University of Gdańsk

Subject card

Subject name and code	Data Analysis in Medicine: Tools and Methods for Medical Physicists, PG_00179181		
Field of study	Medical Physics		
Date of commencement of studies	October 2024	Academic year of realisation of subject	2025/2026
Education level	Master's studies	Subject group	Obligatory subject group in the field of study Optional subject group
Mode of study	full-time studies	Mode of delivery	at the university
Year of study	2	Language of instruction	Polish
Semester of study	3	ECTS credits	6.0
Learning profile	academic	Assessment form	credit
Conducting unit			
Name and surname of lecturer (lecturers)	Subject supervisor	Marlena Rygusik	
	Teachers	Marlena Rygusik	

Lesson types	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	30.0	30.0	0.0	0.0	0.0	60
	E-learning hours included: 0.0						

Learning activity and number of study hours	Learning activity	Participation in didactic classes included in study plan	Participation in consultation hours	Self-study	SUM
	Number of study hours	60	0.0	0.0	60

Subject objectives

The aim of the course is to equip students with practical skills in data analysis as applied in medical physics. Participants will gain knowledge of modern statistical methods, machine learning techniques, and approaches to processing medical signals and images.

The course is designed to prepare students for independent work with medical data from initial preprocessing and data exploration, through the development and evaluation of predictive models, to the interpretation of results with consideration of model interpretability aspects (Explainable AI).

Particular emphasis will be placed on the practical use of Python-based tools in the context of real clinical and diagnostic data, with the goal of developing competencies essential in contemporary medical physics.

Learning outcomes	Course outcome	Subject outcome	Method of verification
	[FIZMEDMU2_U06] is able to adapt the knowledge and methodology of physics as well as the experimental and theoretical methods used to related scientific disciplines	The student is able to practically use the Python environment and its libraries (NumPy, Pandas, SciPy, scikit-learn, TensorFlow) for medical data analysis, including data preparation, modeling, and validation.	[SU2] presentation/project/paper/ report
	[FIZMEDMU2_U05] has the ability to synthesize methods and ideas from various areas of physics and other natural sciences; is able to notice that distant phenomena are sometimes described by similar models	The student is able to interpret the results of analytical and predictive models (Explainable AI) in a clinical context and effectively communicate them within an interdisciplinary team (physicist – physician – analyst).	[SU2] presentation/project/paper/ report
	[FIZMEDMU2_W06] has knowledge of current directions in the development of physics, in particular within the chosen specialization	The student knows and understands advanced data analysis methods used in medical physics, including fundamental statistical concepts, machine learning techniques, and medical signal and image processing.	[SW2] presentation/project/paper/ report

Subject contents	**Course Outline** **1. Introduction to Data Analysis in Medicine** • The role of data analysis in medical physics • Types of medical data: clinical, signal, and imaging data • Ethics and data security in medicine (anonymization, GDPR) **2. Python Environment and Data Analysis Tools** • Overview of libraries: NumPy, Pandas, Matplotlib, Seaborn • Working with tabular and time-series data • Data loading and preprocessing (cleaning, transformations) **3. Introduction to Medical Statistics** • Descriptive and exploratory statistics • Statistical tests (parametric and non-parametric) • Correlation analysis, linear and logistic regression **4. Medical Signal and Image Processing** • Introduction to biological signals (ECG, EEG) • Basics of signal processing (filtering, FFT) • Medical image processing • Image segmentation and feature extraction **5. Machine Learning in Medical Data Analysis** • Classification and regression: decision trees, SVM, KNN • Neural networks and deep learning (TensorFlow/Keras) • Application examples: risk prediction, image analysis **6. Data Analysis Workflow** • Stages of data work: exploration, preparation, modeling, validation • Data splitting: train/test/validation

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Preventing overfitting
Model evaluation metrics: accuracy, ROC-AUC, precision/recall

7. Model Interpretability (Explainable AI)

The importance of interpretability in medicine
XAI methods: SHAP, LIME, feature importance
Drawing clinical conclusions based on model results

8. Teamwork and Results Presentation

Data visualization and presentation of analysis results
Preparing reports and presentations for medical teams
Interdisciplinary communication (physicist physician data analyst)

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<tr><td>Prerequisites and co-requisites</td><td>Basic knowledge of the Python programming language (data structures, functions, fundamental libraries)

Understanding of the fundamentals of medical physics, including the operation of diagnostic devices (MRI, CT, PET, EEG, ECG)

Basic mathematics and statistics: linear algebra, calculus, and fundamental statistical concepts (mean, variance, distributions, statistical tests)

Ability to work with data files (CSV, TXT, DICOM)</td></tr>
<tr><td>Assessment methods and criteria</td><td>
<table>
<tr><th>Subject passing criteria</th><th>Passing threshold</th><th>Percentage of the final grade</th></tr>
<tr><td>project with presentation</td><td>51.0%</td><td>100.0%</td></tr>
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<tr><td>Recommended reading</td><td>
<table>
<tr><td>Basic literature</td><td>1. Grus J. Data Science od podstaw. Analiza danych w Pythonie. Gliwice: Helion; 2020
2. Zhou SK, Greenspan H, Shen D, editors. Deep Learning for Medical Image Analysis. London: Academic Press; 2017.
3. https://scikit-learn.org/ dokumentacja scikit-learn
4. https://pandas.pydata.org/ dokumentacja Pandas
5. https://www.tensorflow.org/ dokumentacja TensorFlow</td></tr>
<tr><td>Supplementary literature</td><td>Alan C. Bovik (red.), The Essential Guide to Image Processing, Academic Press, 2009.</td></tr>
<tr><td>eResources addresses</td><td></td></tr>
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<tr><td>Example issues/ example questions/ tasks being completed</td><td></td></tr>
<tr><td>Work placement</td><td>Not applicable</td></tr>
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