AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Module name: Bio-Inspired Artificial Intelligence

Academic year: 2019/2020 Code: ZSDA-3-0106-s ECTS credits: 6

Faculty of: Szkoła Doktorska AGH

Field of study: Szkoła Doktorska AGH Specialty: —

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

Lecture language: English Profile of education: Academic (A) Semester: 0

Course homepage: http://drezewski.eu5.net

Responsible teacher: dr hab. inż. Dreżewski Rafał (drezew@agh.edu.pl)

Module summary

The course acquaints the student with modern bio-inspired artificial intelligence algorithms, including open research questions and future research directions. The student learns current research methods in bio-inspired AI and develops the ability to independently and creatively solve encountered research problems during the realization of a research project. Also, the ability to write scientific papers and present research results is developed during the classes.

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	The student is able to critically asses non-technical aspects and consequences of the applications of bio-inspired artificial intelligence algorithms.	SDA3A_K02, SDA3A_K01, SDA3A_K03	Scientific paper, Project, Presentation, Participation in a discussion, Involvement in teamwork, Execution of a project, Activity during classes
Skills: he can			
M_U001	The student can identify open research problems in the area of bio-inspired artificial intelligence and solve them carrying out the research.	SDA3A_U07, SDA3A_U06, SDA3A_U01	Scientific paper, Project, Presentation, Participation in a discussion, Execution of a project, Activity during classes
M_U002	The student can develop and implement modern bio-inspired artificial intelligence algorithms using selected programming tools and libraries.	SDA3A_U07, SDA3A_U06, SDA3A_U02, SDA3A_U05, SDA3A_U01	Involvement in teamwork, Project, Execution of a project, Activity during classes

M_U003	The student can carry out experiments using the developed bio-inspired artificial intelligence algorithms.	SDA3A_U06, SDA3A_U01	Project, Involvement in teamwork, Execution of a project, Activity during classes
M_U004	The student can analyze and interpret the results of experiments performed with the use of developed bio-inspired artificial intelligence algorithms.	SDA3A_U01	Scientific paper, Project, Execution of a project, Activity during classes
M_U005	The student can write a scientific paper presenting the performed research in the area of bio-inspired artificial intelligence algorithms.	SDA3A_U02, SDA3A_U03, SDA3A_U05, SDA3A_U01, SDA3A_U04	Scientific paper, Execution of a project, Activity during classes
M_U006	The student can prepare a presentation showing the most important outcomes of the performed research.	SDA3A_U02, SDA3A_U03, SDA3A_U05, SDA3A_U04	Project, Presentation, Participation in a discussion, Execution of a project, Activity during classes
Knowledge: he knows and understands			
M_W001	The student knows and understands modern bio-inspired artificial intelligence algorithms.	SDA3A_W03, SDA3A_W04, SDA3A_W01, SDA3A_W02	Project, Scientific paper, Presentation, Participation in a discussion, Execution of a project, Activity during classes
M_W002	The student knows and understands open research questions and future research directions in the area of bio-inspired artificial intelligence.	SDA3A_W03, SDA3A_W05, SDA3A_W01, SDA3A_W02	Scientific paper, Project, Presentation, Participation in a discussion, Execution of a project, Activity during classes
M_W003	The student knows and understands possible areas of real-life applications of bio-inspired artificial intelligence algorithms.	SDA3A_W03, SDA3A_W07, SDA3A_W05, SDA3A_W04, SDA3A_W06	Scientific paper, Project, Participation in a discussion, Execution of a project, Activity during classes

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
60	10	0	0	30	0	20	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	The student is able to critically asses non-technical aspects and consequences of the applications of bio-inspired artificial intelligence algorithms.	+	-	-	+	-	+	-	-	-	-	-
Skills: he can												
M_U001	The student can identify open research problems in the area of bio-inspired artificial intelligence and solve them carrying out the research.	-	-	-	+	-	-	-	-	-	-	-
M_U002	The student can develop and implement modern bio-inspired artificial intelligence algorithms using selected programming tools and libraries.	-	-	-	+	-	-	-	-	-	-	-
M_U003	The student can carry out experiments using the developed bio-inspired artificial intelligence algorithms.	-	-	-	+	-	-	-	-	-	-	-
M_U004	The student can analyze and interpret the results of experiments performed with the use of developed bio-inspired artificial intelligence algorithms.	-	-	-	+	-	-	-	-	-	-	-
M_U005	The student can write a scientific paper presenting the performed research in the area of bio-inspired artificial intelligence algorithms.	-	-	-	+	-	-	-	-	-	-	-
M_U006	The student can prepare a presentation showing the most important outcomes of the performed research.	-	-	-	-	-	+	-	-	-	-	-
Knowledge: he knows and understands												
M_W001	The student knows and understands modern bio-inspired artificial intelligence algorithms.	+	-	-	+	-	+	-	-	-	-	-
M_W002	The student knows and understands open research questions and future research directions in the area of bio-inspired artificial intelligence.	+	-	-	+	-	+	-	-	-	-	-
M_W003	The student knows and understands possible areas of real-life applications of bio-inspired artificial intelligence algorithms.	+	-	-	+	-	+	-	-	-	-	-

Student workload (ECTS credits balance)

Student activity form	Student workload
Udział w zajęciach dydaktycznych/praktyka	60 h
Preparation for classes	35 h
przygotowanie projektu, prezentacji, pracy pisemnej, sprawozdania	50 h
Realization of independently performed tasks	30 h
Contact hours	5 h
Summary student workload	180 h
Module ECTS credits	6 ECTS

Additional information

Module content

Lectures

1. Introduction to the bio-inspired artificial intelligence – its origins and possible future.
2. Evolutionary algorithms – from evolutionary biology to evolutionary AI.
3. Co-evolutionary algorithms – AI resulting from intra- and inter-species interactions.
4. Speciation algorithms – using species formation processes to obtain intelligent behavior.
5. Multi-modal and multi(many)-objective evolutionary algorithms – applications in real-life problems.
6. Agent-based evolution – making the evolutionary AI more realistic.
7. Open research questions and future research directions and trends in bio-inspired AI.

Project classes

1. Development and implementation of innovative or known from the literature bio-inspired AI algorithm.
2. Conducting preliminary experiments using the implemented bio-inspired AI algorithm. Verification of the correctness of the results and tuning the algorithm. Possible modification of the algorithm and further experiments.
3. Conducting target experiments using the implemented algorithm.
4. Analysis and interpretation of the obtained experimental results.
5. Preparation of a scientific publication based on the results of the conducted research.

Seminar classes

Students analyze, present and discuss modern bio-inspired AI approaches and algorithms, including open research questions and problems. The exemplary research areas subjected to analysis and discussion during classes include:

1. Differential Evolution.
2. Swarm Intelligence.
3. Ant colony optimization.
4. Particle Swarm Optimization.

5. Memetic algorithms.
6. Cultural algorithms.
7. Hybrid evolutionary algorithms.
8. Agent-based evolutionary approaches.
9. Novel bio-inspired algorithms.

Teaching methods and techniques:

Lectures: The content of the lecture is presented in the form of a multimedia presentation in combination with a traditional blackboard lecture enriched with discussions with the audience related to the presented open research issues.
Project classes: Students carry out a given project themselves, consulting the encountered problems with the teacher, however, without any significant interference on his part. The goal is to become acquainted with current research methods and techniques and to develop the ability to independently and creatively solve encountered research problems. The aim of the classes is also to develop the ability to write scientific papers.
Seminar classes: Students analyze, present, and discuss modern algorithms and methods of bio-inspired artificial intelligence, also the open research problems in that area. The goal is to become acquainted with current trends and research directions in the field of bio-inspired AI and to develop the ability to analyze and discuss the results of scientific research critically.

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

1. Lectures: realization of the research project, preparation of a scientific publication, and active participation in the seminars.
2. Project classes: realization of the research project and preparation of a scientific publication based on the results of carried out research.
3. Seminar classes: presentation of selected research topics in the area of bio-inspired AI and active participation in discussions.

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

Lectures:
– Attendance is mandatory: Yes
– Participation rules in classes: Students take part actively in classes and acquire knowledge in the field of bio-inspired artificial intelligence, according to the plan of lectures. Students should keep asking questions and clarifying doubts during the lectures. Audiovisual registration of the lecture requires the lecturer’s consent.
Project classes:
– Attendance is mandatory: Yes
– Participation rules in classes: Students carry out a project aimed at the development and implementation of innovative or selected from the literature bio-inspired artificial intelligence algorithm, conducting experiments, and analyzing their results. The method of project realization and the final results described in the scientific publication are assessed.
Seminar classes:
– Attendance is mandatory: Yes
– Participation rules in classes: Students actively participate in seminars, presenting, analyzing, and discussing current research trends, directions, and problems in the field of bio-inspired artificial intelligence.

Method of calculating the final grade

The final grade is calculated in the following way:
0.3 • development and implementation of the selected bio-inspired AI algorithm + 0.15 • conducting experimental research and analysis and interpretation of the experimental results + 0.3 • preparation of a scientific publication describing the developed AI algorithm and conducted experiments + 0.25 • presentation of the selected research topics in the area of bio-inspired AI and participation in the discussions on open research issues during the seminar classes.

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

The way of clearing backlogs resulting from the student's absence during classes includes carrying out a project on the subject set with the teacher and preparation of the scientific paper based on the performed research.

Prerequisites and additional requirements

Students should know the basics of artificial intelligence methods (at the level of engineering or MSc studies). Also, the students should be able to write programs in Java/Scala/Python/C++ or another programming language in which it is possible to implement a selected bio-inspired AI algorithm. The basic knowledge of statistical methods and tools (for example, R language) is also required.

Recommended literature and teaching resources

1. Floreano D., Mattiussi C., *Bio-Inspired Artificial Intelligence: Theories, Methods, and Technologies*, The MIT Press, 2008.
2. Pétrowski A., Ben-Hamida S., *Evolutionary Algorithms*, ISTE Ltd and John Wiley & Sons, London, UK and Hoboken, USA, 2017.
3. Simon D., *Evolutionary Optimization Algorithms*, John Wiley & Sons, Inc., Hoboken, New Jersey, 2013.
4. Price K. V., Storn R. M., Lampinen J. A., *Differential Evolution. A Practical Approach to Global Optimization*, Springer-Verlag, Berlin Heidelberg, 2005.
5. Russell S., Norvig P., *Artificial Intelligence: A Modern Approach*, Pearson, 2010.
6. Wooldridge M., *An Introduction to MultiAgent Systems*, Wiley, 2009.
7. Ferber J., *Multi-Agent Systems: An Introduction to Distributed Artificial Intelligence*, Addison-Wesley, 1999.
8. Sarker R.A., Ray T., (ed.), *Agent-Based Evolutionary Search*, Springer, 2010.
9. Engelbrecht A.P., *Fundamentals of Computational Swarm Intelligence*, Wiley, 2005.
10. Dorigo M., Stützle T., *Ant Colony Optimization*, The MIT Press, 2004.
11. Lee R.S.T. (ed.), *Computational Intelligence for Agent-based Systems*, Springer-Verlag, 2007.

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

1. R. Dreżewski, S. Kruk, and M. Makówka. The evolutionary optimization of a company's return on equity factor: Towards the agent-based bio-inspired system supporting corporate finance decisions. *IEEE Access*, 6:51911–51930, 2018.
2. R. Dreżewski and M. Klęczar. Artificial intelligence techniques for the Puerto Rico strategy game. In G. Jezic, M. Kusek, Y.-H. J. Chen-Burger, R. J. Howlett, and L. C. Jain, editors, *Agent and Multi-Agent Systems: Technology and Applications. 11th KES International Conference, KES-AMSTA 2017 Vilamoura, Algarve, Portugal, June 2017 Proceedings*, volume 74 of Smart Innovation, Systems and Technologies, pages 77-87. Springer International Publishing, 2018
3. R. Dreżewski and K. Doroz. An agent-based co-evolutionary multi-objective algorithm for portfolio optimization. *Symmetry*, 9(9):168, 2017.
4. L. Siwik and R. Dreżewski. Hierarchical and massively interactive approaches for hybridization of evolutionary computations and agent systems-comparison in financial application. In Leszek Rutkowski, Marcin Korytkowski, Rafał Scherer, Ryszard Tadeusiewicz, Lotfi A. Zadeh, and Jacek M. Zurada, editors, *Artificial Intelligence and Soft Computing. 15th International Conference, ICAISC 2016, Zakopane, Poland, June 12-16, 2016, Proceedings, Part I*, volume 9692 of Lecture Notes in Computer Science, pages 505-516. Springer International Publishing, 2016
5. R. Dreżewski, K. Cetnarowicz, G. Dziuban, S. Martynuska, and A. Byrski. Agent-based neuro-evolution algorithm. In G. Jezic, R. J. Howlett, and L. C. Jain, editors, *Agent and Multi-Agent Systems: Technologies and Applications. 9th KES International Conference, KES-AMSTA 2015 Sorrento, Italy, June 2015, Proceedings*, volume 38 of Smart Innovation, Systems and Technologies, pages 95-108. Springer International Publishing, 2015.
6. A. Byrski, R. Dreżewski, L. Siwik, and M. Kisiel-Dorohinicki. Evolutionary multi-agent systems. *The Knowledge Engineering Review*, 30(2):171-186, 2015.

Additional information

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