SYLLABUS

Fundamentals of Robotics and Artificial Intelligence

Semester: Summer School

Lecturers and Instructors:

Vladislav S. Gromov, PhD, Associate Professor
Oleg I. Borisov, PhD, Associate Professor
Sergei A. Kolyubin, D.Sc., Professor
Alexey A. Vedyakov, PhD, Associate Professor
Sergei V. Shavetov, PhD, Associate Professor

Course Description

The school takes 6 ECTS and consists of several consecutive modules: Trajectories Planning, Motion Control for Robots, Computer Vision for Robotics Applications, Artificial Intelligence and Data-Driven Methods in Robotics, Reinforcement Learning in Robotics. The school will start in July 2025 and takes 4 weeks.

Learning objectives

The **Trajectories Planning** module consists of the 8 lessons with 45 minutes each duration and will consider following topics:

1. Types of Non-Industrial Robots.
2. Types of Industrial Robots.
3. Common Robotics Applications and Features.
4. Modeling and Control of Mobile Robot.
5. Simulation Mobile Robot in Simulink.
6. Modeling and Control of Industrial Robot.
7. Simulation Industrial Robot in Simulink.
8. Path and Trajectory Planning for Robots.

The teacher of this module is Vladislav S. Gromov, PhD, Associate Professor, ITMO University. Contact work with students takes 8 hours and 32 hours takes students' self-work.

The **Motion Control for Robots** module consists of the 8 lessons with 45 minutes each duration and will consider following topics:

1. Introduction to Control of Robotic Systems: Basic Concepts and Approaches.
2. Robust Control of Robotic Systems.
3. Exogenous Inputs Rejection in Robotic Systems.
4. Adaptive Control of Robotic Systems.
5. Application Study: Control of a Robotic Surface Vessel.
6. Application Study: Control of a PMSM.
7. Application Study: Control of a Quadrotor.
8. Application Study: Control of a Robotic Arm.

The teacher of this module is Oleg I. Borisov, PhD, Associate Professor, ITMO University. Contact work with students takes 8 hours and 32 hours takes students' self-work.

The **Computer Vision for Robotics Applications** module consists of the 6 lessons with 45 minutes each duration and will consider following topics:

1. Introduction to Digital Images. General Properties, Color Models, Basic Operations.
2. Geometric Transformations, Correction, Stitching, Filtering. Feature Detectors and Descriptors.

The teacher of this module is Sergei V. Shavetov, PhD, Associate Professor, ITMO University. Contact work with students takes 8 hours and 32 hours takes students' self-work.

The **Artificial Intelligence and Data-Driven Methods in Robotics** module consists of the 6 lessons with 45 minutes each duration and will consider following topics:

1. Introduction to Machine Learning
2. Machine Learning in Robotics
3. Fundamentals of Data-Driven Robot Modelling

Teacher of this module is Sergei A. Kolyubin, D.Sc., Professor, ITMO University. Contact work with students takes 6 hours and 28 hours takes students' self-work.

The **Reinforcement Learning in Robotics** module consists of the 12 lessons with 45 minutes each duration and will consider following topics:

1. Introduction to Reinforcement Learning
2. Reinforcement Learning: Q-table
3. Reinforcement Learning: Deep Q-network
4. Reinforcement Learning: Policy Gradient

Teacher of this module is Alexey A. Vedyakov, PhD, Associate Professor, ITMO University. Contact work with students takes 12 hours and 50 hours takes students' self-work.

Grade System

The description of the result mark and grade is presented below:

Result score (%)	Result grade	Result mark	Explanation
91 – 100	A	Pass	Excellent
84 – 90	B	Pass	Very good
75 – 83	C	Pass	Good
68 – 74	D	Pass	Satisfactory
60 – 67	E	Pass	Satisfactory
0 – 59	FX	Fail	Unsatisfactory

At the first introduction lesson all students will obtain the list of possible projects. During the school students should perform the task and finalize the project. At the end of the course each student should defend project in an oral way using the presentation.

Course schedule

№	Topic	Date	Time	Module & Lecturer
	Introduction. Syllabus. Project Topics	**21.07.2025**	**14:00-14:45**	Sergei A. Kolyubin
	Excursion	**21.07.2025**	**14:45-15:30**	**Labs** Olga V. Vasileva
1	Introduction to Control of Robotic Systems: Basic Concepts and Approaches	**22.07.2025**	**9:50-11:20**	**Motion Control for Robots** Oleg I. Borisov
2	Robust Control of Robotic Systems			
3	Exogenous Inputs Rejection in Robotic Systems	**22.07.2025**	**11:30-13:00**	
4	Adaptive Control of Robotic Systems			
5	Application Study: Control of a Robotic Surface Vessel	**23.07.2025**	**9:50-11:20**	
6	Application Study: Control of a PMSM			
7	Application Study: Control of a Quadrotor	**23.07.2025**	**11:30-13:00**	
8	Application Study: Control of a Robotic Arm			
1	Types of Non-Industrial Robots	**24.07.2025**	**9:50-11:20**	**Trajectories Planning** Vladislav S. Gromov
2	Types of Industrial Robots			
3	Common Robotics Applications and Features	**24.07.2025**	**11:30-13:00**	
4	Modeling and Control of Mobile Robot			
5	Simulation Mobile Robot in Simulink	**25.07.2025**	**9:50-11:20**	
6	Modeling and Control of Industrial Robot			
7	Simulation Industrial Robot in Simulink	**25.07.2025**	**11:30-13:00**	
8	Path and Trajectory Planning for Robots			
1	Introduction to Digital Images. General Properties, Color Models, Basic Operations	**28.07.2025**	**9:50-11:20** **11:30-13:00**	**Computer Vision for Robotics Applications** Sergei V. Shavetov
2	Geometric Transformations, Correction, Stitching, Filtering. Feature Detectors and Descriptors	**29.07.2025**	**9:50-11:20** **11:30-13:00**	
1	Introduction to Machine Learning	**30.07.2025**	**9:50-11:20** **11:30-13:00** **13:30-15:00**	**Artificial Intelligence and Data-Driven Methods in Robotics**
2	Machine Learning in Robotics			
3	Fundamentals of Data-Driven Robot Modelling			

				Sergei A. Kolyubin
1	Introduction to Reinforcement Learning	**31.07.2025**	**10:00-11:30** **11:40-13:10**	**Reinforcement Learning in Robotics** Alexey A. Vediakov
2	Reinforcement Learning: Q-table	**01.08.2025**	**9:50-11:20**	
3	Reinforcement Learning: Deep Q-network	**01.08.2025**	**11:30-13:00**	
4	Reinforcement Learning: Policy Gradient	**04.08.2025**	**9:50-11:20** **11:30-13:0**	
1	Project Defending	**07.08.2025**	**9:50-11:20** **11:30-13:0**	ALL
1	Certification & Photo	**14.08.2025**	**10:00-11:30**	ALL