GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Self-Learning Networks, PG_00054190		
Field of study	Informatics		
Date of commencement of studies	February 2024	Academic year of realisation of subject	2024/2025
Education level	second-cycle studies	Subject group	Optional subject group Subject group related to scientific research in the field of study
Mode of study	Full-time studies	Mode of delivery	at the university
Year of study	1	Language of instruction	Polish
Semester of study	2	ECTS credits	3.0
Learning profile	general academic profile	Assessment form	assessment
Conducting unit	Department of Multimedia Systems -> Faculty of Electronics, Telecommunications and Informatics		
Name and surname of lecturer (lecturers)	Subject supervisor	dr inż. Jerzy Dembski	
	Teachers	dr inż. Jerzy Dembski	

Lesson types and methods of instruction

Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
Number of study hours	15.0	0.0	30.0	0.0	0.0	45

E-learning hours included: 0.0

Learning activity and number of study hours

Learning activity	Participation in didactic classes included in study plan	Participation in consultation hours	Self-study	SUM
Number of study hours	45	5.0	25.0	75

Subject objectives

The aim of the course is to provide the student with knowledge of the theoretical and practical aspects of defining and designing artificial neural networks capable of self-learning to solve complex decision problems, including approximation of the utility functions of states or actions in reinforcement learning.

Learning outcomes

Course outcome	Subject outcome	Method of verification
[K7_W05] Knows and understands, to an increased extent, methods of process and function support, specific to the field of study.	The student knows the basic definitions and issues related to learning with the reinforcement and teaching of artificial neural networks.	[SW3] Assessment of knowledge contained in written work and projects [SW1] Assessment of factual knowledge
[K7_U11] can manage team work	The student is able to divide a complex task with the use of a self-learning network into subtasks and to coordinate the work of team members carrying out individual subtasks.	[SU1] Assessment of task fulfilment
[K7_U06] can analyse the operation of components, circuits and systems related to the field of study; measure their parameters; examine technical specifications; interpret obtained results and draw conclusions	The student is able to translate the knowledge acquired during the lecture and individual studies in the field into practical issues requiring the planning of experiments and the analysis of the results.	[SU3] Assessment of ability to use knowledge gained from the subject [SU1] Assessment of task fulfilment
[K7_W03] Knows and understands, to an increased extent, the construction and operating principles of components and systems related to the field of study, including theories, methods and complex relationships between them and selected specific issues - appropriate for the curriculum.	The student understands the multi-stage decision processes, the Markov decision process and issues related to the methods of learning with reinforcement with neural approximation of the utility functions of states or actions.	[SW1] Assessment of factual knowledge

Subject contents	1. Overview of the principles of conducting the lecture and laboratory. Overview of the catalog of concepts and mathematical foundations necessary to learn the issues discussed during the lecture. 2 Discuss the concept of reinforcement learning. Differences and possibilities in relation to supervised and unsupervised methods. Examples of common uses and limitations. 3 Fundamentals of Reinforcement Learning. Introduce the concepts used in reinforcement learning. An introduction to the principles of accumulating experience and knowledge in Reinforcement Learning. 4 Overview of Markov's decision-making process 5 Understanding the maximum return and expected return (value function) 6 Overview of the Bellman equation 7 Overview of Reinforcement Learning. Prediction problem vs Control problem. 8 Reinforcement learning techniques part I. Explore-Exploit dilemma. Epsilon-Greedy method. Application examples and limitations. 9 Reinforcement learning techniques part II. Monte Carlo method. Temporal-Difference methods. Q-Learning method. Application examples and limitations. 10 Definition of a practical problem to be solved with the use of reinforcement learning. 11 Selecting the optimal model of reinforcement learning for the practical problem being solved. Definition of agent, environment and episode. State and action definition. The definition of the award. 12 Selection of the optimal model of the artificial neural network for the practical problem being solved. Types of layers in neural networks. Types of neural network architectures. Activation functions. Loss functions. Input and output. (Reinforcement learning does not have a fixed training set and the typical techniques for supervised learning do not always work. During the course, it is necessary to focus on achieving the best possible learning outcomes (in this case, the level of play of the neural network), and this requires optimization and on the side of the network itself and on the side of the agent operation algorithms. Neural networks and agents would start to peak their capabilities, and students would start to wonder why. It is worth returning to the mathematics presented earlier, because students understand the implications of it.)You can shorten the lectures here and add one more lecture about the unpredictability of long episodes. On this occasion, elements of the chaos theory could be incorporated into the lecture. 13 Problems of learning artificial neural networks (re-learning, lack of progress). Principles and techniques of selecting the optimal size of the model. Principles and techniques to eliminate the problem of overfitting and improve the ability of the neural network to generalize (Regularization. Dropuot). Principles and techniques for optimizing the learning process. 14 Summary. Discussion and comparison of the results of laboratory projects. 15 Global trends and achievements (DeepMind. OpenAI). Alternative learning methods.

Prerequisites and co-requisites	- basic knowledge of linear algebra - basic knowledge of probability theory

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
	60.0%	50.0%
	60.0%	50.0%

Recommended reading

Basic literature	Richard Sutton, Andrew G. Barto, Reinforcement Learning: An Introduction, MIT Press, Cambridge, MA, 2018. http://incompleteideas.net/book/the-book-2nd.html Paweł Cichosz, Systemy uczące się, Wydawnictwa Naukowo-Techniczne, Warszawa 2000, str. 712-792. Lillicrap, T.P., Hunt, J.J., Pritzel, A., Heess, N., Erez, T., Tassa, Y., Silver, D.,Wierstra, D.: Continuous control with deep reinforcement learning. In: Bengio, Y.,LeCun, Y. (eds.) ICLR (2016)Mnih, V., Kavukcuoglu, K., Silver, D., Rusu, A.A., Veness, J., Bellemare, M.G.,Graves, A., Riedmiller, M., Fidjeland, A.K., Ostrovski, G., et al.: Human-levelcontrol through deep reinforcement learning. nature 518(7540), 529533 (2015)
Supplementary literature	Silver, David; Hubert, Thomas; Schrittwieser, Julian; Antonoglou, Ioannis; Lai, Matthew; Guez, Arthur; Lanctot, Marc; Sifre, Laurent; Kumaran, Dharshan; Graepel, Thore; Lillicrap, Timothy; Simonyan, Karen; Hassabis, Demis (December 5, 2017). "Mastering Chess and Shogi by Self-Play with a General Reinforcement Learning Algorithm". arXiv:1712.01815
eResources addresses	Adresy na platformie eNauczanie:

Example issues/ example questions/ tasks being completed

Understand the Markov decision process and the idea of the Bellman equation

Embedding an example problem in a reinforcement learning model:choosing the right definition of the state choosing the right definition of an action selecting the proper function of the reward

Designing the neural network architecture appropriate to the analyzed problem:selection of the number and type of layers selection of activation functions selection of the loss function

Drawing conclusions from the network learning process: overfitting of the network learning progress

Ability to create, learn and analyze models in the Tensorflow 2.x system

Work placement

Not applicable