COURSE DESCRIPTION CARD - SYLLABUS

Course name
Application of artificial intelligence and vision systems [S2MiBM2>ZMSI]

Course

Field of study
Mechanical Engineering

Year/Semester
1/2

Area of study (specialization)
Production Engineering

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
45

Other
0

Tutorials
0

Projects/seminars
0

Number of credit points

6,00

Coordinators

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Lecturers

Prerequisites

The student should have basic knowledge in the following areas: mathematics; physics, with particular emphasis on optics; knowledge of algorithms and data structures; automation and control engineering; and programming. They should also possess the ability to obtain information from specified sources and be willing to engage in teamwork.

Course objective

Acquisition by the student of skills in designing and programming selected artificial intelligence methods and implementing selected components of machine vision systems.

Course-related learning outcomes

Knowledge:
1. Knows the principles of operation of machine vision systems and main development trends in the field of mechanical engineering.
2. Knows how to develop and design the device's communication with a higher level system, e.g. PLC or PC.
3. Knows how to set up optical elements on the camera.

4. Knows which system elements to choose for a given task.
5. Knows the basics of optics.
6. Knows the basic methods of artificial intelligence and has structured, theoretically based knowledge of the use of information systems in the design of machines and technological processes.
7. Knows what classification and detection of features in an image are.
8. Has detailed knowledge of metrology and measurement systems. Knows the mathematical apparatus used in experimental research and data analysis.

Skills:
1. Is able to design and program a vision system taking into account social, economic, legal, ecological and other non-technical conditions in solving engineering problems.
2. Is able to select elements, including a controller, and design simple vision systems.
3. Is able to select elements of a vision system to work on a production line.
4. Is able to program the exchange of camera data with the superior system.
5. Is able to select methods and algorithms to solve a specific problem of classification and detection in an image.
6. Is able to use the vision system in practice.
7. Is able to use IT systems in the design of machines and technological processes relevant to mechanics and machine construction. Is able to use CAx systems to design machines and simulate engineering issues.

Social competences:
1. Understands the need for lifelong learning; can inspire and organize the learning process of others
2. Is able to determine priorities for implementing a specific task
3. Able to cooperate and work in a group
4. Is able to think and act in an entrepreneurial way
5. Is aware of responsibility for his own work and is ready to comply with the principles of team cooperation and responsibility for jointly performed tasks

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Lecture:
An examination on theory covering the lecture material in the form of a test, both electronically and conventionally, consisting of 10-15 questions.
Grades:
3,0 <50%;60%), 3,5 <60%;70%), 4,0<70%;80%), 4,5<80%;90%), 5,0 <90%;100%).

Laboratory:
Passing based on the correct completion of exercises and reports from each laboratory session according to the instructions of the laboratory instructor. Ongoing assessment of preparation for labs, with an optional final written quiz for the laboratory.

Grades:
3,0 <50%;60%), 3,5 <60%;70%), 4,0<70%;80%), 4,5<80%;90%), 5,0 <90%;100%).

Programme content

Lecture:
1) Introduction to Artificial Intelligence Methods:
 a) History,
 b) Definitions and basic concepts.
2) Basics of Python Programming:
 a) Variables, data types, and casting,
 b) Program flow control - conditions and loops,
 c) Basics of object-oriented programming.
3) Artificial Neural Networks, Structure and Operating Principles:
 a) Supervised learning: Perceptron, MLP - Multi-Layer Perceptron,
 b) Unsupervised learning: SOM - Self-Organizing Map, Kohonen networks,
 c) Reinforcement learning.

4) Fuzzy Logic, Structure and Operating Principles.
5) Evolutionary Algorithms.
6) Neuro-fuzzy Systems and Networks with Global Weight Optimization Using Evolutionary Algorithms.
7) Introduction to Vision Systems:
 a) History,
 b) Definitions and basic concepts,
 c) Structure of vision systems.
8) OpenCV Library.
9) Filters in Vision Systems and Calibration.
10) Shape Detection in Vision Systems.
11) Methods of Feature Detection in Images (SURF, SIFT, ORB).
12) Template Matching Algorithms.
13) Artificial Neural Networks: YOLO and Convolutional Neural Networks.

Laboratory:
1) Basics of Python Programming: environment setup, data types and variables, program flow control, object-oriented programming.
2) Perceptron – Classification, Regression.
3) MLP, SOM.
4) OpenCV – Basics of Using the Library.
5) Detection of Lines and Shapes (simple shapes, face).
6) Filters in Vision Systems.
7) Measurement of Quantities and Dimension Calculation.
8) Pattern Recognition.
9) Artificial Neural Networks in Vision Data Analysis.

Course topics

The course "Application of Artificial Intelligence Methods and Vision Systems" aims to familiarize students with fundamental and advanced techniques of artificial intelligence (AI) and their practical applications in vision systems.

Lecture:

The classes begin with an introduction to artificial intelligence methods, where the history of AI development, key definitions, and basic concepts are discussed. This allows students to understand the context and significance of AI in today's technology landscape.

Next, we focus on the basics of programming in Python. Students learn about variables, data types and casting, program flow control using conditions and loops, and the fundamentals of object-oriented programming. This knowledge is essential for implementing AI algorithms and working with image processing libraries.

An important element is artificial neural networks. We discuss their structure and operating principles, concentrating on different types of learning:

Supervised learning: Perceptron and MLP (Multi-Layer Perceptron) as basic neural network models for classification and regression tasks.
Unsupervised learning: SOM (Self-Organizing Map) and Kohonen networks, which are used for data clustering and dimensionality reduction.
Reinforcement learning, which allows for developing models that learn based on interaction with the environment.
In the subsequent part of the course, we cover the topic of fuzzy logic, its structure and operating principles, enabling modeling of uncertainty and imprecision in data.

We also discuss evolutionary algorithms, inspired by biological evolution processes, used to solve complex optimization problems. We combine these methods in neuro-fuzzy systems, where neural networks are optimized using evolutionary algorithms, allowing for global weight optimization.

We introduce students to the subject of vision systems, presenting their history, definitions, basic concepts, and structure. They become acquainted with the OpenCV library, which is a key tool for image processing and analysis.

We discuss filters in vision systems and calibration, which are essential for proper image data processing. Students learn shape detection, and get to know methods of feature detection in images such as SURF, SIFT, and ORB.

We also cover template matching algorithms and advanced neural networks like YOLO and convolutional neural networks, which are used in object detection and classification in images.

Laboratory:

Laboratory classes enable practical application of theoretical knowledge. Students start with the basics of Python programming, where they set up the working environment, work with data types and variables, control program flow, and apply object-oriented programming.

Practical exercises include implementing a perceptron for classification and regression tasks and working with MLP and SOM, allowing for a deeper understanding of neural network operation.

Using the OpenCV library, students undertake projects related to line and shape detection, including the detection of simple shapes and faces. They experiment with filters in vision systems to improve image quality and extract significant features.

In the laboratories, measurements and dimension calculations are conducted based on image data, applicable in many fields of engineering and industry.

Students learn pattern recognition and utilize artificial neural networks in vision data analysis, enabling the practical application of advanced AI methods.

By combining lectures with intensive practical exercises, the course prepares students to independently solve problems in artificial intelligence and vision systems and to implement these solutions in real-world projects.

Teaching methods

Theoretical lectures with multimedia presentations, case studies.
Laboratory exercises with practical application of the discussed methods.
Discussions dedicated to current issues and innovations in the field.

Bibliography

Basic:
1. Jähne B., Digital Image Processing, Springer, 2005, 6th revised and extended edition
2. Siciliano B., Khatib O., Springer Handbook of Robotics, Springer, 2008, 1st Edition
3. Rutkowski L., Metody i techniki sztucznej inteligencji, Wydawnictwo Naukowe PWN, 2009

Additional:
1. Sankowski D., Morosov W., Strzecha K., Przetwarzanie i analiza obrazów w systemach przemysłowych, PWN, Warszawa, 2011

Breakdown of average student's workload

	Hours	ECTS
Total workload	150	6,00
Classes requiring direct contact with the teacher	77	3,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	73	3,00