UNIVERSITY OF WARSAW

UNIVERSITY'S INTEGRATED DEVELOPMENT PROGRAMME

Course syllabus

Course title	Advanced applications of neural networks (deep learning)
Instructor(s)	
Contact details	Please indicate in which way students can preferably contact you, such as e-mail or office hours (specify room number).
Affiliation	
Course format	Class
Number of hours	30 hours
Number of ECTS credits	**3 ECTS credits**
Brief course description	This class provides students hands-on experience in training modern neural networks architectures, acting as universal feature extractors (deep learning). Specialized feed-forward (convolutional network) and recurrent (long short-term memory networks) architectures are introduced. The material is organized around specific applications concerning topics important for cognitive science, for example image recognition, language modeling, modeling action and perception, cognitive robotics. Students train their own models, and experiment with already published models from various domains. The course uses Python programming language and popular neural network libraries (PyTorch, Keras, TensorFlow).
Full course description	Neural networks form a very interesting group of computational models with a rich history of applications in cognitive science. Initially they were devised as a simplified model of biological neurons, but later it was discovered that they may be used to model arbitrary dynamical processes, learn mappings between points in high-dimensional spaces and generalize that knowledge. Research in the field of neural networks was pioneered also by cognitive psychologists, who used them to model processes of attention, language acquisition, language production etc. In the last few years multi-layer neural networks gained popularity as trainable extractors of meaningful features from unstructured data. Progress in network architectures as well as in computer hardware resulted in unprecedented successes in image and audio recognition, text processing, robotic control. Techniques of transfer learning allow generalization from one domain to another. This makes neural networks not only natural candidates for conceptual models of cognitive processes, but also practical tool for analyzing experimental data.

	The course will be structured around concrete applications of neural networks relevant to cognitive science. It should provide students with intuitions regarding strengths and limitations of these models. After this class students should be able to use existing models and adapt them to their purposes.
Learning outcomes	Student knows and understands: - Python libraries for building deep neural networks (K_W04, K_W08) - strength and weaknesses of neural networks, their modern applications and different roles they perform in cognitive science (K_W01, K_W02) Student is able to: - discuss particular applications of neural networks within the domain of cognitive science (K_U01) - train new deep learning models or adapt existing ones to model particular phenomena (K_U02, K_U03, K_U04, K_U05) - track recent advances in a rapidly evolving field of deep learning (K_K01, K_K02)
Learning activities and teaching methods	The class will be conducted in a computer laboratory. It will consist of programming exercises interspersed with short lectures and demonstrations.
List of topics/classes and bibliography	Specific topics covered will depend on the interests of the instructor and the group. Some examples include: ● Object recognition in static images or videos. ● Image segmentation, generating image descriptions. ● Deep reinforcement learning. ● Generating text with recurrent networks. ● Image generation with generative adversarial networks (GANs). ● Biologically realistic spiking neural networks. ● Analyzing neuroimaging data with deep learning. Literature: ● Ian Goodfellow, Yoshua Bengio and Aaron Courville (2016). Deep Learning https://www.deeplearningbook.org/ ● Vincent François-Lavet, Peter Henderson, Riashat Islam, Marc G. Bellemare and Joelle Pineau (2018), An Introduction to Deep Reinforcement Learning https://arxiv.org/abs/1811.12560 ● Li Deng and Dong Yu (2014), Deep Learning: Methods and Applications https://www.microsoft.com/en-us/research/publication/deep-learning-methods-and-applications/ ● Nikola Kasabov (2019). Time-Space, Spiking Neural Networks and Brain-Inspired Artificial Intelligence https://link.springer.com/book/10.1007/978-3-662-57715-8

Assessment methods and criteria	**Projects (100%)** Students work in pairs and prepare one larger project during the semester. The project should concern applications of neural networks to cognitive phenomena. Topics are discussed individually with the instructor.
Attendance rules	Two unexcused absences are allowed in the semester.
Prerequisites	Good grasp of Python ("Advanced Python for cognitive scientists" course), understanding of standard machine learning techniques ("Introduction to machine learning" course).
Academic honesty	Students must respect the principles of academic integrity. Cheating and plagiarism (including copying work from other students, internet or other sources) are serious violations that are punishable and instructors are required to report all cases to the administration.
Remarks	