UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Complex Systems: Models and Simulations

2627-2-F9202P027

Aims

Students will learn new models, abstractions and mechanisms for the modeling of complex systems but also practical tools for the design and development of systems (not exclusively aimed at the simulation of complex systems) based on an agent-based approach. This class requires students to design, implement, and document a project (individual or for a group of 2/3 students) focused on simulating complex systems, drawing upon relevant academic literature. The learning objectives extend beyond the acquisition of technical knowledge and its application (presented above); they are designed to cultivate critical thinking skills, independent learning abilities – particularly in researching and evaluating scholarly sources and utilizing appropriate software tools – and effective communication skills. Students will demonstrate these competencies through a written project report adhering to established academic standards and an oral presentation defending their work, potentially supported by visual aids.

Contents

This course aims at introducing conceptual and computational models and instruments developed in the contexts of the Sciences of Complexity and Distributed Artificial Intelligence supporting simulation of complex systems or the design of systems characterized by the presence of autonomous interacting components (agents). Cellular Automata and multi-agent system models are growingly diffused in the study of complex systems (such as biological, socioeconomic systems), but they also represent useful abstractions and mechanisms for the design of distributed computer systems (e.g. monitoring and control systems, smart environments, computer supported cooperative work systems, advanced web applications).

Detailed program

1. Introduction to the concepts of agent and multi-agent system (from single intelligent agent to a multi-agent

system, agent architectures, agent interaction models, agents and environments)
2. Cellular Automata and complex systems modeling: complex vs. complicated systems, 1D and 2D cellular automata and their application to paradigmatic case studies (traffic and population dynamics)
3. From cellular automata to multi-agent systems: agent-based modeling and simulation of crowds of pedestrians; social simulation; integration of heterogeneous approaches; additional case studies
4. Learning agents: brief introduction to reinforcement learning and sample applications
5. Validation of complex systems simulators; examples of techniques for the analysis of collective behaviours in complex systems
6. Brief introduction to deliberative agents
7. Brief discussion of other applications of agent based and multi-agent systems

Prerequisites

None. Basic computer programming proficiency could be useful to implement the project required for the final assessment.

Teaching form

Theoretical and methodological aspects will be presented along with practical examples and case studies, employed to exemplify the introduced topics; specific tools for the realization of simulators based on presented models and approaches will be presented; suitable references to the relevant and recent scientific literature will be given for supporting an in depth study of the treated topics. The course and the teaching materials are in English.

The course consists of 50 hours, of which 40 hours are lectures (approximately 66% of which are expository and the rest interactive) and 10 hours are interactive exercises. The lectures and exercises are conducted in person, unless unforeseen problems or changes arise, which will be promptly announced, and will be recorded and made available for study and review.

Textbook and teaching resource

Text book (for point 1 of the detailed course program): Multi-Agent System: An Introduction to Distributed Artificial Intelligence. Jacques Ferber, Harlow: Addison Wesley Longman, 1999, ISBN 0-201-36048-9

Additional teaching material: slides made available through the eLearning platform and links to scientific papers.

Semester

Second semester.

Assessment method

The learning assignments are essentially related to the production of an essay related to the introduced topics, that implies the realization of a project (a practical implementation and experimentation of prototypical simulator, discussing the relevant literature on the topic) and its discussion in an oral exam that concerns all the topics introduced throughout the course.

The topic of the essay and project is typically agreed upon with the instructor, even during the course; the instructor provides an assessment of the adequacy and level of difficulty of the proposed work, and he proposes indications for the organization of work.

Office hours

Wednesday from 9:30 to 11:30 or other days/times always by appointment, potentially also via teleconferencing systems.

Sustainable Development Goals

SUSTAINABLE CITIES AND COMMUNITIES