POZNAN UNIVERSITY OF TECHNOLOGY
EUROPEAN CREDIT TRANSFER AND ACCUMULATION SYSTEM (ECTS)
pl. M. Skłodowskiej-Curie 5, 60-965 Poznań

COURSE DESCRIPTION CARD - SYLLABUS

Course name
Application of intelligent materials and methods

Course

Field of study
Mechatronics

Area of study (specialization)

Level of study
Second-cycle studies

Form of study
full-time

Year/Semester
1 / 1

Profile of study
general academic

Course offered in
Polish

Requirements
compulsory

Number of hours

Lecture	Laboratory classes	Other (e.g. online)
30	30	
Tutorials	Projects/seminars	

Number of credit points

4

Lecturers

Responsible for the course/lecturer:
PhD Dariusz Sędziak
e-mail: dariusz.sedziak@put.poznan.pl

Faculty of Mechanical Engineering

Piotrowo 3, 60-965 Poznań

phone.: 61 665 23 62

Responsible for the course/lecturer:
Msc Tymoteusz Lindner

email: tymoteusz.lindner@put.poznan.pl

Faculty of Mechanical Engineering

Piotrowo 3, 60-965 Poznań

Prerequisites

Linear algebra, matrix calculus, Python object-oriented programming. Performing operations on matrices and numbers, operations on sets, basics of construction and operation of artificial neurons and neural networks. The student understands the need to learn and acquire new knowledge.

The student learned the basics of the basics of machine and automation construction, electronic components, and basic knowledge in the field of material science.

Course objective

Acquiring the knowledge of the advanced methods of artificial intelligence and the possibility of their application in the control of mechatronic devices.

Acquiring the knowledge of the modern materials with controlled parameters and properties. Acquiring the ability to use intelligent materials in technology

Course-related learning outcomes

Knowledge

Has extended knowledge of the structure of deep artificial neuron networks.

Has basic knowledge of the methods of improving artificial neural networks in order to improve their qualitative indicators.

Has basic knowledge of the methods of image processing and the basics of machine vision using artificial neural networks.

Has basic knowledge of the architecture of convolutional neural networks, including those applications for the classification and detection of various objects.

Has basic knowledge of the operation and basics of Reinforcement Learning algorithms.

Has extended knowledge of how to use AI methods in practice.

Student is able to characterize generally materials from the group of intelligent, has the basis to model the selected device with such materials. Learns the applications and typical operating parameters of selected material groups

Skills

Ability to choose a neural network and prepare data for its training with the use of the Python programming language.

Ability to select appropriate initializers and optimizers for various architectures of neural networks.

Ability to design a convolutional neural network for the classification and detection of various objects.

Ability to apply various Reinforcement Learning algorithms to control mechatronic devices.

The student is able to identify applications and pre-design a device using intelligent materials. Can model the basic properties of devices with intelligent materials

Social competences

The student understands the need for lifelong learning; can inspire and organize the learning process of others. Is aware of the role of different types of materials and AI methods in the modern economy and their importance for society and the environment. Is able to set priorities for the implementation of a specific task.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Lecture: Credit based on a written exam consisting of general questions in the subject.

Grading scale:

<51%-60%> points - 3.0,

(60%-70%> points - 3.5,

(70%-80%> points - 4.0,

(80%-90%> points - 4.5,

(90%-100%> points - 5.0.

Laboratory: Assessment is based on an oral or written answer from the content of the performed exercise and assessment of the reports on each exercise. Final written test. Credit from the laboratory takes place after meeting all the criteria.

Programme content

Deep neural networks and methods of their learning. Improving neural networks. Parameter initialization methods, regularizations, optimizers. Designing models based on convolutional neural networks. Neural networks learning methods. Studies of convolutional neural network architectures. The use of convolutional neural networks to recognize and detect objects in the image. Basics of Reinforcement Learning algorithms. The idea of an agent and the environment. Implementation of simple algorithms. State-of-the-art Reinforcement Learning algorithms. Principle of operation. Implementation. Use to control mechatronic devices.

General characteristics and classification of controllable materials. Electro- (ER) and magnetorheological (MR) fluids: structure and theoretical models. Mathematical description of shear, compression and valve mode. Basics of designing devices with ER and MR liquids. Sample constructions. Magnetic circuit design. Electronic control systems for devices with ER and MR liquids. Piezo elements: construction, types, characteristics. Designs of mini drives with piezo elements. Shape memory materials: structure, characteristics and applications. Electro- and magnetostrictive elements. Electro- and magnetorheological elastomers. Other materials with variable properties. Materials with different luminescence sources, their characteristics and applications

Laboratory:

1. Improving neural networks.

2. Convolutional neural networks.

3. Classification of objects with the use of convolutional neural networks.

4. Object detection with the use of convolutional neural networks.

5. Basics of Reinforcement Learning algorithms.

6. The use of Reinforcement Learning algorithms to control mechatronic devices.

7. Research on the characteristics of a beam piezoelement.

8. Research of brake with magnetorheological fluid.

9. Research of an actuator with magnetic shape memory (MSM).

10. Research on the system for energy recovery with MSM.

11. Research on materials with SMA shape memory materials.

12. Modeling of devices with intelligent material in Matlab Simulink environment.

Teaching methods

Lecture: multimedia presentation illustrated with examples

Laboratory: individual practical exercises, performing experiments, solving tasks, discussion, team work

Bibliography

Basic

1. Bengio Yoshua, Courville Aaron, Goodfellow Ian; Deep Learning; 2018

2. Sebastian Raschka; Python Machine Learning; 2019

3. Milecki A., Ciecze elektro- i magnetoreologiczne oraz ich zastosowania w technice, Wydawnictwo Politechniki Poznańskiej, Poznań, 2010

Additional

Richard S. Sutton, Andrew G. Barto, Francis Bach; Reinforcement Learning; 2019; MIT Press

Materiały dodatkowe, udostępniane przez producentów materiałów i urządzeń inteligentnych, np. Designing with MR Fluids (Lord), Designing with Piezoelectrics (Pi Ceramic)

Breakdown of average student's workload

	Hours	ECTS
Total workload	102	4,0
Classes requiring direct contact with the teacher	62	2,5
Student's own work (literature studies, preparation for laboratory classes/tutorials, preparation for tests/exam, project preparation) [1]	40	1,5

[1] delete or add other activities as appropriate