SYLLABUS

1. Information regarding the programme

1.1 Higher education institution	**Babeş-Bolyai University of Cluj-Napoca**
1.2 Faculty	**Faculty of Mathematics and Computer Science**
1.3 Department	**Doctoral School in Mathematics and Computer Science**
1.4 Field of study	**Computer Science**
1.5 Study cycle	**Doctoral studies**
1.6 Study programme	**TRAINING PROGRAM BASED ON ADVANCED ACADEMIC STUDIES**

2. Information regarding the discipline

2.1 Name of the discipline	**Advanced machine learning methods**						
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 evaluation	**C**	2.7 Type of discipline	**Optional**

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

3.1 Hours per week	3	Of which: 3.2 course	2	3.3 seminar/laboratory	1 sem
3.4 Total hours in the curriculum	36	Of which: 3.5 course	24	3.6 seminar/laboratory	12
Time allotment:					hours
Learning using manual, course support, bibliography, course notes					50
Additional documentation (in libraries, on electronic platforms, field documentation)					62
Preparation for seminars/labs, homework, papers, portfolios and essays					69
Tutorship					17
Evaluations					16
Other activities:					

3.7 Total individual study hours	214
3.8 Total hours per semester	250
3.9 Number of ECTS credits	10

4. Prerequisites (if necessary)

4.1. curriculum	Artificial Intelligence
4.2. competencies	Good programming skills

5. Conditions (if necessary)

5.1. for the course	
5.2. for the seminar /lab activities	Laboratory with computers; high level programming language environment

6. Specific competencies acquired

Professional competencies	• Advanced ability to approach, model and solve phenomena and problems from nature and economy using fundamental knowledge from mathematics and computer science. • Ability to approach and solve complex problems using various techniques of computational intelligence.
Transversal competencies	• Ethic and fair behavior, commitment to professional deontology • Team work capabilities; able to fulfill different roles • Professional communication skills; concise and precise description, both oral and written, of professional results, negotiation abilities. • Entrepreneurial skills; working with economical knowledge; continuous learning • Good English communication skills

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

7.1 General objective of the discipline	● To provide an introduction to the fundamental principles, techniques, and applications of Machine Learning.
7.2 Specific objective of the discipline	● To cover the principles, design, implementation and validation of learning programs which improve their performance on some set of tasks by experience. ● To offer a broad understanding of machine learning algorithms and their use in data-driven knowledge discovery and program synthesis. ● To offer an understanding of the current state of the art in machine learning in order to conduct original research in machine learning.

8. Content

8.1 Course	Teaching methods	Remarks
1. Machine Learning. ● Issues in Machine Learning ● Designing a learning system ● Feature engineering	● Interactive exposure ● Explanation ● Conversation ● Didactical demonstration	
2. Statistical foundations ● Event space and Probability function ● Elementary Information Theory	● 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	
5. Support Vector machines ● Main idea ● Linear SVMs ● Non-linear SVMs ● Applications	● Interactive exposure ● Explanation ● Conversation ● Didactical demonstration	
6. Bayesian learning (1) ● Specific problems ● Bayes theorem ● Naive Bayes Classifier	● Interactive exposure ● Explanation ● Conversation ● Didactical demonstration	
7. Bayesian learning (2) ● Bayesian Belief Networks ● EM algorithm ● Examples	● Interactive exposure ● Explanation ● Conversation ● Didactical demonstration	
8. Instance based learning (1) ● *k*-Nearest Neighbor learning ● Locally weighted regression ● Applications	● Interactive exposure ● Explanation ● Conversation ● Didactical demonstration	
9. Instance based learning (2) ● Radial basis functions ● Case based reasoning	● Interactive exposure ● Explanation ● Conversation ● Didactical demonstration	
10. Unsupervised Learning (1) ● Cluster analysis ● Self organizing maps	● Interactive exposure ● Explanation ● Conversation ● Didactical demonstration	
11. Unsupervised Learning (2) ● Hebbian learning ● Applications	● Interactive exposure ● Explanation ● Conversation ● Didactical demonstration	
12. Reinforcement Learning ● The reinforcement learning task ● Markov Decision Processes ● Q-learning ● Temporal Difference learning ● Applications	● Interactive exposure ● Explanation ● Conversation ● Didactical demonstration	
13. ML research reports presentation	● Interactive exposure ● Conversation	
14. ML research reports presentation	● Interactive exposure ● Conversation	
Bibliography		

1. Ian Goodfellow and Yoshua Bengio and Aaron Courville, Deep Learning, MIT Press, 2016
2. Mitchell, T., Machine Learning, McGraw Hill, 1997
3. Russell, J.S, Norvig, P., Artificial Intelligence- A Modern Approach, Prentice- Hall, Inc., New Jersey, 1995
4. Sutton, R.S., Barto, A.G., Reinforcement learning, The MIT Press Cambridge, Massachusetts, London, England, 1998
5. Gabriela Czibula, Sisteme inteligente. Instruire automata, Ed. Risoprint, Cluj-Napoca, 2008
6. Manning, C., Schutze, H., Foundations of Statistical NLP, MIT Press, 2002
7. Cristiani, N., Support Vector and Kernel Machines, BIOwulf Technologies, 2001

8.2 Seminar / laboratory	Teaching methods	Remarks
		The lab is structured as 2 hours classes every second week
1. Survey of the sources of information available on Internet and Intranet; chosing the paper topic and scheduling the presentation.	● Documentation ● Explanation ● Conversation	
2-4. *Presentation of theoretical research reports*. Each PhD student will have to prepare and present a theoretical research report. The report will present the current state-of-the-art in the field of ML applied in the topic of the PhD thesis.	● Presentation ● Explanation ● Conversation	
5-7. *Presentation of experiemental research reports*. Each PhD student will have to prepare and present a report containing the experimental results obtained based on the theoretical report.	● Presentation ● Explanation ● Conversation	

Bibliography

1. Ian Goodfellow and Yoshua Bengio and Aaron Courville, Deep Learning, MIT Press, 2016
2. Mitchell, T., Machine Learning, McGraw Hill, 1997
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

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 the discipline is consistent with the similar disciplines from other PhD programs from romanian universities and universities from abroad.

10. Evaluation

Type of activity	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Share in the grade (%)
10.4-5 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)	50%
	● An experimental research report based on the theoretical	Evaluation of the experimental report (documentation and demonstration)	50%

	report will be prepared and presented		

10.6 Minimum performance standards

- Each PhD 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 these knowledge in a coherent form, that (s)he has the ability to establish certain connections and to use the knowledge in solving different problems.

Date	Signature of course coordinator	Signature of seminar coordinator
30.06.2021	Prof. dr. Gabriela Czibula	Prof. dr. Gabriela Czibula

Date of approval	Signature of the head of doctoral school
07.07.2021	Prof. dr. Gabriela Czibula