COURSE DESCRIPTION CARD - SYLLABUS

Course name

Neuro-fuzzy control

Course

Field of study

Automation and Robotics

Year/Semester

1/2

Area of study (specialization)

Control and Robotics Systems

Profile of study

general academic

Level of study

Second-cycle studies

Course offered in

polish

Form of study

full-time

Requirements

compulsory

Number of hours

Lecture

15

Laboratory classes

0

Other (e.g. online)

0

Tutorials

0

Projects/seminars

30

Number of credit points

3

Lecturers

Responsible for the course/lecturer:

dr hab. inż. Jakub Bernat

email: Jakub.Bernat@put.poznan.pl

tel. 61 665 2751

Faculty of Control, Robotics and Electrical Engineering

ul. Piotrowo 3, 60-965 Poznań

Responsible for the course/lecturer:

Prerequisites

Knowledge: The student should have knowledge of control theory, in particular issues related to stability, modeling of continuous and discrete systems, systems identification and adaptive control. Student should know the basics of neural networks, network training methods and methods related to deep neural networks. The student starting this course should have basic knowledge of mathematics and programming.

Skills: The student should have the ability to program and simulate dynamic systems. The student should have the ability to obtain information from literature. Student should have the ability to actively participate in organized lectures for a large group of people, be aware of the need to expand theoretical and practical knowledge and constantly update acquired knowledge due to dynamic technological and changes in modern technology.

Social Competences: The student should also understand the need to expand their competences and constantly update the acquired theoretical and practical knowledge due to the dynamic development of modern technology. Student should be ready to cooperate as part of a team carrying out a laboratory exercise or a joint project.

Course objective

Course objective is to provide students with basic knowledge about knowledge of the control of systems using artificial intelligence.

Course-related learning outcomes

Knowledge

Student has a knowledge of artificial intelligence methods and their application in automation and robotics systems.

Skills

Student is able to design and implement the control of systems using artificial intelligence. Student is able to use advanced programs to support project design and is able to solve engineering tasks.

Social competences

Student is aware of the need for a professional approach to technical issues, familiarization with the documentation and environmental conditions in which the devices and their components can function; Student is ready to comply with the principles of professional ethics and to require this from others, respecting the diversity of views and cultures.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Rating:

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

assessment of knowledge and skills demonstrated during the written exam (3 questions, 10 points per question).

b) in the scope of laboratories - grade based on the project performed by student (or group of students).

Assessment rules (for passing the lecture and tutorials):

5.0 - above 90% points

4.5 - 80% -90% of points

4.0 - 70% -80% of points

3.5 - 60% -70% of points

3.0 - 50% -60% of points

2.0 - less than 50% of points

Programme content

The lecture program covers the following topics:

1. Presentation of the problems of neuro-fuzzy control. Influence of the latest developments in neural networks, including deep learning, on automation and robotics.

2. Identification and control using neural networks. The problem of dynamic and static backpropagation. Application of the Universal Approximation theorem to approximation of nonlinear dynamics. Identification by a parallel, series-parallel structure. Presentation of models used in neural control: NARMA, NARMA-L1, NARMA-L2 and the possibilities of their use for control.

3. The use of neural networks in control methods, in particular: adaptive control with the use of linear parametric neural networks and predictive control with a neural model of a dynamical system. Neural network architectures and deep learning methods in control problems.

4. Reinforcement learning in control and automation and robotics problems.

5. Mathematical foundations of fuzzy systems. Operations on fuzzy sets (measures of fuzzy sets, fuzzy versus probability, fuzzy inference rules, Mamdani-Zadeh fuzzy inference systems, Takagi-Sugeno-Kang inference model).

6. Fuzzy neural networks (TSK fuzzy network structure, Wang-Mendel network structure, hybrid fuzzy network learning algorithm, self-organization algorithm for learning a fuzzy network, adaptive self-organization algorithm for a fuzzy network). Fuzzy controllers (general principles of construction of fuzzy controllers, e.g. two-state, linear, with approximation of straight segments, PI and PID controllers).

Laboratory classes are conducted in the form of 2-hour exercises that take place in the laboratory, preceded by an instructional session at the beginning of the semester. At the beginning of the semester, students are given descriptions of projects to be implemented as part of the exercises. Projects are carried out individually or in 2-person teams, depending on the expected difficulty of project implementation. Part of the above mentioned program content is implemented in the student's own work.

Teaching methods

Teaching methods:

1. lecture: multimedia presentation, example simulations.

2. laboratories: desigin and implemenation of control systems using artificial neural networks

Bibliography

Basic

1. Ian Goodfellow, Yoshua Benglo, Aaron Courville, Deep Learning systemy uczące się, PWN, 2018

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

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

4. Andrzej Piegat, Modelowanie i sterowanie rozmyte, Akademicka Oficyjna Wydawnicza EXIT, Warszawa 1999

Additional

1. Piotr Tatjewski, Sterowanie Zaawansowane obiektów przemysłowych – struktury i algortmy

2. R. S. Sutton and A. G. Barto, Reinforcement Learning – An introduction, The MIT Press, 2018

3. Kumpati S. Narendra, Snehasis Mukhopadhyay, Adaptive Control Using Neural Networks and Approximate Models, IEEE Transactions On Neural Networks, Vol. 8, No. 3, 1997

4. Kumpati S. Narendra, Neural Networks for Control: Theory and Practice, Proceedings Of The IEEE, Vol 84, No. 10, 1996

5. Martin T. Hagan, Howard B. Demuth and Orlando De Jesus, An introduction to the use of neural networks in control systems, Int. J. Robust Nonlinear Control, Vol. 12, 2002

6. Yann LeCun, Yoshua Bengio, Geoffrey Hinton, Deep learning, Nature, Vol. 21, 2015

Breakdown of average student's workload

	Hours	ECTS
Total workload	75	3
Classes requiring direct contact with the teacher	45 (15w, 30p)	2
Student's own work (literature studies, preparation for laboratory classes/tutorials) [1]	30	1

[1] delete or add other activities as appropriate