GSAW 2020 Tutorial I:

Ontologies for Space and Ground Systems

Length: Half day

Overview:

Background

When the term 'ontology' was first used in AI research in the 1970s, an ontology was conceived as the formal codification of some body of knowledge. To make such knowledge shareable and analyzable in different systems, the idea of knowledge interchange formats arose. By the early 2000s the latter had evolved to become what we now know as the Ontology Web Language (OWL). Since then, OWL has been used in the development of many kinds of ontologies, typically to promote the sharing and analysis of specific, locally important bodies of data. Unfortunately, such ontologies almost always lose their usefulness with the addition of new sorts of data. Over time, therefore, ontology development efforts came to be dismissed in many circles because they were seen as being too fragile to be of long-term usefulness.

In the wake of the Human Genome Project, however, there arose independently a new way of viewing ontologies. As massive quantities of -omics data came onstream, ways had to be found to make these data useful to clinical diagnosis. The needed connection was established by creating controlled structured vocabularies – called 'ontologies' – for different parts of traditional biology and medicine. Importantly, these were viewed from the beginning as part of a single suite of interoperable ontology modules, and were designed to be useful even as data, and software, and hardware, and scientific and clinical knowledge change.

Scope and structure of this tutorial

These ontologies were exploited in a massive exercise of data and literature tagging, so that hitherto divergent bodies of data and information became discoverable, integratable, and analyzable using a single common modular framework of ontology terms. This tutorial will describe on-going initiatives to extend this modular approach into other domains, focusing specifically on space and ground systems. It will survey existing ontologies of relevance, show how ontologies in these domains are created and used, and describe how individuals and groups can join these efforts.

Basic Formal Ontology: The organizational hub in each case is Basic Formal Ontology (BFO), which was approved as ISO standard (ISO/IEC 21838-2) in October 2019. BFO provides the general architecture shared by domain ontologies on lower tiers, and we will describe how BFO works and how BFO serves as starting point for building domain ontologies on lower levels.

Three types of domain ontologies: When data analysts work for example with source data deriving from some satellite feed, then they are interested primarily on what these data describe, for example forest fires or shipping movements. The analyst's work requires also, however, a secondary focus, targeted to the data and information artifacts themselves – including images, reports, emails – through which such information is conveyed. These artifacts have attributes – including format, purpose, evidence, provenance, reliability, and so forth – data about which are vital to the effective exploitation of the object-level data by humans and machines. This implies that we need domain ontologies relating not only to (1) real-world objects and processes, (2) information entities such as data and images, but also to (3) the processes performed by data analysts and by the software and hardware they use.

Ontologies relevant to space and ground system domains: We will survey the Common Core Ontologies (CCO) developed under the IARPA KDD initiative, and the Space Domain Ontologies, a suite of space situational awareness ontologies which extends the CCO. Specifically we will examine the following ontology modules:

Agent Ontology (person and organization profiles, including identifiers, roles, employment history, skills, capabilities)

Sensor Ontology (types of sensors, primary systems, principal components, functions and capabilities, sensor processes)

Cyber Ontology (types of hardware and software and processes including cyber attacks)

Cognitive Process Ontology (CPO)
Space Domain Ontologies (SDO)
Spacecraft Mission Ontology Spacecraft Ontology
Space Event Ontology Space Object Ontology

Background Reading: R. Arp, et al., Building Ontologies with Basic Formal Ontology, MIT Press, 2015

Instructor: Barry Smith, National Center for Ontological Research

Biography:
Barry Smith is one of the world's foremost authorities in the field of ontology. He is Director of the National Center for Ontological Research (NCOR) and Distinguished Professor of Philosophy, Biomedical Informatics, Computer Science and Engineering, and Neurology at SUNY Buffalo. Smith is lead developer of Basic Formal Ontology (BFO), which was launched in 2004. Initially it was designed to serve as organizing hub in a suite of biomedical ontologies created in the wake of the Human Genome Project to bridge the divide between genomic and clinical data. The result is the most widely used resource in the entire ontology field. Since 2004, BFO has been used as backplane for an open systems modular approach to ontologies applied in over 300 domain ontology initiatives, including on-going efforts to create suites of interoperable ontologies for use in digital manufacturing, in intelligence analysis, and in model-based systems engineering.

Description of Intended Students and Prerequisites:
Intended audience is all persons who have faced problems in discovering, integrating, analyzing, or reasoning with data deriving from heterogeneous sources. No prior knowledge of ontology is presupposed. Some familiarity with managing data presupposed.

What can Attendees Expect to Learn:
Attendees will learn what an ontology is, why ontology efforts in the past have so often failed, where high quality sustainable ontologies are to be found, how sustainable ontologies are being built in the intelligence domain, including ontologies of space and ground systems, and how such ontologies are being used. Attendees will also learn about current efforts to create modular ontologies in the space and ground systems domains, and how to engage with such efforts.