2021/2022

Computational Logic

Code: 106500
ECTS Credits: 6
Type: FB Year: 1 Semester: 1

Degree

1488 – Artificial Intellingence

The contents of this guide are provisional and may be subject to minor changes. The final version of the guide will be available at the beginning of the semester.

The proposed teaching and assessment methodology that appear in the guide may be subject to changes as a result of the restrictions to face-to-face class attendance imposed by the health authorities

Contact

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Use of languages

Principal working language: English

Some groups entirely in English: Yes

Some groups entirely in Catalan: No

Some groups entirely in Spanish: No

Prerequisites

There are no prerequisites.

Objectives and Contextualisation

This course is an introduction to logic in computer science. Students will acquire the basic techniques for the logical analysis of reasoning, emphasizing the computational aspects of logic. We will introduce algorithmic problems in logic, such as SAT-solving and automated theorem proving. The course will present the basics of logic-based knowledge representation and reasoning in Artificial Intelligence, learning how knowledge can be represented symbolically and manipulated in an automated way by reasoning programs.

Competences

- To identify, understand and apply the fundamental concepts and techniques of knowledge representation, reasoning and machine learning to solve artificial intelligence problems.
- To know, understand, use and apply in a proper way the mathematical foundations that are necessary to develop systems for reasoning, learning and manipulation of large volumes of data.
- To design, implement, analyse and validate efficient and robust algorithmic solutions to computational problems derived from the design of intelligent systems.
- To develop critical thinking to analyse in a grounded and reasoned way alternatives and proposals, both own and others.
- To analyse and solve problems effectively, generating innovative and creative proposals to achieve the objectives.
- To work autonomously, with responsibility and initiative, planning and managing the time and available resources, adapting to unforeseen situations

Learning outcomes

- To know the different models of reasoning and inference in Artificial Intelligence (AI).
- To understand the utility of theorem provers to solve problems represented in logical language.
- To know the basic notions and the mathematical foundations of classical logical formalisms, automatic reasoning techniques, and argumentation in AI.
- To know the modelling of problems in logical languages and their resolution using algorithms based on satisfiability.

Content

Introduction to computational logic. Types of arguments. The scope of logic. Knowledge representation and Classical Logic.

Part A. Propositional Logic (Truth-functional Logic, TFL)

1. First steps to symbolization. Alphabet and syntax of TFL. Connectives. Sentences of TFL.
2. Semantics of TFL. Characteristic truth tables. Truth-functional connectives. Complete truth tables. Semantic concepts. Truth table shortcuts. Partial truth tables.
3. Natural deduction for TFL Constructing proofs, basic and derived rules for TFL. Automated Theorem Proving.
4. Resolution for TFL. Conjunctive and Disjunctive Normal Forms. SAT-solvers. Reasoning with Horn Clauses. Horn-SAT.

Part B. First-order Logic (FOL)

5. Syntax of FOL. Quantifiers. Formulas and sentences. Identities. Basic symbolization in FOL
6. Semantics of FOL. Extensionality. Interpretations. Truth in FOL. Reasoning about interpretations.
7. Natural deduction for FOL. Proofs with quantifiers. Rules for identity. Derived rules.
8. Resolution for FOL. Prenex normal forms. Unification and resolution.
9. Introduction to First-Order Logic Programming.

Methodology

The methodology of the course is based on flipped learning. Students complete readings at their home, and work on live problem-solving during class time. In lectures, the course will not distinguish between theory, problem and practical lectures. Lectures will be organized in four hours per week in groups of around 40 students. It is recommended that students bring their laptops to class if they have one. In addition, a set of exercises will have to be solved individually throughout the course (some of them will be evaluated as part of the evaluation of the course, and discussed in lectures), and other exercises have to be solved in groups. They should serve to understand, integrate and apply the concepts developed in lectures.

The student must complete the lectures with autonomous personal work to do the proposed exercises, and that should serve to understand the contents of the course. It must be borne in mind that the syllabus of the subject has a logical continuity throughout the course, so that to follow correctly a class it is necessary to understand what was explained in the previous sessions.

Activities

Title	Hours	ECTS	Learning outcomes
Type: Directed			
Introduction and discussion of the main theoretical concepts	12	0.48	
Exercise-based classes	30	1.2	
Type: Supervised			
Follow-up in the assimilation of theoretical concepts	10	0.4	
Reinforcement and follow-up in the resolution of exercises	12	0.48	
Type: Autonomous			
Autonomous work and readings	38	1.52	
Preparing and solving exercises	28	1.12	

Assessment

There are three evaluation activities: two synthesis tests, and a series of exercises, both individual and in group. The first test will evaluate the content on propositional logic, and will be worth 30% of the grade; the second test will evaluate the contents of first-order logic, and will be worth also 30% of the grade. The exercises will be worth 40% of the grade (20% individual exercises, and 20% in group exercises). At the time of carrying out each evaluation activity, the teacher will inform the students (via Moodle, which is the usual communication platform between lecturers and students) of the procedure and date of review of the qualifications.

There will be a final test during the official exam period. This final test will permit to compensate any of the partial tests and will only have to be done by students who have not passed any of the two partial tests. If one of the two partial tests has been passed, but the other does not, in this test only the part of the subject corresponding to the partial test that has not been passed must be re-assessed.

Pass the course with honours: In order to pass the course with honours, the final grade must be a 9.0 or higher. Because the number of students with this distinction cannot exceed 5% of the number of students enrolled in the course, this distinction will be awarded to whoever has the highest final grade.

A "**non-assessable**" grade cannot be assigned to students who have participated in any of the individual partial tests or the final test

Review of assessment: For each assesement activity, a place, date and time of review will be indicated allowing students to review the activity with the lecturer. In this context, students may discuss the activity grade awarded by the lecturers responsible for the subject. If students do not take part in this review, no further opportunity will be made available.

Important note: copies and plagiarism.

Notwithstanding other disciplinary measures deemed appropriate, and in accordance with the academic regulations in force, assessment activities will receive a zero whenever a student commits academic irregularities that may alter such assessment. Assessment activities graded in this way and by this procedure will not be reassessable. If passing the assessment activity or activities in question is required to pass the subject, the awarding of a zero for disciplinary measures will also entail a direct fail for the subject, with no opportunity to re-assess this in the same academic year. Irregularities contemplated in this procedure include, among others: the total or partial copying of a practical exercise, report, or any other evaluation activity; allowing others to copy; presenting group work that has not been done entirely by the members of the group; presenting any materials prepared by a third party as one's own work, even if these materials are translations or adaptations, including work that is not original or exclusively that of the student; having communication devices (such as mobile phones, smart watches, etc.) accessible during theoretical-practical assessment tests (individual exams): talk with peers during the theoretical evaluation tests-individual practices (exams); copy or attempt to copy other students during the theoretical-practical assessment tests (exams); use or attempt to use writings related to the subject during the performance of theoretical-practical assessment tests (exams), when these have not been explicitly allowed. In these cases, the grade in the Transcript of Records (ToR) will be the lowest value between 3.0 and the weighted average grade (and therefore re-assessment will not be possible). In the assesment of problems and the project, tools to detect code plagiarism will be used.

Note on the planning of the assesment activities: Continuous-assessment dates will be published on Moodle and on the presentation slides. Specific programming may change when necessary. Any such modification will always be communicated to students through Moodle.

Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Title	Weighting	Hours	ECTS	Learning outcomes
Test 1 - Propositional Logic	30%	2	0.08	
Test 2 - First-order Logic	30%	2	0.08	
Continuous assessment - Individual exercises	20%	8	0.32	
Continuous assessment - Group exercises	20%	8	0.32	

Bibliography

1. P. D. Magnus, *Forallx*, University at Albany. With additions under a Creative Commons License by T. Button, P. Dellunde, J. R. Loftis, and R.Trueman, 2021, http://forallx.openlogicproject.org/

2. R. J. Brachman, H. J. Levesque: *Knowledge representation and reasoning*. Elsevier, 2004.

3. M. Ben-Ari: *Mathematical Logic for Computer Science.* Springer, 2012.

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6. M. Huth, M. Ryan: *Logic in Computer Science. Modelling and Reasoning about Systems.* Cambridge University Press, 2004.

7. U. Schoning, *Logic for Computer Scientists*. Modern Birkäuser Classics, 2nd. edition, 2008.