International Cartographic Association
Association Cartographique Internationale

Making Machine Map Meaning: Notes on Cartographic 'Absence' in Semantic Context

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Keywords: Map Portrayal; Language semantics; GIS; Logic; Knowledge Graphs

Abstract:

The semantic meanings represented by a map is central to its design and use. Unlike the subject of map semiotics, that is the study of signs, semantics is the analysis of the truth conditions, coherence, correspondence, and references of representative assertions and their denotation. Cartographic theory in the twentieth century concurred that meaning is interpreted by the map user within the context of society and technology. Petchenik (1975) asserted that map design is a process to mediate varying individual viewpoints. Whether map meaning is machine transferable for mediation within multiple contexts is uncertain within network interoperability. Map users assign meaning to their perception of the map within what they know. Such knowledge formalization could advance semi-automated design, information search models, multiple user input and technical entry points, and context sensitivity through common, universal, or naturalized knowledge. Recent research explores approaches for formalizing map semantic interpretation by clarifying distinctions between cartography, linguistics, and logics for these objectives. The brief review summarized here focuses on the critical role 'absence' plays in cartographic representation for map semantic formalization.

The compositional elements cartography employs within the scope of semiotics has signs for design and perception, the representational meanings of those signs, and their interpretation. Contemporary cartography has a strong basis for combining syntax/semantic relations generalized as map syntactics. Knowledge represented by portrayal is not intrinsically included in commonly used style layer descriptor (SLD) such as those described by the Open Geospatial Consortium. Transcriptions of style sheet to applied ontology (Fellah 2016) support machine interoperability and integrate easily with graphs but remain primarily a description of the portrayal, not the decision making behind the map. Decisions that influence the meaning of a portrayal can be created, automated, and described through algorithmic workflows, for example by web mapping that employ Java, JavaScript, or python libraries, but algorithms are inflexible in an interoperable context to broaden diversity and reuse of information. A semantic transcription can be created between entity-relation models of information/data with correspondences to cartographic signs to determine the semantics of the graphical object (shape, color, etc).

. Prado et al (2000) used an interpretation function to correlate cartographic element to entity data of the geographical reality to be represented. Validation tested whether concepts that bridge feature and sign are clarified. Their results indicated that geographic information systems (GIS) mapping functions for communicating cartographic semantics is less expressive than the iconography of a maps, and though more general, support richer data semantics than a map.

Research for systematizing map semantics sometimes compares elements of linguistic and cartographic representation. How components contribute to unified representational content are fundamentally distinct with regard to predication, particularly truth conditions as functions. Attaching a marker to map coordinates acts as a predicate to asserting a truth condition (Casati and Varzi 1999). The object-location interpretation functions as the predicate of the geographical reality to the map collection of symbol-location pairs. Arguments against map predication assert that the Absence Intuition (AI) differentiate maps from language (Rescorla 2009). Semantic meaning is rooted in variable levels of related circumstances or contexts of information. Predicating a property can imply logical exclusivity, that other objects lack the property.

The example below demonstrates the semantic meaning when linguistic predicates in the form of verbs, prepositions, or verb-preposition pairs are absent for the statement 'You're dwelling on the cliff instead of the dwelling on the cliff.'

- Absent Verb (V): You on the cliff instead of the dwelling on the cliff
- Absent Preposition (P): You're dwelling the cliff instead of the dwelling the cliff
- Absent V/P pair: You the cliff instead of the dwelling the cliff.

Abstracts of the International Cartographic Association, 6, 261, 2023.
31st International Cartographic Conference (ICC 2023), 13–18 August 2023, Cape Town, South Africa.
https://doi.org/10.5194/ica-abs-6-261-2023 |

Data absence does not degrade map syntactics as it generally does within language. Absence of map markers makes predication more ambiguous than it would linguistically. Ambiguity inherent in some maps requires that the role played by syntactical organization of an account of truth-conditions as a trade-off between variability and underlying meaning. Concepts such as figure-ground, generalization, or geographic scale, for which absence is required, implies locational association that is either 'false' or missing. Ordinary predication, as in basic linguistic composition, lacks the absence intuition found in cartography. This challenges the truth conditions assumption of semantic theory and poses an obstacle to map analysis through predication.

How does absence address missing information detail so that word and image schemas inter-relate and reasoning processes are possible on symbol instantiation? Formalizing structured map semantics for a cartographic model context is researched through Knowledge Graphs for the representation of relational context. Formalizing data within graphs broadens machine readability to make cartographic models and flows more flexible and to support map meaning. AI encoding information by default assumption compares in applied ontology to the Open World Assumption (OWA) that allows the existence of an entity even if it is not asserted. Ontology can be open or closed to the OWA for exclusivity through First Order Logic (FOL). Li and Jingkuan (2010) employed description logics (DL), a type of FOL to build a cartographic semantic model. Ontology patterns have disambiguated cartographic semantic assertions such as geographic scale variability with DL through Web Ontology Language (Carral and others 2013).

A geovisualization knowledge base by Huang and Harrie (2020) coupled ontology and semantic rules for visualization. Knowledge about how data are designed or visualized is formalized as a Context Ontology (CO) with rules for scale, portrayal, and source core knowledge. The CO is stored in named graphs and applied in a linked data environment. The cartographic scale vocabulary for multiple representations is modelled and linked using Simple Knowledge Organizing System (SKOS) at the geometry set level. Multiple geometry sets are grouped by level of detail. SPARQL Inferencing Notation (SPIN) rules are created for geospatial feature portrayal using compositional elements such as Style, Symbol, Symbology, Legend, and Graphic modules. Style applications employ different rules for symbolization under different conditions. Triplestore code rules includes the 'no data 'situation and were tested within a reasoning engine. Semantically rich application results were validated by faster 'joins 'and 'relates 'so competency questions led more directly to context information. Semantic enrichment for visualization supported narrative cartography ontology using KGs from within GIS (Mai and others 2022) that combine map content and cartography modules. A SPARQL rule base formed the core of a portrayal ontology through which a particular symbolizer enables a broader range of semantic enrichment and enables inference over features through the interface of feature instances to symbol symbolizer.

Although the production of maps is generally aimed at collective map-reading operations (prescriptive semantics), they are mostly read by individuals (pragmatic semantics). Users interpret a type of sign language implied from their context using content analysis and in turn, create representations on the basis of those semantics. The role visual portrayal plays for map users making sense of data is helped by knowing the means by which design decisions created the visualization and involved interactivity and context. The semantic absence of the cartographic process challenges cartographers to re-examine cartographic training to systematize map semantics leveraging technological forms in which cartography design rules may be without many precedents and must be devised through research.

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