PROJECTS 2023/24

Instituto Superior Técnico

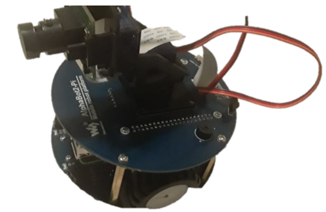
Departamento de Engenharia Electrotécnica e de Computadores

April 2024

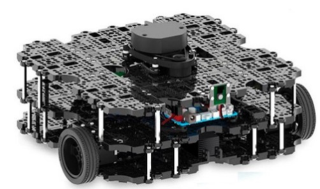
LIST OF AVAILABLE REAL ROBOTS AND DEVICES

Pioneer 3DX (7 units)

AlphaBot2 with camera (40 units)



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.

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

LIST OF TOPICS (REAL ROBOTS)

		7x Pioneer 3DX	5x Turtlebot3	40x 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**	**SKA**
	FastSLAM	**SFP**	**SFT**	**SFA**

PROJECT

14 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)

- **<u>Continuous assessment</u>**: *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, <u>max 20 minutes including presentation (10-15 mins) and Q&A (slides not mandatory but highly recommended)</u>*

- **<u>Project progress presentations during laboratory sessions</u>** *start on 22 April (second week of classes)*

- *Projects presented by faculty on 15 April in the theoretical classes*

<u>Project report and code deadline</u>: **07-Jun-2024**
(6 page IEEE paper template)

<u>Project discussions</u>: **week of 10-Jun-2024**

PROJECT ASSESSMENT AND SCHEDULE (2)

	Seg	Ter	Qua	Qui	Sex
08:00					
08:30			L 6.1		L 6.2
09:00		L 2.1	LSDC1		LSDC1
09:30		LSDC1			
10:00	T1		T1		L 5.2
10:30		L 4.1			LSDC1
11:00	Fa1	LSDC1	Ea1		
11:30	PL		PL		
12:00	L 2.2	L 5.1			
12:30	LSDC1	LSDC1			
13:00					L 3.2
13:30	L 3.1				LSDC1
14:00	LSDC1				
14:30					
15:00		L 4.2			
15:30		LSDC1			
16:00					
16:30					
17:00					
17:30					
18:00					
18:30					
19:00					

PROJECT ASSESSMENT AND SCHEDULE (3)

		Session				
Shift	**Slot**	**1**	**2**	**3**	**4**	**5**
2	1	23-April	7-May	14-May	21-May	28-May
	2	22-April	6-May	13-May	20-May	27-May
3	1	22-April	6-May	13-May	20-May	27-May
	2	26-April	10-May	17-May	24-May	31-May
4	1	23-April	7-May	14-May	21-May	28-May
	2	23-April	7-May	14-May	21-May	28-May
5	1	23-April	7-May	14-May	21-May	28-May
	2	26-April	10-May	17-May	24-May	31-May
6	1	24-April	8-May	15-May	22-May	29-May
	2	26-April	10-May	17-May	24-May	31-May

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 15 April 17:00 to 17 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