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# Master's programme

DS412 - Deep Learning in Applications
Syllabus, Radoslav Neychev, Anastasia Ianina

## 1| Dates of module

June 8, 2020 - June 26, 2020

## 2| Abstract

State of the art approaches in different domains of Artificial Intelligence are based on Deep Learning techniques (e.g. in Computer Vision, Natural Language Processing, Reinforcement Learning, etc.) Deep neural architectures show great potential and promise even better results, so now is definitely the time to explore this field.

In this course we will start from the basics and rapidly dive into the latest results in Deep Learning, focusing on the NLP and RL domains. This course focuses both on practical skills and theoretical background to provide the students thorough theoretical knowledge and ability to work on their own in the Deep Learning area.

This course accompanies the Machine Learning course (Module 7).

Programming assignments will be implemented in Python 3. PyTorch framework will be used for Deep Learning practice.

## 3| Objectives & Learning Goals

As a result of the course, the students will:

- Learn to apply Deep Learning techniques in practice
- Get familiar with both fundamental and most recent approaches in Natural Language Processing and Reinforcement Learning
- Get ready to face the real world problems and to apply the Deep Learning techniques to them
- Gain essential experience with PyTorch framework

## 4| Methodology

The course will be organised in three-hour sessions and self-study practical assignments. Sessions will contain both theoretical and practical parts with different ratio depending on the materials.

## 5| Evaluation and grading

Evaluation will be based on

(60%) Homework Assignments
(15%) Midterm Test
(25%) Final Exam

## 6| Outline

### Session 1

**Natural Language Processing intro**
Main problems in NLP. Text classification and generation. Deep Learning techniques in NLP. Regularization in DL recap. Word Embeddings recap.

### Session 2

**Convolutional Neural Networks in text classification.**
CNN approach to context analysis. Similarities and differences from RNN.

### Session 3

**Neural Machine Translation**
Machine Translation and Neural Machine Translation. Encoder-Decoder architecture, sequential modeling.

### Session 4

**Attention in Encoder-Decoder architecture**
Encoder-Decoder architecture bottleneck. Attention mechanism. Attention outside NLP.

### Session 5

**Transformers in NLP**
Self-attention technique. Transformer architecture overview.

### Session 6

**Contextual Embeddings**
Transformer-based contextual embeddings. ELMo, BERT, GPT-2, XLM overview.

### Session 7

**Question Answering**
Q&A systems. Bi-directional attention flow (BiDAF)

### Session 8

**Midterm test**
NLP open problems. Discussion, section outro.

### Session 9

**Introduction to Reinforcement Learning**
Reinforcement Learning problem statement. Stochastic and black box optimization.

### Session 10

**Value based methods in RL**
Discounted reward in RL. Value iteration. Policy iteration.

### Session 11

**Model free learning. Q-learning, SARSA**
On policy and off policy algorithms. N-step

### Session 12

**Approximate Q-learning**
Value function approximation using complex

algorithms.

functions and neural networks. DQN. Experience replay.

| Session 13 | Session 14 |
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| **Policy gradient methods**<br>Policy gradient. REINFORCE algorithm. Advanced actor critic. | **RL outside games**<br>Policy gradient as optimization approach in different areas. Policy gradient for sequence modeling. |

| Session 15 |
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| **Midterm test**<br>RL open problems, discussion. Course outro. |

## 7| Bibliography


1. I. Goodfellow, Y. Bengio, A. Courville. Deep Learning. MIT Press, 2016.
2. Richard S. Sutton and Andrew G. Barto. Reinforcement Learning
3. L. Deng, D. Yu. Deep Learning: Methods and Applications. Foundations and Trends in Signal Processing, vol. 7 (3-4), 2014.


## 8| Prerequisites

1. Machine Learning course (Module 7) or equivalent, e.g. Introduction to Deep Learning and Computer vision course
2. Python programming experience, PyTorch basics.
3. At least basic knowledge of Linear Algebra, Probability Theory, Optimisation

## APPENDIX| Mini CV

**Radoslav Neychev**
Assistant Professor, Moscow Institute of Physics and Technology
ex. Senior Quantitative Analysis Officer at Raiffeisen Bank Russia,
ex. Research Engineer at Yandex-CERN group
Machine Learning Instructor, BigData Team

Radoslav Neychev is a data scientist with focus on Deep Learning and Reinforcement Learning techniques. He has worked on a variety of research (CERN LHCb, MIPT Machine Intelligence Lab, CC RAS) and industrial

projects (Yandex, RaiffeisenBank) in different domains vary from particle identification problem to fraudulent transactions detection.

Radoslav graduated from Moscow Institute of Physics and Technology, majoring in Applied Mathematics and Machine Learning. Radoslav is reading lectures and organising practical classes at Russian top-tier universities, tech companies and summer schools.

*Faculty webpage: [http://harbour.space/Faculty/Data-Science/Radoslav-Neychev](http://harbour.space/Faculty/Data-Science/Radoslav-Neychev)*

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**Anastasia Ianina**
Research Scientist, Samsung AI Center
Lecturer at Moscow Institute of Physics and Technology
Research Engineer, Gigster

Anastasia Ianina graduated from Moscow Institute of Physics and Technology with a major in Computer Science. She received thorough knowledge of math and machine learning, and gained a significant amount of hands-on experience: interning at Lyft and working on self-driving cars, holding a Data Scientist position at Yandex, working as a researcher at the MIPT machine intelligence lab, and writing papers to top-level international conferences.

Anastasia's research interests include Machine Learning, Natural Language Processing, Text Analytics and Deep Learning. Mainly, she is focusing on Natural Language Understanding and topic-based text representations.

Anastasia currently teaches students from MIPT Machine Learning and Natural Language Processing. Moreover, she takes part in creating online educational courses: she authored the course "Dynamic Neural Network Programming with PyTorch" for Packt Publishing, co-authored online-course "Neural Networks and Natural Language Processing" and worked on Coursera NLP specialisation.

*Faculty webpage: [http://harbour.space/Faculty/Data-Science/Anastasia-Ianina](http://harbour.space/Faculty/Data-Science/Anastasia-Ianina)*