



UNIVERSITÉ DE TECHNOLOGIE DE BELFORT-MONTBÉLIARD

# Introduction

RO51 - Introduction to Mobile Robotics

**Zhi Yan**

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<https://yzrobot.github.io/>

[www.utbm.fr](http://www.utbm.fr)

# Lecturers



Zhi Yan  
Assistant Professor  
Module Coordinator



Iaroslav Okunevich  
Ph.D. Student  
Teaching Assistant

Goal of this course:

- Provide an overview of problems and approaches in mobile robotics
- Hands-on experience

## About the course

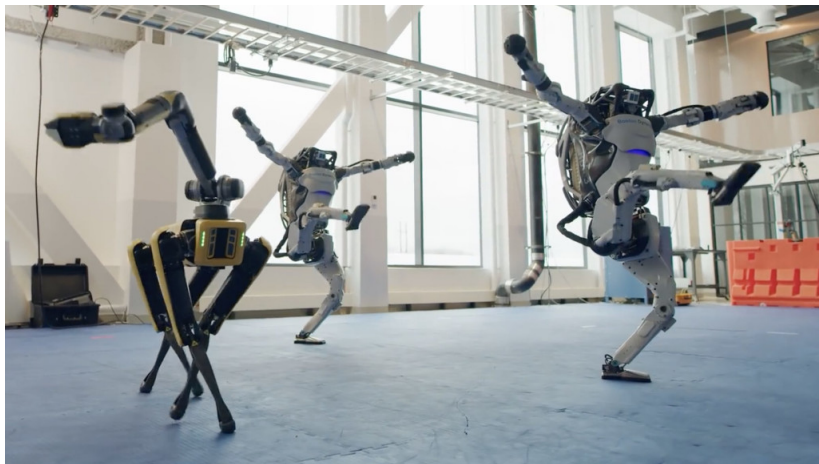
- Created in 2021, covering my 14+ years of experience in mobile robotics:
  - Lecture 1: Introduction
  - Lecture 2: Locomotion
  - Lecture 3: Kinematics
  - Lecture 4: Perception
  - Lecture 5: SLAM (Simultaneous Localization And Mapping)
  - Lecture 6: Exploration
  - Lecture 7: Motion and Task Planning
  - Lecture 8: Navigation (including self-driving car)
  - Lecture 9: Multi-robot Systems
  - Lecture 10: Software for Robotics (especially ROS)
- The course homepage is under construction:  
[https://yzrobot.github.io/introduction\\_to\\_mobile\\_robotics/](https://yzrobot.github.io/introduction_to_mobile_robotics/)  
Welcome to come back for a visit in the future!

## About the course

- CM, TD, TP: face-to-face, in English
- Attendance confirmation: No (study for yourself)
- Following the course requires some math and programming foundation
- Objectives of TD and TP (need and problem oriented):
  - TD (you work with me): identify and understand specific problems
  - TP (I work with you): achieve goals and solve problems
- Mode of examination: midterm exam (handwriting or programming) + final project (including source code, report and defense)

# Mobile Robotics Today

Represented by YouTube celebrity Boston Dynamics:



# What is a robot?

## Origin of Words

The word **robot** was first used in 1921 by Czech author Karel Capek in his science fiction play R.U.R. (Rossum's Universal Robots). It comes from the Czech word "robota", which means "forced labor".

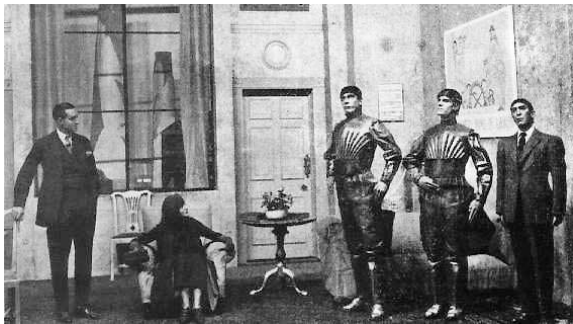


Figure: A scene from the play, showing three robots.

# What is a robot?

## Origin of Words

According to the Oxford Dictionary, a robot is a machine that can perform a complicated series of tasks by itself.

- Definition reflecting to some extent people's expectations for robot autonomy.
- Existing robots have a wider range of manifestations, including but not limited to, fully autonomous, semi-autonomous, and remote controlled.
- The impact of its introduction into the human society on the labor market: a supplement while at the same time generating competition.
- The ethical issues: compliant human ethics, military use, etc.

## Industrial and service robots

According to the International Federation of Robotics (IFR), existing robots can be divided into two categories:

- **Industrial robot:** an automatically controlled reprogrammable multipurpose manipulator, programmable in three or more axes.
- **Service robot:** a robot that performs useful tasks for humans or equipment excluding industrial automation applications.



# Industrial and service robots



Figure: Two different types of robots. Left: industrial robots, where the upper picture shows the first autonomous and programmable modern robot, the Unimate in 1961, and the lower picture shows the KUKA robot cluster deployed on the automobile production line in 1983. Right: HSR service robot manufactured by Toyota in 2017.

# Industrial and service robots

- The first modern robot can be traced back to 1961: Unimate (an industrial robotic arm).
- Industrial robots have been deployed on a larger scale and more widely used than service robots.
- The situation is related to the complexity of the problem the robot addresses.
  - **Robotic arms:** work in constrained workspaces, have absolute measurements of position, not really need to perceive the world around them.
  - **service robots:** operate in unconstrained environments, need external detection to determine position and avoid obstacles.

# Industrial and service robots

- Industrial robotic arms:
  - Save humans from heavy and repetitive tasks.
  - Improve production efficiency and quality.
- Service robots (are placed more expectations):
  - Highly repetitive, risky or unpleasant tasks in a variety of sectors: agriculture, construction, transport, healthcare, firefighting or cleaning services, etc.
  - Something to think about and discuss: *should robots in the future be (over) anthropomorphic (whether in terms of hardware or software design)?*

# Asimov's Three Laws

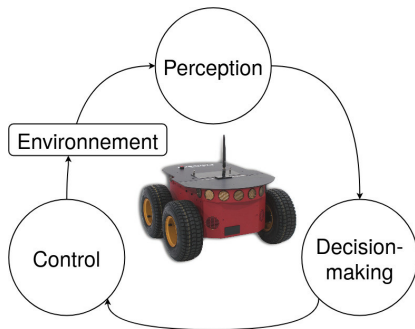
- ① A robot may not injure a human being or, through inaction, allow a human being to come to harm.
- ② A robot must obey the orders given it by human beings except where such orders would conflict with the First Law.
- ③ A robot must protect its own existence as long as such protection does not conflict with the First or Second Laws.

— *short story "Runaround", 1942, by Isaac Asimov*

# Service robots

## Operational definition

- The “sense-think-act” paradigm: perception, decision-making, and control.
- Interaction with the environment in this paradigm can be regarded as an abstract imitation of human activities (I feel (see/smell/listen/touch/etc.), I think, and I react).



# Service robots

## Operational definition

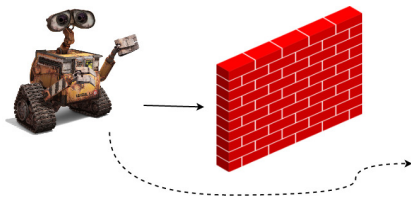
- **Perception**: what looks like around me?
- **Decision-making**: what should I do?
- **Control**: how do I achieve the action?

# Service robots

## An example

When a robot encounters an obstacle while moving autonomously, it:

- **senses (perception)**: there is an obstacle (i.e. a wall) in front of me;
- **thinks (decision-making)**: turn slightly to the right to avoid and go around the obstacle; and ultimately,
- **acts (control)**: adjust the speed of the wheels.



# Service robots

## Current trends

- Entertainment, toys
- Personal services
- Medical, surgery
- Industrial automation
- Hazardous environments
- Self-driving cars
- etc.

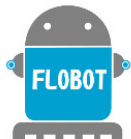
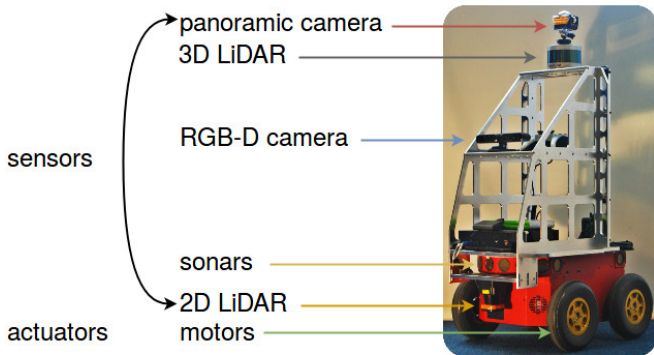


# Mobile robotics

- Mobile robotics is concerned with a fundamental question of service robots, namely, how to move in the physical world.
- Mobile robots typically have to answer three fundamental questions:
  - Where am I?
  - Where am I going?
  - How to get there?
- To answer these questions the robot must:
  - take measurements,
  - model the environment,
  - locate itself,
  - and plan a path to its goal location.

# Mobile robotics

A typical modern mobile robot



# Mobile robotics

## ROS

Since our TD and TP will be based on ROS, we need to briefly introduce some of its basic knowledge first.

- ROS: Robot Operating System
- In 2010, ROS became the de facto standard for robotics software.



Open Source Robotics Foundation

# Mobile robotics

## ROS

### What is ROS?

- A meta-operating system for robots, something between the operating system and the middleware
- A distributed architecture for inter-process and inter-machine communication and configuration
- A collection of software packages and building tools
- A set of development tools for system execution and data analysis

### What is ROS not?

- A real operating system
- A programming language
- A programming environment (like IDE)
- A hard real-time architecture (ROS2 will be)

# Mobile robotics

## History of ROS

- In 2007, ROS was initially developed by the *Stanford Artificial Intelligence Laboratory*.
- From 2008 to 2013, development was carried out mainly by the laboratory *Willow Garage*.
- Since 2013, managed by *Open Source Robotics Foundation* (later became *Open Robotics* in 2017).



# Mobile robotics

## History of ROS

- 13 versions have been released since 2010.
- Naming convention: alphabetical (starting with B because there was an unofficial version of the initial release).
- Noetic: last ROS 1 release, May 2020 - May 2025, our working version.



# Mobile robotics

## ROS2

- As for now ROS is not very popular in the industry, and lacks some of the most important requirements, such as real-time, safety, certification, security.
- One of the goals for ROS2 is to make it compatible with industrial applications.



# Mobile robotics

## ROS Philosophy

- **Reuse:** The main goal of ROS is to support code reuse in robotics research and development.
- **Peer-to-peer:** Individual programs communicate over defined API (*Application Programming Interface, such as ROS messages, services, etc.*).
- **Distributed:** Programs can be run on multiple computers and communicate over the network.
- **Multi-language support:** ROS modules can be written in any programming language for which a client library exists (C++, Python, MATLAB, Java, etc.).
- **Light-weight:** Stand-alone libraries are wrapped around with a thin ROS layer.
- **Free and open-source:** Most ROS software is open-source and free to use.



# Mobile robotics

## ROS Concepts

The ROS architecture has been designed and divided into three sections or levels of concepts:

- **The Filesystem level:** A group of concepts are used to explain how ROS is internally formed, the folder structure, and the minimum number of files that it needs to work.
- **The Computation Graph level:** All the concepts and mechanisms that ROS has to set up systems, handle all the processes, and communicate with more than a single computer, etc.
- **The Community level:** A set of tools and concepts to share knowledge, algorithms, and code between developers.

# Mobile robotics

yzrobot

- `https://github.com/yzrobot`
- `https://www.youtube.com/channel/UChui-GSECJsc4jK5EQmM2Qg`

# The end

Thank you for your attention!

Any questions?