LEARNING MODULE DESCRIPTION

GENERAL INFORMATION

1. Module title: Computational modelling of complex systems
2. USOS code: 04-W-CMCS-45
3. Term: Summer
4. Duration: 30h Lecture + 15h Seminar
5. ECTS: 5
6. Module lecturer: Adam Lipowski
7. E-mail: lipowski@amu.edu.pl
8. Language: English

DETAILED INFORMATION

1. Module aim (aims)
   Recently, computer simulations are so powerful that they enable researchers to examine systems evading scientific approaches for decades. Considering societies or ecosystems, or financial markets, as composed of interacting sub-units, and using computer simulations to model them, one can analyse the behavior of such complex systems. The goal of the course is to provide an introduction to this rapidly developing interdisciplinary field.

2. Pre-requisites in terms of knowledge, skills and social competences (where relevant)
   None

READING LIST

Lecture Notes provided by lecturer (distributed via Teams in pdf format)

SYLLABUS:

Week 1: Methodology of computer simulations, definitions and examples of complex systems
Week 2: Self-organized criticality and prevalence of broad distributions
Week 3: Scale invariance and power-laws in critical systems, cellular automata
Week 4: Basic elements of game theory; zero- and non-zero sum games, applications in economy, politics and biology
Week 5: Social dilemma, Iterated Prisoner Dilemma and Axelrod tournaments, evolutionary stable strategies in IPD
Week 6: Ultimatum game, computational approaches to iterated games
Week 7: Introduction to sociophysics: traffic jams, modelling of panic, phase separation in Schelling model
Week 8: Models of opinion formation: discrete spin models, social impact, bounded rationality models, models of dissemination of culture, hysteresis in social sciences (crime rate, marriages)
Week 9: Discrete logistic equation and deterministic chaos
Week 10: Modeling of population dynamics, prey-predator systems, Lotka-Volterra models and its limitations
Week 11: Introduction to complex networks, examples of real networks and their properties, preferential attachment and Barabasi-Albert model
Week 12: Graphs: basic definitions, types of graphs and their characterization, random graphs
Week 13: Milgram experiment, small worlds and model of Watts and Strogatz, Kleinberg's geographical model
Week 14: Modularity, algorithms that find modules in complex networks, networks drawing
Week 15: Dynamics on networks: disease spreading, opinion formation models on networks