

## Advanced Machine Learning Technologies

<b>Course Workload</b>		<b>Assessment form (examination/ graded test/ ungraded test)</b>
<b>ECTS</b>	<b>Hours</b>	
<b>3</b>	<b>108</b>	<b>Exam, course project</b>

The course examines modern algorithms for constructing deep neural networks that allow solving applied problems related to image and video processing, natural language analysis, generation of new objects, as well as reinforcement learning methods. Lectures are accompanied by intensive laboratory exercises devoted to the practical application of the algorithms discussed in the theoretical part of the course.

### Course structure:

#### 1. Neural network architectures

- 1.1. Optimization problem statement. Gradient and non-gradient optimization methods.
- 1.2. McCulloch-Pitts model. Rosenblatt's perceptron. Neural implementation of logical functions.
- 1.3. Sequence Analysis Problems. The principle of constructing recurrent neural networks.
- 1.4. Modern convolutional networks. VGG-16 and ResNet models. Attention mechanism. Problems of convolutional networks and capsule networks.
- 1.5. Convolutional neural network architecture. The principle of “shared weights”, folding, pooling, padding.
- 1.6. Training data: train, test, sample validation. Monitoring the learning process of the network.
- 1.7. Using parallel computing in deep learning.
- 1.8. Activation functions and error functions. Error functions for classification and regression problems.
- 1.9. Recurrent neural networks. LSTM and GRU cells. Attention mechanism.
- 1.10. Gradient descent modifications: the method of moments, the RMSProp algorithm and the Adam algorithm.
- 1.11. Neural network training as an optimization problem. Stochastic gradient descent with moments, RMSProp and Adam algorithms.
- 1.12. Parallel optimization of neural network hyperparameters.
- 1.13. Gradient descent and its types. Stochastic gradient descent and mini-batch method.

- 1.14. Multilayer neural network. Backpropagation method. The problem of damped and exponentially growing gradients.
- 1.15. Convolutional neural network architecture. The principle of “shared weights”, folding, pooling, padding.
- 1.16. Methods for initializing neural network weights.

## 2. Applied problems of modern machine learning

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- 2.1. Autoencoder architecture. Encoder and decoder.
- 2.2. Algorithms and architectures of neural networks for 3D detection of objects in the image.
- 2.3. Autoencoders and code space. Generation of new objects. Variational autoencoders.
- 2.4. Application of the attention mechanism in neural networks. "Multi-head attention".
- 2.5. Gradients by strategies and the REINFORCE algorithm.
- 2.6. Applied thematic modeling. Assessment of the quality of highlighting topics in the corpus of documents.
- 2.7. Conditional GAN architecture. Adding a condition to the input of the model.
- 2.8. Transformers architecture ("Attention is all you need").
- 2.9. Capsule neural networks and inverse graphics.
- 2.10. Application of deep learning methods in the task of developing unmanned vehicles.
- 2.11. Topic modeling methods. LDA method. Visualization of the results of thematic modeling.
- 2.12. GANs architectures for generating 3D objects.
- 2.13. Natural language processing tasks. A bag of words approach. TF-IDF method. Stemming. Lemmatization. Stop words.
- 2.14. Reinforcement learning and the Q-learning algorithm.
- 2.15. Reinforcement learning problem. Markov decision making process.
- 2.16. Vector word representation and embeddings. The word2vec model.
- 2.17. Generative adversarial networks. GAN learning algorithm.
- 2.18. Style transfer. "Style error" and "content error".