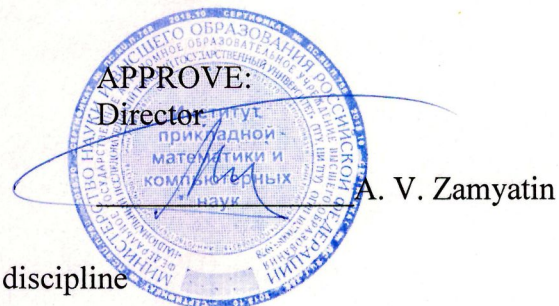


Ministry of Science and Higher Education of the Russian Federation  
NATIONAL RESEARCH  
TOMSK STATE UNIVERSITY (NR TSU)

Institute of Applied Mathematics and Computer Science



Work program of the discipline

**Deep Learning - I**

in the major of training

**01.04.02 Applied mathematics and informatics**

Orientation (profile) of training:

**Big Data and Data Science**

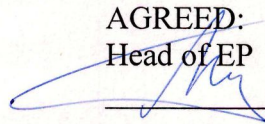
Form of study  
**full-time**

Qualification  
**Master**

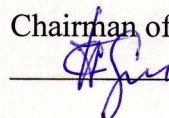
Year of admission  
**2023**

Code of discipline in the curriculum: B1.O.08

AGREED:  
Head of EP

 A.V. Zamyatin

Chairman of the EMC

 S.P. Sushchenko

Tomsk – 2023

## **1. Purpose and planned results of mastering the discipline**

The purpose of mastering the discipline is the formation of the following competencies:

- UK-1 - the ability to carry out a critical analysis of problem situations based on a systematic approach, to develop an action strategy;
- GPC-3 - the ability to develop mathematical models and analyze them when solving problems in the field of professional activity;
- PC-6 - the ability to manage the receipt, storage, transmission, processing of big data.

The results of mastering the discipline are the following indicators of the achievement of competencies:

IUK-1.1 Identifies a problem situation, on the basis of a systematic approach, carries out its multifactorial analysis and diagnostics.

IUK-1.2 Carries out the search, selection and systematization of information to determine alternative options for strategic solutions in a problem situation.

IUK-1.3 Suggests and justifies the strategy of action, taking into account the limitations, risks and possible consequences.

IOPC-3.3 Develops and analyzes new mathematical models for solving applied problems of professional activity in the field of applied mathematics and informatics.

IPK-6.1 Monitors and evaluates the performance of big data processing.

IPK-6.2 Uses methods and tools for receiving, storing, transmitting, processing big data.

IPK-6.3 Develops proposals to improve the performance of big data processing..

## **2. Tasks of mastering the discipline**

To train students to carry out work on the study of big data using deep learning technologies and develop intelligent systems using the tools of Python, R libraries, public cloud services, evaluate the effectiveness of their work and implement them in applications:

- to train students to identify, form and agree on the requirements for the results of analytical work using deep learning technologies;
- to teach students the principles of planning and organizing analytical work using deep learning technologies;
- to train students to prepare data for analytical work on the study of big data using deep learning methods;
- train students to conduct analytical research and develop applications using deep learning technologies in accordance with customer requirements.

## **3. The place of discipline in the structure of the educational program**

Discipline belongs to the mandatory part of the educational program.

## **4. Semester of mastering and form of intermediate certification in the discipline**

Second semester, exam.

## **5. Entrance requirements for mastering the discipline**

For the successful mastering of the discipline, training outcomes are required in the following disciplines: "Mathematics & Statistics for Data Science", "Introduction to Data Science & Data Mining".

## **6. Implementation language**

English.

## **7. Scope of discipline**

The total labor intensity of the discipline is 5 credits, 180 hours, of which:

- lectures: 20 hours
- laboratory: 40 hours
- including practical training: 0 h.

The volume of independent work of the student is determined by the curriculum.

## **8. The content of the discipline, structured by topics**

### **Section 1.** Fundamentals and architectures of deep neural networks

Deep Neural Network Architectures

### **Section 2.** Develop applications that use deep learning

Designing and Deploying Applications Using Deep Neural Networks

### **Section 3.** Practical aspects of training deep neural networks

Methods for improving the efficiency of development and training of deep neural networks

### **Section 4.** Practical Aspects of Sequence Modeling

Deep neural networks for the study of time sequences

### **Section 5.** Practical aspects of using deep neural networks in computer vision

Convolutional Neural Networks and Autoencoders for Solving Computer Vision Problems

### **Section 6.** Practical Aspects of Using Deep Neural Networks in Natural Language

Understanding Problems

Using Deep Neural Networks in Natural Language Understanding Problems

### **Section 7.** Deep Generative Models

Generative Adversarial Neural Networks

### **Section 8.** Deep Learning Research

Adaptation of neural network models. Reinforcement training.

## **9. Ongoing evaluation**

Current control is carried out by checking laboratory work in the form of a discussion of the performance of the implemented artificial intelligence systems and the results of their work.

To strengthen the studied material, it is planned to carry out an individual project within hours of independent work. The project can be completed both individually and in a mini-group (2-3 people), provided that the amount of work will also be increased. At the end of the semester, a mini-presentation on the results of the work is presented for each project. The theme of the individual project is related to the theme of the master's degree student. The purpose of the work is the use of deep learning methods in their scientific work.

## **10. The procedure for conducting and criteria for evaluating the intermediate certification**

The exam in the second semester is held in writing by tickets. The student is allowed to take the exam if he has passed all the laboratory work. The examination paper consists of two parts. The duration of the exam is 1.5 hours.

The first part is a question on the lecture course of sections 1-8, checking IUK-1.1, IUK-1.2, IUK-1.3. The answer to the question of the first part is given in the form of a written answer with a detailed presentation of the material.

The second part contains one task that checks IPC-5.1, IPC-5.2 and IPC-5.3. The answer to the question of the second part involves the software implementation of the proposed problem with the theoretical justification of the solution and the interpretation of the results.

An approximate list of theoretical questions:

1. Which of the following neural network models is best suited for predicting time sequences?

a) Single-Layer Perceptron	b) CNN
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c) LSTM	d) Multi-layer Perceptron
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2. What is the name of several examples from the training set that are used to simultaneously calculate the gradient and weights of the network?
3. Why do models based on convolutional neural networks show the best performance in classifying objects in images compared to other models?

a) They are highly optimized for handling vectors with numeric rather than categorical features.	b) They have a wide range of feature space transformation tools that can be varied by the developer in the model.
c) They take into account the correlation of adjacent components of the vector	d) They use a significantly larger number of adjustable parameters compared to other models

The results of the exam are determined by the marks "excellent", "good", "satisfactory", "unsatisfactory". The final grade is set as the arithmetic mean based on the results of control and laboratory work and the examination grade, rounded to the nearest integer.

### 11. Educational and methodological support

a) Electronic training course on the discipline at the electronic university "Moodle"

Lecture course and practical tasks SQUOT AI 1: Basic concepts of modern artificial intelligence [Electronic resource] / Electronic University - MOODLE. - TSU 2020. - URL: <https://moodle.ido.tsu.ru/course/view.php?id=1168> (date of access: 10/15/2020).

Lecture course and practical tasks SQUOT AI 2: Modern tools to support the development of artificial intelligence systems [Electronic resource] / Electronic University - MOODLE. - TSU 2020. - URL: <https://moodle.ido.tsu.ru/course/view.php?id=1169> (date of access: 10/15/2020).

Lecture course and practical tasks SQUOT AI 3: Development of artificial intelligence applications [Electronic resource] / Electronic University - MOODLE. - TSU 2020. - URL: <https://moodle.ido.tsu.ru/course/view.php?id=11701168> (date of access: 10/15/2020).

Lecture course and practical tasks SQUAT AI 4: Artificial intelligence in cybersecurity problems [Electronic resource] / Electronic University - MOODLE. - TSU 2020. - URL: <https://moodle.ido.tsu.ru/course/view.php?id=1171> (date of access: 10/15/2020).

Lecture course and practical tasks SQUOT AI 5: Knowledge acquisition in artificial intelligence systems [Electronic resource] / Electronic University - MOODLE. - TSU 2020. - URL: <https://moodle.ido.tsu.ru/course/view.php?id=1172> (date of access: 10/15/2020).

b) Assessment materials of the ongoing evaluation and intermediate certification in the discipline.

### 12. List of educational literature and Internet resources

a) basic literature:

– Joel Grace. Data Science: Data science from scratch. 2nd edition. ISBN 978-5-9775-6731-2. – St. Petersburg: BHV-Petersburg. 2021.

– Sebastian Raska, Vahid Mirjalili Python and machine learning. ISBN 978-5-907203-57-0. – M.: Dialectics. 2020.

– Ameet V. Joshi Machine Learning and Artificial Intelligence. ISBN 978-3-030-26621-9. – Springer Nature Switzerland AG. 2020

– Denis Rothman Artificial Intelligence by Example. Second Edition. ISBN 978-1-83921-153-9. – Packt Publishing. 2020

– Stuart Russel, Peter Norvig Artificial Intelligence. A Modern Approach. 4th Edition. ISBN: 978-0-13-461099-3. – Hoboken: Pearson. 2021

– Andrew Glassner Deep learning without math. Volume 1. Basics. ISBN 978-5-97060-701-5. – Moscow: DMK Press. 2020

- Andrew Glassner Deep learning without math. Volume 2. Practice ISBN 978-5-97060-767-1. – M.: DMK Press. 2020
- Ian Goodfellow, Joshua Bengio, Aaron Courville Deep Learning. Second color edition, revised. ISBN 978-5-97060-618-6. – Moscow: DMK Press. 2018
- Roman Shirkin Artificial Intelligence. The Complete Beginners' Guide to Artificial Intelligence. ISBN: 9798609154415. – Amazon KDP Printing and Publishing. 2020
- François Chollet Deep Learning with Python. ISBN 978-5-4461-0770-4. – St. Petersburg: St. Petersburg. 2018

### **13. List of information technologies**

a) licensed and freely distributed software:

- Google Colab cloud service, Anaconda package (Python, R), Tensorflow deep learning libraries, Keras, Pytorch, OpenAI services.

### **14. Logistics**

When mastering the discipline, computer classes of the IPMKN TSU are used with access to the resources of the Scientific Library of TSU, including domestic and foreign periodicals and the Internet.

### **15. Authors information**

Aksyonov Sergey Vladimirovich – Ph.D. tech. Sciences, Associate Professor, Department of Theoretical Foundations of Informatics, TSU.