



Universitat de Lleida

DEGREE CURRICULUM
COMPUTATIONAL LOGIC

Coordination: ANSOTEGUI GIL, CARLOS JOSE

Academic year 2016-17

Subject's general information

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|---|---|---------------|-----------------|------------------|
| Subject name | COMPUTATIONAL LOGIC | | | |
| Code | 102004 | | | |
| Semester | 1st Q(SEMESTER) CONTINUED EVALUATION | | | |
| Typology | Degree | Course | Typology | Modality |
| | Double bachelor's degree: Degree in Computer Engineering and Degree in Business Administration and Management | 1 | COMMON | Attendance-based |
| | Bachelor's Degree in Computer Engineering | 1 | COMMON | Attendance-based |
| ECTS credits | 6 | | | |
| Groups | 1GG,4GM | | | |
| Theoretical credits | 3 | | | |
| Practical credits | 3 | | | |
| Coordination | ANSOTEGUI GIL, CARLOS JOSE | | | |
| Department | INFORMATICA I ENGINYERIA INDUSTRIAL,MATEMATICA | | | |
| Teaching load distribution between lectures and independent student work | 6 ECTS = 25*6 = 150 working hours. 40% --> 60 in-class hours. 60% --> 90 autonomous work hours. | | | |
| Important information on data processing | Consult this link for more information. | | | |
| Language | Catalan | | | |
| Distribution of credits | ALSINET BERNADO, MA.TERESA 7,5 | | | |
| | ANSOTEGUI GIL, CARLOS JOSE 7,5 | | | |
| Office and hour of attention | Maria Teresa Alsinet Bernadó Contact me to arrange a mutually suitable time | | | |

| Teaching staff | E-mail addresses | Credits taught by teacher | Office and hour of attention |
|-------------------------------|--------------------------|---------------------------|------------------------------|
| ALSINET BERNADÓ, MARIA TERESA | tracy@diei.udl.cat | 7,5 | |
| ANSOTEGUI GIL, CARLOS JOSE | carlos@diei.udl.cat | 6,9 | Office 2.16 |
| GARRA ORONICH, RICARD JOSEP | garra@matematica.udl.cat | ,6 | |

Subject's extra information

To address this subject properly skills on analysis and logical reasoning are recommended.

For any question, please, send an email to the teachers.

This subject is scheduled in the fall semester of the 1st year.

Learning objectives

At the end of the course, the student will be able to:

- Model sentences in propositional logic.
- Reason about the validity of propositional logic formulas.
- Apply systems of automatic reasoning to propositional logic formulas.
- Model sentences in first order logic.
- Reason about the validity of first order logic formulas.
- Apply systems of automatic reasoning to first order logic formulas.

Competences

EPS1. Capacity to solve problems and prepare and defence arguments inside the area of studies.

EPS5. Capacity of abstraction and of critical, logical and mathematical thinking.

EPS9. Capacity for unidisciplinary and multidisciplinary teamwork.

EPS12. To be motivated for the quality and steady improvement.

GII-FB3. Capacity to understand and master the basic concepts of discreet mathematics, logical, algorithmic and computational complexity, and its application to solve engineering problems.

GII-FB4. Basic knowledge of the use and programming of computers, operating systems, databases and computer programs with applications in engineering.

GII-FB5. Knowledge of the structure, organisation, operation and interconnection of the computer systems, the basics of programming, and its application to solve engineering problems.

GII-CRI7. Knowledge, design and efficient use of the types and data structure more suitable for solving a problem.

GII-CRI9. Capacity to know, comprise and evaluate the structure and architecture of computers, as well as the basic components that conform them.

Subject contents

The contents of the subject are the following:

Theme 1: Introduction to Logic Systems and Automated Reasoning

Theme 2: Propositional Logic

Theme 3: First Order Logic

Theme 4: Logic Programming

Theme 2: Propositional Logic:

- Syntax, Semantics and Truth Tables
- Taxonomy of Sentences (satisfiable, unsatisfiable and tautology)
- Logic Equivalence, Equisatisfiability and Logic Consequence
- Modelling Sentences
- Normal Forms: Translations into Clausal Form
- Resolution Principle
- Automated Reasoning to Prove Validity of Formulas

Theme 3: First Order Logic:

- Syntax and Semantics
- Taxonomy of Sentences (satisfiable, unsatisfiable and tautology)
- Logic Equivalence
- Modelling Sentences
- Substitution, Composition of Substitutions and Application of Substitutions to Expressions
- Unification of Expressions and Most General Unifier
- Normal Forms: Translations into Clausal Form
- Resolution Principle
- Automated Reasoning to Prove Validity of Formulas

Theme 4: Logic Programming

- Logic Programs
- SLD Resolution
- Introduction to Prolog

Methodology

The course contents are divided into two blocks. The first block presents the logical system of propositional logic . The second presents the logical system of logic predicates. For each logical system we study: the syntax and semantics of the language and the proof procedure based on resolution . Additionally, for each system we study how to model problems and use state-of-the-art tools for solving them . In this sense, for propositional logic we use SAT solvers and Prolog for predicate logic .

For each block we propose a collection of problems that student must solve independently. This work is supervised during the Large Group and Medium Group sessions.

Every week the student attends to two physical classes of the Large Group and 2 hours with the Small Group. Small Group Sessions will be taught in the laboratory. At Large Group we present the classical logical systems : propositional logic and first order logic .

Finally, in Small Group sessions we give support to complete the mandatory lab exercises.

Development plan

| Semana | Descripción | Actividad Presencial GG | Actividad Presencial GM | Trabajo autónomo |
|--------|---|--|---|---------------------------------|
| 1 | Presentation of the subject . Introduction to the subject: Formal languages and logical systems. | Topic 1: Introduction to Logic Systems and Automated Reasoning | Syntax, semantics and proof procedures | Bibliography and Linux tutorial |
| 2 | Propositional Logic : Syntax, Semantics and Truth Tables | Topic 2: Propositional Logic | Introduction to user environment: interpreters, simulators and solvers to use Description and organization of the first compulsory lab activity (A1) | Linux tutorial, SAT solvers |
| 3 | Classification of statements (satisfiable , unsatisfiable and tautology) and Modeling | Topic 2: Propositional Logic | Exercices Topic 2 | A1 Exercices Topic 2 |
| 4 | Transformation of statements in Normal Forms : clausal form | Topic 2: Propositional Logic | A1 | A1 Exercices Topic 2 |
| 5 | Resolution principle | Topic 2: Propositional Logic | Exercices Topic 2 | A1 Exercices Topic 2 |
| 6 | Demonstration automatic | Topic 2: Propositional Logic | Exercices Topic 2 | A1 Exercices Topic 2 |
| 7 | Validity of statements | Topic 2: Propositional Logic | A1 Exercices Topic 2 | A1 Exercices Topic 2 |
| 8 | Syntax and Semantics | T3- Lógica Primer Orden | Deliverable A1 Doubts session on Topic 2 | Exercices Topic 2 |
| 9 | | 1st Exam | | To study |
| 10 | Classification of statements (satisfiable , unsatisfiable and tautology) and Modeling. | Topic 3: First Order Logic | Description and organization of the second compulsory lab activity (A2) Exercices Topic 3 | A2 Exercices Topic 3 |
| 11 | Substitutions, compositions and application of substitutions. Unification and most general unifier. | Topic 3: First Order Logic | A2 | A2 Exercices Topic 3 |
| 12 | Transformation into Conjunctive Normal Form. | Topic 3: First Order Logic | A2 Exercices Topic 3 | A2 Exercices Topic 3 |

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|----|--|----------------------------|---------------------------------|---------------------------------------|
| 13 | Resolution principle. Automatic demonstration of validity of statements. | Topic 3: First Order Logic | Exercices Topic 3 | A2 Exercices Topic 3 |
| 14 | Programs and Resolution | Topic 4: Logic Programming | P2, PROLOG Exercices Topic 4 | A2, PROLOG Exercices Topic 4 |
| 15 | Introduction to SLD Prolog | Topic 4: Logic Programming | Doubts on Topics 3 and 4 | Exercices Topic 4 |
| 16 | | Second exam | Deliverable A2 | Study |
| 17 | | Second exam | | Study |
| 18 | | | | |
| 19 | | Recovery | | Study |

Evaluation

Evaluation

| Acronym | Evaluation activity | Weighing | Minimum grade | Group activity | Compulsory activity | Recoverable |
|---|------------------------|--------------------|---------------|--------------------------|---------------------|-------------|
| PE1 | First Exam | 35% | 3 | NO | YES | YES |
| PE2 | Second Exam | 35% | 3 | NO | YES | YES |
| P1 | Laboratory activity 1 | 15% | - | YES (maximum 2 students) | YES | NO |
| P2 | Laboratory activity 2 | 15% | - | YES (maximum 2 students) | YES | NO |
| PCL | Participation in class | Maximum 0,5 points | NO | NO | NO | NO |
| Final grade = 0,35*PE1 + 0,35*PE2 + 0,15*P1 + 0,15*P2 + 0,05*PCL | | | | | | |

Recovery of exams 1 and 2:

If the grade on some exam is < 3 or the final grade < 5, the student can recover/improve these exams (the student can choose one exam or both).

First exam: Percentatge 35% Type Compulsory / Individual

Evaluation: The activity will be evaluated over 10 punts . To approve the subject the mark obtained in this written

test must be ≥ 3 .

Objectives

Model sentences in propositional logic.
Reason about the validity of propositional logic formulas.
Apply systems of automatic reasoning to propositional logic formulas.

Laboratory activity 1:

Percentage 15% Type Compulsory / Group

Evaluation: The activity will be evaluated over 10 points. This activity can not be recovered.

Objectives

Use a SAT solver.
Model sentences as logic formulas.
Reason about the validity of logic formulas.
Automate proof systems.
Reason about proof systems.
Apply proof systems.
Apply automated reasoning logic systems of propositional logic to mathematical and computer science problems.

Second exam:

Percentage 35% Type Compulsory / Individual

Evaluation: The activity will be evaluated over 10 points. To approve the subject the mark obtained in this written test must be ≥ 3 .

Objectives:

Model sentences in first order logic.
Reason about the validity of first order logic formulas.
Apply systems of automatic reasoning to first order logic formulas.

Laboratory activity 2:

Percentage 15% Type Compulsory / Group

Evaluation: The activity will be evaluated over 10 points. This activity can not be recovered.

Use the Prolog environment.

Model sentences as logic formulas.
Reason about the validity of logic formulas.
Automate proof systems.
Reason about proof systems.
Apply proof systems.
Apply automated reasoning logic systems of first order logic to mathematical and computer science problems.

Bibliography

Basic References:

- Teresa Hortalá, Narciso Martí, Miguel Palomino, Mario Rodríguez, Rafael del Vado. *Lógica matemática para informáticos*. Pearson, Prentice Hall, 2008.

- Paniagua E., Sánchez J.L. y Martín F.: *Lógica Computacional*. Thomson-Paraninfo, 2003.
- J.W. Lloyd. *Foundations of Logic Programming*. Springer-Verlag, second edition, 1987.

Complementary Bibliography

- Gallier, J.: *Logic for Computer Science: Foundations of Automatic Theorem Proving*, 2003.
(<http://www.cis.upenn.edu/~jean/gbooks/logic.html>)
- U. Schöning. *Logic for Computer Scientists*. Birkhäuser, Boston, 1989.
- Tymoczko T. and Henle J.: *Razón, dulce razón. Una Guía de Campo de la Lógica Moderna*. Ariel, 2002.