# Machine learning applications in remote sensing

Course description sheet

## Basic information

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|---|---|
| **Field of study**<br>Geodesy, Surveying and Cartography<br>**Major**<br>Geoinformation, Photogrammetry and Remote Sensing<br>**Organisational unit**<br>Faculty of Geo-Data Science, Geodesy, and Environmental Engineering<br>**Study level**<br>Second-cycle (engineer) programme<br>**Form of study**<br>Full-time studies<br>**Profile**<br>General academic | **Didactic cycle**<br>2024/2025<br>**Course code**<br>DGIKGFS.IIi4.15202.24<br>**Lecture languages**<br>English<br>**Mandatoriness**<br>Elective<br>**Block**<br>Elective Modules in Foreign Language<br>**Course related to scientific research**<br>Yes |

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|---|---|
| **Course coordinator** | Wojciech Drzewiecki |
| **Lecturer** | Wojciech Drzewiecki |

| **Period** | **Method of verification of the learning outcomes** | **Number of ECTS credits** |
|---|---|---|
| Semester 3 | Completing the classes<br><br>**Activities and hours**<br>Discussion seminars: 30 | 3 |

## Goals

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|---|---|
| C1 | The main purpose is to familiarise the students with typical applications of machine learning in remote sensing. |

## Course's learning outcomes

| Code | Outcomes in terms of | Learning outcomes prescribed to a field of study | Methods of verification |
|---|---|---|---|
| **Knowledge – Student knows and understands:** | | | |
| W1 | typical applications of machine learning in remote sensing. | GIK2A_W01, GIK2A_W02, GIK2A_W05, GIK2A_W06 | Execution of exercises, Execution of a project, Oral answer |
| **Skills – Student can:** | | | |
| U1 | apply regression techniques to analyze remote sensing data | GIK2A_U04, GIK2A_U07, GIK2A_U08, GIK2A_U10 | Execution of exercises, Execution of a project, Oral answer |
| U2 | use machine learning methods to classify remote sensing images | GIK2A_U08, GIK2A_U09 | Execution of exercises, Execution of a project, Oral answer |
| U3 | choose appropriate machine learning methods to solve selected tasks in the field of remote sensing | GIK2A_U04, GIK2A_U10 | Activity during classes, Execution of a project, Oral answer |
| U4 | evaluate and compare the results obtained using different machine learning techniques | GIK2A_U04, GIK2A_U07, GIK2A_U10 | Activity during classes, Execution of exercises, Oral answer |
| **Social competences – Student is ready to:** | | | |
| K1 | responsible use of learned machine learning techniques in practice, while being aware of their capabilities and limitations | GIK2A_K01 | Activity during classes, Execution of a project, Oral answer |

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

The student will acquire basic knowledge about the possibilities of using machine learning techniques to solve remote sensing tasks.

## Student workload

| Activity form | Average amount of hours* needed to complete each activity form |
|---|---|
| Discussion seminars | 30 |
| Preparation for classes | 12 |
| Realization of independently performed tasks | 12 |
| Contact hours | 5 |
| Preparation of project, presentation, essay, report | 29 |
| Examination or final test/colloquium | 2 |
| | |
| **Student workload** | **Hours**<br>90 |

| Workload involving teacher | Hours<br>30 |
|---|---|

* hour means 45 minutes

## Program content

| No. | Program content | Course's learning outcomes | Activities |
|---|---|---|---|
| 1. | 1. Introduction to machine learning applications in remote sensing - applicability, processing steps, main concepts and techniques. Applications in regression and classification tasks. Image data mining. Deep learning in remote sensing.<br>2. Students project: Machine learning in remote sensing - regression tasks.<br>3. Students project: Machine learning in remote sensing - classification tasks. | W1, U1, U2, U3, U4, K1 | Discussion seminars |

## Extended information/Additional elements

### Teaching methods and techniques :

Discussion, Case study

| Activities | Methods of verification | Credit conditions |
|---|---|---|
| Discussion seminars | Activity during classes, Execution of exercises, Execution of a project, Oral answer | The condition for passing is participation in classes, execution of exercises and projects, presentation of reports and / or presentation of the results obtained |

### 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

Student must prepare and present on time the results of project exercise. The methodological correctness of adopted sollutions, the final result and the form of project presentation are evaluated. To complete the course all project exercises must be evaluated at least for 3.0. The final grade is an arithmetic mean of all marks. The basic term for project completion is the day of last classes in the semester. The instructor and students will agree two additional deadlines for completion of project tasks.

### Method of determining the final grade

The final grade is the grade of the project.

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

If student misses the class, she/he may be required to perform additional exercises at home and present the results to the instructor.

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

Classes are obligatory. Students carry out practical work aimed at obtaining competences assumed by the syllabus.

## Literature

**Obligatory**


1. David J. Lary, Amir H. Alavi, Amir H. Gandomi, Annette L. Walker: Machine learning in geosciences and remote sensing, Geoscience Frontiers, Volume 7, Issue 1, 2016, Pages 3-10
2. Lei Ma, Yu Liu, Xueliang Zhang, Yuanxin Ye, Gaofei Yin, Brian Alan Johnson: Deep learning in remote sensing applications: A meta-analysis and review, ISPRS Journal of Photogrammetry and Remote Sensing, Volume 152, 2019, Pages 166-177


**Optional**


1. Rissouni Youssef, Moumen Aniss, Chao Jamal: Machine Learning and Deep Learning in Remote Sensing and Urban Application: A Systematic Review and Meta-Analysis. GEOIT4W-2020: Proceedings of the 4th Edition of International Conference on Geo-IT and Water Resources 2020, Geo-IT and Water Resources 2020March 2020 Article No.: 18Pages 1–5
2. Karsten Schulz, Ronny Hänsch, Uwe Sörgel: Machine learning methods for remote sensing applications: an overview. Proceedings Volume 10790, Earth Resources and Environmental Remote Sensing/GIS Applications IX; 1079002 (2018)
3. Kuhn M., Johnson K.: Applied Predictive Modelling, Springer, New York, NY, 2013.


## Scientific research and publications

**Publications**


1. Bernat K., Drzewiecki W.: Two-stage subpixel impervious surface coverage estimation: comparing classification and regression trees and artificial neural networks. Proc. SPIE 9244, Image and Signal Processing for Remote Sensing XX, 92441I (October 23, 2014); doi:10.1117/12.2067308
2. Bernat K., Drzewiecki W., Twardowski M.: Two-stage subpixel impervious surface coverage estimation: comparing C 5.0/cubist and random forest. W: SGEM 2014 : GeoConference on Informatics, geoinformatics and remote sensing: international multidisciplinary scientific geoconference : 17–26 June, 2014, Albena, Bulgaria : conference proceedings. Vol. 3, Photogrammetry and remote sensing cartography and GIS. — Sofia : STEF92 Technology Ltd., 343-350
3. Drzewiecki W., Wawrzaszek A., Krupiński M., Aleksandrowicz S., Bernat K.: Comparison of selected textural features as global content-based descriptors of VHR satellite image - the EROS-A study. 2013 Federated Conference on Computer Science and Information Systems, 43-49
4. Drzewiecki W., Wawrzaszek A., Aleksandrowicz S., Krupiński M., 2012: Initial Evaluation of the Applicability of Multifractal Measures as Global Content-Based Image Descriptors. Proc. of ESA-EUSC-JRC 8th Conference on Image Information Mining, DOI: 10.2788/49465.
5. Drzewiecki W.: Thorough statistical comparison of machine learning regression models and their ensembles for sub-pixel imperviousness and imperviousness change mapping, Geodesy and Cartography, 2017 vol. 66 no. 2, s. 171–209
6. Drzewiecki W. Improving sub-pixel imperviousness change prediction by ensembling heterogeneous non-linear regression models , Geodesy and Cartography, 2016 vol. 65 no. 2, s. 193–218
7. Wojciech DRZEWIECKI, Anna Wawrzaszek, Michał Krupiński, Sebastian Aleksandrowicz, Katarzyna Bernat: Applicability of multifractal features as global characteristics of WorldView-2 panchromatic satellite images. European Journal of Remote Sensing, 2016 vol. 49, s. 809–834
8. Drzewiecki W.: Comparison of selected machine learning algorithms for sub-pixel imperviousness change assessment. 2016 Baltic Geodetic Congress (Geomatics) : Gdansk, Poland 2–4 June 2016 : proceedings. S. 67–72.

## Learning outcomes prescribed to a field of study

| Code | Content |
|---|---|
| GIK2A_K01 | działania w sposób kreatywny i przesiębiorczy z uwzględnieniem krytycznej oceny posiadanej wiedzy i potrzeby konsultacji eksperckich |
| GIK2A_U04 | planować i przeprowadzać eksperymenty z wykorzystaniem zaawansowanych metod analitycznych i symulacyjnych oraz formułować, projektować i rozwiązywać skomplikowane zadania inżynierskie, prawidłowo szacując nakład pracy i koszty realizacji, a także rozumiejąc ich znaczenie |
| GIK2A_U07 | formułować i testować hipotezy statystyczne związane z problemami inżynierskimi i badawczymi |
| GIK2A_U08 | ocenić przydatność i możliwości wykorzystania nowych technik i technologii pozyskiwania danych przestrzennych oraz zaawansowanych narzędzi informatycznych służących do przetwarzania i analizy wyników obserwacji, dokonać krytycznej analizy ich funkcjonowania i zaproponować usprawnienia istniejących rozwiązań |
| GIK2A_U09 | rozwiązywać złożone zadania inżynierskie z zakresu wybranej specjalności na kierunku Geodezja i Kartografia, stosując nowoczesne metody i uwzględniając komponent badawczy, w tym dokonać identyfikacji i sformułować specjalistyczną specyfikację zadania oraz opracować procedurę realizcji uwzględniając aspekty pozatechniczne |
| GIK2A_U10 | zaprojektować i wykonać badania relacji przestrzennych w środowisku oraz zinterpretować ich wyniki, dokonując krytycznej analizy stosowanych metod, z uwzględnieniem komponentu badawczego i aspektów pozatechnicznych |
| GIK2A_W01 | zaawansowane zagadnienia z matematyki przydatne do formułowania i rozwiązywania szczegółowych problemów z geodezji i kartografii oraz dziedzin pokrewnych |
| GIK2A_W02 | najnowsze osiągnięcia i trendy rozwojowe w dziedzinach i dyscyplinach naukowych, właściwych dla dyscypliny naukowej Inżynieria lądowa i transport |
| GIK2A_W05 | metody, techniki, narzędzia i materiały stosowane przy rozwiązywaniu złożonych zadań inżynierskich z dziedziny geodezja i kartografia oraz dziedzin pokrewnych |
| GIK2A_W06 | specjalistyczne metody pozyskiwania, analizowania, modelowania i wizualizowania danych przestrzennych i zmian tych danych spowodowanych procesami naturalnymi i technologicznymi |