STUDY MODULE DESCRIPTION FORM

Name of the module/subject **Basics of Smart Systems**			Code **1010532111010559182**
Field of study **Automatic Control and Robotics**		Profile of study (general academic, practical) **general academic**	Year /Semester **1 / 1**
Elective path/specialty **Smart Aerospace and Autonomous Systems**		Subject offered in: **Polish**	Course (compulsory, elective) **obligatory**
Cycle of study: **Second-cycle studies**	Form of study (full-time,part-time) **full-time**		
No. of hours Lecture: **30** Classes: **-** Laboratory: **30** Project/seminars: **-**			No. of credits **4**
Status of the course in the study program (Basic, major, other) **major**	(university-wide, from another field) **from field**		
Education areas and fields of science and art			ECTS distribution (number and %**)**

Responsible for subject / lecturer:

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Prerequisites in terms of knowledge, skills and social competencies:

1	**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).
2	**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.
3	**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.

Assumptions and objectives of the course:

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.

Study outcomes and reference to the educational results for a field of study

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; - [K_W1]

2. have knowledge on selected branches of physics necessary to understand basic effects taking place in control and robotics systems, particularly using neural techniques and fuzzy reasoning; - [K_W2]

Skills:

1. acquire information from literature, databases and other sources sources, also in foreign language; - [K_U1]

2. 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; - [K_U9]

3. 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; - [K_U15]

4. is able to assess usefulness and possibility of employing new developments in the field of robotics and control (methods and tools); - [K_U16]

Social competencies:

1. is responsible for his/her own work, is able to collaborate and cooperate in a team, can conduct a small team, and may take responsibility for the jointly performed tasks, - [K_K3]

2. is aware of the necessity to approach technical aspects professionally, to get acquainted in detail with documentation and environmental conditions in which devices and elements will operate, - [K_K4]

Assessment methods of study outcomes

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.

Course description

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.

Learning 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

Basic bibliography:

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 bibliography:

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

Result of average student's workload

Activity	Time (working hours)
1. participating in laboratory classes	30
2. preparing to laboratory classes	15
3. finishing solving the problems from the laboratory classes	10
4. participation in consultations related to the subject of the course	1
5. participating in lectures	30
6. studying of literature / learning aids (10 pages = 1 hour)	10
7. preparing to and participating in the exam	15

Student’s workload

Source of workload	hours	ECTS
Total workload	111	4
Contact hours	63	3
Practical activities	53	2