COURSE DESCRIPTION CARD - SYLLABUS

Course name

CONVOLUTIONAL NEURAL NETWORKS FOR MEDICAL IMAGE PROCESSING AND ROBOT VISION, LEARNING AND CONTROL [S5AEEITK>KSNPOM]

Course

Proposed by Discipline
–

Year/Semester
2/4

Level of study
Doctoral School

Course offered in
English

Form of study
full-time

Requirements
elective

Number of hours

Lecture
8

Laboratory classes
0

Other
0

Tutorials
0

Projects/seminars
0

Number of credit points

2,00

Coordinators

prof. dr inż. Eduardo Jose Bayro Corrochano
eduardo.bayro@put.poznan.pl

Lecturers

Prerequisites

Knowledge: The student starting this module should have basic knowledge of linear algebra, digital signal processing and neurocomputing. Skills: He/she should have skills to solve basic problems related to using of sensory information and the ability to acquire information from given sources. The student should understand the necessity of extending his/her competences. Social Competencies: Furthermore, regarding social skills, the student should demonstrate qualities such as honesty, responsibility, perseverance, curiosity, creativity, good manners, respect for others, and the ability to collaborate effectively in research teams.

Course objective

1) Provide students with knowledge of signal and image processing and analysis techniques in the field of signal and image preprocessing, segmentation, deep learning for medical image processing and the recognition and interpretation of visual information for use in control and robotics. 2) Provide students with knowledge of elements of machine vision systems and deep learning, their structure and possible applications in electrical engineering, communications, bioinformatics, biomechanics, robotics vision learning and control, and quantum computing. 3) Develop students' skills to select the appropriate signal and image processing methods and deep learning CNNs depending on the given tasks and the ability to use this technology for applications in diverse fields like electrical engineering, communications, bioinformatics, biomechanics, robotics vision learning and control, and quantum computing.

Course-related learning outcomes

A PhD student who graduated from doctoral school knows and understands:
1) global achievements, covering theoretical foundations as well as general and selected specific issues that are relevant to scientific disciplines studied at the Doctoral School, to the extent that enables revision of existing paradigms [P8S_WG/SzD_W01],
2) key developmental trends of disciplines of science in which education at the Doctoral School takes place [P8S_WG/SzD_W02],
3) scientific research methodology in disciplines represented at the Doctoral School [P8S_WG/SzD_W03],
4) principles of disseminating results of scientific activity, also in an open access mode [P8S_WG/SzD_W04].

Skills
A PhD student who graduated from doctoral school can:
1) use knowledge from different branches of science to creatively identify, formulate and innovatively solve complex problems or to perform research tasks such as: - define the aim and subject of scientific research, form a research hypothesis, - develop research methods, techniques and tools and use them creatively, - draw conclusions on the basis of research results, [P8S_UW/SzD_U01],
2) critically analyze and assess scientific research results, work of experts and other creative activities together with their contribution into knowledge development, [P8S_UW/SzD_U02],
3) transfer the results of scientific activity to the economic and social sphere, [P8S_UW/SzD_U03],
4) communicate on specialist issues on the level that allows active participation in the international scientific community, [P8S_UK/SzD_U04],
5) share results of scientific activity also in a popular form, [P8S_UK/SzD_U05],
6) initiate debates, [P8S_UK/SzD_U06],
7) take part in scientific discourse, [P8S_UK/SzD_U07],
8) use the English language on at least B2 level, according to the Common European Framework of Reference for Languages (CEFR), to a degree which allows active participation in the international scientific and professional community, [P8S_UK/SzD_U08],
9) plan and implement individual and team research projects, also in the international community, [P8S_UO/SzD_U09],
10) independently plan and act for their self-development as well as inspire and organize development of others, [P8S_UU/SzD_U10],
11) plan classes and groups of classes and conduct them with the use of up-to-date methods and tools [P8S_UU/SzD_U11],

Social competencies
A PhD student who graduated from doctoral school is ready to:
1) critically assess achievements within a given scientific discipline, [P8S_KK/SzD_K01],
2) critically evaluate their own contribution to development of a given scientific discipline, [P8S_KK/SzD_K02],
3) acknowledge the importance of knowledge in solving cognitive and practical problems, [P8S_KK/SzD_K03],
4) fulfilling the social obligations of researchers and creators, [P8S_KO/SzD_K04],
5) initiate actions in the public interests, [P8S_KO/SzD_K05],
6) think and act in an entrepreneurial manner, [P8S_KO/SzD_K06],
7) maintain and develop the ethos of research and creative communities, including: - conducting independent scientific activity, - respecting the principle of public ownership of the results of scientific activities, including the principles of intellectual property protection, [P8S_KR/SzD_K07].

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Verification of assumed learning objectives related to lectures is performed based on evaluation of acquired knowledge based on the written exam in the test form with 25-30 questions (pass threshold 50%) and individual discussion on results of the exam.
In the scope of the final project, the objectives are verified based on an assessment of the current progress of the project, evaluation of student's knowledge and skills related to implementation, and evaluation of report connected with presentation of the project.

Programme content

The module program covers the following topics:
1. Foundations of Convolutional Neural Networks,
2. Signal and Image Processing using Deep Learning CNN,
3. 3D Object and Pose Recognition using CNNs,
4. Deep reinforcement learning for continuous robot control tasks,
5. Deep Learning for Bioinformatics,
6. Introduction Machine Learning and Quantum Computing.

Course topics

Neurocomputing has been applied to problems in object recognition, speech recognition, speech synthesis, forecasting, scientific computing, control, robotics, and many more. The resulting applications are touching all of our lives in areas such as healthcare and medical research, human-computer interaction, robotics, communication, transport, conservation, manufacturing, and many other fields of human endeavour.

This course consists in four lectures covering following topics:
i. Train models in electrical engineering, signal and image processing, natural language processing, tabular data, and bioinformatics, robot modelling and control.
ii. Learn the latest deep learning techniques that matter most in practice
iii. Improve accuracy, speed, and reliability by understanding how deep learning models work
iv. Discover how to turn your models into web applications
v. Implement deep learning algorithms from scratch

After taking the class, the students will be able to apply deep learning CNNs methods for the following:
- Topics in Electrical Engineering and Power Systems
- Signal and image processing
- Communications
- Medical image processing
- Object recognition and localization
- Robotics
- Bioinformatics
- Machine Learning and Quantum Computing

Teaching methods

1) Lectures: multimedia presentation illustrated with examples using Matlab, Phyton and other demonstration in areas such as healthcare and medical research, human-computer interaction, robotics, communication, transport, conservation, manufacturing, and many other fields of human endeavour.
2) Project: individual work solving project tasks.

Bibliography

Basic:
Christopher M. Bishop, Hugh Bishop, Deep Learning: Foundations and Concepts, Springer, 2023

Additional:
Jeremy Howard and Sylvain Gugger, Deep Learning for Coders with fastai and PyTorch: AI Applications Without a PhD, 1st Edition, O´Reilly, 2020

Rowel Atienza, Advanced Deep Learning with TensorFlow 2 and Keras, Packt Publishing Limited, 2020.

Breakdown of average student's workload

	Hours	ECTS
Total workload	50	2,00
Classes requiring direct contact with the teacher	8	0,00
Doctoral student's own work (literature studies, preparation for laboratory classes/tutorials, preparation for tests/exam, project preparation)	42	2,00