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	**Department of Computer Science**
1.4 Field of study	**Computer Science**
1.5 Study cycle	**Master**
1.6 Study program / Qualification	**Advanced Computational Intelligence**

2. Information regarding the discipline

2.1 Name of the discipline				**Numerical Modelling in Data Analysis / Modelare Numerică în Analiza Datelor**			
2.2 Course coordinator				**Prof. Dr. Lehel Csató**			
2.3 Seminar coordinator				**Prof. Dr. Lehel Csató**			
2.4. Year of study	**1**	2.5 Semester	**1**	2.6. Type of evaluation	**E**	2.7 Type of discipline	**Compulsory**
2.8 Code				**MME8172**			

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
3.4 Total hours in the curriculum	42	Of which: 3.5 course	28	3.6 seminar/laboratory	14
Time allotment:					hours
Learning using manual, course support, bibliography, course notes					42
Additional documentation (in libraries, on electronic platforms, field documentation)					24
Preparation for seminars/labs, homework, papers, portfolios and essays					28
Tutoring					12
Evaluations					4
Other activities:					-

3.7 Total individual study hours	108
3.8 Total hours per semester	150
3.9 Number of ECTS credits	6

4. Prerequisites (if necessary)

4.1. curriculum	Algebra and calculus, knowledge of python / MATLAB / Julia languages
4.2. competencies	• Basic mathematics • Using computers for programming.

5. Conditions (if necessary)

5.1. for the course	• Using of online TEAMS application.
5.2. for the seminar /lab activities	• Students will use – if possible – their own laptop

6. Specific competencies acquired.

Professional competencies	• Understanding the mathematical concepts used in data modelling. • CE1.3 - Using methods from artificial intelligence in solving real-world problems. • CE3.4 - Analysis and modelling of data.
Transversal competencies	• CT1. - The ability to apply intelligent data analysis methods in solving real world problems. • CT3 - The usage of efficient methods and techniques that facilitate the learning, the information, the research, and the development process.

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

7.1 General objective of the discipline	Familiarization with the mathematics and numerical methods that can be used in machine learning.
7.2 Specific objective of the discipline	- to highlight the use of the numerical methods in data analysis - to familiarize with programming languages that implement these methods, - to highlight the need for understanding the mathematics behind data analysis methods.

8. Content

8.1 Course	Teaching methods	Remarks
Week 1: Administration and organization Introducing the objectives of the course.	• Interactive exposure • Explanation	
Week 2: Mathematical background: the convolution, the notions related to probabilities.		
Week 3: Maximum Likelihood and the respective geometric interpretations. Illustrations on toy and real data. The MAP method		
Week 4: Bayesian parameter estimation		
Week 5: The classification problem and different likelihood functions		
Week 6: Approximating the likelihood functions. The first and second order methods. Variational methods.		
Week 7: Unsupervised methods and the manifold hypothesis.		
Week 8: The Principal Component Analysis		
Week 9: Probabilistic Principal Components. Comparisons and applications.		
Week 10: Independent Component Analysis. Applications		

Week 11. Clustering methods and the EM algorithm		
Week 12. Autoencoders.		
Week 13, 14. Presentations related to other advanced methods in machine learning: • SVN • Gaussian Processes, • Ensemble methods		

Bibliography

[1] Bishop C.M (2006) Pattern Recogntion and Machine Learning, Springer Verlag
freely available at: https://www.microsoft.com/en-us/research/people/cmbishop/prml-book/

[2] Deisenroth M.P, Faisal A.A, Soon Ong C (2020) Mathematics for Deep learning, Cambridge University Press
freely available at: https://mml-book.github.io/ (freely available) accessed 04.01.2022

[3] Li M, Lipton Z.C, Smola A.J, Zhang A (2020): Dive into Deep Learning, Online book, release 0.14.4,
freely available at: https://d2l.ai/ accessed 04.01.2022

8.2 Seminar / laboratory	Teaching methods	Remarks
1. Administration. presenting the working environment, setting up the topics for presentation The 'julia' language for computational modelling	• Interactive exposure • Explanation • Conversation	
2. The specifics of using Julia, using the notebook environment, using comprehensions.	• Interactive exposure • Explanation • Conversation	
3. Tutoring related to the presentation topics	• Interactive exposure • Explanation • Conversation	
4-5. Tutoring and scoring the progress of the presentations	• Interactive exposure • Explanation • Conversation	
6-7. Final presentations	• Interactive exposure • Explanation • Conversation	

Bibliography

[4] Hastie T, Tibshirani R, Friedman R (2009) The Elements of Statistical Learning, Springer Verlag
freely available at: https://web.stanford.edu/~hastie/ElemStatLearn/

[5] Haykin S (2009) Neural Networks and Learning Machines, Third Edition, Pearson Education.

[6] Murphy K.M (2012) Machine Learning, a Probabilistic Perspective, The MIT Press.

[7] Sherrington M (2015) Mastering Julia, Pact Publishing.

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 international universities from abroad – e.g. Stanford, ELTE. It also confirms to the requirements from potential employers asking for intelligent data analysists.

10. Evaluation

Type of activity	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Share in the grade
10.4 Course	Correctness of the accumulated knowledge.	Written exam (in the regular session)	50%
10.5 Seminar/lab activities	LAB activity	Grade awarded pro rata	10%
	Laboratory exercises	Evaluation of the work that was handed in during the semester	40%
10.6 Minimum performance standards			
• The students should be able to use the Julia language, able to code functions that (1) load a dataset, (2) initialize a model, (3) optimize the parameters, • The students should be able to convert different noise models to error functions, to generate datasets based on a specified error, to analyze the performance – and limit – of a model. • Attendance on 90% of the LAB activities is compulsory; the bookkeeping is via TEAMS handed assignments.			

Date
04.04.2023

Signature of course coordinator
Prof. dr. Lehel CSATÓ

Signature of seminar coordinator
Prof. dr. Lehel CSATÓ

Date of approval

27.04.2023

Signature of the head of department
Prof. dr. Anca Andreica