

Ontology Summit 2021

Ontology Generation and Harmonization

Third Synthesis Session

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Narrative: Second Draft

- Ontologies are proliferating, producing a **landscape** of many types for many purposes.
- The roles that ontologies play is also a landscape, such as
 - **Generated** by machine learning tools
 - Used by machine learning to **improve** the quality of the results
 - **Integrated** into deep learning architectures.
- The variety has made it difficult to communicate about them and between them. There is a need for **harmonization** and better **definitions**.
- It isn't enough to construct ontologies, they must be **sustained**.

Rule of Least Power

- Principle: Powerful languages inhibit information reuse.
- Good Practice: Use the least powerful language suitable for expressing information, constraints or programs on the World Wide Web. (Berners-Lee, Mendelsohn)
 - There is a tradeoff in choosing between languages that can solve a broad range of problems and languages in which programs and data are easily analyzed.
 - Computer Science in the 1960s through 1980s spent a lot of effort making languages that were as powerful as possible.
 - Nowadays we have to appreciate the reasons for picking not the most powerful solution but the least powerful. Expressing constraints, relationships and processing instructions in less powerful languages increases the flexibility with which information can be reused: the less powerful the language, the more you can do with the data stored in that language.

Rule of Least Power for Ontologies

- Ontologies are languages
 - There is a tradeoff between power and flexibility.
 - Axioms designed for a narrowly defined domain improve inferences within the domain but can inhibit broader reuse.
- Best Practice for the Rule of Least Power for Ontologies
 - Not fully understood or articulated
 - Difficult to apply proactively

The Ontological Landscape

- Ontologies are for communication of many kinds (Schneider)
- The interface between the business language and the technical language is fundamental to ontology development (Bennett, Woods)
- Dialogue is an essential requirement for communication (Sowa)
- There are 4 main 'types' of ontologies (Schneider)
- However, the landscape has many dimensions and aspects (Schneider, Bennett)
- **New landscapes: Definitions, Probabilistic Ontologies, Sustainability**

Ontological Landscape Dimensions

- Truth makers and data surrogates (Bennett)
- Another dimension: from Ontology to ontology (pluralistic attitude toward "reality") (Masolo)
- Yet another dimension: From Logic to logic (different forms of reasoning) (Masolo)
- Manage ontologies by modularization (Masolo)
- What is "ontological commitment"?

Definitions

- Notion of a definition (Berg-Cross, Seppälä)
- Writing a good definition requires training and experience (Berg-Cross, Seppälä)
- Even for well understood domains, the results of manual classification tasks are highly inconsistent (Westerinen)
- Examples from the earth sciences (Buttigieg)

Definitions

- Creating definitions is a collaborative effort within and between communities (Blumberg)
- Events and narratives can be an effective means for communication (Westerinen)
- The interface between the business (natural) language and the technical language (FOL) helps human-machine communication (Woods)

Definitions

- Terms may be standardized but the meaning has to be too. (Berg-Cross)
- Definitions will vary according to context of use and target audience. (Berg-Cross)
- There is a spectrum of kinds of definition ranging from pure logic semantics to the shimmering semantics of human language (Baclawski, Seppälä)
- Definitions occur in a network and must be harmonized within the network and between networks. (Berg-Cross)
- Seppälä, Ruttenberg, and Smith. "Guidelines for writing definitions in ontologies". <https://philpapers.org/archive/SEPGFW.pdf>

Neuro-Symbolic Learning Ontologies

- There are significant benefits for tighter integration of neural and symbolic paradigms, but how can it be done?
- There are different roles that the neuro and symbolic models could perform in a system: A landscape is emerging. (Kautz)
 - Generation of ontologies by machine learning techniques (Sriram)
 - Using ontologies to develop better neural network models (Sriram)
 - Symbiosis of neural networks and ontologies (Sriram)

Neuro-Symbolic Symbiosis

- Various connectionist modal/temporal models (Lamb)
- RDFS reasoning using memory networks (Hitzler)
- Generative RDFS reasoning using pointer networks (Hitzler)
- Completion reasoning emulation for the description logic EL+ (Hitzler)
- Logic Tensor Networks for first-order predicate logic (Hitzler)

Neuro-Symbolic Symbiosis

- Ontology from graph signal processing (Majumdar)
- Cognitive Memory (Sowa)
- Modularity is suitable to knowledge extraction, which can result in the development of effective knowledge extraction methods towards explainable AI. (Lamb)

Neuro-Symbolic Symbiosis

- Human understanding is probabilistic. To reflect our best understanding of the world, ontologies must be, too. (Breiner)
 - Landscape of probabilistic ontologies
 - Need a meta-theory for probabilistic ontology that is compositional and probability-native.

Neuro-Symbolic Symbiosis

- Intuition behind why deep learning needs knowledge (Sheth):
Intelligence = Learning from Data + Knowledge/Experience + Reasoning
- Knowledge-Infused Learning (Sheth)
 - Ranges from shallow to deep infusion
 - Potential impacts on robotics, cognitive science, autonomous vehicles, and personal assistants
- Logical Neural Networks for Rule Learning (Kapanipathi)
- Logic Embeddings approach that can answer logical queries over incomplete knowledge bases (Kapanipathi)

Sustainability

- The three pillars:
 - Economic Viability (Support)
 - Social Equity (Unbiased Approach)
 - Environmental Protection (Maintainability)
- Documentation and harmonization assist both Social Equity and Maintainability (Dickerson)
- Data Has Inherent Bias that Deep Learning won't find on its own. (Sheth)
 - Knowledge-Infused Learning can help to discover and mitigate bias.

Sustainability

- Putting things into production is a whole new world (Uschold)
 - Reuse
 - Consistency
 - Checking
 - Automation

Communiqué

- Summarize invited talks and discussions
- Describe some lessons learned
- Endorse guidelines
- Identify challenges and opportunities
- Collect references