COURSE DESCRIPTION CARD - SYLLABUS

Course name
Basics of smart systems [S2AiR1E-ISLiSA>PSI]

Course

Field of study
Automatic Control and Robotics

Year/Semester
1/1

Area of study (specialization)
Smart Aerospace and Autonomous Systems

Profile of study
general academic

Level of study
second-cycle

Course offered in
english

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
30

Laboratory classes
30

Other (e.g. online)
0

Tutorials
0

Projects/seminars
0

Number of credit points

4,00

Coordinators

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Lecturers

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Prerequisites

Knowledge: The student starting this module should have basic knowledge on control of dynamic systems (feedback system, stability, controller properties, compensation, state space description) and robotic systems (manipulator kinematics, Jacobian, dynamics equations, trajectory). Skills: He/she should have skills to solve basic problems of linear algebra, logic and mathematical analysis. He/she should also have the ability to acquire information from given sources. The student should understand the necessity of extending his/her competences. Social competencies: In addition, in respect to the social skills the student should represent such features as honesty, responsibility, perseverance, curiosity, creativity, manners, and respect for other people.

Course objective

1. Provide students with knowledge on selected structures of artificial neural networks and learning algorithms as well as on reasoning based on fuzzy systems. 2. Developing the ability of solving problems related to control with special emphasis on practical implementation of neural networks and fuzzy logic. 3. Developing students' skills to select the appropriate network structure or fuzzy reasoning system on the basis of control description and simulation experiments as well as correct evaluation of quality of the proposed solution.

Course-related learning outcomes

Knowledge
1. have extended knowledge on selected branches of mathematics necessary to formulate and solve complex tasks from the area of artificial neural networks modeling and fuzzy reasoning; - [K2_W1]
2. has detailed knowledge in the field of artificial intelligence methods and their applications in automatics and robotics systems; - [K2_W2]
Skills
1. is able to evaluate information from literature, databases and other information sources (in Polish and English); - [K2_U1]
2. is able to carry out simulation and analysis of a complex control system, where neural or fuzzy controller has been implemented, as well as plan and conduct simulation and experimental verification; - [K2_U9]
3. is able to formulate and solve tasks is able to make use of analytic, simulation, and experimental methods, and particularly develop and program simulations of selected tasks with aid of artificial intelligence methods; - [K2_U15]
4. is able to assess usefulness and possibility of employing new developments in the field of automatics and robotics (methods and tools); - [K2_U16]
5. is able to develop an algorithm for solving a complex engineering task and a simple research problem and to implement, test and run it in a chosen programming environment for selected operating systems; - [K2_U25]
Social competences
1. is aware of responsibility for their own work, is able to collaborate and cooperate in a team, and take responsibility for the jointly performed tasks; is able to lead a team, set goals and assign priorities to realize a specific task; - [K2_K3]
2. is aware of the necessity to approach technical aspects professionally, to acquaint themselves in detail with documentation and environmental conditons in which devices and elements will operate; - [K2_K4]

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) laboratory classes:
i. evaluation of current progress in performing the assigned tasks,
Total assessment:
a) for lectures - verification of pre-assumed learning objectives:
i. evaluation of acquired knowledge and skills on the basis of the written exam, partially in the test form,
ii. individual discussion of the results of the exam,
b) for laboratory classes - verification of pre-assumed learning effects:
i. evaluation of student's knowledge and skills related to the accomplished lab classes and selected problem tasks,
ii. evaluation of the report prepared partially during the lab class and partially afterwards.
Additional points may be gained for activity during classes, and especially for:
i. discussing additional aspects of the subject,
ii. effectiveness of the application of the knowledge gained when solving the problem,
iii. ability to work in a team,
iv. remarks related to improving learning aids,
v. pointing out perception difficulties which allows current improvement of the teaching process.

Programme content

The lecture program should cover the following topics:
Mathematical models and connection architectures of artificial neural networks; learning algorithms. Simple perceptron network; Rosenblatt learning algorithm. Adaptive linear weighted element Adaline; Widrow-Hoff learning algorithm, Madaline networks. Multi-layer networks; error backpropagation algorithm and its modifications. Radial networks; Cover theorem; regularization of radial networks; k-means (concentration) method of radial networks learning. Elements of the unidirectional networks theory; generalization, approximation, Vapnik-Chervonenkis dimension. Crisp and fuzzy sets; membership function; fuzzy sets properties; triangle norms. Operations on fuzzy sets; decomposition theorem. Cartesian product of fuzzy sets; extension rule. Fuzzy numbers; L_R representations of fuzzy numbers. Fuzzy inference system; fuzzification; reasoning; aggregation defuzzification (Takagi-Sugeno and Mamdani methods). Example applications of the presented problems in control. Neuro-fuzzy techniques, perameters tuning of control devices.

Laboratory classes are conducted as 15 2-hour meetings in the lab. Two-person teams perform lab classes and solve selected problem tasks. The lab program covers the following problems:
1. Data classification with use of neural networks. As an example bitmaps representing letters are used. Students get acquainted with methodology of using neural networks, preparing data for learning and with influence of structure and network parameters to the learning/recognition process.
2. Application of a neural network as the two-wheel mobile robot controller. Students prepare simulation of the robot moving to paint and tracking. The robot performs perception of the environment with use of a simple sensor consisting of photo-elements.
3. Results of the former problem are used in implementation of control of two robots moving along the reference trajectory with constant distance between them.
4. Fuzzy controller programming for stabilization of a mass placed on an inclined plane.
Each laboratory class is carried out in two stages: first according to suggestions of the teacher, then is developed according to suggestions of students (each group implements other version) when accepted by the teacher.

Teaching methods

1. lecture: presentation illustrated with examples, multimedia presentations
2. laboratory classes: performing simulation experiments, discussion, cooperation in a 2-person team, developing of the carried out experiment in alternative variants suggested by students

Bibliography

Basic
1. Neural Networks: A Comprehensive Foundation, S.S. Haykin, Prentice Hall, 1998
2. Neural Networks for Modelling and Control of Dynamic Systems, M. N?rgaard, O. Ravn, N.K. Poulsen, L.K. Hansen, Springer 1999
3. An Introduction to Fuzzy Control, D. Driankov, H. Hellendoorn, M. Reinfrank, Springer 1993
4. Essentials of Fuzzy Modeling and Control, R.R. Yager, D. Filev, Wiley 1994
Additional
1. Neural Networks for Pattern Recognition, C.M. Bishop, Oxford University Press 1995
2. Neural Networks and Fuzzy Systems, B. Kosko, Addison Addison Wesley, Reading, MA 1992

Breakdown of average student's workload

	Hours	ECTS
Total workload	100	4,00
Classes requiring direct contact with the teacher	63	2,50
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	37	1,50