POZNAN UNIVERSITY OF TECHNOLOGY

EUROPEAN CREDIT TRANSFER AND ACCUMULATION SYSTEM (ECTS)

COURSE DESCRIPTION CARD - SYLLABUS

Course name
Computer Vision [S2Inf1-SzInt>WKOM]

Course

Field of study
Computing

Year/Semester
1/1

Area of study (specialization)
Artificial Intelligence

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
30

Other
0

Tutorials
0

Projects/seminars
0

Number of credit points

5,00

Coordinators

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Lecturers

Prerequisites

Learning objectives of the first cycle studies defined in the resolution of the PUT Academic Senate

Course objective

1. To make the students familiar with the fundamentals and selected advanced topics of computer vision and image processing, with emphasis on connections with artificial intelligence and computational intelligence, and in particular with machine learning. 2. To help the students in developing skills of solving problems pertaining to object detection, segmentation, classification and localization, and acquiring experience in applying those skills in selected practical applications. 3. To help the students in developing capabilities of leading and participating in small software projects involving image processing and analysis, including teamwork skills and good practices.

Course-related learning outcomes

Knowledge:
has a structured and theoretically founded general knowledge related to key issues in the field of computer vision [k2st_w2].
has advanced detailed knowledge regarding selected topics in computer vision, in particular image

acquisition and image processing, scene analysis, and design of systems that perform scene-based reasoning [k2st_w3].
has advanced and detailed knowledge of the processes occurring in the life cycle of computer vision systems, including data acquisition techniques, and designing, testing and deployment of such systems [k2st_w5].
knows advanced methods, techniques and tools used to solve complex engineering tasks and conduct research within computer vision, in particular the methodology pertaining to conducting computational experiments and metrics for assessment of the quality of computer vision systems [k2st_w6].

Skills:
is able to plan and carry out experiments, including computer measurements and simulations, interpret the obtained results and draw conclusions and formulate and verify hypotheses related to complex engineering problems and simple research problems in computer vision [k2st_u3].
can use analytical, simulation and experimental methods to formulate and solve engineering problems and simple research problems in computer vision [k2st_u4].
can - when formulating and solving engineering tasks - integrate knowledge from different areas of computer science (and if necessary also knowledge from other scientific disciplines) and apply a systemic approach, also taking into account non-technical aspects [k2st_u5].
is able to assess the suitability and the possibility of using new achievements (methods and tools) and new it products [k2st_u6].
can carry out a critical analysis of existing technical solutions used in computer vision systems and propose their improvements (streamlines) [k2st_u8].
is able - using among others conceptually new methods - to solve complex tasks involving design and implementation of computer vision systems, including atypical tasks and tasks containing a research component [k2st_u10].
is able - in accordance with a given specification, taking into account non-technical aspects - to design a complex device, it system or process typical for the computer vision area and implement this project - at least in part - using appropriate methods, techniques and tools, including adapting to this purpose existing tools or developing new ones [k2st_u11].

Social competences:
understands that in the field of computer vision the knowledge and skills quickly become obsolete [k2st_k1].
understands the importance of using the latest knowledge in the field of computer vision in solving research and practical problems [k2st_k2].

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

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Formative assessment:
a) lectures:
● asking student questions pertaining to the material presented in previous lectures,
b) laboratory classes:
● evaluation of progress in project realization (checkpointing)
Total assessment:
a) verification of assumed learning objectives related to lectures:
● Evaluation of acquired knowledge in the form of a written exam (5-8 open questions pertaining to lecture contents). Roughly half of questions are theoretical (define, describe, characterize, etc.), the other half are practical and require manual calculations (e.g., apply the erosion algorithm to a small binary image). Maximum total score: 25 points, of which 13 are required to obtain a positive grade.
b) verification of assumed learning objectives related to laboratory classes:
● Evaluation of progress along the semester classes, based on the project carried out by students and based on its documentation; students work on the project in part during the classes, and partially individually. The assigned grade reflects also student’s teamwork skills.
● Evaluation of student’s “defense” of project report and project presentation taking place at the last laboratory class, with the other students in the audience.
Additional assessment elements include:
● Student’s capability of applying the acquired knowledge to the problem posed in the project.

● Student’s remarks aimed at improving the quality of teaching material.
● Indications of students’ problems at acquisition and understanding of the knowledge presented at the lectures, aimed at improving the overall quality of the teaching process.

Programme content

Lecture:
Introduction. The place of computer vision within computer science, artificial intelligence, and related disciplines. Application areas and scientific reading. Characteristics of visual information. Classes of images and methods of image representation. Image parameters: dimensions, depth, resolution. Color representation spaces. Image acquisition. External and internal camera parameters. Image detectors. Single-point image processing. Gamma correction. Pseudocoloring. Image arithmetic. Linear filtering. Definition and properties of convolution. Frequency-domain image processing. Fourier transform. Interpretation of image spectrum. Morphological image processing: dilation, erosion, opening, closing. Effective algorithms for morphological filtering. Generalization to grayscale images. Discrete geometry. Edge detection and contour following algorithms. Hough transform.
Shape and texture features. Measurement of object dimensions and shape. Shape coefficients. Skeletons. Geometrical moments. Fractal dimension. Textural features: autocorrelation, cooccurrence matrix, spectrum. Structural methods for texture description. Image segmentation. Classes of algorithms for image segmentation: thresholding, edge detection, region growing and region splitting. Distance transform. Watershed segmentation.
Convolutional neural networks and deep learning for selected tasks in computer vision: object classification, detection and segmentation. Semantic segmentation and instance segmentation. Selected algorithm for training neural models and metrics for model assessment. Typical design patterns for neural networks applied to image processing and computer vision. Milestone neural architectures in computer vision. Evolutionary feature selection and synthesis for image interpretation.
Stereovision. Canonical camera system. Disparition. Depth estimation. Motion analysis. Optical flow. Kalman filter. Case studies.
Algorithmic aspects of computer vision and image analysis, with particular emphasis on computational complexity and memory complexity.
Lab:
The lab classes (15 x 2 hours) take place in computer laboratories. They start with a 6-hour preparatory part (three meetings in the beginning of the semester). The exercises and projects are carried out in two-people teams. Introduction (2h): Presentation of the outline of lab classes. Presentation of software tools used in lab classes (software libraries, software development environments). Preparatory sessions (6h): Hands-on training in software implementation of selected image processing and analysis algorithms in popular programming languages (C++, Python). Testing the implemented algorithms on real-world images and synthetic benchmarks. Assessment of algorithm correctness and efficiency (in particular time complexity/efficiency). Good practices in design and implementation of image processing and analysis algorithms. Common pitfalls and how to avoid them. Software project (22h): Students form two-people teams and carry out software projects concerning specific image processing and analysis tasks. Examples of projects: face identification; object detection in aerial and satellite imagery; fingerprint identification; enhancement and analysis of medical imaging (microscopy, magnetic resonance imaging, optical coherence tomography).

Course topics

none

Teaching methods

1. Lectures: multimedia presentation, illustrated with examples, with occasional use of black board. Software demonstration.
2. Labs: practical exercises, problem solving, design and implementation of image analysis systems, performing computational experiments, discussion, teamwork, presentation of project outcomes (software and computational experiments).

Bibliography

Basic
1. Gonzalez, Wintz, Digital Image Processing. Addison-Wesley 2017 (wydanie IV, lub wcześniejsze).

2. Domański, M., Obraz cyfrowy. WKŁ 2010.
3. Goodfellow, I., Bengio, Y., Courville, A., Deep learning: systemy uczące się. Wydawnictwo Naukowe PWN, 2018.
Additional
1. Zieliński, T.P., Cyfrowe przetwarzanie sygnałów. WKŁ 2009.
2. Cyganek, B., Komputerowe przetwarzanie obrazów trójwymiarowych. EXIT 2002.
3. Owen, M., Przetwarzanie sygnałów w praktyce. WKŁ 2009.
4. Choraś, R. Komputerowa wizja. Metody interpretacji i identyfikacji obiektów. EXIT, 2006.

Breakdown of average student's workload

	Hours	ECTS
Total workload	125	5,00
Classes requiring direct contact with the teacher	60	3,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	65	2,00