POZNAN UNIVERSITY OF TECHNOLOGY

EUROPEAN CREDIT TRANSFER AND ACCUMULATION SYSTEM (ECTS)

COURSE DESCRIPTION CARD - SYLLABUS

Course name
Neural networks and genetic algorithms [N2AiR1-SW>SNiAG]

Course

Field of study
Automatic Control and Robotics

Year/Semester
2/3

Area of study (specialization)
Vision 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
0

Tutorials
0

Projects/seminars
10

Number of credit points

4,00

Coordinators

prof. dr hab. inż. Adam Dąbrowski
adam.dabrowski@put.poznan.pl

dr inż. Damian Cetnarowicz
damian.cetnarowicz@put.poznan.pl

Lecturers

Prerequisites

Knowledge: The student starting this course should have basic knowledge of linear algebra and digital signal processing. Skills: Should have the ability to solve basic problems in signal processing and optimization using a higher-level language, as well as the ability to obtain information from indicated sources. They should also understand the need to expand their competences and be ready to cooperate in a team. Social Competences: In addition, in terms of social competences, the student must show such qualities as honesty, responsibility, perseverance, cognitive curiosity, creativity, personal culture, respect for other people.

Course objective

1. Provide students with basic knowledge of learning algorithms in the field of artificial neural networks and genetic algorithms. 2. Developing students' skills in solving data processing problems by means of machine learning and reproducing the knowledge thus obtained.

Course-related learning outcomes

Knowledge
A student:
1. possess detailed knowledge of artificial intelligence methods and their application in automation and robotics systems - [K2_W2].
2. possess knowledge of adaptation systems - [K2_W9].
3. possess knowledge of the neurobiological basics of artificial neural networks and the basics of biological evolution in the field of genetic algorithms - [-].
Skills
A student:
1. can use advanced methods of signal processing and analysis, including video signal and extract information from the analyzed signals - [K2_U11].
2. is able to formulate and verify (simulation or experimentally) hypotheses related to engineering tasks and simple research problems in the field of automation and robotics - [K2_U15].
Social competences
A student:
1. is aware of responsibility for their own work and is ready to submit to the principles of teamwork and responsibility for jointly performed tasks; can lead a team, set goals and define priorities leading to the implementation of a task - [K2_K3].
2. is aware of the differences between the natural neural network and the artificial neural network; is aware of the differences between biological evolution and its machine equivalent, i.e. genetic algorithm - [-].

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Learning outcomes presented above are verified as follows:
Formative assessment:
a) in the scope of lectures:
based on answers to questions about the material discussed in previous lectures
b) in the scope of laboratories and projects, assesment of the assumed learning outcomes is based on:
i. assessment of student's preparation for individual sessions of laboratory classes ("entrance" test)and assessment of skills related to the implementation of laboratory exercises,
ii. continuous assessment, during each class (oral answers) -rewarding the increase in the ability to use known principles and methods,
iii. assessment of the laboratory reports prepared partly during the classes and partly at home; this assessment also includes teamwork skills.
Obtaining additional points for activity during classes, in particular for:
i. discuss of additional aspects of the issue,
ii. effectiveness of applying the acquired knowledge while solving a given problem,
iii. ability to work as part of a team that practically performs a specific task in the laboratory,
iv. comments related to the improvement of teaching materials,
v. indicating students' perceptive difficulties enabling ongoing improvement of the didactic process.
Summative assessment:
a) in the scope of lectures the verification of the assumed learning outcomes is carried out by:
i. assessment of the knowledge and skills shown in the exam - written work containing problem questions and written calculation tasks; getting 50% of the number of total points give a positive rating, the questions are a detailed version of the issues made available to students in order to prepare for the exam,
ii. discussion about exam results,
b) in the scope of laboratories and projects, it is a resultant assessment resulting from the formative assessments.

Programme content

The program presents the issues of artificial neural networks and genetic algorithms as applied to the implementation of tasks in the field of automation and robotics.

Course topics

The lecture covers the following topics:
1. Biological neural networks: the nervous system of organisms, biological neuron, sodium-potassium pump - Jens Christian Skou, neuronal action potential, Huxley and Hodgkin's model of neuron membranes,

synapse (John Tsarev Eccles achievements).
2. Artificial neural networks (ANN) - new field of technical sciences, history and review of issues: McCulloch-Pitts neuron, Hebb rule, Rosenblatt perceptron, John von Neumann's artificial brain concepts, Bernard Widrow and Ted Hoff's ADALINE and MADALINE networks, Marvin Minsky and Seymour Papert's critical monograph? the period of discouragement with the issues of neural networks and stagnation, John Anderson and Teuv Kohonen associative networks, backpropagation method, cognitron and neocognitron, new concepts, ART (adaptive resonance theory), CNN (cellular neural networks) by Leon Chuy, another period of enthusiasm and turbulent development of ANN.
3. Models of artificial neural networks: applications of the McCulloch-Pitts neuron model, general model of neurons in AR, activation functions, perceptron, signal space of the ANN layer; neuron as a classifier, unidirectional neural network, example of a two-layer neural network, neural networks with feedback.
4. Rules for learning neural networks: learning process, adaptation and generalization, hard- and soft-decision optimization methods, matching of equilibrium states, learning with and without a teacher, general rule for teaching neural networks, Amari rule, Hebb rule, perceptron rule, delta rule, Widrow-Hoff rule, correlation rule, "winner takes all" rule, exit star rule.
5. Neural classifiers: neural decision systems, decision function, signaling of classification to many classes, dichotomizer, minimal-distance classification, linearly separated and non-separated decision areas, teaching (nonparametric design) of the dichotomizer.
6. Continuous dichotomizers: activation functions, teacher's signal, error and correction and their energy, gradient neuron learning algorithm, continuous dichotomizer learning.
7. Classifiers for many classes: signaling of classification to many classes (local representation, distributed representation), classifier with maximum selector, classifier with discrete activation functions.
8. Unidirectional multilayer networks: the concept of multilayer neural networks? mapping space, classification of linearly non-separated signals, implementation of XOR functions; delta learning rule of single-layer networks, delta learning rule of two-layer networks, back propagation error method.
9. Associative memories: traditional memory systems and associative memories, associations and self-associations, description of associative memories, linear associator, Hopfield associator.
10. The method of data classification using support vectors (SVM support vector machine): SVM concept, SVM algorithms, computational trick consisting in changing and selecting the kernel functions.
11. Cellular neural networks: spatial structures of neural networks, the importance of local interactions and feedback, generation and recognition of patterns in nonlinear cell networks.
12. Genetic algorithms: global optimum and local optima, the concept of hard and soft selection, the concept of population evolution through random mutations and natural selection, probabilistic optimization methods, evolutionary calculations.
13. Signal separation: the concept of blind signal separation, PCA (SVD) and ICA methods and algorithms, implementation of the ICA method using neural networks, signal separation using auxiliary information.
14. Processing of non-negative data: method of non-negative matrix factorization (NNMF), processing of large data sets, NNMF iterative algorithms, applications of NNMF for text, face and voice recognition.
15. Deep convolutional neural networks and examples of applications of neural networks and genetic algorithms: issues of artificial intelligence and computational intelligence, OCR algorithms, reproduction and improvement of signal quality.Laboratory classes are conducted in the form of seven 2-hour exercises in the laboratory, preceded by a 1-hour instructional session at the beginning of the semester. Individual exercises are performed by teams of 2/3 people.
Laboratory classes are conducted in the form of seven 2-hour exercises in the laboratory, preceded by a 1-hour instructional session at the beginning of the semester. Individual exercises are performed by teams of 2/3 people.

Laboratory exercises topics:
1. Models of neurons in technology and a network of neurons as a classifier.
2. Learning the discrete dichotomizer.
3. Error back propagation algorithm (using Matlab and Neural Network Toolbox).
4. Teaching without a teacher (PCA, ICA).
5. Support vector machine (SVM).
6. Associative memories.
7. Genetic (evolution) algorithm in optimization applications.

Design classes (projects) covers the following issues, from which one task is selected:
1. Analysis of selected neural networks or genetic algorithms for the implementation of tasks in the field of automation and robotics (eg character recognition, inverted pendulum control, gait recognition, blind signal separation).

2. Development of the implementation of selected neural networks or genetic algorithms for the implementation of tasks in the field of automation and robotics.

Teaching methods

1. Lecture: multimedia presentation, presentation illustrated with examples given on the board, solving problems
2. Laboratory classes: problem solving, practical exercises, conducting experiments, case studies, teamwork
3. Design classes (projects): implementation of a given project, team work

Bibliography

Basic
1. Sztuczne sieci neuronowe, Żurada J., Barski M., Jędruch W., PWN, Warszawa, 1996
2. Sieci neuronowe, Tadeusiewicz R., Akademicka Oficyna Wydawnicza RM, Warszawa, 1993
3. Sieci neuronowe w praktyce ? programowanie w języku C++, Masters T., WNT, Warszawa, 1996
Additional
1. Sieci neuronowe do przetwarzania informacji, Osowski S., Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa, 2000
2. Algorytmy genetyczne i ich zastosowanie, Goldberg D., WNT, Warszawa, 1995
3. Algorytmy genetyczne + struktury danych = programy ewolucyjne, Michalewicz Z., WNT, Warszawa, 1999
4. Neural networks ? a comprehensive foundation, Haykin S., Prentice-Hall, cop. 1999

Breakdown of average student's workload

	Hours	ECTS
Total workload	100	4,00
Classes requiring direct contact with the teacher	40	1,50
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	60	2,50