Contextual Representation of Vague Spatial Features

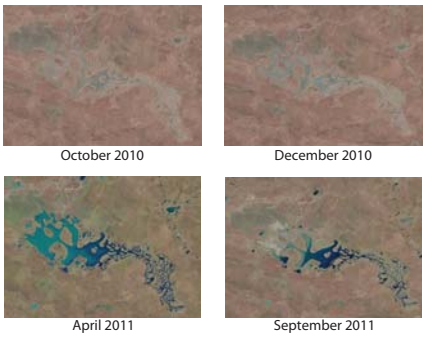
Mohammed Imaduddin Humayun, Research Initiative A: Situated Semantic Integration, University of Münster
humayun@uni-muenster.de

IRTG SIGI
Semantic Integration of Geospatial Information

Spatial Vagueness

Motivation

- Vague and uncertain features are challenging to represent in information systems.
- Different representation methods can be used to model vague entities.
  - Probabilistic, fuzzy set, egg-yolk model, rough set model, supervaluation, ...
- It is unclear which method to adopt for a given application. Choosing it randomly would be sub-optimal.

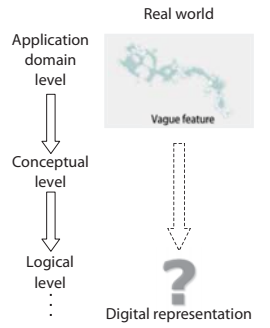


Lake Carnegie, Western Australia (Courtesy: U.S. Geological Survey)

Challenge

- Representation of vagueness is contextually dependent on the application.
- Given a task, choose a representation method which fits the purpose best.
  - Identify criteria with which to differentiate between different methods.
  - Analyze different methods with respect to these criteria.
  - Use a decision making process to select a suitable method for a given case.

Criteria for Differentiation



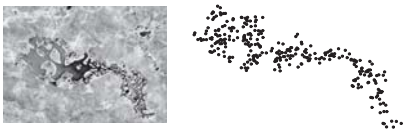
- Relevant criteria are identified at different levels of abstraction when modelling vague features in an information system.

Conceptualization of Space

- Differences in the way space is conceived depend on the adopted perspective of vagueness.

Data Model

- Determines what sources of data can be used.



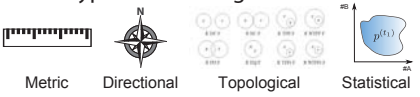
Formal model

- Influences the kinds of reasoning that can be performed. Decides compatibility with other models.

Stochastic — Fuzzy logic — Classical logic — Multi-valued logic

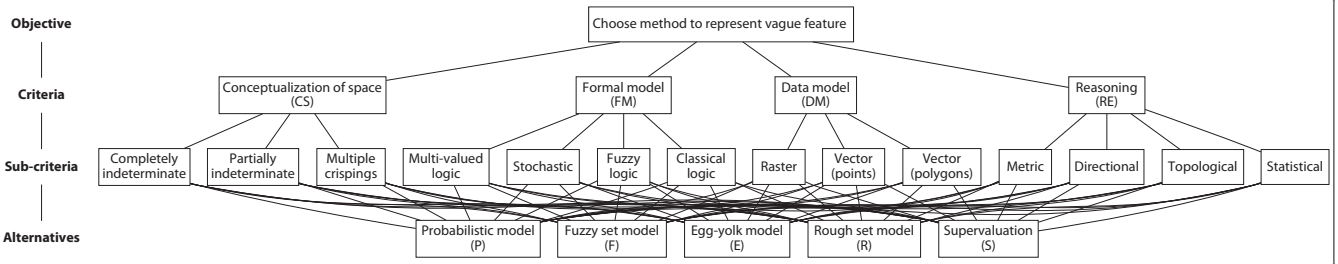
Reasoning Capability

- Some methods are more suited for a particular type of reasoning than others.



Decision Making Approach

- Analytic Hierarchy Process (AHP) is used. AHP allows users' subjective judgements to be exercised.
- The problem is organized in the form of a hierarchy with the goal at the top, alternatives at bottom, with the various criteria and sub-criteria inbetween.



- Perform pairwise comparisons between nodes at each level using a predefined scale. This is subjective to the given task.
- Compute priority of each node and use it to perform global weighting for the alternatives.
- **Sample Case:**

M - *Matrix of pairwise comparisons*
W - *Matrix of computed priorities for a node*

$$M_{\substack{Completely\\Indeterminate}} = \begin{array}{c} \\ P \\ F \\ E \\ R \\ S \end{array} \begin{array}{c} \begin{array}{ccccc} P & F & E & R & S \end{array} \\ \begin{pmatrix} 1 & 1 & 9 & 9 & 9 \\ 1 & 1 & 9 & 9 & 9 \\ 1/9 & 1/9 & 1 & 1 & 1 \\ 1/9 & 1/9 & 1 & 1 & 1 \\ 1/9 & 1/9 & 1 & 1 & 1 \end{pmatrix} \end{array}$$

Pairwise comparisons between alternatives with respect to the sub-criterion *Completely Indeterminate* using a predefined AHP scale

$$W_{\substack{Completely\\Indeterminate}} = \begin{array}{c} \\ P \\ F \\ E \\ R \\ S \end{array} \begin{array}{c} \\ \begin{pmatrix} 0.42857 \\ 0.42857 \\ 0.04762 \\ 0.04762 \\ 0.04762 \end{pmatrix} \end{array}$$

Compute priorities for the alternatives with respect to chosen sub-criterion

Repeat for all nodes. Use values from higher level nodes to weigh global priorities for lower nodes

Probabilistic	0.33 (1)
Fuzzy set model	0.25 (2)
Egg-yolk model	0.12 (3)
Rough set mode	0.13 (4)
Supervaluation	0.11 (5)

Preferred alternative has more priority and is ranked highest

Universität Bremen
Westfälische Wilhelms-Universität Münster
University at Buffalo The State University of New York
Deutsche Forschungsgemeinschaft DFG