Geospatial Semantics

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Outline

- What is geospatial semantics?
- Why do we need it?
- Existing researches.
- Conclusions.

What is geospatial semantics?

- Semantics
  - The meaning of expressions
- Syntax
  - How you express the meaning

- E.g. “I love GIS”

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  - How you express the meaning

- E.g. “I love GIS” Different syntaxes
  “I ♥ GIS” Same meaning

What is geospatial semantics?

- Geospatial semantics
  - The meaning of geospatial data
    - Thematic information, Data source, coordinate systems, data collection time…
  - The meaning of geospatial functions
    - The meaning of the input data, the capability of this function, the meaning of the output data …

Why do we need geospatial semantics?

- Making computers understand the meaning of geospatial data and functions.
  - Computers cannot truly understand the meaning of data and functions.
    - E.g. Contours– treated as polylines
- Systems are like “parrots” mimicking language without understanding it.

Why do we need geospatial semantics?

"I like GIS" (human language)

What did I say???

Why do we need geospatial semantics?

- Why do we need to make computers understand the geospatial data and functions, since our humans can do that?

Why do we need geospatial semantics?

- The reason lies in the distributed geospatial data and functions.

Why do we need geospatial semantics?

- Previously, geospatial data and functions resided locally (which can be easily understood by local community members)
- Today, they are distributed at different places throughout the world (which requires much interpretation work)

Why do we need geospatial semantics?

- How can we make computers autonomously retrieve the right geospatial data and functions without human intervention?

Why do we need geospatial semantics?

- Several approaches
  - Syntactically define geospatial services
    - E.g. Web service description language (WSDL) defines the type of the input and output data
    - Does not semantically define the services
    - Services with different meanings may be falsely combined together. (temperature and wind direction)

Why do we need geospatial semantics?

- Several approaches
  - Metadata (Data's data)
    - Synonymy (Different words same meaning)
      - UC Santa Barbara and UCSB
      - Zip code and postal code
    - Polysemy (Same word has different meanings)
      - Address (location or speech?)
      - Wood (a piece of tree or an area covered with trees?)

How can we make computers understand the meaning of geospatial data and functions since it is so complicated?

Existing work on geospatial semantics

I want to find the service about **"bank"**, but which one…

Web service A
Name: Bank
Description: The number of banks in this area
Output: Integer

Web service B
Name: Riverside
Description:
The number of riversides in this area
Output: Integer

Existing work on geospatial semantics

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Existing work on geospatial semantics

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  - Writing an algorithm to make computer understand the literal meaning of the word?
    - But only given the word “bank”, even humans cannot understand its exact meaning.
  - Using more detailed metadata to describe the function of the two services?
    - But different service providers will describe the services in different ways. How can we suppose a computer to understand these various descriptions?

Existing work on geospatial semantics

- Experience of dealing with geographic information gives us the inspiration to solve this problem.

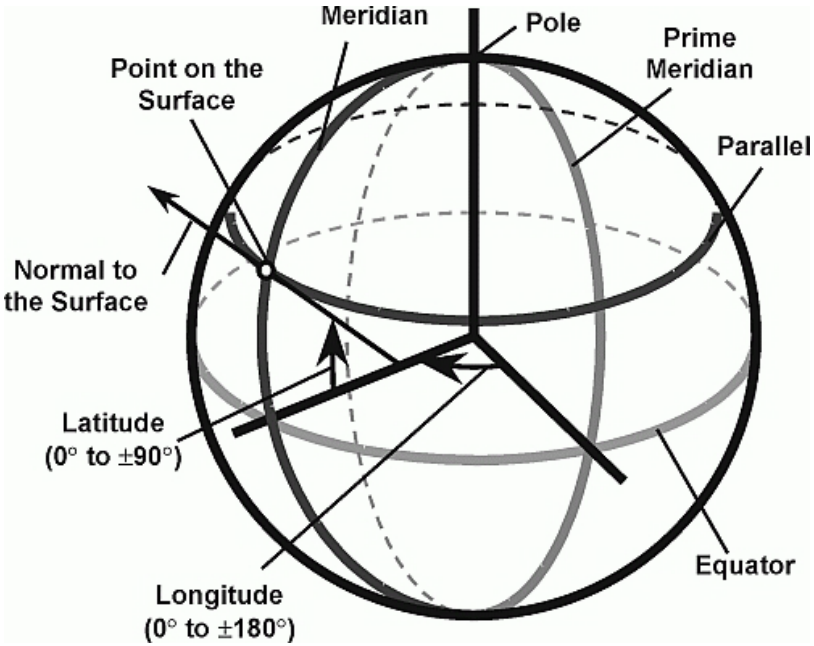
- A piece of geographic information can be decomposed as three parts: spatial, temporal and thematic data.

Existing work on geospatial semantics

- Spatial data (Where)

(X, Y) →

Spatial reference system

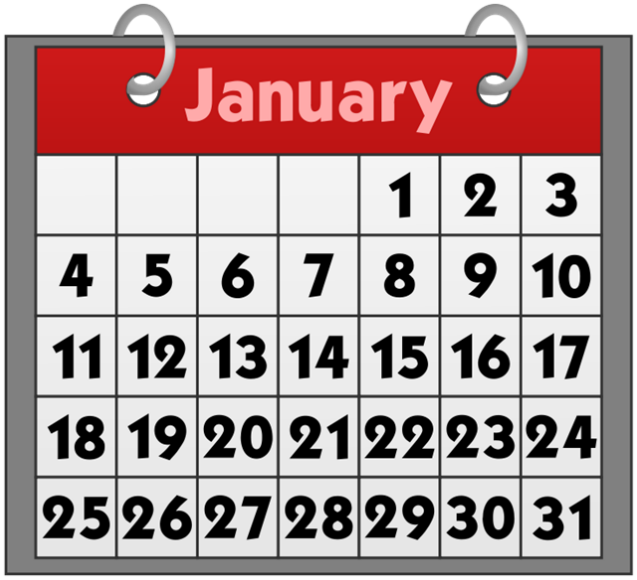


Existing work on geospatial semantics

- Temporal Data (When)

Temporal reference system (Calendar)

Jan. 12th, 2012 →

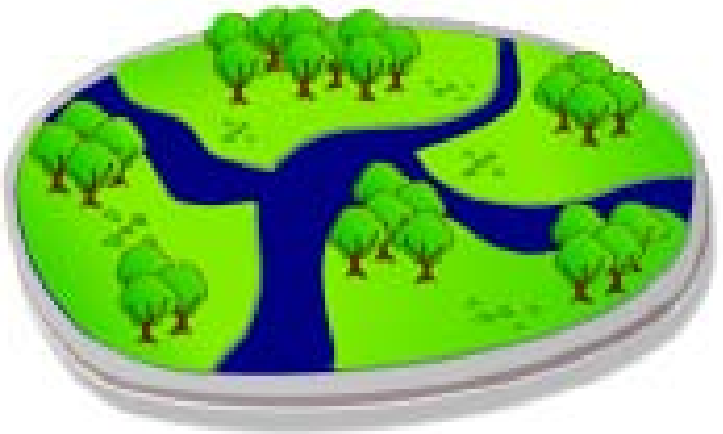


Existing work on geospatial semantics

- Thematic Data (What)

Would it be nice if we also have a semantic reference system ?

"Bank" →



Existing work on geospatial semantics

- Impossible?
  - Imagine the world before spatial reference systems and calendars, accurately expressing spatial and temporal information would be as difficult as describing thematic data.

Existing work on geospatial semantics

- How to establish semantic reference systems?

Existing work on geospatial semantics

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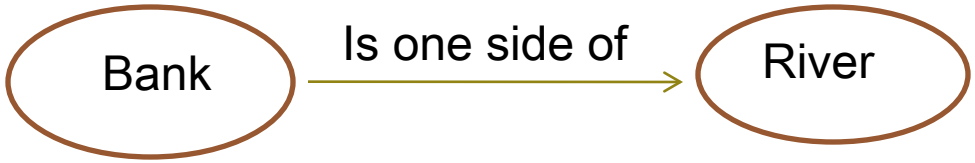
Ontologies

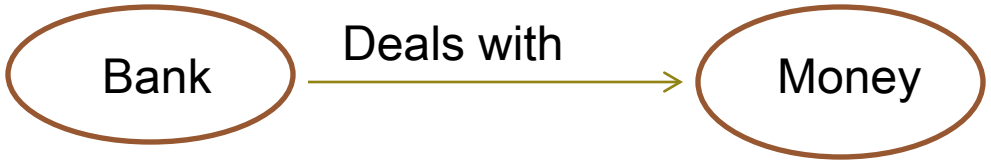
Existing work on geospatial semantics

- Ontologies
  - Originally come from philosophy.
  - Now used in computer and information science.
  - Specify the meaning of the terms used in a domain and the relations among these terms.
  - Common components in an ontology
    - **Classes**: concepts about things e.g. “car”, “table”
    - **Properties**: relations connecting classes e.g. “is a”, “has”
    - **Individuals**: specific objects e.g. “this car”, “that table”

Existing work on geospatial semantics

- In ontologies, we can have





Existing work on geospatial semantics

- Problem solved?
  - Our solution is based on the assumption that people also agree on using the classes of “river” and “money” and the properties of “is one side of” and “deals with”.

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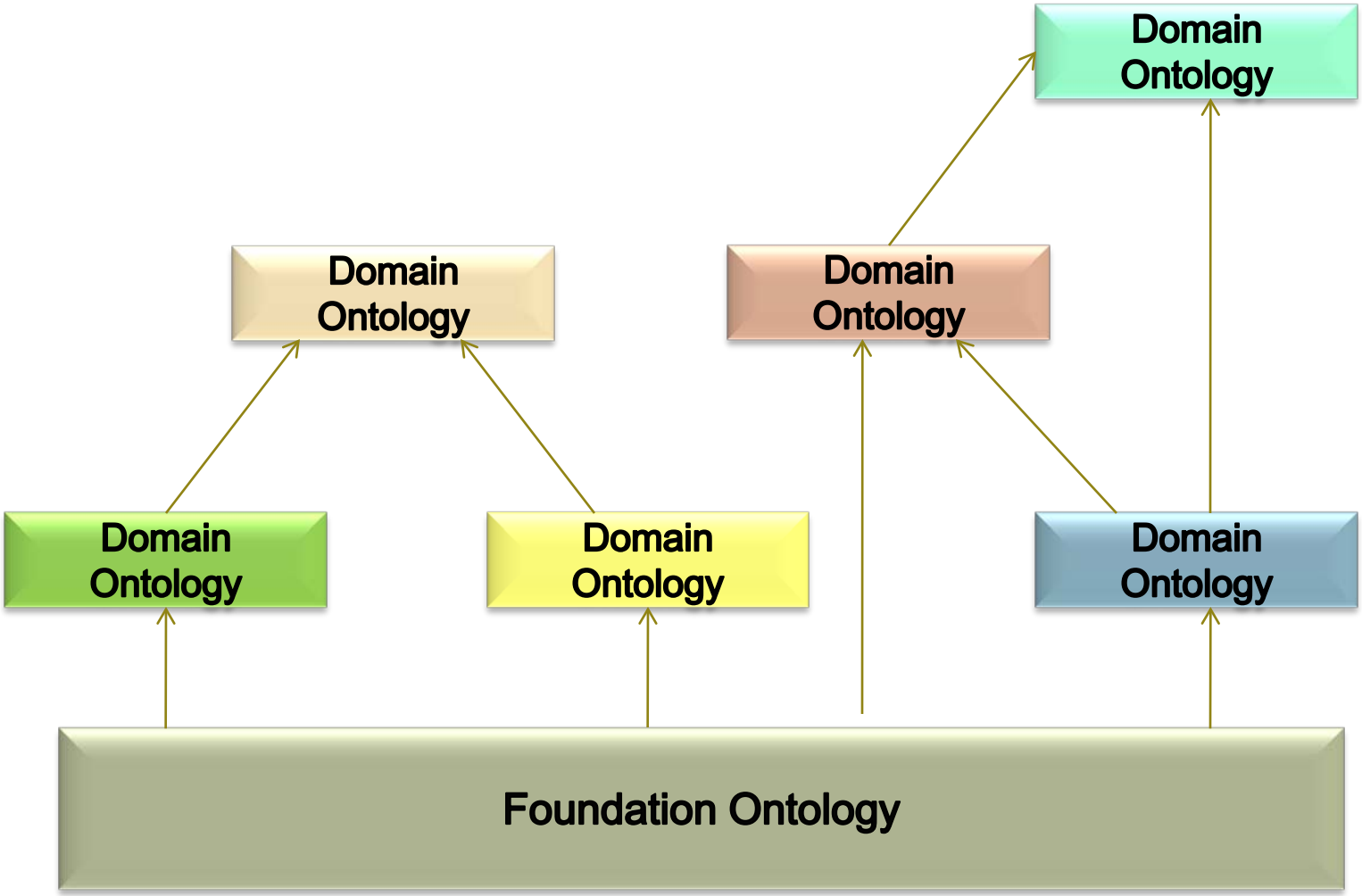
- Problem solved?
  - Our solution is based on the assumption that people also agree on using the classes of “river” and “money” and the properties of “is one side of” and “deals with”.
  - What if some people use “stream” instead of “river” in their ontologies?
  - Then do we have to create ontologies to define every word in our world? That may be even more difficult than creating a new language.

Existing work on geospatial semantics

- Foundation ontology (upper ontology)
  - An ontology which describes general terms across domains and which is agreed and shared by a large community.
  - Classes and properties are considered as primitive elements.

- Domain ontologies
  - Ontologies for a specific domain.
  - Concepts are constructed based on primitive elements.
  - Shared by people in particular fields.

Existing work on geospatial semantics



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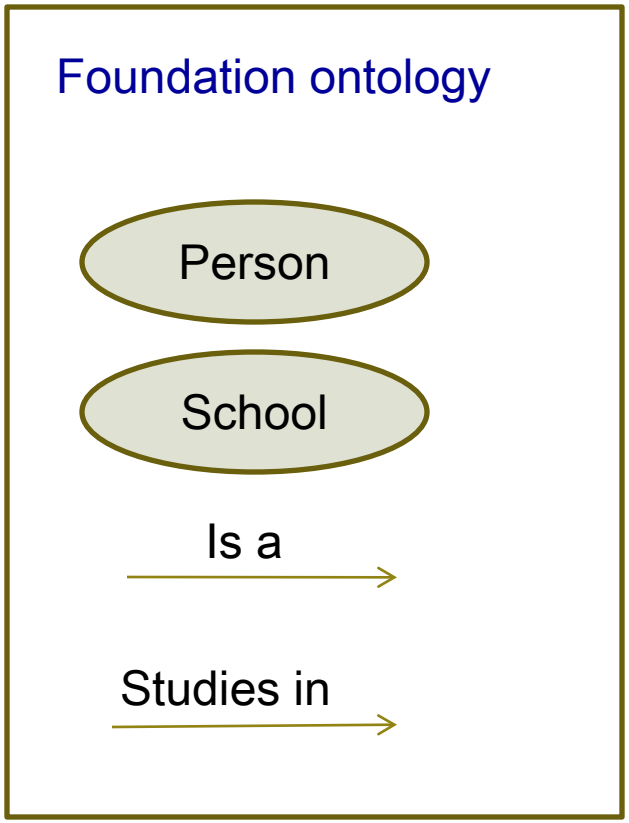

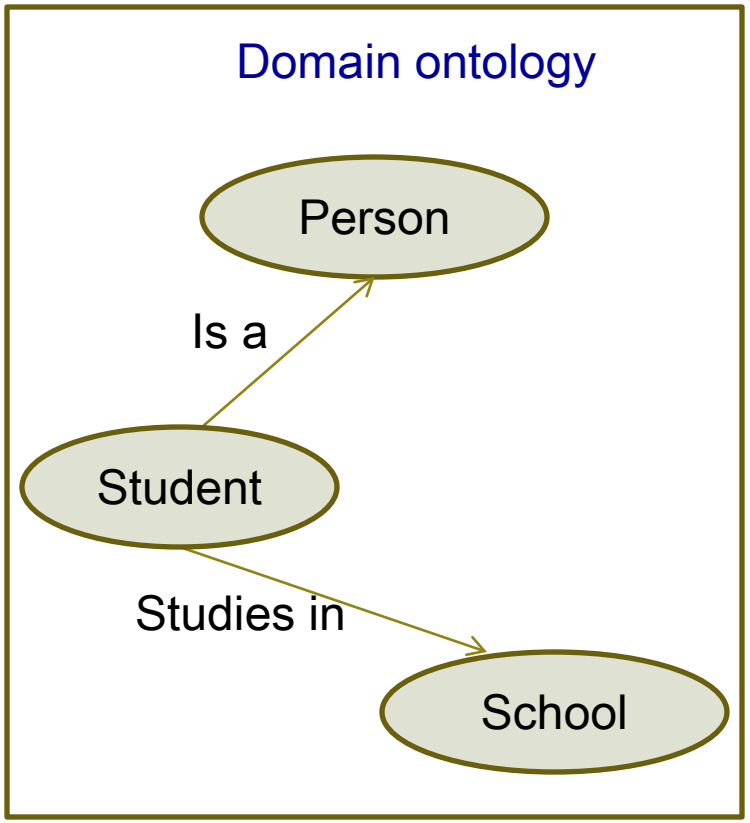

Existing work on geospatial semantics

- Different domain ontologies can be transformed to one another since they are all constructed based on the foundation ontology.
- Just like one spatial reference systems can be transformed to another based on mathematical methods.

Existing work on geospatial semantics

- Problems remain
  - Is it possible to create a foundation ontology agreed by most people?
    - The number of primitive elements is not infinite. It is estimated that there may be 2,000 to 10,000 classes and properties in the foundation ontology.
    - It does not have to be agreed by everyone in this world. Developers will use it to make profits if there is a shared agreement in a large enough community.
    - Existing foundation ontologies: Descriptive Ontology for Linguistic and Cognitive Engineering (DOLCE), Basic Formal Ontology (BFO)…

Conclusions

- Geospatial semantics means the meaning of geospatial data and functions.
- Geospatial semantics can help computers find the right data and functions without human intervention.
- Ontologies can be used to construct semantic reference systems that can clarify the meaning of data and functions.

Reference

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