Syllabus

1. Data about the program of study

1.1 Institution	Technical University of Cluj-Napoca
1.2 Faculty	Automation and Computer Science
1.3 Departament	Automation
1.4 Field of study	Systems Engineering
1.5 Cycle of study	Bachelor of Science
1.6 Program of study/Qualification	Automation and Applied Informatics (English)
1.7 Form of education	Full time
1.8 Subject code	34.00

2. Data about the subject

2.1 Subject name	***System identification***				
2.2 Course responsible/lecturer	Prof. dr. ing. Lucian Busoniu – Lucian.Busoniu@aut.utcluj.ro				
2.3 Teachers in charge of applications	Prof. dr. ing. Lucian Busoniu – Lucian.Busoniu@aut.utcluj.ro Assist. Dr. ing. Zoltan Nagy – Zoltan.Nagy@aut.utcluj.ro				
2.4 Year of study	3	2.5 Semester	1	2.6 Assessment *(E/C/V)*	E
2.7 Type of subject	*DF – fundamental, DID – in the field, DS – specialty, DC – complementary*				DD, DI
	DOB – compulsory, DOP – elective, FAC – optional				DOB

3. Estimated total time

3.1 Number of hours per week	5	of which:	Course	2	Seminar	0	Laboratory	2	Project	1
3.2 Number of hours per semester	70	of which:	course	28	Seminar	0	Laboratory	28	Project	14
3.3 Individual study										
(a) Manual, lecture material and notes, bibliography										20
(b) Supplementary study in the library, online and in the field										10
(c) Preparation for seminars/laboratory works, homework, reports, portfolios, essays										10
(d) Tutoring										2
(e) Exams and tests										3
(f) Other activities:										10

3.4 Total hours of individual study (sum of (3.3(a)…3.3(f)))	55
3.5 Total hours per semester (3.2+3.4)	125
3.6 Number of credit points	5

4. Pre-requisites (where appropriate)

4.1 Curriculum	Physics; Electrotechnics; Basics of electronic circuits; Mechanics; Mathematical analysis; Process modeling; System theory
4.2 Competence	Special mathematics; Linear algebra and analytical geometry; Numerical calculus; Programming and experimental competencies, Analytical spirit

5. Requirements (where appropriate)

5.1. For the course	Exposition, questions, discussions
5.2. For the applications	Solving the laboratory assignments is mandatory

6. Specific competences

6.1 Professional competences	C3. Fundamental usage of automation, modeling, simulation, identification and analysis of systems; of computer-assisted design techniques C3.1 Identification of fundamental concepts of systems theory, of control engineering, of basic principles of modeling and simulation, as well as system analysis techniques, with the goal of explaining the fundamental problems in the field.
6.2 Cross competences	

7. Course objectives

7.1 General objective	The student will be formed to choose and apply system identification methods in MATLAB, given an unknown system
7.2 Specific objectives	The student will have the following skills: - use the concept of dynamical model for control - choose the experiment and input signal - choose model type and order - identify model parameters from experimental data - validate the model and select the best model among several alternatives

8. Contents

8.1 Lecture	No.hours	Teaching methods	Notes
1. Foundations of system identification (dynamical models for control)	2	- Exposition using the videoprojector and the board - Interactive questions and exercises - Discussions with students - Optional lecture quizzes	
2. Identification of first and second order systems from the step response (zero and non-zero initial conditions)	2		
2. Identification of first and second order systems from the impulse response (zero and non-zero initial conditions)	2		
4. Mathematical foundations: Linear regression and statistics	2		
5. Identification of higher order systems, e.g. using correlation analysis	2		
6. Prediction error methods: ARX identification	2		
7. Input signals (PRBS, multisine)	2		
8. Prediction error methods: model structures and identification procedure	2		
9. Prediction error methods: identification procedure; optimization	2		
10. Instrumental variable methods	2		
11. Advanced identification techniques: state-space or closed-loop identification	2		
12. Recursive identification	2		
13. Model validation	2		
14. Practical considerations and case study	2		

Bibliography *(minimal bibliography of the subject containing at least one bibliographical reference work of the subject, which is available to students in an appropriate number of copies)*

1.Eykhoff P. System Identification: Parameter and State Estimation. John Wiley, London, 1974.
2.Goodwin G.C., Payne R.L. Dynamic System Identification: Experiment Design and Data Analysis. Academuc Press,
3.New York, 1984.
4.Isermann R. Special Issue on System Identification. Automatica, 17(1), 1981.
5.Söderström T., Stoica P. System Identification. Prentice Hall Inc., Hertfodshire, 1989. Disponibilă online: http://user.it.uu.se/~ts/bookinfo.html
6.Ljung L. System Identification - Theory for the User. Prentice Hall, New York, 2006.
7.Landau I.D. Adaptive Control - The Model Reference Approach. Dekker, New York, 1979.
8.Ljung L., Söderström T. Theory and Practice of Recursive Identification. MIT Press, Cambridge, Massachusetts, 1983.
9.Landau I.D. Lecture Notes on Adaptive Control. University of California, Continuing Education in Engineering, Berkeley, California, 1983.
10.Goodwin G.C., Sin K.S. Adaptive Filtering Prediction and Control. Prentice Hall, New Jersey, 1984.
11.Landau I.D. A Feedback System Approach to Adaptive Filtering. IEEE Trans. on Information Theory, April, 1984.

8.2 Aplications (seminar/laboratory/project)	No.hours	Teaching methods	Notes
Using MATLAB/SCILAB for identification experiments	2	- Lab quizzes - Matlab/Simulink implementation - Testing/validation with the help of physical systems	
Identification of first and second order systems from the step response	2		
Identification of first and second order systems from the impulse response	2		
Mathematical foundations	2		

Identification of higher order systems using e.g. correlation analysis	2	- Verification and discussions of solutions with students	
The ARX method	2		
Input generation and analysis for identification of parametric patterns (pseudo binary random signal)	2		
Pre-processing of experimental data to identify parametric models	2		
Identification of output error models with the Gauss-Newton method	2		
The instrumental variables method	2		
Identification in state space or closed loop	2		
The recursive least squares method	2		
Identification of dead time systems and validation of models	2		
Practical considerations and parameter estimation in a case study	2		
Project: Identify the corresponding dynamic model of a nonlinear system (and the necessary regression fundamentals), an electrical circuit, or a brushless DC motor driven in-plane positioning system (control signal generation, data acquisition, model structure determination, parameter estimation and model validation)	14		

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1.Ljung L. System Identification - Theory for the User. Prentice Hall, New York, 2006.
2.Söderström T., Stoica P. System Identification. Prentice Hall Inc., Hertfodshire, 1989. Disponibilă online: http://user.it.uu.se/~ts/bookinfo.html
3.Landau I.D. Adaptive Control - The Model Reference Approach. Dekker, New York, 1979.
4.Ljung L., Söderström T. Theory and Practice of Recursive Identification. MIT Press, Cambridge, Massachusetts, 1983.

9. Bridging course contents with the expectations of the representatives of the community, professional associations and employers in the field

Laboratory work focused in the fields of interest of companies active in the local/regional market.
Identification methods are a prerequisite for the application of automation: system analysis, controller design, state feedback controllers, etc. These considerations apply to both industry and R&D.

10. Evaluation

Activity type	Assessment criteria	Assessment methods	Weight in the final grade
Course	Correct solution of proposed problems	A combination of the following: written exam, online exam, online quiz, lecture homework	30-60%
Seminar	N/A	N/A	N/A
Laboratory	Using Matlab/Scilab for identification	A combination of the following: lab activity, validated lab solutions; anti-plagiarism check; lab test; lab quizzes	20-40%
Project	Practical experience	Project report and/or presentation	20-30%
Minimum standard of performance: labs and project solved correctly and originally, rounded combined grade at exam, lab tests, and project at least 5			

Date of filling in:		Title Firstname NAME	Signature
20.03.2023	Course	Prof. dr. eng. Lucian Busoniu	
	Aplications	Prof. dr. eng. Lucian Busoniu	

Date of approval by the Department Board _____	Head of Departament Prof.dr.ing. Honoriu VĂLEAN
Date of approval by the Faculty Council _____	Dean Prof.dr.ing. Liviu Cristian MICLEA