SYLLABUS

Intelligent Algorithms in Bioinformatics

University year 2025-2026

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	**Departament of Computer Science**
1.4. Field of study	**Computer Science**
1.5. Study cycle	**Master**
1.6. Study programme/Qualification	**Data Science for Industry and Society**
1.7. Form of education	**Full-Time**

2. Information regarding the discipline

2.1. Name of the discipline	**Intelligent Algorithms in Bioinformatics**					Discipline code	**MME8189**
2.2. Course coordinator				**Assoc. Prof. Dr. Bocicor Maria Iuliana**			
2.3. Seminar coordinator				**Assoc. Prof. Dr. Bocicor Maria Iuliana**			
2.4. Year of study	**2**	2.5. Semester	**3**	2.6. Type of evaluation	E	2.7. Discipline regime	**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**
3.4. Total hours in the curriculum	**42**	of which: 3.5 course	**28**	3.6 seminar/laborator	**14**
Time allotment for individual study (ID) and self-study activities (SA)					**hours**
Learning using manual, course support, bibliography, course notes (SA)					43
Additional documentation (in libraries, on electronic platforms, field documentation)					40
Preparation for seminars/labs, homework, papers, portfolios and essays					40
Tutorship					4
Evaluations					6
Other activities:					
3.7. Total individual study hours	**133**				
3.8. Total hours per semester	**175**				
3.9. Number of ECTS credits	**7**				

4. Prerequisites (if necessary)

4.1. curriculum	Algorithms, data structures
4.2. competencies	Average software development skills in Python

5. Conditions (if necessary)

5.1. for the course	Projector
5.2. for the seminar /lab activities	Laboratory with computers /laptop; internet access

6.1. Specific competencies acquired [1]

[1] 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.

Professional/essential competencies	• Modeling and solving real-life problems in interdisciplinary teams with complementaries in knowledge • Acquire skills needed to transform large amounts of information into complex projects, by using a wide range of quantitative and qualitative methods • Use of Machine Learning methods, techniques and algorithms to model solutions to classes of problems • Identification and explanation of Machine Learning techniques and algorithms and their use for solving specific problems • Using models and solutions from Machine Learning in dedicated applications
Transversal competencies	• Ethic and fair behavior, committment to professional deontology. • Application of efficient work rules and responsible attitudes towards the scientific domain, for the creative exploitation of one's own potential according to the principles and rules of professional ethics • Efficient conduct of activities organized in an interdisciplinary group and development of empathic capacity of interpersonal communication, networking and collaboration with diverse groups

6.2. Learning outcomes

Knowledge	The student knows: • The fundamental machine learning models and how these work, as well as some recently developed models. • To implement applications that use these algorithms to solve complex problems in Bioinformatics. • To collect, represent, analyse and visualize data from various fields (biology, medicine).
Skills	The student is able to: • Model a given problem from a Machine Learning perspective. • Propose theoretical and practical Machine Learning based solutions for various problems in Bioinformatics. • Implement applications that use this algorithms and evaluate these models experimentally using real biological or medical data.
Responsibility and autonomy:	The student has the ability to work independently to: • Research a chosen topic and document, interpret and communicate the results obtained by the selected Machine Learning techniques through scientific reports about the topic selected for investigation. • Design and implement an individual project (software application) which uses Machine Learning techniques to solve a chosen problem.

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

7.1 General objective of the discipline	• To introduce the basic techniques and concepts in Machine Learning, as well a series of complex problems in Bioinformatics and illustrate a series of approaches for these problems using Machine Learning models.
7.2 Specific objective of the discipline	• To offer a broad understanding of machine learning algorithms and their use in Bioinformatics. • Problem modelling from a Machine Learning perspective. • Proposal of theoretical and practical Machine Learning based solutions for complex problems in Bioinformatics. • Application and evaluation of the proposed solutions using real biological or medical data.

8. Content

8.1 Course	Teaching methods	Remarks
1. Introduction to Artificial Intelligence. Administration and organisation.	• Interactive exposure • Explanation • Conversation • Examples • Didactical demonstration	
2. Introduction to Machine Learning – General Concepts.		
3. Supervised Learning Models for Regression and Classification: Linear, Logictic Regression, The Perceptron. Application: Disease Diagnosis Based on Biological Data		
4. Supervised Learning Models for Regression and Classification: K-Nearest Neighbour, Decision Tree Learning		
5. Supervised Learning Models for Regression and Classification: Support Vector Machines. Application: Promoter Identification in DNA		
6. Data Analysis and Processing: Feature Selection and Dimensionality Reduction techniques. Application: Disease Prediction Based on Gene Expression		
7. Ensemble Learning: Bagging, Boosting, Stacking		
8. Artificial Neural Networks		
9. Deep Learning: Convolutional Neural Networks, Recurrent Neural Networks. Application: Pneumonia Prediction from X-Ray Images		
10. Unsupervised Learning: Autoencoders, Clustering. Application: Protein-Protein Interactions		
11. Reinforcement Learning. Application: Multiple Sequence Alignment		
12. Applications: Text Mining in Bioinformatics, Temporal Ordering of Biological Samples, Analysis of Protein Dynamics. Course Review. Examination guide		
13. Presentation of research projects		
14. Presentation of research projects		

Bibliography

1. Goodfellow, I., Bengio, Y., Courville, A., & Bengio, Y. (2016). Deep learning (Vol. 1, No. 2). Cambridge: MIT press.
2. Larranaga, P., Calvo, B., Santana, R., Bielza, C., Galdiano, J., Inza, I., ... & Robles, V. (2006). Machine learning in bioinformatics. Briefings in bioinformatics, 7(1), 86-112.
3. A.E. Hassanien, M.G. Milanova, Smolinski T.G., and Abraham A. Computational Intelligence in Solving Bioinformatics Problems: Reviews, Perspectives, and Challenges. Computational Intelligence in Biomedicine and Bioinformatics Studies in Computational Intelligence, 151:3-47, 2008.
4. N.M. Luscombe, D. Greenbaum, and M. Gerstein. What is bioinformatics? An introduction and overview. Yearbook of Medical Informatics, pages 83-100, 2001.
5. Greener, J. G., Kandathil, S. M., Moffat, L., & Jones, D. T. (2022). A guide to machine learning for biologists. Nature reviews Molecular cell biology, 23(1), 40-55.
6. Baldi, P., & Brunak, S. (2001). *Bioinformatics: the machine learning approach*. MIT press.

8.2 Seminar / laboratory	Teaching methods	Remarks
1. Study and discussion regarding the topic for the research paper and software application.	• Explanation	

2. Survey of the state of the art. Selection of topic for the research paper and software application.	• Conversation	
3. Problem statement and relevance in Bioinformatics.		
4. Methodology and Machine Learning approach for the chosen problem – iteration 1. Discussions, comments about the solution.		
5. Methodology and Machine Learning approach for the chosen problem – iteration 2. Discussions, comments about the solution.		
6. Experimental evaluation of the approach using public/acquired data sets.		
7. Presentation of the final software application.		

Bibliography

1. Goodfellow, I., Bengio, Y., Courville, A., & Bengio, Y. (2016). Deep learning (Vol. 1, No. 2). Cambridge: MIT press.
2. Larranaga, P., Calvo, B., Santana, R., Bielza, C., Galdiano, J., Inza, I., ... & Robles, V. (2006). Machine learning in bioinformatics. Briefings in bioinformatics, 7(1), 86-112.
3. A.E. Hassanien, M.G. Milanova, Smolinski T.G., and Abraham A. Computational Intelligence in Solving Bioinformatics Problems: Reviews, Perspectives, and Challenges. Computational Intelligence in Biomedicine and Bioinformatics Studies in Computational Intelligence, 151:3-47, 2008.
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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 universities from abroad.

10. Evaluation

Activity type	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Percentage of final grade
10.4 Course	• Writing and oral presentation of a research paper. The topic must be a Bioinformatics problem approached via Machine Learning techniques. The paper must be similar to a research article, in topic and structure.	Evaluation of the research report + presentation	45%
	• The correctness and completeness of the accumulated knowledge.	Written examination (in the regular session)	30%

10.5 Seminar/laboratory	• Development of a software application related to the research paper. • Correctness and punctuality of delivered laboratory assignments.	Evaluation of the application (software implementation, demonstration).	25%
10.6 Minimum standard of performance			
• Each student has to prove that they acquired an acceptable level of knowledge and understanding of the core concepts taught in the class, that they are capable of using knowledge in a coherent form, that they have the ability to establish certain connections and to use the knowledge in solving different Bioinformatics problems. • Successfully passing of the examination is conditioned by the final grade that has to be at least 5.			

11. Labels ODD (Sustainable Development Goals)[2]

Not applicable.

Date:
15.04.2025

Signature of course coordinator

Assoc. Prof. PhD. Bocicor Maria Iuliana

Signature of seminar coordinator

Assoc. Prof. PhD. Bocicor Maria Iuliana

Date of approval:
...

Signature of the head of department

Assoc.prof.phd. Adrian STERCA

[2] 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*.".