COURSE DESCRIPTION CARD - SYLLABUS

Course name
Artificial Intelligence in Biomedical Informatics [S2SI1E>SIB]

Course

Field of study
Artificial Intelligence

Year/Semester
2/3

Area of study (specialization)
–

Profile of study
general academic

Level of study
second-cycle

Course offered in
English

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
15

Laboratory classes
15

Other
0

Tutorials
0

Projects/seminars
0

Number of credit points

2,00

Coordinators

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Lecturers

Prerequisites

The student starting this module should have basic knowledge and skills in statistics, data science, and artificial intelligence (AI) with particular emphasis on machine learning, deep learning, and artificial neural networks. Basic knowledge is medical informatics and biology is welcome, but not required. The student should be able to develop (using existing libraries and environments, mainly in Python) relatively simple modules allowing for performing computational and simulation experiments. They should be also able to obtain information from the indicated sources, often in English. The student should show attitudes such as honesty, persistence, creativity, and respect for other people.

Course objective

1. Acquainting the students with the methods of AI usually applied in solving a range of problems originating from the field of biomedical informatics, requiring sophisticated analysis of biological and medical data, representation of the discovered knowledge in the form of complex models, and explaining the operation of these models. 2. Acquainting the students with exemplary systems and programming tools implementing selected techniques of AI applied in biomedical informatics. 3. Developing students' skills to design and carry out computational and simulation experiments for problems originated from the field of biomedical informatics. 4. Developing students' ability to independently search and obtain information related to the use of AI techniques in biomedical informatics.

Course-related learning outcomes

Knowledge:
As a result of the conducted course, the student:
1. Has advanced and in-depth knowledge of intelligent information systems applied in biomedical informatics, theoretical foundations of their construction and methods, tools and programming environments used to implement them.
2. Has knowledge about development trends and the most important cutting edge achievements in biomedical informatics and AI
3. Knows advanced methods, techniques and tools applied to solve complex engineering tasks and conduct research in the field of biomedical informatics and AI.

Skills:
As a result of the conducted course, the student:
1. Is able to plan and carry out computational and simulation experiments, interpret the obtained results and draw conclusions and formulate and verify hypotheses related to engineering and research problems in the field of biomedical informatics and AI.
2. Can - when formulating and solving engineering tasks - integrate knowledge from different areas of computer science and AI (and if necessary also knowledge from other scientific disciplines, e.g., medicine or biology).
3. Is able - using among others conceptually new methods - to solve complex IT tasks in the field of biomedical informatics and AI, including untypical tasks and tasks containing a research component.

Social competences:
As a result of the conducted course, the student:
1. Understands that in the field of biomedical informatics and AI the knowledge and skills quickly become obsolete.
2. Understands the importance of using the latest knowledge in the field of biomedical informatics in solving research and practical problems.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

The knowledge and skills acquired during the course (considering both the lecture and the laboratories) are verified by a 45-minute test. The test is carried out during the last lecture and the students solve it on their own. The test includes about 10 questions (open and closed, differently marked). Passing threshold: 50% of points.

The skills acquired during the laboratories are verified based on partial grades obtained from the mini-projects carried out during the classes. To pass the laboratories it is necessary to realize and present every considered mini-project. The final grade is the average of all partial grades.

Programme content

During the lectures, we will present the following topics:

1. In the field of bioinformatics:
- Applying machine learning techniques for comprehensive analysis of various biological data.
- Reviewing artificial intelligence techniques for solving selected problems in structural bioinformatics.

2. In the field of medical informatics:
- Applying machine learning techniques for multi-modal data analysis.
- Using distributed machine learning techniques.
- Employing techniques to explain obtained models and decisions.
- Utilizing domain knowledge and integrating it with knowledge discovered from data.

During the laboratory classes, students will complete in groups 4 mini-projects related to the lecture content.

Course topics

The lecture program covers the following topics

1. In the field of bioinformatics:
- application of machine learning techniques (selected classical methods and approaches using deep learning) for integration and comprehensive analysis of diverse biological data,
- review and analysis of artificial intelligence techniques for solving selected problems in the field of structural bioinformatics with particular emphasis on modeling and quality assessment of spatial structures of biological molecules, discovery and classification of molecular interactions crucial for the design of new generation drugs.

2. In the field of medical informatics
- application of machine learning techniques that allow the analysis of multimodal data (images, texts, time series), including approaches using different variants of data fusion,
- application of distributed machine learning techniques (including federated learning) ensuring confidentiality at the level of data and the obtained decision models,
- the use of techniques to clarify the structure of the extracted models and justify suggestions for particular decision-making problems,
- application of domain knowledge in symbolic form (e.g., ontologies, graphs) and related inference methods, and integration of techniques using expert knowledge and knowledge discovered from data.

During the laboratory classes, students complete in groups four mini-projects related to biomedical informatics. The projects are practical in nature and involve the implementation of computational modules for solving the indicated problems and conducting the necessary experiments (e.g., training decision-making models, verifying their operation). Students have one to two weeks to complete each project, depending on its complexity. Progress is checked on an ongoing basis during class, and the completion of each project ends with the preparation of a short report and its presentation to the group. The list of proposed projects is updated before the beginning of the semester according to the current state of biomedical informatics development.

Teaching methods

1. Lecture: slide show presentation illustrated with additional examples presented on the board if needed.
2. Laboratory classes: practical exercises at the computer carried out according to a specific scenario, implementation of relatively simple programs and performing computational experiments, discussion of applied solutions, and case studies.

Bibliography

Basic
1. S. Mitra, S. Datta, T. Perkins, G. Michailidis, "Introduction to Machine Learning and Bioinformatics".
2. P. Baldi, S. Brunak, "Bioinformatics: The Machine Learning Approach".
3. V. Buffalo,"Bioinformatics Data Skills: Reproducible and Robust Research with Open Source Tools".
4. E.H. Shortliffe, J.J. Cimino (eds): "Biomedical Informatics: Computer applications in Health Care and Biomedicine". Springer, 2014.

Additional
1. A. D. Baxevanis, G. D. Bader, D. S. Wishart, "Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins".
2. P. Compeau, P. Pevzner, "Bioinformatics Algorithms".
3. A. Holzinger (ed.): Machine Learning for Health Informatics. State-of-the-Art. and Future Challenges,

Springer, 2016.
4. B. Nordlinger, C. Villani, D. Rus: Healthcare and Artificial Intelligence. Springer, 2020.

Breakdown of average student's workload

	Hours	ECTS
Total workload	50	2,00
Classes requiring direct contact with the teacher	30	1,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	20	1,00