Course guide
270404 - CRA - Knowledge and Automatic Reasoning

Last modified: 13/07/2023

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

Degree: BACHELOR'S DEGREE IN ARTIFICIAL INTELLIGENCE (Syllabus 2021). (Compulsory subject).

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

LECTURER

Coordinating lecturer: RAMON SANGÜESA SOLE

Others: Primer quadrimestre:
CAROLINE LEONORE KÖNIG - 11, 12
RAMON SANGÜESA SOLE - 11, 12

PRIOR SKILLS

The usual ones in a first university course with special relevance of the contents of science and mathematics,

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CE02. To master the basic concepts of discrete mathematics, logic, algorithmic and computational complexity, and its application to the automatic processing of information through computer systems . To be able to apply all these for solving problems.
CE15. To acquire, formalize and represent human knowledge in a computable form for solving problems through a computer system in any field of application, particularly those related to aspects of computing, perception and performance in intelligent environments or environments.
CE18. To acquire and develop computational learning techniques and to design and implement applications and systems that use them, including those dedicated to the automatic extraction of information and knowledge from large volumes of data.

Generical:
CG2. To use the fundamental knowledge and solid work methodologies acquired during the studies to adapt to the new technological scenarios of the future.
CG4. Reasoning, analyzing reality and designing algorithms and formulations that model it. To identify problems and construct valid algorithmic or mathematical solutions, eventually new, integrating the necessary multidisciplinary knowledge, evaluating different alternatives with a critical spirit, justifying the decisions taken, interpreting and synthesizing the results in the context of the application domain and establishing methodological generalizations based on specific applications.
CG5. Work in multidisciplinary teams and projects related to artificial intelligence and robotics, interacting fluently with engineers and professionals from other disciplines.

Transversal:
CT4. Teamwork. Be able to work as a member of an interdisciplinary team, either as a member or conducting management tasks, with the aim of contributing to develop projects with pragmatism and a sense of responsibility, taking commitments taking into account available resources.
CT5. Solvent use of information resources. Manage the acquisition, structuring, analysis and visualization of data and information in the field of specialty and critically evaluate the results of such management.

TEACHING METHODOLOGY

The teaching methodology will consist of the exposition of the theory in theory classes and the application of the concepts in the problem and laboratory classes and to small projects to be worked in group.

LEARNING OBJECTIVES OF THE SUBJECT

1.To know and understand the concept of logic
2.To know now how to apply logical foundations to the increasing number of applications of reasoning methods in computing.
3.To be able to analyze the knowledge that is necessary to solve a problem.
4.To be able to analyze a problem an decide which representation and reasoning techniques are the mos suitable to solve it
5.To be able to elicit and represent the necessary knowledge to build an application in the field of knowledge-based systems.
7.To understand, write and manipulate proficiently formulase in various logics (propositional logic, first order logic, description logics, fuzzy logics), with special emphasis on application

STUDY LOAD

Type	Hours	Percentage
Hours large group	30,0	20.00
Hours small group	30,0	20.00
Self study	90,0	60.00

Total learning time: 150 h

CONTENTS

Introduction: Intelligence, Knowledge, Reason, Reasoning and Computing.

Description:
Presentation of the role of reasoning in intelligence. Knowledge and its representation in relation to reasoning. The various types of knowledge: declarative (relational, heritable, inferable), procedural, implicit, a priori and actionable.

Reasoning and logic

Description:
Logic as a representation of knowledge. Logic as a reasoning mechanism. Logical closure.

Propositional Logics.

Description:
Introduction to logics and the basic concepts needed to characterize and use it: satisfaction, tautology, consequence and equivalence. Expressive power vs. computational cost. Deduction in Propositional Logic.

First-order logic

Description:
First-order logics: normal forms, literal forms and clauses. Expressive power and decidability. Properties of computational logic systems. Deduction in First Order Logic.

Logic Programming.

Description:
Introduction to logical programming answer calculation, resolution strategies, backtracking management.

Other forms of inference:

Description:
Induction, abduction, analogy, case-based reasoning. Model and execution cycle of case-based reasoning systems. Internal organization of the Case Base.

Semantic Knowledge Modeling

Description:
Semantic Networks and Frame Networks. Description Logics.

ACTIVITIES

Intelligence, Knowledge, Reason, Reasoning and Computing

Description:
Presentation of the fundamental concepts that link intelligence with reasoning, reasoning with knowledge and this with its representation. Reasoning as manipulation of representations. Reasoning as a calculation.

Specific objectives:
1, 2, 7

Related competencies :
CG4. Reasoning, analyzing reality and designing algorithms and formulations that model it. To identify problems and construct valid algorithmic or mathematical solutions, eventually new, integrating the necessary multidisciplinary knowledge, evaluating different alternatives with a critical spirit, justifying the decisions taken, interpreting and synthesizing the results in the context of the application domain and establishing methodological generalizations based on specific applications.
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CE02. To master the basic concepts of discrete mathematics, logic, algorithmic and computational complexity, and its application to the automatic processing of information through computer systems . To be able to apply all these for solving problems.

Full-or-part-time: 4h
Theory classes: 2h
Self study: 2h

Propositional Logic.

Specific objectives:
1, 7

Related competencies :
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Full-or-part-time: 18h
Theory classes: 6h
Practical classes: 4h
Self study: 8h

First-Order Logic.

Description:
Hay que entender y practicar las diveres formas y métodos de inferencia lógica así como incluir los límites expresivos de este lenguaje, que resulta una extensión de lo que permite la lógica proposicional y al mismo tiempo nos permite entender su relación con las propiedades que interesan desde el punto de vista de su realización por medios computacionales. Esto permite entender las bases de la programación lógica.

Specific objectives:
1, 2, 3, 7

Related competencies :
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CE02. To master the basic concepts of discrete mathematics, logic, algorithmic and computational complexity, and its application to the automatic processing of information through computer systems . To be able to apply all these for solving problems.
CT5. Solvent use of information resources. Manage the acquisition, structuring, analysis and visualization of data and information in the field of specialty and critically evaluate the results of such management.

Full-or-part-time: 31h
Theory classes: 8h
Practical classes: 7h
Self study: 16h

Logic Programming

Description:
It is necessary to understand the language of logical programming as a computational transposition of the inference mechanisms of first-order logic and at the same time to understand its differences. It will be practiced intensively in the laboratory with exercises of increasing difficulty that will serve to prepare the specific examination of logical programming.

Specific objectives:
1, 2, 3, 7

Related competencies :
CG4. Reasoning, analyzing reality and designing algorithms and formulations that model it. To identify problems and construct valid algorithmic or mathematical solutions, eventually new, integrating the necessary multidisciplinary knowledge, evaluating different alternatives with a critical spirit, justifying the decisions taken, interpreting and synthesizing the results in the context of the application domain and establishing methodological generalizations based on specific applications.
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CT5. Solvent use of information resources. Manage the acquisition, structuring, analysis and visualization of data and information in the field of specialty and critically evaluate the results of such management.

Full-or-part-time: 40h
Theory classes: 8h
Practical classes: 1h
Laboratory classes: 10h
Self study: 21h

Other inferences forms

Description:
It must be understood that deduction is a form of reasoning among many others that we have developed. We will understand and practice through exercises the inductive inference, the basis of the experimental sciences and, in general, of all those that generalize from observations (and the corresponding data); abductive inference as a generative inference and case-based analogy or reasoning as a type of reasoning where the similarity between the components and structure of a situation sets in motion a reasoning that has useful and practical consequences. The various exercises will allow us to strengthen the knowledge of the possibilities and limitations of these types of knowledge, always comparing them with the properties of standard logic.

Specific objectives:
1, 2, 3, 4, 5, 7

Related competencies :
CG4. Reasoning, analyzing reality and designing algorithms and formulations that model it. To identify problems and construct valid algorithmic or mathematical solutions, eventually new, integrating the necessary multidisciplinary knowledge, evaluating different alternatives with a critical spirit, justifying the decisions taken, interpreting and synthesizing the results in the context of the application domain and establishing methodological generalizations based on specific applications.
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CT5. Solvent use of information resources. Manage the acquisition, structuring, analysis and visualization of data and information in the field of specialty and critically evaluate the results of such management.
CT4. Teamwork. Be able to work as a member of an interdisciplinary team, either as a member or conducting management tasks, with the aim of contributing to develop projects with pragmatism and a sense of responsibility, taking commitments taking into account available resources.

Full-or-part-time: 8h
Theory classes: 2h
Practical classes: 1h
Laboratory classes: 1h
Self study: 4h

Semantic Knowledge Modeling. Ontologies.

Description:
Ontologies are formalisms based on hierarchies of concepts and relationships. We will study the main realizations and formalisms and in the laboratory we will work with ontology development environments. Students should not only attend lessons, but also do exercises on the use of ontologies and discuss with the teacher and other students when it is best to use each technique. In the lab students will apply what they have learned to a problem.

Specific objectives:
2, 3, 4, 5

Related competencies :
CG4. Reasoning, analyzing reality and designing algorithms and formulations that model it. To identify problems and construct valid algorithmic or mathematical solutions, eventually new, integrating the necessary multidisciplinary knowledge, evaluating different alternatives with a critical spirit, justifying the decisions taken, interpreting and synthesizing the results in the context of the application domain and establishing methodological generalizations based on specific applications.
CG5. Work in multidisciplinary teams and projects related to artificial intelligence and robotics, interacting fluently with engineers and professionals from other disciplines.
CG2. To use the fundamental knowledge and solid work methodologies acquired during the studies to adapt to the new technological scenarios of the future.
CE15. To acquire, formalize and represent human knowledge in a computable form for solving problems through a computer system in any field of application, particularly those related to aspects of computing, perception and performance in intelligent environments or environments.
CE18. To acquire and develop computational learning techniques and to design and implement applications and systems that use them, including those dedicated to the automatic extraction of information and knowledge from large volumes of data.
CE02. To master the basic concepts of discrete mathematics, logic, algorithmic and computational complexity, and its application to the automatic processing of information through computer systems . To be able to apply all these for solving problems.
CT5. Solvent use of information resources. Manage the acquisition, structuring, analysis and visualization of data and information in the field of specialty and critically evaluate the results of such management.
CT4. Teamwork. Be able to work as a member of an interdisciplinary team, either as a member or conducting management tasks, with the aim of contributing to develop projects with pragmatism and a sense of responsibility, taking commitments taking into account available resources.

Full-or-part-time: 15h
Theory classes: 2h
Practical classes: 2h
Laboratory classes: 4h
Self study: 7h

Final Exam

Description:
Theoretical-practical exercise that covers the topics of the course.

Specific objectives:
1, 2, 3, 4, 5, 7

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CG4. Reasoning, analyzing reality and designing algorithms and formulations that model it. To identify problems and construct valid algorithmic or mathematical solutions, eventually new, integrating the necessary multidisciplinary knowledge, evaluating different alternatives with a critical spirit, justifying the decisions taken, interpreting and synthesizing the results in the context of the application domain and establishing methodological generalizations based on specific applications.
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CE18. To acquire and develop computational learning techniques and to design and implement applications and systems that use them, including those dedicated to the automatic extraction of information and knowledge from large volumes of data.
CE02. To master the basic concepts of discrete mathematics, logic, algorithmic and computational complexity, and its application to the automatic processing of information through computer systems . To be able to apply all these for solving problems.
CT5. Solvent use of information resources. Manage the acquisition, structuring, analysis and visualization of data and information in the field of specialty and critically evaluate the results of such management.
CT4. Teamwork. Be able to work as a member of an interdisciplinary team, either as a member or conducting management tasks, with the aim of contributing to develop projects with pragmatism and a sense of responsibility, taking commitments taking into account available resources.

Full-or-part-time: 10h
Guided activities: 2h
Self study: 8h

Practical project of Logic Programming

Description:
Team project using a logic programming environment that focuses on solving a limited problem by applying knowledge about logic programming and reasoning strategies

Specific objectives:
1, 2, 7

Related competencies :
CG4. Reasoning, analyzing reality and designing algorithms and formulations that model it. To identify problems and construct valid algorithmic or mathematical solutions, eventually new, integrating the necessary multidisciplinary knowledge, evaluating different alternatives with a critical spirit, justifying the decisions taken, interpreting and synthesizing the results in the context of the application domain and establishing methodological generalizations based on specific applications.
CG2. To use the fundamental knowledge and solid work methodologies acquired during the studies to adapt to the new technological scenarios of the future.
CE15. To acquire, formalize and represent human knowledge in a computable form for solving problems through a computer system in any field of application, particularly those related to aspects of computing, perception and performance in intelligent environments or environments.
CE18. To acquire and develop computational learning techniques and to design and implement applications and systems that use them, including those dedicated to the automatic extraction of information and knowledge from large volumes of data.
CE02. To master the basic concepts of discrete mathematics, logic, algorithmic and computational complexity, and its application to the automatic processing of information through computer systems . To be able to apply all these for solving problems.

Full-or-part-time: 18h
Self study: 18h

Midterm Exam

Description:
Evaluation of the content, techniques and methods covered up to the time of the exam. Theoretical-practical exam with questions about readings, concepts and exercises.

Specific objectives:
1, 2, 7

Related competencies :
CG4. Reasoning, analyzing reality and designing algorithms and formulations that model it. To identify problems and construct valid algorithmic or mathematical solutions, eventually new, integrating the necessary multidisciplinary knowledge, evaluating different alternatives with a critical spirit, justifying the decisions taken, interpreting and synthesizing the results in the context of the application domain and establishing methodological generalizations based on specific applications.
CG2. To use the fundamental knowledge and solid work methodologies acquired during the studies to adapt to the new technological scenarios of the future.
CE15. To acquire, formalize and represent human knowledge in a computable form for solving problems through a computer system in any field of application, particularly those related to aspects of computing, perception and performance in intelligent environments or environments.
CE18. To acquire and develop computational learning techniques and to design and implement applications and systems that use them, including those dedicated to the automatic extraction of information and knowledge from large volumes of data.
CE02. To master the basic concepts of discrete mathematics, logic, algorithmic and computational complexity, and its application to the automatic processing of information through computer systems . To be able to apply all these for solving problems.

Full-or-part-time: 6h
Self study: 6h

GRADING SYSTEM

The evaluation is based on several test of the thematic blocks that made up the course and an final examen as well as an evaluation of the assignments of the course in problems and laboratory classes. The final examination tests the knowledge about the theoretical aspects of the course and of the methodology acquired by the students during the course. The grading of the course assignments will be based on the presentations of small problems proposed during the course.

The final grade will be calculated as follows:

0.30* Logic Programming Project + 0.3* Midterm Exam+ 0.40 * Final Exam

Assessment of competencies

The assessment of teamwork competence is based on the work done during the practical work.

Competency assessment. Solvent use of information resources is based on both internship work and problem-solving exercises and laboratories.

BIBLIOGRAPHY

Basic:
- Bramer, Max. Logic programming with prolog. Springer, 2013. ISBN 9781447154860.
- Levesque, Hector J.. Thinking as Computation: A First Course. 0262016990. MIT press, 2012.

Complementary:
- Pearl, Judea. Probabilistic reasoning in intelligent systems : networks of plausible inference. San Mateo: Morgan Kaufmann, Publishers, 1988. ISBN 0934613737.