A Multidimensional Geographic Feature System

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Introduction

Geographic phenomena and processes can be effectively represented with a three-dimensional framework of space, theme, and time in which attributes and relationships of these dimensions are structured through object-orientation. The association of attributes with individual geographic entities (features) and the relationships between and among entities may be conceptualized as shown in the following table.

Attributes and Relationships of Fundamental Geographic Dimensions

Feature	Space	Theme	Time
Attributes	ϕ,λ,Z point, line, area, volume, pixel, voxel, ...	color, size, shape, pH, ...	duration date, period, ...
Relationships	topology, Direction distance ...	topology, is_a, kind_of, part_of, ...	topology, is_a, was_a, will_be, ...

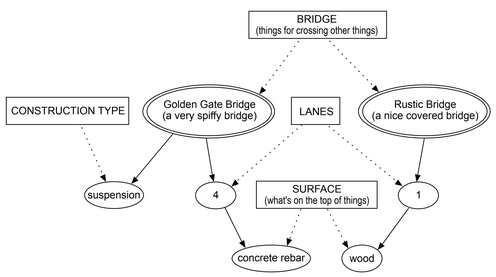
Objectives

The objectives of this research are to develop a multidimensional theory in which geographic features exist in the real world and to develop an appropriate representation of this theory that can be used to implement geographic phenomena and processes. The theory is firmly grounded in geographic and cartographic abstraction and modeling principles and in cognitive category theory. This theory and implementation are being tested in applications for watershed and water-quality management and feature extraction from multimodal sources.

Overview

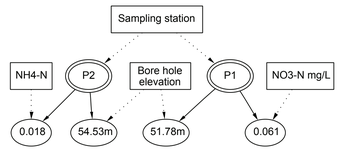
The design of the conceptual model supports attributes and relationships to include geometric representations, such as vector coordinate lists and topology, raster matrices, spectral response curves, and mathematical formulas; that can be used to depict change in geometric and thematic attributes over time. Our current implementation supports many of the capabilities described above, including vector and raster data as attributes of features and is built by extension of previous USGS efforts at feature design.

Structure of Attributes



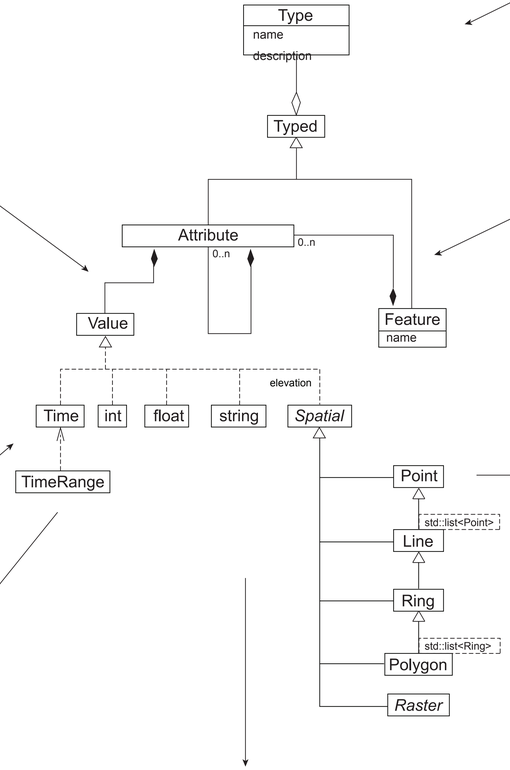
Attributes may be structured as text or numeric fields, vector or raster images, mathematical equations, or graphic representations. Multiple attributes wiuth multiple values for each attribute are supported.

Implementation of Feature Instance

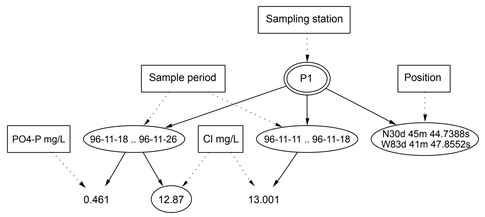


Instance data examples from the USGS National Hydrography Dataset (NHD) for the Piscola Creek Watershed structured from the SDTS vector loader into the feature llibrary.

Conceptual Model Design of the Feature Library

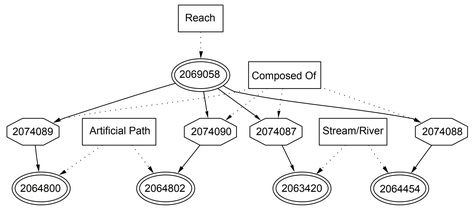


Implementation of Time Attributes



Time is supported with time stamps as attributes providing a basis for multiple representations of the same feature with different time stamps. Change over time can be modeled as difference in attributes from time stamp dates. Dynamic representation of time as a continuous equation is supported in the design and implementation is under development

Structure of Relationships

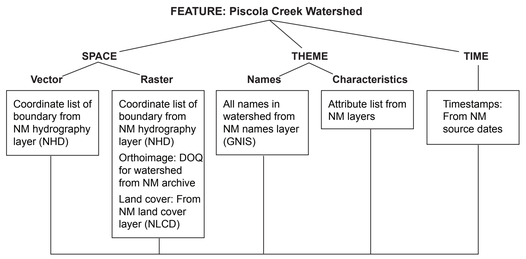


Thematic and temporal relationships are modeled as separate classes. A generic relationship class exists that allows any type of relationship to be defined and entered into the system. Relationships may be one-to-one, one-to-many, and many-to-many.

Populating the Feature Library with Instances

--Format imports
  SDTS translation interface
  Geotiff interface
--Tabular input
  CSV files
--Direct entry (under development)
  Features, attributes, relationships are built in interactive session
--Commercial software for specific applications (under development)
  Example: ERDAS Imagine for feature extraction from images

Applications of the Feature Library



The feature library will access information from *The National Map* to build the basic features and can be used for update. In initial form, *The National Map* will be layer based with nationwide mo-saics of horizontally-integrated layers including the National Elevation Dataset (NED), the National Hydrography Dataset (NHD), the National Land Cover Dataset (NLCD), the Geographic Names Information System (GNIS) and a high resolution image base in the form of digital orthophotos (DOQ). Later versions of *The National Map* will be feature-oriented similar to the

Conclusions

A theoretical model for geographic phenomena must include attributes and relationships of the three fundamental dimensions of all geographic phenomena, space, theme, and time. Such a model has been developed and an initial implementation using object orientation developed. The model and implementation show potential to serve a variety of applications with initial testing being performed in the context of applications in watershed modeling and feature extraction to support the USGS efforts to construct The National Map.

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