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

Course Syllabus: Knowledge Representation and Reasoning - CS 213

Division	Computer, Electrical and Mathematical Sciences & Engineering
Course Number	CS 213
Course Title	Knowledge Representation and Reasoning
Academic Semester	Spring
Academic Year	2017/2018
Semester Start Date	01/28/2018
Semester End Date	05/24/2018
Class Schedule (Days & Time)	01:00 PM - 02:30 PM | 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 demand.

Teaching Assistant(s)

Name	Email

Course Information

Comprehensive Course Description	The aims of the course are to introduce key concepts of knowledge representation and its role in artificial intelligence, enable students to design and apply knowledge-based systems, and understand the limitations and complexity of algorithms for representing knowledge. The course will begin with a review of basic concepts in first order logics, including syntax, semantic, and different deductive systems (Hilbert style systems, sequent calculus). We will then discuss resolution as a method for generating proofs, illustrate implementation strategies and limitations of resolution-based algorithms. As second major formalism we will introduce Description Logics for expressing terminological knowledge and ontologies. Description Logics form one of the foundations of the Semantic Web, and we will discuss a decision procedure for the basic Description Logic ALC as well as algorithms for different variants of ALC. In the third part of the course, we will introduce methods to represent and reason about common sense knowledge, including Default Logic and Circumscription, as well as Answer Set Programming. The final topic of the course will be about reasoning over actions and the application to knowledge-based planning.
Course Description from Program Guide	
Goals and Objectives	At the end of the course, students will be able to (1) represent knowledge of a domain formally, (2) design, implement and apply a knowledge-based system, and (3) understand the limitations and complexity of reasoning algorithms applied in knowledge based systems.
Required Knowledge	Knowledge in discrete mathematics, in particular set theory; complexity theory (e.g., CS260 or related experience in undergraduate studies).
Reference Texts	Language, Proof and Logic, Jon Barwise & John Etchemendy, CSLI Publications (1999); ch 9-11, 19. Knowledge representation and Reasoning, Ronald J. Brachman & Hector J. Levesque, Elsevier (2004); ch 2-5, 9, 11. The Description Logic Handbook: Theory, implementation, and applications, Franz Baader, Deborah L. McGuinness, Daniele Nardi and Peter F. Patel-Schneider, Cambridge University Press(2010); ch 2, 5-6.

Method of evaluation	**40.00**% - Final exam **30.00**% - Midterm exam **30.00**% - Homework /Assignments
Nature of the assignments	The course will have two assignments in which students implement a reasoning algorithm in a programming language of their choice and apply it to toy problems. There will be one midterm exam and one final exam.
Course Policies	Late submission of assignments leads to automatic reduction of grade for that assignment (10% for each week).
Additional Information	

Tentative Course Schedule

(Time, topic/emphasis & resources)

Week	Lectures	Topic
1	Sun 01/28/2018 Wed 01/31/2018	First-order logic: syntax and semantics, key theorems In the first two weeks, we will review the language of first-order logic, introducing its syntax and semantics, different deduction systems (Hilbert's axioms, sequent calculus), and briefly address key theorems (correctness, completeness, cut elimination).
2	Sun 02/04/2018 Wed 02/07/2018	First-order logic: syntax and semantics, key theorems In the first two weeks, we will review the language of first-order logic, introducing its syntax and semantics, different deduction systems (Hilbert's axioms, sequent calculus), and briefly address key theorems (correctness, completeness, cut elimination).
3	Sun 02/11/2018 Wed 02/14/2018	Representing knowledge: introduction This lecture will describe methods for representing knowledge. It will discuss the notion of facts, distinguishing between terminological knowledge and assertions, and will introduce the axiomatic method. We will also cover reasoning over formalized knowledge. We will identify key theorems that enable reasoning over theories in first-order logic (completeness, cut elimination), discuss decidability and semi-decidability of automated reasoning, and introduce the inference rule of resolution.
4	Sun 02/18/2018 Wed 02/21/2018	Resolution The lecture will introduce resolution as a method for automated reasoning.
5	Sun 02/25/2018 Wed 02/28/2018	Resolution (2) We will deepen the discussion of resolution as a method for automated reasoning. We will introduce Skolemization and Skolem normal form, forward chaining and backward chaining (SLD resolution) algorithms, Horn clauses, and show soundness and completeness of the resolution inference procedure.
6	Sun 03/04/2018 Wed 03/07/2018	Description Logic The language ALC is introduced as a basic form of a Description Logic language. We will discuss syntax and semantics of the language, and show a tableaux algorithm for determining concept satisfiability in ALC.
7	Sun 03/11/2018 Wed 03/14/2018	Description Logic (2) We will further discuss the decision procedures for concept satisfiability in ALC, and show complexity of ALC reasoning. Finally, we will discuss extensions of ALC as well as reasoning procedures for the logic EL++.
8	Sun 03/18/2018 Wed 03/21/2018	Web Ontology Language (OWL) This lecture will introduce the Description Logic based language OWL, one of the key languages in the Semantic Web. We will discuss OWL expressivity and different OWL profiles, as well as methods and tools for OWL reasoning (distinguishing between general reasoning over OWL-DL knowledgebases and tractable reasoning over OWL profiles).
9	Sun 03/25/2018 Wed 03/28/2018	Default Logic In this lecture, different kinds of default reasoning and default logic will be discussed. We will distinguish between closed- and open-world reasoning, introduce the notion of non-monotonic inference, and discuss default logic and circumscription as two specific formalisms that support default reasoning.
10	Sun 04/01/2018 Wed 04/04/2018	Answer Set Programming Following the introduction of defaults, we will discuss the formalism of answer set programming as one of the most popular implementations of default reasoning. We will introduce the stable model semantics for answer set programs, and efficient algorithms for finding stable models.
11	Sun 04/08/2018 Wed 04/11/2018	Actions We will introduce Situation Calculus as a framework for reasoning over dynamic domains. After introducing basic concepts such as situations, fluents, actions, we will discuss basic problems of reasoning over actions, such as the frame problem.
12	Sun 04/15/2018 Wed 04/18/2018	Actions We discuss more on reasoning over actions in the situation calculus, and discuss different solutions to the frame problem, such as those based on non-monotonic reasoning. We will also introduce the Yale Shooting Problem.
13	Sun 04/22/2018 Wed 04/25/2018	Knowledge-based planning Plannings involves finding a sequence of actions to move from one situation to a situation in which certain conditions (the goals) are satisfied. We will introduce planning as a problem that can be formulated in languages that represent actions, and discuss possible approaches for finding a plan.
14	Sun 04/29/2018 Wed 05/02/2018	Knowledge-based planning We will discuss forward- and backward-chaining algorithms for planning, including informed search, STRIPS and GraphPlan, and discuss complexity and limitations.
15	Sun 05/06/2018 Wed 05/09/2018	Revision/Exam

16	Sun 05/13/2018 Wed 05/16/2018	
17	Sun 05/20/2018 Wed 05/23/2018	
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Note

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