

## SYLLABUS

### *High Performance Machine Learning*

University year 2026-2027

#### 1. Information regarding the programme

1.1. Higher education institution	Babes-Bolyai University Cluj-Napoca
1.2. Faculty	Mathematics and Computer Science
1.3. Department	Computer Science
1.4. Field of study	Computer Science
1.5. Study cycle	Masters
1.6. Study programme/Qualification	High Performance Computing and Big Data
1.7. Form of education	Full time

#### 2. Information regarding the discipline

2.1. Name of the discipline	<b>High Performance Machine Learning</b>			Discipline code	<b>MME8042</b>		
2.2. Course coordinator	Lector dr. Ing. Cristian-Paul Bara						
2.3. Seminar coordinator	Lector dr. Ing. Cristian-Paul Bara						
2.4. Year of study	1	2.5. Semester	2	2.6. Type of evaluation	E	2.7. Discipline regime	Compulsory

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

3.1. Hours per week	4	of which: 3.2 course	2	3.3 seminar/laboratory/project	<b>1 sem + 1 pr</b>
3.4. Total hours in the curriculum	56	of which: 3.5 course	28	3.6 seminar/laboratory/project	<b>28</b>
<b>Time allotment for individual study (ID) and self-study activities (SA)</b>					<b>hours</b>
Learning using manual, course support, bibliography, course notes (SA)					20
Additional documentation (in libraries, on electronic platforms, field documentation)					30
Preparation for seminars/labs, homework, papers, portfolios and essays					28
Tutorship					6
Evaluations					10
Other activities:					
<b>3.7. Total individual study hours</b>					<b>94</b>
<b>3.8. Total hours per semester</b>					<b>150</b>
<b>3.9. Number of ECTS credits</b>					<b>6</b>

#### 4. Prerequisites (if necessary)

4.1. curriculum	Artificial Intelligence
4.2. competencies	Programming

#### 5. Conditions (if necessary)

5.1. for the course	Lecture hall with projector
5.2. for the seminar /lab activities	

#### 6.1. Specific competencies acquired <sup>1</sup>

<sup>1</sup> One can choose either competences or learning outcomes, or both. If only one option is chosen, the row related to the other option will be deleted, and the kept one will be numbered 6.

<b>Professional/essential competencies</b>	<ul style="list-style-type: none"> <li>• Capacity to analyze and synthesize</li> <li>• Gaining knowledge about methods for modeling, optimization, large data set analysis and visualization</li> <li>• Efficient Modeling and solving of real world problems</li> </ul>
<b>Transversal competencies</b>	<ul style="list-style-type: none"> <li>• Honourable conduct, ethics, respecting professional deontology</li> <li>• Team work, familiarity with the different roles for developing and leading a project</li> </ul>

## 6.2. Learning outcomes

<b>Knowledge</b>	<p>The student knows:</p> <ul style="list-style-type: none"> <li>- Principles, techniques, and basic applications of machine learning</li> <li>- Ethical and deontological norms and rules in scientific research</li> </ul>
<b>Skills</b>	<p>The student is able to</p> <ul style="list-style-type: none"> <li>- Applying new algorithms, using software infrastructure, and methods for (storing, acquisition, and analysis) big data</li> <li>- Managing large volumes of digital data in diverse formats (text, video, financial, medical, etc.)</li> </ul>
<b>Responsibility and autonomy:</b>	<p>The student has the ability to work independently to obtain</p> <ul style="list-style-type: none"> <li>- Development of services for diverse business fields based on large volumes of data</li> <li>- Translate academic knowledge in professional, economic, social, etc. contexts</li> </ul>

## 7. Objectives of the discipline (outcome of the acquired competencies)

<b>7.1 General objective of the discipline</b>	<ul style="list-style-type: none"> <li>• Presenting principles, techniques, and applications in High Performance Machine Learning</li> </ul>
<b>7.2 Specific objective of the discipline</b>	<ul style="list-style-type: none"> <li>• Presenting design, development, and validation principles for applications that learn from experience</li> <li>• Understanding of algorithms for machine learning and their use in big data</li> <li>• The state of the art in machine learning research for applying in original research</li> </ul>

## 8. Content

8.1 Course	Teaching methods	Remarks
1. Administrative topics and review of	- Exposition	

<p>Statistics</p> <ul style="list-style-type: none"> <li>• Event spaces and probability functions</li> <li>• Introduction to information theory</li> <li>• Examples</li> </ul>	<ul style="list-style-type: none"> <li>- Explanation</li> <li>- Conversation</li> <li>- Demonstration</li> </ul>	
<p>2. Introduction to Machine learning</p> <ul style="list-style-type: none"> <li>• Definitions and evolution of the machine learning problem</li> <li>• Major Paradigms</li> <li>• The process for Supervized Learning</li> </ul>	<ul style="list-style-type: none"> <li>- Exposition</li> <li>- Explanation</li> <li>- Conversation</li> <li>- Demonstration</li> </ul>	
<p>3. Instance based learning</p> <ul style="list-style-type: none"> <li>• The K-Nearest Neighbours algorithm</li> <li>• Locally weighted Regression</li> <li>• RFB networks</li> <li>• Case by case reasoning</li> <li>• Examples</li> </ul>	<ul style="list-style-type: none"> <li>- Exposition</li> <li>- Explanation</li> <li>- Conversation</li> <li>- Demonstration</li> </ul>	
<p>4. Bayesian learning</p> <ul style="list-style-type: none"> <li>• Specific problems</li> <li>• Bayes' theory</li> <li>• The Naive bayes Classifier</li> </ul>	<ul style="list-style-type: none"> <li>- Exposition</li> <li>- Explanation</li> <li>- Conversation</li> <li>- Demonstration</li> </ul>	
<p>5. Support Vector Machines</p> <ul style="list-style-type: none"> <li>• Basic Idea</li> <li>• Linear SVMs</li> <li>• Non-Linear SVMs</li> </ul>	<ul style="list-style-type: none"> <li>- Exposition</li> <li>- Explanation</li> <li>- Conversation</li> <li>- Demonstration</li> </ul>	
<p>6. Decision Trees</p> <ul style="list-style-type: none"> <li>• Decision tree based representations</li> <li>• The ID3 algorithm</li> <li>• Statistical measures for decision tree based learning: entropy informational gain</li> <li>• Applications</li> </ul>	<ul style="list-style-type: none"> <li>- Exposition</li> <li>- Explanation</li> <li>- Conversation</li> <li>- Demonstration</li> </ul>	
<p>7. Neural Networks</p> <ul style="list-style-type: none"> <li>• Representations with neural networks</li> <li>• Specific problems</li> <li>• The Perceptron</li> <li>• Deep Neural Networks</li> <li>• Back-propagation</li> <li>• Convolutional NN</li> </ul>	<ul style="list-style-type: none"> <li>- Exposition</li> <li>- Explanation</li> <li>- Conversation</li> <li>- Demonstration</li> </ul>	
<p>8. Neural Networks (continuation)</p> <ul style="list-style-type: none"> <li>• Sequence to Sequence Problems</li> <li>• Recurrent Neural Networks</li> <li>• Attention Networks</li> </ul>	<ul style="list-style-type: none"> <li>- Exposition</li> <li>- Explanation</li> <li>- Conversation</li> <li>- Demonstration</li> </ul>	
<p>9. Unsupervised Learning</p> <ul style="list-style-type: none"> <li>• Cluster Analysis</li> <li>• Autoencoders</li> <li>• Hebbian Learning</li> <li>• Applicaitons</li> </ul>	<ul style="list-style-type: none"> <li>- Exposition</li> <li>- Explanation</li> <li>- Conversation</li> <li>- Demonstration</li> </ul>	
<p>10. Reinforcement Learning</p> <ul style="list-style-type: none"> <li>• The reinforcement learning problem</li> <li>• Markov Decision Processes</li> <li>• Q-Learning</li> </ul>	<ul style="list-style-type: none"> <li>- Exposition</li> <li>- Explanation</li> <li>- Conversation</li> <li>- Demonstration</li> </ul>	
<p>Research report Evaluation</p>	<ul style="list-style-type: none"> <li>- Interactive Exposition</li> </ul>	

	- Conversation - Oral Evaluation	
Bibliography		
<ol style="list-style-type: none"> <li>1. Mitchell, T, Machine Learning, McGraw Hill, 1997</li> <li>2. Russell, J.S, Norvig, P, Artificial Intelligence- A Modern Approach, Prentice- Hall, Inc., New Jersey, 1995</li> <li>3. Sutton, R.S., Barto, A.G., Reinforcement learning, The MIT Press Cambridge, Massachusetts, London, England, 1998</li> <li>4. Gabriela Czibula, Sisteme inteligente. Instruire automata, Ed. Risoprint, Cluj-Napoca, 2008</li> <li>5. Manning, C., Schutze, H., Foundations of Statistical NLP, MIT Press, 2002</li> <li>6. Cristiani, N., Support Vector and Kernel Machines, BIOwulf Technologies, 2001</li> <li>7. Nillson, N., Introduction to Machine Learning, Stanford University, 1996</li> </ol>		
8.2 Seminar / laboratory	Teaching methods	Remarks
1. Administrative Aspects	- Interactive Exposition - Explanation - Conversation	2 hours per week every 2 weeks
2. Documenation for the selectionof the research topic and evaluation schedule	- Documentation - Explanation - conversation	
The first project shall be implemented using an open source library. The second Project shall be implemented entirely without external libraries		
3. Instalation of software libraries: description of selected libraries	- Lab Work - Explanation - conversation	
4. Problem Definition	- Lab Work - Explanation - conversation	
5. Demonstration and review of the first project. Problem definition for the second project	- Lab Work - Explanation - conversation	
6. Review of the solution proposal and problem analysis for project 2	- Lab Work - Explanation - conversation	
7. Project documentation, source code for project 2. Demonstration of the second project	- Lab Work - Explanation - conversation	
Bibliography		
<ol style="list-style-type: none"> <li>1. Mitchell, T, Machine Learning, McGraw Hill, 1997</li> <li>2. Sutton, R.S., Barto, A.G., Reinforcement learning, The MIT Press Cambridge, Massachusetts, London, England, 1998</li> <li>3. Gabriela Czibula, Sisteme inteligente. Instruire automata, Ed. Risoprint, Cluj-Napoca, 2008</li> </ol>		

**9. Corroborating the content of the discipline with the expectations of the epistemic community, professional associations and representative employers within the field of the program**

- The content of this course is sconsistent with similar courses found at other universities foreign and domestic, as well as with the demands of potential employers in the field of Machine Learning.

## 10. Evaluation

Activity type	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Percentage of final grade
10.4 Course	- A research report shall be written on the topic of ML containing results from research	Evaluation of the report (written article and oral presentation)	45%
	- The correctness and breath of accumulated knowledge	Oral evaluation	
10.5 Seminar/laboratory	- Development of a software project incorporating a ML opensource library	Project Evaluation (documentation and demonstration)	40%
	- Development of a ML project with no external libraries	Project Evaluation (implementation, documentation and demonstration)	
10.6 Activity	Attendance in Class and Seminar		15%
10.7 Minimum standard of performance			
<ul style="list-style-type: none"> <li>• Knowledge of the fundamental elements of theory. Each student must demonstrate that he has reached an acceptable level of knowledge and understanding of the field of Machine Learning, that he is able to express knowledge of it in a coherent form, that he has the ability to establish certain connections and to use knowledge in solving problems.</li> <li>• The minimum passing grade is 5</li> </ul>			

## 11. Labels ODD (Sustainable Development Goals)<sup>2</sup>

*Not applicable.*

Date:  
02.05.2026

Signature of course coordinator

Lector dr. Ing. Cristian-Paul Bara

Signature of seminar coordinator

Lector dr. Ing. Cristian-Paul Bara

Date of approval:

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Signature of the head of department

Assoc.prof.phd. Adrian STERCA

<sup>2</sup> Keep only the labels that, according to the [Procedure for applying ODD labels in the academic process](#), suit the discipline and delete the others, including the general one for *Sustainable Development* – if not applicable. If no label describes the discipline, delete them all and write „*Not applicable.*”.

