COURSE DESCRIPTION CARD - SYLLABUS

Course name

Artificial Intelligence in Biomedical Informatics

Course

Field of study

Computing

Area of study (specialization)

Artificial Intelligence

Level of study

Second-cycle studies

Form of study

full-time

Year/Semester

2/3

Profile of study

general academic

Course offered in

Polish

Requirements

elective

Number of hours

Lecture

30

Tutorials

Laboratory classes

30

Projects/seminars

Other (e.g. online)

Number of credit points

3

Lecturers

Responsible for the course/lecturer:

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Responsible for the course/lecturer:

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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.

Moreover, the student should show attitudes such as honesty, persistence, creativity, and respect for other people. Finally, they should be able to obtain information from the indicated sources, often in English.

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 advanced detailed knowledge regarding selected AI- and IT-related issues in the field of biomedical informatics.

3. Has knowledge about development trends and the most important cutting edge achievements in biomedical informatics and other selected and related scientific disciplines.

4. Knows advanced methods, techniques and tools applied to solve complex engineering tasks and conduct research in a selected area of biomedical informatics.

Skills

As a result of the conducted course, the student:

1.Is able to obtain information from literature, databases and other sources (both in Polish and English), integrate , interpret and critically evaluate it, draw conclusions and formulate and fully justify opinions.

2. 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 complex engineering problems and simple research problems in the field of biomedical informatics.

3. Can - when formulating and solving engineering tasks - integrate knowledge from different areas of biomedical informatics (and if necessary also knowledge from other scientific disciplines, e.g., medicine or biology) and apply a systemic approach, also taking into account non-technical aspects.

4. Is able to assess the suitability and the possibility of using new achievements (i.e., AI methods and tools) and new IT products in the field of biomedical informatics.

5. Is able - using among others conceptually new methods - to solve complex IT tasks in the field of biomedical informatics, 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 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 60-minute test. The test is carried out during the last lecture and the students solve it on their own. The test includes about 20 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

The lecture program covers the following topics:

a) in the field of medical informatics:

- application of machine learning techniques allowing for the analysis of multi-modal data (images, texts, time series), including approaches using various variants of data fusion,

- application of distributed techniques of machine learning (including federated learning) ensuring confidentiality at the level of data and obtained decision models,

- application of techniques allowing to explain the structure of the developed models and justify suggestions for the particular decision problems,

- application of domain knowledge in the form of medical ontologies and related inference methods, as well as the integration of techniques using expert knowledge and the knowledge discovered from data,

- application of mathematical and simulation models for clinical trials and decision support,

- application of advanced planning techniques and tools to support therapeutic decisions,

- ethical issues related to the application of artificial intelligence techniques in clinical practice, including autonomous solutions,

b) 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 solving selected problems in the field of structural bioinformatics, with particular emphasis on modeling and assessing the quality of tertiary structures of biological molecules, discovery and classification of molecular interactions crucial in the design of new generation drugs.

- application of generative adversarial networks in prediction 3D protein structures.

- application of convolutional neural networks to assess the overall quality of 3D RNA structures.

- application of convolutional and recursive neural networks (LSTM) for the prediction of RNA secondary structures.

Laboratories conducted in the form of 15 two-hour classes are taking place in the computer lab. During the laboratory classes, students individually or in groups of two carry out 6-7 mini-projects related to biomedical informatics. The projects are practical and include the implementation of relatively simple computational modules for solving the indicated problems and conducting the necessary experiments (e.g., training and evaluation of decision models). Students have 2-3 weeks to implement each project, depending on its complexity. Progress is continuously traced during the classes, and the implementation of each project ends with a short presentation in the group forum. The list of proposed projects is made available before the beginning of the semester and periodically updated according to the current state of development of biomedical informatics.

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 (red.): "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. Hozlinger (red.): 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	75	3,0
Classes requiring direct contact with the teacher	60	2,0
Student's own work (literature studies, preparation for laboratory classes/tutorials, preparation for tests/exam, project preparation) [1]	15	1,0

[1] delete or add other activities as appropriate