COURSE DESCRIPTION CARD - SYLLABUS

Course name
Artificial neural networks

Course

Field of study
Automatic Control and Robotics
Area of study (specialization)
Control and Robotics Systems
Level of study
Second-cycle studies
Form of study
part-time

Year/Semester
2 / 3
Profile of study
general academic
Course offered in
Polish
Requirements
elective

Number of hours

Lecture
12
Tutorials
-

Laboratory classes
12
Projects/seminars
-

Other (e.g. online)
-

Number of credit points

4

Lecturers

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Prerequisites

Knowledge: A student starting this subject should have basic knowledge of mathematics - including, mainly matrix calculus, knowledge of mathematical logic elements, basics of mathematical analysis and probability calculus.

Should have the ability to solve systems of linear and nonlinear equations.

Skills: Should have the ability to efficiently use a PC and external devices, as well as the ability to obtain information from specified sources. He should also have a basic knowledge of the basics of automation and control theory. He should have the ability to actively participate in organized lectures for a large group of people, being aware of the need to expand theoretical and practical knowledge and to constantly update acquired knowledge due to dynamic technological and systemic changes in modern technology.

Social Competences: He should also understand the need to broaden his competences and be ready to cooperate as part of a team implementing e.g. a joint project.

Course objective

1. Providing students with basic knowledge of Artificial Intelligence covering issues of fuzzy logic, evolutionary calculations, neural networks, and their use especially in problems of automation and robotics. Developing students' skills to solve so-called AI problems - difficult, such as: making decisions in the absence of all data (or having only uncertain data), implementation of systems using "rational reasoning", knowledge management, preferences and information in robotics, expert and diagnostic systems, controlling objects about complex dynamics and strong non-linearity of the model, difficult to identify.

2. Developing students' teamwork skills during the implementation of the final project within the laboratory.

Course-related learning outcomes

Knowledge

1. has structured and in-depth knowledge of artificial intelligence methods and their applications in automation and robotics systems; - [KW_2]

2. has structured and in-depth knowledge of modeling and identification of linear and nonlinear systems; - [KW_5]

3. has advanced and in-depth knowledge of methods of analysis and design of control systems; - [KW_7]

Skills

1. is able to simulate and analyze the operation of complex automation systems and plan and carry out experimental verification; - [KU_9]

2. is able to critically assess and select the appropriate methods and tools to solve the task in the field of automation and robotics; can use innovative and unconventional tools in the field of automation and robotics; - [KU_22]

Social competences

1. is aware of the importance and understands the non-technical aspects and effects of engineering activities, including its impact on the environment and the associated responsibility for decisions; is ready to develop his professional heritage; - [K_K4]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Formative assessment:

a) in terms of lectures: based on answers to questions about the material discussed in previous lectures,

b) in the scope of laboratories / exercises: based on the assessment of the current progress of tasks,

Summative rating:

a) in the scope of lectures, verification of assumed learning outcomes is carried out by:

i. assessment of knowledge and skills demonstrated during the problem-type written exam consisting of 5 questions out of 40 questions presented on the general list of questions, previously provided to students.

Grading rules:

5.0 - above 90% of exam points (W); average of grades from lab exercises above 4.75 (L)

4.5 - 80% -90% of exam points (W); average of grades from lab exercises 4.25-4.75 (L)

4.0 - 70% -80% of exam points (W); average of grades from lab exercises 3.75-4.25 (L)

3.5 - 60% -70% of exam points (W); average of grades from lab exercises 3.25-3.75 (L)

3.0 - 50% -60% of exam points (W); average of grades from lab exercises 2.75-3.25 (L)

2.0 - less than 50% of exam points (W); average grades from lab exercises below 2.75 (L)

ii. discussion of passing results,

b) in the scope of laboratories / exercises, verification of assumed learning outcomes is carried out by:

a. assessment of student's preparation for individual laboratory sessions (entrance test)

b. assessment of the laboratory exercise carried out (report)

Programme content

The lecture program includes the following topics:

1. Biological basis of neuron activity, types of neural network models, overview of neural network applications.

2. Models of neurons and methods of their learning (perceptron, sigmoid neuron, adaline neuron, Grossberg instar and outstar, WTA neurons, Hebba neuron model, neuron stochastic model).

3. Unidirectional sigmoid type (FFN) multilayer networks - single layer network, multilayer perceptron network, gradient network learning algorithms (back propagation method, selection of learning factor),

heuristic methods of network learning, comparison of effectiveness of learning algorithms, elements of global optimization, methods of weight initialization.

4. Problems of practical use of neural networks. Principles of network architecture selection (selection of optimal network architecture, methods of network expansion, selection of network learning samples, inserting noise into learning patterns, examples of perceptron network applications). Radial neural networks (mathematical foundations, radial neural network, methods of learning radial neural networks, examples of the use of radial networks, methods of selecting the number of basic functions, comparison of radial networks with sigmoid networks).

5. Recursive networks as associative memories (Hopfield auto-associative network, Hamming network, BAM network, etc.).

6. Recursive networks created on the basis of a perceptron (perceptron network with feedback, Elman recursive network, RTRN network). Self-organizing networks on the basis of competition (basic dependencies of self-organizing networks through competition, algorithms teaching self-organizing networks, applications of self-organizing networks, hybrid network).

7. Deep neural networks. Deep network architectures (AlexNet, ResNet, Inception, GAN). Deep recursive networks (architecture and learning method). LSTM (long-short term memory) memory gain module.

8. Deep neural networks in control. Learning the network by reinforcing desired behavior (reinforcement learning) and by approximating the objective function (Q-learning). Applications of data architectures to control robots.

9. Applications of deep networks in image and signal processing (classification and detection of objects), applications in the analysis of large image and text databases. GAN capabilities to generate new learning patterns (images).

Laboratory classes are conducted in the form of 2-hour exercises that take place in the laboratory, preceded by a 2-hour instructional session at the beginning of the semester. The initial part of the laboratory consists of exercises carried out by teams of 1 students according to exercises selected by the teacher and given in the script to the laboratory. In the middle of the semester, students are issued descriptions of projects to be implemented as part of the exercises. Projects are implemented individually or in teams of 2, depending on the expected difficulty of project implementation.

The laboratory program includes the following issues:

Selected problems and methods of selecting learning data, creating a validation and test set for artificial neural networks. Familiarization with the back propagation method of network learning, the importance and selection of the optimization method used in network learning. Analysis of the choice of network type according to the type of problem solved by the network, selection of network architecture and optimization of this architecture (Kolmogorov theorem), problem solving: "the network cannot learn", "the network is learned", the ability of the network to generalize acquired knowledge. Using the properties of different types of networks in issues of classification, control, optimization, image processing, etc.

Part of the above-mentioned program content is implemented in the student's own work.

Teaching methods

1. lecture: multimedia presentation, presentation illustrated with examples given on the board, as well as multimedia shows and demonstrations using, among others MATLAB program

2. laboratory exercises: performing experiments, examining prepared implementation problems and methods of learning artificial neural networks (using a script with developed exercises), discussion, teamwork, multimedia show, workshops - independent development of the design of a selected neural network and the method of learning it, used to solutions to the problem of control, optimization, classification, etc.

Bibliography

Basic

1. Osowski S., Sieci neuronowe do przetwarzania informacji, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa, 2000 rok.

2. Osowski S., Sieci neuronowe w ujęciu algorytmicznym, WNT, Warszawa, 1996 rok.

3. Tadeusiewicz R., Elementarne wprowadzenie do techniki sieci neuronowych z przykładowymi programami, Akademicka Oficyna Wydawnicza PLJ, Warszawa, 1999.

Additional

1. Sztuczne sieci neuronowe - Laboratorium, praca zbiorowa pod red. A. Rybarczyka, Wydawnictwo Politechniki Poznańskiej, Wyd.I, Poznań 2007, ISBN 978-83-7143-261-3, Wydanie II (2009).

2. Żurada J., Barski M., Jędruch W., Sztuczne sieci neuronowe, PWN, Warszawa, 1997.

Breakdown of average student's workload

	Hours	ECTS
Total workload	100	4
Classes requiring direct contact with the teacher	24	1
Student's own work (literature studies, preparation for laboratory classes/tutorials, preparation for tests/exam, project preparation) [1]	76	3

1 delete or add other activities as appropriate