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 Codul disciplinei	56.10

2. Data about the subject

2.1 Subject name	Estimators in dynamic systems control				
2.2 Course responsible/lecturer	Zsófia Lendek, Zsofia.lendek@aut.utcluj.ro				
2.3 Teachers in charge of applications	Zsófia Lendek, Zsofia.lendek@aut.utcluj.ro				
2.4 Year of study	4	2.5 Semester	2	2.6 Assessment *(E/C/V)*	C
2.7 Type of subject	*DF – fundamental, DID – in the field, DS – specialty, DC – complementary*				DS
	DOB – compulsory, DOP – elective, FAC – optional				DO

3. Estimated total time

3.1 Number of hours per week	4	of which:	Course	2	Seminar		Laboratory		Project	1
3.2 Number of hours per semester	42	of which:	course	28	Seminar		Laboratory		Project	14
3.3 Individual study										
(a) Manual, lecture material and notes, bibliography										10
(b) Supplementary study in the library, online and in the field										20
(c) Preparation for seminars/laboratory works, homework, reports, portfolios, essays										47
(d) Tutoring										3
(e) Exams and tests										3
(f) Other activities:										

3.4 Total hours of individual study (sum of (3.3(a)…3.3(f)))	83
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	Numerical calculus, analysis, linear algebra, differential equations, control engineering
4.2 Competence	Numerical calculus, analysis, linear algebra, differential equations, control engineering, Matlab

5. Requirements (where appropriate)

5.1. For the course	
5.2. For the applications	Presence and successfully completing the project are compulsory

6. Specific competences

6.1 Professional competences	**C1** Using knowledge of mathematics, physics, mechanical engineering, chemistry, electrical and electronic engineering in systems engineering C3 Using basics of control engineering, methods of modeling, simulation, identification and analysis of processes, computer assisted design techniques.
6.2 Cross competences	

7. Course objectives

7.1 General objective	- Estimation problems in control engineering - Design of commonly used observers
7.2 Specific objectives	- Formulating an estimation problem - Observability analysis - Methods used for state estimation for a linear system

8. Contents

8.1 Lecture	No.hours	Teaching methods	Notes
Introduction. State-space description of dynamical systems. Formulating an estimation problem. Soft sensors. Case studies: electromechanical systems, 3D crane, inverted pendulum, robotic manipulators, quadcopters.	6	Exposition Questions Discussions with students Proofs	Possibly online on Teams
Observers for linear systems. Luenberger observers in discrete and continuous time. Convergence of the estimated values to the real ones. Limitations. Case studies: experiments from the Rotary package (Quanser).	4		
Linear regression. Least squares methods. The effect of noise. Case study: 3D crane.	2		
Noises and disturbances. Kalman filters in continuous and discrete time. Analysis. Estimation with bounded inputs and states. Prediction and smoothing. Limitations. Case studies: sensor fusion for mobile robots.	6		
Sensor and actuator faults. Fault detection. Case studies: electromechanical systems.	4		
Observers design for control. The separation principle. Case studies: robotic systems.	6		
Bibliography 1.Beyond the Kalman filter : particle filters for tracking applications, Branko Ristic, Sanjeev Arulampalam, Neil Gordon 2.Modern control design : with MATLAB and SIMULINK, Ashish Tewari 3.Stability analysis and nonlinear observer design using Takagi-Sugeno fuzzy models, Zsofia Lendek, Thierry Marie Guerra, Robert Babuska, Bart De Schutter 4.Optimal State Estimation: Kalman, H-infinity, and Nonlinear Approaches, Dan Simon.			
8.2 Aplications (seminar/laboratory/project)	No.hours	Teaching methods	Notes
State-space representation of linear systems. Examples. Variables and parameters that need to be estimated. Applications.	2	Implementation and analysis. Literature study, implementing methods or applications, report writing	Attendance mandatory. Matlab will be used. Possibly online on Teams
Luenberger observers. Applications.	3		
Linear regression. Applications.	2		
Kalman filters in continuous and discrete time. Prediction and smoothing. Extended Kalman filters. Applications.	4		
Sensor and actuator faults. Observer design for fault detection. Applications.	3		
Bibliography 1.Beyond the Kalman filter : particle filters for tracking applications, Branko Ristic, Sanjeev Arulampalam, Neil Gordon 2.Modern control design : with MATLAB and SIMULINK, Ashish Tewari 3.Stability analysis and nonlinear observer design using Takagi-Sugeno fuzzy models, Zsofia Lendek, Thierry Marie Guerra, Robert Babuska, Bart De Schutter 4.Optimal State Estimation: Kalman, H-infinity, and Nonlinear Approaches, Dan Simon.			

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

Since in general not all variables can be measured, observers need to be employed. The methods taught at this course represent the basis in this subject. Thus, the students will be capable to recognize if an observer is necessary, formulate the estimation problem, to analyse the problem, determine the methods that can be used to solve it and interpret the results.

The knowledge acquired can be applied both in the academic community and in industry (state-feedback control, optimization of industrial processes)

10. Evaluation

Activity type	Assessment criteria	Assessment methods	Weight in the final grade
Course	Level of understanding of the material	Exam	1
Seminar			
Laboratory			
Project	Implementation, analysis, report, discussion	Verification during the semester	
Minimum standard of performance: project successfully completed and final grade >=5			

Date of filling in:		**Title Firstname NAME**	**Signature**
	Course	Prof dr ing Zsófia Lendek	
	Aplications	Prof dr ing Zsófia Lendek	

Date of approval by the Department Board ……..

Head of Departament .....
Prof.dr.ing. Honoriu VĂLEAN

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Date of approval by the Faculty Council ……

Dean
Prof.dr.ing. Liviu Cristian MICLEA

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