AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Module name:	Artificial intelligence and machine learning in biomedicine
Academic year:	2019/2020
Code:	ZSDA-3-0048-s
ECTS credits:	3
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://home.agh.edu.pl/~horzyk/lectures/ahdydaimlbm.php
Responsible teacher:	dr hab. Horzyk Adrian (horzyk@agh.edu.pl)

Module summary

The module is focussed on universal modern models, methods, algorithms, and techniques of machine learning used to create various models of artificial and computational intelligence that might be used in biomedicine to analyze, cluster, classify and predict data. We will deal with classic and sequential data. We will discuss which methods and approaches can behave better and how to optimize hyperparameters and the model to achieve satisfactory results.

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	They can share knowledge, findings, discoveries, and achievements. They can collaborate and communicate with other team members. They are able to think creatively and use the tools of creative thinking like brainstorming techniques. They developed the ability to think entrepreneurial about implementation of the developed solution in the industry.	SDA3A_K01, SDA3A_K03	Project, Presentation
Skills: he can			
M_U001	They can use libraries and programming tools for the development of computational intelligence models, training and optimizing them through searching for hyperparameters and evaluating results.	SDA3A_U03, SDA3A_U02, SDA3A_U01, SDA3A_U04	Project, Presentation

M_U002	They can discuss the ideas with other students, present the pros and cons during the discussion, propose other approaches.	SDA3A_U07, SDA3A_U02, SDA3A_U05, SDA3A_U04	Participation in a discussion, Activity during classes
Knowledge: he knows and understands			
M_W001	They have knowledge in the area of designing, implementation, and use of various models, methods, techniques, and algorithms in the field of artificial and computational intelligence and how to use various machine learning approaches and methods.	SDA3A_W03, SDA3A_W02, SDA3A_W01	Project, Presentation

Number of hours for each form of classes

Suma	Form of classes										
	Lectures	Auditorium classes	Laboratory classes	Project classes	Conversation seminar	Seminar classes	Practical classes	Fieldwork classes	Workshops	Prace kontrolne i przejściowe	Lektorat
24	12	0	0	0	0	12	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	They can share knowledge, findings, discoveries, and achievements. They can collaborate and communicate with other team members. They are able to think creatively and use the tools of creative thinking like brainstorming techniques. They developed the ability to think entrepreneurial about implementation of the developed solution in the industry.	+	-	-	-	-	+	-	-	-	-	-
Skills: he can												
M_U001	They can use libraries and programming tools for the development of computational intelligence models, training and optimizing them through searching for hyperparameters and evaluating results.	+	-	-	-	-	+	-	-	-	-	-

M_U002	They can discuss the ideas with other students, present the pros and cons during the discussion, propose other approaches.	-	-	-	-	-	-	-	-	-	-	-
Knowledge: he knows and understands												
M_W001	They have knowledge in the area of designing, implementation, and use of various models, methods, techniques, and algorithms in the field of artificial and computational intelligence and how to use various machine learning approaches and methods.	+	-	-	-	-	+	-	-	-	-	-

Student workload (ECTS credits balance)

Student activity form	Student workload
Udział w zajęciach dydaktycznych/praktyka	24 h
Preparation for classes	6 h
przygotowanie projektu, prezentacji, pracy pisemnej, sprawozdania	18 h
Realization of independently performed tasks	40 h
Examination or Final test	2 h
Summary student workload	90 h
Module ECTS credits	3 ECTS

Additional information

Module content

Lectures

Development and Training of Deep Neural Network Models
We will focus on the design, development, learning, and optimization of the most popular and effective deep neural network models dealing with classic and sequential data. We will discuss and implement supervised and unsupervised models and approaches. Next, we will try to implement them in individual research tasks.

Development and Training of Deep Associative-Cognitive Models
We will use associative approaches in modeling the cognitive knowledge-based neural systems to represent data and relationships in such a way that allows us to conclude quickly about them. Next, we will try to implement them in individual research tasks.

Seminar classes

Projects on Implementation of Deep Learning and Associative-Cognitive Models
Students will try to use the lectured models, methods, algorithms, techniques, and various training approaches the biomedical and/or own data to achieve satisfactory results of classification, clustering or prediction. We will try to implement them in

individual research tasks.

Teaching methods and techniques:

Lectures: Models, methods, and techniques will be presented in Python or C++/C1. programming languages together with descriptions and notes that allow gaining knowledge and skills in using and implementing them.
Seminar classes: Students will present the collected results during their experiments and describe how they achieved them.

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

Every student is responsible for taking part in the lectures and choosing a project to implement it by themselves. The most important outcome of this course is to acquire knowledge and skills in using AI, CI and ML tools and methods to achieve qualitative classification, clustering or prediction results.

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

Lectures:
– Attendance is mandatory: Yes
– Participation rules in classes: Every student enrolled in this course should be self-motivated in gaining new knowledge about models, methods and techniques that allow them to classify, cluster or predict important results in their scientific work.
Seminar classes:
– Attendance is mandatory: Yes
– Participation rules in classes: Every student enrolled in this course should take part in the seminar classes, discuss the results of other students and try to find interesting conclusions and scientific outcomes.

Method of calculating the final grade

The course grade is based on the completeness, correctness, and quality of the developed models and the final presentation of the collected results and implemented solutions.

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

Students who left the classes are responsible for self-updating their knowledge and skills based on the shared materials on the Internet by the lecturer or from other sources allowing them to design, develop, implement and used the CI and AI tools for machine learning and acquiring results for the chosen datasets.

Prerequisites and additional requirements

Fundamentals in programming (preferably in Python and/or C++/C1.), math, and good knowledge of English (at least on the level B2).

Recommended literature and teaching resources

1. Cruse, Holk; Neural Networks as Cybernetic Systems, 2nd and revised edition, file:///C:/Users/Adrian/Downloads/bmm615.pdf
2. Schwenker, Friedhelm; Kestler, Hans A.; Palm, Günther (2001). “Three learning phases for radial basis function networks”. Neural Networks 14: 439–458. doi:10.1016/s0893-6080(01)00027-2.
3. Martin D. Buhmann (2003). Radial Basis Functions: Theory and Implementations. Cambridge University. ISBN 0-521-63338-9.
4. Bengio, Yoshua (2009). “Learning deep architectures for AI”. Foundations and Trends in Machine Learning 2 (1): 1–127. doi:10.1561/2200000006.
5. Larochelle, Hugo; Bengio, Yoshua; Louradour, Jerdme; Lamblin, Pascal (2009). “Exploring Strategies for Training Deep Neural Networks”. The Journal of Machine Learning Research 10: 1–40.

6. Hinton, G. (2009). “Deep belief networks”. Scholarpedia 4 (5): 5947. doi:10.4249/scholarpedia.5947.
7. B. Ploj (2014). Advances in Machine Learning Research (chapter 3). Nova Science Publishers. ISBN 978-1-63321-214-5.
8. Horzyk, A., Innovative types and abilities of neural networks based on associative mechanisms and a new associative model of neurons – the invited talk and paper at the International Conference ICAISC 2015,
9. Horzyk, A., How Does Generalization and Creativity Come into Being in Neural Associative Systems and How Does It Form Human-Like Knowledge?, Elsevier, Neurocomputing, 2014, pp. 238-257, DOI: 10.1016/j.neucom.2014.04.046.
10. Kohonen, Teuvo (1982). “Self-Organized Formation of Topologically Correct Feature Maps”. Biological Cybernetics 43 (1): 59–69. doi:10.1007/bf00337288.
11. Fernando Canales and Max Chacon (2007). “Modification of the growing neural gas algorithm for cluster analysis”. In Luis Rueda, Domingo Mery, Josef Kittler, International Association for Pattern Recognition. Progress in pattern recognition, image analysis and applications: 12th Iberoamerican Congress on Pattern Recognition, CIARP 2007, Viña del Mar-Valparaiso, Chile, November 13–16, 2007; proceedings. Springer. pp. 684–693. doi:10.1007/978-3-540-76725-1_71. ISBN 978-3-540-76724-4.
12. Jürgen Schmidhuber. Learning complex, extended sequences using the principle of history compression. Neural Computation, 4(2):234–242.
13. Ian Goodfellow, Yoshua Bengio and Aaron Courville, Deep Learning, MIT Press book, 2016 – http://www.deeplearningbook.org/.
14. N.Kasabov, Time-Space, Spiking Neural Networks and Brain-Inspired Artificial Intelligence, Springer (2018) 750p., https://www.springer.com/gp/book/9783662577134

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

1. Basawaraj, J. A. Starzyk, A. Horzyk, Episodic Memory in Minicolumn Associative Knowledge Graphs, IEEE Transactions on Neural Networks and Learning Systems, Vol. 30, Issue 11, Nov. 2019, pp. 3505-3516, DOI: 10.1109/TNNLS.2019.2927106 (TNNLS-2018-P-9932).
2. A. Horzyk, K. Gołdon, and J.A. Starzyk, Temporal Coding of Neural Stimuli, In: 28th International Conference on Artificial Neural Networks (ICANN 2019), Springer-Verlag, LNCS 11731, pp. 607-621, 2019, DOI: 10.1007/978-3-030-30493-5_56.
3. A. Horzyk and J.A. Starzyk, Associative Data Model in Search for Nearest Neighbors and Similar Patterns, In: 2019 IEEE Symposium Series on Computational Intelligence (SSCI 2019), IEEE Xplore, pp. 932-939, 2019.
4. J.A. Starzyk, R. Niemiec, and A. Horzyk Concurrent Associative Memories with Synaptic Delays, In: 2019 IEEE Symposium Series on Computational Intelligence (SSCI 2019), IEEE Xplore, pp. 908-915, 2019.
5. A. Horzyk, A. Czajkowska, Associative Pattern Matching and Inference Using Associative Graph Data Structures, In: Proc. of 18-th Int. Conf. ICAISC 2019, Rutkowski, L., Scherer, R., Korytkowski, M., Pedrycz, W., Tadeusiewicz, R., Zurada, J.M. (Eds.), Artificial Intelligence and Soft Computing, Springer-Verlag, LNAI 10509, pp. 371-383, 2019, DOI 10.1007/978-3-030-20915-5_34.
6. A. Horzyk, Associative Representation and Processing of Databases Using DASNG and AVB+trees for Efficient Data Access, In: Knowledge Discovery, Knowledge Engineering and Knowledge Management, Eds.: Ana Fred, David Aveiro, Jan Dietz, Kecheng Liu, Ana Carolina Salgado, Jorge Bernardino and Joaquim Filipe, ISBN: 978-3-030-15639-8, Springer Verlag, pp. 242-267, 2019.
7. A. Horzyk and J.A. Starzyk, Associative Fine-Tuning of Biologically Inspired Active Neuro-Associative Knowledge Graphs, In: 2018 IEEE Symposium Series on Computational Intelligence (SSCI 2018), IEEE Xplore, pp. 2068-2075, 2018.
8. A. Horzyk, Associative Graph Data Structures with an Efficient Access via AVB+trees, In: 2018 11th International Conference on Human System Interaction (HSI), 2018, IEEE Xplore, pp. 169 – 175, DOI: 10.1109/HSI.2018.8430973.
9. A. Horzyk and J.A. Starzyk, Multi-Class and Multi-Label Classification Using Associative Pulsing Neural Networks, In: 2018 IEEE World Congress on Computational Intelligence (WCCI 2018), 2018 International Joint Conference on Neural Networks (IJCNN 2018), IEEE Xplore, pp. 427-434, 2018.
10. A. Horzyk, J. A. Starzyk, J. Graham, Integration of Semantic and Episodic Memories, IEEE Transactions on Neural Networks and Learning Systems, Vol. 28, Issue 12, Dec. 2017, pp. 3084 – 3095, DOI: 10.1109/TNNLS.2017.2728203.
11. A. Horzyk, Neurons Can Sort Data Efficiently, In: Rutkowski L., Korytkowski M., Scherer R., Tadeusiewicz R., Zadeh L., Zurada J. (eds), Artificial Intelligence and Soft Computing, Proc. of ICAISC 2017, Springer-Verlag, LNCS, Vol. 10245, pp. 64-74, 2017, DOI: 10.1007/978-3-319-59063-9_6.
12. A. Horzyk, Deep Associative Semantic Neural Graphs for Knowledge Representation and Fast Data Exploration, Proc. of KEOD 2017, SCITEPRESS Digital Library, 2017, pp. 67-79. DOI:

10.5220/0006504100670079.
13. A. Horzyk and J.A. Starzyk, Fast Neural Network Adaptation with Associative Pulsing Neurons, IEEE Xplore, In: 2017 IEEE Symposium Series on Computational Intelligence, pp. 339-346, 2017, DOI: 10.1109/SSCI.2017.8285369.
14. Basawaraj, Janusz A. Starzyk and A. Horzyk, Lumped Mini-Column Associative Knowledge Graphs, IEEE Xplore, In: 2017 IEEE Symposium Series on Computational Intelligence, pp. 347-354, 2017, DOI: 10.1109/SSCI.2017.8285413.
15. Horzyk, A., Human-Like Knowledge Engineering, Generalization and Creativity in Artificial Neural Associative Systems, Springer Verlag, AISC 11156, ISSN 2194-5357, ISBN 978-3-319-19089-1, ISBN 978-3-319-19090-7 (eBook), DOI 10.1007/978-3-319-19090-7, Springer, Switzerland, 2016, pp. 39-51.
16. Horzyk, A., Innovative types and abilities of neural networks based on associative mechanisms and a
new associative model of neurons – the invited talk and paper at the International Conference ICAISC 2015, Springer Verlag, LNAI 9119, 2015, pp. 26-38, DOI 10.1007/978-3-319-19324-3_3.
17. Tadeusiewicz, R., Horzyk, A., Man-Machine Interaction Improvement by Means of Automatic Human Personality Identification, Springer-Verlag, LNCS 8838, 2014, pp. 278-289.
18. Horzyk, A., How Does Generalization and Creativity Come into Being in Neural Associative Systems and How Does It Form Human-Like Knowledge?, Elsevier, Neurocomputing, 2014, pp. 238-257, DOI: 10.1016/j.neucom.2014.04.046.
19. Horzyk, A., How Does Human-Like Knowledge Come into Being in Artificial Associative Systems, Proc.
of the 8-th International Conference on Knowledge, Information and Creativity Support Systems, ISBN 978-83-912831-8-9, Krakow, Poland, 2013, pp. 189-200.
20. Horzyk, A., Artificial Associative Systems and Associative Artificial Intelligence, Academic Publishing House EXIT, Warsaw, 2013, postdoctoral monograph, pp. 1-280.
21. Horzyk, A., Gadamer, M., Associative Text Representation and Correction, Springer Verlag Berlin Heidelberg, LNAI 7894, 2013, pp. 76-87.
22. Horzyk, A., Information Freedom and Associative Artificial Intelligence, Springer Verlag Berlin Heidelberg, LNAI 7267, ISBN 978-3-642-29346-7, 2012, pp. 81-89.
23. Horzyk, A., Self-Optimizing Neural Network 3, L. Franco, D. Elizondo, J.M. Jerez (eds.), Constructive Neural Networks, Springer, Series: Studies in Computational Intelligence, ISBN 978-3-642-04511-0, Vol. 258, 2009, pp. 83-101.

Additional information
None