# Introduction to Autonomous Robotics

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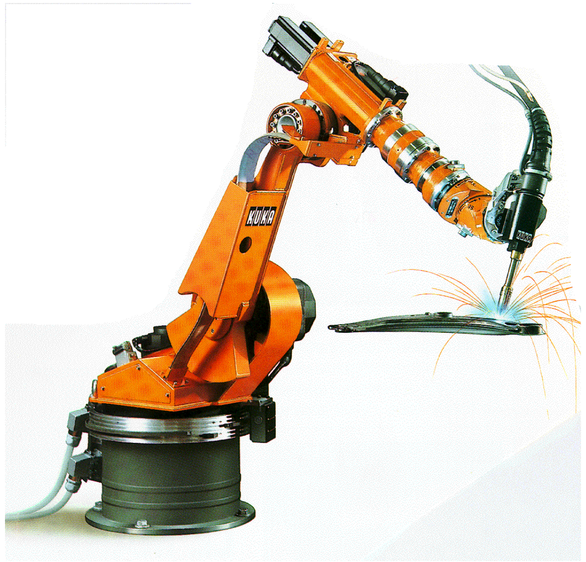
## A definition of "Robot" [Robot Institute of America]:

A robot is a reprogrammable, multifunctional **manipulator** designed to move material, parts, tools, or specialized devices through variable programmed motions for the performance of a variety of tasks.



This refers to **Industrial robots**, which are:

- fixed to the floor → can not change their locations
- very good at what they do, but repeat always the same thing (regardless of the workspace conditions)
- working space is simple and perfectly known

We will not talk about this kind of robots!

**We will cover here a more AI-related perspective of Robotics**

Autonomous mobile robots

Should be able to …

- operate (and move) in an environment where not everything is known a priori
- make intelligent decisions based on sensorial data

# Trends in Robotics

Classical Robotics (mid-70's)
- exact models
- no sensing necessary

Reactive Paradigm (mid-80's)
- no models
- relies heavily on error-free sensing

Hybrids (since 90's)
- model-based at higher levels
- reactive at lower levels

**This will be the focus of this course**

Probabilistic Robotics (since mid-90's)
- seamless integration of models and sensing
- inaccurate models, inaccurate sensors

# Probabilistic Paradigm (for robotics)

The key idea in Probabilistic Robotics is **dealing with the uncertainty** inherent to sensing and motion, which propagates to

- the robot state (e.g. location),
- world representation (mapping) and
- planning and decision making.

## Why

- Deal with inaccurate models of the world and the robot actions
- Deal with errors in sensors
- Robust to real-world changes (moving objects,  unpredicted events, …)

## Limitations

- Computationally demanding
- False assumptions about the probability distributions
- Approximate solutions

# Key questions in robotics

## Where am I?

- What's my position, within the places I already know? (Localization)
- What's in the workspace? Objects, landmarks, free-space (Mapping/SLAM)

## How do I get there (safely)?

- How should I drive to avoid obstacles? (Obstacle avoidance)
- What is the best path to reach the goal? (Path planning)

## How do I solve my mission?

(Task Planning)

# AI and Robotics

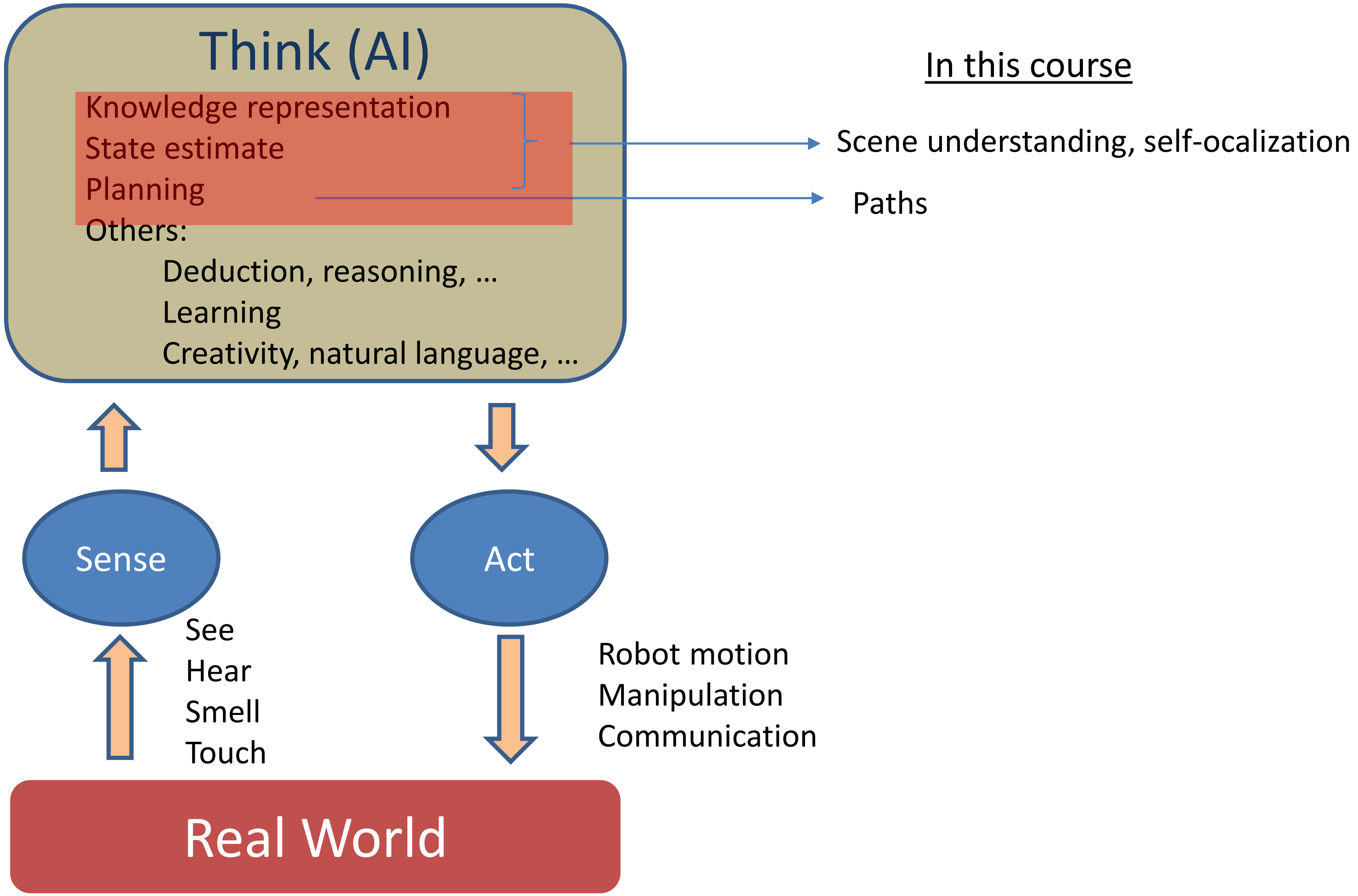
- An intelligent system needs "embodiment"
- Just software is not enough

Embodiment entails both:

- Change the world (e.g. move) and
- Perceive the world

Robotics connects an AI system to the world using a **sensory-motor system**

# AI and Robotics



# Related disciplines

Robotics involves many transversal disciplines

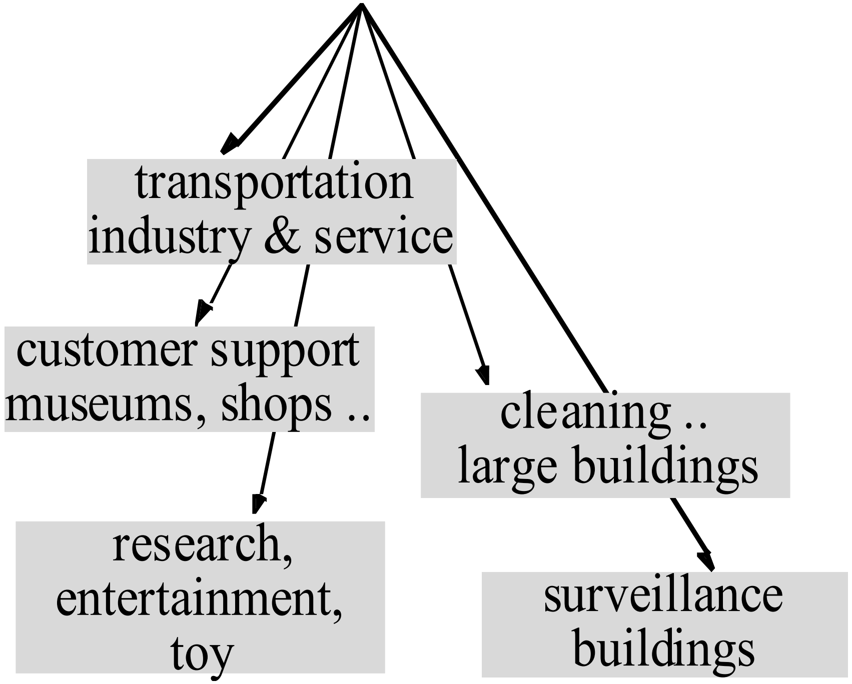
- Machine Learning
- Cognitive Science
- Computer Vision
- Mechanical Engineering
- Control theory
- Software engineering

AI-related

# Applications of Mobile Robots

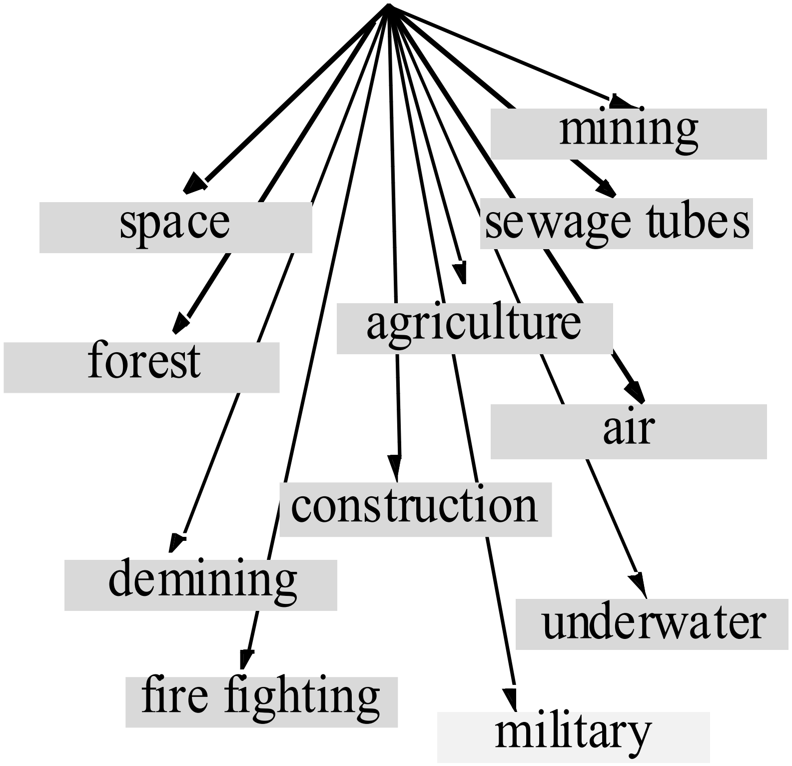
## Indoor

Structured Environments




## Outdoor

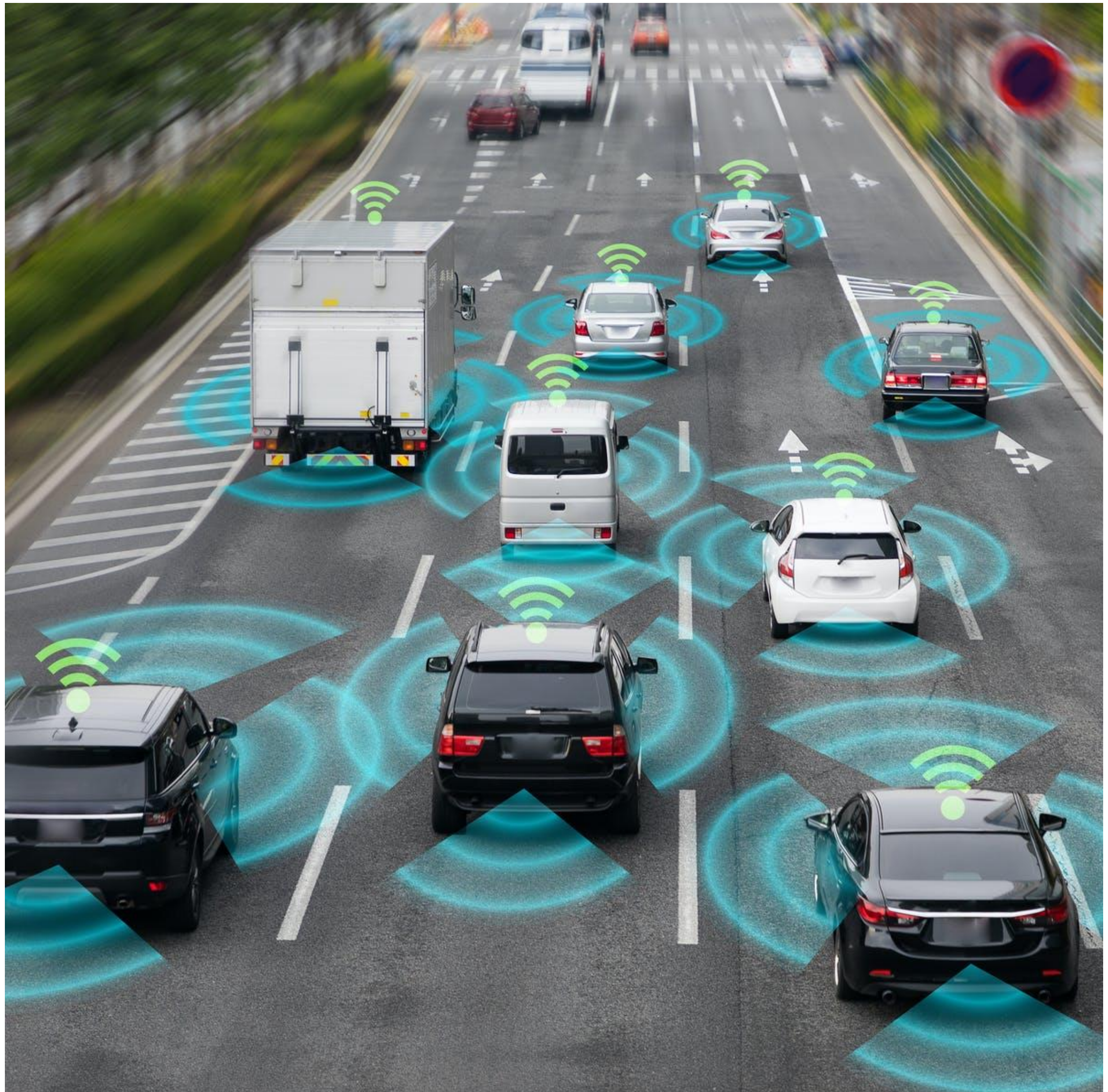
Unstructured Environments



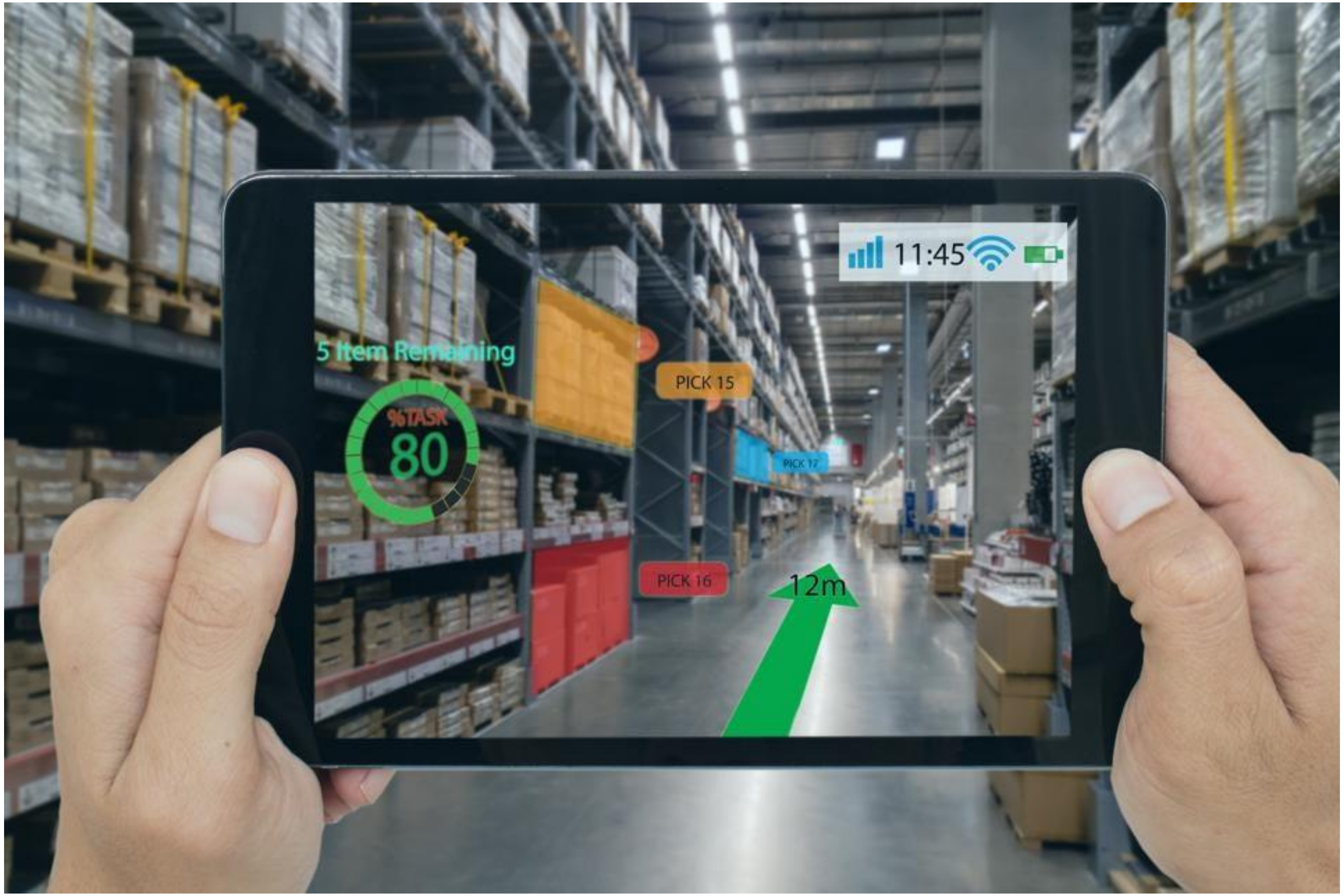
In this course we'll learn algorithms and techniques behind these emerging applications

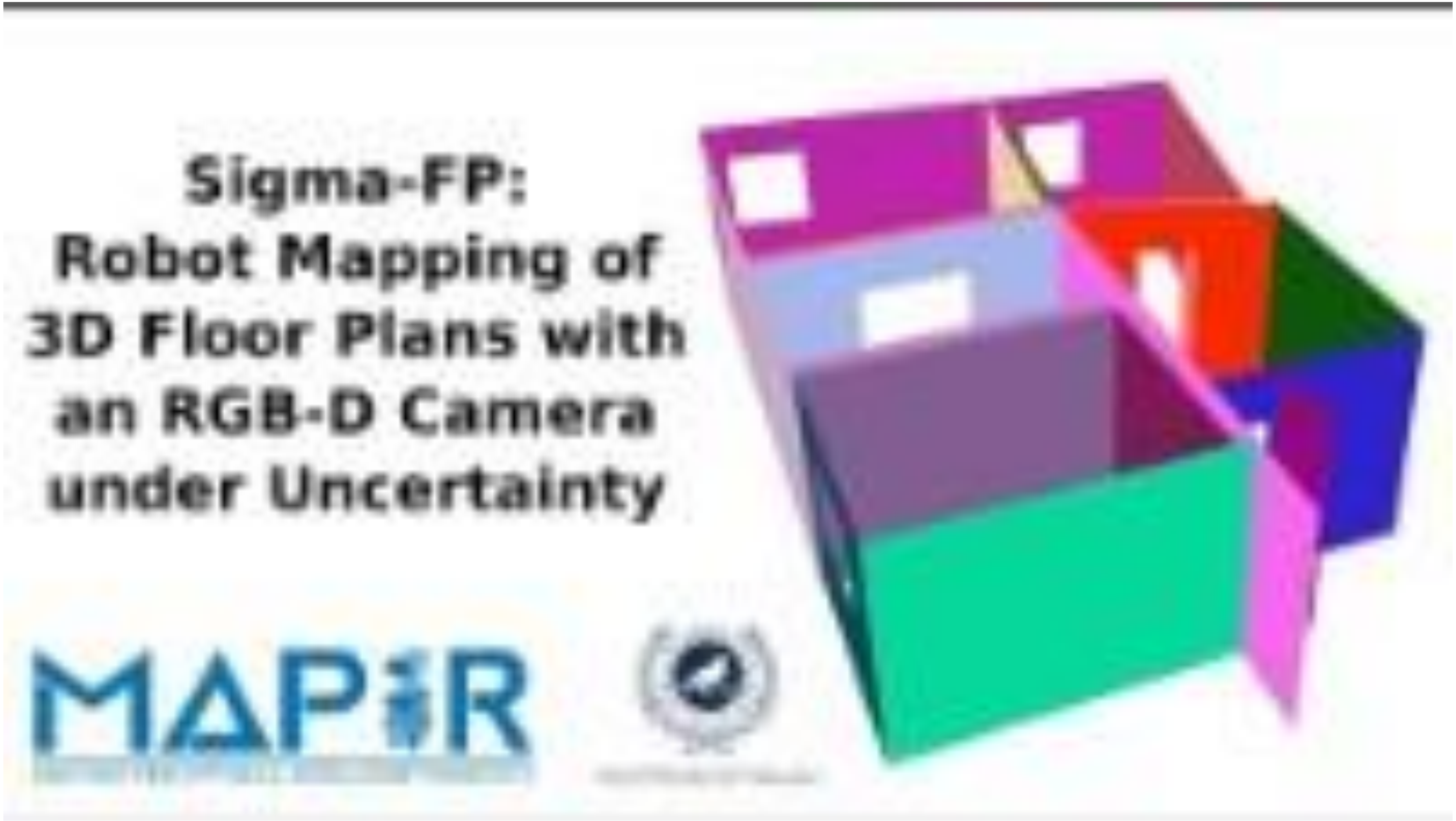
Autonomous vacuum cleaners

# Autonomous cars



# Augmented reality





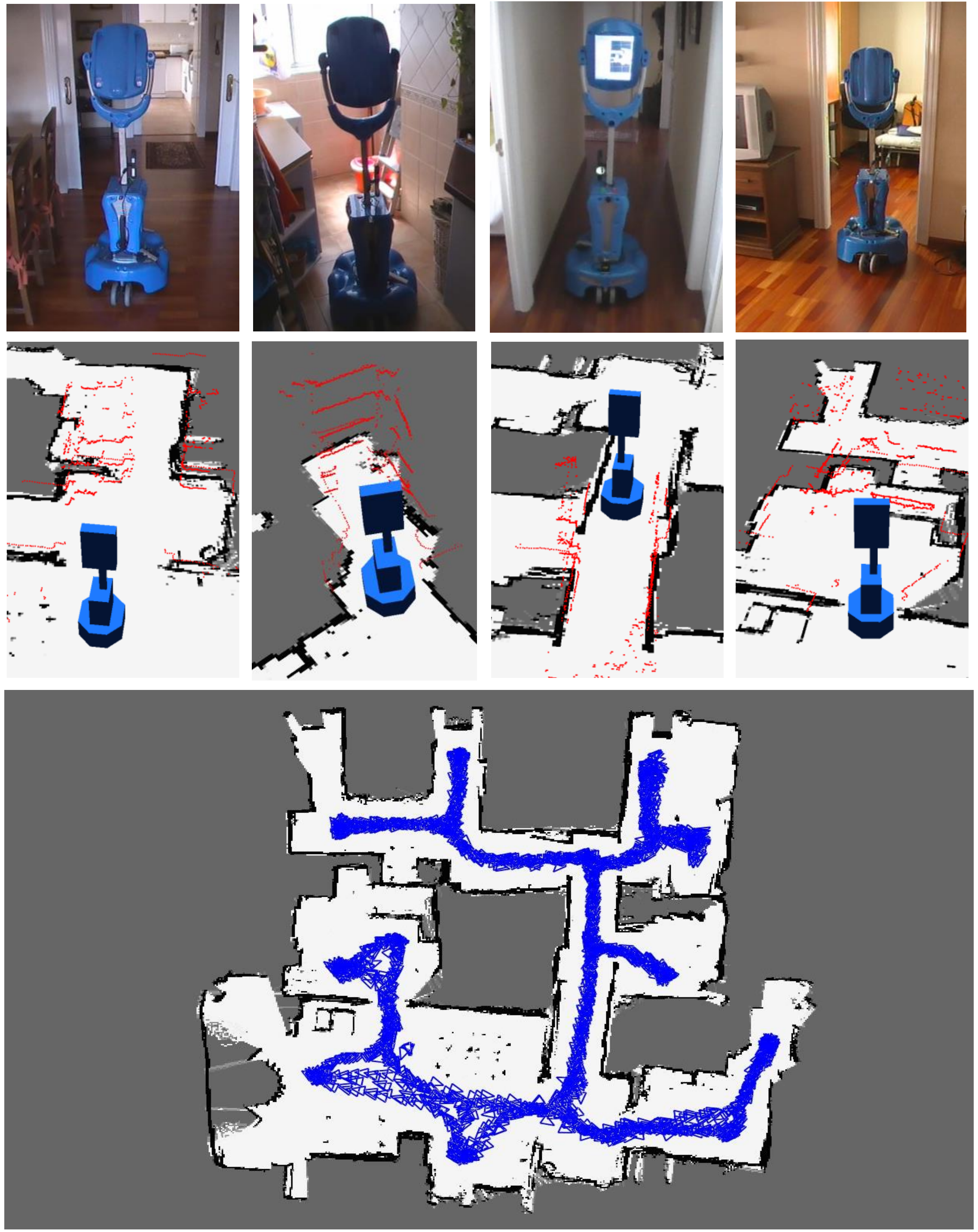

https://www.youtube.com/watch?v=7aaD1H4IXb8


https://www.youtube.com/watch?v=uF0VXeY2_Oo

# MAPIR-UMA

(http://mapir.isa.uma.es)

The robot **Giraff**



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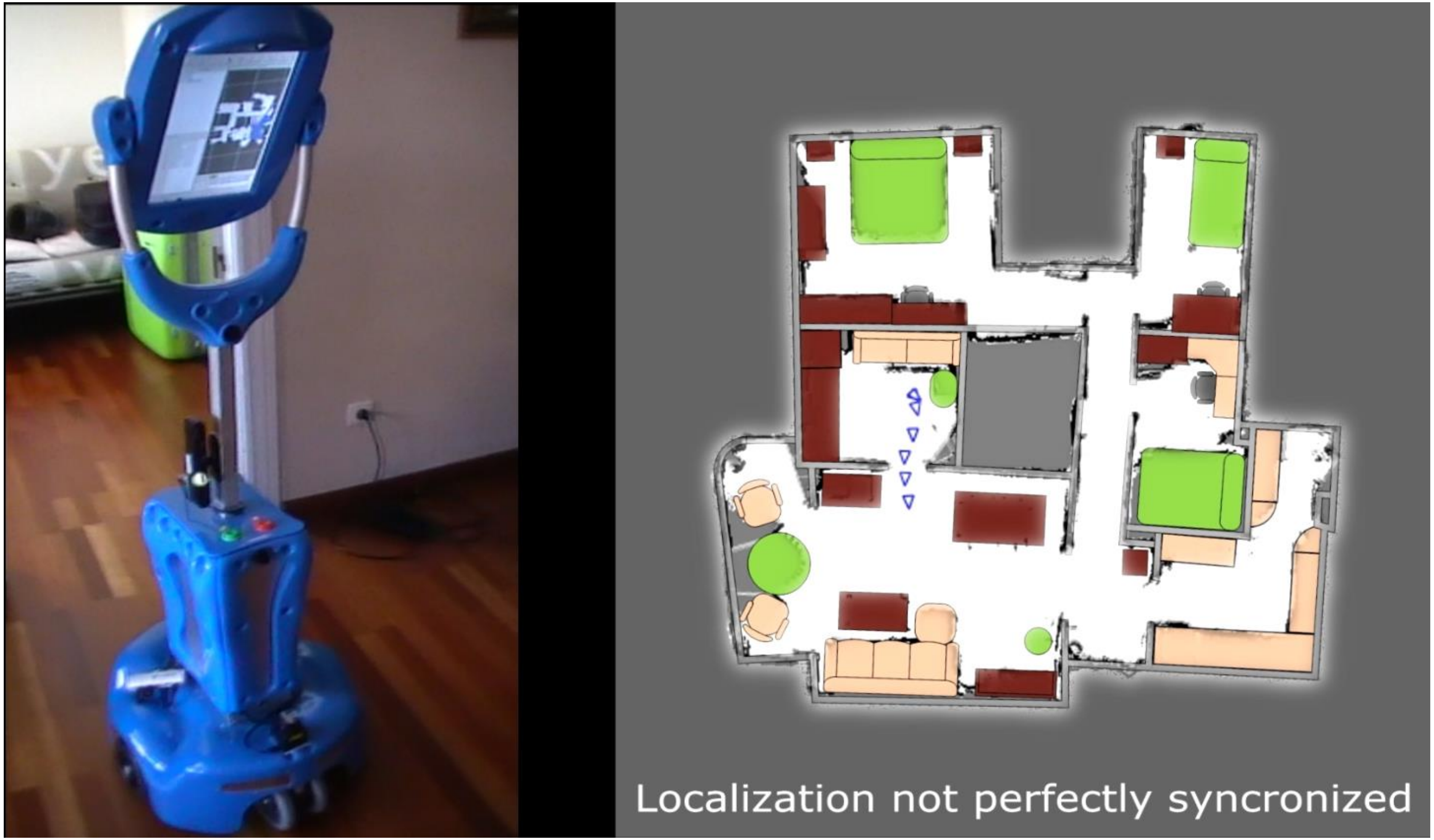

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The robot **Rhodon**

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# The robot Rhodon

http://www.youtube.com/watch?v=BsQMewX8yNQ

# Syllabus

1. Introduction to Autonomous Robotics (this lecture)
2. Probability Basis for Robotics
3. Robot motion models
4. Robot sensors
5. Mobile Robot Localization
6. Mapping
7. SLAM
8. Motion planning
9. Robot Control Architecture

# Evaluation

**Exam: 60 %**

- Two exams (based on test questionnaires)
- Includes questions on theory and practical sessions
- 4.5/10  needed to pass the course (mínimum 4/10 in each exam)

**Practical sessions: 40 % (Compulsory)**

- Quality and completeness of the practical sessions