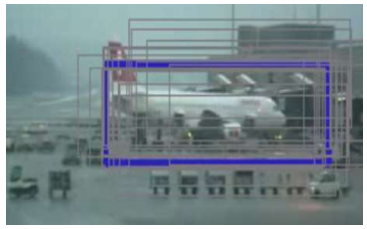
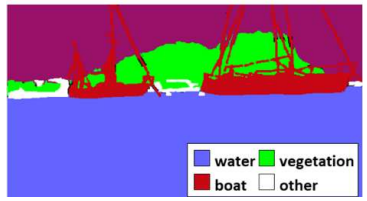
UNIVERSITÀ di VERONA | Dipartimento di INFORMATICA

Laurea magistrale in Ingegneria e scienze informatiche





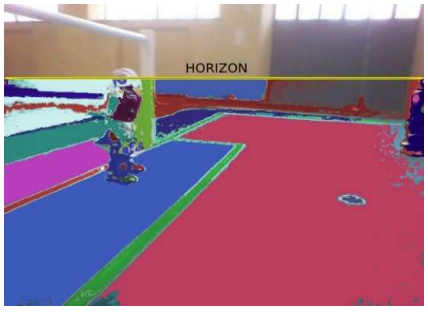





# Introduzione

*Corso di Robotica*
*Parte di Laboratorio*

Docente:
Domenico Daniele Bloisi


*Ottobre 2017*

# Domenico Daniele Bloisi

- Ricercatore RTD presso il Dipartimento di Informatica dell'Università di Verona
  profs.scienze.univr.it/~bloisi
- Team manager SPQR Robot Soccer Team presso il Dipartimento di Informatica, Automatica e Gestionale Università degli studi di Roma "La Sapienza"
  www.dis.uniroma1.it/~bloisi
- Interessi di ricerca: intelligent surveillance, multi-sensor data fusion, image processing, robotic vision, steganography

# Ricevimento

- In aula, subito dopo le lezioni
- Su appuntamento (da richiedere tramite invio di una email) presso:
  Ca' Vignal 2, I piano, stanza 1.63A

Email: domenico.bloisi@univr.it

# Il corso

- Home page del corso → qui
- Docenti: Prof. Paolo Fiorini (coordinatore)
  ing. Domenico Daniele Bloisi
- Periodo: I semestre ottobre 2017 – gennaio 2018

Teoria → Mercoledì 11:30-14:30 (Laboratorio Ciberfisico),
Laboratorio → Giovedì 9:30-11:30 (Laboratorio Ciberfisico)

Web page della parte di laboratorio
http://profs.scienze.univr.it/~bloisi/corsi/robotica.html

# Programma della parte di Laboratorio

## Parte I – Robot Mobili

- Legged Robots
- Wheeled Robots

## Parte II – Cinematica per Robot Mobili

## Parte III - Percezione

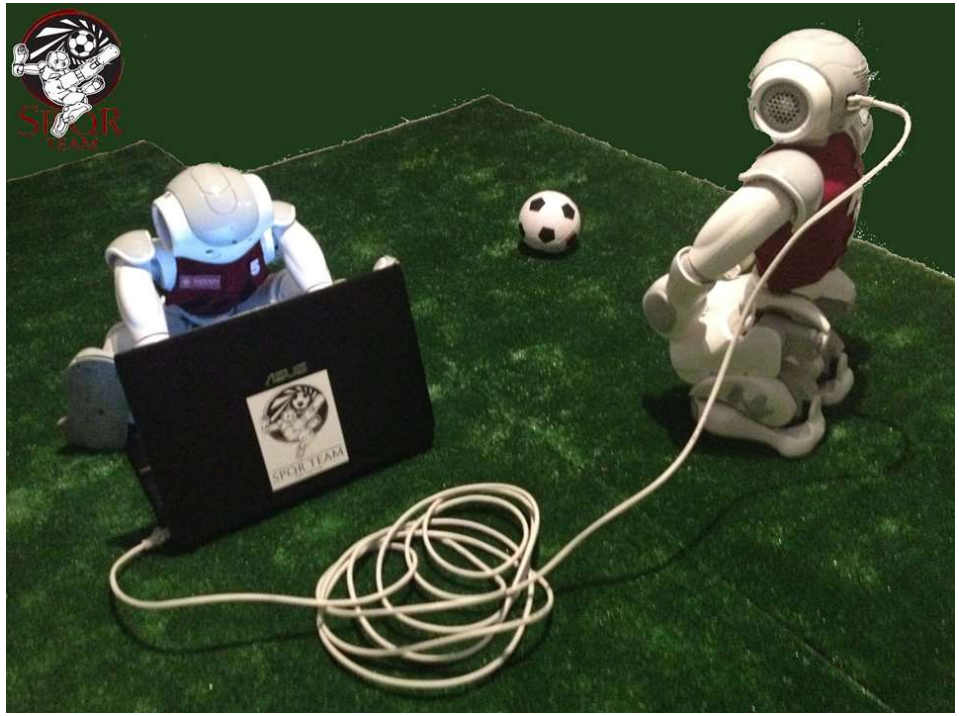
- Sensori
- Tecniche di Visione Artificiale

## Parte IV – Localizzazione

- Cenni di SLAM

## Parte V – Pianificazione e Navigazione

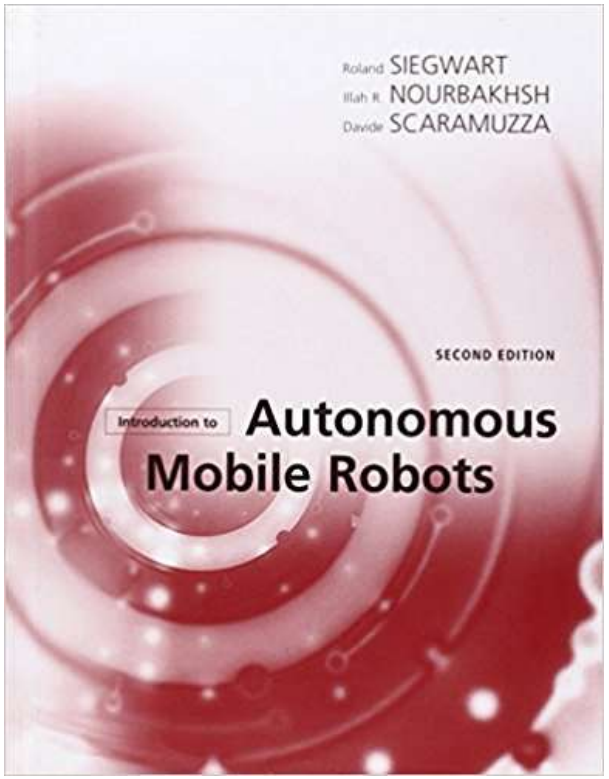
- Obstacle Avoidance



# Libro di Testo

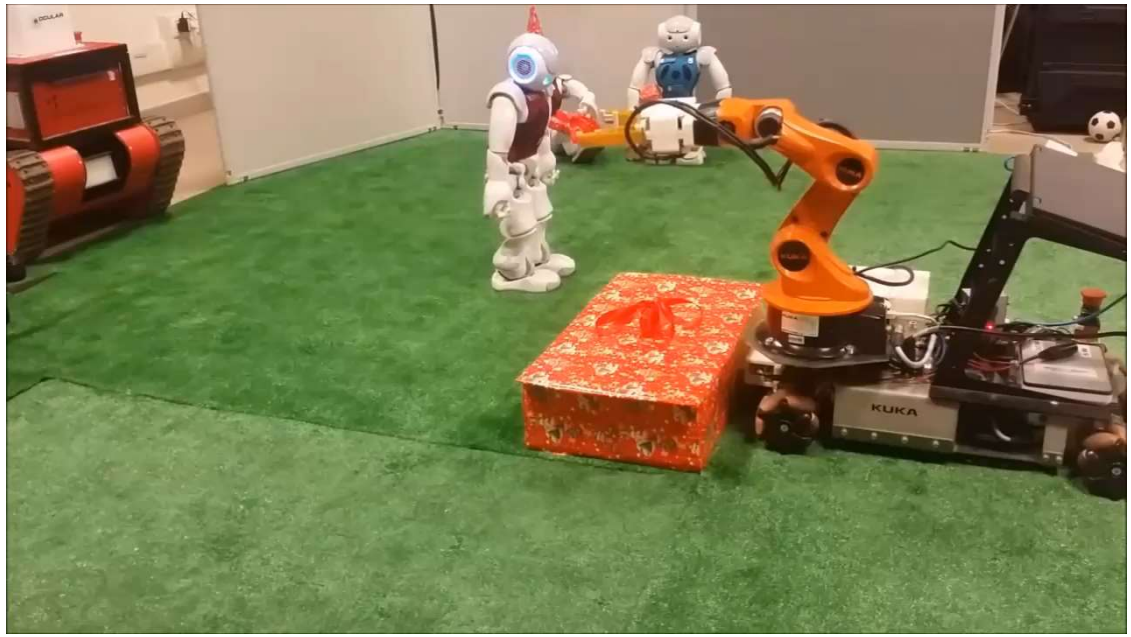
Roland Siegwart, Illah Nourbakhsh, Davide Scaramuzza
Introduction to Autonomous Mobile Robots
2nd Edition
The MIT Press 2011

Book web page
http://www.mobilerobots.ethz.ch/



# Obiettivo del corso

- Obiettivo del corso è la descrizione dei concetti fondamentali dell'analisi, controllo e programmazione di sistemi robotici.
- In particolare, verranno presi in considerazione veicoli autonomi e manipolatori.



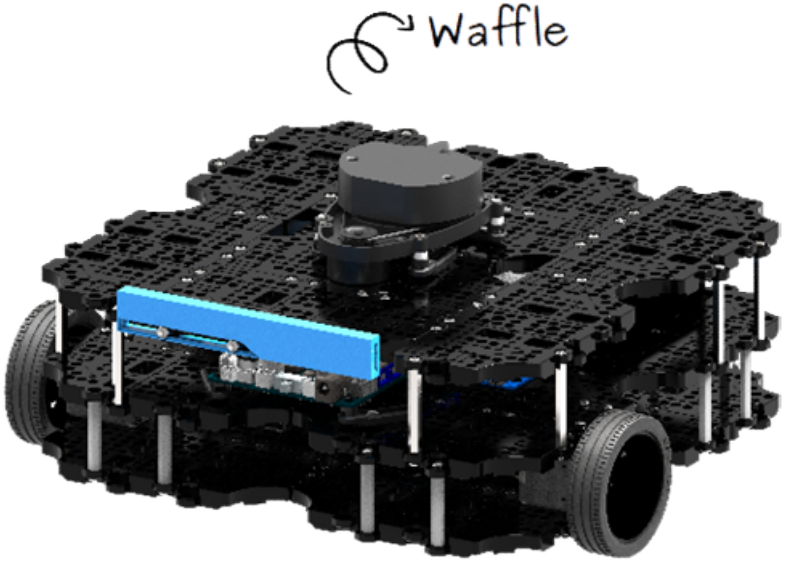

https://www.youtube.com/watch?v=l9KYJlLnEbw

# Esame

L’esame consiste nella realizzazione di un progetto finale.
Si potrà sviluppare una propria idea nell'ambito della robotica
e condurre simulazioni ed esperimenti sul proprio progetto.
La piattaforma robotica di sviluppo è il robot Turtlebot 3

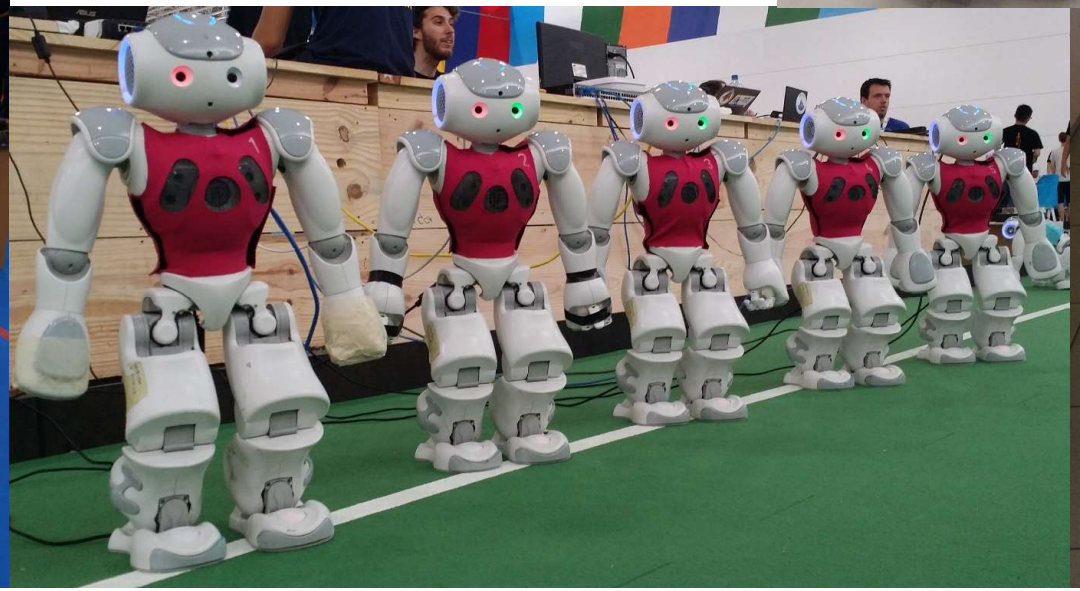
TURTLEBOT3

http://www.turtlebot.com/



# Parte I

# Robot Mobili



# Hard Easy Problems

"The main lesson of thirty-five years of AI research is that the hard problems are easy and the easy problems are hard.
The mental abilities of a four year-old that we take for granted – recognizing a face, lifting a pencil, walking across a room, answering a question – in fact solve some of the hardest engineering problems ever conceived."

STEVEN PINKER, The Language Instinct

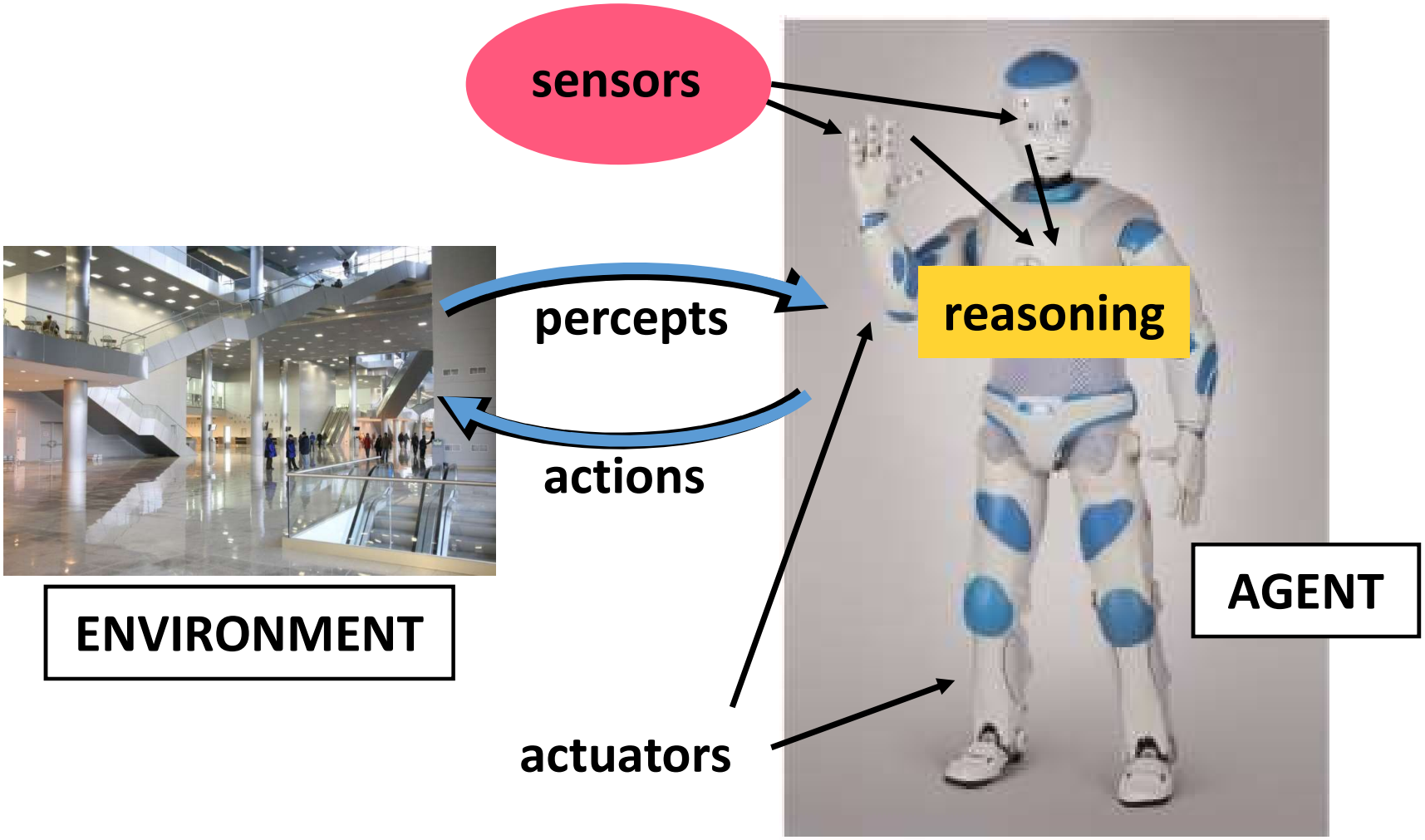
# Esempio iCub

**3D Stereo Estimation and Fully Automated Learning of Eye-Hand Coordination in Humanoid Robots**

S.R. Fanello, U. Pattacini, I. Gori, V. Tikhanoff,
M. Randazzo , A. Roncone, F. Odone and G. Metta


Link al video: https://www.youtube.com/watch?v=mQpVCSM8Vgc

# Perceive-Reason-Act Cycle



# Robot mobile autonomo

- **Autonomia**: capacità di portare a termine un compito basandosi sullo stato e sulle percezioni correnti, senza intervento umano.

- **Sistema autonomo**: un sistema che prende decisioni da solo, agendo senza la guida di un umano.

- **Robot mobile autonomo**: sistema robotico autonomo capace di muoversi nell'ambiente.

Prestes et al. 2013 "Towards a core ontology for robotics and automation"
Ambrose et al. 2010 "NASA Robotics, Tele-Robotics and Autonomous Systems Roadmap"

# Stato di un robot

**Modello del Mondo**

- Geometria
- Traversabilità
- Altri oggetti in movimento
- …

**Configurazione**

- Cinematica
- Dinamica
- Livello delle batterie
- …


image from
https://www.extremetech.com

# Autonomous Cars

Waymo
formerly the Google self-driving car project
https://waymo.com/

Tesla
full self-driving capability
https://www.tesla.com/models

# Sensori Laser 3d

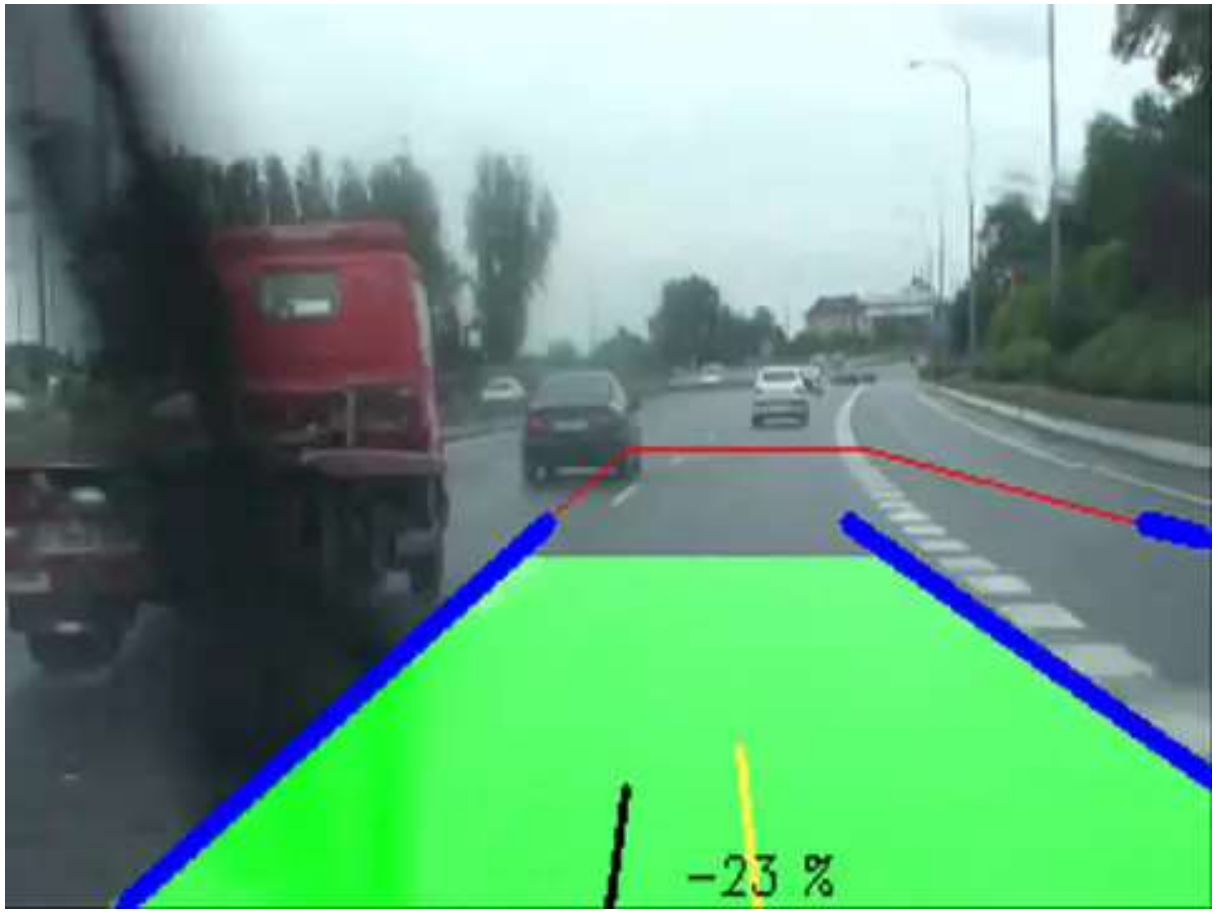

Google Self-Driving Car Project (estate 2015)

- Più di 20 veicoli in uso
- Più di 2,7 mln km, 1.5 mln km in modalità autonoma
- 11 incidenti

# Telecamere

Detection e tracking di

- Corsie
- Segnali stradali
- Altri veicoli




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

# Domande chiave nella Robotica Mobile

- Dove sono?
- Dove sto andando?
- Come ci arrivo?

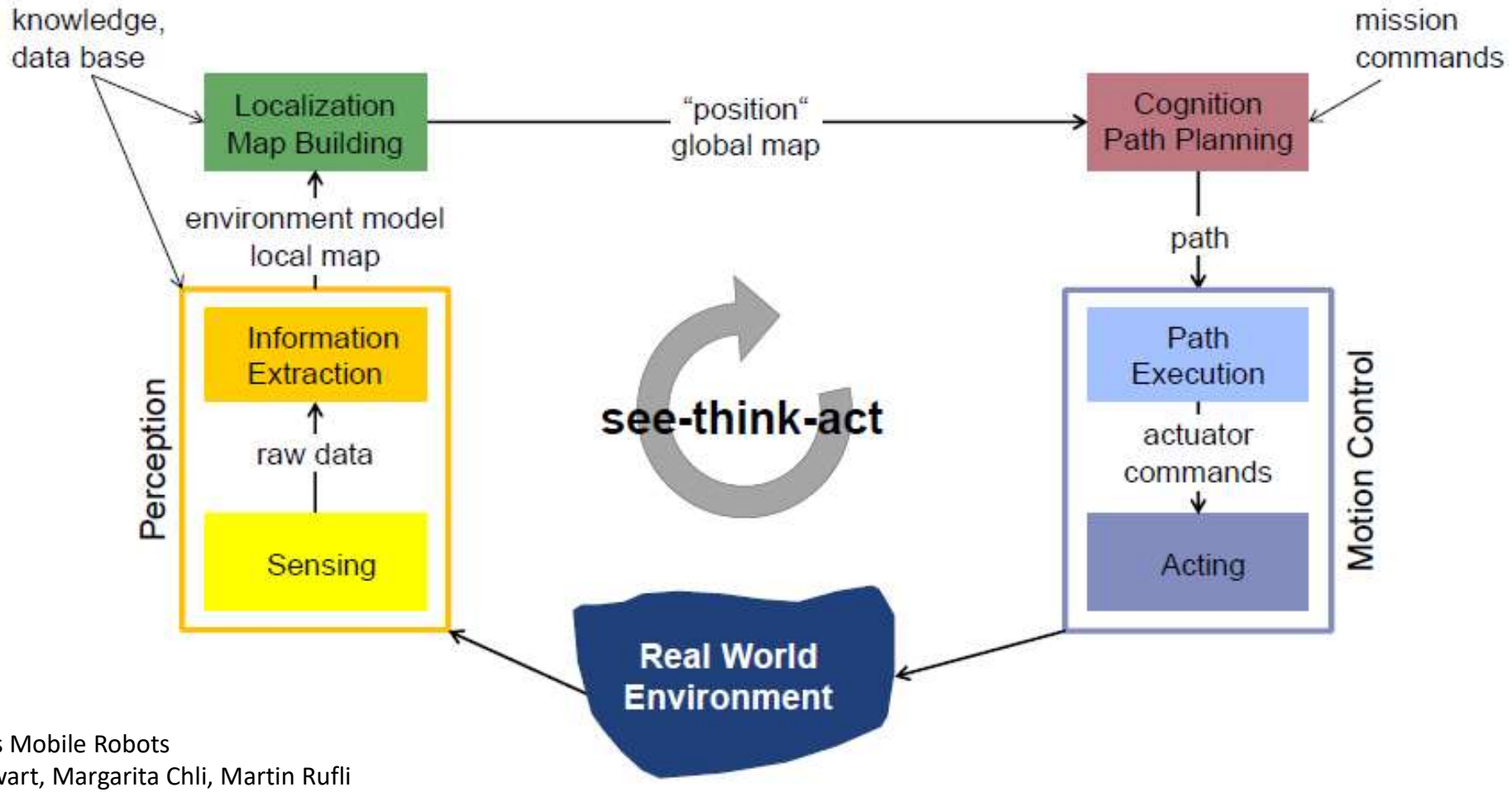
http://www.irobot.it/roomba/serie-900/

Per rispondere a queste domande un robot deve:

- Avere un modello dell'ambiente *(dato o da costruire)*
- Percepire ed analizzare l'ambiente
- Trovare la sua posizione nell'ambiente
- Pianificare ed eseguire il movimento

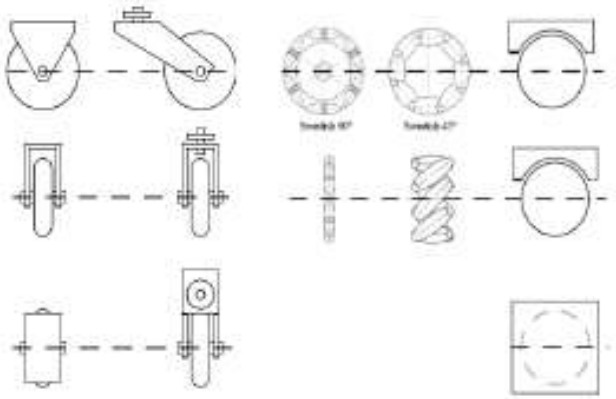
Autonomous Mobile Robots
Roland Siegwart, Margarita Chli, Martin Rufli

# See-Think-Act Cycle



# Motion Control

- Wheel types and its constraints
  - Rolling constraint
  - no-sliding constraint (lateral)

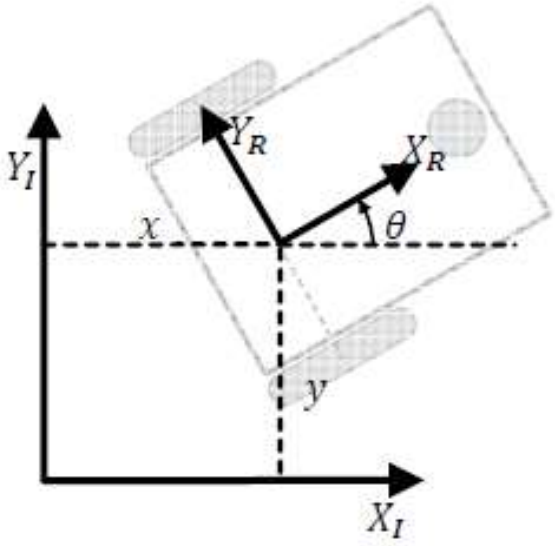


- Motion control

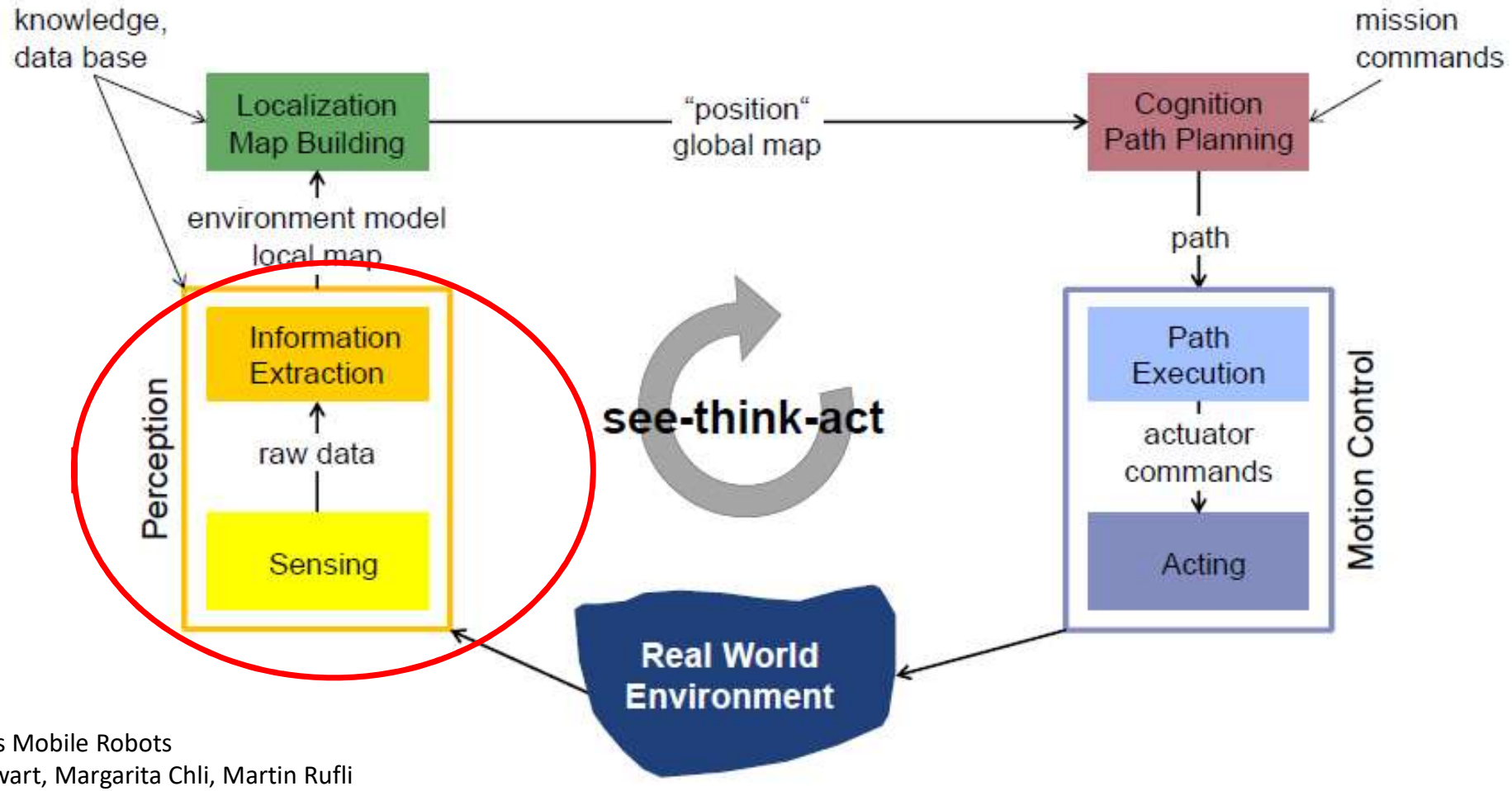
$$\begin{bmatrix}\dot{x}\\ \dot{y}\\ \dot{\theta}\end{bmatrix} = f(\dot{\varphi}_1 \cdots \dot{\varphi}_n, \theta, geometry)$$

$$\begin{bmatrix}\dot{\varphi}_1\\ \vdots\\ \dot{\varphi}_n\end{bmatrix} = f(\dot{x}, \dot{y}, \dot{\theta})$$

?

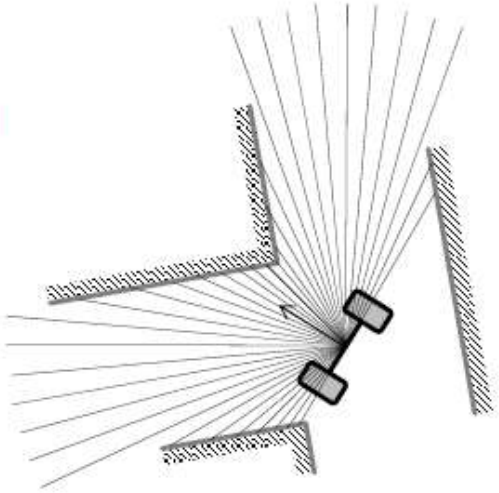


# See-Think-Act Cycle

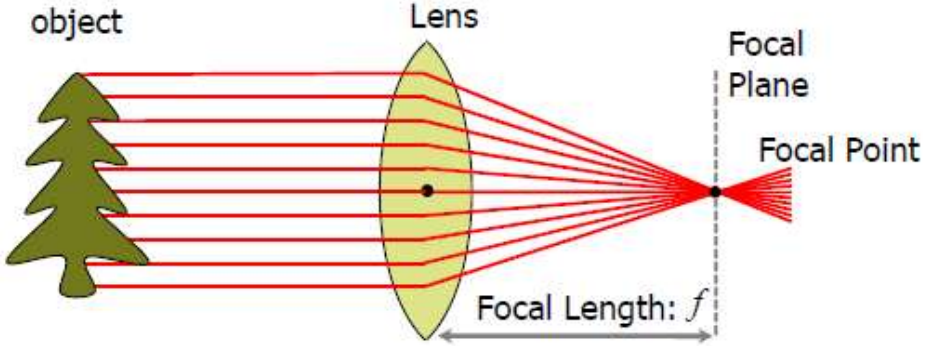


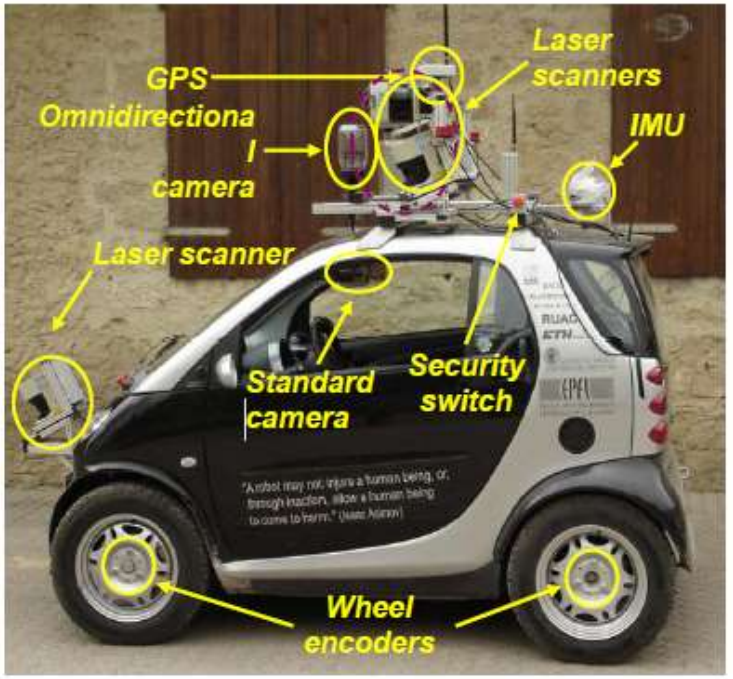
# Percezione

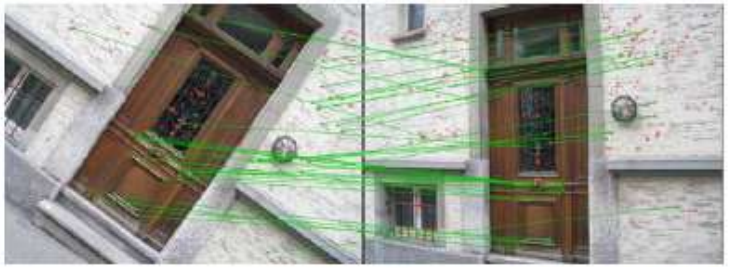
- Laser scanner
  - time of flight



- Camera



# Sensori

stereo camera

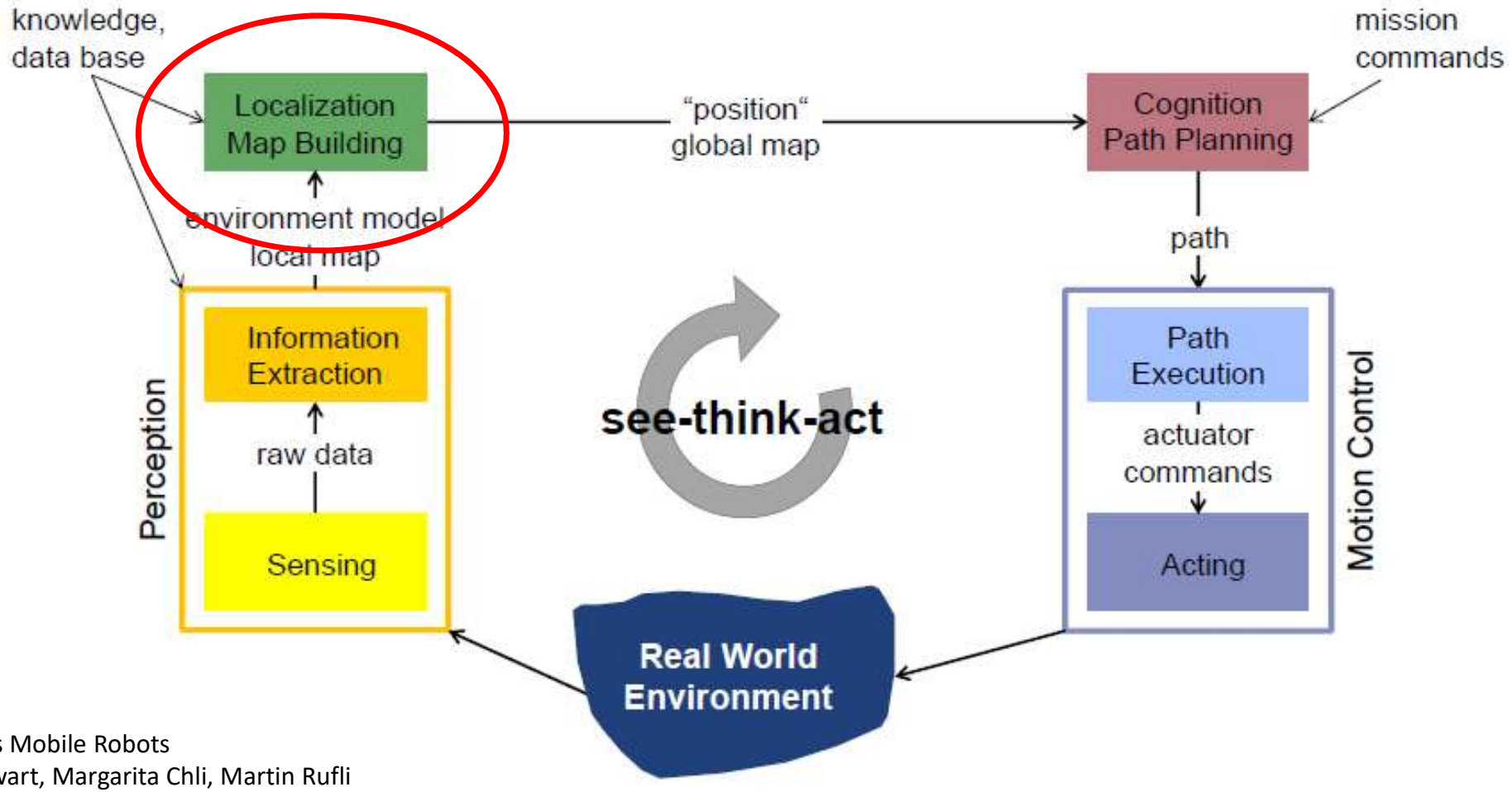
multiple cameras

infrared

radar

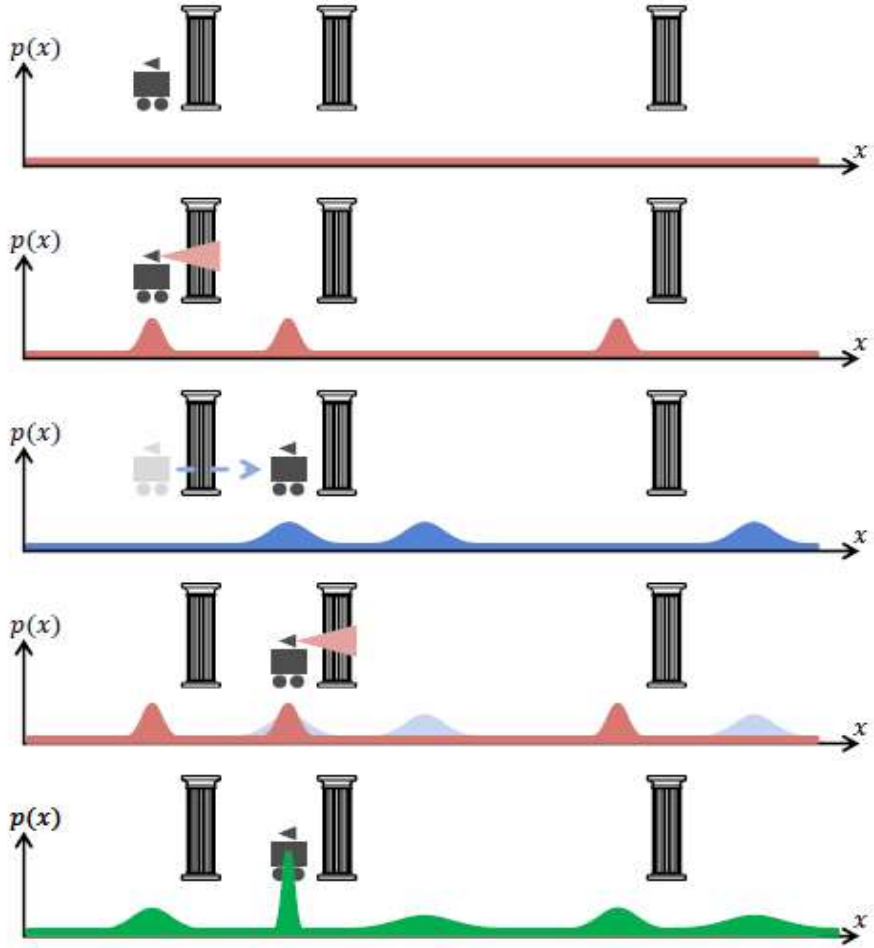

RGB-D

# See-Think-Act Cycle



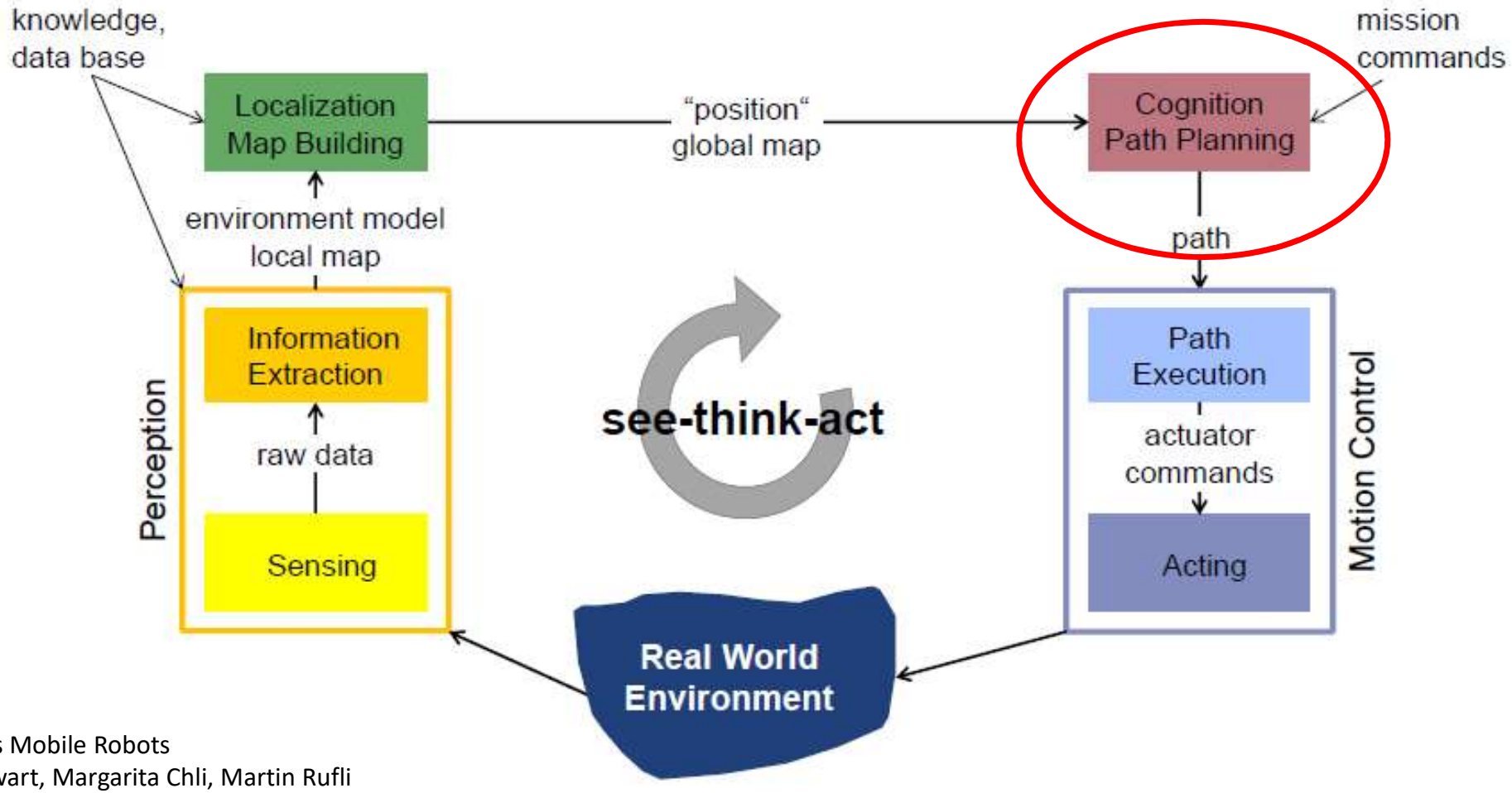
# Localizzazione

- SEE: il robot controlla i dati dei sensori → si accorge di essere vicino ad un pilastro
- ACT: Il robot si muove un metro in avanti
  - il movimento viene stimato usando gli encoder delle ruote
  - si accumula incertezza
- SEE: il robot controlla di nuovo i dati dei sensori → si accorge di essere vicino ad un pilastro
- Belief update (fusione di informazione)

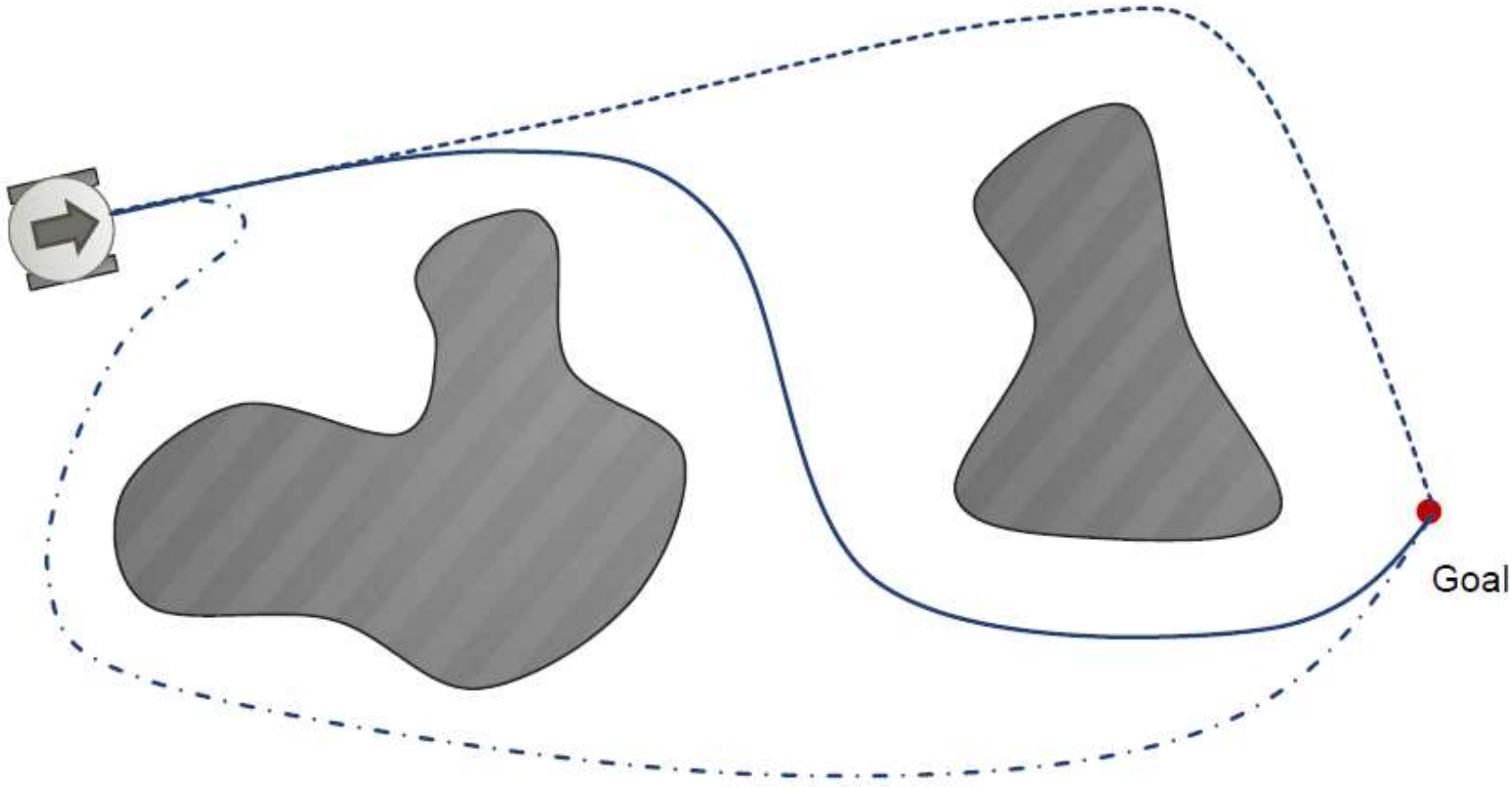



Autonomous Mobile Robots
Roland Siegwart, Margarita Chli, Martin Rufli

# See-Think-Act Cycle

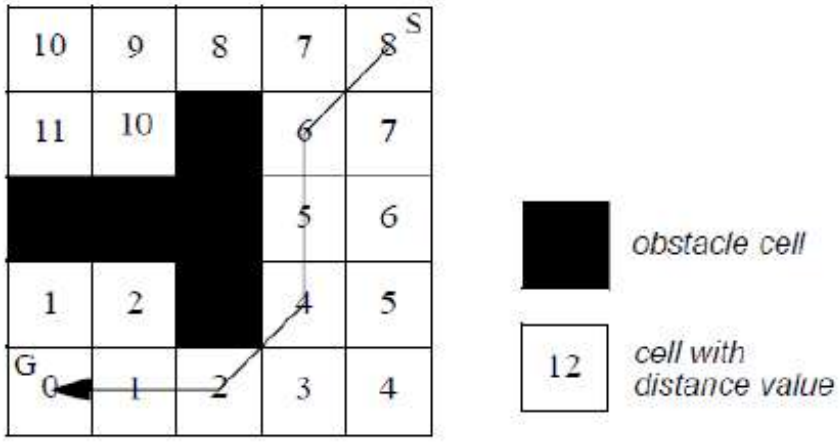


# Cognition

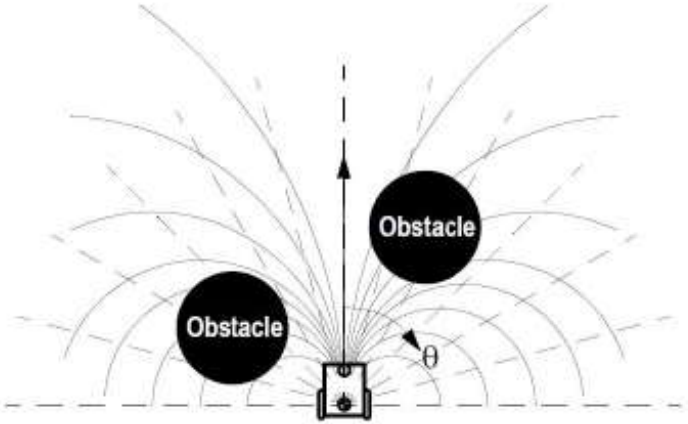


# Path Planning

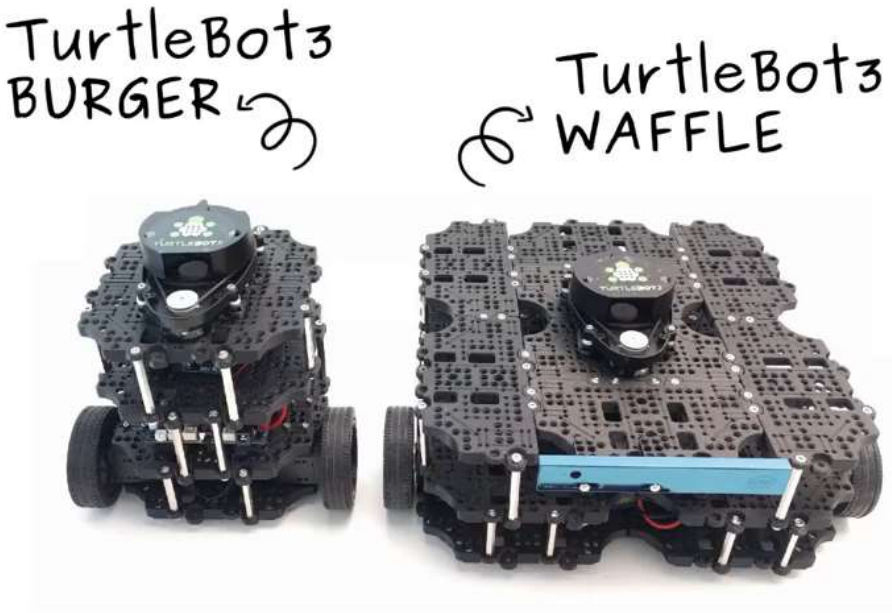
- Global path planning
  - Graph search




- Local path planning
  - Local collision avoidance



# Turtlebot 3 Navigation Example

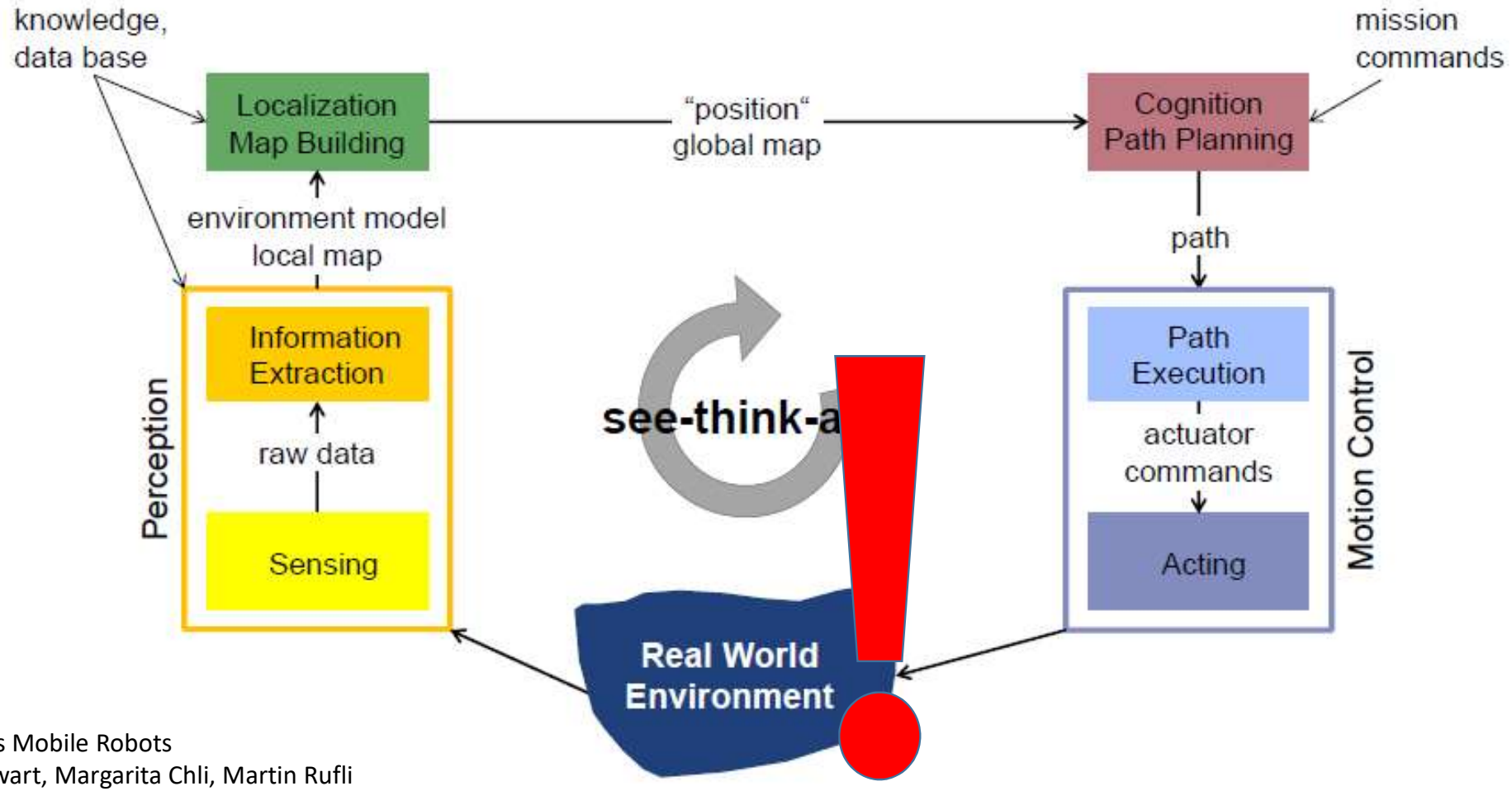




**Navigation Demo**

Link al video: https://www.youtube.com/watch?v=VYlMywwYALU

# See-Think-Act Cycle



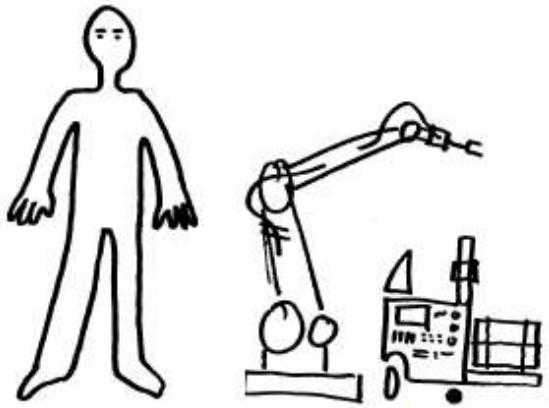
# Esempio DARPA Urban Challenge


Link al video: https://www.youtube.com/watch?v=fBtZ6EA2fpI

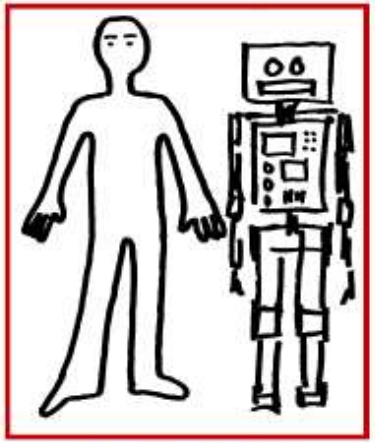
# Esempio DARPA Challenge


Link al video https://www.youtube.com/watch?v=g0TaYhjpOfo

# Industrial vs Service Robots

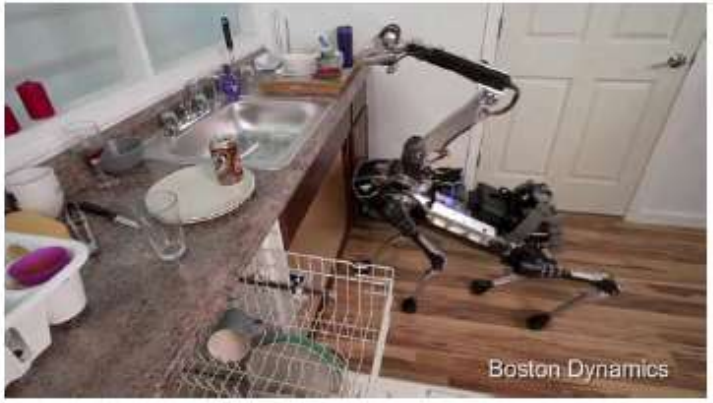


Industrial Robots

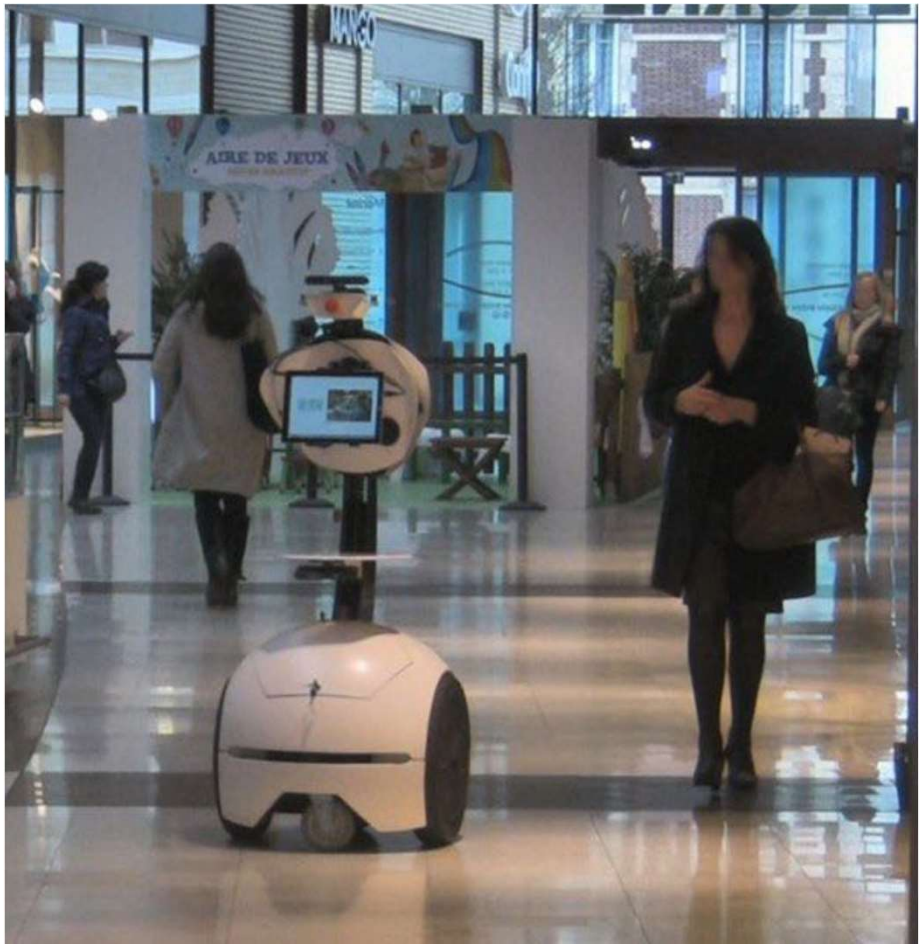


Service Robots

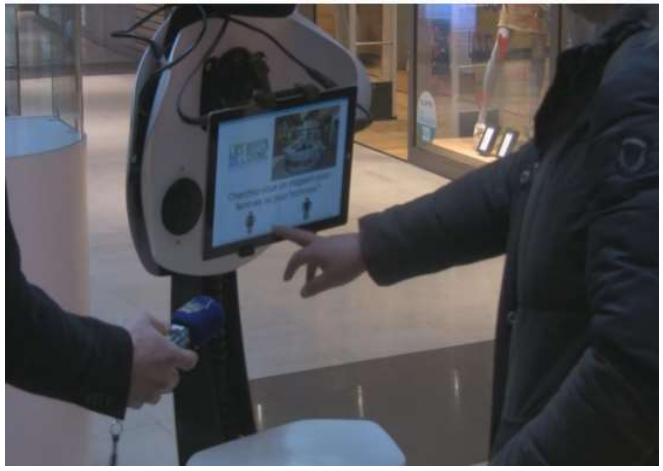
Cyborgs




# Robot Sociali




I robot sociali possono adoperare molteplici canali di percezione



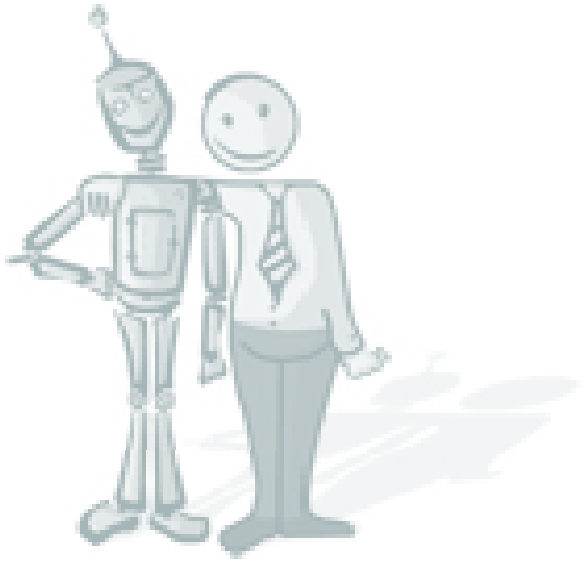
interazione
multi-modale

# Approccio sociale

**Idea**

Consentire ad un robot di imparare dagli umani nello stesso modo in cui una persona può imparare da un'altra.

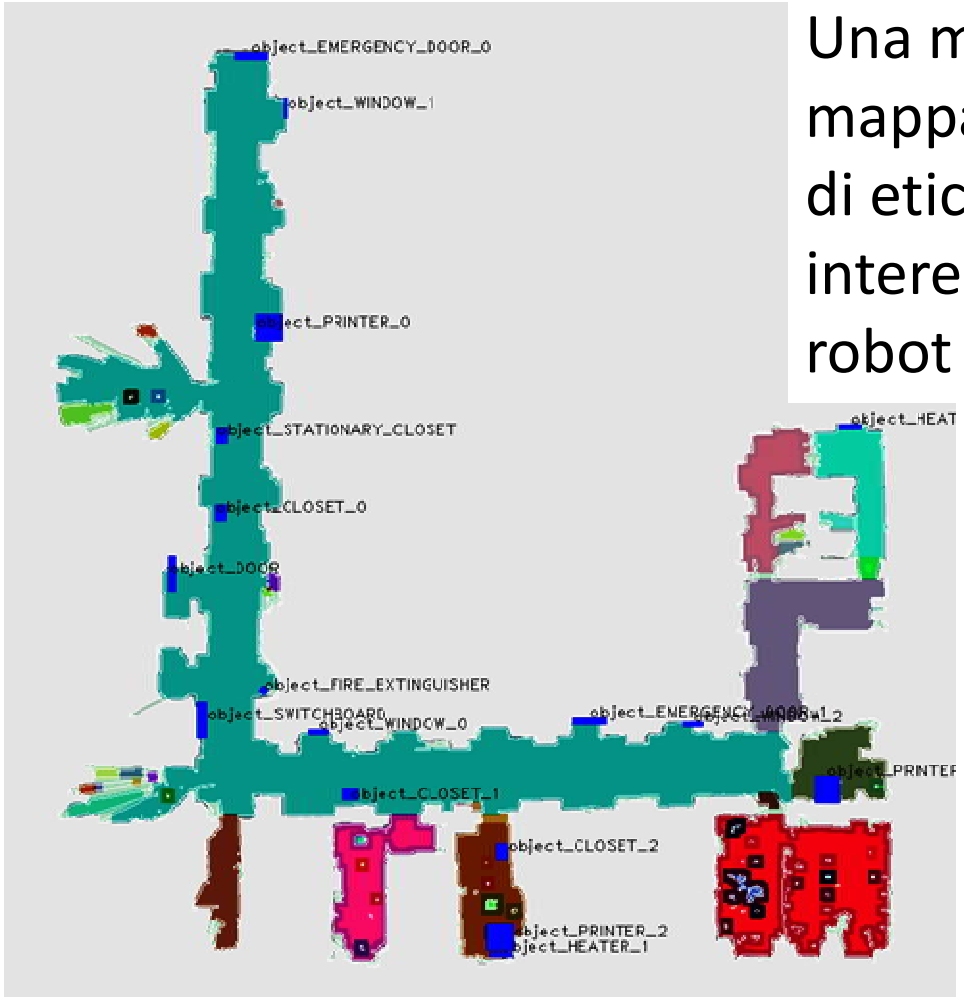
Il robot usa l'interazione con gli umani per superare le proprie difficoltà e i propri limiti



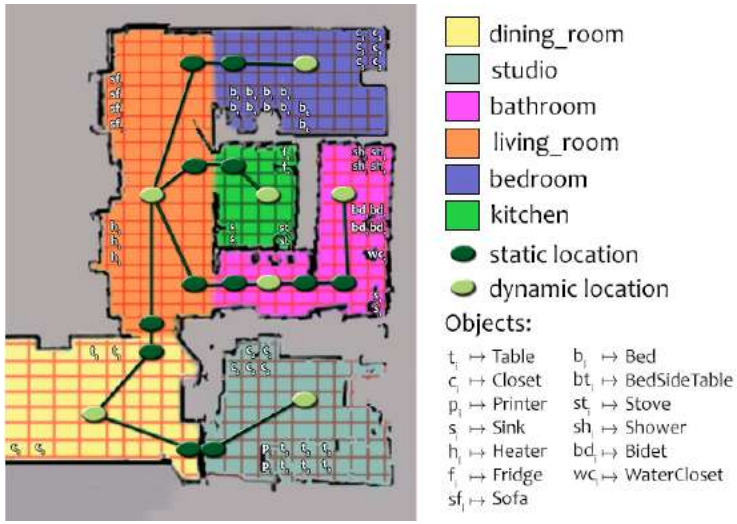
# Richiesta di aiuto a svolgere un compito

https://youtube.com/video/a41rTVVdj_k

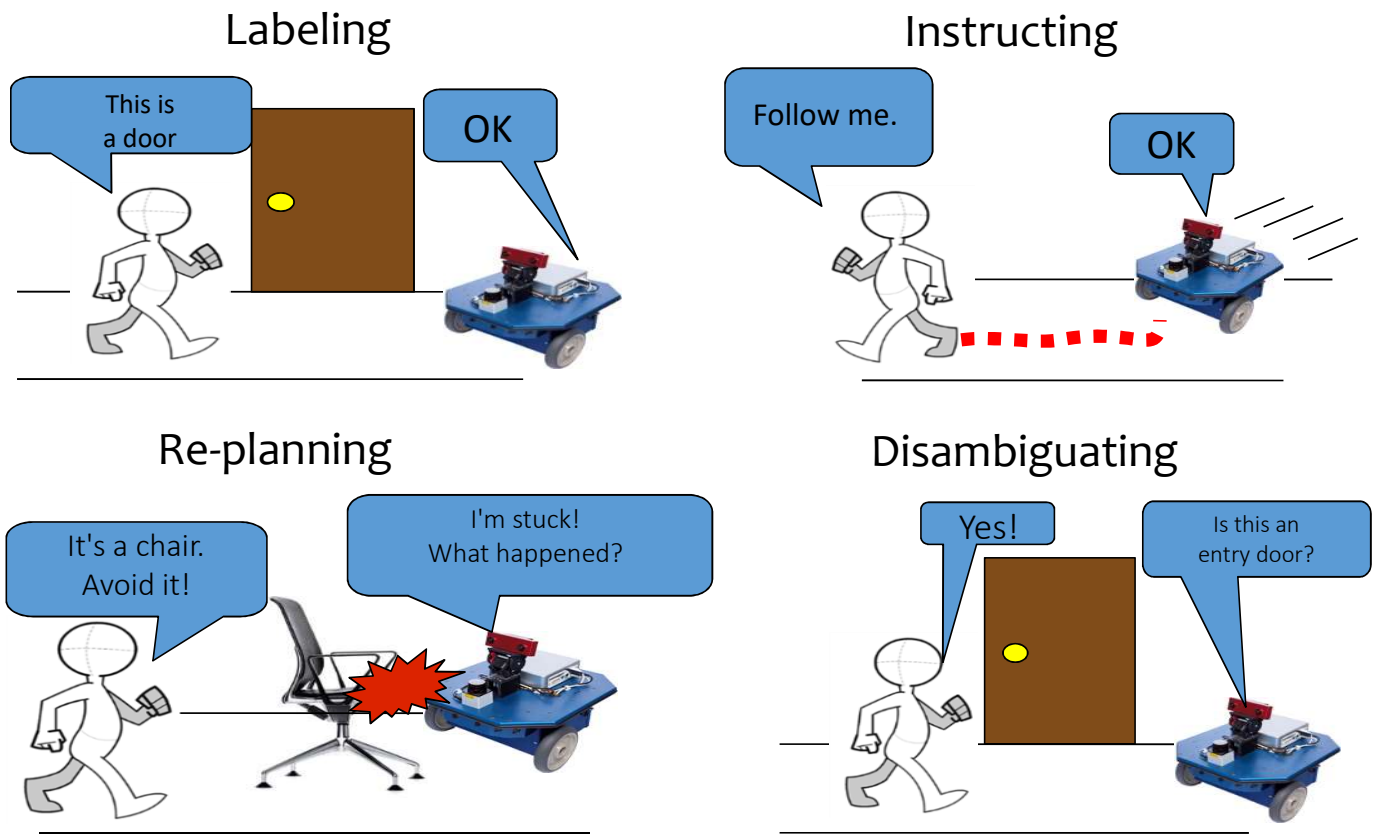
# Mappa Semantica




Una mappa semantica è una mappa metrica con l'aggiunta di etichette per gli oggetti di interesse, della cui presenza il robot deve essere al corrente

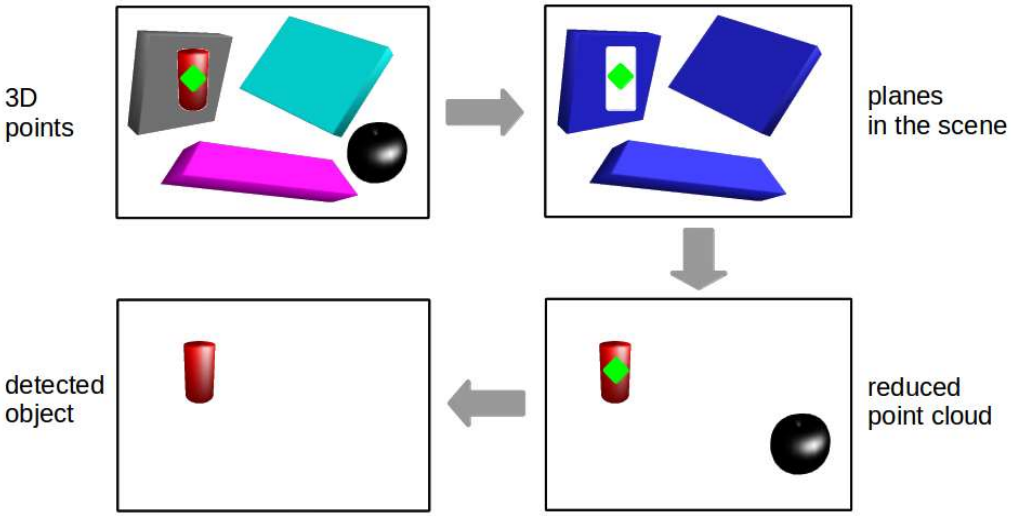


# Human-in-the-loop

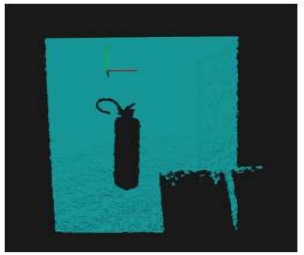


# Semantic Mapping

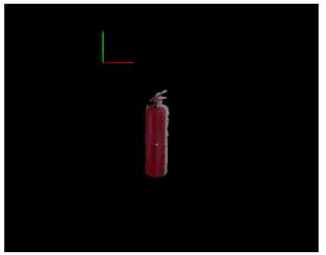
La posizione e l'etichetta degli oggetti vengono comunicate al robot da un umano




Initial 3D point cloud containing the laser dot

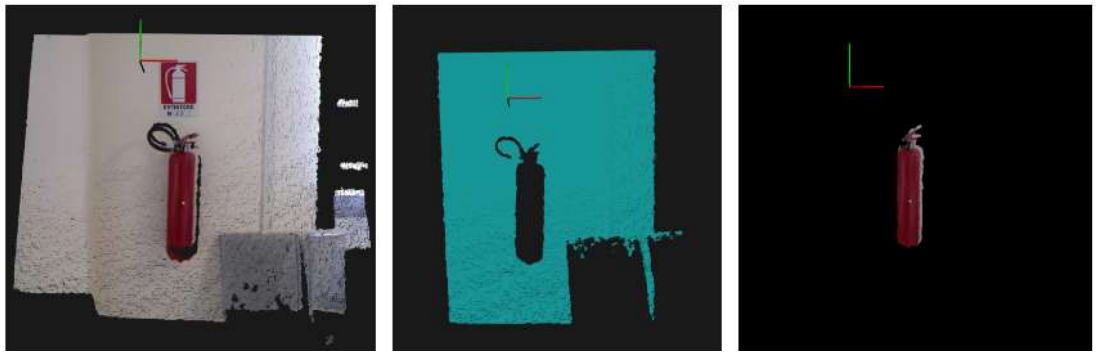


Planes in the scene that do not contain the laser dot

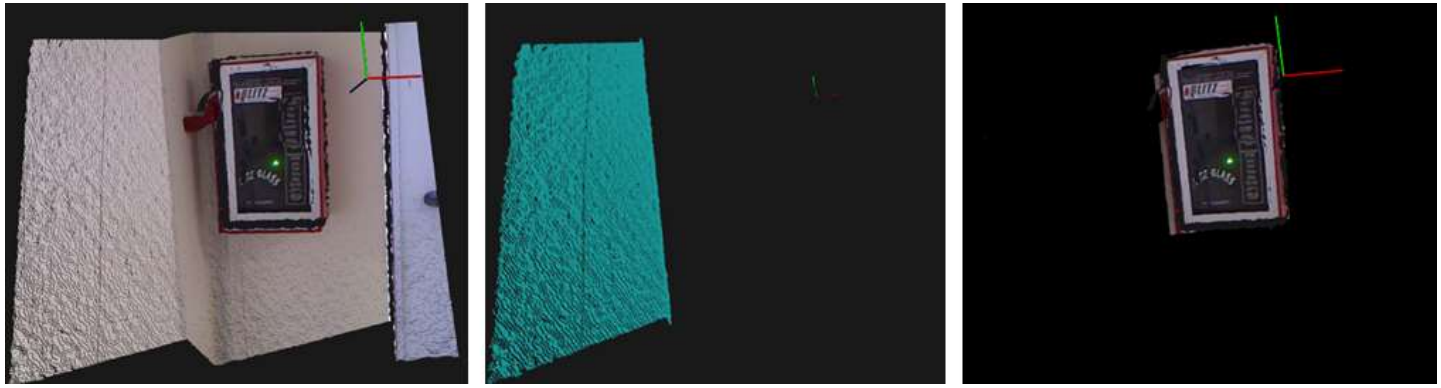


Segmented object

# Esempi di tagging



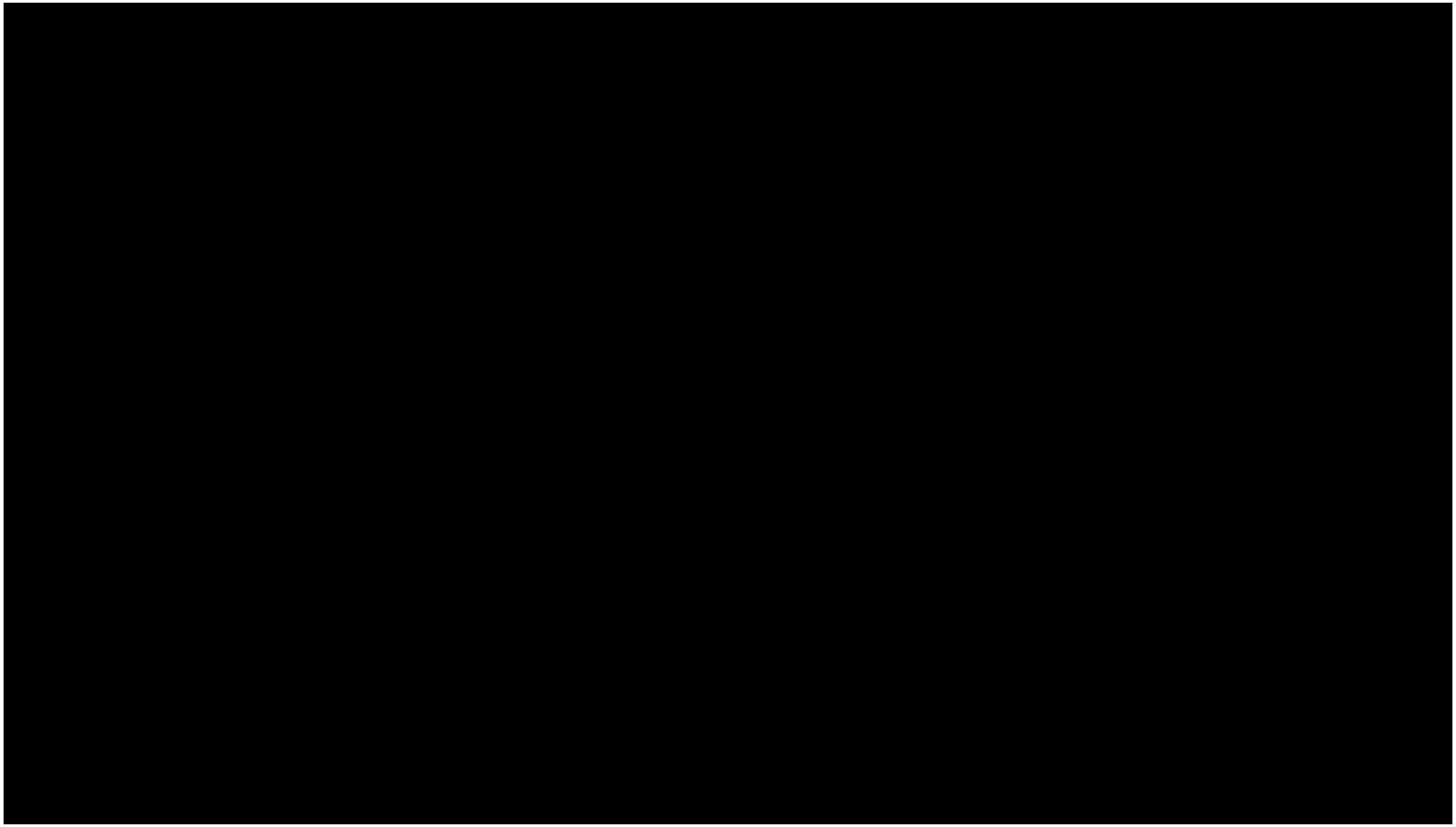
fire extinguisher



hydrant box

printer

# Semantic Mapping e Human Robot Interaction



Link ai video: http://www.dis.uniroma1.it/~gemignani/Articles/iser14.html

# Autonomus boats for water quality monitoring

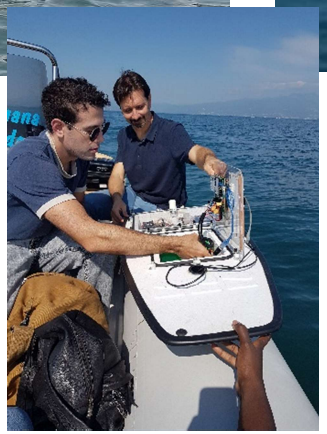
INTCATCH

2020

in water propellers

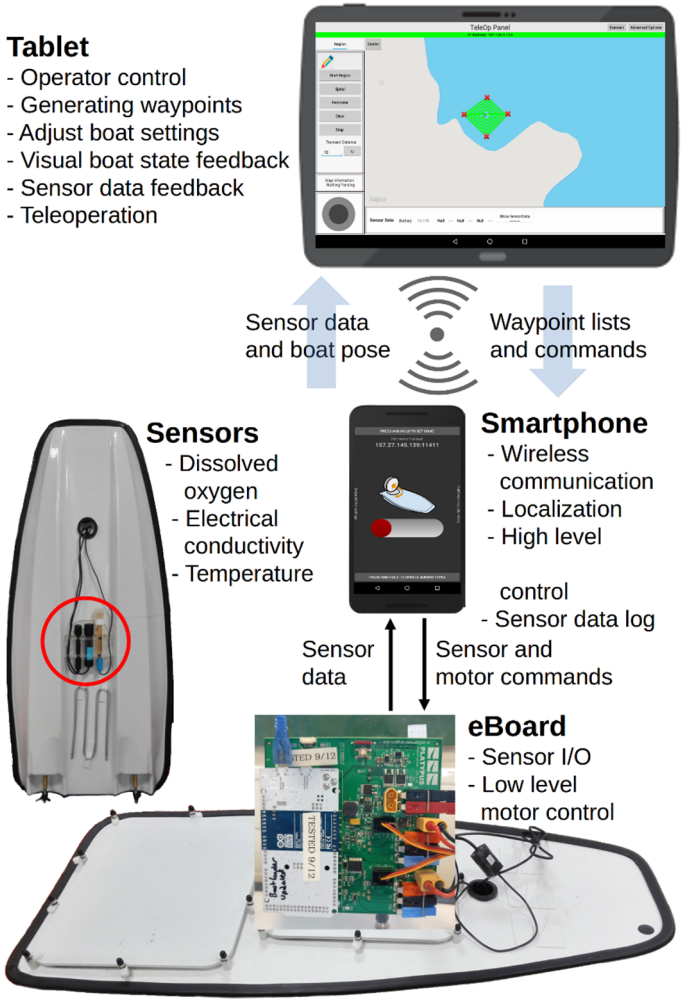
airboat

- Low-cost
- Autonomous
- Long-endurance
- Easy to deploy



# Architettura del sistema

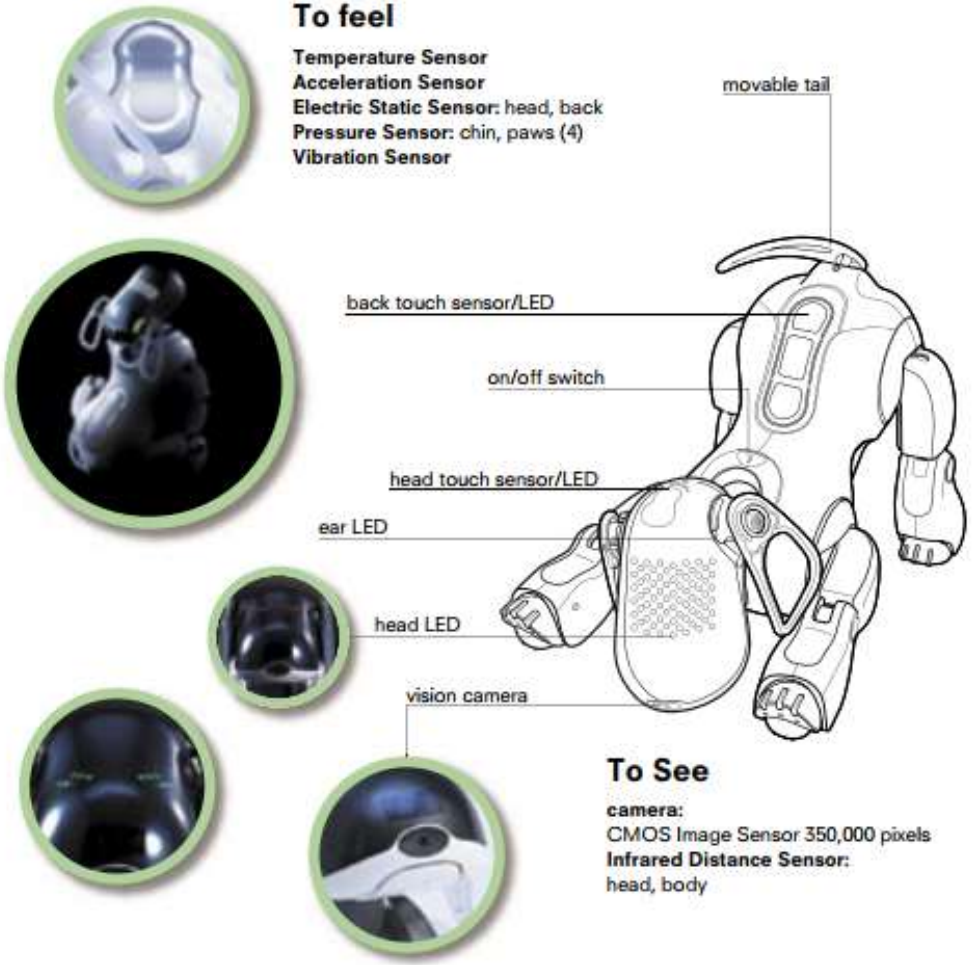
- I comandi ad alto livello vengono impartiti usando un tablet connesso in wi-fi
- L'utente può definire un percorso sul tablet che verrà seguito dalla barca. **La navigazione è autonoma**
- Differenti sensori misurano la conducibilità elettrica, la temperature e l'ossigeno disciolto



# Wide area monitoring on Lake Garda


https://www.youtube.com/watch?v=oLHaSqY-egE

# Four legs (quadruped) Robots

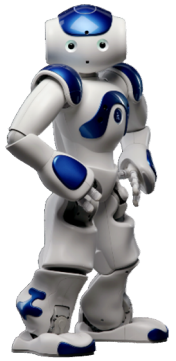

http://www.sony-aibo.com

# BigDog


https://youtu.be/cNZPRsrwumQ

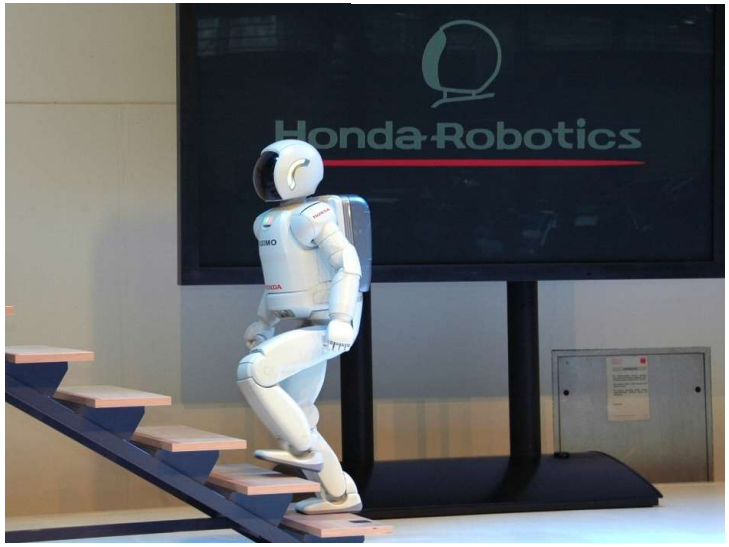
# Humanoid Robots

NAO



Darwin-OP


https://www.bostondynamics.com/atlas



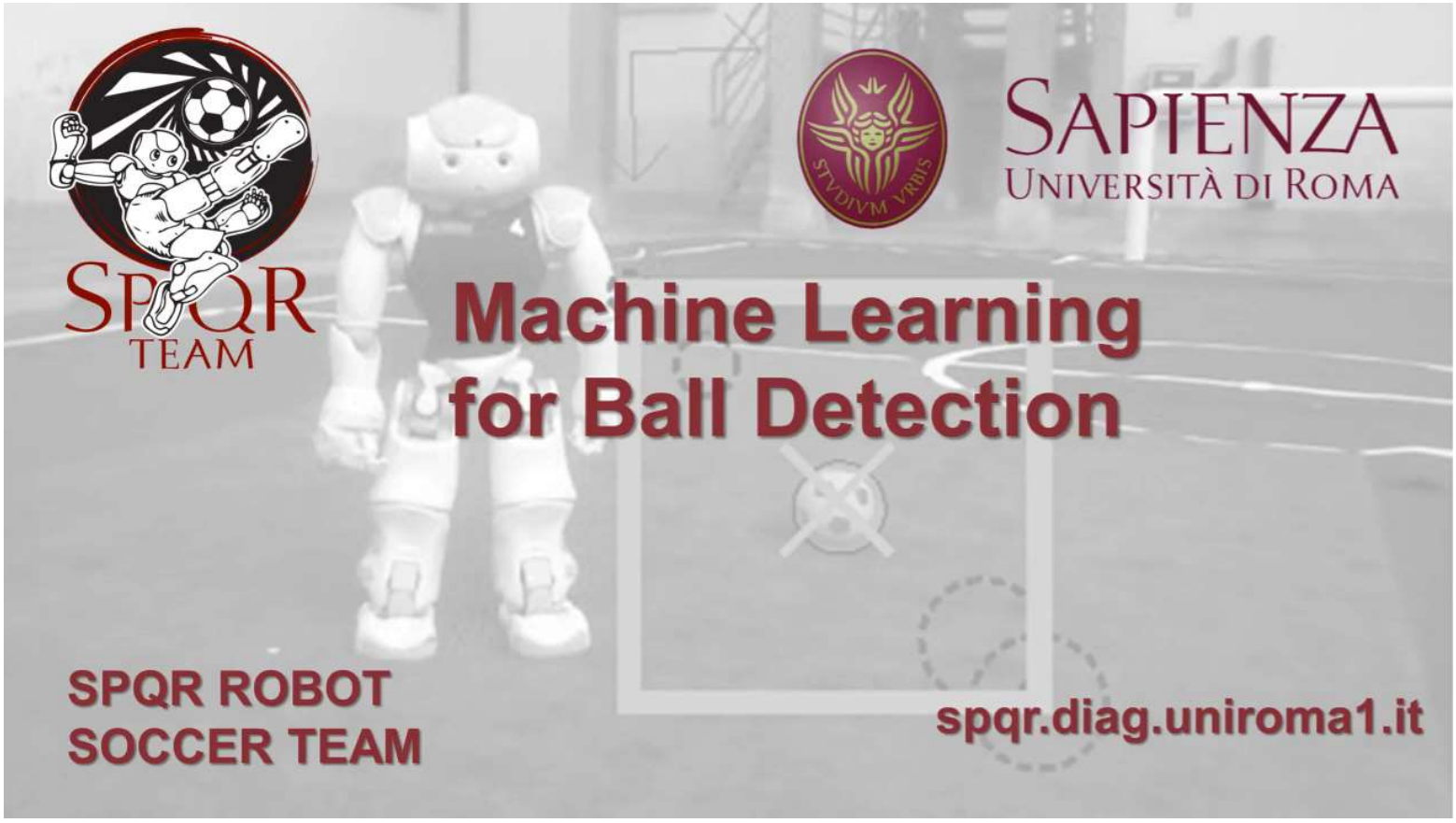

http://asimo.honda.com/

https://projetromeo.com/

# SPQR Team @RoboCup2016


Link al video: https://www.youtube.com/watch?v=lqGMN1nbNCM

# SPQR Team Ball Perceptor




Link al video: https://www.youtube.com/watch?v=fIgEwHRe6Bk

# SPQR Team @GermanOpen2017

RoboCup GERMAN OPEN 2017

SAPIENZA UNIVERSITÀ DI ROMA

## SPQR Team highlights

SPQR ROBOT SOCCER TEAM

SPQR TEAM

spqr.diag.uniroma1.it

Link al video: https://www.youtube.com/watch?v=V7NywBs1rWE

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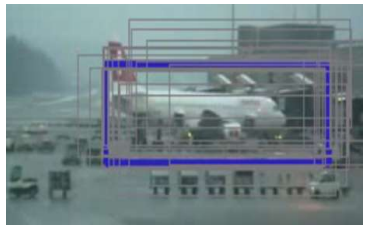
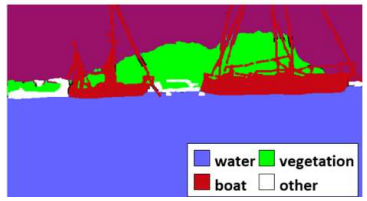
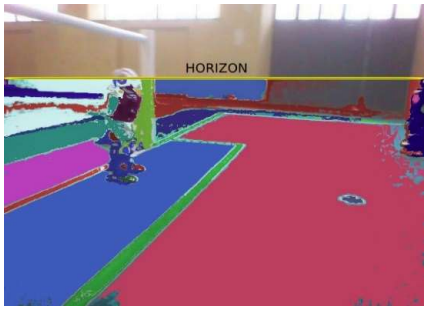





# Introduzione

*Corso di Robotica*
*Parte di Laboratorio*

Docente:
Domenico Daniele Bloisi


*Ottobre 2017*