COURSE DESCRIPTION

Advanced machine learning methods

University year 2026-2027

1. Programme-related data

1.1. Higher education institution	Babeş-Bolyai University of Cluj-Napoca
1.2. Faculty	Faculty of Mathematics and Computer Science
1.3. Doctoral School	Mathematics and Computer Science
1.4 Field of study	Computer Science
1.5. Level of study	Doctoral

2. Course-related data

2.1. Course title	**Advanced machine learning methods**			Course code	**MDE8164**
2.2. Course coordinator	Prof. PhD Czibula Gabriela				
2.3. Seminar coordinator	Prof. PhD Czibula Gabriela				
2.4. Year of study	1	2.5. Semester	1	2.6. Type of assessment	Exam
2.7. Course status	Optional			2.8. Course type	Core subject

3. Total estimated time (hours/semester of teaching activities)

3.1. Number of hours per week	3	of which: 3.2. course	2	3.3. seminar/laboratory/project	1 sem
3.4. Total hours in the curriculum	36	of which: 3.5. course	24	3.6. seminar/laboratory/project	12

Time allocation for individual study (IS) and self-taught activities (ST)	**hours**
Learning from textbooks, course materials, bibliography, and notes (IS)	45
Additional research in the library, on subject-specific electronic platforms, and on-site	55
Preparing seminars/ laboratories/ projects, assignments, reports, portfolios, and essays	54
Tutoring (professional guidance)	31
Examinations	29
Other activities	
3.7. Total hours of individual study (IS) and self-taught activities (ST)	**214**
3.8. Total hours per semester	**250**
3.9. Number of credits	**10**

4. Prerequisites (if necessary)

4.1. curriculum-related	Artificial Intelligence
4.2. skills-related	Programming skills

5. Specific conditions (if necessary)

5.1. course-related	Classroom with a projector
5.2. seminar /laboratory-related	

6. Subject-specific learning outcomes

Knowledge
1. The student knows the ethical and legal principles and rules in scientific research.
2. The student knows modelling methods, being able to analyse real-life problems and to translate them in concrete requirements and to design a corresponding software model.

3. The student has knowledge related to specifying the requirements of research activities in the domain of computational intelligence in general and machine learning in particular, and he/she understands the role of research in promoting progress.
4. The student knows to conduct original research in the field of Machine Learning.
Skills
1. The student can use specific language and terminology for the field of Machine Learning, being able to communicate and interact with members of a team.
2. The student can use advanced computational intelligence knowledge starting from a high level of abstraction and being able to offer implementation solutions for complex software systems.
3. The student can apply Machine Learning techniques to solve real-world problems.
Responsibility and autonomy
1. The student can work independently to obtain the knowledge necessary for designing, managing, and evaluating research activities in the field of Machine Learning.
2. The student can devise, model, and design software applications in the field of Machine Learning.

7. Contents

7.1 Course	**Teaching and learning methods**	**Remarks[1]**
1. **Introduction in Machine Learning.** • Issues in Machine Learning • Designing a learning system • Examples	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
2. Statistical foundations • Event space and Probability function • Elementary Information Theory • Examples	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
3. Decision Tree learning • Decision tree representation • ID3 learning algorithm • Statistical measures in decision tree learning: entropy, information gain • Issues in DT learning • Applications	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
4. Artificial Neural Networks • Neural Network representations • Appropriate problems for Neural Network Learning • Perceptrons • Multilayer Networks and the Backpropagation algorithm • Advanced topics in Artificial Neural Networks	• Interactive exposure • Explanation • Conversation • Didactical demonstration	

[1] For example, organisational aspects, recommendations for students, specific aspects relating to the course/seminar, such as inviting experts in the field, etc.

5. Support Vector machines • Main idea • Linear SVMs • Non-linear SVMs • Applications	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
6. Bayesian learning • Specific problems • Bayes theorem • Naive Bayes Classifier	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
7. Instance based learning • *k*-Nearest Neighbor learning • Locally weighted regression • Radial basis functions • Case-based reasoning • Applications	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
8. Unsupervised learning • Cluster analysis • Self-organizing maps • Hebbian learning • Applications	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
9. Reinforcement Learning • The reinforcement learning task • Markov Decision Processes • Q-learning • Temporal Difference learning • Applications	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
ML research reports presentation	• Interactive exposure • Conversation • Oral assessment	

Bibliography
1. Mitchell, T., Machine Learning, McGraw Hill, 1997
2. Russell, J.S, Norvig, P., Artificial Intelligence- A Modern Approach, Prentice- Hall, Inc., New Jersey, 1995
3. Sutton, R.S., Barto, A.G., Reinforcement learning, The MIT Press Cambridge, Massachusetts, London, England, 1998
4. Gabriela Czibula, Sisteme inteligente. Instruire automata, Ed. Risoprint, Cluj-Napoca, 2008
5. Manning, C., Schutze, H., Foundations of Statistical NLP, MIT Press, 2002
6. Cristiani, N., Support Vector and Kernel Machines, BIOwulf Technologies, 2001
7. Nillson, N., Introduction to Machine Learning, Stanford University, 1996

7.2 Seminar / laboratory	**Teaching and learning methods**	**Remarks**
1. Administration of labs. Survey of the sources of information available on Internet and Intranet	• Interactive exposure • Explanation • Conversation	
2. Survey of the sources of information available on Internet and Intranet; choosing the paper topic and scheduling the presentation.	• Documentation • Explanation • Conversation	
A software project will be fully implemented, without using existing ML environments.		
3. Problem definition	• Lab assignment • Explanation • Conversation	
4-5. Comments about the solution, problem analysis and related work	• Lab assignment • Explanation • Conversation	
6-7. Design documentation; the electronic	• Lab assignment	

version of the source code, test files and any other files required to test the software project. Project 2demonstration	• Explanation • Conversation	
Bibliography 1. Mitchell, T., Machine Learning, McGraw Hill, 1997 2. Sutton, R.S., Barto, A.G., Reinforcement learning, The MIT Press Cambridge, Massachusetts, London, England, 1998 3. Gabriela Czibula, Sisteme inteligente. Instruire automata, Ed. Risoprint, Cluj-Napoca, 2008		

8. Evaluation

Type of activity	8.1 Evaluation criteria[2]	8.2 Evaluation methods[3]	8.3 Percentage in the final grade
8.4 Course	A theoretical research report on a learning technique, based on some recent research papers should be prepared and presented	Evaluation of the research report (a written paper of about 10 pages and an oral presentation)	45%
	The correctness and completeness of the accumulated knowledge.	Oral assessment	
8.5 Seminar/laboratory	A software project implemented using a ML framework	Evaluation of the project (software implementation, documentation and demonstration)	40%
8.6 Activity	Class attendance (lectures, labs) and activity		15%
8.7 Minimum standard for passing			
• Each student has to prove that (s)he acquired an acceptable level of knowledge and understanding of the Machine Learning domain, that (s)he is capable of stating this knowledge in a coherent form, that (s)he can establish certain connections and use the knowledge in solving different problems. • Successful passing of the exam is conditioned by the final grade that has to be at least 5.			

9. SDG labels (Sustainable Development Goals)[4]

Not applicable.

Date of entry: 16.02.2026

Signature of course coordinator: Prof. PhD Gabriela CZIBULA

Signature of seminar coordinator: Prof. PhD Gabriela CZIBULA

Date of approval in the department:

Signature of the head of department

[2] The evaluation criteria must directly reflect the learning outcomes targeted at the level of the degree programme respectively at the level of the subject. More specifically, the learning outcomes set out in the expected learning outcomes are assessed.

[3] Both final evaluation methods and ongoing evaluation strategies should be established.

[4] Select a single label which, according to the *Implementation of SDG labels in the academic process*, best matches the subject. If the subject addresses sustainable development in a generic manner (i.e. by presenting/introducing the general framework of sustainable development, etc.), then the Sustainable Development generic label may be applied. If none of the labels describe the subject, select the last option: *"No label applies."*