Introduction to autonomous robotics

ST5 Autonomous robotics

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2022-09-02

Presentation

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- researcher in robotics
- Inria Nancy Grand-Est – Loria
- Larsen[1] team: long-term autonomy and interaction
- keywords: state estimation, mapping, navigation
- lectures, tutorials, lab works

Jérémy Fix

- associate professor
- CentraleSupélec – Loria
- Biscuit[2] team: unconventional computation models
- lab works

[1] `https://team.inria.fr/larsen` [2] `https://biscuit.loria.fr`

Aim of the lecture

Introduction to autonomous robotics

- overview of robotics
- various aspects of autonomy
- implementation of simple techniques
- test in simulation and real robots

Aim of this session

- definition of robotics
- overview of autonomy

Organization

Lectures

- overview of a subject
- focus on a technique/algorithm

Tutorials

- theoretical exercises

Lab work

- implementation in Python using ROS (skeleton files)
- experimentation
- introduced by preparatory exercises

Exam

- main concepts (no document)
- some exercises (no code)

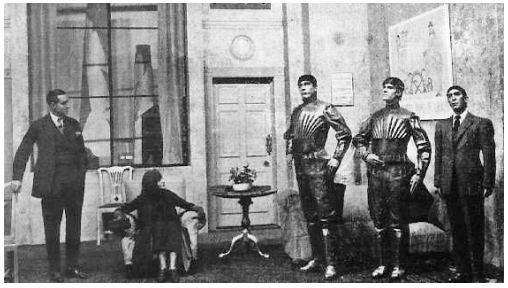
01

Robots and robotics

What is a robot?

Etymology

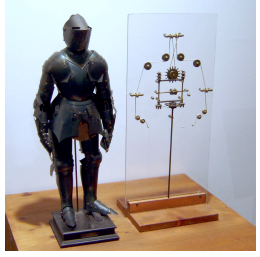
- Josef Čapek in R.U.R. from his brother Karel in 1920
- humanoids produced in a factory
- from the Czech “robota”: corvée, serf labor



a scene from R.U.R.

Automaton

- mechanical device which moves alone
- powered by water, wind, spring, pendulum, ...
- able to perform sequences of motion



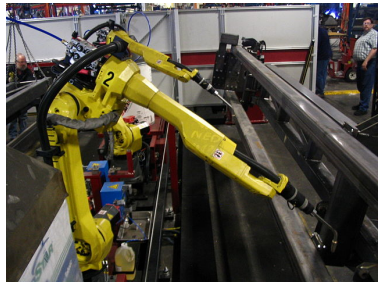
Leonardo da Vinci

What is a robot?

Definitions (`en.wiktionary.org`)

- "(chiefly science fiction) An intelligent mechanical being designed to look like a human or other creature"
- "A machine built to carry out some complex task or group of tasks by physically moving, especially one which can be programmed"
- In French: multi-function kitchen appliance

i, Robot (2004)



Fanuc welding robot

KitchenAid

What is an autonomous robot?

Autonomous robot, for us:

- mechatronic device (mechanics, electronics, and software),
- which can perform a task by itself,
- in a non-dedicated environment,
- through the interaction between perception and action,
- with some decision autonomy.

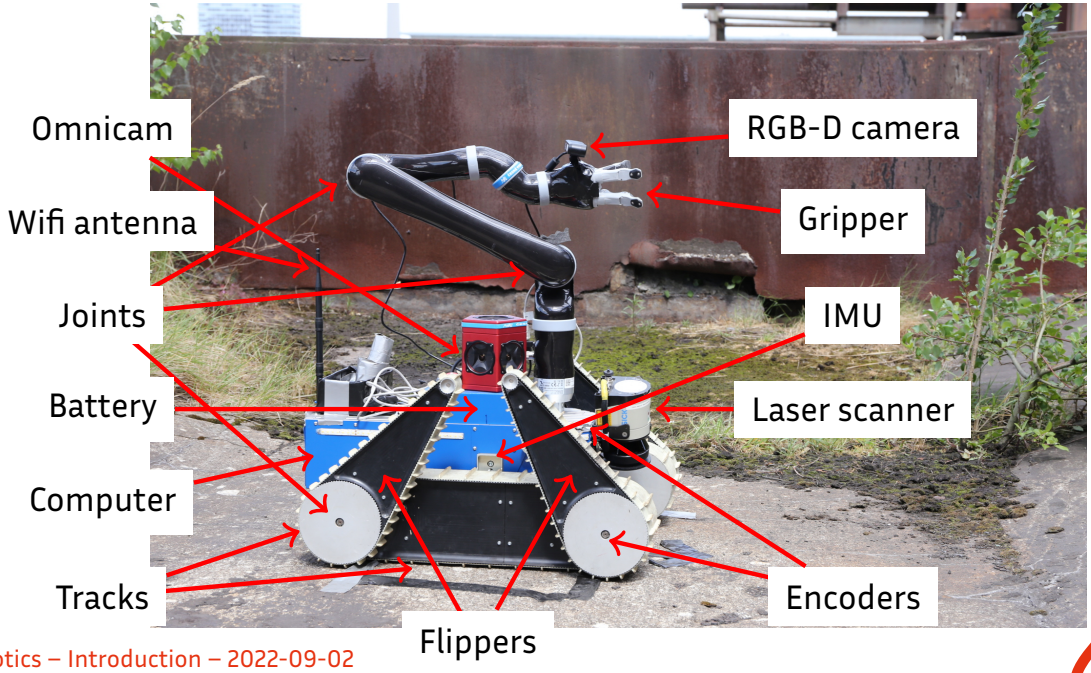
Tasks examples

- cleaning floor
- museum tour guide
- demining
- create a map of a place
- operate in human unfriendly environments

Robot anatomy

Components

- mechanical structure
- actuators (joints, wheels...)
- sensors (sonar, encoders...)
- electronics (power, communication bus, computers)
- software



Examples of autonomous robots

Industry

- removal of security cages
- cooperation with human operators
- quick and local issue solving
- fast learning of new tasks

Universal Robot UR5 at Atria

Baxter from Rethink Robotics

Examples of autonomous robots

Services

- cleaning (floor, swimming pool)
- logistics
- receptionist, tour guide

Rhino (1997)

iRobot Roomba

iRobot Mirra

Kiva Systems (Amazon)

Softbank Pepper

Other examples in services

Lely Astronaut

AscTec Falcon 8

Packbot

Giraff

Robot research – Locomotion

Ground locomotion

- bipedal walk
- quadrupedal walk
- run
- wheels on challenging ground

Talos (PAL Robotics)

ANYmal (RSL, ETHZ)

Absalom/Nifti (Bluebotics)

Robot research – Locomotion

Groundless locomotion

- underwater
- boats
- planes, drones

LAUV (LSTS, Porto)

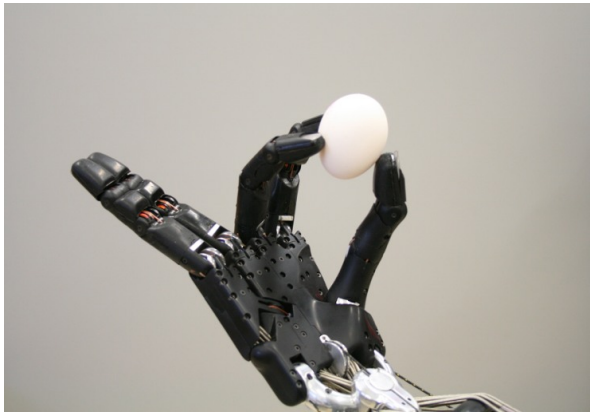
Kingfisher (Clearpath robotics)

Atlantik Solar (ASL, ETHZ)

Robot research – Manipulation

Manipulation

- dexterous manipulation
- bimanual manipulation
- non-rigid objects
- dynamic manipulation



HYFLAM (UHAM)

HDMS (Re^2)

PR2 Willow Garage)

Autonomous robots

Deployed autonomous robots

- industry: collaboration with humans
- services: cleaning, logistics, or reception

Research robots

- locomotion: on ground or not
- manipulation

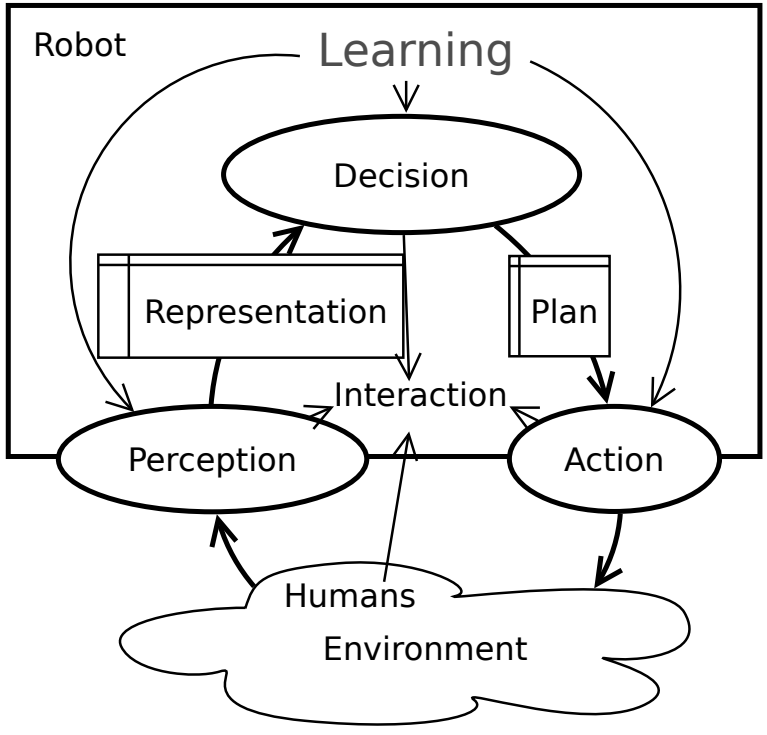
02

Autonomy

Functions of an autonomous robot

Main functions

- perception and representation of the environment
- motion and action
- decision and planning
- learning
- communication and interaction



Perception

Perception

- interpretation of the sensor values
- inference on the environment
- inference on the state of the robot
- building of an internal representation

Implementation

- sensors
- representation space
- sensor models

Motion

Action

- achievement of a given motion
- control of an actuator

Implementation

- actuators
- control space
- actuator model
- loop closing with a sensor

Decision

Decision and planning

- choice of actions to achieve a given goal
- definition of a plan
- simulation of the consequences of actions

Implementation

- current representation
- planning domain
- action model

Learning

Machine learning

- model optimization
- definition of new models
- for perception, action, or decision

Implementation

- training data
- generic model

Interaction

Communication and interaction

- sharing information
- joint performing a task
- with humans or other robots

Implementation

- model of the others
- model of the interaction

03

Conclusion

Conclusion

Autonomous robotics

- variety of robots, environments, and tasks
- different functions:
  - perception
  - action
  - decision
  - learning
  - interaction

Program

Lectures

- L1: intro (done)
- L2: introduction to ROS
- L3: Bayesian inference
- L4: sensors and state estimation
- L5: localization
- L6: mapping and SLAM
- L7: path planning
- L8: navigation
- L9: architecture and interaction

Tutorials and lab work

- LW1: ROS, simulation, and real robot
- TU1: state estimation
- LW2: state estimation
- TU2: localization
- LW3: localization
- LW4: mapping and SLAM
- LW5: path planning
- LW6: navigation
- LW7: integration on a real robot

Bibliography

Robotics books

- Latombe, *Robot Motion Planning*, Kluwer Academic Publishers, 1991.
- Thrun *et al.*, *Probabilistic Robotics*, MIT Press, 2005.
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- Siegwart *et al.*, *Introduction to Autonomous Mobile Robots*, MIT Press, 2011.
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Other books

- Bishop, *Pattern Recognition and Machine Learning*, Springer, 2007.
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Thanks for your attention

Questions?