

MIE 1510
FORMAL TECHNIQUES IN ONTOLOGY ENGINEERING
2025

Instructor: Dr. M. Gruninger, BA8122, 416-946-8853, gruninger@mie.utoronto.ca

Times: Tuesdays, 1400 - 1600.

Location:

Prerequisite: MIE 1501, MIE 457, background in logic, or permission of the instructor

Course Description: This course will explore theoretical techniques for the design and analysis of formal ontologies. Topics for 2024 will focus on the representation of the physical world – objects, qualities, states, process, space, and time. These ideas will be applied to the specification of benchmarking problems to evaluate the application of ontologies for question answering.

Grading:

- Assignments: 60%
- Ontology Project: 40%
 - The project may consist of
 - the design and evaluation of a new ontology in some domain;
 - analysis of existing ontologies;
 - case study of an application of ontologies.

COURSE OUTLINE

Introduction and Review. (7 January)

What are ontologies and how are they used?

Readings:

- Uschold, M. and Gruninger, M.(1996), Ontologies: Principles, Methods, and Applications, *Knowledge Engineering Review*, 1:96-137.
- Ontology Summit 2011 Communique (Making the Case for Ontology)
http://ontolog.cim3.net/cgi-bin/wiki.pl?OntologySummit2011_Communique
- OntologySummit2011: Application and Use Cases synthesis
http://ontolog.cim3.net/cgi-bin/wiki.pl?OntologySummit2011_ApplicationCases_Synthesis
- OntologySummit2011 ApplicationFramework Synthesis
http://ontolog.cim3.net/cgi-bin/wiki.pl?OntologySummit2011_ApplicationFramework_Synthesis
- Ontology Summit 2008 Communique (Towards an Open Ontology Repository)
http://ontolog.cim3.net/cgi-bin/wiki.pl?OntologySummit2008_Communique

Space. (14 / 21 January)

Research Question: *What is the correct axiomatization of spatial prepositions (i.e. spatial relations in natural language)?*

Assignment:

Axiomatize the intended semantics of your assigned spatial preposition.

Readings:

- Aameri, B.; and Gruninger, M (2020) Location ontologies based on mereotopological pluralism. *Applied Ontology* 15(2): 135-184.
- Gruninger, M.; and Aameri, B. (2017) A New Perspective on the Mereotopology of RCC8. In Clementini, E.; Donnelly, M.; Yuan, M.; Kray, C.; Fogliaroni, P.; and Ballatore, A., editor(s), 13th International Conference on Spatial Information Theory, COSIT 2017, September 4-8, 2017, L'Aquila, Italy, volume 86, of LIPIcs, pages 2:1-2:13, 2017.
- Bateman, J. and Hois, J. and Ross, R. and Tenbrink, T. (2010) A Linguistic Ontology of Space for Natural Language. *Artificial Intelligence* 174:1027-1071
- Davis, E. (2013) Qualitative Spatial Reasoning in Interpreting Text and Narrative. *Spatial Cognition and Computation* 13:264-294.
- Bateman, J. (2013) Space, Language, and Ontology: A Response to Davis. *Spatial Cognition and Computation* 13:295-314.
- Davis, E. (2013) Space, Language, and Ontology: A Response to Bateman. *Spatial Cognition and Computation* 13: 315-318.
- Talmy, Leonard (1983) How Language Structures Space. In *Spatial Orientation: Theory, Research, and Application*, Pick, Herbert L. and Acredolo, Linda P. (eds).

State. (28 January / 4 February)

Research Question: *How do we represent changeability, that is, relationships in the world that can possibly change?*

Assignment:

- (1) Specify the domain state ontology for the axiomatization of your spatial relation (from the previous session).
- (2) Identify a relationship that can possibly change among physical objects in the world. Specify the domain ontology and the domain state ontology for this relationship.

Readings:

- Aameri, B. (2012). Using partial automorphisms to design process ontologies. In *Formal Ontology in Information Systems* (pp. 309-322). IOS Press.
- Shoham, Y. (1988) Reasoning about change : time and causation from the standpoint of artificial intelligence. MIT Press.
- Allen, J. F. (1984). Towards a general theory of action and time. *Artificial intelligence*, 23(2), 123-154

Process Ontologies. (11 / 25 February)

Research Questions: *What are the fundamental ontological commitments for processes? What are the distinctions among process, event, action?*

Assignment:

Axiomatize the intended semantics of the processes corresponding to your assigned verb.

Readings:

- Bohnemeyer, J., Pederson, E. (2011) *Event Representation in Language and Cognition*. Cambridge University Press.
- Gruninger, M. Using the PSL Ontology. In Staab, S.; and Studer, R., editor(s), *Handbook on Ontologies*, of *International Handbooks on Information Systems*, pages 423-443. Springer, 2009
- Hacker, P.M.S. (1982) Events, Ontology and Grammar. *Philosophy* 57:477-486.
- Jarrar, M., Ceusters W. (2017) Classifying Processes and Basic Formal Ontology 8th International Conference on Biomedical Ontology (ICBO 2017).
- Kalita, J. (2016) Detecting and Extracting Events from Text Documents
- Zacks, J. and Tversky, B. (2001) Event Structure in Perception and Conception. *Psychological Bulletin* 127:3-21.

Time. (4 / 18 March)

Research Question: *What is the correct axiomatization of temporal prepositions and adverbs (i.e. temporal relations among entities in natural language)?*

Assignment:

Axiomatize the intended semantics of your assigned temporal preposition or adverb.

Readings:

- Derczynski, L. (2013) Determining the Types of Temporal Relations in Discourse
- Leeuwenberg, A. and Moens, M.-F. (2019) A Survey on Temporal Reasoning for Temporal Information Extraction from Text. *Journal of Artificial Intelligence Research* 66:341-380.
- Pustejovsky, J. et al (2021) TimeML Annotation Guidelines
- Marc Verhagen, Robert Gaizauskas, Frank Schilder, Mark Hepple, Jessica Moszkowicz, James Pustejovsky (2009) The TempEval challenge: identifying temporal relations in text. *Language Resources Evaluation* 43:161-179.

Quantities and Qualities. (19 / 25 March)

Research Question: *Are concepts such as mass, length, and shape represented as qualities?*

Assignment:

Specify the mappings between the FOUnit and QUDT ontologies.

Readings:

- Aameri, B., Chui, C., Grüninger, M., Hahmann, T., and Ru, Y. (2020). The FOUnit ontologies for quantities, units, and the physical world. *Applied Ontology*, 15(3), 313-359.
- Rijgersberg, H., Van Assem, M., and Top, J. (2013). Ontology of units of measure and related concepts. *Semantic Web*, 4(1), 3-13

Ontologies and Commonsense Reasoning. (1 / 8 April)

Research Question: *What ontologies are needed to represent commonsense reasoning benchmarks?*

Assignment:

Propose your own benchmarking problem and use it to evaluate the ontologies that we have considered throughout the course.

Readings:

- Davis, E. (1998) The Naive Physics Perplex. *AI Magazine* 19:51-79.
- Davis, E. (2015) How to Write Science Questions that are Easy for People and Hard for Computers
- Maria M. Hedblom, Oliver Kutz, Rafael Penaloza, and Giancarlo Guizzardi (2018) What's Cracking? How image schema combinations can model conceptualisations of events. *TriCoLore* 2018.
- Morgenstern, L.(2001) Mid-Sized Axiomatizations of Commonsense Problems: A Case Study in Egg-Cracking. *Studia Logica* 67:333-384