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	System's 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	***Machine Learning***			Subject code	**3.0**
2.2 Course responsible / lecturer	S.l. dr. ing. Liviu-Cristian Miclea				
2.3 Teachers in charge of seminars / Laboratory / project	S.l. dr. ing. Liviu-Cristian Miclea				
2.4 Year of study	1	2.5 Semester	1	2.6 Type of assessment (E - exam, C - colloquium, V – verification)	E
2.7 Subject category	Formative category: DA – advanced, DS – speciality, DC – complementary				DA
	Optionality: DI – imposed, DO – optional (alternative), DF – optional (free choice)				DI

3. Estimated total time

3.1 Number of hours per week	3	of which:	Course	2	Seminars	0	Laboratory	1	Project	0
3.2 Number of hours per semester	42	of which:	Course	28	Seminars	0	Laboratory	14	Project	0
3.3 Individual study:										
(a) Manual, lecture material and notes, bibliography										15
(b) Supplementary study in the library, online and in the field										14
(c) Preparation for seminars/laboratory works, homework, reports, portfolios, essays										23
(d) Tutoring										3
(e) Exams and tests										3
(f) Other activities:										0

3.4 Total hours of individual study (suma (3.3(a)…3.3(f)))	58
3.5 Total hours per semester (3.2+3.4)	100
3.6 Number of credit points	4

4. Pre-requisites (where appropriate)

4.1 Curriculum	N/A
4.2 Competence	Computer programming, Probability Theory

5. Requirements (where appropriate)

5.1. For the course	N/A
5.2. For the applications	Attendance at the laboratory is mandatory.

6. Specific competence

6.1 Professional competences	• Conducts interdisciplinary research • Conducts literature research • Develops professional networks with researchers • Manage research data • Thinks abstractly • Presents analysis results • Synthesizes information
6.2 Transversal competences	• Show initiative • Think analytically • Apply scientific, technological, and engineering knowledge • Work in teams

7. Expected Learning Outcomes

Knowledge	The following concepts related to ML are addressed: - Fundamental concepts and terminology in machine learning, including supervised, unsupervised, and reinforcement learning paradigms. - Mathematical foundations underlying machine learning algorithms, including linear algebra, probability theory, statistics, and optimization. - Core machine learning models such as linear and logistic regression, k-nearest neighbors, decision trees, support vector machines and neural networks including convolutional neural networks. - Learning theory concepts including bias–variance trade-off, overfitting, regularization, generalization, and model capacity. - Common loss functions, optimization methods, and training procedures used in machine learning. - Model evaluation methodologies, including performance metrics, cross-validation, and error analysis. - Data preprocessing techniques such as normalization, feature extraction, dimensionality reduction, and handling missing or noisy data.
Skills	Upon successful completion of the course, the student will be able to: - Formulate real-world problems as machine learning tasks and select appropriate learning paradigms and models. - Implement machine learning algorithms using standard software frameworks and libraries. - Prepare, clean, and preprocess datasets for machine learning applications. - Train, validate, and test machine learning models in a systematic and reproducible manner. - Evaluate and compare machine learning models using appropriate quantitative metrics. - Analyze model behavior, identify sources of error, and apply techniques to improve performance.
Responsibilities and autonomy	Upon successful completion of the course, the student will be able to: - Work autonomously on machine learning tasks, from problem definition to model evaluation. - Take responsibility for the correctness, robustness, and reproducibility of machine learning experiments. - Make informed technical decisions regarding model selection, evaluation criteria, and deployment constraints. - Critically assess the limitations and assumptions of machine learning models in practical applications.

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

8.1 General objective	Knowledge, understanding and use of concepts related to machine learning
8.2 Specific objectives	Knowledge, understanding and use of proper formulation methodologies for machine learning systems. Knowledge, understanding and use of the specific operations of a machine learning system: data pre-processing, dimensional reduction, feature selection, building the prediction model, selection of the optimum model, performance analysis. Understanding and use of machine learning methods using statistical approaches, support vectors, simple classifiers and neural networks.

9. Contents

9.1 Lectures	Hours	Teaching methods	Notes
Intorduction in ML	2	Exposition using oral presentations supported by multimedia tools; discussions, questioning	
Data, models, metrics for ML (1)	2		
Data, models, metrics for ML (2)	2		
Linear regression	2		
Logistic regression and Classification	2		
Support Vector Machine	2		
Perceptron and Neural Networks	2		
Loss functions and optimizations	2		
Convolutional neural networks (part 1) – deep learning theory	2		
Convolutional neural networks (part 2) – backpropagation	2		
Convolutional neural networks (part 3) – object detection	2		
Convolutional neural networks (part 4) – segmentation	2		
Principal Component Analysis	2		
K-Means clustering	2		

Bibliography:

- Convolutional Neural Networks for Visual Recognition, http://cs231n.stanford.edu, 2022
- K. Murphy, "Machine Learning: A Probabilistic Perspective", The MIT Press, 2012
- J. Kelleher, "Deep Learning", The MIT Press, 2019
- Giuseppe Ciaburro, "MATLAB for Machine Learning", Packt Publishing Limited, 2017

9.2 Applications - Seminars/Laboratory/Project	Hours	Teaching methods	Notes
Introduction – ML in Matlab	2	Case studies, presentation of various methods and procedures for prediction, training and evaluation of ML models	
Linear regression for data prediction	2		
Classification for data prediction	2		
Perceptron and MLP	2		
Neural Networks	2		
Convolutional neural networks – common architectures	2		
Convolutional neural network – training a CNN for segmentation	2		

Bibliography

- Convolutional Neural Networks for Visual Recognition, http://cs231n.stanford.edu, 2022
- Giuseppe Ciaburro, "MATLAB for Machine Learning", Packt Publishing Limited, 2017
- Deep learning in Matlab, https://www.mathworks.com/help/deeplearning/ug/deep-learning-in-matlab.html, 2022

**Se vor preciza, după caz: tematica seminariilor, lucrările de laborator, tematica și etapele proiectului.*

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

This course presents a practical way of combining fundamental and practical aspects used in the field of machine learning for master students with expertise in automation. The subject content is correlated with the specific curricula of other Universities, in Romania and abroad. The subject's activities are meant to make the students familiar with the applications and the research directions of the field.
The themes of the laboratory correspond to some applications of many companies in Cluj-Napoca (Bosch, Siemens, Arobs etc) and abroad.

10. Evaluation

Activity type	Assessment criteria	Assessment methods	Weight in the final grade
Course	Knowledge of theoretical aspects and ability to solve problems	Oral exam, based on a course project (CP) and theory questions (T)	60%
Seminar	-	-	
Laboratory	Elaboration of a CNN-based project	Laboratory evaluation based on the project (LP), evaluated orally	40%
Project	-	-	
Minimum standard of performance: Lab>=5, Course>=5;			

Date of filling in: 01.09.2025	**Responsible**	**Title First name Last name**	**Signature**
	Course	S.l. dr. ing. Liviu-Cristian Miclea	
	Applications	S.l. dr. ing. Liviu-Cristian Miclea	

Date of approval in the department of Automation	Head of department, Prof.dr.eng. Honoriu Valean
Date of approval in the Faculty Council	Dean, Prof.dr.eng. Vlad Mureșan