Załącznik Nr 5 do Zarz. Nr 33/11/12

Z1-PU7	WYDANIE N1	Strona 1 z 3

(*faculty stamp*)

COURSE DESCRIPTION

1. Course title: HIERARCHICAL CONTROL	**2. Course code**
3. Validity of course description: 2012/2013	
4. Level of studies: 1st cycle of higher education	
5. Mode of studies: intramural studies	
6. Field of study: MACROCOURSE	(FACULTY SYMBOL)
7. Profile of studies:	
8. Programme: Automatic Control	
9. Semester: 7	
10. Faculty teaching the course: Institute of Automatic Control, RAu1	
11. Course instructor: dr hab. Krzysztof Fujarewicz	
12. Course classification: common courses	
13. Course status: compulsory	
14. Language of instruction: English	
15. Pre-requisite qualifications: Students should have completed courses of: Mathematical analysis, Optimization and decision making, Control fundamentals.	
16. Course objectives: This course is addressed to students interested in systems analysis, control engineering, management and decision making. It covers basic methods used in solving control and optimization problems associated with large-scale and complex systems. After completing the course student has basic knowledge in optimization and control of large scale systems. This knowledge consists of methods of analysis of composite systems, solving structured optimization problems and designing hierarchical and decentralized feedback systems.	

17. Description of learning outcomes:

Nr	Learning outcomes description	Method of assessment	Teaching methods	Learning outcomes reference code
1.	Students understand terms: large-scale system, complex system, hierarchical structure, and know basic structures of control and optimization of complex systems.	SP	WT, WM	T1A_W02, T1A_W03,
2.	Students know methods of mathematical description of complex systems and they are able to numerically model and simulate such systems.	SP	WT, WM	T1A_U01, T1A_U02, T1A_U09.
3.	Students know how to decompose given complex optimization problem and apply the direct (parametric) method of coordination.	CL, PS	L	T1A_U01, T1A_U02, T1A_U03, T1A_U15.
4.	Students can decompose given complex optimization problem and apply the price method of coordination.	CL, PS	L	T1A_U06, T1A_U07.
5.	Students can perform the sensitivity analysis of a given complex system.	CL, PS	L	T1A_U04, T1A_U06.
6.	Students can apply the sensitivity analysis to solve problems of parameter estimation and control optimization for complex and non-linear systems.	CL, PS	L	T1A_U01, T1A_U02, T1A_U09.

7.	Students understand differences between problems of control and optimization for simple and complex structures.	SP	WT, WM	T1A_K01, T1A_K03.

18. Teaching modes and hours

Lecture: 30 hours, Laboratory: 30 hours

19. Syllabus description:

Lectures:

Introduction and the terminology. Large scale systems, complex systems, decomposition coordina-tion. Different types of hierarchical structures: multilayer structure and multilevel structure.

Mathematical models of systems. Static models. Mathematical model of the planning problem for the oil refinery. Dynamical models. Concentrated-parameter models and distributed-parameter models.

Stirred-tank continuous-flow reactor. Types of variables in hierarchical structures: state variables, manipulated and input variables. Constraints. Description of complex systems, subsystems, the structure matrix. Static characteristics.

Multilayer systems. Decomposition. Stabilization layer and its structure: output and control variables, assignment of variables. Multilayer structure of control and optimization for continuous-flow reactor.

Multilevel optimization systems. Simplex method. Decomposition of linear programming problems, Dantzig-Wolf method. Decomposition and coordination in nonlinear static optimization problems. Direct method of coordination. Induced constraints. Direct method with penalty function. The price method. Dynamic programming. Mixed methods.

Identification and optimization of nonlinear dynamical systems. Sensitivity analysis. Gradient derivation. Adjoint systems. Gradient calculation with the adjoint system. Neural models. Hybrid models. Gradient-based identification and optimization of complex nonlinear systems.

Laboratory:

Exercise 1. Continuous-flow reactor.

The aim of the exercise is modeling of a stirred-tank continuous-flow reactor, finding its static characteristics, and designing control system for the reactor.

Exercice 2. Oil refinery optimization

The aim of the exercise is to solve the problem of optimal production in an oil refinery. The problem is formulated as a linear programming (LP) problem which is solved using Matlab software.

Exercise 3. Direct method of coordination

The aim of the laboratory exercise is to apply the direct method of coordination to a complex static system composed of three cross-coupled subsystems.

Exercise 4. Price method of coordination

The aim of the laboratory exercise is to apply the price method of coordaination to a complex static system composed of three crosscoupled subsystems.

Exercise 5. Dynamic programming

The aim of the exercise is to apply dynamic programming method in order to optimize an example of multistage process.

Exercise 6. Identification of complex systems

Students make use of the sensitivity analysis to parameter estimation of nonlinear Hammerstein model.

Exercise 7. Control of complex systems I

During the laboratory students perform gradient-based optimization of close-loop control system.

Exercise 8. Control of complex systems Students make use of the adjoint sensitivity analysis in order to gradient-based optimization of a control signal for given non-linear system.

20. Examination: without an exam

21. Primary sources:

- L.S. Lasdon, Optimization theory for large systems, Mac-Millan, 1970.
- H. Tamura, T Yoshikawa, (eds.) Large-scale systems. Control and decision making, Marcel Dekker, 1990.
- J. Lunze, Feedback control of large-scale systems, Springer-Verlag, 1992.
- W. Findeisen, Wielopoziomowe układy sterowania, PWN 1974. (In Polish)

22. Secondary sources:

- Cruz J. B. (Ed.), System sensitivity analysis, Benchmark papers in electrical engineering and computer science, Dowden, Hutchinson & Ross, Inc., Stroudsburg, 1973.

23. Total workload required to achieve learning outcomes

Lp.	Teaching mode :	Contact hours / Student workload hours
1	Lecture	30/15
2	Classes	/
3	Laboratory	30/15
4	Project	/
5	BA/ MA Seminar	/
6	Other	/
	Total number of hours	60/30

24. Total hours:90

25. Number of ECTS credits: 3

26. Number of ECTS credits allocated for contact hours: 1

27. Number of ECTS credits allocated for in-practice hours (laboratory classes, projects): 2

26. Comments:

Approved:

…………………………… *(date, Instructor's signature)*

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