COURSE DESCRIPTION CARD - SYLLABUS

Course name
Neural Networks and Machine Learning [S2AiR2-SIiB>SNiUM]

Course

Field of study
Automatic Control and Robotics

Year/Semester
2/3

Area of study (specialization)
Intelligent and Unmanned Systems

Profile of study
general academic

Level of study
second-cycle

Course offered in
Polish

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
30

Laboratory classes
15

Other
0

Tutorials
0

Projects/seminars
0

Number of credit points

3,00

Coordinators

dr inż. Marek Kraft
marek.kraft@put.poznan.pl

Lecturers

Prerequisites

The student starting this subject should have a basic knowledge of mathematics, especially linear algebra, matrix calculus, elements of mathematical logic, as well as the basics of mathematical analysis and probability calculus. The student should have a basic understanding of image formation, and of image processing and machine learning algorithms and their practical use using the Python language. The student should have the ability to obtain information from the indicated sources. He/she should be aware of the necessity to expand his/her theoretical and practical knowledge and to continuously update the acquired knowledge due to dynamic changes in modern technology. He/she should also understand the necessity to broaden his/her competences and be ready to cooperate within a team implementing e.g. a joint project.

Course objective

1. To provide students with knowledge of machine learning methods with particular emphasis on methods using multilayer neural networks - convolutional, recurrent and transformer type networks. Examples of neural networks applications in remote sensing - precision agriculture, emergency management, urban planning, senor data analysis based on machine learning algorithms. 2. To develop in students the ability to solve practical data processing problems using machine learning methods. 3. To develop the students' ability to work as a team during the final project in the laboratory.

Course-related learning outcomes

Knowledge:
1. has a structured and in-depth knowledge of artificial intelligence methods and their application in automation and robotics systems; [K2_W2]
2. has knowledge of development trends and the most significant new developments in automation and robotics and related scientific disciplines. [K2_W12]

Skills:
1. is able to use advanced methods of signal processing and analysis, including video signal, and extract information from analysed signals; [K2_U11]
2. is able to perceive non-technical aspects, including environmental, economic and legal aspects when formulating and solving tasks involving the design of automation and robotics systems. [K2_U14]

Social competences:
1. understands the need for and knows the opportunities of continuous education - improving professional, personal and social competences, is able to inspire and organise the learning process of others; [K2_K1]
2.is aware of the responsibility for his/her own work and is ready to follow the rules of teamwork and take responsibility for jointly implemented tasks; he/she is able to lead a team, set goals and determine priorities leading to the implementation of the task [K2_K3].

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Lecture - final test carried out on the Moodle platform.
Labs - completion of a project covering the issues discussed in the course.

Programme content

1. Performance evaluation of machine learning methods - measures and metrics.
2. Multilayer convolutional neural networks, recurrent networks and tranformer networks.
3. Components of neural networks applied to remote sensing as an example.
4. Architectures of example networks - principle of operation and discussion using examples.
5. Training neural networks - back propagation, optimisation algorithms, objective function, metrics, learning control and monitoring, hyperparameters.
6. Transfer learning and data augmentation.
7. Neural networks for image segmentation - binary, semantic and panoptic segmentation, selected architectures and objective functions.
8. Neural networks for object detection - difference between classification and detection, discussion of several architectures (RCNN, YOLO, EfficientDet). Description of the objective function. Networks for detection and segmentation (mask-RCNN, Yolact++).
9 Generative neural networks.
10. Selected other advanced topics (self-supervised learning and other advanced techniques) and applications (depth estimation, optical flow, tracking, embedded systems vs neural networks).
11. Multilayer neural networks - the issue of predictive explainability.
12. Time series analysis.
The laboratory programme includes the following topics: selection of learning data, creation of a validation and test set for machine learning methods; familiarisation with machine learning methods presented in lecture. Solving practical problems using the methods learned.

Course topics

In the course, students are introduced to state-of-the-art, multilayer neural network-based image processing techniques for a range of different applications. The basic components of the networks, the construction of the networks and the specifics of their learning and guidance in their use are presented, with emphasis on remote sensing apllications.

Teaching methods

Lectures with multimedia presentations, additionally uploaded to a streaming service for later playback. Laboratory classes covering implementation and testing of selected algorithms for image and video processing using the Python language and solving selected practical problems.

Bibliography

Basic:
1 Sebastian Raschka, Vahid Mirjalili, Python. Machine learning. Packt, 4th ed.
2 Supplementary material for the course, published online, on Moodle

Additional:
1. Bengio, Yoshua, Ian Goodfellow, and Aaron Courville. Deep learning. Vol. 1. Massachusetts, USA: MIT press, 2017.
2. Selected research papers.

Breakdown of average student's workload

	Hours	ECTS
Total workload	75	3,00
Classes requiring direct contact with the teacher	45	2,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	30	1,00