

BASICS of MOBILE ROBOTICS 0

Introduction

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What is a Mobile Robot? Definition for this course

Definitions: not a clear consensus

- A machine that senses, thinks, and acts. (G.A. Bekey, 2005)
What does “think” mean?
- Oxford English Dictionary : “A machine capable of carrying out a complex series of actions automatically, especially one programmable by a computer.”
What does “complex” mean?

Robots that are not “mobile” will not be tackled in this course, e.g.:

- Industrial robots
- Torsos
- Prostheses

What Kind of Mobile Robots?

Wheeled Robots



Thymio (EPFL)



Roomba (iRobot)



Uranus (CMU)

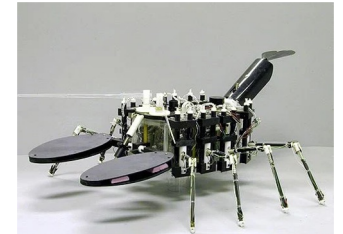
Walking and Running Robots



BigDog (Boston Dynamics)



Asimo (Honda, Japan)



Lobster robot (U of Northeastern USA)

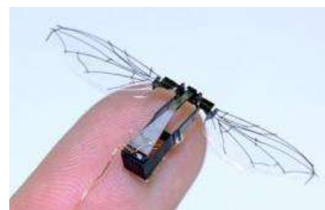
Flying Robots



Hummingbird (AeroVironment)



Dragon fly (WowWee HK)



Micro aerial vehicle, Harvard

Swimming and Crawling Robots



G6 Fish Robot, University of Essex



Penguin Robot (Festo, Germany)



Snake Robot (CMU, USA)

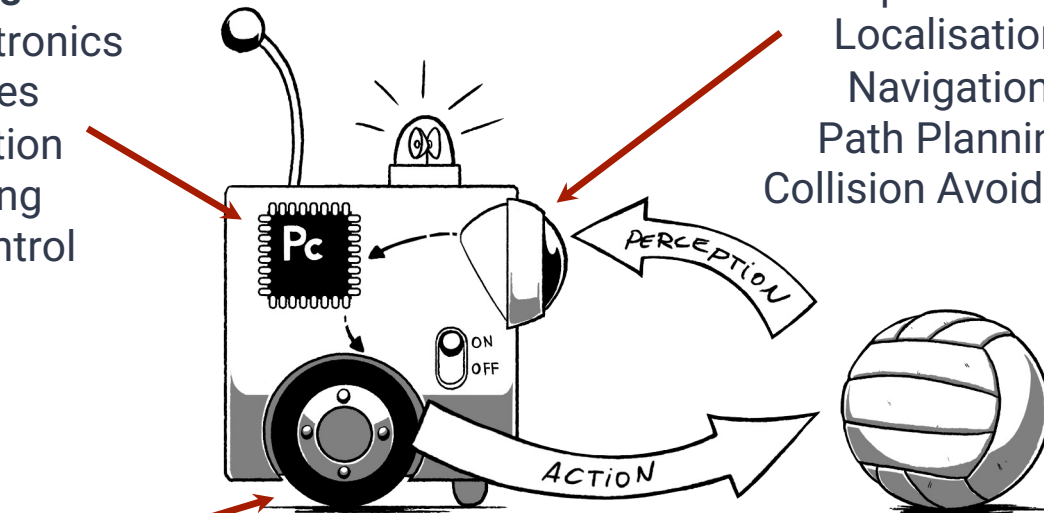
Aspects of Mobile Robotics

System Integration

Processors
Embedded electronics
Architectures
Communication
Programming
Real-time Control

Mechanics
Actuators
Energy
Locomotion

Sensors Integration
Computer Vision
Localisation
Navigation
Path Planning
Collision Avoidance



Course Objectives

1. Get an overview of the mainstream engineering techniques involved in mobile robot development.
2. Get a **deeper understanding** of a subset of techniques, presented more in detail in the course, addressed in the exercises and revised in the case studies.
3. Acquire hands-on experience in mobile robotics by means of practical laboratories on a real robot and a graded project.
4. Acquire transversal skills in group work.
5. Learn to use chatbots as supporting tools.
6. **It's not the destination, it's the journey that matters.**

Course Objectives: deeper understanding

1. The goal of this course is **not** to equip you with a set of formula that you can apply in predefined context and forget after the course
2. The idea here is to explain to you the concepts in the **course**, let you experiment and go deeper in details during the **exercices** (formula included)
3. Train (and check) your deeper understanding with real situations using **case studies**.

Course Topics (with project)

Week 1 (9.9)	Components of a mobile robot	Week 8 (4.11)	Uncertainties (+ team building)
Week 2 (16.9)	Vision	Week 9 (11.11)	Localisation 2 + Project week 1
Week 3 (23.9)	Vision & ANN & ML	Week 10 (18.11)	Project week 2
Week 4] (30.9)	Navigation	Week 11 (25.11)	Project week 3
Week 5 (7.10)	Navigation	Week 12 (2.12)	Project week 4 + Project presentations
Week 6 (14.10)	Localisation 1 (+ team survey)	Week 13 (9.12)	Project presentations
<i>Week of holidays between week 6 and 7</i>			
Week 7 (28.10)	Uncertainties (no class, recorded lesson)	Week 14 (16.12)	Project presentations + Conclusion + Mock Exam

Weekly Course Organisation

- ❖ 15:15-16:00 **Case studies** on the topics seen and trained the week before
- ❖ 16:15-17:00 **Lecture (zoom connection available)**
 - ◆ One global topic
 - ◆ An overview on several techniques related to the topic
 - ◆ Some techniques in more detail
 - ◆ When needed, one numerical example
- ❖ 17:00-19:00 **Exercises + project** (in presence, compulsory) with Python and the Thymio robot.
Assignments on Moodle
<https://moodle.epfl.ch/course/view.php?id=15293>



The course is continuously restructured and adapted, so please be patient 😊 and feedback is always welcome! (see moodle)

Course Organisation

Slides + video on Moodle: <https://moodle.epfl.ch/course/view.php?id=15293>

Enrollment: automatic self-enrolment

Feedback: every week on moodle, anonymous

Case studies: slides presenting the cases on moodle, interactive discussion, more case studies with a chatbot

Exercises: every week on moodle, solution published Friday morning

Project: last part of the semester replacing the exercises

Thymio robot: one for each student for the whole semester

Chatbot tutor: for exercises and project

Course Organisation

Thymio robot : in the past we asked a 50CHF retainer and we lost money and robots. We will not do that anymore.

We apply a simple rule:

- normally the project grade is published ASAP after the project defenses.
- This year we will not publish the grades until ALL Thymio are back, but we will publish the names of students not returning Thymio.

Distribution of Thymios during the exercises of week 1.

Course Material

References :

- **Mobile Robots Course** - EPFL - J.-C. Zufferey, Felix Schill, 2013
- **Introduction to Autonomous Mobile Robots** R. Siegwart, I. Nourbakhsh, and D. Scaramuzza, MIT Press, 2011.
- **Elements of Robotics**, M. Ben-Ari, F. Mondada, Springer, 2018. (free download!)
- **Autonomous Robots: From Biological Inspiration to Implementation and Control** G.A. Bekey, MIT Press, 2005.
- **Probabilistic Robotics** S. Thrun, W. Burgard and D. Fox, MIT Press, 2005.
- **Springer Handbook of Robotics** B. Siciliano, and O. Khatib (Eds.), 2nd edition, Springer, 2016.



Control theory if you missed it until now

“Control systems + TP “ by Colin Jones, on EPFL moodle (lessons 1 to 3 and 7)

<https://moodlearchive.epfl.ch/2021-2022/course/view.php?id=13758>

Or: “Control of Mobile Robots” by Prof. Magnus Egerstedt - 1.1 to 1.7

<https://www.youtube.com/watch?v=aSwCMK96NOw>

<https://www.youtube.com/watch?v=Nb9YPyVTNgs>

<https://www.youtube.com/watch?v=yyE0Y9wvmlw>

https://www.youtube.com/watch?v=n_N9HS0JY6Q

<https://www.youtube.com/watch?v=DJuo9kLdr4M>

<https://www.youtube.com/watch?v=cQhqx65kLfM>

<https://www.youtube.com/watch?v=Mk1ygHj4zxw>

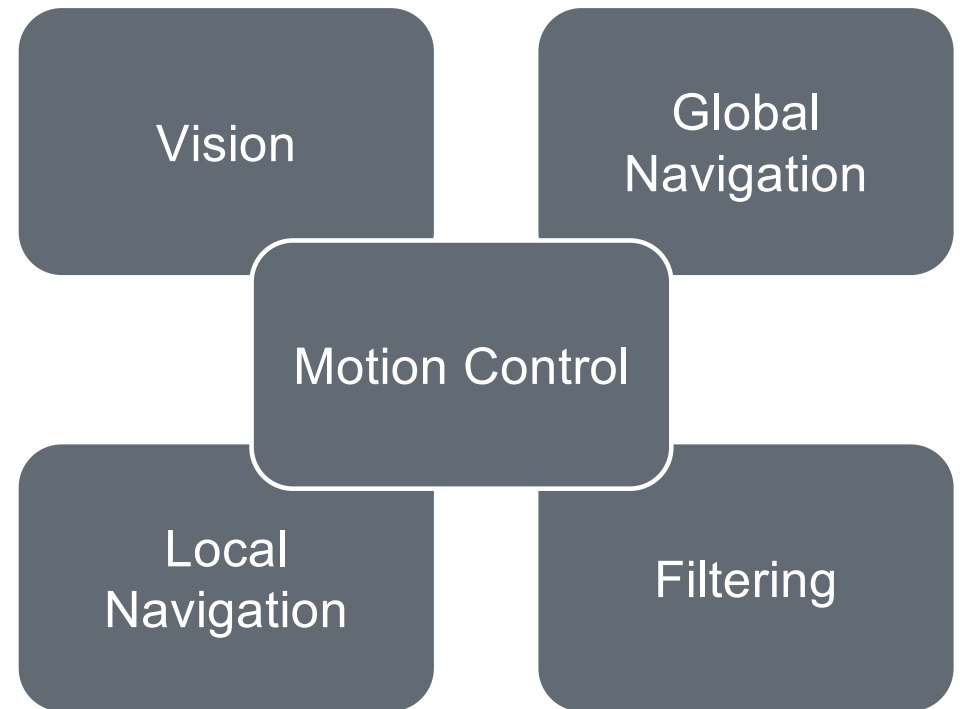
Evaluation

In 2 parts

- ❖ **60% Project** on one of the topics seen during the semester + the exercise sessions, in group of 4 people (in presence, compulsory!)
- ❖ **40% Written (digital) exam** during the winter examination session. Composed of 10 case studies (multiple choice answer + **explanation**)

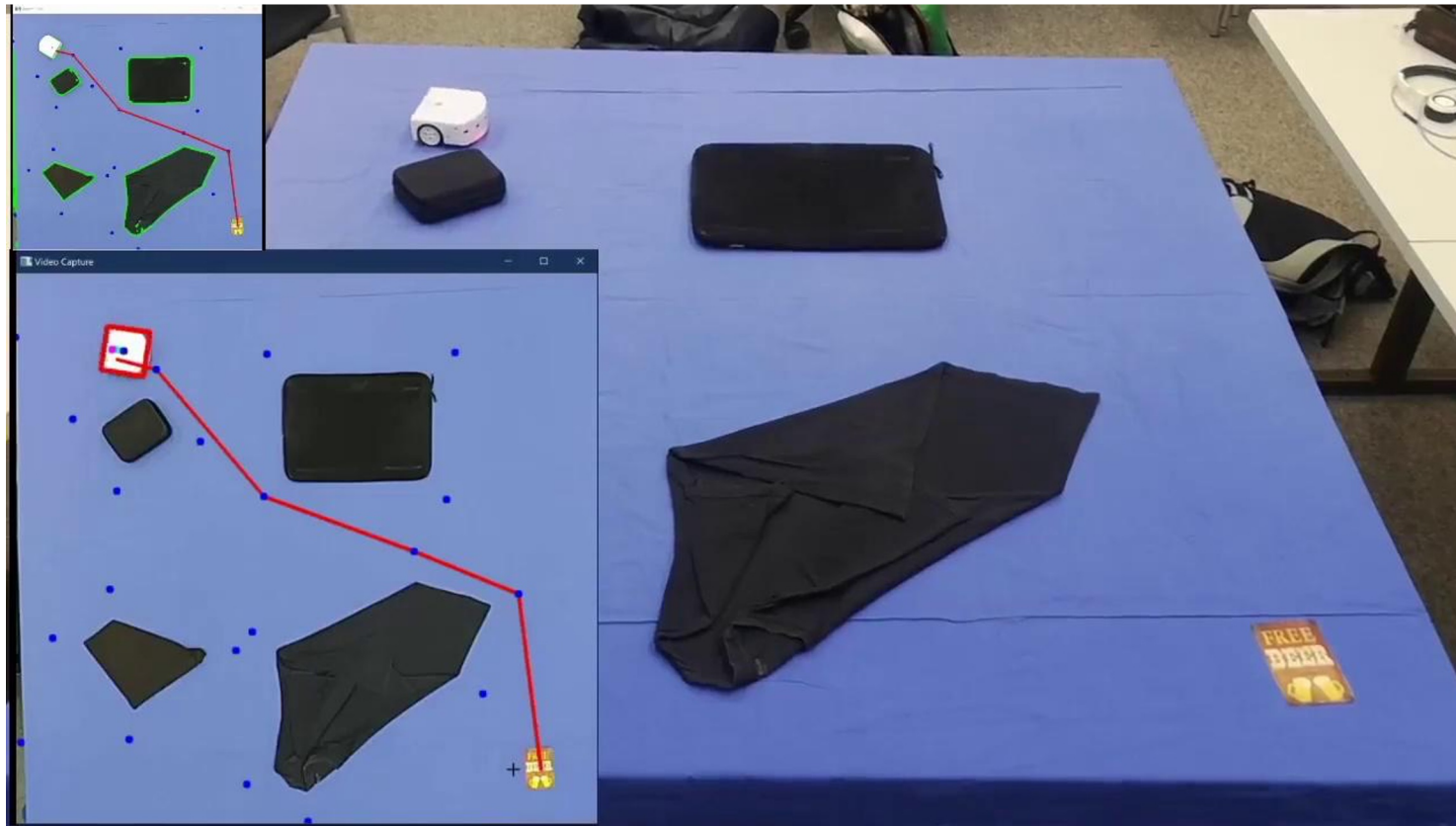
Project Information

- Groups of 4 students (**randomized!**) created in week 8
- 4 weeks without exercise sessions (weeks 9-12) to work on it, note that there will be a full lecture week 9 and a case study week 10.
- TAs available from 17:15 - 19:00 on Tuesdays
- Please use the forum, to allow everybody to benefit from the response.
- Training / development of group working skills
- Presentation of the project in weeks 12 to 14



Components that are required for the project

Examples from Autumn 2019–2020



<https://www.youtube.com/watch?v=UDhiHIIIJEQ>

Core Robotics Labs at EPFL (robotics.epfl.ch)

STI-LIS (Prof. D. Floreano): Flying robots, swarm robotics, bio-inspired A.I.

STI-LASA (Prof. A. Billard): Machine learning, imitation, humanoids

STI-BioRob (Prof. A. Ijspeert): Bio-inspired locomotion, biomedical robotics, industrial robotics

STI-Mobots (Prof. F. Mondada): Robot design, miniature mobile robots, educational robotics

STI-RRL (Prof. J. Paik): Robot design, foldable robots

STI-MICROBS (Prof. S. Sakar): Microrobotics

STI-MICROBS (Prof. M. Sakar): MicroBioRobotic Systems Laboratory

STI-CREATE (Prof. J. Hughes): fabrication and computational design tools

ENAC-DISAL (Prof. A. Martinoli): Collective systems

ENAC-VITA (Prof. A. Alahi): Visual Intelligence for transportation

IC-VILAB (Prof. A. Zamir): computer vision, machine learning, and AI <-> robotics