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	Master
1.6	Program of study/Qualification	Cyber-Physical Systems
1.7	Form of education	Full time

2. Data about the subject

2.1	Subject name			Reinforcement Learning		Subject code	14.00
2.2	Course responsible/lecturer			Prof. dr. eng. Busoniu Lucian – Lucian.Busoniu@aut.utcluj.ro			
2.3	Teachers in charge of seminars			Drd.eng. Pirje Stefan			
2.4 Year of study	2	2.5 Semester	1	2.6 Assessment			Exam
2.7 Subject category	Formative category						DS
	Optionality						DI

3. Estimated total time

3.1 Number of hours per week	3	of which	3.2 Course	2	3.3 Seminars	0	3.3 Laboratory	1	3.3 Project	0
3.4 Number of hours per semester	42	of which	3.5 Course	28	3.6 Seminars	0	3.6 Laboratory	14	3.6 Project	0

3.7 Individual study:	
(a) Manual, lecture material and notes, bibliography	26
(b) Supplementary study in the library, online and in the field	9
(c) Preparation for seminars/laboratory works, homework, reports, portfolios, essays	9
(d) Tutoring	1
(e) Exams and tests	3
(f) Other activities	10

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	Discrete-time systems, basics of probabilities and nonlinear systems, basics of optimization
4.2	Competence	Analytical and programming competencies

5. Requirements (where appropriate)

5.1	For the course	Attendance is not mandatory, but optional graded quizzes will be taken during the lectures
5.2	For the applications seminarului / laboratorului / proiectului	Lab solutions are mandatory and graded; each consists of Matlab/Python code and a report document

6. Specific competences

Professional competences	• Demonstrates disciplinary expertise • Thinks abstractly • Performs data analysis • Analyzes test data • Presents analysis results • Synthesizes information • Uses software libraries • Develops software prototypes • Communicates scientific findings • Writes scientific and academic papers and technical documentation • Applies the principles of scientific ethics and integrity in research activities
Transversal competences	• Think analytically • Apply scientific, technological, and engineering knowledge • Work in teams

7. Expected Learning Outcomes

Knowledge	The student will know: • advanced concepts, principles, and methodologies in systems engineering, automation, and cyber-physical systems • principles of design, operation, and evaluation for complex control systems • advanced applications of AI and machine learning technologies in industrial contexts, including their integration into control systems and automation • interdisciplinary concepts from mathematics, signal processing, automation, control theory, and computer science applicable to the design and optimization of complex systems • the principles of scientific ethics and academic integrity
Skills	The student will be able to: • conduct scientific and interdisciplinary research, analyze data, and communicate results effectively to professional and academic audiences • design, develop, and implement software and control applications for cyber-physical systems • use modeling, simulation, AI, and machine learning to develop intelligent, autonomous, and automated solutions • apply ethical principles, academic integrity, and responsible research practices in professional activities
Responsibilities and autonomy	• The student will be responsible for carrying out professional or research projects • The student will be responsible for ensuring ethical conduct and academic integrity • The student will be responsible for promoting collaboration, teamwork, knowledge transfer, and innovation within professional and research environments

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

8.1	General objective	The student will be able to choose and successfully apply a reinforcement learning method for a given nonlinear, possibly stochastic optimal control problem where the system model is unknown
8.2	Specific objectives	The student will be able to: • Formulate an optimal control problem in the Markov decision process (MDP) setting • Characterize the optimal solution in the MDP setting • Understand and apply exact dynamic programming and reinforcement learning methods • Understand classical and deep-network-based function approximation • Understand and apply approximate (classical and deep) reinforcement learning methods

		• Given a new problem, be able to select an algorithm among exact, approximate, and deep reinforcement learning

9. Contents

9.1. Lectures	Hours	Teaching methods	Notes
1. The reinforcement learning problem	2	• Presentation based on videoprojector slides • Interactive discussions (questions, exercises etc.) • Lecture quizzes	
2. The optimal solution	2		
3. Dynamic programming	3		
4. Classical reinforcement learning	3		
5. Classical function approximation	3		
6. Approximate dynamic programming	3		
7. Approximate reinforcement learning	3		
8. Deep neural networks	3		
9. Deep value-based reinforcement learning	3		
10. Deep policy-gradient reinforcement learning	3		
Bibliography 1. "Reinforcement learning". Lecture notes in the form of slides. 2. L. Busoniu, R. Babuska, B. De Schutter, D. Ernst, Reinforcement Learning and Dynamic Programming Using Function Approximators, CRC Press, Automation and Control Engineering Series. April 2010. 3. D. P. Bertsekas. Dynamic Programming and Optimal Control, volume 2. Athena Scientific, 4th edition, 2017. 4. R. S. Sutton and A. G. Barto. Reinforcement Learning: An Introduction. Bradford, 2018, 2nd ed.			
9.2. Applications - Seminars /Laboratory/Project	Hours	Teaching methods	Notes
1. Dynamic programming: Q-value and policy iteration	3	• Reminder about the objective and method of each lab • Method implementation and usage in Matlab or Python • Interaction with students and solution grading	
2. Exact reinforcement learning: Q-learning	3		
3. Approximate reinforcement learning	3		
4. Deep neural networks	2		
5. Deep reinforcement learning: deep Q-networks	3		
Bibliography 1. "Reinforcement learning". Lecture notes in the form of slides. 2. L. Busoniu, R. Babuska, B. De Schutter, D. Ernst, Reinforcement Learning and Dynamic Programming Using Function Approximators, CRC Press, Automation and Control Engineering Series. April 2010. 3. D. P. Bertsekas. Dynamic Programming and Optimal Control, volume 2. Athena Scientific, 4th edition, 2017. 4. R. S. Sutton and A. G. Barto. Reinforcement Learning: An Introduction. Bradford, 2018, 2nd ed.			

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

The course provides control methods for systems that are insufficiently known and/or too complex (nonlinear, stochastic behavior) to apply classical control methods. These methods are relevant in advanced applications and research into the control of cyber-physical and other systems.

11. Evaluation

Activity type	11.1 Assessment criteria	11.2 Assessment methods (and evaluation form: continuing/final)	11.3 Weight in the final grade
11.4 Course	Correct solution of the proposed questions	Written exam (final evaluation)	50%
11.5 Seminars /Laboratory/Project	Correct Matlab/Python usage for reinforcement learning	Solutions to the lab (code, report), electronically submitted (continuing evaluation)	50%
11.6 Minimum standard of performance			
Original lab solutions (code and report) submitted; at least a rounded grade of 5 combined across the written test, lab solutions, and optional lecture quizzes.			

Date of filling in:		**Title Surname Name**	**Signature**
05.07.2026	Lecturer	Prof. dr. eng. Busoniu Lucian	
	Teachers in charge of application	Drd.ing. Pirje Stefan	

Date of approval in the department of Automation _____	Head of department, Prof.dr.eng. Honoriu VĂLEAN
Date of approval in the Faculty of Automation and Computer Science Council _____	Dean, Prof.dr.eng. Vlad MUREȘAN