PROJECTS 2024/25

Instituto Superior Técnico

Departamento de Engenharia Electrotécnica e de Computadores

April 2025

LIST OF AVAILABLE REAL ROBOTS AND DEVICES

Pioneer 3DX (7 units)

AlphaBot2 with camera (8 units + 23 kits)

Turtlebot3 with RPLIDAR (4 units)

Microsoft Kinect

Hokuyo URG-04LX-UG01 (5 units)

PROJECT TOPICS

Project topics and code scheme:

[L__] – Localization: estimate in real-time the pose (position+orientation) of a mobile robot; evaluate estimation accuracy, as well as absolute localization, and robustness to "kidnapping".

[M__] – Mapping: estimate the map of the environment using Occupancy Grid Mapping; evaluate quality of the map with respect to the ground truth.

[S__] – Simultaneous Localization And Mapping (SLAM): estimate simultaneously the trajectory (position+orientation) of a mobile robot and the landmark positions (map); evaluate estimation accuracy of both trajectory and landmarks.

[DMA] – Decision Making: solve a maze using MDPs/RL and markers to identify the goal and help odometry in localizing the robot

SENSOR CHOICE RECOMMENDATIONS

Localization: fuses relative and absolute sensing:

- for relative sensing, use wheel odometry
- for absolute sensing, prefer Laser or camera (natural landmarks), while sonar is challenging

Mapping: registers distance measurements given known localization

- may use AMCL (from ROS) or well-calibrated odometry
- for distance sensor, may use Laser, depth camera (Kinect) or sonars (challenging)

Simultaneous Localization And Mapping (SLAM): fuses landmark measurements with relative sensing:

- for relative sensing, use wheel odometry
- use fiducials markers, e.g., camera with ARuCO or AprilTag markers

Decision Making (DM): moves in a maze using the optimal policy for a given MDP (in a later stage it can learn it model free using reinforcement learning) and uses fiducial markers (Alphabot camera)

- to help wheel odometry in roughly localizing the robot (e.g., map cell)
- to localize the maze exit/goal

LIST OF TOPICS (REAL ROBOTS)

		7x Pioneer 3DX	4x Turtlebot3	10x AlphaBot2
Localization	Extended Kalman Filter (EKF)	**LKP**	**LKT**	**LKA**
	Monte Carlo Localization (MCL)	**LMP**	**LMT**	**LMA**
Mapping	Occupancy Grid Mapping	**MP**	**MT**	-
SLAM	EKF-SLAM	**SKP**	**SKT**	-
	FastSLAM	**SFP**	**SFT**	**-**
Decision-Making	MDP/RL	-	-	**DMA**

PROJECT

13 PROJECT TYPOLOGIES:

- Groups of 4 students
- Using real robots and sensors
- Validated and evaluated using collected data
- Students suggested to spread over all project typologies (all with same level of difficulty)

PROJECT TIPS

- **Solid theoretical background**
  - formalize the problem, but do not write a tutorial
  - explain the algorithm, not the code
- **Develop and validate your algorithm on a micro-simulator**
- **Test as soon as possible:** it is better to test partial implementations early, than postponing to when everything is implemented
- **Avoid running your algorithm in real time:** instead, datasets should be used (e.g., rosbags), for work productivity and repeatability
- **Thorough experimental results**
  - try a variety of experimental conditions
  - for each one, run multiple times and analyze statistically
- **Objective analysis of the results is more important than "just working"**

PROJECT ASSESSMENT AND SCHEDULE (1)

- **Continuous assessment**: *each group does an oral progress presentation (1 group member per presentation) every week in its designated slot (4 groups per slot) – total of 5 intermediate presentations per group, max 20 minutes including presentation (10-15 mins) and Q&A (slides not mandatory but highly recommended)*

- **Project progress presentations during laboratory sessions** *start on 5 May (second week of classes)*

- *Projects presented by faculty on 28 April in the theoretical classes*

Project report and code deadline: 13/Jun/2025
(6 page IEEE paper template)

Project discussions: 17-18/Jun/2025

PROJECT ASSESSMENT AND SCHEDULE (2)

Autonomous Systems					
Schedule of Lab classes :: 2024/2025					
	Seg	**Ter**	**Qua**	**Qui**	**Sex**
8:00	T1	T2			
8:30			L 7.2		L 7.1
9:00	IA	IA	LSDC1		LSDC1
9:30	PL	PL	AV		AV
10:00					L 6.1
10:30	L 2.2	L 5.2			LSDC1
11:00	LSDC1	LSDC1			AV
11:30	RV	PL			L 3.1
12:00	L 3.2	L 6.2			LSDC1
12:30	LSDC1	LSDC1			RV
13:00	RV	PL			L 4.1
13:30	L 4.2				LSDC1
14:00	LSDC1				RV
14:30	RV				
15:00		L 5.1			
15:30		LSDC1			
16:00		RV			
16:30		L 2.1			
17:00		LSDC1			
17:30		RV			

PROJECT ASSESSMENT AND SCHEDULE (3)

Autonomous Systems						
Dates of Lab classes :: 2024/2025						
		Session				
Shift	Slot	1	2	3	4	5
2	1	6-May	13-May	20-May	27-May	3-June
	2	5-May	12-May	19-May	26-May	2-June
3	1	6-May	13-May	20-May	27-May	3-June
	2	5-May	12-May	19-May	26-May	2-June
4	1	9-May	16-May	22-May	29-May	5-June
	2	5-May	12-May	19-May	26-May	2-June
5	1	6-May	13-May	20-May	27-May	3-June
	2	6-May	13-May	20-May	27-May	3-June
6	1	9-May	16-May	22-May	29-May	5-June
	2	5-May	12-May	19-May	26-May	2-June
7	1	9-May	16-May	22-May	29-May	5-June
	2	7-May	14-May	21-May	28-May	4-June
8	1	9-May	16-May	22-May	29-May	5-June
	2	7-May	14-May	21-May	28-May	4-June

PROJECT ASSESSMENT AND SCHEDULE (3)

Project Grading:

- ***FAIL****: nothing works, not much relevant work done in design + implementation, no reasonable explanation for failure to show results*
- ***10-14****: at least some experimental results can be shown, significant design + implementation work made of at least fair quality*
- ***15-17****: good experimental results, significant design + implementation work made of at least good quality and supported by theory*
- ***18-19:*** *very good experimental results and design + implementation work made and supported by theory*
- ***20****: excellent and flawless experimental results and design + implementation work made and supported by theory; in exceptional cases could correspond to the factors listed for 18-19, extended with some original unsolicited extra work*

WHAT'S NEXT

Hands-on sessions with ROS on **first week**

- Each shift uses 2 assigned lab slots (all shift students go to both slots)
- Prepare for these sessions by reading the "**Laboratory guide**" slides
- First slot in **LSDC1** and second slot in **LSDC4**

1. [from 28 April 17:00 to 30 April 17:00] Choose the project for your group using a web link that will be made available at the course webpage

2. Group start preparing the first presentation, where we expect:

i) problem statement

ii) literature readings

iii) work planning (see next slide)

Workplan suggestion

Session 1: Project presentation - problem statement, readings, workplan

Session 2: Explain by own words the algorithm. Get, visualize and represent robot sensor data

Session 3: Develop and validate in micro-simulator (generate synthetic data from models)

Session 4: Validate in real-data

Session 5: Systematic and comparative (w.r.t. baseline) experimentation with quantitative analysis