UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Artificial Intelligence

2324-2-F1801Q155

Aims

The objective of the course is to enable students to master the basic knowledge and tools necessary to understand, use, and create Artificial Intelligence (AI) systems, along with the ability to analyze different classes of problems and solutions based on AI.

Artificial Intelligence has developed by addressing a wide range of problems, from question answering to the management of autonomous agents in cooperative environments, branching out into a broad set of methodological approaches and more specific disciplines such as knowledge representation, multi-agent systems, machine learning, robotics, etc. While some specific techniques for solving these problems are also addressed in other courses, this course has a dual objective:

- Provide an **overview of the discipline** focused on the concept of intelligent agent, enabling students to critically frame problems, solutions, and specific methodological approaches within the development of intelligent systems.
- Provide an **in-depth exploration** of some themes and solutions of particular importance for the development of intelligent systems today, namely: 1) autonomous AI, 2) embodied and affective AI, 3) knowledge-based and learning-based AI.

Students will be given conceptual, computational, and methodological tools to understand and develop innovative solutions to automation problems through advanced Artificial Intelligence techniques.

Contents

The course adopts an **agent-based paradigm** as a conceptual model to organically frame various problems and models proposed in modern Artificial Intelligence. In particular, agents will be characterized from the perspective of autonomy and relationships such as those between agent and environment, behavior and perception, and behavior

and knowledge.

A second part of the course is dedicated to **modeling the behavior of intelligent agents** based on perception through sensors and coordination in multi-agent systems. Models for simulation through multi-agent systems, perception modeling through sensors in complex systems, and affective computing will be discussed. The applications covered in this part pertain to simulation systems and systems based on the adaptive behavior of agents.

A third part of the course is dedicated to **knowledge-based Artificial Intelligence**, with particular attention to the relationship between knowledge and learning, as well as the relationship between language and thought. The topic of modeling and learning linguistic representations will be introduced, as seen in large language models, as well as structured representation, as seen in knowledge graphs and neuro-symbolic knowledge bases. The applications covered in this part of the course refer to all those applications strongly based on the modeling and retrieval of knowledge about the world in hybrid systems, which integrate symbolic and sub-symbolic representations. Examples of such applications include question answering, modeling "FAIR" AI systems, and analysis of massive amounts of data, among others.

Detailed program

1. Introduction: learning and reasoning in Artificial Intelligence; interpretation, reasoning, prediction, control; the concept of autonomous agent (definition, classification, behavior, models of agents with simple reflexes, with memory, goal-based, utility-based).

2. Models and mechanisms of interaction in Multi-Agent Systems (MAS): collective artificial intelligence and complex systems; modeling, simulation, analysis of self-organizing behaviors.

3. Sensors and affective computing: modeling, simulation, analysis of self-organizing behaviors.

4. From knowledge representation to representation learning: knowledge bases, knowledge graphs, and ontologies; learning linguistic representations, word embeddings, and large language models (BERT, GPT-X); learning representations of knowledge graphs using neural networks: knowledge graph embeddings.

5. End-to-end integration of knowledge and learning: information extraction and knowledge base construction (Named Entity Recognition, Named Entity Linking, relation extraction); neuro-symbolic AI models (Logic Tensor Network).

Prerequisites

Basic knowledge of logics and mathematics. Basic knowledge about machine learning and deep neural networks.

Teaching form

Lectures and exercise with students' personal computers. Moodle e-learning platform. Seminars about usage of semantics in real-world applications given by experts from the industry.

The course is teached in English.

Textbook and teaching resource

Textbooks :

S.J. Russell, P. Norvig, “Intelligenza Artificiale: un approccio moderno“, 2a edizione, Pearson - Prentice Hall, 2005 (volume 1)

J. Ferber, Multi-agent systems: An introduction to distributed artificial intelligence, Addison-Wesley Professional, 1999: sintesi a dispense disponibile sull’e.learning del Corso.

Tommaso Di Noia, Roberto De Virgilio, Eugenio Di Sciascio, Francesco M. Donin. Semantic Web. Tra ontologie e Open Data. 1° ed. (Apogeo, 2013), pp. 240

Recommended reading:

C. Cornoldi, L'intelligenza, Il Mulino Ed., 2009. Cesare Cornoldi. Formicai, imperi, cervelli: introduzione alla scienza della Complessità (Il Mulino, 2007), pp. 235.

Grigoris Antoniou, Paul Groth, Frank van Harmelen, Rinke Hoekstra. A Semantic Web Primer (Information Systems) third edition. The MIT Press; third edition edition (August 24, 2012), pp. 288.

Semester

Semester I

Assessment method

The final evaluation consists of the aggregation of the scores obtained in two independent assessments.

- The first assessment is based on an exam-tailored project or a survey, carried out individually or in groups, and aimed at bringing the student to have an in-depth knowledge and/or hands-on experience of a specific topic covered in the course or linked to topics covered in the course; the project and the survey are both discussed through an oral presentation supported by slides lasting about 20 minutes; it is possible, during the presentation, to include a short demo of the project; the survey consists of a bibliographic review on a topic, in which the student discusses and compares proposed solutions in the state of the art to a specific problem of interest for him. The evaluation is based on: significance of the project with respect to the topics covered in the course, methodological soundness (within the limits of what is reasonable to ask for an exam project); mastery of the in-depth topic demonstrated during the oral presentation.
- The second assessment is based on the verification of the knowledge acquired by the student about the topics addressed during the course by the execution of assignments related to these topics.

Office hours

On demand.

Sustainable Development Goals

QUALITY EDUCATION