COURSE DESCRIPTION CARD - SYLLABUS

Course name
Advanced computer vision [N2AiR1-RiSA>ZPO]

Course

Field of study	Year/Semester
Automatic Control and Robotics	1/2
Area of study (specialization)	Profile of study
Autonomous Robots and Systems	general academic
Level of study	Course offered in
second-cycle	Polish
Form of study	Requirements
part-time	compulsory

Number of hours

Lecture	Laboratory classes	Other
20	20	0
Tutorials	Projects/seminars	
0	0	

Number of credit points

4,00

Coordinators	Lecturers
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Prerequisites

Knowledge: A student beginning this subject should have basic knowledge of mathematics - including, mainly, matrix calculus, knowledge of elements of mathematical logic, basics of mathematical analysis and probability theory. Skills: He or she should have the ability to operate a PC and implement simple algorithms and programming tasks. Additionally, the ability to obtain information from indicated sources is essential.

Course objective

The aim of this course is to learn the theoretical foundations of advanced methods of video information processing, using knowledge that ties the the fields of image processing and machine learning methods. The course is a continuation of "Computer vision" course, enriching the knowledge and skills of students with modern algorithms and methods, mainly based on deep convolutional neural networks. Upon completing the course, the student should be able to choose an algorithm or set of algorithms that make up the task of image or video processing and implement and test such a system on their own.

Course-related learning outcomes

Knowledge

The graduate has an organized and in-depth knowledge of specialized microprocessor systems for control and measurement systems (K2_W18 [P7S_WG])
Skills
Can critically assess and select appropriate methods and tools to solve a task in automation and robotics; can use innovative and unconventional tools in automation and robotics (K2_U22 [P7S_UW])
Social competences
The graduate is aware of the need for a professional approach to technical issues, meticulous familiarization with the documentation and environmental conditions in which the equipment and its components can operate (K2_K4 [P7S_KR])

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

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Lecture - final credit test carried out on Moodle plaftorm.
Laboratories - practical project and final practical programming test.

Programme content

Image processing and machine learning.

 Deep, convolutional neural networks .

Transformer neural networks in image processing.

Components of convolutional neural networks.

Example network architectures for image recognition - principle of operation and discussion on examples.

Training the neural networks - backpropagation, optimization algorithms, loss function, metrics, control and monitoring of the training process, hyperparameters.

Transfer learning and data augmentation.

Explainability of neural networks - GradCAM and LIME methods. Analysis of the operation of the trained networks.

Neural networks for image segmentation - binary, semantic and panoptic segmentation, selected architectures and loss functions.

Neural networks for object detection - difference between classification and detection, discussion of several architectures (RCNN, YOLO, EfficientDet). Description of target functions. Networks for detection and segmentation (mask-RCNN, Yolact++).

Metric learning and the generation of embeddings in image recognition. Example applications - recognition of places, faces. Siamese networks, triplet loss function.

Autoencoders and their applications - improving image quality, detection of anomalies in the image and video.

Generative adversarial networks (GAN) - selected architectures, training and applications.

Genrative diffusion models.

Selected advanced topics (self-supervised learning and advanced techniques, e.g. mixup) and applications (depth estimation, optical flow, tracking, embedded systems and neural networks).

Machine learning ethics.

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.

Teaching methods

Lectures with multimedia presentations, additionally uploaded to a streaming service to be played later.

Laboratory classes covering the implementation and testing of selected algorithms for image and video processing using Python language and solving selected practical problems.

Bibliography

Basic
1. R. Szeliski, Computer Vision: Algorithms and Applications, Springer, 2010
2. Supplementary course materials posted on Moodle
Additional
Selected scientific papers related to the course.

Breakdown of average student's workload

	Hours	ECTS
Total workload	100	4,00
Classes requiring direct contact with the teacher	40	1,50
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	60	2,50