Deep Learning

BASIC INFORMATION ABOUT THE COURSE

Title	**Deep Learning**
Department	**Department of Big Data and Information Retrieval**
Educational Programme	**–**
Implementation period	**3 module 2023/2024 - 4 module 2023/2024**
Language	**English**
Audience coverage	**Home campus students**
Scope course	**4 credits., 152 h. (56 h. contact work, of which: 28 h. lectures, 28 h. seminars, 96 h. independent work)**
Online course	**–**
Tech syllabus	**Lectures: offline classes, seminars: offline classes**
Developers	**Галевская Софья Андреевна, Кононова Елизавета Дмитриевна**
Approval	**Educational Programme: Data Science and Business Analytics, Protocol number: № 2.3-09/290823-16, Meeting date: 2023-08-29**

ABSTRACT

The course is dedicated to studying deep learning, which is the most rapidly developing field of machine learning. The course attendees will learn what konds of machine learning tasks can be solved using neural networks and what types of neural networks are currently in use. The course has a clear practical focus, students will have to train neural networks on the various frameworks

to images and texts.

STUDY OBJECTIVES

The course aims to help students develop an understanding of the principles, algorithms, and applications of deep learning.

The course aims to equip students with the necessary skills and knowledge to apply deep learning techniques to solve real-world problems.

The course focuses on developing a theoretical foundation in deep learning, as well as practical experience in implementing and experimenting with deep learning models.

The course aims to expose students to the latest advances and research in deep learning, and encourage critical thinking and problem-solving skills in the context of deep learning.

The aim of the course is to prepare students for any careers where deep learning techniques are increasingly being used.

EXPECTED LEARNING OUTCOMES

Student are aware of basic concepts and can use Python for NLP deep lerning: recurrent neural networks, convolutional networks, pooling, attention mechanism, transformer.

Knows basic types tasks solved with using deep learning. Is developing architecture, implements, trains and produces optimization neural parameters networks. Solves applied tasks from various areas with using deep learning.

Students are aware of basic concepts of deep learning: tensor, model weighs, layers, various activation functions, loss function and metrics, optimization methods, softmax and crossentropy, dropout, batches, stochastic gradient decent, epoch, batch normalization.

Learn the operation and training of neural networks, and their relation to deep learning

Having completed the topic, students should be able to understand the basic concepts of Bayesian inference

Understand the key computations underlying deep learning, use them to build and train deep neural networks, and apply it to computer vision.

Having completed the topic, students should be able to identify its differences from Frequentist Inference in point and interval estimation, hypothesis testing and prediction.

Can create and use convolutional neural networks

SECTIONS

Bayesian Inference

Lecture 1 h
Seminar 1 h
Self 6 h

Elements of Bayesian inference, prior and posterior distribution.

Artificial Neural Networks (ANN)

Lecture 1 h
Seminar 1 h
Self 6 h

Linear Neural Networks for Regression

Lecture 1 h
Seminar 1 h
Self 6 h

Introduction to neural networks, linear regression as a neural network, architecture of neural networks, activation functions, deep neural networks, fitting neural networks, stochastic gradient descent algorithm, backpropagation.

Linear Neural Networks for Classification

Lecture 1 h
Seminar 1 h
Self 6 h

Introduction to neural networks, softmax regression, loss functions.

Multilayer Perceptrons

Lecture 1 h
Seminar 1 h
Self 6 h

Introduction to deep learning, hidden layers, activation functions, computational graphs, generalization in deep learning, regularization.

Convolutional Neural Networks

Lecture 1 h
Seminar 1 h
Self 6 h

Convolutions for signals and images, convolutional layers, learning a kernel, padding and stride, multiple input and output channels, pooling.

Modern Convolutional Neural Networks

Lecture 1 h
Seminar 1 h
Self 6 h

Batch normalization, large-scale convolutional neural networks, designing convolution network architectures.

Recurrent Neural Networks

Lecture 1 h
Seminar 1 h
Self 6 h

Working with sequences, autoregressive models, converting raw text into sequence data. Neural networks with and without hidden states.

Modern Recurrent Neural Networks

Lecture 1 h
Seminar 1 h
Self 6 h

Long Short-Term Memory (LSTM), Gated Recurrent Units (GRU), Deep Recurrent Neural Networks, The Encoder–Decoder Architecture.

Attention Mechanisms and Transformers

Lecture 1 h

Attention pooling by similarity, the transformer architecture.

Optimization Algorithms

Lecture 1 h
Seminar 1 h
Self 6 h

Goal of optimization, convexity, gradient descent, stochastic gradient descent, minibatch stochastic gradient descent, momentum, learning rate scheduling.

Computer Vision

Lecture 1 h
Seminar 1 h
Self 6 h

Image augmentation, object detection and bounding boxes, multiscale object detection.

Natural Language Processing

Lecture 1 h
Seminar 1 h
Self 6 h

Word embedding (word2vec), word embedding with global vectors (GloVe), Bidirectional Encoder Representations from Transformers (BERT).

Reinforcement Learning

Lecture 1 h
Seminar 1 h
Self 6 h

Markov Decision Process (MDP), value iteration, the Q-learning algorithm.

Generative Adversarial Networks

Lecture 14 h
Seminar 14 h
Self 12 h

Introduction to Generative Adversarial Networks and Deep Convolutional Generative Adversarial Networks.

GRADING SYSTEM

Interim assessment (2023/2024 4th module)

Estimation formula: Home assignments: Homework * 0.3 + Quizzes: Test * 0.2 +

Rounding rules. We use natural grade aggregation in LMS. Usual rounding is used to report 0-10 scale grades to HSE. There are no blocking grading components.

Retake principles: On the first and second retake the cumulative course grade is taken into consideration. In case of receiving an unsatisfactory final grade after the first retake, the student may refuse to participate in the second retake and repeat the course according to the individual curricula. Cumulative grade is formed again as a result of repeated course. After the completion of the repeated course, the student is given a second retake only, from which the student has previously refused.

Midterm Test: Test 0.2

Period: 3rd module 2023/2024, Study period, Online, Without proctoring
Grade: 3rd module 2023/2024
Description: These are individualized, timed, (possibly) proctored and otherwise constrained tests to prevent cheating. In general, expect 60 questions in 60 minutes, some of which you may will have seen in quizzes. The assessment of the test is based on the marking scheme that comes with the exam assignment. Each problem and their sub parts are worth a certain number of points, the sum of these points is equal to 100, which is the maximum grade for the exam on the 100 point scale. The student is awarded the assigned number of points for the correct answer to each part of the question and partial credit may also be awarded.

Criteria for evaluation:
The grade for the exam is equal to the sum of the grades for the problems included in the exam. The number of points awarded for each individual problem is stated in the text of the exam.
If plagiarism is detected, the assessment element will be assigned a score of "0".
If the student is suspected of preparing the task not on his own, the teacher has the right to initiate additional verification or defense of this particular assessment element. Then such an assessment element will be graded based on the additional verification or the defense.

Checks learning outcomes:

Knows basic types tasks solved with using deep learning. Is developing architecture, implements, trains and produces optimization neural parameters networks. Solves applied tasks from various areas with using deep learning.

Understand the key computations underlying deep learning, use them to build and train deep neural networks, and apply it to computer vision.

Student are aware of basic concepts and can use Python for NLP deep lerning: recurrent neural networks, convolutional networks, pooling, attention

Students are aware of basic concepts of deep learning: tensor, model weighs, layers, various activation functions, loss function and metrics, optimization methods, softmax and crossentropy, dropout, batches, stochastic gradient decent, epoch, batch normalization.

Home assignments: Homework 0.3

Amount of controls: 10
Period: 3rd module 2023/2024, 4th module 2023/2024, Study period, Online, Without proctoring
Grade: 4th module 2023/2024
Description: Home assignments. The grade for the current category is calculated as cumulative from the beginning of the course.

Criteria for evaluation:
Homeworks are theoretical and practical. Please note that the weight of each individual homework assignment may vary from semester to semester.
If plagiarism is detected, the assessment element will be assigned a score of "0".
If the student is suspected of preparing the task not on his own, the teacher has the right to initiate additional verification or defense of this particular assessment element. Then such an assessment element will be graded based on the additional verification or the defense.

Checks learning outcomes:
Understand the key computations underlying deep learning, use them to build and train deep neural networks, and apply it to computer vision.

Student are aware of basic concepts and can use Python for NLP deep lerning: recurrent neural networks, convolutional networks, pooling, attention mechanism, transformer.

Learn the operation and training of neural networks, and their relation to deep learning

Quizzes: Test 0.2

Amount of controls: 10
Period: 3rd module 2023/2024, 4th module 2023/2024, Study period, Online, Without proctoring
Grade: 4th module 2023/2024
Description: The grade for the current category is calculated as cumulative from the beginning of the course.

Quizzes are autograded. Please note that the weight of each individual quiz may vary from semester to semester.

If plagiarism is detected, the assessment element will be assigned a score of "0".

If the student is suspected of preparing the task not on his own, the teacher has the right to initiate additional verification or defense of this particular assessment element. Then such an assessment element will be graded based on the additional verification or the defense.

Checks learning outcomes:

Students are aware of basic concepts of deep learning: tensor, model weighs, layers, various activation functions, loss function and metrics, optimization methods, softmax and crossentropy, dropout, batches, stochastic gradient decent, epoch, batch normalization.

Learn the operation and training of neural networks, and their relation to deep learning

Participation 0.1

Amount of controls: 14
Period: 3rd module 2023/2024, 4th module 2023/2024, Study period, Offline
Grade: 4th module 2023/2024
Description: The grade for the current category is calculated as cumulative from the beginning of the course.

Criteria for evaluation:
Participation is graded by lecturers, seminar assistants and head teaching assistant. Please note that the weight of each participation element may vary from semester to semester.

Checks learning outcomes:

Students are aware of basic concepts of deep learning: tensor, model weighs, layers, various activation functions, loss function and metrics, optimization methods, softmax and crossentropy, dropout, batches, stochastic gradient decent, epoch, batch normalization.

Learn the operation and training of neural networks, and their relation to deep learning

Exam: Test 0.2

Period: 4th module 2023/2024, Session, Online, Without proctoring

Is exam

Description: These are individualized, timed, (possibly) proctored and otherwise constrained tests to prevent cheating. In general, expect 60 questions in 60 minutes, some of which you may will have seen in quizzes. The assessment of the exam is based on the marking scheme that comes with the exam assignment. Each problem and their sub parts are worth a certain number of points, the sum of these points is equal to 100, which is the maximum grade for the exam on the 100 point scale. The student is awarded the assigned number of points for the correct answer to each part of the question and partial credit may also be awarded.

Retake an exam: Possible
Retake principles:
Students who fail an exam will be allowed to retake it. Retakes are organized in accordance with the HSE Interim and Ongoing Assessment Regulations. The first retake is conducted in the same format as an exam. The second retake is conducted in oral form with the committee and covers all the topics studied during the course. On the second retake the cumulative course grade is not taken into account.

Criteria for evaluation:
Multiple choice exam is autograded using Moodle LMS.
If plagiarism is detected, the assessment element will be assigned a score of "0".
If the student is suspected of preparing the task not on his own, the teacher has the right to initiate additional verification or defense of this particular assessment element. Then such an assessment element will be graded based on the additional verification or the defense.

Checks learning outcomes:

Knows basic types tasks solved with using deep learning. Is developing architecture, implements, trains and produces optimization neural parameters networks. Solves applied tasks from various areas with using deep learning.

Understand the key computations underlying deep learning, use them to build and train deep neural networks, and apply it to computer vision.

Student are aware of basic concepts and can use Python for NLP deep lerning: recurrent neural networks, convolutional networks, pooling, attention mechanism, transformer.

Students are aware of basic concepts of deep learning: tensor, model weighs, layers, various activation functions, loss function and metrics, optimization methods, softmax and crossentropy, dropout, batches, stochastic gradient decent, epoch, batch normalization.

Having completed the topic, students should be able to understand the basic concepts of Bayesian inference.

Having completed the topic, students should be able to identify its differences from Frequentist Inference in point and interval estimation, hypothesis testing and prediction.

Final grade

Estimation formula: The final grade is calculated according to the interim assessment formula 4th module 2023/2024

BIBLIOGRAPHY

Basis bibliography

📄 Ian Goodfellow, Yoshua Bengio, & Aaron Courville. (2016). Deep Learning. The MIT Press. http://search.ebscohost.com/login.aspx?direct=true&site=eds-live&db=edsebk&AN=2565107

Additional bibliography

📄 James, G. et al. An introduction to statistical learning. – Springer, 2013. – 426 pp https://link.springer.com/book/10.1007%2F978-1-4614-7138-7

MATERIALS

Section is empty

SOFTWARE

Яндекс.Документы

Офисное ПО, Офисное, -

PROFESSIONAL DATABASES, INFORMATION REFERENCE SYSTEMS, INTERNET RESOURCES

https://edu.hse.ru/

LOGISTICS

Classroom type

Lecture Rooms

Classrooms

Classroom equipment

Personal computer

Demonstration equipment - Может включать в себя: мультимедийный проектор, проекционный экран, интерактивная доска, видео панель, интерактивная видео панель, презентационный ноутбук и другие средства демонстрации учебного контента. Допускается использование для проведения занятий переносного набора демонстрационного оборудования.

Board

Screen

Specialized furniture - Доска, столы или парты, стулья.

Wireless Internet access (Wi-Fi)

FEATURES OF THE ORGANIZATION OF THE COURSE

In case of necessity, for students with disabilities (by personal application) could be suggested the following variants of perception the educational information with considering the individual psychophysiological opportunities, including the methods of online-education and distant technologies:

for visually impaired: in printed format with larger font; in the form of digital document; in audio file (converting educational materials into audio file); in printed in braille; individual consultations with help of tiflosound translator; individual tasks and consultations.

for hearing impaired: in printed format, in the form of digital document, video

for persons with disorders of the musculoskeletal system: in printed format, in the form of digital document; in audio file; individual tasks and consultations.