COURSE DESCRIPTION CARD - SYLLABUS

Course name
Machine intelligence methods [N2AiR1-ISAiR>MIM]

Course

Field of study
Automatic Control and Robotics

Year/Semester
1/1

Area of study (specialization)
Intelligent Control and Robotic Systems

Profile of study
general academic

Level of study
second-cycle

Course offered in
polish

Form of study
part-time

Requirements
compulsory

Number of hours

Lecture
20

Laboratory classes
10

Other (e.g. online)
0

Tutorials
0

Projects/seminars
0

Number of credit points

3,00

Coordinators

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Lecturers

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Prerequisites

A student beginning this course should have basic knowledge of mathematics, especially linear algebra, matrix calculus, elements of mathematical logic, and the basics of mathematical analysis and probability calculus. The student should be able to solve systems of linear and nonlinear equations. The student should be familiar with the basics of using programs supporting scientific calculations, such as Scilab, Octave, Matlab. He/she should have the ability to acquire information from pointed sources. He/she should also have basic knowledge of the basics of automation and control theory and computer science, within the scope of knowledge of selected programming languages. The student should be aware of the necessity to broaden the theoretical and practical knowledge and to continuously update the acquired knowledge due to dynamic changes in modern technology. He/she should also understand the necessity of broadening his/her competences and be ready to cooperate within a team realizing e.g. a team project.

Course objective

1. To provide students with basic knowledge of machine learning and soft-computing methods including regression, classification, clustering, fuzzy logic and neural networks, and their use especially in problems of control engineering. Examples of applications include control of objects with complex dynamics and strong model nonlinearity, difficult to identify. 2. To develop in students the ability to solve data processing problems by machine learning and to reproduce the knowledge obtained in this way. 3.To develop in students the ability to work as a team during the final project in the laboratory.

Course-related learning outcomes

Knowledge
1. has organized and advanced knowledge of artificial intelligence methods and their application in control and robotics systems; [K2_W2].
2. has knowledge of the application of selected machine learning methods in control systems for the purposes of identification, control and diagnostics.
Skills
1. is able to formulate and verify (by simulation or experimentally) hypotheses related to engineering tasks and simple research problems in the field of automation and robotics; [K2_U15].
2. is able to assess the usefulness and applicability of new developments (including techniques and technologies) in the field of automation and robotics; [K2_U16].
3. is able to critically evaluate and select appropriate methods and tools to solve a task in the field of automation and robotics; can use innovative and unconventional tools in the field of automation and robotics; [K2_U22]
4. is able to develop an algorithm to solve a complex and unconventional engineering task and a simple research problem and implement, test and run it in a selected programming environment for selected operating systems; [K2_U25].
Social competences
1.understands the need and knows the possibilities of continuous education - improving professional, personal and social competences, can inspire and organize the learning process of others; [K2_K1].
2. is aware of the responsibility for his/her own work and is ready to comply with the rules of teamwork;

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

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Knowledge acquired in lecture is verified by a written exam and an individual discussion of examination questions. The exam consists of 10-15 questions (test and open), variously scored. The pass mark is 50%. Examination problems on the basis of which the questions are prepared are available to the students during the semester.
The skills acquired in the laboratory classes are verified on the basis of reports and the final test, consisting of 5-7 questions/tasks, scored differently depending on their difficulty. The pass mark is 50%.

Programme content

1. Historical outline of artificial intelligence methods, concept of machine learning. Concept of supervised and unsupervised learning. Basic, selected methods of statistical description of a data set. Central and dispersion measures. Histogram and kernel density estimator.
2. Linear regression: concept of hypothesis, cost function. Learning methods: simple gradient, batch learning "Batch Gradient Descent". Hypotheses for multiple variables. Evaluation of the validity of the linear regression algorithm. Normal equation.
3. Concept of classification, logistic regression. Concept of linear separability of classification problem, Multiclass classification. Quality rating of classifiers, sensitivity and specificity.
4. Overfitting and regularization. Improving the performance of linear regression algorithm: Learning / validation / testing.
5. Concept of clustering, application examples. K-means cluster analysis.
6. Principle of dimension reduction by principal component analysis PCA method. Evaluation of data loss in PCA method.
7. Concept of fuzzy system. Implementation of fuzzification and defuzzification tasks. PI/PD/PID controller implemented in fuzzy system.

8. Concept of neural networks. Biological neural networks: biological neuron, neural networks, mathematical models of biological neuron, activation functions, perceptron, neuron as classifier. Learning of a single neuron. Concept of back propagation of error, improvement of learning rate. Application of ANNs in control systems. Neural networks with a feedback.
9. Support vector machine (SVM) data classification method: SVM concept, SVM algorithms, kernel function selection.
10. Random forest method - concept, implementation and applications.
11. Reinforcement learning method. References to the structure of control systems. Methods of teaching. Application in control systems with variable parameters.
12. Selected programming tools for machine learning methods.
During the lecture, students analyze topics of projects related to the research of the department, especially in the field of application of selected methods of machine learning and fuzzy logic in control systems of complex electromechanical objects.
The laboratory program includes the following issues: selection of learning data, creation of validation and test set for machine learning methods; learning the machine learning methods presented in the lecture. Analysis and synthesis of a fuzzy inference system. Implementation of selected methods in control systems - modelling and synthesis of a regulator.

Teaching methods

1. Lecture: multimedia presentation, illustrated by examples given on the board.
2. Laboratory exercises: the execution of laboratory exercises, the study of prepared problems of implementation and methods of machine learning, discussion, teamwork, workshops - independent development of the project to solve the given problem of control, optimization, classification, etc.

Bibliography

Basic
1. Lecture materials progressively provided by the instructor in electronic form.
2. Osowski S., Sieci neuronowe do przetwarzania informacji, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa, 2000 rok
3. Rutkowska D., Piliński M., Rutkowski L: Sieci neuronowe, algorytmy genetyczne i systemy rozmyte PWN Warszawa
Additional
1. Geron A.: Machine learning with Scikit-Learn and TensorFlow
2. Raschka S.: Python. Machine Learning
3. Chollet F.: Deep Learning
4. Sejnowski T. J.: Deep Learning. The deep revolution.

Breakdown of average student's workload

	Hours	ECTS
Total workload	75	3,00
Classes requiring direct contact with the teacher	30	1,50
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	45	1,50