Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Cybernetics and Robotics (K29W12ND02)

SUBJECT CARD

Name of subject in Polish: **Modelowanie i identyfikacja**
Name of subject in English: **Modeling and identification**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **obligatory**
Subject code: **W12AIR-SM0711**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		30		
Number of hours of total student workload (CNPS)	90		60		
Form of crediting	Crediting with grade		Crediting with grade		
For group of courses mark (X) the final course					
Number of ECTS points	3		2		
including number of ECTS points for practical (P) classes			2.0		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	2.0		1.6		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. None

SUBJECT OBJECTIVES
C1. Gaining the knowledge about generation of pseudo-random numbers
C2. Gaining the knowledge about foundations of estimation theory and assessment of estimation quality
C3. Learning parametric and nonparametric methods of estimation of the probability density function and the regression function
C4. Learning identification methods of linear dynamic systems excited and disturbed by random signals
C5. Learning the least squares method, its properties, scope of applicability and numerical procedures
C6. Learning the instrumental variables method, and procedures of generation of instruments
C7. Learning selected method of identification of block-oriented (Hammerstein and Wiener) systems
C8. Introduction to 'System Identification Toolbox' of Matlab

SUBJECT LEARNING OUTCOMES
Relating to knowledge:
PEU_W01 - knows the methods of computer modeling of random environment
PEU_W02 - knows parametric and nonparametric algorithms of synthesis of linear and nonlinear systems on the basis of uncertain data
PEU_W03 - knows computer realizations of typical methods of system identification
PEU_W04 - knows the methods of generation of random numbers
PEU_W05 - knows selected methods of identification of block-oriented (Hammerstein and Wiener) systems
Relating to skills:
PEU_U01 - can use measurement data for building and testing models of linearand nonlinear plants under various prior knowledge
PEU_U02 - can forecast time series on the basis of collected data
PEU_U03 - can select suitable model for data
PEU_U04 - can conduct experimental analyses using dedicated software
Relating to social competences:
PEU_K01 - is aware of the importance of the ability of data searching and analysis
PEU_K02 - understand the necessity of further self-education and broadening knowledge and skills

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Random number generation by the inversion method	2
Lec2	Random number generation by the rejection method	2
Lec3	Estimation theory, quality of the estimate, limit theorems, types of probabilistic convergence. Parametric and nonparametric approach	2
Lec4	Nonparametric estimation of the distribution function	2
Lec5	Nonparametric estimation of the probability density function	2
Lec6	Regression function estimation – kernel method	2
Lec7	Regression function estimation – orthogonal expansion method	2
Lec8	Identification of linear dynamic systems. Least squares method - synthesis.	2

Lec9	Least squares method – properties	2
Lec10	Least squares method – recursive version	2
Lec11	Linear system excited by random signal. Cross-correlation analysis. Inverse filtering. Gauss-Markov estimate.	2
Lec12	Instrumental variables method	2
Lec13	Computational algorithms of the least square s method (spectral analysis, LU and SVD decomposition)	2
Lec14	Hammerstein and Wiener systems	2
Lec15	Summary	2
	Total hours:	30

Laboratory		**Number of hours**
Lab1	Generation of random numbers – inverse method	2
Lab2	Generation of random numbers – rejection method	2
Lab3	Estimation, limit theorems, mean and sample median and their properties	2
Lab4	Nonparametric identification of distribution function	2
Lab5	Nonparametric identification of probability density function	2
Lab6	Regression function estimation. Kernel method	2
Lab7	Regression function estimation. Orthogonal expanssion method	2
Lab8	Identification of linear systems by the least squares method	2
Lab9	Recursive least squares method	2
Lab10	Cross-correlation analysis, inverse filtering. Gauss-Markov estimate	2
Lab11	Instrumental variables method	2
Lab12	Computational algorithms of the least squares method (spectral analysis, LU and SVD decomposition)	2
Lab13	Hammerstein system	2
Lab14	Wiener system	2
Lab15	Summary	2
	Total hours:	30

TEACHING TOOLS USED
N1. traditional lecture using video projector
N2. laboratory classes
N3. Consultations
N4. independent work - self study and preparation for the final exam
N5. independent work - preparation for the laboratory classes

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01 ÷ PEU_W05	final written exam

F2	PEU_U01 ÷ PEU_U04 PEU_K01 ÷ PEU_K02	Written tests, Observation on the laboratory, Written reports
P(Lecture) = F1, P(Laboratory)= F2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Greblicki, Pawlak – „Nonlinear system identification", Cambridge 2008.
[2] Kincaid, Cheney — "Analiza numeryczna", WNT Warszawa, 2006.
[3] Ljung "System Identification - Theory For the User"
[4] Söderström, Stoica — "Identyfikacja systemów", WNT, Warszawa 1997. wersja angielska: "System identification", Prentice Hall, 1989.
[5] http://diuna.ict.pwr.wroc.pl
[6] L. Ljung, System identification: Theory for the user, Peorson Education (US), 2008
[7] R. Pintelon and J. Schoukens. System Identification: A Frequency Domain Approach. Wiley-IEEE Press, 2004.
[8] J. Schoukens, Mastering System Identification in 100 Exercises , Wiley, 2012.

SECONDARY LITERATURE:

[1] Chow, Teicher — "Probability theory"
[2] Strang — "Introduction to linear algebra"
[3] Hannan, Deistler — "The statistical theory of linear systems"

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)

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