

**Federal State Autonomous Educational Institution of Higher Education "Moscow
Institute of Physics and Technology
(National Research University)"**

APPROVED

**Head of the Phystech School of
Applied Mathematics and
Informatics**

A.M. Raygorodskiy

Work program of the course (training module)

course:	Support and Implementation of Machine learning Solutions/Поддержка и внедрение решений на основе машинного обучения
major:	Applied Mathematics and Informatics
specialization:	Modern State of Artificial Intelligence/Современные методы искусственного интеллекта “Pusk” Online and Supplementary Education Centre Chair of Machine Learning and Digital Humanities
term:	2
qualification:	Master

Semester, form of interim assessment: 3 (fall) - Grading test

Academic hours: 60 AH in total, including:

lectures: 15 AH.

seminars: 45 AH.

laboratory practical: 0 AH.

Independent work: 75 AH.

In total: 135 AH, credits in total: 3

Author of the program: R.G. Neychev, senior professor

The program was discussed at the Chair of Machine Learning and Digital Humanities 06.03.2024

Annotation

Modern artificial intelligence methods require significant amounts of data and computing resources. This course examines methods of storing, processing and using large amounts of data in training, as well as techniques for serialization and model delivery in applied tasks. This course complements Machine Learning and Software Development courses.

1. Study objective

Purpose of the course

- learn how to solve machine learning problems using modern methods of conducting experiments and serialization of models.

Tasks of the course

- explore ways to speed up computing when using a distributed infrastructure;
- explore approaches to the distributed use of data by multiple instances.

2. List of the planned results of the course (training module), correlated with the planned results of the mastering the educational program

Mastering the discipline is aimed at the formation of the following competencies:

Code and the name of the competence	Competency indicators
Gen.Pro.C-1 Address current challenges in fundamental and applied mathematics	Gen.Pro.C-1.3 Understand interdisciplinary relations in applied mathematics and computer science and apply them in professional tasks
Gen.Pro.C-2 Improve upon and implement new mathematical methods in applied problem solving	Gen.Pro.C-2.1 Assess the current state of mathematical research within professional settings
	Gen.Pro.C-2.2 Assess the relevance and practical importance of applied mathematical research in professional settings
	Gen.Pro.C-2.3 Understand professional terminology used in modern scientific and technical literature and present scientific results in oral and written form
Pro.C-1 Become part of a professional community and conduct local research under scientific guidance using methods specific to a particular professional setting	Pro.C-1.1 Apply principles of scientific work, methods of data collection and analysis, ways of argumentation; prepare scientific reviews, publications, abstracts, and bibliographies on research topics in Russian and English
	Pro.C-1.2 Understand the verification process of software models used to solve related scientific problems

3. List of the planned results of the course (training module)

As a result of studying the course the student should:

know:

- the main ways of parallelization of calculations;
- basic distributed data storage systems;
- basic techniques for serialization of models.

be able to:

- configure the process of parallel data processing using a distributed infrastructure;
- evaluate the level of reproducibility of experiments;
- to carry out experimental verification of hypotheses.

master:

- basic skills of working with distributed machine learning systems.

4. Content of the course (training module), structured by topics (sections), indicating the number of allocated academic hours and types of training sessions

4.1. The sections of the course (training module) and the complexity of the types of training sessions

№	Topic (section) of the course	Types of training sessions, including independent work			
		Lectures	Seminars	Laboratory practical	Independent work
1	Methods for accelerating calculations	5	15		25
2	Methods of parallel processing of large amounts of data	5	15		25
3	Methods for serializing machine learning models and conducting experiments	5	15		25
AH in total		15	45		75
Exam preparation		0 AH.			
Total complexity		135 AH., credits in total 3			

4.2. Content of the course (training module), structured by topics (sections)

Semester: 3 (Fall)

1. Methods for accelerating calculations

Streams. Multithreading.
Methods of finding consensus. Consensus Algorithms
Using distributed computing

2. Methods of parallel processing of large amounts of data

Using SQL with large amounts of data
Hive
Spark
NoSQL
Hadoop and MapReduce

3. Methods for serializing machine learning models and conducting experiments

CI/CD approaches
Distributed learning of deep learning models
Model serialization techniques
ONNX
TensorRT
Methods of conducting reproducible experiments

5. Description of the material and technical facilities that are necessary for the implementation of the educational process of the course (training module)

A classroom equipped with a computer and multimedia equipment (projector, sound system).

6. List of the main and additional literature, that is necessary for the course (training module) mastering

Main literature

Литература кафедры:

1. Tom White. Hadoop: The Definitive Guide: Storage and Analysis at Internet Scale 4th Edition. O'Reilly Media; 2015
2. Vijay K. Garg. Elements of Distributed Computing. Wiley-IEEE Press, 2012

Additional literature

Литература кафедры:

1. Maarten van Steen, Andrew S. Tanenbaum. Distributed Systems. CreateSpace Independent Publishing Platform, 2017

7. List of web resources that are necessary for the course (training module) mastering

<http://dm.fizteh.ru/>

8. List of information technologies used for implementation of the educational process, including a list of software and information reference systems (if necessary)

Multimedia technologies are used in lecture classes, including presentation demonstrations.

In the process of independent work of students, it is assumed to use such software tools as git, CLI (command-line interface), Jupyter Notebook, etc.

9. Guidelines for students to master the course

Successful completion of the course requires intense independent work of the student. The course program provides the minimum required time for a student to work on a topic. Independent work includes:

- study of educational material (based on lecture notes, educational and scientific literature);
- preparation for practical classes, home theoretical and practical tasks.

Assessment funds for course (training module)

major: Applied Mathematics and Informatics
specialization: Modern State of Artificial Intelligence/Современные методы искусственного интеллекта
“Pusk” Online and Supplementary Education Centre
Chair of Machine Learning and Digital Humanities
term: 2
qualification: Master

Semester, form of interim assessment: 3 (fall) - Grading test

Author: R.G. Neychev, senior professor

1. Competencies formed during the process of studying the course

Code and the name of the competence	Competency indicators
Gen.Pro.C-1 Address current challenges in fundamental and applied mathematics	Gen.Pro.C-1.3 Understand interdisciplinary relations in applied mathematics and computer science and apply them in professional tasks
Gen.Pro.C-2 Improve upon and implement new mathematical methods in applied problem solving	Gen.Pro.C-2.1 Assess the current state of mathematical research within professional settings
	Gen.Pro.C-2.2 Assess the relevance and practical importance of applied mathematical research in professional settings
	Gen.Pro.C-2.3 Understand professional terminology used in modern scientific and technical literature and present scientific results in oral and written form
Pro.C-1 Become part of a professional community and conduct local research under scientific guidance using methods specific to a particular professional setting	Pro.C-1.1 Apply principles of scientific work, methods of data collection and analysis, ways of argumentation; prepare scientific reviews, publications, abstracts, and bibliographies on research topics in Russian and English
	Pro.C-1.2 Understand the verification process of software models used to solve related scientific problems

2. Competency assessment indicators

As a result of studying the course the student should:

know:

- the main ways of parallelization of calculations;
- basic distributed data storage systems;
- basic techniques for serialization of models.

be able to:

- configure the process of parallel data processing using a distributed infrastructure;
- evaluate the level of reproducibility of experiments;
- to carry out experimental verification of hypotheses.

master:

- basic skills of working with distributed machine learning systems.

3. List of typical control tasks used to evaluate knowledge and skills

1. What is JIT?
2. What is the difference between relational and non-relational databases?
3. What is a stream?
4. What is a race condition? How to avoid it
5. What properties should distributed file systems have?

4. Evaluation criteria

1. What is machine learning and how does it differ from traditional programming?
2. Describe the main types of machine learning: supervised, unsupervised and reinforcement learning.
3. What are the key stages in the process of developing a machine learning model?
4. Name and briefly describe three popular machine learning algorithms.
5. What is the difference between regression and classification?
6. What is overfitting and how can it be avoided?

7. What are the main stages of data preprocessing before training the model?
8. Why is it important to divide the data into training and test samples?
9. What is data normalization and standardization? In what cases should they be used?
10. What metrics are used to assess the quality of machine learning models?
11. Explain what cross-validation is and why it is needed.
12. How to interpret the results of the error matrix (confusion matrix)?
13. How to ensure the scalability of a machine learning solution?
14. What factors should be taken into account when integrating the model into the existing IT infrastructure?
15. What ethical issues may arise when using machine learning?
16. How can bias be minimized in machine learning models?
17. What popular libraries and frameworks are used to develop machine learning solutions?
18. How do I choose the right tool for working with data and models?
19. Describe an example of a project to implement a machine learning solution: from idea to implementation.

отлично

10 всесторонние, систематизированные, глубокие знания учебной программы дисциплины и умение уверенно применять их на практике при решении конкретных задач, свободное и правильное обоснование принятых решений;

9 систематизированные, глубокие знания учебной программы дисциплины и умение уверенно применять их на практике при решении конкретных задач, правильное обоснование принятых решений;

8 глубокие знания учебной программы дисциплины и умение применять их на практике при решении конкретных задач, правильное обоснование принятых решений;

хорошо

7 твердо знает материал, грамотно и по существу излагает его, умеет применять полученные знания на практике, но допускает в ответе или в решении задач некоторые неточности;

6 знает материал, грамотно излагает его, умеет применять полученные знания на практике, но допускает в ответе или в решении задач некоторые неточности;

5 знает основной материал, грамотно излагает его, умеет применять полученные знания на практике, но допускает в ответе или в решении задач неточности;

удовлетворительно

4 фрагментарный, разрозненный характер знаний, недостаточно правильные формулировки базовых понятий, нарушения логической последовательности в изложении программного материала, но при этом он владеет основными разделами учебной программы, необходимыми для дальнейшего обучения и может применять полученные знания по образцу в стандартной ситуации;

3 характер знаний достаточен для дальнейшего обучения и может применять полученные знания по образцу в стандартной ситуации;

неудовлетворительно

2 не знает большей части основного содержания учебной программы дисциплины, допускает грубые ошибки в формулировках основных понятий дисциплины и не умеет правильно использовать полученные знания при решении типовых практических задач.

1 не знает формулировок основных понятий дисциплины и не умеет использовать полученные знания при решении типовых практических задач.

5. Methodological materials defining the procedures for the assessment of knowledge, skills, abilities and/or experience

Во время проведения дифференцированного зачёта обучающиеся могут пользоваться программой дисциплины.