Course guide
270740 - MASD - Multiagent System Design

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

Degree:	MASTER'S DEGREE IN ARTIFICIAL INTELLIGENCE (Syllabus 2017). (Optional subject).

Academic year: 2024   **ECTS Credits:** 4.0   **Languages:** English

LECTURER

Coordinating lecturer:	JAVIER VAZQUEZ SALCEDA
Others:	Segon quadrimestre: JAVIER VAZQUEZ SALCEDA - 10

PRIOR SKILLS

Prior skills on Logics:
- Knowledge of the basic concepts: logical propositions and predicates
- Ability to formulate a problem in logical terms.
- Knowledge of logical inference and decision. Understanding resolution strategies.

Prior skills on Algorithmics and Programming:
- Knowledge on tree and graph structures,
- Knowledge pn tree and graph search algorithms.
- Basic notions in algorithmic complexity.

Prior Skills on Agent Programming adquired in the previous course "Introduction to Multi-Agent Systems"*:
- Knowledge of the basic concepts: agent, multiagent system, environment, perception, actuation.
- Knowledge of the basic coordination mechanisms.
- Knowledge of the agent communication mechanisms
- Basic notions on programming multiagent suystems composed by reactive agents.

*Those students which have not passed the previous course ("Introduction to Multi-Agent Systems") will receive some extra material in order to get the basic level needed for the proper understanding of this course.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CEP3. Capacity for applying Artificial Intelligence techniques in technological and industrial environments to improve quality and productivity.
CEP7. Capability to respect the legal rules and deontology in professional practice.

Generical:
CG3. Capacity for modeling, calculation, simulation, development and implementation in technology and company engineering centers, particularly in research, development and innovation in all areas related to Artificial Intelligence.

Transversal:

CT3. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

CT4. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

CT7. ANALISIS Y SINTESIS: Capability to analyze and solve complex technical problems.

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

The classroom sessions are divided into theory and problem sessions.

Theory sessions introduce the knowledge of the course concepts, switching between the exhibition of new material with examples and discussion with students on concepts and examples.

Problem sessions deepen the knowledge on techniques and methodologies, explained in the Theory sessions. The participation of students will be stimulated to discuss possible alternatives.

Apart of the classroom sessions, students will work in groups on small practical assignments by using Agent-Oriented Software Engineering tools and languages □in order to practice and enhance the students' knowledge on the concepts, techniques and methodologies presented in the course. Students will present the results of their practical assignments to their peers in dedicated classroom sessions.

LEARNING OBJECTIVES OF THE SUBJECT

1. Understand the origins and foundations of distributed computing on the Internet
2. Knowing the possible applications of artificial intelligence for distributed systems on the Internet
3. Understanding the basics of Agent Orientation
4. To analyze a problem distributed in nature to identify the different actors and their functionalities
5. Designing distributed systems using an agent-oriented methodology
6. Extract and represent knowledge about the context necessary to build a distributed application on the Internet that is flexible and robust.
7. Designing context ontologies by applying a methodology properly

STUDY LOAD

Type	Hours	Percentage
Self study	64,0	64.00
Hours large group	36,0	36.00

Total learning time: 100 h

CONTENTS

Introduction to Agent Orientation

Description:
Trends in modern (distributed) computing. Origins of Multiagent design. Agent Design and Society Design. Approaches to Agent-Oriented Design. Agent properties. Environment properties. Agent types and architectures.

Agent Design: Reasoning in Agents

Description:
Definition of Reasoning. Automated Reasoning. Reasoning Paradigms. Symbolic Reasoning Agents. Deductive Reasoning Agents. Agent-Oriented Programming. MetateM. Practical Reasoning. BDI Agents. BDI Agent Control Loop

Agent-Oriented Methodologies

Description:
Current trends in Software engineering. Agent-Oriented Software Engineering. Agent-Oriented Methodologies. The GAIA Methodology. The Prometheus Methodology

Social Design: Coordination and Social Models

Description:
Coordination in MAS. Coordination Structures. Social Models for Coordination. Trust and Reputation Models. Organizational Models. Institutional Models.

Applications of Agent-Oriented Design.

Description:
Agent-Oriented Design for 1) Electronic Negotiation Support, 2) Flexible Dynamic Web services, 3) Multi-robotic environments. Case studies for the practical assignments.

ACTIVITIES

Introduction to Agent Orientation

Description:
Students will learn the origins and foundations of Agent Orientation and some of the application areas. To reinforce learning, the student must read chapter 1 of the book of Russell & Norvig (available online) and the book "Agent Technology: Computing as interaction. A Roadmap to Agent Based Computing" (also available online).

Specific objectives:
1, 3

Related competencies :
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.
CEP3. Capacity for applying Artificial Intelligence techniques in technological and industrial environments to improve quality and productivity.
CG3. Capacity for modeling, calculation, simulation, development and implementation in technology and company engineering centers, particularly in research, development and innovation in all areas related to Artificial Intelligence.
CT4. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

CT7. ANALISIS Y SINTESIS: Capability to analyze and solve complex technical problems.

Full-or-part-time: 10h
Self study: 7h
Theory classes: 3h

Reasoning in Agents

Description:
Students not only should attend the teacher lectures, but also participate in discussions with the teacher and other students on when is best to use each of the algorithms. During the first assignment students should identify the kind of reasoning supported by the chosen agent programming framework. During the presentation of the first assignment students will present at the classroom the results on this analysis to the rest of the class.

Specific objectives:
3, 5

Related competencies :
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.
CEP3. Capacity for applying Artificial Intelligence techniques in technological and industrial environments to improve quality and productivity.
CG3. Capacity for modeling, calculation, simulation, development and implementation in technology and company engineering centers, particularly in research, development and innovation in all areas related to Artificial Intelligence.
CT4. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

CT3. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

CT7. ANALISIS Y SINTESIS: Capability to analyze and solve complex technical problems.

Full-or-part-time: 21h 18m
Self study: 14h
Guided activities: 0h 30m
Theory classes: 6h
Practical classes: 0h 48m

Agent-oriented Methodologies

Description:
Students not only should attend the teacher lectures, but also participate in discussions with the teacher and other students on how to model distributed systems using the proposed methodologies. During the second assignment students should apply one of the methodologies to a real-like scenario to make an agent oriented design. During the presentation of the second assignment students will describe at the classroom their proposed design to the rest of the class.

Specific objectives:
4, 5

Related competencies :
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.
CEP3. Capacity for applying Artificial Intelligence techniques in technological and industrial environments to improve quality and productivity.
CG3. Capacity for modeling, calculation, simulation, development and implementation in technology and company engineering centers, particularly in research, development and innovation in all areas related to Artificial Intelligence.
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CT7. ANALISIS Y SINTESIS: Capability to analyze and solve complex technical problems.

Full-or-part-time: 17h 30m
Self study: 10h
Guided activities: 0h 30m
Theory classes: 5h
Practical classes: 2h

First Practical Assignment presentation: Analysis on an agent-oriented framework/language

Description:
This work will have two parts

* A 30-45 min presentation (if possible with slides) in which students present their analysis on the agent-oriented framework they have chosen. The presentation should be understandable
and didactic, and students should answer the questions
made by others about their analysis.

* a short written document which summarizes the important
parts of the analysis made.

Specific objectives:
1, 3

Related competencies :
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.
CEP3. Capacity for applying Artificial Intelligence techniques in technological and industrial environments to improve quality and productivity.
CG3. Capacity for modeling, calculation, simulation, development and implementation in technology and company engineering centers, particularly in research, development and innovation in all areas related to Artificial Intelligence.
CT4. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

CT7. ANALISIS Y SINTESIS: Capability to analyze and solve complex technical problems.

Full-or-part-time: 1h
Guided activities: 1h

Coordination and Social Models

Description:
Students not only should attend the teacher lectures, but also participate in discussions with the teacher and other students on the different social structures and abstractions presented and how to model more flexible distributed systems. During the second assignment students should apply one or some of the social structures to their design. During the presentation of the second assignment students will describe at the classroom the social abstrations they included into thier design to the rest of the class.

Specific objectives:
4, 5, 6

Related competencies :
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.
CEP3. Capacity for applying Artificial Intelligence techniques in technological and industrial environments to improve quality and productivity.
CEP7. Capability to respect the legal rules and deontology in professional practice.
CG3. Capacity for modeling, calculation, simulation, development and implementation in technology and company engineering centers, particularly in research, development and innovation in all areas related to Artificial Intelligence.
CT4. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

CT3. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

CT7. ANALISIS Y SINTESIS: Capability to analyze and solve complex technical problems.

Full-or-part-time: 15h 30m
Self study: 8h
Guided activities: 0h 30m
Theory classes: 6h
Practical classes: 1h

Applications of Agent-Oriented Design

Description:
Students not only should attend the teacher lectures, but also participate in discussions with the teacher and other students on the discussion bout the different application examples. Furthermore, during the second assignment students should propose a real-like scenario where agent-oriented solutions are appropriate and apply the abstractions, mechanisms and social structures seen in the course. During the presentation of the second assignment students will describe at the classroom the chosen real-like scenario and motivate the suitability of an agent-oriented solution for it.

Specific objectives:
2, 4, 5, 6, 7

Related competencies :
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.
CEP3. Capacity for applying Artificial Intelligence techniques in technological and industrial environments to improve quality and productivity.
CEP7. Capability to respect the legal rules and deontology in professional practice.
CG3. Capacity for modeling, calculation, simulation, development and implementation in technology and company engineering centers, particularly in research, development and innovation in all areas related to Artificial Intelligence.
CT4. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

CT3. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

CT7. ANALISIS Y SINTESIS: Capability to analyze and solve complex technical problems.

Full-or-part-time: 12h 42m
Self study: 7h
Guided activities: 0h 42m
Theory classes: 4h
Practical classes: 1h

Second Practical Assignment presentation: Design of an Agent-Oriented System

Description:
This work has two parts:

* A 30-45 min presentation (if possible with slides) in which students explain the results of the programming exercise in a concise and dydactic way. At the end of the presentations the students should also properly answer the questions
made by others about their work.
* A demo of the prototype that has been built.
* A written document which properly describes A) Description of the problem to solve; B) Design of a multiagent system using an Agent-oriented
methodology seen during the course; C) Description of the prototype finally built; D) Analysis of the chosen agent language/platform

Specific objectives:
2, 4, 5, 6, 7

Related competencies :
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.
CEP3. Capacity for applying Artificial Intelligence techniques in technological and industrial environments to improve quality and productivity.
CEP7. Capability to respect the legal rules and deontology in professional practice.
CG3. Capacity for modeling, calculation, simulation, development and implementation in technology and company engineering centers, particularly in research, development and innovation in all areas related to Artificial Intelligence.
CT4. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

CT3. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

CT7. ANALISIS Y SINTESIS: Capability to analyze and solve complex technical problems.

Full-or-part-time: 2h
Guided activities: 2h

Final Exam

Description:
Final exam covering all the course contents

Specific objectives:
1, 3, 4, 5

Related competencies :
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.
CEP3. Capacity for applying Artificial Intelligence techniques in technological and industrial environments to improve quality and productivity.
CG3. Capacity for modeling, calculation, simulation, development and implementation in technology and company engineering centers, particularly in research, development and innovation in all areas related to Artificial Intelligence.
CT4. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

CT3. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

CT7. ANALISIS Y SINTESIS: Capability to analyze and solve complex technical problems.

Full-or-part-time: 8h
Self study: 6h
Guided activities: 2h

GRADING SYSTEM

The student assessment will consist of a final exam mark and the practical assignments' reports and presentations.

The calculation of the final mark will be as follows:

FPA = first practical assignment
SPA = second practical assignment
FM = final exam mark

MARK = FPA*0.3 + SPA*0.5 + FM*0.2

The competences assigned to this course will be avaluated through the practical assignments and the final exam.

BIBLIOGRAPHY

Basic:
- Weiss, G. (ed.). Multiagent systems. Cambridge, Mas.: The MIT Press, 2013. ISBN 9780262018890.
- Wooldridge, M. An introduction to multiagent systems. 2nd ed. Chichester: John Wiley & Sons, 2009. ISBN 9780470519462.
- Russell, S.J.; Norvig, P. Artificial intelligence: a modern approach. 4th ed. Harlow: Pearson, 2022. ISBN 9781292401133.
- Boehm, C. Moral origins: the evolution of virtue, altruism, and shame. New York: Basic Books, 2012. ISBN 9780465020485.
- Luck, M.; McBurney, P.; Shehory, O.; Willmott, S. Agent technology: computing as interaction: a roadmap for agent based computing. Southampton: University of Southampton, 2005. ISBN 0854328459.

Complementary:
- Rosenschein, J.S.; Zlotkin, G. Rules of encounter: designing conventions for automated negotiation among computers. Cambridge: The MIT Press, 1994. ISBN 0262181592.