DEGREE CURRICULUM

COMPUTATIONAL MODELS AND COMPLEXITY

Coordination: VALLS MARSAL, MA MAGDALENA

Academic year 2020-21

COMPUTATIONAL MODELS AND COMPLEXITY 2020-21

Subject's general information

<table>
<tr><td>Subject name</td><td>COMPUTATIONAL MODELS AND COMPLEXITY</td></tr>
<tr><td>Code</td><td>102039</td></tr>
<tr><td>Semester</td><td>2nd Q(SEMESTER) CONTINUED EVALUATION</td></tr>
<tr><td>Typology</td><td>
<table>
<tr><th>Degree</th><th>Course</th><th>Character</th><th>Modality</th></tr>
<tr><td>Bachelor's Degree in Computer Engineering</td><td>3</td><td>COMPULSORY</td><td>Attendance-based</td></tr>
</table>
</td></tr>
<tr><td>Course number of credits (ECTS)</td><td>6</td></tr>
<tr><td>Type of activity, credits, and groups</td><td>
<table>
<tr><th>Activity type</th><th>PRAULA</th><th>TEORIA</th></tr>
<tr><td>Number of credits</td><td>3</td><td>1.5</td></tr>
<tr><td>Number of groups</td><td>1</td><td>1</td></tr>
</table>
</td></tr>
<tr><td>Coordination</td><td>VALLS MARSAL, MA MAGDALENA</td></tr>
<tr><td>Department</td><td>MATHEMATICS</td></tr>
<tr><td>Teaching load distribution between lectures and independent student work</td><td>6 ECTS correspond to a workload of 60 h of lectures and assesment and 90 h autonomous study work for each student.</td></tr>
<tr><td>Important information on data processing</td><td>Consult this link for more information.</td></tr>
<tr><td>Language</td><td>Preferably in catalan. Lectures can be given in spanish or english, if required.</td></tr>
<tr><td>Distribution of credits</td><td>Maria Magdalena Valls Marsal 3
Josep M. Miret Biosca 3</td></tr>
</table>

COMPUTATIONAL MODELS AND COMPLEXITY 2020-21

Teaching staff	E-mail addresses	Credits taught by teacher	Office and hour of attention
MIRET BIOSCA, JOSE MARIA	josepmaria.miret@udl.cat	1,5	
VALLS MARSAL, MA MAGDALENA	magda.vallsmarsal@udl.cat	3	

Subject's extra information

Previous knowledge on the subjects *Algebra*, *Computational Logics* and *Algorithmics and Complexity* and *Discrete Mathematics* is recommended.

This subject is scheduled in the spring semester of the 3rd year, in the especialization on *Computation*.

The knowledge and competencies adquired in this subject will be useful to follow other subjects in the same specialisation, and in particular for the subject *Language Processing Algorithms.*

Learning objectives

- Understand the concept of language, being able to adequately describe languages and deal with operations between languages.
- Recognize the language accepted by a finite state automaton.
- Being able to minimize and determinize a finite state automaton.
- Properly use regular expressions to represent a regular language.
- Understand the basic Turing machine model, its relationship with the finite automata and possible extensions of this model.
- Design Turing machines as language recognizers or as function calculators.
- Distinguish between recursively enumerable and recursive languages, and know their properties.
- Get some examples of non-recursive languages.
- Understand the concept of reduction between languages and be able to give reduction functions.
- Understand the relationship between recursive / recursively enumerable languages and decidable / undecidable problems.
- Distinguish between complexity of an algorithm and complexity of a problem.
- Recognize the different kinds of complexity of a problem: P, NP-complete, NP

Competences

Specific competences

- GII-C1 - Capacity to have a deep knowledge of the basic principles and models for computation and to know how to apply them in order to interpret, select, value, model, and create new concepts, theories, uses and technological developments related with the informatics.
- GII-C3 - Capacity to evaluate the computational complexity of a problem, to know the algorithmic strategies that can drive to its solving and recommend, develop and implement the one which guarantee the best performance in accordance with the requirements.

Cross-disciplinary competences

- EPS6 - Capacity of analysis and synthesis.

University strategic competences

- CT2 - Mastering a foreign language, especially English.
- CT3 - Training experience in the use of the new technologies and the information and communication technologies.

Subject contents

1. Alphabets and languages

- Alphabets, words and languages.
- Concatenation of words.
- Universal language.
- Operations with languages.
- Kleene star on a language.

2. Finite automata

- Deterministic finite automata.
- Language accepted by a deterministic finite automaton.
- Indeterministic finite automata.
- Determinization of finite automata.
- Minimization of finite automata.
- Operations with regular languages.
- Regular Expressions

3. Turing machines

- Basic Turing machine model.
- Extensions on the basic Turing machine model.
- Turing machine as languages recognizor.
- Turing machine as function calculator .
- Algorithms and Turing machines.
- Church-Turing thesis.
- Gödel number of a Turing machine.
- Universal Turing machine.

4. Recursive languages

- Recursive and recursively enumerable languages.
- Operations with recursive languages.
- Operations with recursively enumerable languages.
- The halting problem.

5. Reductions

- Reductions between languages.
- Properties of the reductions.

6. Undecidability

- Decidable and undecidable problems.
- Undecidable problems on Turing Machines: the halting problem and the belonging problem
- PCP, the Post correspondence problem.

7. Complexity

- Classes of complexity.

- Reductions between problems in polynomial time.
- SAT, the satisfiability problem.
- Other NP-complete problems.
- P = NP?

Methodology

Lectures combine theoretical concepts with practical ones. The lectures present the basics of the subject, incorporating illustrative examples that facilitate its understanding. In the classes of problems we combine joint resolution on the board, individual resolution and group resolution.

Students prepare an extension work related with some topics on Theoretical Computer Science. The students have to search for appropiate bibliography and they have to analize it. The work is presented and discussed in the classroom, with all the students and teachers.

Development plan

Week	Lesson	Activities	Student workload
1	Introduction. Lesson 1		3 hours. Study and problem solving.
2	Lesson 1		3 hours. Study and problem solving.
3	Lesson 2	Work topic assignment	3 hours. Study and problem solving.
4	Lesson 2		6 hours. Study and problem solving. Work development.
5	Lesson 2		6 hours. Study and problem solving. Work development.
6	Lesson 3		6 hours. Study and problem solving. Work development.
7	Lesson 3		6 hours. Study and problem solving. Work development.
8	Lesson 3		6 hours. Study for exams.
9		Partial 1 Assesment	8 hours. Study for exams.
10	Lesson 4		3 hours. Study and problem solving.
11	Lesson 4/5		4 hours. Study and problem solving.
12	Lesson 5		6 hours. Study and problem solving. Prepare work presentation.
13	Lesson 6		6 hours. Study and problem solving. Prepare work presentation..
14	Lesson 6/7	Work presentation	4 hours. Study and problem solving.
15	Lesson 6		6 hours. Study for exams.
16		Tutorization	6 hours. Study for exams.
17		Partial 2 Assesment	8 hours. Study for exams.
18		Tutorization	
19		Final assesment	

Evaluation

Acr.	Assessment activities	Weight	Minimum mark	Resit
P1	*Partial 1. Lessons 1, 2 ,3.*	5 points	1.5 punt	YES
P2	*Partial 2. Lessons 4, 5, 6, 7*	4 points	1 punt	YES
AC	*Complementary activitities : development and presentation of a work on complementary aspects*	1 point	NO	NO
PCL	*Participation*	1 point	NO	NO

A student with final mark below 5 or who has not reached the minimum marks required, can resit either P1, P2 or both.
Up to 1 additional point can be assigned, according to participation in the classroom and delivered problems.

FinalMark = P1 + P2 + AC+ PCL

Bibliography

Basic bibliography:

CASAS, R; MÁRQUEZ, L. Llenguatges, gramàtiques i autòmats,Curs bàsic. Aula Teòrica 58, Edicions UPC, 1997.

MIRET, J.M; VALLS, M. Recull de problemes de Models de Computació i Complexitat. Universitat de Lleida, 2012.

SERNA, M.; ALVAREZ, C.; CASES, R.; LOZANO, A.Els límits de la computació. indecidibilitat i NP-completesa. Edicions UPC, 2001.

Complementary bibliography:

BORGES, Q.; SERRA, J.; ARQUES, J.M. Teoria d'autòmats. Materials 28, Servei de Publicacions UAB.

HOPCROFT, J.E; ULLMAN, J.D. Introduction to Automata Theory, Languages and Computation. Addison- Wesley, 1979.

KELLEY, D. Teoría de Autómatas y Lenguajes Formales. Prentice-Hall, 1995.

ROCHA, J; ROSSELLÓ, F. Autòmats i Llenguatges: verificació, implementació i concurrència. Materials didàctics 107, Universitat de les Illes Balears, 2003.