SYLLABUS

1. Data about the program of study

1.1	Institution	The Technical University of Cluj-Napoca
1.2	Faculty	Faculty of Automation and Computer Science
1.3	Department	Automation
1.4	Field of study	Systems Engineering
1.5	Cycle of study	Research Masters
1.6	Program of study/Qualification	CYBER PHYSICAL SYSTEMS
1.7	Form of education	Full time
1.8	Subject code	16.10

2. Data about the subject

2.1	Subject name			Emerging Control Systems for Industry 5.0			
2.2	Subject area						
2.2	Course responsible/lecturer			Prof.Dr.Ing. Cristina I. Muresan – cristina.muresan@aut.utcluj.ro			
2.3	Teachers in charge of seminars			Sl. Dr. Ing. Isabela Birs – isabela.birs@aut.uctluj.ro			
2.4 Year of study	2	2.5 Semester	2	2.6 Assessment	E		
2.7 Subject category	Formative category					DA	
	Optionality					DO	

3. Estimated total time

3.1 Number of hours per week	3	of which	3.2 Course	2	3.3 Seminar		3.3 Laborator	1	3.3 Proiect	
3.4 Total hours in the curriculum	42	of which	3.5 Course	28	3.6 Seminar		3.6 Laborator	14	3.6 Proiect	

3.7 Individual study:	
(a) Manual, lecture material and notes, bibliography	23
(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	

3.8 Total hours of individual study (summ (3.7(a)…3.7(f)))	58
3.9 Total hours per semester (3.4+3.8)	100
3.10 Number of credit points	4

4. Pre-requisites (where appropriate)

4.1	Curriculum	System Theory I+II, Control Engineering I+II
4.2	Competence	Fundamental knowledge of automation

5. Requirements (where appropriate)

5.1	For the course	Bibliography reading for lectures
5.2	For the applications	Laboratory classes are compulsory

6. Specific competences

Professional competences	C4. Analysis, synthesis and implementation of advanced control startegies with practical applications C4.1 Performance criteria for advanced process control methods C4.2 Use of interdisciplinary and multidisciplinary knowledge and information to integrate advanced process control methods in an industrial setting C4.3 Creative use of principles and advanced methods to ensure safety, security and employment of advanced process control methods C4.5 Development of professional or/and interdisciplinary research projects, while meeting quality, security and safety standards
Cross competences	Team work Scientific communication of results

7. Discipline objectives (as results from the *key competences gained*)

7.1	General objective	• Introduction into basic concepts related to fractional order control, autotuning methods and event-based implementations
7.2	Specific objectives	• Industry 5.0 concepts and modernization of control systems • Emerging control methods • Analysis and synthesis of fractional order control strategies • Analysis and synthesis of auto-tuning methods • Event-based implementation possibilities and advantages

8. Contents

8.1. Lecture (syllabus)	Number of hours	Teaching methods	Notes
Introduction: from Industry 1.0 towards Industry 5.0. Industry 4.0 and cyber physical systems. Industry 5.0 and cyber physical cognitive systems (CPGS). Modern control systems.	4	PPT presentations, open discussions, demonstration, case studies	In case of major force classes will be held online using Teams
Emerging control methods suitable for Industry 5.0. Basics of auto-tuning methods	4		
Fractional order control systems: introduction, advantages, tuning, implementation	4		
Fractional order control systems and auto-tuning methods. A time domain approach. Implementation and validation on CPGS	4		

Fractional order control systems and auto-tuning methods. A frequency domain approach. Implementation and validation on CPGS	4		
Fractional order event-based control systems. Increasing the efficiency of control systems by reducing energy use according to the sustainability standards sought by Industry 5.0.	4		
Industrialization of fractional order control systems. Case studies	4		

Bibliography

1. Monje, C.A.; Chen, Y.Q.; Vinagre, B.; Xue, D.; Feliu, V. Fractional Order Systems and Controls: Fundamentals and Applications; Springer: Berlin, Germany, 2010
2. C. Copot, C.M. Ionescu, C.I. Muresan (2020), Image-Based and Fractional-Order Control for Mechatronic Systems. Theory and Applications with MATLAB®, ISBN 978-3-03-042005-5, 978-3-03-042006-2, DOI: 10.1007/978-3-030-42006-2, Springer
3. Cristina I. Muresan, Robin De Keyser, Revisiting Ziegler–Nichols. A fractional order approach, ISA Transactions, 2022,DOI: 10.1016/j.isatra.2022.01.017
4. I. Birs, I. Nascu, C. Ionescu, C. Muresan (2020), "Event-based fractional order PID control", Journal of Advanced Research, Volume 25, pp.191-203, DOI: 10.1016/j.jare.2020.06.024 BURNS Roland S., Advanced control engineering, 2004, Oxford
5. Vilanova, Ramón and Antonio Visioli. "PID control in the Third Millennium: lessons learned and new approaches." (2012).

8.2. Seminars /Laboratory/Project	Number of hours	Teaching methods	Notes
Introduction into Industry 5.0 and analysis of modern control systems	2	Practical use of dedicated equipment, case studies, demonstration, brainstorming	In case of major force classes will be held online using Teams
Implementation of standard auto-tuning methods. Case study: vertical take-off and landing	2		
Analysis and implementation of fractional order control systems using various software tools (FOMCOM, NINTEGER, AFOPI, FLOreS). Matlab simulation. Case study: anesthesia control	2		
Practical implementation and validation of fractional order control systems. Case study: vertical take-off and landing.	2		
Practical implementation and validation of fractional order control systems and auto-tuning methods. Case study: DC motor control.	2		
Practical implementation and validation of fractional order control systems and auto-tuning methods. Case study: vertical take-off and landing platform.	2		

Event-based implementation of fractional order controllers. Case study: vertical take-off and landing platform.	2		

Bibliography

1. Tepljakov, Aleksei, et al. “FOMCON Toolbox for Modeling, Design and Implementation of Fractional-Order Control Systems.” Applications in Control, De Gruyter, 2019, pp. 211–36, doi:10.1515/9783110571745-010.
2. Lennart van Duist, Gijs van der Gugten, Daan Toten, Niranjan Saikumar, Hassan HosseinNia, FLOreS - Fractional order loop shaping MATLAB toolbox, IFAC-PapersOnLine, Volume 51, Issue 4, 2018,Pages 545-550, DOI: 10.1016/j.ifacol.2018.06.152.
3. QNET 2.0 VTOL Board for NI ELVIS, Student workbook, Quanser, Ontario, Canada, 2011
4. https://www.mathworks.com

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

The content of the lectures and laboratory classes corresponds to some of the newest approaches in control engineering. Selected case studies refer to emerging applications, ranging from aerodynamics to biomedical engineering. The content of the lectures and the laboratory classes has been discussed with companies in Romania.

10. Evaluation

Activity type	10.1 Assessment criteria	10.2 Assessment methods	10.3 Weight in the final grade
10.4 Course	Evaluation of the acquired skills, activity within lectures	Written exam	50%
10.5 Seminars /Laboratory/Project	Evaluation of the practical skills, attendance, activity within laboratory classes	Oral exam	50%
10.6 Minimum standard of performance Exam grade >5, Laboratory grade>5			

Date of filling in:		**Title Surname Name**	**Signature**
4.06.2024	Lecturer	Prof. dr.ing. Cristina I. Muresan	
	Teachers in charge of application	SL.dr.ing. Isabela R. Birs	

Date of approval in the department of Automation _____	Head of department Prof.dr.ing. Honoriu Valean
Date of approval in the faculty of Automation and Computer Science _____	Dean Prof.dr.ing. Mihaela Dinsoreanu