# 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?

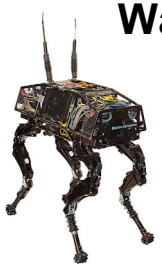
## Wheeled Robots

Thymio (EPFL)

Roomba (iRobot)

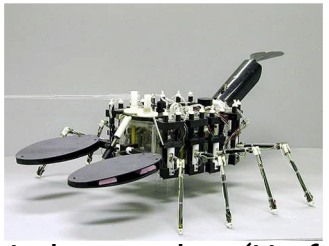
Uranus (CMU)

## Walking and Running Robots



BigDog (Boston Dynamics)

Asimo (Honda, Japan)

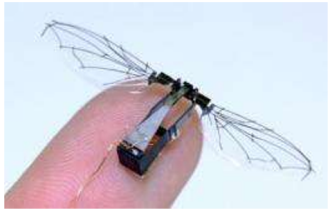


Lobster robot (U of Northeastern USA)

## Flying Robots

Hummingbird (AeroVironment)

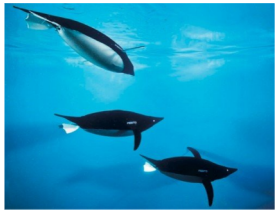
Dragon fly (WowWee HK)



Micro aerial vehicle, Harvard

## Swimming and Crawling Robots

G6 Fish Robot, University of Essex



Penguin Robot (Festo, Germany)

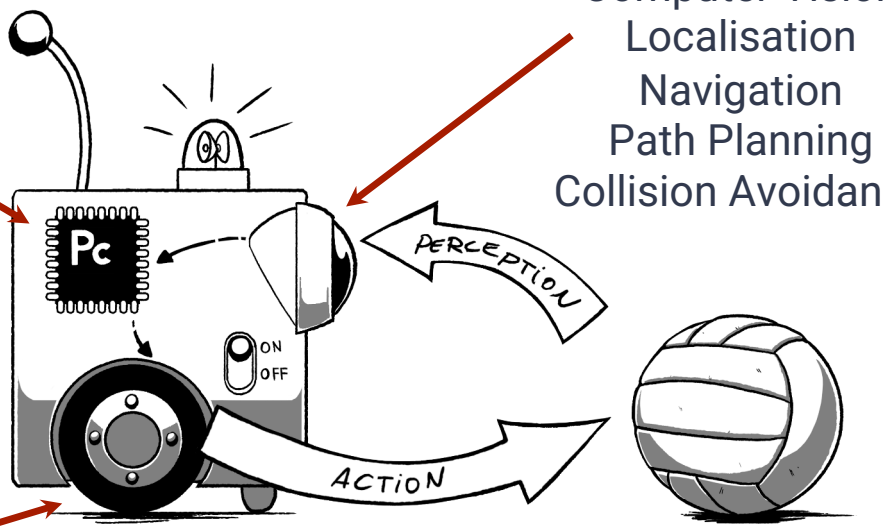
Snake Robot (CMU, USA)

# Aspects of Mobile Robotics

## System Integration

**Processors**
Embedded electronics
Architectures
Communication
Programming
Real-time Control

**Sensors Integration**
Computer Vision
Localisation
Navigation
Path Planning
Collision Avoidance




**Mechanics**
Actuators
Energy
Locomotion

# 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 Topics (with project)

| | | | |
|---|---|---|---|
| **Week 1** | Components of a mobile robot | **Week 8** | Uncertainties (+ team building) |
| **Week 2** | Vision | **Week 9** | Localisation 2 + Project week 1 |
| **Week 3** | Vision & ANN & ML | **Week 10** | Project week 2 |
| **Week 4** | Navigation | **Week 11** | Project week 3 + group work check |
| **Week 5** | Navigation + chatbot | **Week 12** | Project week 4 + Project presentations |
| **Week 6** | Localisation 1 (+ team survey) | **Week 13** | Project presentations + group debriefing |
| **Week 7** | Uncertainties + chatbot | **Week 14** | Project presentations + Conclusion + Mock Exam |

Week of holidays between week 6 and 7

# 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

**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

# 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**

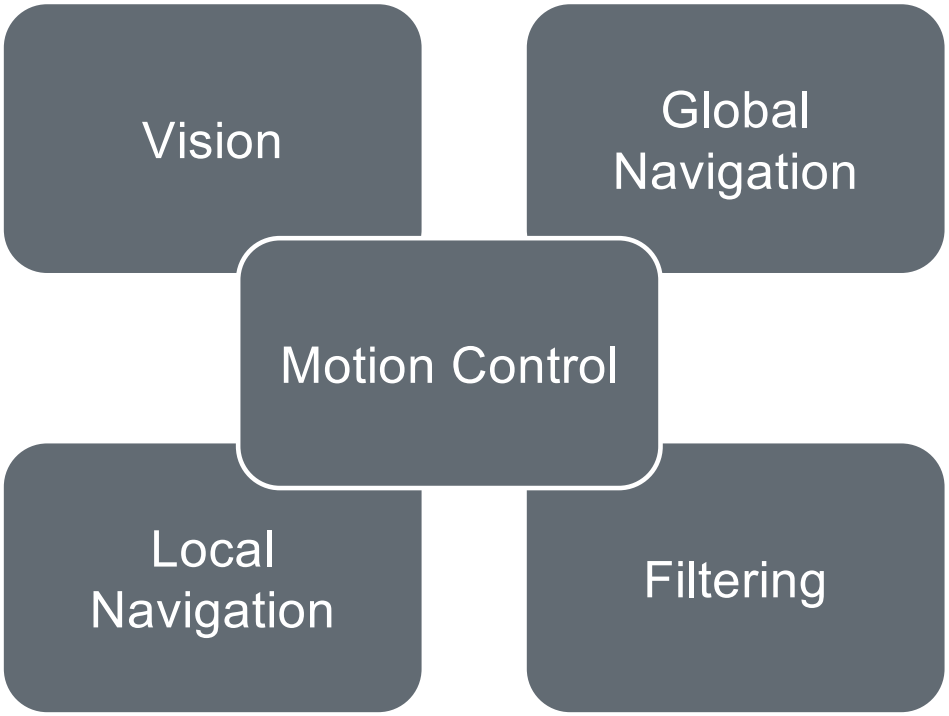
# Evaluation

**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=UDhiHlllJEQ

# 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