Vision Statement

Climate Change and Locality Knowledge

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Abstract

An orientation toward user-centered design facilitates how science data and knowledge is translated across a framework with multiple points of entry into applications to mitigate physical and social disruption from climate change. For understanding human-environmental systems, GeoAI and reasoning driven by geospatial data and visualization, critical elements of locality environments can be represented for analysis and understanding by users. Semantic technology system communities benefit from interacting with climate systems. Graph data models characterize places by including any number of attributes and properties related to entities. An example implementation and research and teaching agenda conclude the vison statement.

Introduction

Complex societal problems, such as those presented by climate change phenomena require cooperation from a range of diverse sectors, disciplines, and experts to merge ideas, approaches, and technologies. The understanding of climate change is largely driven by modeling techniques; however, the connection between a model, the parameter settings, the data used to generate it, the task it solves, and the data on which the model is tested is not captured by the model, data, or task. Furthermore, climate models are not easily reusable or explainable. This contributes to the result that large sectors of society deny the validity of those scientific findings.

An orientation toward user-centered design supports how new knowledge is translated into practical applications that are more easily grasped. Science to mitigate physical and social disruption from climate change and to build resiliency needs a cross-cutting framework with multiple points of entry for understanding complex human-environmental systems. By employing complementary technologies of GeoAI and reasoning driven by geospatial data and visualization, critical elements of locality environments are better represented for analysis and social understanding. Those representations are better recognized by expert peers and non-expert consumers.

Vision Statement

Communities around semantic technology systems express promising benefits for interacting with climate systems. Among these are graph data models to support the characterization of places through the inclusion of any number of attributes and properties centered on concepts.

Informal, or cognitively represented spatial ontology and semantics, though well researched in literature, has been limited in technical implementation leading to labor and cost intensive integration of information, systems, and users. For many users, the basic properties of latitude and longitude of geographic coordinate points are frequently the only representation of location a broad range of users can presently implement. Geographic Information Systems (GIS) automated additional analytical functions, yet semantic relationships beyond the relational table or raster models lack specification. Though these data and models may be available through spatial data infrastructures that provide public accessibility for knowledge constructions about climate at certain scales of generalization that are often too broad for easy learning by humans.

Greater semantic specifics for localities bridge broader social and user understanding and interaction through specifics yet are primarily represented linguistically in multiple texts. Semantic technology captures metadata and logical relations from texts and modeling that provide context to subjects of study in the form of graphs and networks. Specific yet complex connections can be derived through processing along graph properties. Expanding the expression of climate-related spatial representation in knowledge graphs (KG) enable human and automated semantic capture that can be extended from the same data that serve as the foundation for generating and evaluating climate models and to other related data.

Semantics and Ontology of Experiential Spaces

Key roles for geospatial geographic semantics within the broader realm of climate change will require greater sensitivity to how people act and navigate through their world. Such studies and experiences are well described in an extensive body of literature as 'Place' concepts, but Place semantics vary among user communities. As institutions structure their data design for socially determined objectives, decisions result about inclusion, exclusion, and related assumptions. Infrastructure often determines findability, accessibility, interoperability, and usability for locality semantics.

Semantic elucidation from legacy and popular database types exist as sources of fields and objects as key concepts in spatial cognition and they are modeled in GIS either as vector or raster data forms. Elucidation and application standards are the primary sources for representation.

An Implemented Example

Multiple factors are involved in environmental problems such as wildfire understanding, preparedness, and recovery. A concept such as burn severity is modeled on multiple attributes occurring at geographic scales. Spatial data science must be efficiently delivered based on real time. Cascading hazards and multiple events require integrated logical processes.

Using a user profile of a scientist, an example project involving technical environments for climate science is demonstrated by the KnowWhereGraph (KWG), created as an Open Knowledge Network supported by National Science Foundation (KWG 2024). One of the developed thematic use cases of the KWG is Wildfire Observations, which are taken from a variety of data sources: for example, the Monitoring Trends in Burn Severity and the National Interagency Fire Center vector data as ESRI Shapefiles (MTBS 2024; USGS and USDA-FS 2024; Eidenshink and Others 2007, NIFC 2024). The specific observations from these data are populated according to the Sensor, Observation, Sampling, and

Actuation (SOSA) ontology and validated using Shape Constraint Language (SHACL) (Zhu and others 2021; Haller and others 2017). These are integrated along a common spatial backbone, which takes the form of a Discreet Global Grid System called S2 as a scalable geospatial framework and the Time Ontology in Web Ontology Language (OWL) (Cox and Little 2022), and a core Process ontology, together with a common phenomenological taxonomy for integrating hazards.

To expand the knowledge graph by elucidating other sources, the original wildfire data is related to elevation data in a way appropriate with other field-type data models such as those for soils and with the broader based Department of Interior Wildland Fire Program enterprise data scheme and entities that involve programs and policies in their administration.

Schemas of datasets are often guided by user design. An unstructured concept such as Place commonly comes from curated sources such as knowledge area topics of the University Consortium GIS (UCGIS) Geospatial Body of Knowledge (2017). Natural Language Processing offers methods of formalizing linguistic sources but may be elucidated from other sources such as user participation. to understand how it impacts the people living in those areas. For example, knowledge graphs make it easy to assess the impact of a hazard such as wildfire on logistics, infrastructure, housing, and food sources, either through primary or secondary effects. The association of human contextual data, such as the top impacted demographics, can help analysts find systematic bias in response times or safe infrastructure.

A Proposed Agenda

A proposed agenda for understanding systems of climate impacts and human responses could include the following topics:

- Incorporating unstructured writing and other expressions such as art maps.
- Research or pedagogy to close the representational gap between, data captured at real-time or temporally static resolutions, verbal and graphic representations, and institutional and publicly exchanged observations to accelerate the exchange and discourse around climate science.
- Semantic elucidation creating consistency. For example, many modern models are intuitively explained via figures that describe their architectures or relating multimodal information such as images and tables from publications.
- Describing research that AI artifacts lack the necessary context for reuse.

Key roles for the geospatial sciences within the broader realm of climate science to relate institutions, environments, technology, and users include:

- Grounded theoretical basis of graph theory to enable network-type queries
- Institutional psychology about the adoption of technology in working culture and for bringing users, designers, implementers together.
- Develop deep learning techniques for entity and relation extraction, entity linking, and the construction of a knowledge graph that interconnects these aspects.
- Technology to automatically identify and catalog public highly reusable tools and climate data.

By incorporating the insights of locality semantics into a knowledge graph, researchers would provide communities with more intuitive and structured means of navigating the complex relationships among datasets, models, tools, and methods. This will not only facilitate the discovery and reuse of existing research artifacts but also foster collaboration and innovation in the field of climate knowledge among non-experts, and whose responses may even be more enthusiastic because they see themselves in the science.

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