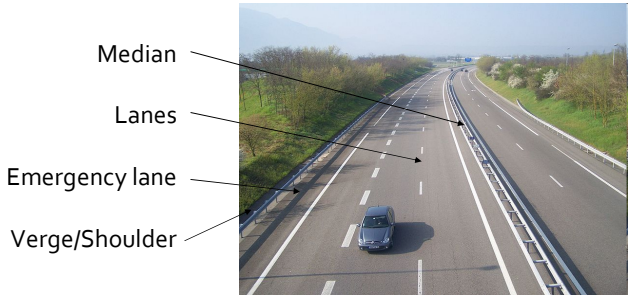


About ribbons

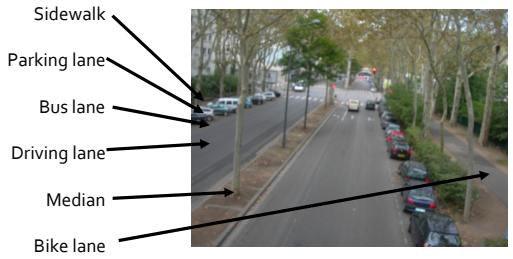
- Line with some width
- ➔ area
- Rectangular ribbon
- Extended ribbon
- Loose ribbon
- Relations between ribbons



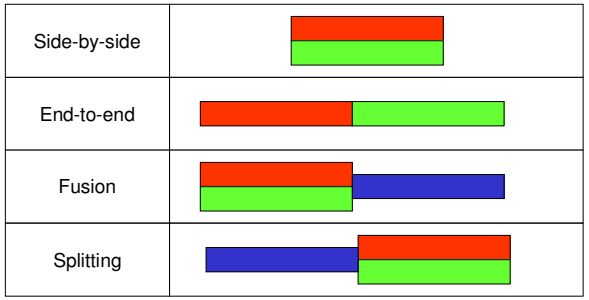
Modeling with ribbons



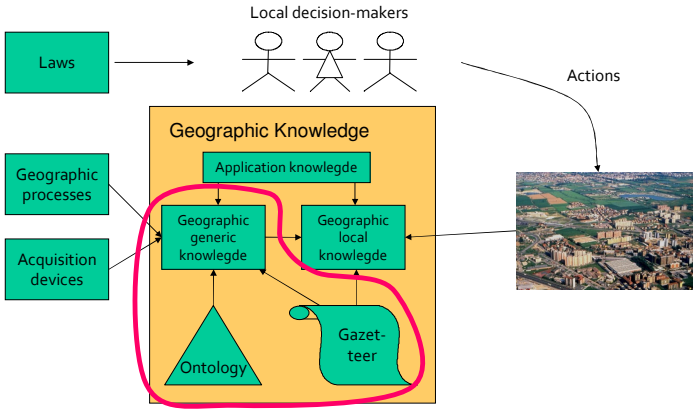
Urban example



Relations between ribbons



Organization of Geographic Knowledge

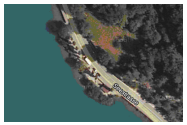


3 – Generic Geographic knowledge

- Geographic knowledge valid everywhere
- Linked to
  - Maths
  - Linguistics
  - Acquisition devices
- Only three types
  - Mutation of topological relations
  - Gazetteers and toponyms
  - About raster reasoning

3.1 – Mutation of topological relations

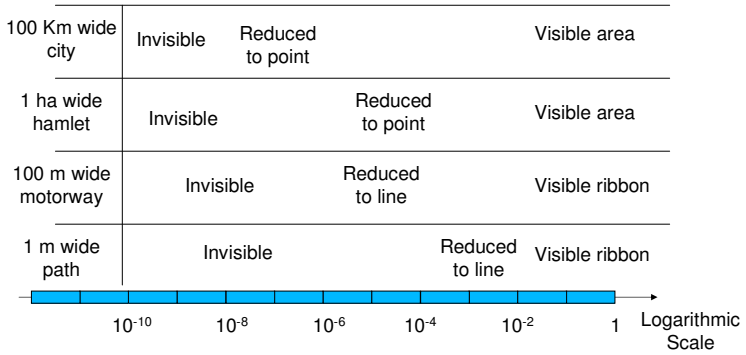
- Granularity of interest
- Independence from scale
- Ex. Road along a coast
  - Touches
  - Disjoint
- According to scales, topological relations can vary



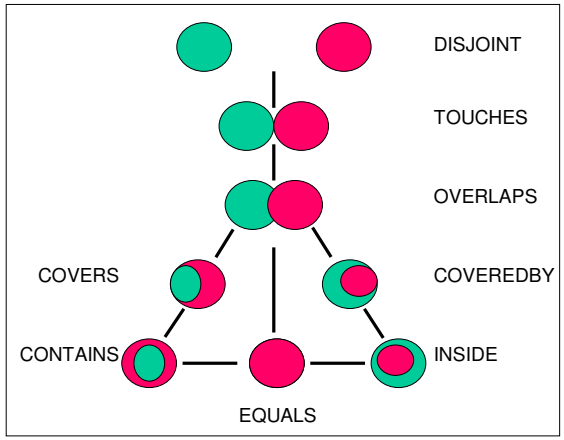
Visual acuity

- According to scale, objects are present or not.
- Cities: area, then point, then nothing
- River: ribbon, then line, then nothing
- Threshold for visual acuity
  - 0.1 mm (object no more visible)
  - 1 mm (ribbon is transformed into a line)

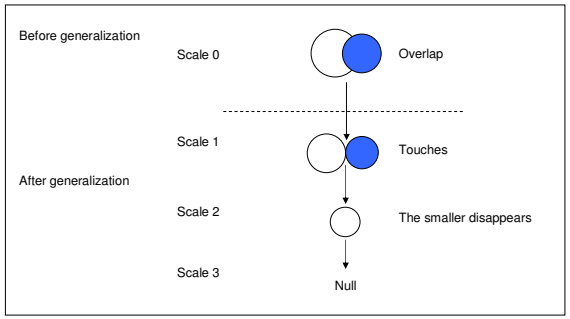
Features and mutation of their corresponding geographic objects



Vicinity of topological relations



Example: Overlap-to-Touches



Ex. From OVERLAPS to TOUCHES

$$\forall O^1, O^2 \in \text{GeObject}, (\forall \sigma \in \text{Scale})$$
$$\wedge (O^1_\sigma = 2Dmap(O^1, \sigma)) \wedge (O^2_\sigma = 2Dmap(O^2, \sigma))$$
$$\wedge (Overlaps(O^1, O^2)) \wedge (Area(O^1 \bigcap O^2) < Area(\neg(O^1 \bigcap O^2)))$$
$$\Rightarrow Touches(O^1_\sigma, O^2_\sigma).$$

In which *2Dmap* is a cartographic function

Other possible mutations

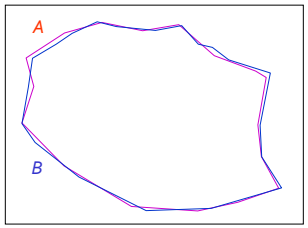
- Disjoint-to-Touches
- Overlaps-to-Covers
- Contains-to-Touches

3.2 – Gazetteers and toponyms

- Geographic information retrieval
- Multilingualism
- Concepts in different languages are different

Geometric homology

- Taking measurement errors or uncertainties into account
- The same feature can have different geometric representations
- Geometry: polygons with point coordinates



$A \approx B$

Linguistic homology

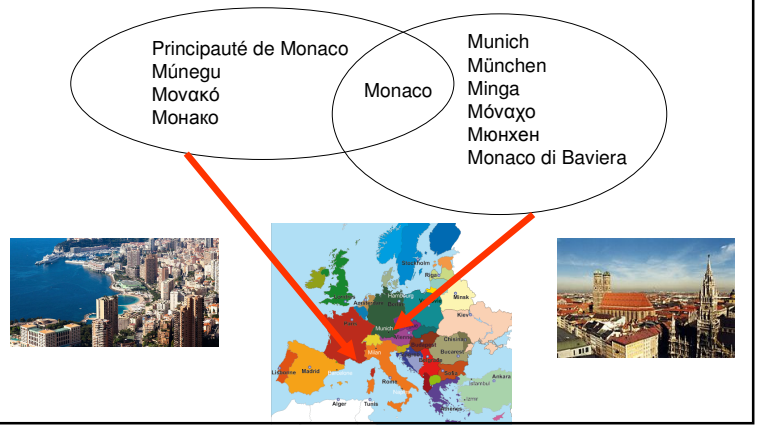
Homology class
(Objects linked by ≈)

Equivalence class
(Objects linked by ≡)

- United States of America
- United States
- USA
- U.S.A.

- Etats Unis d'Amérique
- Estados Unidos de América
- Stati Uniti d'America
- Vereinigte Staaten von Amerika
- Соединённые Штаты Америки
- etc

Non-linguistic transitivity



Type homology

- Consider two geographic ontologies in different languages
- Equivalence or homology
- Example: French « quai », three meanings
  - Wharf ≈ *muelle*
  - Riverside ≈ *avenida a lo largo de un río*
  - Platform ≈ *andén*



Formalization

- Set of languages: $\lambda \in \Lambda$
- Ontology of types: Ω = set of *Types* with relations between them
- Gazetteer: Γ = set of *Toponyms*
- Set of spatial relations
- Geometric Earth: *Geoid*

Definition of GK System

- $GKS = \{T, \lambda, \Omega, \Gamma, Og, \mathcal{R}\}$
  - *T Inside Geoid*
  - $\lambda \in \Lambda$
  - $Og = \{Og^1, \ldots Og^n : n \in N\}$
- $Og^i = (id^i, geom^i, Type^i, Toponym^i]$
  - $Type^i \in \Omega$
  - $Toponym^i \in \Gamma$
- $\mathcal{R}$ set of relationships $\{Og^i \; R \; Og^j : (i, j \leq n) \wedge (i, j \in N)\}$
- *R* relation

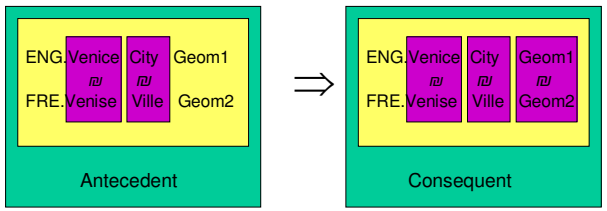
Considering 2 GKS

- $GKS_1 = \{T_1, \lambda_1, \Omega_1, \Gamma_1, Og_1, \mathcal{R}_1\}$
- $GKS_2 = \{T_2, \lambda_2, \Omega_2, \Gamma_2, Og_2, \mathcal{R}_2\}$
  - *With*
  - $T_1 \cap T_2 \neq \varnothing$
  - $\lambda_1 \neq \lambda_2$
  - $\Omega_1 \neq \Omega_2$
  - $\Gamma_1 \neq \Gamma_2$

Same features
But different geographic objets
And maybe different relationships

Inferring geometry: Rule #1

IF
Homologous toponyms AND
Homologous types
THEN
Homologous geometry



Rule 1bis: with MBR

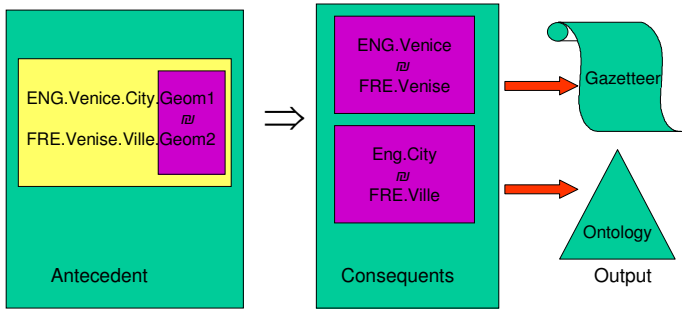
Inferring types and toponyms Rule #2

IF

Homologous geometry

THEN

Homologous toponyms
homologous types



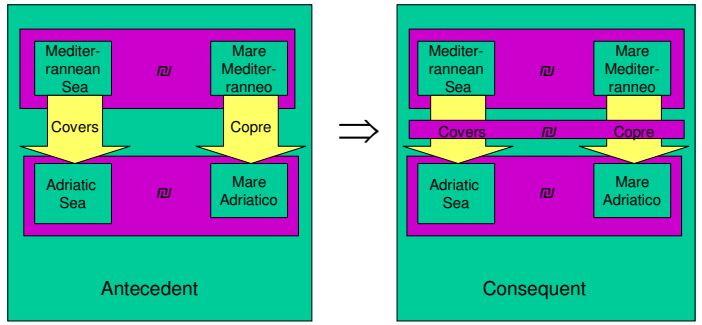
Rule #3

IF

Two pair of homologous geographic objets are linked thru 2 different relations

THEN

Those relations are homologous



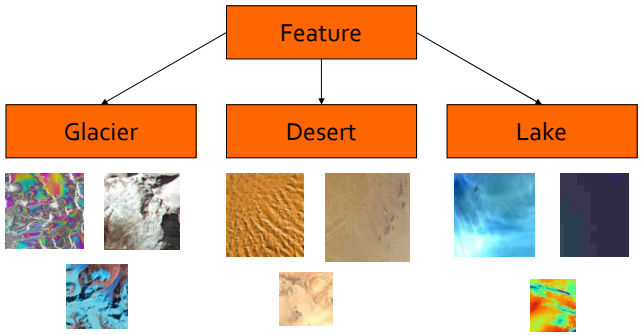
3.3 – From raster representation

- Aerial photos / Satellite images
- Analysis
  - Pattern recognition
- Usage
  - Feature recognition
  - Updating

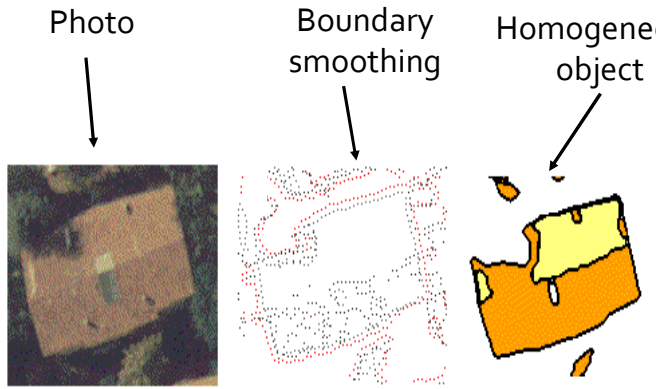
Visual Ontology

- In addition to feature type, several samples taken at different scales
- Samples = pictures from sky
  - Hyperspectral
  - Different channels
  - Different focus
  - Etc.
- Pictures only at lower level

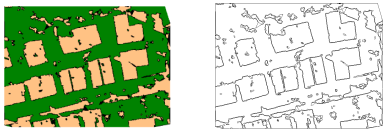
Excerpt of a visual ontology



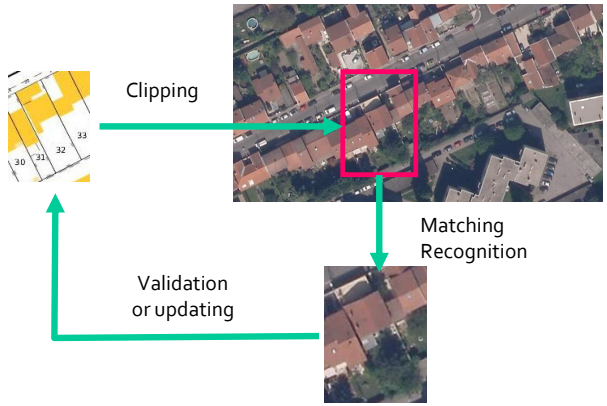
Feature recognition



Definitive result



Comparing aerial photo and cadaster



Raster rules

- Identification of features, of their characteristics
- Updating geographic objects
- Analysis

3.4 General characteristics

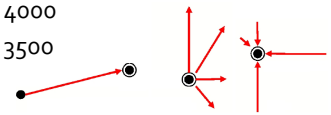
- Geographic knowledge reasoning
  - Independence from scale
  - Independence from data acquisition techniques
  - Independence from languages
  - Easy integration of
    - Spatial analysis
    - Network analysis

4 – Visual representations

- Four types:
  - Natural Language (classic geography)
  - Mathematics (description logic, etc.)
  - XML dialects
  - Visual

Elementary knowledge (1/2)

- Facts
  - Italy.population= 60 000 000
  - Touches (Italy, Switzerland)
- Flow
  - Bi-directional flow
    - Flow (Dublin, Limerick) = 4000
    - Flow (Limerick, Dublin) = 3500
  - Converging flows
  - Diverging flows



Elementary knowledge (2/2)

- Clusters
  - UK= Union (England, Scotland, Wales, NorthenIreland, etc)
- Co-location relation
  - Co-location (CityHall, Church)

Example

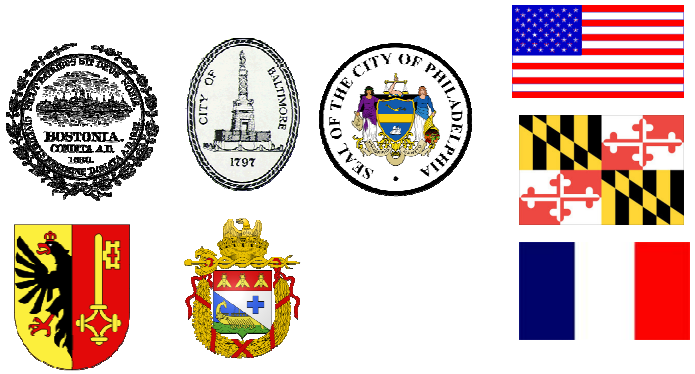
- If
  - Lake
  - Road going to the lake
- Then
  - Restaurant

Logic

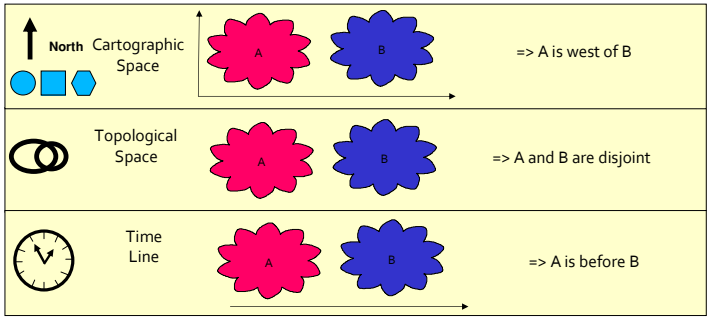
- $\forall l \in Lake \wedge \forall s \in Road \wedge (touches\ (l, s)$
- $\Rightarrow$
- $\exists r \in Restaurant \wedge (distance\ (r,l) < 100 \wedge (distance(r,s) < 100$

Vocabulary (generic objects)

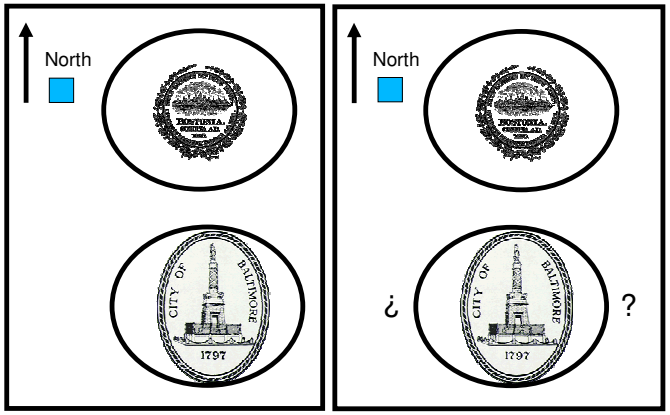
Visual Gazetteer



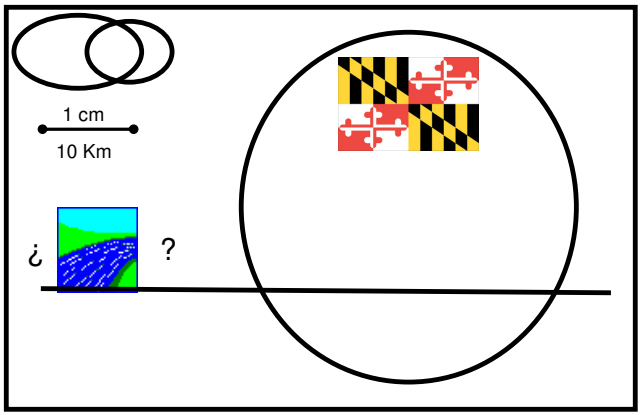
Contexts of interpretation



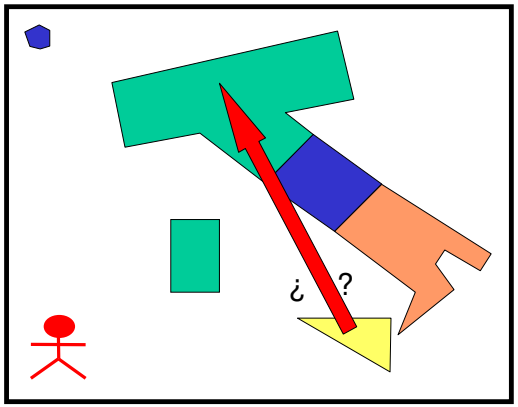
Fact statement and query



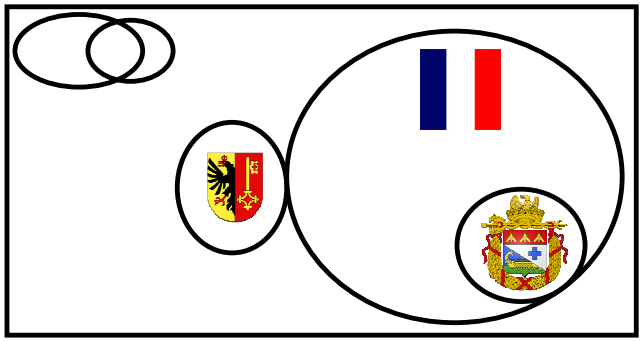
Topological query



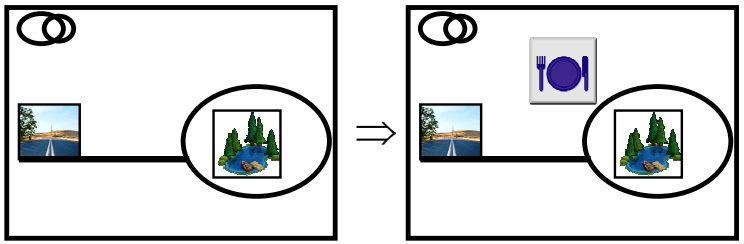
Chorem, cluster, area and query



Topological constraint



Co-location rule



5 – Conclusion (1/2)

- Importance of geographic knowledge
- Several layers
  - Generic layers
  - Specific layers
  - Application layers
- First steps to geographic reasoning

Conclusions (2/2)

- Other minor contributions
  - Ribbon
  - Ribbon topology
  - Homology relations
  - Generalization of topological relations
  - Visual knowledge representation

Main recent references

- LAURINI R. (2014a) "*A Conceptual Framework for Geographic Knowledge Engineering*", Journal of Visual Languages and Computing (2014), Volume 25, pp.2-19,
- LAURINI R. (2014b) "*Fundamentals of Geographic Knowledge Engineering for Territorial Intelligence*" in the book "Knowledge Engineering: Principles, Methods and Applications" To be published by for NovaPublishers.
- LAURINI R. (2014c) "*Geographic Ontologies, Gazetteers and Multilingualism*" submitted to the journal Future Internet
- LEJDEL B., LAURINI R (2014) "*Ribbons and Generalizing Topological Relations*" submitted to the "Inter'l Journal of Geographic Information Sciences"

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http://liris.insa-lyon.fr/robert.laurini/ftp/GKS.zip

For any contact:

Robert.Laurini@insa-lyon.fr

Thanks for your attention!