ITMO

MACHINE LEARNING IN ROBOTICS

Course Workload		Assessment form (examination/ graded test/ ungraded test)
ECTS	Hours	
6	216	Oral exam / Course work

The course is designed to give students knowledge on machine learning methods and tools to solve applied problems from building a model to robot navigation, motion planning and control.

Course structure:

1. MACHINE LEARNING TASKS IN ROBOTICS. BASIC THEORY
   1.1. Mathematical Formulation of Machine Learning Problems and Applied Machine Learning Problems in Robotics.
   1.2. Classification of machine learning methods.
   1.3. Mathematical methods for machine learning: LSM, logistic regression, Bayesian classification, singular decomposition, support vector methods, principal components, independent components.
   1.4. Neural networks: types and architectures, limitations and hyperparameter tuning.

2. SUPERVISED LEARNING TO DETECT AND CLASSIFY OBJECTS IN THE ENVIRONMENT
   2.1. Detection, segmentation, position estimation and classification tasks in object manipulation.
   2.2. Feature extraction in the video stream.
   2.3. Semantic annotation.
   2.4. Learning on synthetic data.

3. SIMULTANEOUS LOCALIZATION AND MAPPING BASED ON BAYESIAN APPROACHES AND UNSUPERVISED LEARNING METHODS
   3.1. Bayesian methods of simultaneous localization and mapping: probabilistic measurement and motion models, particle filters.
   3.2. Visual SLAM algorithms.
   3.3. Neural network methods for software depth map reconstruction.
   3.4. Classification of stationary and moving objects.

4. MACHINE LEARNING METHODS FOR MODELING AND IDENTIFICATION
   4.1. Problem statement of dynamic systems identification, regression models and types of identification.
   4.2. The problem of balanced dimensionality reduction.
   4.3. Autoencoders for dynamic systems.
   4.4. SINDy sparse identification algorithm for nonlinear dynamical systems.

5. LEARNABLE COMPOSITE CONTROL ALGORITHMS FOR ROBOTIC SYSTEMS

  5.1. Direct and indirect adaptation methods.
  5.2. Control algorithms with moving horizon.
  5.3. Machine learning and evolutionary computing in controller design.
  5.4. Composite control algorithms.

6. PLANNING AND CONTROL OF ROBOT MOVEMENTS BASED ON REINFORCEMENT LEARNING METHODS

  6.1. Markov chain.
  6.2. Problem statement, policies, and trade-offs of reinforcement learning.
  6.3. Machine learning methods for solving the inverse kinematics problem.
  6.4. Manipulator trajectory planning based on reinforcement learning.
  6.5. Reinforcement learning for walking robots.