



# Machine Learning, Application of Mathematics

## Course description sheet

### Basic information

<b>Field of study</b> Remote Sensing and Geo Informatics	<b>Didactic cycle</b> 2025/2026	
<b>Major</b> All	<b>Course code</b> DRSGIS.II2.15495.25	
<b>Organisational unit</b> Faculty of Geo-Data Science, Geodesy, and Environmental Engineering	<b>Lecture languages</b> English	
<b>Study level</b> Second-cycle studies	<b>Mandatoriness</b> Obligatory	
<b>Form of study</b> Full-time studies	<b>Block</b> Foundation Modules	
<b>Profile</b> General academic	<b>Course related to scientific research</b> Yes	
<b>Course coordinator</b>	Beata Hejmanowska	
<b>Lecturer</b>	Beata Hejmanowska, Mariusz Twardowski	
<b>Period</b> Semester 2	<b>Method of verification of the learning outcomes</b> Completing the classes	<b>Number of ECTS credits</b> 6
	<b>Activities and hours</b> Lectures: 15 Workshop classes: 60	

### Goals

C1	To familiarize students with the basic methods and algorithms of machine learning and their theoretical foundations
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### Course's learning outcomes

Code	Outcomes in terms of	Learning outcomes prescribed to a field of study	Methods of verification
<b>Knowledge - Student knows and understands:</b>			
W1	machine learning and basic deep learning methods and algorithms and their theoretical basis	RSGI2A_W01, RSGI2A_W05	Participation in a discussion, Test, Project, Report
W2	measures for assessing the quality of machine learning models	RSGI2A_W01, RSGI2A_W05	Participation in a discussion, Test, Project, Report
W3	currently available Python libraries dedicated to machine learning and deep learning tasks	RSGI2A_W01, RSGI2A_W04, RSGI2A_W05	Participation in a discussion, Test, Project, Report
<b>Skills - Student can:</b>			
U1	design and implement effective solutions based on machine learning and deep learning algorithms, to solve practical problems	RSGI2A_U02, RSGI2A_U03, RSGI2A_U04	Activity during classes, Participation in a discussion, Project, Report
U2	apply machine learning and deep learning techniques in remote sensing and geoinformation tasks	RSGI2A_U03, RSGI2A_U04	Activity during classes, Participation in a discussion, Project, Report
U3	qualitatively and quantitatively compare the outcomes of machine learning models	RSGI2A_U03, RSGI2A_U04	Activity during classes, Participation in a discussion, Project, Report
<b>Social competences - Student is ready to:</b>			
K1	responsible use of learned machine learning and deep learning techniques in practice, while being aware of their capabilities and limitations	RSGI2A_K01, RSGI2A_K02	Participation in a discussion, Project, Report

## Program content ensuring the achievement of the learning outcomes prescribed to the module

The student will acquire knowledge about the theory of different methods for regression, classification, and clustering as well as the possibilities of using machine learning methods in remote sensing and geoinformation science applications. The course will include both a theoretical basis and an applied part, where students will implement their own solutions to solve a specific problem in remote sensing and/or geoinformation science.

## Student workload

Activity form	Average amount of hours* needed to complete each activity form
Lectures	15
Workshop classes	60
Preparation for classes	30
Examination or final test/colloquium	2

Preparation of project, presentation, essay, report	45
Realization of independently performed tasks	20
<b>Student workload</b>	<b>Hours</b> 172
<b>Workload involving teacher</b>	<b>Hours</b> 75

\* hour means 45 minutes

## Program content

No.	Program content	Course's learning outcomes	Activities
1.	<p>An introduction to machine learning. Types of machine learning. Basic exploratory data analysis. Basic methods of data transformation. Basic methods of data reduction: selection of variables, analysis of principal components. The concepts of training, test and validation sets. Cross-validation and multiple cross-validation. Machine learning in regression tasks: linear regression, general linear model, regression trees, artificial neural networks, combinations of models. Machine learning in binary classification tasks: logistic regression, nearest neighbor method, naïve Bayesian classifier, decision trees, classifier committees, support vector machines, artificial neural networks. Cluster analysis: k-means method, hierarchical methods, data segmentation. Evaluation criteria for regression and classification models.</p> <p>An introduction to deep learning algorithms. Mathematical basis of neural networks. Selected deep learning models and architectures. Examples of usage in remote sensing and geoinformation applications.</p>	W1, W2, W3, U1, U2, U3, K1	Lectures, Workshop classes

## Extended information/Additional elements

### Teaching methods and techniques :

Workshop, Problem Based Learning, Design thinking, Case study, E-learning, Discussion, Lectures

Activities	Methods of verification	Credit conditions
Lectures	Test	Lectures are optional. The condition for passing is to obtain a positive grade in the final test checking the knowledge of machine learning and deep learning theoretical foundations.
Workshop	Activity during classes, Participation in a discussion, Project, Report	Workshops are mandatory. Credit is based on student's activity and presented project task reports.

### Conditions and the manner of completing each form of classes, including the rules of making

## retakes, as well as the conditions for admission to the exam

Lectures are passed on the basis of the results of the final test. The basis for passing the classes is the performance of current practical exercises and the timely presentation of reports on the completed project tasks (or presentation of the completed project during classes). In the case of evaluating a project task, the correctness of the adopted methodology for solving the task, quality of the prepared code, its final effect and the quality of results presentation will be assessed. The oral answer of the student may be an element of passing the project exercise. To pass the course, it is required to actively participate in project exercises (performing current tasks and exercises during classes) and to obtain positive grades (minimum 3.0) from the final test from the theoretical basis and from each of the completed projects. The final grade from the exercises will be the average of the grades obtained from individual projects. The basic deadline for obtaining a credit is the end of classes in a given semester. The student has the right for resit twice.

## Method of determining the final grade

The final grade is a weighted average of the grade of the test checking the knowledge of theoretical basis (35%) and the project grade based on the quality of the submitted project code and report (65%).

## Manner and mode of making up for the backlog caused by a student justified absence from classes

Compensating for the backlog caused by absence: depending on the classes subject – self-realisation of exercises with the help of individual consultations with the instructor.

## Prerequisites and additional requirements

Basic knowledge of mathematical statistics. Python for remote sensing.

## Rules of participation in given classes, indicating whether student presence at the lecture is obligatory

Lecture: Attendance optional. Audiovisual recording of the lecture requires the consent of the lecturer. Project exercises: Attendance at exercises is obligatory. Students perform, in accordance with the guidelines and materials provided by the teacher, practical work aimed at obtaining the competences assumed by the syllabus. The student is obliged to prepare himself in the subject of the exercise, which can be verified in an oral or written test. The method of performing the exercises and the final effect, including the way of presenting the results, are assessed.

## Literature

### Obligatory

1. Mathematics for Machine Learning – Deisenroth, Faisal & Ong <https://mml-book.github.io/>
2. Deep Learning – Goodfellow, Bengio & Courville <https://www.deeplearningbook.org/>

### Optional

1. Geographic Data Science with Python – Rey & Arribas-Bel <https://geographicdata.science/book/>

## Scientific research and publications

### Research

1. 2020-2022 Integracja danych teledetekcyjnych na potrzeby kontroli w systemie dopłat bezpośrednich do rolnictwa (IACS), Inicjatywa Doskonałości – Uczelnia Badawcza – AGH,

### Publications

1. The potential of U-Net in detecting mining activity: accuracy assessment against GEE classifiers / Beata HEJMANOWSKA, Krystyna MICHAŁOWSKA, Piotr KRAMARCZYK, Ewa GŁOWIENKA // Applied Sciences (Basel) [Dokument elektroniczny]. — Czasopismo elektroniczne ; ISSN 2076-3417. — 2025 — vol. 15 iss. 17 art. no. 9785, s. 1-37. — Wymagania systemowe: Adobe Reader. — Bibliogr. s. 35-37, Abstr. — Publikacja dostępna online od: 2025-09-05
2. Challenges in preparing datasets for super-resolution on the example of Sentinel-2 and Planet Scope images / A.

MALCZEWSKA, J. Malczewski, B. HEJMANOWSKA // The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences ; ISSN 1682-1750. — 2023 — vol. 48-1/W3-2023, s. 91-98. — Bibliogr. s. 97-98, Abstr. — Publikacja dostępna online od: 2023-10-19. — 2nd GEOBENCH Workshop on Evaluation and BENCHMARKing of sensors, systems and GEOspatial data in photogrammetry and remote sensing : 23-24 October 2023, Krakow, Poland

3. The potential of U-Net in detecting mining activity: accuracy assessment against GEE classifiers / Beata HEJMANOWSKA, Krystyna MICHAŁOWSKA, Piotr KRAMARCZYK, Ewa GŁOWIENKA // Applied Sciences (Basel) [Dokument elektroniczny]. — Czasopismo elektroniczne ; ISSN 2076-3417. — 2025 — vol. 15 iss. 17 art. no. 9785, s. 1-37. — Wymagania systemowe: Adobe Reader. — Bibliogr. s. 35-37, Abstr. — Publikacja dostępna online od: 2025-09-05

## Learning outcomes prescribed to a field of study

Code	Content
RSGI2A_K01	is ready to resolve conflicts, negotiate, work in a team
RSGI2A_K02	is ready for creative time management, working under time pressure
RSGI2A_U02	can acquire remote environmental data
RSGI2A_U03	is able to process geospatial data and automate data processing in an advanced manner
RSGI2A_U04	is able to use IT tools for spatial data processing
RSGI2A_W01	has a deep knowledge of mathematics in remote sensing data analysis
RSGI2A_W04	has a deep understanding of methods, algorithms and automation of spatial data processing
RSGI2A_W05	has an enhanced knowledge of the use of computer science in geoscience