جامعة الملك عبدالله
للعلوم والتقنية
King Abdullah University of
Science and Technology

Course Syllabus: Applied Ontology - CS 322

Division	Computer, Electrical and Mathematical Sciences & Engineering
Course Number	CS 322
Course Title	Applied Ontology
Academic Semester	Fall
Academic Year	2019/2020
Semester Start Date	08/25/2019
Semester End Date	12/10/2019
Class Schedule (Days & Time)	09:00 AM - 10:30 AM | Sun Wed

Instructor(s)

Name	Email	Phone	Office Location	Office Hours
Robert Hoehndorf	robert.hoehndorf@kaust.edu.sa	+966128081643	4222, 3, Ibn Sina (bldg. 3)	On request.

Teaching Assistant(s)

Name	Email

Course Information

Comprehensive Course Description	The course covers advanced topics in conceptual modelling, data management, integration and analysis, all of which have applications in data-intensive disciplines such as biology, biomedicine and others. The aims of the course is to provide an in-depth understanding of the state of the art in formal ontologies, including their role in integrating and analyzing data. While Knowledge Representation and Reasoning (CS213) introduced basic logic formalisms that can be used to express knowledge, the Applied Ontology course focuses on how to structure the content of a knowledge base and how to combine symbolic logic with machine learning and optimization methods. We will explore the theories for mereological (parthood) relations and theories of space and time, as well as recent developments in using symbolic logic and automated reasoning to exploit background knowledge in data analysis.
Course Description from Program Guide	The course covers advanced topics in conceptual modelling, data management, integration and analysis, all of which have applications in data-intensive disciplines such as biology, biomedicine and others. The aims of the course is to provide an in-depth understanding of the state of the art in formal ontologies, including their role in integrating and analyzing data. While Knowledge Representation and Reasoning (CS213) introduced basic logic formalisms that can be used to express knowledge. Examples include the theories for mereological (parthood) relations, or theories of space and time and the consequences of selecting a particular theory in formalized knowledge bases. The Course is split in two parts, the first focusing on concrete applications with examples taken from the biomedical domain, the second focusing on the theoretical framework underlying formal ontologies and their role in information systems.
Goals and Objectives	The aims of the course is to provide an in-depth understanding of the state of the art in formal ontologies, including their role in integrating and analyzing data. At the end of the course, students will be able to apply methods of ontological analysis and modelling to generate formal knowledge bases and use ontology-base approaches such as semantic similarity measures and neuro-symbolicmethods to analyze data.
Required Knowledge	The course relies on knowledge of first order logic, including basic model theory and deductive inference (completeness theorem). The course project requires basic knowledge in data analytics. Prerequisite courses: Knowledge representation and Reasoning (CS213) or Introduction to AI, Data Analytics

Reference Texts	Knowledge Representation: Logical, Philosophical, and Computational Foundations. John Sowa, Brooks Cole Publishing Co, 1995. Formal Ontology and Information Systems. Nicola Guarino, Proceedings of Formal Ontology and Information Systems, IOS Press, 1998. A Catalog of Temporal Theories. Pat Hayes, Beckman Institute and Departments of Philosophy and Computer Science, 1996. General Formal Ontology (GFO) - A Foundational Ontology Integrating Objects and Processes. Herre, Heller, Burek, Hoehndorf, Loebe, Michalek, Onto-Med Report, 2006. WonderWeb Deliverable 18: Ontology Library. Masolo, Borgo, Gangemi, Guarino, Oltramari, 2003. An overview of OntoClean. Nicola Guarino, Christopher Welty. Handbook on Ontologies, Springer, New York, 2004. The role of ontologies in biological and biomedical research: a functional perspective. Hoehndorf, Schofield, Gkoutos, Briefings in Bioinformatics, 2015. Semantic Similarity in Biomedical Ontologies. Pesquita, Faria, Falco, Lord, Couto, Plos Computational Biology, 2009.
Method of evaluation	**20.00**% - Scientific review article presentation **30.00**% - Final exam **50.00**% - Course Project(s)
Nature of the assignments	The final grades will be based on one research project in which an algorithm is designed that uses ontologies as background knowledge in a continuous or discrete optimization problem. Additionally, each student will present 2 research papers as part of the course (10% each). A final exam (30%) will test basic concepts taught in the course.
Course Policies	The course project must be finalized and the final report submitted by approximately 1 week before the end of the semester.
Additional Information	

Tentative Course Schedule *(Time, topic/emphasis & resources)*		
Week	**Lectures**	**Topic**
1	Sun 08/25/2019 Wed 08/28/2019	Semester starts
2	Sun 09/01/2019 Wed 09/04/2019	Representation formats for biomedical ontologies: We will discuss formal languages to represent biomedical ontologies, including the OBO Flatfile Format and the Web Ontology Language (OWL), as well as their interrelations. We will also discuss approaches for generating graph representations of ontologies.
3	Sun 09/08/2019 Wed 09/11/2019	Description Logic: ALC and its extensions.
4	Sun 09/15/2019 Wed 09/18/2019	Description Logic: ALC and its extensions. Tableaux algorithm.
5	Sun 09/22/2019 Wed 09/25/2019	Basic model theory: theorems of Loewenheim-Skolem, compactness, completeness
6	Sun 09/29/2019 Wed 10/02/2019	Basic model theory: theorems of Loewenheim-Skolem, compactness, completeness
7	Sun 10/06/2019 Wed 10/09/2019	Decidability, axiomatizability, elementary equivalence
8	Sun 10/13/2019 Wed 10/16/2019	Special theories: mereology; metatheoretical discussion (completeness, decidability)
9	Sun 10/20/2019 Wed 10/23/2019	Special theories: space and time (assumptions, completeness, decidability); Hilbert's axioms; Tarsk's axioms; basic introduction to second order logic
10	Sun 10/27/2019 Wed 10/30/2019	Fuzzy-logic, neuro-fuzzy systems, fuzzy Description Logic
11	Sun 11/03/2019 Wed 11/06/2019	Neuro-symbolic systems: introduction, basic properties
12	Sun 11/10/2019 Wed 11/13/2019	Neuro-symbolic systems: extensions, theory
13	Sun 11/17/2019 Wed 11/20/2019	Knowledge graphs, graph embeddings, embeddings for logic programs
14	Sun 11/24/2019 Wed 11/27/2019	Knowledge graphs, graph embeddings, embeddings for logic programs
15	Sun 12/01/2019 Wed 12/04/2019	Project presentations
16	Sun 12/08/2019	Exam

Note

The instructor reserves the right to make changes to this syllabus as necessary.