Knowledge Organization Systems for Semantic Models

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• Models Rather than Ontologies
  • Indexing articles from historical newspapers
  • Traditional full-text indexing ineffective
  • Better to develop a community model
Direct Representation of Scientific Research Reports

• Models rather than Ontologies
  • Models are integral to research reports
  • Snowball Earth theory
    • Geological claim that the earth may have frozen over completely – an extreme ice age
    • Main question – how the earth escaped that extreme ice age

• In this talk, we will consider some issues for how to build these models
  • Specifically, the relationship of knowledge representation systems to object-oriented programming languages
  • These models have complex objects and systems (parts, states, mechanisms), microworlds, and context
From Upper Ontologies to Object-Oriented Models

• Upper Ontology (Basic Formal Ontology - BFO)
  • Establishes categories of entities allowed in application ontologies
  • Realist, Aristotelian, Universals/Particulars
  • Main distinctions:
    • Continuants/Occurrents
    • Independent Continuants/Dependent Continuants

• Programming Languages
  • Basic Features:
    • Data Types, State Machines, Guard Conditions, Threads, Concurrency, Conditionals

• Object-oriented Analysis, Models, and Programs
  • Smalltalk is a better example of object-oriented programming than Java.
  • Language Features: Inheritance, Classes and Methods
  • Typical Applications: Microworlds
Representation of Semantics of Complex Objects (#1)

• Transitionals (implement state changes)
  • BFO focuses on Processes, but state changes seem equally important
  • Conditions on whether a transition will occur
  • Sequences of Transitionals are common
    • Mechanisms, Workflows, Other sequences
  • Natural language verbs have semantic roles, which should be applied in semantic modeling.

• Relationships
  • BFO Core relationships (“inheres in”).
    • Increasingly, BFO applications include ad hoc relationships.
  • Many ad hoc relationships are actually events
    • If there is a person, there is necessarily a birth event
  • Rules/Axioms
    • Rules are like ad hoc relationships about the world we are trying to model.
    • Example: “Predators eat Prey”

• Definitions
  • Describe what implied about the relationship of the given object to other objects
    • A waterfall must have water and a stream with a drop.
    • A bakery must have a baker, an oven, and baked goods, and be a commercial establishment.
  • For modeling, we need a structure to describe these connections.
Representation of Semantics of Complex Objects (#2)


• *Component/Integral object (handle/cup, punchline/joke)*
  • Parts associated with activities
  • Distinct functional units or structural parts.

• *Feature/Activity (paying/shopping)*
  • Subprocess/Process.
  • Segments of an activity may be modeled with states and threads.

• *Portion/Mass (slice/pie, grain/salt)*
  • If a portion is distinct, it may be a fiat-object part

• *Place/Area (Everglades/Florida, oasis/desert)*
  • Nested spatial regions or nested sites

• *Member/Collection: (tree/forest, card/deck)*
  • Object aggregates, such as “a heap of stones” and “a symphony orchestra”

• *Stuff/Object: (gin/martini, steel/bike)*
  • A material and an object made from it.
Representation of Semantics of Complex Objects (#3)

• States and Stages
  • Simple states attach dependent continuants
  • Complex states are more difficult. Is ice a different entity that liquid water?
    • Representation issues
    • Perhaps it is the state of an aggregate of water molecules, but the details are not clear.

• Configurations of Components and Scenarios
  • A person and the shirt they are wearing
  • Meta-operators, Yoked material entities

Representation of Semantics of Complex Objects (#4)

• Functions
  • In BFO, Functions are Realizable Dispositions
    • For example: “the function of amylase is to break down starch into sugar”
    • Depends on context

• Systems
  • A foundation of programming languages
  • Composed of interacting mechanisms
  • Many complex objects can be considered as systems

• Microworld
  • Environment for interacting objects
    • Can include gravity, temperature, pressure, etc
  • Focus on specific issues by nesting microworlds
  • Could be conceptualized as a type of system

Example: Semantic Model of Cardio-Pulmonary System
Constructed purely from local interaction (message passing) between material entities.
Evidence and Discourse

• Evidence
  • Snowball Earth model is based on a lot of details geological evidence.
  • Evidence has its own model that needs to be related to the broader model.

• Collecting evidence
  • Workflows for the collection of evidence
  • Measurement procedures

• Style of presentation in a research report
  • One approach: Tracking the emergence and synergies of the model and the evidence
  • A second approach: Direct Model descriptions
    • Follow the mechanisms of the model.
  • Ideally, one framework could support both approaches.
Conclusion

• We describe a modeling framework that is centered on complex objects.
• We have discussed solutions to several modeling puzzles.
• Future work can include more advanced Object-oriented modeling techniques such as:
  • Actors model (can include timing of interactions)
  • Object-oriented system dynamics
• Overall, modeling is a useful perspective.