Intelligent Control Systems

COURSE SYLLABUS

Code and name of specialty	122 – Computer Science	**Institute**	**Computer Sciences and Software Engineering**
Program name	Computer Science and intelligence systems	**Department**	Software Engineering and Management Information Technologies
Type of program	**Educational and Professional**	**Language of instruction**	**Ukrainian**

LECTURER

Nikulina Olena Mykolayivna Olena.Nikulina@khpi.edu.eu

Doctor of Technical Sciences, Associate Professor, Professor of Software Engineering and Management Information Technologies Department. Number of scientific and educational publications – 90. (h-index = 5, i10-index = 2 in Google Scholar - https://scholar.google.com/citations?hl=en&user=ZEe2GlcAAAAJ&view_op=list_works&sortby=title; ORCID ID-https://orcid.org/0000-0003-2938-4215, Scopus ID-57203114988).

Leading lecturer of the courses: *Object-Oriented Programming (Bachelors) (Ukrainian), Numerical Methods (Bachelors) (Ukrainian), Operations Research (Bachelors) (Ukrainian), Intelligent Control Systems (Bachelors), Distributed Computing Models and Software (PhD) (Ukrainian)*

GENERAL DESCRIPTION OF THE COURSE

Summary	The course "Intelligent Control Systems" is a course in the cycle of professional compulsory training of the specialty 122 "Computer Science". It is taught in the fourth semester in the amount of 120 hours (4 ECTS credits), in particular: lectures – 20 hours, laboratory classes – 10 hours, independent work – 90 hours. There are no individual tasks. The study of the discipline ends with the exam. The discipline is interrelated with such disciplines as "Discrete Mathematics", "Operations Research", "Decision Theory" and "Methods of Computational Intelligence".
Course objectives	To acquaint students with the basic approaches to solving intellectual problems, to form the development of basic principles of construction and operation of intelligent systems, to develop skills and abilities to choose methods for solving typical intellectual problems, to acquaint with the basic principles of construction and functioning of intelligent control systems.
Types of classes and control	Lectures, Laboratory work, control works, consultations. The course ends with a final exam
Term	8

Student workload (credits) / Type of course	4 / Mandatory	**Lectures (hours)**	20	**Workshops (hours)**	10	**Self-study (hours)**	90

Program competences	GC1. Ability to abstract thinking, analysis and synthesis. GC2. Ability to apply knowledge in practical situations. GC3. Knowledge and understanding of the subject area and understanding of professional activity. GC6. Ability to learn and master modern knowledge.

	GC7. Ability to search, process and analyze information from various sources. PC2. Ability to detect statistical patterns of non-deterministic phenomena, the use of computational intelligence methods, including statistical, neural network and fuzzy data processing, machine learning and genetic programming methods, etc. PC3. Ability to think logically, build logical conclusions, use formal languages and models of algorithmic calculations, design, development and analysis of algorithms, evaluate their efficiency and complexity, solvability and unsolvability of algorithmic problems for adequate modeling of subject areas and creation of software and information systems. PC5. Ability to provide a formalized description of operations research tasks in organizational, technical, and socio-economic systems for different purposes, to determine their optimal solutions, to build optimal management models taking into account changes in the economic situation, to optimize management processes in different systems and hierarchies. PC6. Ability to think systematically, apply the systems analysis methodology to study complex problems of different nature, methods of formalization and solution of system problems with conflicting goals, uncertainties, and risks. PC7. Ability to apply the theoretical and practical basics of methotodology and modeling technology to study the characteristics and behavior of complex objects and systems, to conduct computational experiments with processing and of results. PC11 Ability to conduct intelligent data analysis based on methods of computational intelligence, including large and poorly structured data, their operational processing and visualization of analysis results in the process of solving applied problems. PC15. Ability to analyze and perform functional modelling of business processes, construction and practical application of functional models of organizational, economic, and production-technical systems, methods of risk assessment of their design. PC17. Ability to apply the theoretical and practical basics of modern management theory for complex organizational, technical and socio-economic systems to build intelligent management systems, in the process of designing intelligent systems to use modern information processing technologies and methods of computational intelligence. PC18. Ability to apply modern methods of decision-making theory, including methods of ranking, formation, and coordination of collective expert assessments, multi-criteria optimization etc., to build intelligent management systems. PC19. Ability to comprehensively use for the creation of intelligent management systems methods of mathematical modelling and analysis of complex systems, methods of modelling and analysis of business processes, information technologies for the management of business systems. PC20. Ability to develop the architecture of software systems and their particular components during the design of intelligent management systems in various fields, to manage the life cycle of intelligent management systems software.

Learning outcomes	Teaching and learning methods	Forms of assessment (continuous assessment CAS, final assessment FAS)
PLO1. Apply knowledge of the fundamental forms and laws of abstract-logical thinking, the basics of the methodology of scientific knowledge, forms and methods of extraction, analysis, processing, and synthesis of information in the subject area of computer science.	Interactive lectures with presentations, discussions, practical classes, teamwork, case method, method of feedback from students, problem-based learning	Written individual assignments for laboratory work (CAS), assessment of knowledge in laboratory classes (CAS), express survey (CAS), final / semester control in the form of a semester exam, according to the schedule of the educational process (FAS)
PLO3. Use knowledge of the laws of random phenomena, their properties and operations with them, models of random processes, and modern software environments to solve problems of statistical data processing and construction of predictive models.	Interactive lectures with presentations, discussions, practical classes, teamwork, case method, method of feedback from students, problem-based learning	Written individual assignments for laboratory work (CAS), assessment of knowledge in laboratory classes (CAS), collection of data on individual assignments and reporting on research results (CAS), final / semester control in the form of a semester exam, according to the learning process schedule (FAS)
PLO4. Use methods of computational intelligence, machine learning, neural network, and fuzzy data	Interactive lectures with presentations, discussions, practical classes, teamwork, case	Written individual assignments for laboratory work (CAS), assessment of knowledge in laboratory classes (CAS), collection of data on individual assignments and reporting on research

processing, genetic and evolutionary programming to solve problems of recognition, prediction, classification, identification of management objects, etc.	method, research, project training	results (CAS), final / semester control in the form of a semester exam, according to the learning process schedule (FAS)
PLO7. Understand the principles of modelling organizational and technical systems and operations; use methods of operations research, solve single- and multicriteria optimization problems of linear, integer, nonlinear, stochastic programming.	Interactive lectures with presentations, discussions, practical classes, teamwork, case method, research, project training	Written individual assignments for laboratory work (CAS), assessment of knowledge in laboratory classes (CAS), collection of data on individual assignments and reporting on research results (CAS), final / semester control in the form of a semester exam, according to the learning process schedule (FAS)
PLO8. Use the methodology of system analysis of objects, processes, and systems for the tasks of analysis, prediction, management, and design of dynamic processes in macroeconomic, technical, technological, and financial objects.	Interactive lectures with presentations, discussions, practical classes, teamwork, case method, research, project training	Written individual assignments for laboratory work (CAS), assessment of knowledge in laboratory classes (CAS), collection of data on individual assignments and reporting on research results (CAS), final / semester control in the form of a semester exam, according to the learning process schedule (FAS)
PLO12 Apply methods and algorithms of computational intelligence and intelligent data analysis in the tasks of classification, prediction, cluster analysis, search for associative rules using software tools to support multidimensional data analysis based on technologies DataMining, TextMining, WebMining.	Interactive lectures with presentations, discussions, practical classes, teamwork, case method, research, project training	Written individual assignments for laboratory work (CAS), assessment of knowledge in laboratory classes (CAS), collection of data on individual assignments and reporting on research results (CAS), final / semester control in the form of a semester exam, according to the learning process schedule (FAS)
PLO14 Apply knowledge of methodology and CASE tools for designing complex systems, methods of structural analysis of systems, object-oriented design methodology in the development and study of functional models of organizational-economic and production-technical systems.	Interactive lectures with presentations, discussions, practical classes, teamwork, case method, research, project training	Written individual assignments for laboratory work (CAS), assessment of knowledge in laboratory classes (CAS), collection of data on individual assignments and reporting on research results (CAS), final / semester control in the form of a semester exam, according to the learning process schedule (FAS)
PLO17 Apply for the construction of intelligent management systems theoretical and practical foundations of modern management theory, design intelligent systems using modern information processing technologies and methods of computational intelligence.	Interactive lectures with presentations, discussions, practical classes, teamwork, case method, research, project training	Written individual assignments for laboratory work (CAS), assessment of knowledge in laboratory classes (CAS), collection of data on individual assignments and reporting on research results (CAS), final / semester control in the form of a semester exam, according to the learning process schedule (FAS)
PLO19. Create intelligent management systems using methods of mathematical modeling and analysis of complex systems, methods of modeling and analysis of business processes, information technologies for the management of business systems.	Interactive lectures with presentations, discussions, practical classes, teamwork, case method, research, project training	Written individual assignments for laboratory work (CAS), assessment of knowledge in laboratory classes (CAS), collection of data on individual assignments and reporting on research results (CAS), final / semester control in the form of a semester exam, according to the learning process schedule (FAS)
PLO20 Develop the architecture of software systems and their particular components during the construction of intelligent management systems in various fields, as well as manage the life cycle of intelligent management systems software.	Interactive lectures with presentations, discussions, practical classes, teamwork, case method, research, project training	Written individual assignments for laboratory work (CAS), assessment of knowledge in laboratory classes (CAS), collection of data on individual assignments and reporting on research results (CAS), final / semester control in the form of a semester exam, according to the learning process schedule (FAS)

ASSESSMENT AND GRADING

Ranges of points corresponding to grades

Total score (points) for all types of learning activities	ECTS grading scale	The national grading scale
90-100	A	excellent
82-89	B	good
74-81	C	
64-73	D	satisfactory
60-63	E	
35-59	FX	Unsatisfactory (with the exam retake option)
0-34	F	Unsatisfactory (with mandatory repetition of the course)

Allocation of grade points

100% **final assessment** in the form of exam (30%) and current assessment (70%).
30% **exam**: semester exam, according to the schedule of the educational process
70% **continuous assessment**:
• 40% assessment of tasks in laboratory work;
• 30% intermediate control (3 control works)

Course policy

Follow the rules of the University internal regulations. Take an active part in the learning process. Students must attend all classes according to the study schedule and adhere to the norms of academic ethics. To study the course, students need to have their personal computer and (or) use computers of the computer center at the department. Students must work with compulsory and recommended reading, including Internet resources. Students must complete and submit all laboratory works during the semester in which the course is taught, before the examination session. The final assessment is not carried out without the personal presence of students.

COURSE STRUCTURE AND CONTENT

Lecture 1	Basic concepts. Definition and history of origin. Examples of intellectual problems. General characteristics of intelligent systems. Characteristics of algorithmic and declarative approaches. Quasi-algorithms and main sources of quasi-algorithmicity	**Laboratory work 1**	Implementation of the salesman's task using the ant algorithm	**Self-Study**	Salesman task model
Lecture 2	Purpose and tasks of object management. The concept of control object. Principles of building control systems. Architecture of control systems				Swarm optimization algorithms
Lecture 3	Modeling of control objects. General principles of modeling control systems. General structures of control systems. Modeling of regulators. Modeling of control systems with different regulators.	**Laboratory work 2**	Automated adjustment of the PID controller using the Simulink software package		Sensory information processing and natural language interface in intelligent control systems.
Lecture 4	Definition of intelligent system. A typical scheme of functioning of an				Hybrid intelligent control systems

	intelligent system. Representation of knowledge in intelligent systems.				Principles of construction of neuro-fuzzy regulators
Lecture 5	Approaches to knowledge representation. Verbal-deductive definition of knowledge. Expert systems. Data and knowledge. Properties and models of knowledge.	**Laboratory work 3**	Development of elements of an expert system that implements direct and inverse derivation		Soft calculations. Computational intelligence
Lecture 6	Logical models and method of resolutions. Automatic proof of theorems and the principle of resolutions. The concept of logical programming.				Frames The relationship between semantic networks and frames
Lecture 7	Production models. General characteristics. The case of fuzzy production rules.	**Laboratory work 4**	Forming a set of input and output linguistic variables of a fuzzy control system using Fuzzy Logic Toolbox		Intellectual works. Intelligent systems in modern robotics
Lecture 8	Principles of training and setting up intelligent control systems. Optimization of control system parameters using genetic algorithms.				Intelligent virtual reality systems
Lecture 9	Intelligent control systems using fuzzy logic. Features of fuzzy inference in control problems of complex dynamic objects.	**Laboratory work 5**	Construction of a fuzzy control system using Fuzzy Logic Toolbox		Fundamentals of cognitive modeling. Cognitive modeling procedures software.
Lecture 10	General principles of constructing fuzzy algorithms for managing dynamic objects. Procedure for the synthesis of fuzzy regulators.				Construction and analysis of the stability of fuzzy cognitive maps. Use fuzzy cognitive maps for decision making.
RECOMMENDED READING					

Compulsory	1. Russell S., Norvig P. (2006) Artificial intelligence. Modern approach. Moscow 2. Subbotin S.O.(2018) Presentation and processing of knowledge in artificial intelligence systems and decision support. Zaporozhye: ZNTU 3. Rudenko O.G., Bodyansky E.V.(2016) Artificial neural networks: Textbook. Kharkiv: SMIT Company LLC 4. Kotsovsky V.M. (2016) Methods and systems of artificial intelligence Lecture notes. Uzhhorod, 5. Yampolsky L.S., Lisovichenko O.I. Oiler. V.V. (2016) Neurotechnologies and neurocomputer systems: a textbook / К : «Дорадо-Друк» 6. Ertel WIntroduction to Artificial Intelligence Springer. International Publishing AG, (2017)	**Recommended**	1. Dorofeev Y.I. (2009) Methodical instructions for laboratory classes in the discipline "Expert systems and knowledge bases" for students majoring in 7.080201 "Informatics", 7.080202 "Applied Mathematics", 7.080203 "System Analysis and Management" - Kharkiv: NTU "KhPI". 2. Dorofeev Y.I. (2009) Methodical instructions for laboratory classes in the discipline "Artificial Intelligence Systems" for students of "Applied Mathematics", "Systems Analysis" and "Informatics" - Kharkiv: NTU "KhPI". 3. Zvenigorodsky A.S., Katkov Y.I.(2019) Methodical instructions for practical classes in the discipline "Artificial Intelligence" for students majoring in: 121 Software Engineering, 123 Computer Engineering, 124 System Analysis, 125 Cybersecurity, 126 Information systems and technologies of all forms of education: Kyiv: DUT. 4. Zhukovsky V.V. (2016) Methodical instructions for laboratory work in the discipline "Fundamentals of designing artificial intelligence systems and pattern recognition" for students majoring in 113 "Applied Mathematics", 122 "Computer Science and Information Technology". - Rivne, NUVGP 5. Glybovets M.M., Oletsky O.V.(2017) Artificial intelligence systems: textbook. pos. -Kyiv: ed. "KM Academy"

ACADEMIC INTEGRITY

Students are expected to adhere to the Code of Ethics of Academic Relations and Integrity of NTU “KhPI”.

The content of this syllabus is consistent with the course program.