Course guide
270614 - AGT - Algorithmic Game Theory

Last modified: 02/02/2024

Unit in charge: Barcelona School of Informatics
Teaching unit: 723 - CS - Department of Computer Science.

Degree: MASTER'S DEGREE IN INNOVATION AND RESEARCH IN INFORMATICS (Syllabus 2012). (Optional subject).

Academic year: 2023 **ECTS Credits:** 6.0 **Languages:** English

LECTURER

Coordinating lecturer: MARIA JOSE SERNA IGLESIAS

Others: Segon quadrimestre:
MARIA JOSE SERNA IGLESIAS - 10

PRIOR SKILLS

Basic knowledge of algorithm analysis methods (in particular asymptotic complexity).
Basic knowledge on algorithms. Linear Programming. Maximum flow. Local search. Graph and Network algorithms.
Basic knowledge on algebraic reasoning.
Basic knowledge on computational complexity, classes and reductions.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CEE3.1. Capability to identify computational barriers and to analyze the complexity of computational problems in different areas of science and technology as well as to represent high complexity problems in mathematical structures which can be treated effectively with algorithmic schemes.
CEE3.2. Capability to use a wide and varied spectrum of algorithmic resources to solve high difficulty algorithmic problems.
CEE3.3. Capability to understand the computational requirements of problems from non-informatics disciplines and to make significant contributions in multidisciplinary teams that use computing.

Generical:
CG1. Capability to apply the scientific method to study and analyse of phenomena and systems in any area of Computer Science, and in the conception, design and implementation of innovative and original solutions.
CG3. Capacity for mathematical modeling, calculation and experimental designing in technology and companies engineering centers, particularly in research and innovation in all areas of Computer Science.
CG5. Capability to apply innovative solutions and make progress in the knowledge to exploit the new paradigms of computing, particularly in distributed environments.

Transversal:
CTR6. REASONING: Capacity for critical, logical and mathematical reasoning. Capability to solve problems in their area of study. Capacity for abstraction: the capability to create and use models that reflect real situations. Capability to design and implement simple experiments, and analyze and interpret their results. Capacity for analysis, synthesis and evaluation.

Basic:
CB6. Ability to apply the acquired knowledge and capacity for solving problems in new or unknown environments within broader (or multidisciplinary) contexts related to their area of study.
CB8. Capability to communicate their conclusions, and the knowledge and rationale underpinning these, to both skilled and unskilled public in a clear and unambiguous way.
CB9. Possession of the learning skills that enable the students to continue studying in a way that will be mainly self-directed or autonomous.

TEACHING METHODOLOGY

There will be two kinds of classes: theoretical sessions and practical sessions. On average, two hours per week are dedicated to theory and one
hour per week to exercises. The teacher will allocate the hours in accordance to the subject matter.

The theory classes take the form of lectures in which the teacher sets out new concepts or techniques. Those are complemented with examples illustrating the introduced concepts. Sessions will consist of a presentation of the main topics of each content's item, mainly based in selected original research papers.
A high level of students' participation is expected at each session. Current lines of research in each topic will be discussed at the end of each topics' presentation.

The practical classes are used to carry out exercises in which students take an active part. Usually teachers set the exercises in advance. Students are
required to submit the exercises and then discuss the various solutions/alternatives in class.

LEARNING OBJECTIVES OF THE SUBJECT

1.Become acquainted with the main techniques and problems in the algorithmic game theory domain and identify their major properties.
3.Examine conditions under which cooperation and antagonism appear. Perform an analysis and extract the fundamental properties of problems from different domains in order to assess the suitability of a game theoretical analysis and its limitations.

STUDY LOAD

Type	Hours	Percentage
Self study	96,0	64.00
Hours large group	54,0	36.00

Total learning time: 150 h

CONTENTS

Introduction to Algorithmic Game Theory

Description:
Centralized versus decentralized decisions. Games and Internet. Game types, solution concepts, strategies and equilibria. Social choice.

Strategic games and computational aspects of Nash equilibria

Description:
Strategic games, pure and mixed strategies. Solution concepts. Pure Nash equilibria and the complexity of its computation. Pure Nash equilibria versus local optima: Potential games. Mixed strategies and Nash equilibria. The complexity of computing a Nash equilibria.

Price of anarchy and price of stability

Description:
Definitions. Social cost. Best and worst Nash equilibria. Network Games: utility-based resource allocation. Selfish routing and Congestion games. Network formation games. Other examples

Cooperative game theory

Description:
Cooperative and simple games. Types of coalition. Power indices. Examples: voting games, combinatorial games and influence games on social networks.

Weighted voting games

Description:
Definitions and examples. Power and weight. Dimension and co-dimension.

ACTIVITIES

Development of syllabus topics.

Description:
Development of syllabus topics and practice exercices.

Specific objectives:
1, 3

Related competencies :
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CB9. Possession of the learning skills that enable the students to continue studying in a way that will be mainly self-directed or autonomous.
CB6. Ability to apply the acquired knowledge and capacity for solving problems in new or unknown environments within broader (or multidisciplinary) contexts related to their area of study.
CB8. Capability to communicate their conclusions, and the knowledge and rationale underpinning these, to both skilled and unskilled public in a clear and unambiguous way.

Full-or-part-time: 96h
Theory classes: 28h
Practical classes: 14h
Guided activities: 3h
Self study: 51h

Final Exam

Description:
Theory questions and problem-solving exam

Specific objectives:
1, 3

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Full-or-part-time: 20h
Guided activities: 2h
Self study: 18h

Control 1

Description:
In class problem assignment

Specific objectives:
1, 3

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Full-or-part-time: 16h
Guided activities: 1h
Self study: 15h

Presentation of a research paper

Description:
Optional activity. Presentation of a scientific journal article describing a research topic in some of the topics covered in the course or in other related areas of interest to the student.

Specific objectives:
1, 3

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Full-or-part-time: 18h
Guided activities: 3h
Self study: 15h

GRADING SYSTEM

Mark componnents:

C = participation in class, problem solving and presentation (0-10).
A = presentation of a research article (0-10).

P1 = mid term exam (over the first part of AGT) (0-10) .
P2 = final term exam (over the second part of AGT) (0-10) .

FT = final exam (over all the contents of AGT) (0-10).

E = global examen mark

In the date assigned to the final exam you wil have the option to do the final term exam or the final exam. In the first case, E= (P1 + P2)/ 2, and in teh second, E= FT.

La nota final de l'assignatura es calcula amb la formula:

Nota = 20% C + 20% A + 60% E

BIBLIOGRAPHY

Basic:
- Nisan, N. [et al.] (eds.). Algorithmic game theory. Cambridge University Press, 2007. ISBN 978-0521872829.
- Osborne, M.J. An introduction to game theory. Int. ed. Oxford University Press, 2009. ISBN 9780195322484.
- Chalkiadakis, G.; Elkind, E.; Wooldridge, M.J. Computational aspects of cooperative game theory. Morgan & Claypool, 2012. ISBN 9781608456529.
- Taylor, A.D.; Pacelli, A.M. Mathematics and politics: strategy, voting, power and proof. 2nd ed. Springer, 2008. ISBN 9780387776439.

Complementary:
- Brandt, F.; Conitzer, V.; Endriss, U.; Lang, J.; Procaccia, A.D. Handbook of computational social choice. Cambridge University Press, 2016. ISBN 9781107060432.
- Rothe, Jörg. Economics and computation : an introduction to algorithmic game theory, computational social choice, and fair division. Heidelberg: Springer, [2016]. ISBN 9783662479032.