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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
Data Structure and Algorithm

Field of study	11.03.02 Infocommunication Technologies and Communication Systems
Profile	Intelligent Data Processing in Infocommunication Systems and Networks
Year of start of training	2026
Form of study	Full-time
Implemented in a semester	5

Developed by
Associate Professor at the School of Digital Education,
of Robotic Systems and Electronics
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1. Purpose and objectives of mastering the discipline (module)

The purpose of mastering the discipline is to form a set of universal competencies of the future bachelor and specialist. Formation of students' theoretical knowledge and practical skills in the field of algorithms and data structures necessary for effective solution of robotics problems, including movement planning, navigation, sensor data processing and robot control in real time.

Objectives of mastering the discipline:

- study of basic algorithms and data structures;
- the use of algorithms in robotic tasks;
- development and optimization of algorithms for robotic systems;
- analysis and comparison of algorithmic solutions.

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

The discipline belongs to block 1 "Disciplines (modules)" (variable part). Its development takes place in the 3rd semester.

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
PC-2. Capable of conceptual, functional and logical design of systems of medium and large scale and complexity	ID-6PC-2 Applies methods and algorithms for optimizing executable code	Able to design complex algorithmic systems in robotics, from concept to logical implementation, taking into account scalability, performance and modularity, including working with ROS, distributed computing and robotic platforms.
	ID-7PC-2 Uses modern software development methodologies and programming technologies	
	ID-14PK-2 Defines and applies the necessary algorithms and data structures to solve the problems of navigation, planning, sensor data processing, control and decision-making in robotic systems	
	ID-9PC-2 Designs Data Structures	

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

Scope of classes: total: 3 EC 108 academic hours.	OFO, In acad. hours
Contact work:	
Lectures/from them practical training	
Laboratory work/from them practical training	-
Practical training/of which practical training	24.00
Independent work	84.00
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 and summary	Emerging competencies, indicators	Full-time				Current Forms control Academic Performance
			Contact work of students with the teacher / of them in the form of practical training, hours			Independent work, hours	
			Lectures	Practical exercises	Laboratory work		
1	Topic 1. Introduction to algorithms and data structures for robotics. The role of algorithms in robotics (navigation, control, SLAM, machine learning). Criteria for evaluating algorithms: time complexity, memory, accuracy. An overview of languages and frameworks (C++, Python, ROS). Examples of tasks: path planning, sensory data processing. Practical Work: Determining the Complexity Function of Algorithms	ID-6PK-2 ID-7PK-2 ID-14PK-2 ID-9PK-2	-	2	-	10	Interview
2	Topic 2 Linear data structures and their applications. Arrays, lists, stacks, queues. Robotics applications: buffering sensor data (queues); real-time task management (call stack). Optimize data access. Practical work: Simulation modeling of the job flow service system	ID-6PK-2 ID-7PK-2 ID-14PK-2 ID-9PK-2	-	2	-	10	Interview

3	Topic 3. Trees and graphs in robotics. Binary trees, heaps, graphs (view, crawl). Application: Management decision trees; Navigation map (SLAM) graphs. DFS/BFS algorithms in route planning. Practical work: Construction of an environment graph for a pathfinding algorithm	ID-6PK-2 ID-7PK-2 ID-14PK-2 ID-9PK-2	-	2	-	10	Interview
4	Topic 4. Pathfinding algorithms. Dijkstra, A*, Jump Point Search algorithms. Optimized for dynamic environments (D* Lite). Examples in ROS (navfn, global_planner). Practical work: Simulation of a mobile robot in a warehouse (using Gazebo)	ID-6PK-2 ID-7PK-2 ID-14PK-2 ID-9PK-2	-	2	-	10	Interview
5	Topic 5. Data hashing and optimization. Hash tables, bloom filters. Application: quick search for objects by sensor data; data duplication in distributed systems. Practical work: Optimizing algorithms using hash tables	ID-6PK-2 ID-7PK-2 ID-14PK-2 ID-9PK-2	-	2	-	10	Interview
6	Topic 6. Multithreaded and parallel algorithms. Parallel data structures. Distributed algorithms for robot swarms. Examples: Parallelizing image processing. Practical work: Implementation of a multithreaded algorithm	ID-6PK-2 ID-7PK-2 ID-14PK-2 ID-9PK-2	-	2	-	10	Interview

7	Тема 7. Алгоритмы SLAM (Simultaneous Localization and Mapping). Overview of methods (Gmapping, Cartographer). Data structures for maps (octotrees, voxels). Resource-based optimization. Practical work: Implementation of the SLAM algorithm	ID-6PK-2 ID-7PK-2 ID-14PK-2 ID-9PK-2	-	4	-	10	Interview
8	Topic 8. Machine learning algorithms in robotics. Classification and clustering of data. Decisive trees and ensembles for management. Neural Networks in Robot Computer Vision. Practical work: Introduction to the YOLO architecture for object detection.	ID-6PK-2 ID-7PK-2 ID-14PK-2 ID-9PK-2	-	4	-	10	Interview
9	Topic 9. Optimization and testing of algorithms. Code profiling (gprof, valgrind). Unit tests and integration testing. Deployment on real robots. Practical work: Algorithm optimization using a profiler	ID-6PK-2 ID-7PK-2 ID-14PK-2 ID-9PK-2	-	4	-	4	Interview
	TOTAL		-	24.00	-	84	

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

The Assessment Tools Fund (WFD) for the discipline (module) "Data Structures and Algorithms" is based on a list of mastered competencies with indicators. FAT provides objective control over the achievement of planned learning outcomes. 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 conducted in order to consolidate the learned information, to acquire skills for 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. Pavlov L. A., Pervova N. V. Struktury i algoritmy obrabotki dannykh : uchebnik dlya vuzov [Structures and algorithms of data processing: a textbook for universities]. — 3rd ed., ster. — St. Petersburg : Lan, 2021. — 256 p. — ISBN 978-5-8114-7259-8. — Text : electronic // Lan : electronic library system. — URL: <https://e.lanbook.com/book/156929> (accessed: 11.04.2025). — Mode of access: for authoriz. users.

2. Makarov L. M. Proektirovanie beznavitel'nykh transportnykh sredstva : uchebnoe posobie [Design of unmanned vehicles: a textbook]. — St. Petersburg: SPbSUT named after M.A. Bonch-Bruевич, 2023. — 107 p. — Text : electronic // Lan : electronic library system. — URL: <https://e.lanbook.com/book/381488> (accessed: 11.04.2025). — Mode of access: for authorization. users.

8.1.2. List of additional literature:

1. Kork, P. Machine Vision. Fundamentals and Algorithms with Examples on Matlab: A Guide / P. Kork ; translated from English by V. S. Yatsenkov. — Moscow : DMK Press, 2023. — 584 p. — ISBN 978-5-93700-222-8. — Text : electronic // Lan : electronic library system. — URL: <https://e.lanbook.com/book/456581> (accessed: 11.04.2025). — Mode of access: for authoriz. users.

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

1. Guidelines for the implementation of practical work in the discipline "Algorithms and data structures in robotics".

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

1. [http:// biblioclub.ru/](http://biblioclub.ru/) University Library Online
2. <http://www.habr.ru> - Electronic platform for analytical and training articles
3. https://docs.exponenta.ru/robotics/index.html?s_tid=CRUX_lftnav — Electronic documentation for Robotics System Toolbox for MatLab.

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://catalog.ncfu.ru/catalog/ncfu> – Official website of the Scientific Library of the FGAOU HE NCFU.
- 2 <http://www.consultant.ru> – Official website of Consultant Plus
- 3 <https://www.mnr.gov.ru> – Official website of the Ministry of Natural Resources and Environment of the Russian Federation
- 4 Information and Legal Portal "Garant" - <http://www.garant.ru/>

Software:

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

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

Lectures	Classroom for training sessions, equipped with multimedia equipment and technical teaching aids.
Practical exercises	Classroom for training sessions, equipped with multimedia equipment and technical teaching aids.
Independent work	Room for independent work of students, equipped with computer equipment with the ability to connect to the Internet and the ability to access the electronic information and educational environment of the university

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 of 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.