AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Module name: Soft computing in modeling and control

Academic year: 2019/2020 Code: RIMM-1-713-s ECTS credits: 3

Faculty of: Mechanical Engineering and Robotics

Field of study: Mechanical and Materials Engineering Specialty: —

Study level: First-cycle studies Form and type of study: Full-time studies

Lecture language: English Profile of education: Academic (A) Semester: 7

Course homepage: —

Responsible teacher: dr hab. inż. Smoczek Jarosław (smoczek@agh.edu.pl)

Module summary

The course is intended to provide the students with the knowledge and understanding of computational intelligence and soft computing concepts and their applicability to solve the real-world decision-making, modeling and control problems. The selected soft computing concepts and techniques, including fuzzy logic, artificial neural network, evolutionary computing, swarm intelligent and their hybrids are introduced and discussed with application examples.

Description of learning outcomes for module

MLO code	Student after module completion has the knowledge/ knows how to/is able to	Connections with FLO	Method of learning outcomes verification (form of completion)
Social competence: is able to			
M_K001	Student knows that computational intelligence and soft computing methodologies can be effectively applied to solve real-world decision-making, modeling and control problems.	IMM1A_K01	Activity during classes
Skills: he can			
M_U001	Student is able to apply the software tools in Matlab program to implement the soft computing methods for modeling and control system design.	IMM1A_U10	Execution of exercises
M_U002	Student is able to select and apply the supervised or unsupervised techniques for fuzzy model/controller identification/design.	IMM1A_U10	Activity during classes
M_U003	Student is able to identify, select and implement a suitable soft computing method to solve the problem.	IMM1A_U10	Execution of exercises
Knowledge: he knows and understands			

M_W001	Student has knowledge in modeling of dynamic systems and control system design using soft computing methods: knowledge engineering, fuzzy logic, artificial neural networks, evolutionary algorithms, and their hybrids.	IMM1A_W13	Test
M_W002	Student has knowledge about the soft computing techniques and their applicability to solve the real word problems.	IMM1A_W13	Test

Number of hours for each form of classes

	Form of classes										
Suma	Lectures	Auditorium classes	Laboratory classes	Project classes	Conversation seminar	Seminar classes	Practical classes	Fieldwork classes	Workshops	Prace kontrolne i przejściowe	Lektorat
30	20	0	0	0	0	10	0	0	0	0	0

FLO matrix in relation to forms of classes

MLO code	Student after module completion has the knowledge/ knows how to/is able to	Form of classes										
		Lectures	Auditorium classes	Laboratory classes	Project classes	Conversation seminar	Seminar classes	Practical classes	Fieldwork classes	Workshops	Prace kontrolne i przejściowe	Lektorat
Social competence: is able to												
M_K001	Student knows that computational intelligence and soft computing methodologies can be effectively applied to solve real-world decision-making, modeling and control problems.	+	-	-	-	-	-	-	-	-	-	-
Skills: he can												
M_U001	Student is able to apply the software tools in Matlab program to implement the soft computing methods for modeling and control system design.	+	-	-	-	-	+	-	-	-	-	-
M_U002	Student is able to select and apply the supervised or unsupervised techniques for fuzzy model/controller identification/design.	+	-	-	-	-	+	-	-	-	-	-
M_U003	Student is able to identify, select and implement a suitable soft computing method to solve the problem.	+	-	-	-	-	+	-	-	-	-	-

Knowledge: he knows and understands												
M_W001	Student has knowledge in modeling of dynamic systems and control system design using soft computing methods: knowledge engineering, fuzzy logic, artificial neural networks, evolutionary algorithms, and their hybrids.	+	-	-	-	-	+	-	-	-	-	-
M_W002	Student has knowledge about the soft computing techniques and their applicability to solve the real word problems.	+	-	-	-	-	-	-	-	-	-	-

Student workload (ECTS credits balance)

Student activity form	Student workload
Udział w zajęciach dydaktycznych/praktyka	30 h
Preparation for classes	15 h
przygotowanie projektu, prezentacji, pracy pisemnej, sprawozdania	20 h
Realization of independently performed tasks	15 h
Examination or Final test	2 h
Summary student workload	82 h
Module ECTS credits	3 ECTS

Additional information

Module content

Lectures

The general program of lectures:

1. Introduction to artificial intelligence, computational intelligence and soft computing. Review of the main soft computing components and their hybrids. Examples of artificial applications to real world problems.
2. Introduction to fuzzy logic, fuzzy set theory.
3. Fuzzy approximate reasoning. Mamdani inference system. TS fuzzy inference systems. Analytical methods in fuzzy modeling and control.
4. Fuzzy logic control. Knowledge-based and analytical methods of fuzzy controller design.
5. Type-2 fuzzy logic. Interval type-2 fuzzy sets and logic.
6. Fundamentals of artificial neural network. Multilayer perceptrons and backpropagation learning algorithm.
7. Data-based fuzzy modeling (machine learning, fuzzy clustering).
8. Evolutionary computation. Simple genetic algorithm. Real coded genetic algorithm.
9. Evolutionary strategies. Genetic fuzzy systems.

10. Swarm intelligence.

Seminar classes

During seminar classes students present seminar presentations reporting artificial intelligence applications and take active part in a discussion.

Individual/team presentation:
• presentation topics will be assigned, discussed and scheduled at the beginning of the course,
• students are expected to prepare a presentation and send it via e-mail to the instructor for evaluation before a seminar meeting,
• during seminar classes students present their presentations and take active part in a discussion.

Teaching methods and techniques:

Lectures: The lectures are in the form of multimedia presentations.
Seminar classes: multimedia presentation presented by students; active participation in a discussion

Warunki i sposób zaliczenia poszczególnych form zajęć, w tym zasady zaliczeń poprawkowych, a także warunki dopuszczenia do egzaminu:

Condition of gaining credit: attendance to the classes, presentation given during a seminar meeting, participation in a discussion.

Individual/team presentation:
• presentation topics will be assigned, discussed and scheduled at the beginning of the course,
• students are expected to prepare a presentation and send it via e-mail to the instructor for evaluation before a seminar meeting,
• during seminar classes students present their presentations and take active part in a discussion.

Zasady udziału w poszczególnych zajęciach, ze wskazaniem, czy obecność studenta na zajęciach jest obowiązkowa:

Lectures:
– Attendance is mandatory: No
– Participation rules in classes: Attendance to the lecture is not obligatory but recommended, and rewarded with the student’s final grade being raised.
Seminar classes:
– Attendance is mandatory: Yes
– Participation rules in classes: Students are expected to prepare a presentation and send it via e-mail to the instructor for evaluation before the seminar meeting in which the student is scheduled to present his/her work.

Method of calculating the final grade

Final grade: presentation, active participation in a seminar discussion (bonus/penalty for attendance to the classes).

Sposób i tryb wyrównywania zaległości powstałych wskutek nieobecności studenta na zajęciach:

Students who have missed class should contact with the instructor during his consultation hours to make up missed work.

Prerequisites and additional requirements

Prerequisites and additional requirements not specified

Recommended literature and teaching resources

J.-S. R. Jang, C.-T. Sun, E. Mizutani: "Neuro-Fuzzy and Soft Computing, A Computational Approach to Learning and Machine Intelligence", Pentice Hall, Upper Saddle River, NJ, 1997.

Scientific publications of module course instructors related to the topic of the module

1.Smoczek J., Szpytko J., Particle swarm optimization-based multivariable generalized predictive control for an overhead crane, IEEE-ASME Transactions on Mechatronics, 22 (1), pp. 258-268, 2017.
2.Smoczek J., Experimental verification of a GPC-LPV method with RLS and P1-TS fuzzy-based estimation for limiting the transient and residual vibration of a crane system, Mechanical Systems and Signal Processing, vol. 62-63, pp. 324-340, 2015.
3.Smoczek J.: Fuzzy crane control with sensorless payload deflection feedback for vibration reduction. Mechanical System and Signal Processing 46 (1), pp. 70-81, 2014.
4.Smoczek J., Szpytko J.: Evolutionary algorithm-based design of a fuzzy TBF predictive model and TSK fuzzy anti-sway crane control system. Engineering Applications of Artificial Intelligence 28, pp. 190-200, 2014.
5.Smoczek J. Soft computing methods in overhead travelling crane control. Publishing House of Sustainable Technologies – National Research Institute, Radom 2013.
6.Smoczek J.: Interval arithmetic-based fuzzy discrete-time crane control scheme design. Bulletin of the Polish Academy of Sciences – Technical Sciences 61 (4), pp. 863-870, 2013.
7.Smoczek J.: Evolutionary optimization of interval mathematics-based design of TSK fuzzy controller for anti-sway crane control. International Journal of Applied Mathematics and Computer Science 23 (4), pp. 749-759, 2013.

Additional information

None