

Introduction to Robotics

1st Semester P1 – 2024/2025

Course Presentation

Course Objectives

- Recognize the main modules of a robotic system (perception, navigation, decision-making and task execution) and their organization and interconnection.
- Introduce the main techniques for modeling, sensory processing, navigation and decision-making in Robotics, to develop autonomous robots with machine-intelligence.

1. What is a robot. Examples of robots. Introduction to ROS.
2. Perception
 - a. Sensors in Robotics (encoders, gyroscopes, accelerometers, laser scanner, ...)
 - b. Representation of sensor uncertainty - model of observation
3. Mobile Robot Localization
 - a. The localization problem: relative localization and absolute localization
 - b. Coordinate systems. Homogeneous coordinate transformations.
 - c. Basic concepts on Probabilistic Robotics: Bayes Filter
 - d. Particular cases of the Bayes filter: Kalman filter, particle filter
 - e. Kalman filter based localization
 - f. Monte-Carlo Localization

4. Mobile Robot Motion Planning and Guidance

- a. The "bug" algorithm
- b. Potential Fields for Path Planning
- c. RRT (Rapidly-exploring Random Trees)
- d. Path following: closed loop control; path as the control system reference signal. Differential kinematics

5. Learning, Decision Making and Execution

- a. The decision-making problem
- b. Uncertainty in robot systems
- c. Decision making under uncertainty: MDPs
- d. Reinforcement learning

6. Robot Systems Architectures

- a. Functional architectures (hierarchical, behavior-based, hybrid)
- b. Software and hardware architectures

- Course faculty
 - T: Rita Cunha
 - L: José Gaspar, Rita Cunha
- Lectures
 - Mondays and Thursdays: 08:00 – 10:00 (EA5)
- Labs
 - Tuesdays, 08:00-11:00, 15:30-18:30 / Fridays, 09:30-12:30
(LSDC4 – North Tower, 5th floor)
- Webpage
 - <https://fenix.tecnico.ulisboa.pt/disciplinas/IRobo11/2024-2025/1-semester>
 - Check the webpage for regular updates: slides, mini-projects material and other useful information.

Lab Classes – enrolment and schedule

- Group enrolment through fenix
 - from Monday, 9 Sep. at 18h00 to 10 Sep. at 13h00
 - Groups of 3
 - Choose one of the available shifts:
Tuesdays, 08:00-11:00, 15:30-18:30 / Fridays, 09:30-12:30
- Week 1:
 - Enrolment
- Week 2:
 - Short course on ROS
- Week 3-7:
 - Project progress presentations by each group
- Continuous access to the lab
 - Access based on student list / talk to Mr. Manuel Ribeiro for access

- 3 mini-projects
 - P1: Localization – 2 weeks
 - P2: Navigation (path planning) – 2 weeks
 - P3: Decision making under uncertainty and policy execution – 1 weeks (duration is estimated)
- 1 final report on the consolidated work of the mini-projects
 - Report submission in fenix in date to be announced
- Grading:
 - 90 %: 6 weekly progress presentations in the Lab classes (weeks 2-7) [20%] + written final report on the consolidated work of the mini-projects [70%]
 - 10 %: final presentation in the week after classes
- Check the webpage for more instructions and updates.