Course title: INTELLIGENT SYSTEMS

Lecturers	Full Prof. Božidar Kliček, Ph.D. Assoc. Prof. Dijana Oreški, Ph.D. Dunja Višnjić, M.Econ.
Language of instruction	Croatian and English
Study level	Master
Study programme	Databases and Knowledge Bases
Semester	3rd (winter)
ECTS	4
Goal	This course studies how to realize the intelligent behaviors of a computer. The ultimate goal of intelligent systems (IS) is to make a computer that can learn, plan, and solve problems autonomously. Although IS has been studied for more than half a century, we still cannot make a computer that is as intelligent as a human in all aspects. However, we do have many successful applications. In this course, we will study the most fundamental knowledge for understanding Artificial Intelligence. We will introduce some basic search algorithms for problem solving; knowledge representation and reasoning; pattern recognition; fuzzy logic; and neural networks.
General and specific learning outcomes	
Content	**1. Introduction** Overview of intelligent systems taxonomy, methods and architectures. **2. Formal methods, search methods and heuristics; genetic algorithms** Mathematical models, graphs and decision trees. Induction and search trees. Simple tree searching methods: first in depth, width and iterative deepening. Heuristic search. Partial search. Formal models of forward and backward chaining, conflict resolution, hybrid approaches. Optimization algorithms. Local minimum problem. Genetic algorithms: introduction, problem representation, description of algorithms, operations: selection, crossover, mutation. A typical example of genetic algorithm application, parameter variation. Technical resources for implementation. Variations of genetic algorithms. Parallel genetic algorithms. Comparison with other paradigms. **3. Uncertainty** The probability theory, the finite probability spaces, conditional probability and the Bayesian theorem, the independence of complex events, and random variables. Bayesian networks and directed acyclic graphs. Types of Bayesian Networks. Dempster-Schafer theory of belief. Fuzzy sets, fuzzy logic and fuzzy reasoning. 4. **Knowledge representation** Object oriented Systems. Encapsulation, binding variables, messages and call functions, framework-based systems. **5. Agents** Intelligent agents. Intelligent agents. Agents and Objects, Architecture, Multi-Agent Systems. Properties, structure, types, environment, environment description. **6. Learning**

	Symbolic learning. Induction. Decision trees learning. Case based reasoning: basics, calculation problems, modified metrics, choice of relevant features. **7. Neural networks** Neural Networks: biological and artificial neurons. Supervised learning (perceptron, single layer and multilayer), radial neurons, time delay networks. Neural networks for unsupervised learning. Overview of neural network models, fuzzy neural networks, hierarchical and modular networks. **8. Deep learning** Deep learning foundations. Technologies that are drivers of deep learning. **9. Big data** Big data characteristics. Understanding of 4V-s. Organization, analysis and interpretation of big data. **10. Artificial intelligence - the revolution of human society in the 21st century** What are the Artificial Intelligence perspectives? Will machines destroy us? Will we live in the "Matrix," like the toys in the hands of powerful computers and robots, whose future power can not even be considered? Or will humanity enjoy the benefits of the new technological revolution?
Exercises	**1. Chaining and searching** Techniques for searching. Heuristic search. Backward and forward chaining – benefits and limitations. Comparison of chaining approaches. **2. Genetic algorithms** Introduction to genetic algorithm theory. Basic concepts - chromosomes, genes, genotypes, generations, fitness functions, reproductions, crossings, mutations. Genetic algorithms development phases - an overview of possible solutions to problems over the chromosomes, generating more generations of chromosomes, chromosome efficiency, random selection. Analysis of a simple example of using genetic algorithms. Accounting Tasks. Creating a example of genetic algorithms - XpertRule Knowledge Builder. Determining the variables. Defining attributes. Making a procedure. Connecting variables and genetic algorithms through procedures. Making decision trees. The optimization. Programming Tasks. Optimization with genetic algorithms. Creating Complex Programming Examples - XpertRule Knowledge Builder. **3. Uncertainty – Bayesian nets** Bayesian theorem. Belief measures – characteristics. Example of mathematical calculations. **4. Uncertainty factors** Definition of fuzzy variables. Differences between uncertainty and fuzzy variables. Impact of uncertainty on reasoning. Operations with fuzzy variables. Examples and case studies. **5. Big data** Overview of tools for storage, visualization and analysis of big data. **6. Neural networks** Neural networks principles. Basic terminology - neurons, input and output layers, weights, internal activation, sigmoid, tanh. Matematical models of neural networks.

	Neural networks modeling in BigML tool. Back-propagation algorithm. Multilayer network. Unsupervised learning. Training and testing of network. Learning of networks. Parameters of learning. Unsupervised and supervised learning. Neural networks learning tools. Learning and testing. Determination and initialization of weights in the network. Setting up learning parameters and checking learning outcomes. Network optimization. **7. Deep learning** Deep learning basics. Technologies for deep learning. Overview of principles and tools for deep learning. **8. Python for Data science** Python specifics for big data analytics. Lists in Python. Functions and pacakages. NumPy. Jupyter notebooks. Pandas. Matplotlib. Git.
Realization and examination	Classes: lectures and exercises
Related courses	1. Foundations of AI, Albert-Ludwigs-Universität Freiburg, Institut für Informatik
Literature	Basic: Luger, G.F. Artifical intelligence: structures and strategies for complex problem solving. 6th ed., Pearson Addison Wesley, Boston, 2009. Munakata, T. Fundamentals of the new artificial intelligence: neural, evolutionary, fuzzy and more. 2nd ed., Springer, London, 2008. Hopgood, A.A. Intelligent Systems for Engineers and Scientists. 2nd ed., CRS, Boca Raton, 2000. Additional: Proceedings of the AAAI National Conference on Artificial Intelligence Proceedings of the AAAI Innovative Applications of Artificial Intelligence Conference Proceedings of the Florida AI Research Symposium Conferences (FLAIRS) Proceedings of the Knowledge Discovery and Data Mining Conference