

Документ подписан простой электронной подписью

Информация о владельце:

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MINISTRY OF SCIENCE AND HIGHER EDUCATION OF THE RUSSIAN FEDERATION
Federal State Autonomous Educational Institution of Higher Education
"NORTH CAUCASUS FEDERAL UNIVERSITY"

APPROVED BY

Acting Director of the Institute

Advanced Engineering

A. A. Porokhnya

WORK PROGRAM OF THE DISCIPLINE

"Statistical Methods in Machine Learning"

Field of study/specialty

11.03.02 Infocommunication Technologies
and Communication Systems

Profile/specialization

Intelligent Data Processing in
Infocommunication Systems and Networks

Year of start of training

2026

Form of study

Full-time

Implemented in a semester

3

Developed by

Associate Professor at the School of Digital
Education,

Robotics and Electronics

Institute of Advanced Engineering

Candidate of Technical Sciences, Associate

Professor R. A. Voronkin

1. Purpose and objectives of mastering the discipline (module)

The purpose of the discipline is to form, according to the educational program, the competencies of the student.

To achieve this goal, the following tasks are solved in the course of studying the discipline: familiarization with the basic concepts and types of machine learning problems; study of data preparation methods, including cleansing, normalization and engineering transformation of features; mastery of basic supervised learning models, such as linear and logistic regression; mastering stochastic gradient descent as a method of model optimization; forming ideas about metrics for assessing the quality of classification and interpretation of model results; studying methods for combating overfitting, including regularization and cross-validation; mastering classification algorithms based on the nearest neighbor method and the support vector method; studying algorithms for building decision trees and ensemble models, such as random forest and gradient boosting; familiarity with unsupervised learning methods, including clustering algorithms; mastering methods for reducing dimensionality and data visualization, such as PCA and t-SNE; developing practical skills in tuning models using hyperparameter selection; formation of skills to compare and interpret the results of various models based on objective metrics.

2. Place of the discipline (module) in the structure of the educational program

Discipline refers to the part formed by the participants of educational relations.

3. List of planned learning outcomes in the discipline (module) correlated with the planned results of the development of the educational program

Code, formulation of competence	Indicator code, wording	Planned learning outcomes in the discipline (module), characterizing the stages of the formation of competencies, indicators
OPK-1. Able to use the provisions, laws and methods of natural sciences and mathematics to solve problems of engineering activities	ID-1 OPK-1 understands the fundamental laws of nature and the basic physical mathematical laws and methods of accumulating, transmitting and processing information.	Knows and understands optimization methods in the design of AI and ML systems, is able to justify the choice.
	ID-2 OPK-1 applies physical laws and mathematical methods to solve problems of a theoretical and applied nature.	Ability to solve optimization problems in the design of machine learning systems.
	ID-3 OPK-1 uses the knowledge of physics and mathematics to solve practical problems.	Collecting, processing, and analyzing the results of ready-made machine learning systems for compliance.

4. Scope of the academic discipline (module) and forms of control *

Scope of classes: total: 3 EC 108 academic hours.	OFO, In acad. hours
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Contact work:	
Lectures/from them practical training	32.00
Laboratory work/from them practical training	-
Practical training/of which practical training	
Independent work	76.00
Forms of control	
Exam	-
Credit	Yes
Credit with a grade	-
Course work	no

* The discipline (module) provides for the use of e-learning, distance learning technologies
(unless otherwise established by the educational standard)

5. The content of the discipline (module), structured by topics (sections) with an indication of the number of hours and types of classes

№	Section (topic) of the discipline	Implemented competencies, indicators	Full-time				Forms of current monitoring of progress
			Contact work of students with the teacher, hours			Independent work, hours	
			Lectures	Practical exercises	Laboratory work		
Semester 3							
1	Introduction to Artificial Intelligence and Machine Learning Basic concepts of AI and ML. Approaches to learning. Areas of application. Installation of Python, Jupyter Notebook. Practical Work No1 The Basics of Working with Jupyter Notebook, JupyterLab, and Google Colab	OPK-1 ID-1OPK-1 ID-2OPK-1 ID-3OPK-1	-	2	-	6	Interview

2	Machine learning tasks and types Supervised and unsupervised learning. Main tasks: classification, regression, clustering, search for anomalies in data, dimensionality reduction, reinforcement learning.	OPK-1 ID-1OPK-1 ID-2OPK-1 ID-3OPK-1	-	-	-	6	Interview.
3	Data Preparation and Feature Engineering ML pipeline. NumPy Basics. Matplotlib Basics. Pandas Series and DataFrame Data Structures. Introduction to Exploratory Data Analysis (EDA). Practical Work No2 NumPy Package Basics Practical Work No3 Basics of working with the matplotlib package Practical Work No4 Introduction to pandas: Object Series Practical Work No5 Introduction to pandas:	OPK-1 ID-1OPK-1 ID-2OPK-1 ID-3OPK-1	-	10	-	6	Interview. Problem solving.

	DataFrame object Practical Work No6 Fundamentals of Research Data Analysis						
4	Linear regression Loss function. Model and analytical solution. Interpretation of coefficients. Practice No7 Linear Regression	OPK-1 ID-1OPK-1 ID-2OPK-1 ID-3OPK-1	-	2	-	6	Interview. Problem solving.
5	Stochastic Gradient Descent The idea of gradient descent. Mini-batches. Updating model parameters.	OPK-1 ID-1OPK-1 ID-2OPK-1 ID-3OPK-1	-	-	-	6	Interview.
6	Tackling Overfitting: Regularization and Cross-Validation L1 and L2 regularization. Cross-validation. Overtraining and undertraining	OPK-1 ID-1OPK-1 ID-2OPK-1 ID-3OPK-1	-	-	-	6	Interview.
7	Logistic regression Binary classification. Sigmoid. Loss function. Practical Work No8 Logistic Regression	OPK-1 ID-1OPK-1 ID-2OPK-1 ID-3OPK-1	-	2	-	6	Interview. Group creative tasks
8	Classification Model Quality Metrics	OPK-1 ID-1OPK-1 ID-2OPK-1 ID-3OPK-1	-	2	-	6	Interview. Group creative tasks

	Error matrix. Accuracy, Precision, Recall, F1, ROC-AUC. Interpretation of the results. Practice No9 Quality Metrics of Classification Models						
9	Nearest Neighbor Method and Support Vector Method KNN and SVM algorithms. Hyperparamet er tuning. Practical Paper No10 Nearest Neighbor Method and Support Vector Method	OPK-1 ID-1OPK-1 ID-2OPK-1 ID-3OPK-1	-	2	-	6	Group creative tasks
10	Decision trees Algorithms for building a tree. Division criteria. Visualization Practical work No11 Decision trees	OPK-1 ID-1OPK-1 ID-2OPK-1 ID-3OPK-1	-	2	-	6	Interview. Group creative tasks
11	Model Ensembles: Random Forest and Gradient Boosting Combining models. The basics of Random Forest and Gradient	OPK-1 ID-1OPK-1 ID-2OPK-1 ID-3OPK-1	-	4	-	6	Interview. Group creative tasks

	Boosting. Comparing results. Practical Work No12 Random Forest Practical Work No13 Gradient Boosting						
12	Clustering: Unsupervised Learning K-means algorithms, hierarchical clustering, DBSCAN. Clustering estimation. The "elbow" method ("broken cane") Practical Work No14 Unsupervised Learning: Data Clustering Tasks	OPK-1 ID-1OPK-1 ID-2OPK-1 ID-3OPK-1	-	2	-	4	Interview. Group creative tasks
13	Dimensionality reduction and data visualization PCA, t-SNE, UMAP. Visualization in 2D. Application for model analysis and diagnostics. Practical Work No15 Unsupervised Learning: Data Dimensionality Reduction Problems	OPK-1 ID-1OPK-1 ID-2OPK-1 ID-3OPK-1	-	2	-	4	Interview. Group creative tasks
14	Model Hyperparameter Selection	OPK-1 ID-1OPK-1 ID-2OPK-1	-	2	-	2	Interview. Group

	GridSearchCV , RandomizedSearchCV. The effect of parameters on the quality of models. Practical Work No16 Selection of Model Hyperparameters	ID-3OPK-1					creative tasks
	TOTAL for the 3rd semester		-	32	-	76	
	TOTAL		-	32	-	76	

6. Fund of assessment tools for the discipline (module)

The Assessment Tools Fund (WF) for a discipline (module) is based on a list of mastered competencies with an indication of indicators. The FAT provides objective control over the achievement of the planned learning outcomes. The FAT includes:

- description of indicators and criteria for assessing competencies at various stages of their formation, description of assessment scales;
- methodological materials that determine the procedures for assessing knowledge, skills, and (or) work experience that characterize the stages of competence formation (included in the methodological guidelines for those types of work that are provided for by the curriculum and provide for the assessment of the formation of competencies);
- standard assessment tools necessary for assessing knowledge, skills and the level of competence formation.

The FAT is an appendix to this program of the discipline (module).

7. Methodical instructions for students on the development of the discipline

Starting work, each student should take into account the following provisions.

The discipline (module) is built on a thematic principle, each topic is a logically complete section.

The lecture material is devoted to the consideration of the key, basic provisions of the courses and the explanation of educational tasks submitted for independent work of students

Practical classes are held in order to consolidate the information learned, to acquire the skills of its application in solving practical problems in the relevant subject area

Independent work of students is aimed at independent study of additional material, preparation for practical and laboratory classes, as well as the performance of all types of independent work.

For the successful development of the discipline, it is necessary to perform all types of independent work, using the recommended sources of information.

8. Educational, methodological and information support of the discipline

8.1. List of basic and additional literature necessary for mastering the discipline (module)

8.1.1. List of basic literature:

1. Bolotsky, A. V.; Investigation of operations and optimization methods Electronic resource / Bolotsky A. V., Kochetkova O. A. - St. Petersburg : Lan, 2020. - 116 p. - ISBN 978-5-8114-4568-4

2. Saraev, P. V.; Methods of Machine Learning Electronic resource: Guidelines and tasks for laboratory work on the course / P. V. Saraev. - Lipetsk : Lipetsk State Technical University, EBS ASV, 2017. - 48 p. - The book is in the premium version of EBS IPR BOOKS. - ISBN 2227-8397

3. Sopov, E. A.; Multi-criteria neuroevolutionary systems in the problems of machine learning and human-machine interaction Electronic resource / Sopov E. A., Ivanov I. A. : monograph. - Krasnoyarsk : SibFU, 2019. - 160 p. - ISBN 978-5-7638-3969-2

8.1.2. List of additional literature:

1. Methodical recommendations for practical classes in the discipline "Theory and Practice of Machine Translation": Direction of training 45.04.02 Linguistics. Master's program "Translation and Translation Studies". Qualification of the graduate - master. Form of study - full-time. Curriculum 2015. Studied in the 3rd semester. - Stavropol : NCFU, 2015. - 9 p.

2. Nedelko, V. M.; Fundamentals of Statistical Methods of Machine Learning Electronic resource: Textbook / V. M. Nedelko. - Novosibirsk : Novosibirsk State Technical University, 2010. - 72 p. - The book is in the premium version of EBS IPR BOOKS. - ISBN 978-5-7782-1385-2

3. Rapakov, G. G.; Methods and algorithms of machine learning in the adoption of managerial decisions in the regional system of medical prevention (experience of the Vologda region) Elektronnyi resurs / Rapakov G. G., Kasimov R. A. : monograph. - Vologda : VoGU, 2014. - 143 p. - ISBN 978-5-87851-548-1

8.2. List of educational and methodological support for students' independent work in the discipline (module)

1. Saraev, P. V. Methods of machine learning Electronic resource: Guidelines and tasks for laboratory work on the course / P. V. Saraev. - Lipetsk: Lipetsk State Technical University, EBS ASV, 2017. - 48 p. - The book is in the premium version of EBS IPR BOOKS. - ISBN 2227-8397

8.3. List of resources of the information and telecommunication network "Internet" necessary for mastering the discipline (module) of mastering the discipline

1. <http://biblioclub.ru/> – University Library online "Biblioclub"

2. <http://www.iprbookshop.ru> – EBS "IPRbooks".

3. <http://catalog.ncfu.ru/catalog/ncfu> - NCFU Electronic Catalog.

9. List of information technologies used in the implementation of the educational process in the discipline (module), including a list of software and information reference systems

When reading lectures, computer equipment is used, demonstrations of presentation multimedia materials. At seminars and practical classes, students present presentations prepared by them during the hours of independent work.

Information reference systems:

Information and reference and information and legal systems used in the study of the discipline:

- 1 <http://biblioclub.ru/> – University Library Online "Biblioclub"
- 2 <http://www.iprbookshop.ru> – EBS "IPRbooks".
- 3 <http://catalog.ncfu.ru/catalog/ncfu> - NCFU Electronic Catalog.

Software:

- 1 Viola Workstation 10
- 2 Alt Workstation K
- 3 Office software package - P7-Office
- 4 Viola "Server"

10. Description of the material and technical base necessary for the implementation of the educational process in the discipline (module)

Lectures	The classroom is equipped with specialized furniture and technical training aids: EpsonEB-536Wi short-throw multimedia projector, DeII OptiPlex3040i3-6100 PC with Internet connection and access to EIOS, Acer PD527W PROJECTOR, HP LaserJet 3052 MFP, ASUS K42JC laptop, HP nx7300 T5600 notebook, laptop, portable projector, demonstration equipment and educational and visual aids (maps, atlases, handouts)
Practical exercises	The classroom is equipped with specialized furniture and technical training aids: EpsonEB-536Wi short-throw multimedia projector, DeII OptiPlex3040i3-6100 PC with Internet connection and access to EIOS, Acer PD527W PROJECTOR, HP LaserJet 3052 MFP, ASUS K42JC laptop, HP nx7300 T5600 notebook, laptop, portable projector, demonstration equipment and educational and visual aids (maps, atlases, handouts)
Independent work	The classroom is equipped with specialized furniture and technical training aids: EpsonEB-536Wi short-throw multimedia projector, DeII OptiPlex3040i3-6100 PC with Internet connection and access to EIOS, Acer PD527W PROJECTOR, HP LaserJet 3052 MFP, ASUS K42JC laptop, HP nx7300 T5600 notebook, laptop, portable projector, demonstration equipment and educational and visual aids (maps, atlases, handouts)

11. Features of mastering the discipline (module) by persons with disabilities

Students with disabilities are provided with special textbooks, teaching aids and didactic materials, special technical teaching aids for collective and individual use, the services of an assistant (assistant) who provides students with the necessary technical assistance, as well as the services of sign language interpreters and typhlo-sign interpreters.

The development of a discipline (module) by students with disabilities can be organized together with other students, as well as in separate groups.

The development of a discipline (module) by students with disabilities is carried out taking into account the characteristics of psychophysical development, individual capabilities and health status.

In order to ensure the accessibility of higher education under the educational program by persons with disabilities when mastering the discipline (module), the following is ensured:

1) for visually impaired persons:

- the presence of an assistant who provides the student with the necessary technical assistance, taking into account individual characteristics (helps to take a workplace, move, read and complete the task, including by writing down by dictation),
- written tasks, as well as instructions on the procedure for their implementation, are drawn up in enlarged font,
- special textbooks, teaching aids and didactic materials (with large print or audio files),

- individual uniform lighting of at least 300 lux,
- if necessary, the student is provided with a magnifying device to complete the task;
- 2) for persons with hearing disabilities:
 - the presence of an assistant who provides the student with the necessary technical assistance, taking into account individual characteristics (helps to take a workplace, move, read and complete the task, including by writing down by dictation),
 - the availability of sound-amplifying equipment for collective use is ensured, if necessary, the student is provided with sound-amplifying equipment for individual use;
 - is provided with appropriate sound means of reproducing information;
- 3) for persons with disabilities with musculoskeletal disorders (including those with severe disorders of the motor functions of the upper extremities or the absence of upper limbs):
 - written tasks are performed on a computer with specialized software or dictated to an assistant;
 - At the request of the student, tasks can be performed orally.

12. Features of the implementation of the discipline using distance educational technologies and e-learning

According to Part 1 of Article 16 of the Federal Law of December 29, 2012 No 273-FZ "On Education in the Russian Federation", *e-learning* is understood as the organization of educational activities with the use of information contained in databases and used in the implementation of educational programs and information technologies, technical means, as well as information and telecommunication networks that ensure the transmission of this information through communication lines, the interaction of students and teachers. Distance *educational technologies* are understood as educational technologies implemented mainly with the use of information and telecommunication networks with indirect (at a distance) interaction between students and teachers.

The discipline can be implemented using distance learning technologies and e-learning in whole or in part. The components of the discipline's teaching materials (the discipline's work program, assessment and methodological materials, forms of certification), implemented using distance learning technologies and e-learning, contain an indication of their use.

When organizing educational activities with the use of distance educational technologies and e-learning, asynchronous and synchronous ways of interacting with participants in educational relations through the information and telecommunication network "Internet" may be provided.

When using distance learning technologies and e-learning, the schedule for the discipline indicates: ways of interaction between participants in educational relations through the information and telecommunication network "Internet" (videoconferencing, ET - electronic testing); links to the electronic information and educational environment of NCFU, to educational platforms and resources of other organizations to which open access is provided through the information and telecommunication network "Internet"; for synchronous learning - the time of online classes and teachers; for asynchronous learning - the authors of online courses.

When organizing interim certification using distance learning technologies and e-learning, the Methodological Recommendations for the Use of Technical Means That Ensure the Objectivity of Results in the Conduct of Interim and State Final Certification in Educational Programs of Higher Education - Bachelor's Degree Programs, Specialist Programs and Master's Degree Programs with the Use of Distance Educational Technologies (Letter of the Ministry of Education and Education of Russia dated 07.12.2020 No MN-19/1573-AN "On the Direction of Methodological Recommendations") are used.

The implementation of the discipline using e-learning and distance learning technologies is carried out using the electronic information and educational environment of NCFU, to which students have access through the information and telecommunication network "Internet", or using the resources of other organizations, including platforms that provide services for video

conferences, online meetings and distance learning (MTS-Link), as well as using the capabilities of social networks for communication between students and teachers.

Educational and methodological support of the discipline implemented with the use of e-learning and distance educational technologies includes a work program, teaching aids or a course of lectures presented in electronic form, guidelines for the implementation of various types of educational activities of students provided for by the discipline, and other educational materials posted in the information and educational environment of NCFU.