Tárgyleírás

Tárgy neve: Collective Intelligence

Tárgyfelelős neve: Gulyás László

Tárgyfelelős tudományos fokozata: PhD

Tárgyfelelős MAB szerinti akkreditációs státusza: AT

Az oktatás célja angolul / Aim of the subject:

Knowledge

- They have comprehensive and up-to-date knowledge of general mathematical and computing principles
- Posess the knowledge of specific tools and methods of Artificial Intelligence

Abilities:

- They are able to apply their mathematical, computer science and informatics skills in a novel way in order to solve tasks in IT research and development.
- They are able to formalize complex IT tasks, to identify and study their theoretical and practical background and then to solve them.

Attitude:

- They follow professional and technological developments in their IT field.
- They are committed to lifelong learning and are open to acquiring new IT competencies.

Autonomy, responsibility:

- They take responsibility for their professional decisions made in their IT-related activities.
- They undertake to meet deadlines and to have deadlines met.
- They bear responsibility for their own work as well as for the work of their colleagues they work together with in a project.
- Regarding mission critical IT systems, they can be entrusted with developing and operational responsibilities that are in accordance with their professional competencies.

Az oktatás tartalma angolul / Major topics:

1. Introduction to Decentralised Intelligence
    a. Concepts: Micro and Macro behavior, Emergence, etc.
    b. Problems: Selfish, local optimum vs Global optimum (examples: basic Prisoner Dilemma, Tragedy of Commons)
    c. Possible assumptions: cooperation vs competitiveness, rationality vs bounded rationality (the cases of limited information and limited processing power)

2. Methods to Study and their formalisms
    . Systems Dynamics (definitions, basic approach and diagrams, basic concepts: trajectory, equilibrium, dynamic equilibrium, chaotic systems). Lotka-Volterra model, Lorentz equations.
    a. Cellular Automata (definitions, 2D case, game of life, elementary CA)
    b. Agent-Based Modeling (definitions, explicit assumptions of limits to rationality and of interaction topoligy, examples)

3. Market Mechanisms, Market-Based Control
    a. Basic concepts and definitions (preferences, demand, supply, market equilibrium)
    b. The importance of heterogeneity (for basic market mechanisms), The Santa Fé Bar problem, The advantages of heterogeneity (Sycara).
    . The role of information, limited information situations. The Huber experiment. Zero Intelligence Agents.

4. Swarm Intelligence (Biologically inspired self-organisation)
    a. Biologically Inspired algorithms, the concept of stigmergy
        i. Termite nest building
        ii. Flocking / Swarming
        iii. Ant Sorting
        iv. Task Allocation in Social Insects
        v. Foraging Ants
    b. Generalizations
        i. Ant Colony Optimization
        i. Other variants

5. Evolutionary Game Theory
    a. Summary of Basic Game Theory Concepts (payoffs, games, dominance, equilibrium, Nash-equilibrium – complete information, full rationality)
    b. Cooperation and reciprocal altruism. Iterated Prisoner's Dilemma (concept, strategies, Axelrod tournaments). Evolutionary Iterated Prisoner's Dilemma. Spatially explicit models. Dependence on topology. Tagging.
    c. Evolutionary Stable Strategies (basic assumptions and definitions). Pure and mixed strategies. Games with more ESSs, games without ESS.
    d. Replicator dynamics The continuous and discrete replicator dynamics for pure strategies. Fixed points and their stability. Replicator dynamics in the case of mixed strategies.

6. Classic Interaction Topologies (Network Science primer)
    a. Basic concepts. The three levels of network statistics.
    b. Sparse networks. Short path lengths. The Erdős-Rényi model. Network transitivity. The Watts-Strogatz model. Degree distributions. The Barabási-Albert (Preferential Attachment) model.
    c. Network centralities (degree, closeness, betweenness, eigen vector centrality). Community detection and network clustering.

7. Implementation Theory / Mechanism Design
    . Mechanism design (concepts and definitions: social welfare function, preferences, assumption of rationality).
    a. Auctions. Examples: first-price auction, second-price auction, other examples. Revelation principle, incentive compatibility.

b. Single-dimensional mechanism design, surplus-optimal mechanism (VCG), revenue-optimal mechanism (Myerson).
c. Computational tractability. Approximations.

A számonkérés és értékelés rendszere angolul / Requirements and evaluation:

Mixed Assessment, Practice Grade

Irodalom / Literature:

- J.H.Holland, Hidden Order: How Adaptation Builds Complexity. Reading: AddisonWesley
- Miller, John & Page, Scott. (2007). Complex Adaptive System. An Introduction to Computational Models of Social Life. Complex Adaptive Systems: An Introduction to Computational Models of Social Life.
- Tilman Börgers: An Introduction to the Theory of Mechanism Design, Oxford University Press, 2015.
- Albert-László Barabási, M. Pósfai: Network Science, Cambridge University Press, Cambridge, 2016, http://networksciencebook.com/
- Sigmund, Karl. (2011). Introduction to evolutionary game theory. Evolutionary Game Dynamics. 69. 10.1090/psapm/069/2882632.