

# **BLG456E**

## **Robotics**

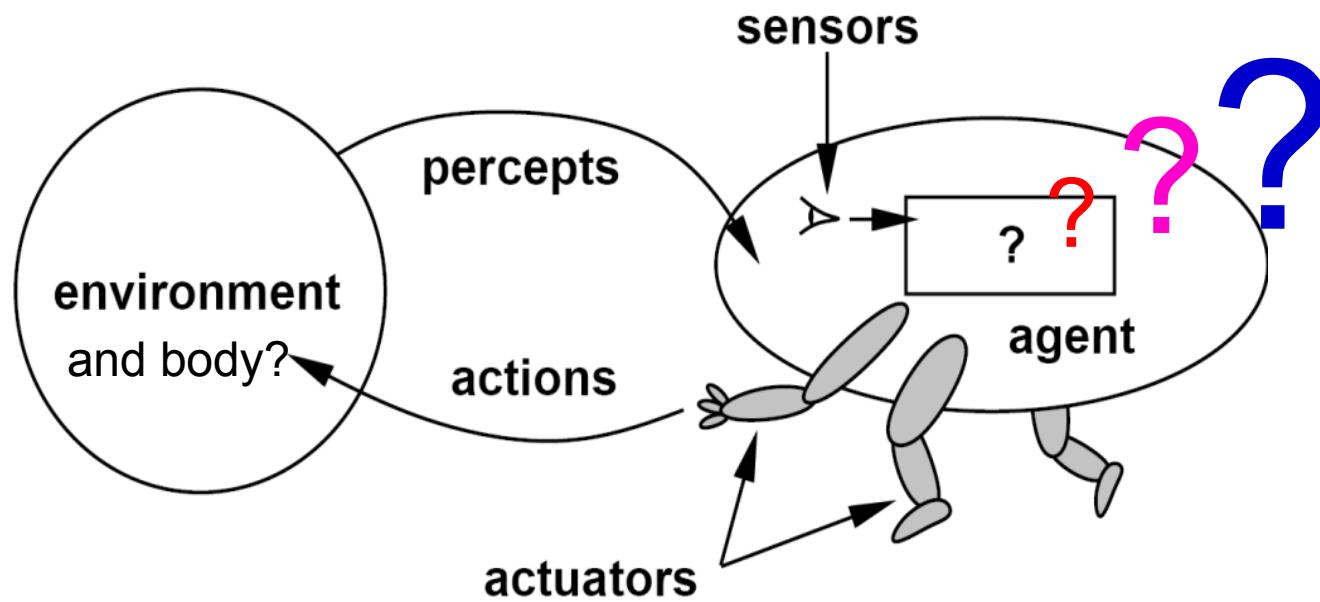
### **Introduction to Robotics**

#### **Lecture Contents**

- Basic theoretical approaches.
- Definitions & a little history.
- Main problems in robotics.

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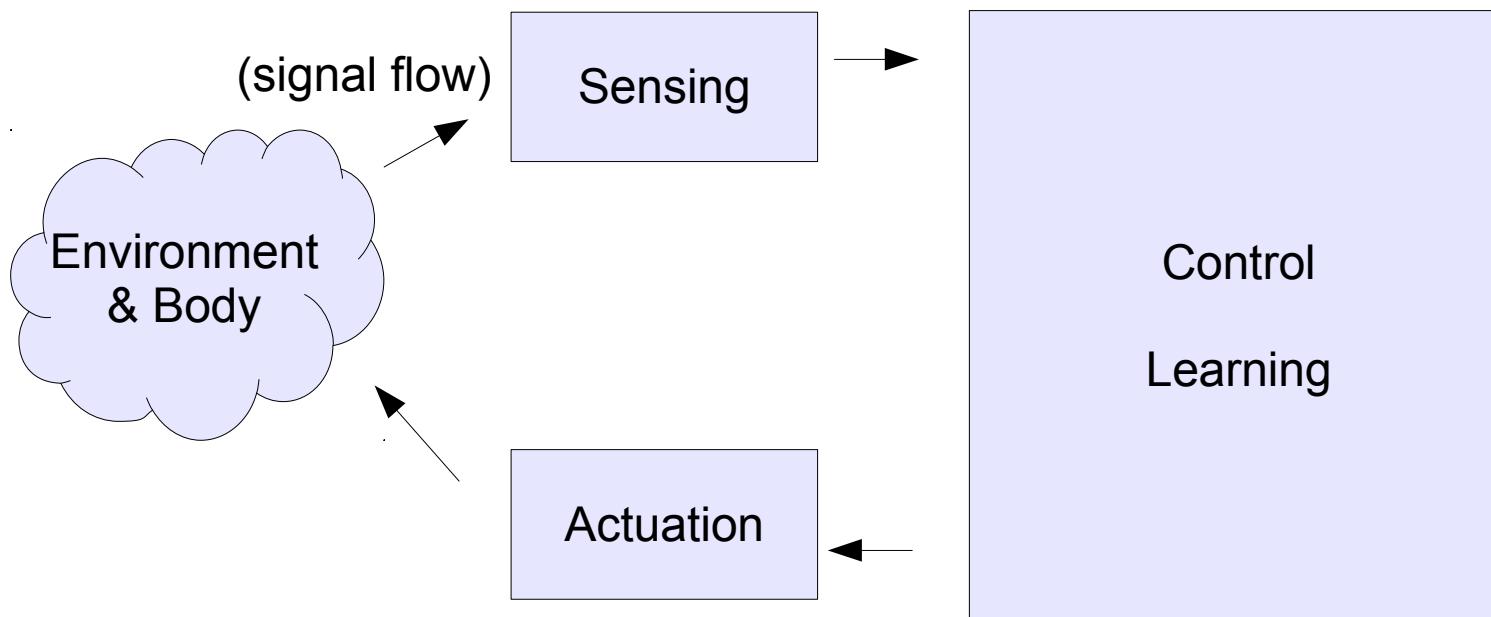
# The computational problem of autonomous robotics



$$f : \mathcal{P}^* \rightarrow \mathcal{A}$$

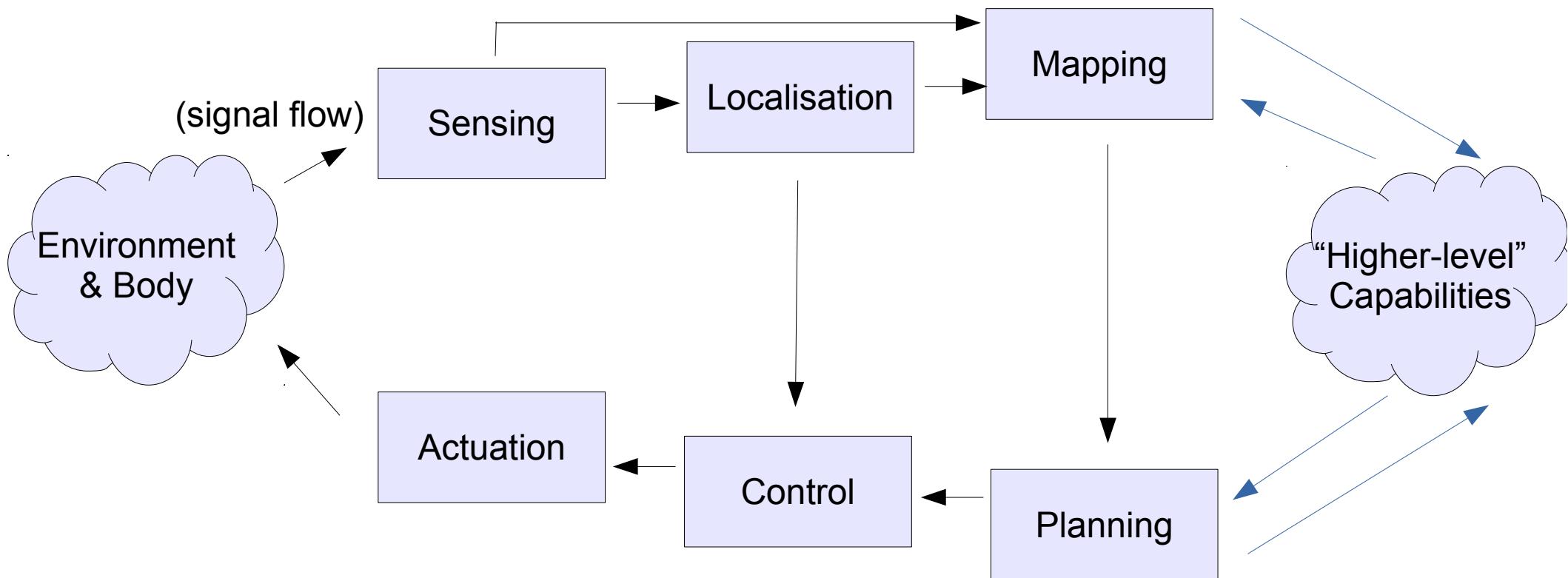
# Reactive/learning approach

(sense - act+learn)



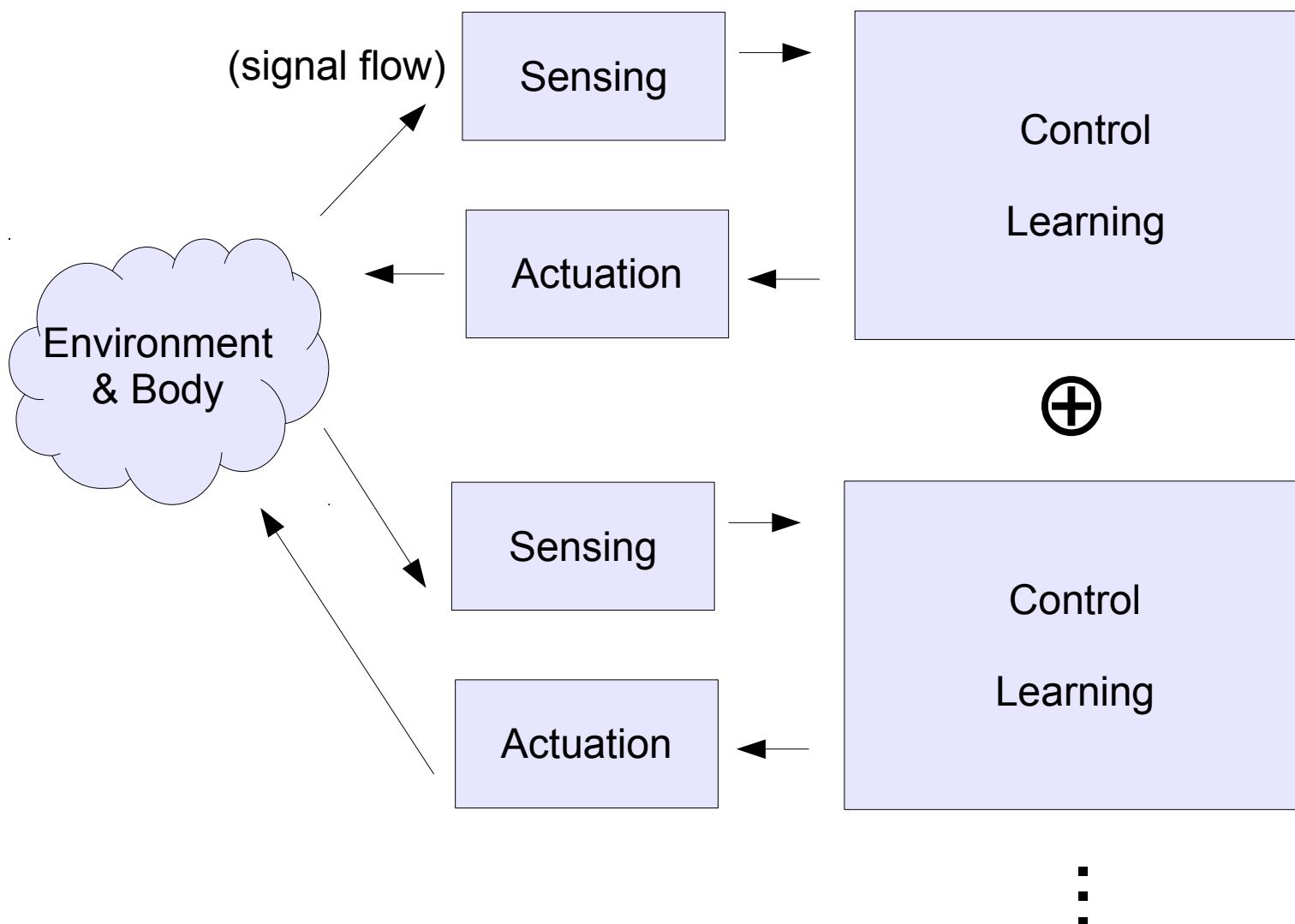
# Cognitive approach

(sense - represent - decide - act)



# Behaviour-based approaches

(combine (mostly reactive) behaviours)



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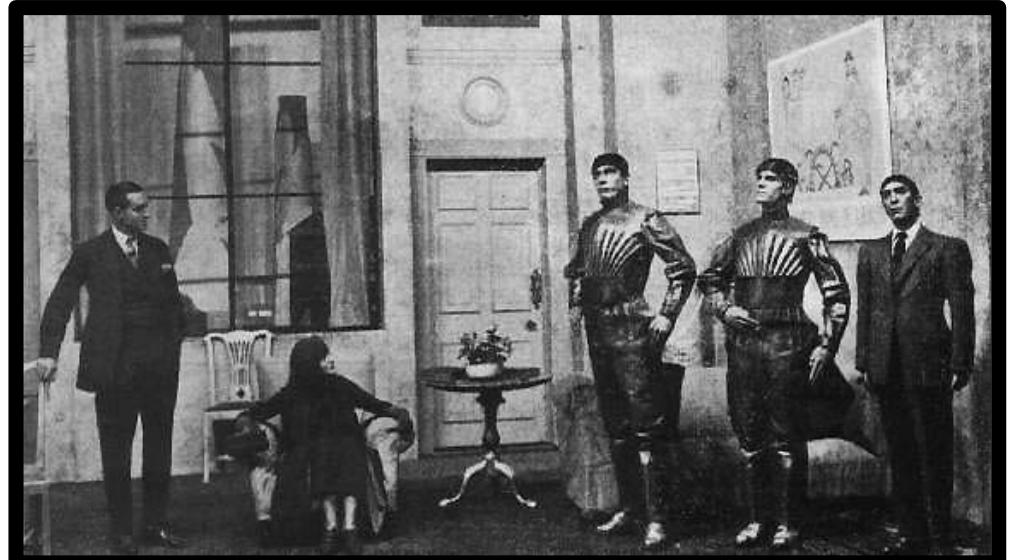
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# Robot etymology

Karel Čapek: *R.U.R. (Rossum's Universal Robots)*, 1921

- "Obligatory Work" (Czech)
- More like clones.

"God hasn't the least notion of modern engineering."



# Robot definition

- "*A robot is a reprogrammable, multifunctional manipulator designed to move materials, parts, or specialized devices through variable programmed motions for the performance of a task*" (Robotics Industry Association)
- Maja Mataric's definition, 2007:

An autonomous system which

- exists in the physical world.
- can sense the environment.
- act on it.
- to achieve its goals.

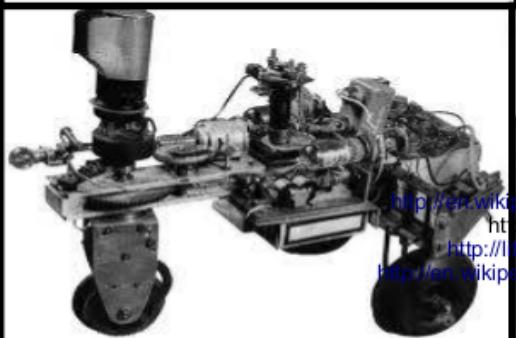
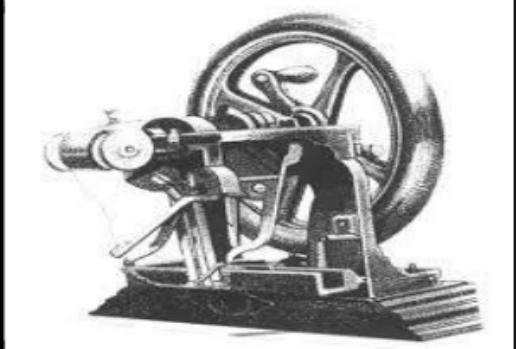
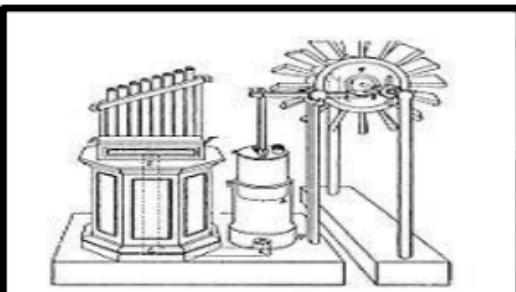


# Robot definition

- Is an observation drone a robot?
- Is a “guide robot” a robot?
- Is a thermostat a robot?
- Is a food processor a robot?
- Is a worm a robot?
- Is a human a robot?

Autonomous Robots?

# Milestones in Robotics



- Automatons: e.g. Heron of Alexandria 10-70.
- Mechanical Turk 1770.
- Industrial revolution 18th – 19th century.
- Grey Walter's Turtles 1948-1949.
- Stanford's Shakey 1966-1972.
- 21st century abundance.

[http://en.wikipedia.org/wiki/Hero\\_of\\_Alexandria](http://en.wikipedia.org/wiki/Hero_of_Alexandria)  
[http://en.wikipedia.org/wiki/The\\_Turk](http://en.wikipedia.org/wiki/The_Turk)  
<http://library.thinkquest.org/4132/info.htm>  
[http://en.wikipedia.org/wiki/William\\_Grey\\_Walter](http://en.wikipedia.org/wiki/William_Grey_Walter)  
ROBOT, Moravec, Oxford, 1998,

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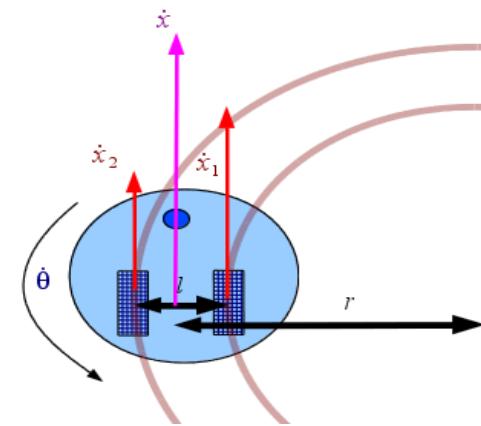
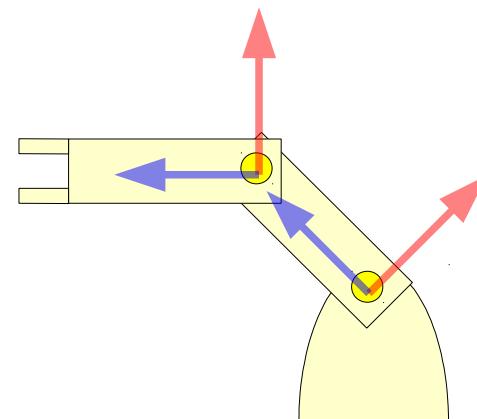
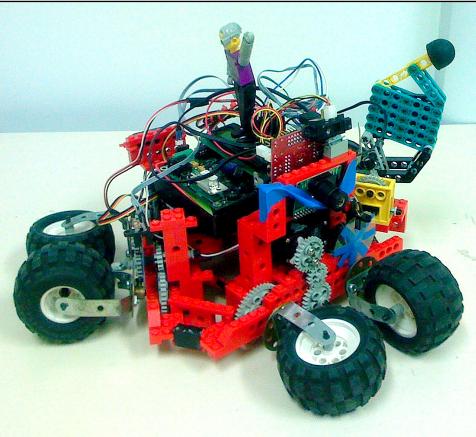
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# Main problems in robotics: Kinematics

- Kinematics:
  - “*The study of (instantaneous) motion*”.
- E.g.
  - Joint angles → effector position (**forward kinematics**)
  - Effector position → joint angles (**inverse kinematics**).
  - Wheel motion & steering ↔ angular/linear motion.





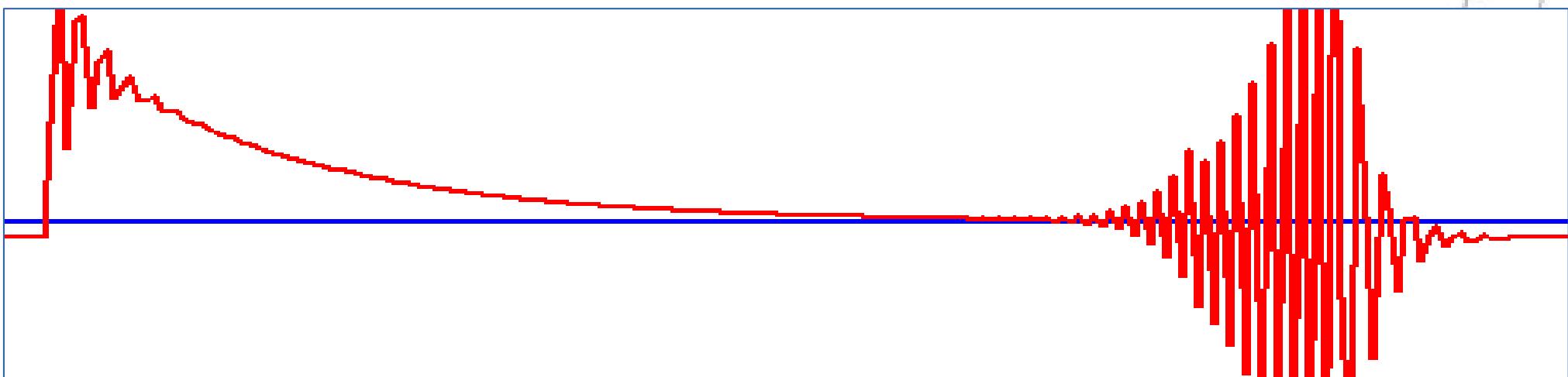
# Main problems in robotics: Dynamics

- Dynamics:
  - *“The study of motion and the causes of motion”.*
- E.g.
  - Robot finger torques → applied force.
  - Desired car motion → engine torque.



# Main problems in robotics: Control

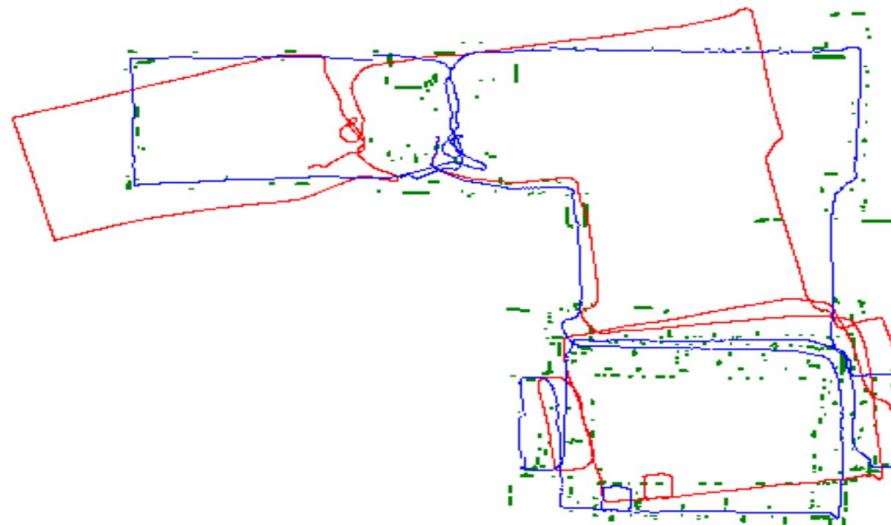
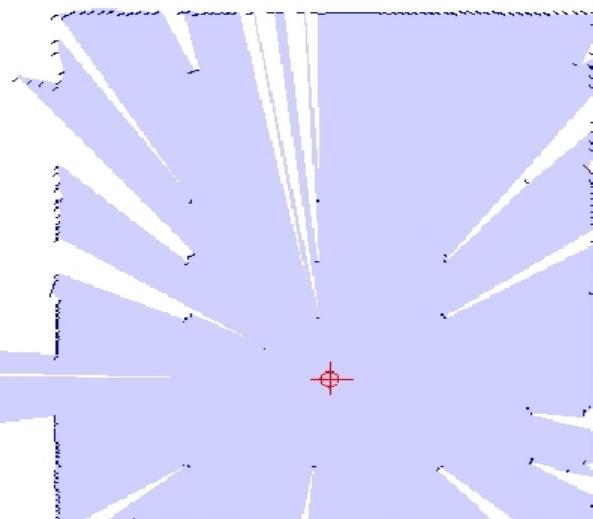
- Control:
  - *“The (mathematical) study of getting dynamical systems to behave in desirable ways.”*
- E.g.
  - Turn steering wheel to go in straight line.
  - Apply correct force to lift a box.





# Main problems in robotics: Localisation

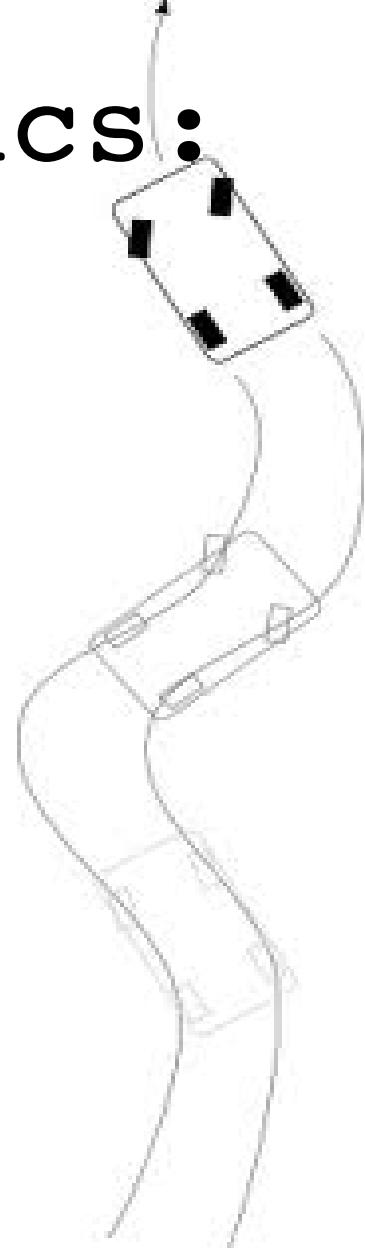
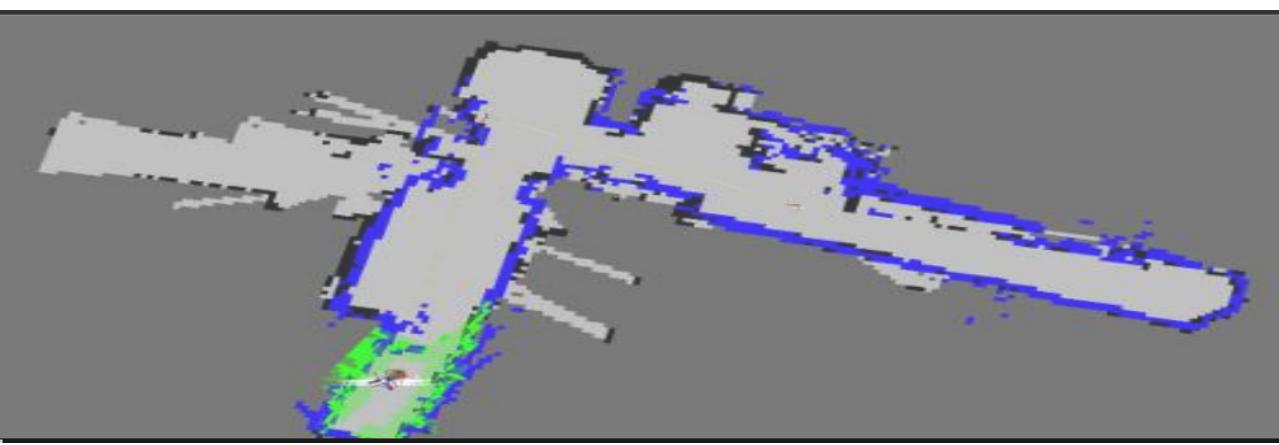
- Localisation:
  - Finding robot's pose in known area.
- E.g.
  - Odometry & laser scans → car location.



# Main problems in robotics:

## Mapping

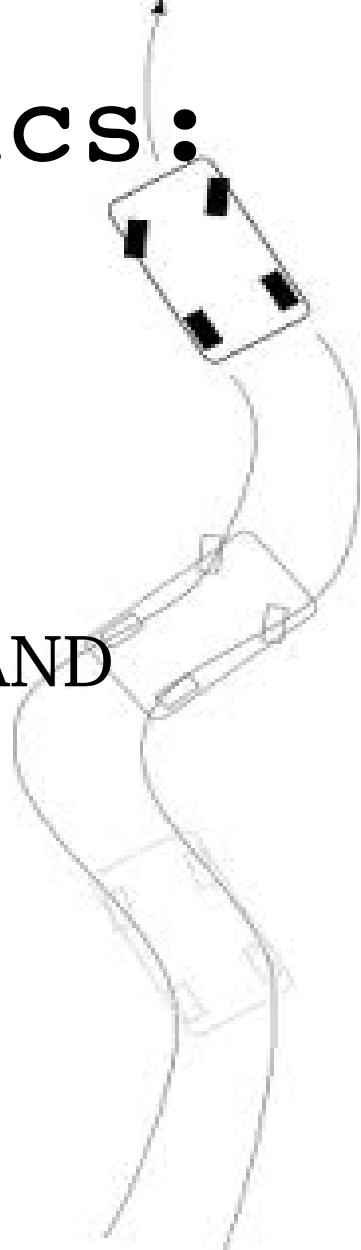
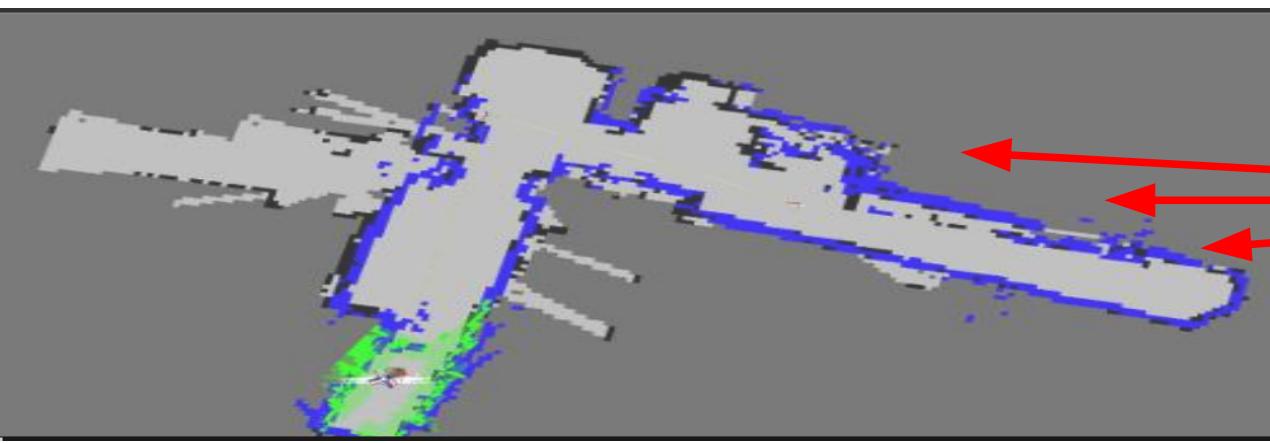
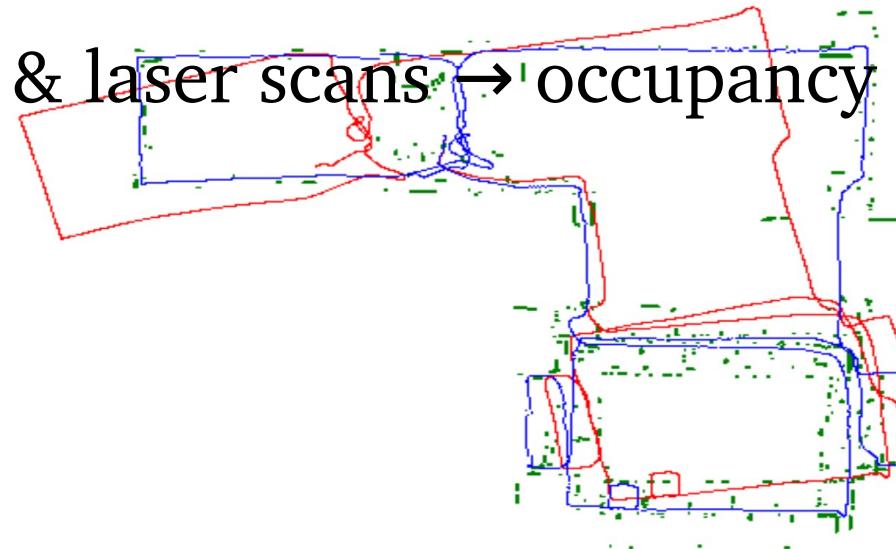
- Mapping:
  - Building a world-map.
- E.g.
  - Odometry & laser scans → occupancy grid.



# Main problems in robotics: SLAM

- Simultaneous Localisation And Mapping.
- E.g.

- Odometry & laser scans → occupancy map AND location.

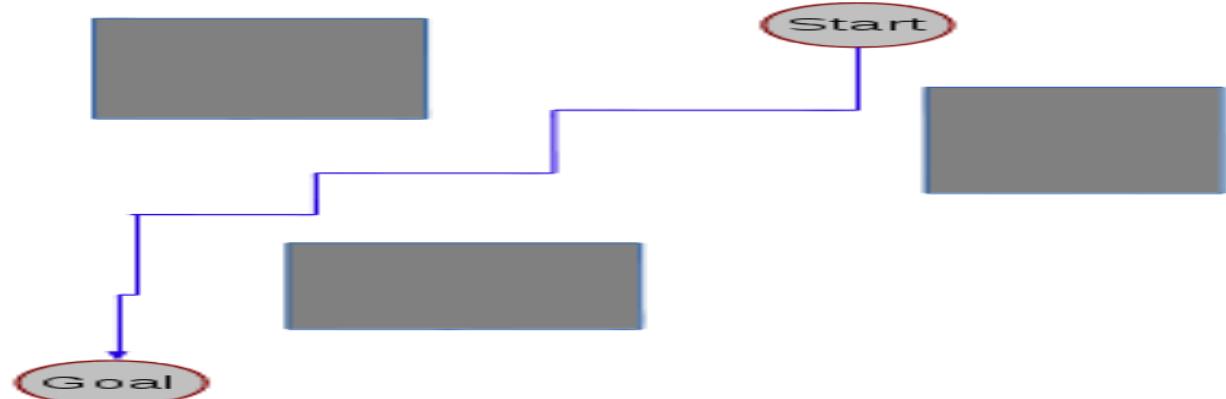
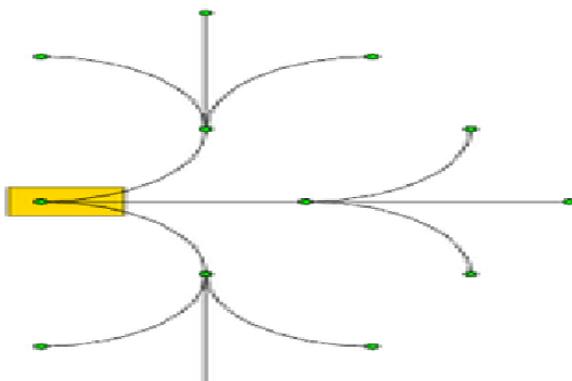




# Main problems in robotics:

## Motion planning

- Motion planning:
  - “The study of paths that robots can take to get to a goal”.
- E.g.
  - Move robot arm past an obstacle.
  - Move car through crowd.



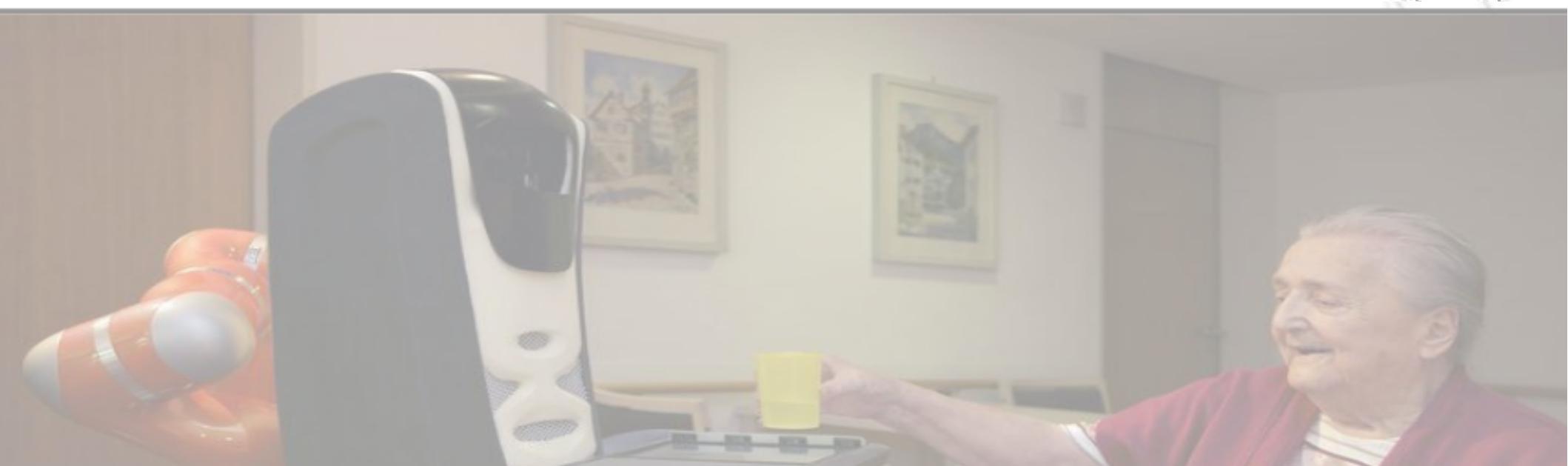
# Main problems in robotics: Task planning

- Task planning:
  - “The study of sequences of actions that robots can take on objects to achieve a particular goal”.
- E.g.
  - Warehousing strategies & stacking.
  - Cooking a meal.



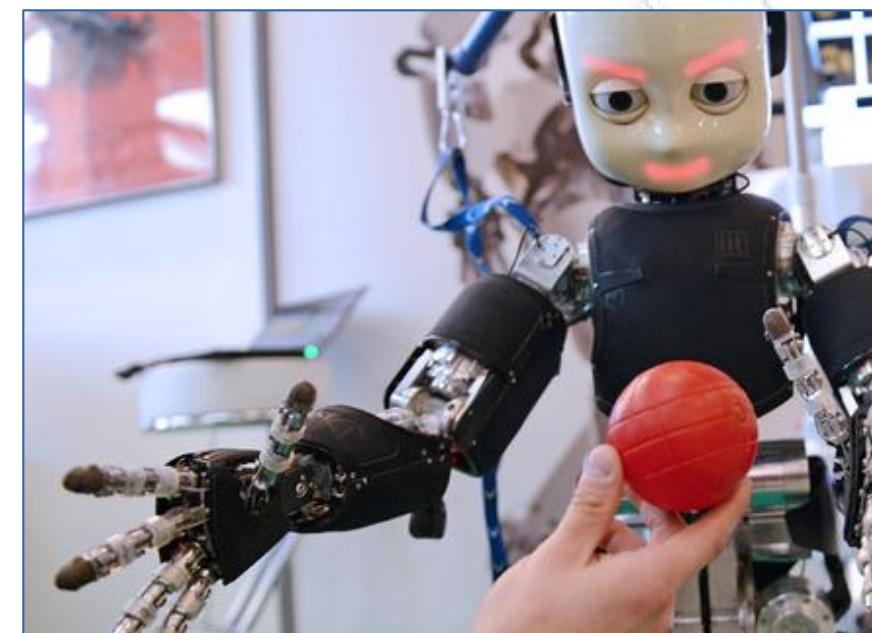
# Main problems in robotics: People-centered

- Speech recognition & generation.
- Action, intention detection.
- Safety & soft robotics.
- Human factors & human psychology.



# Main problems in robotics: Learning

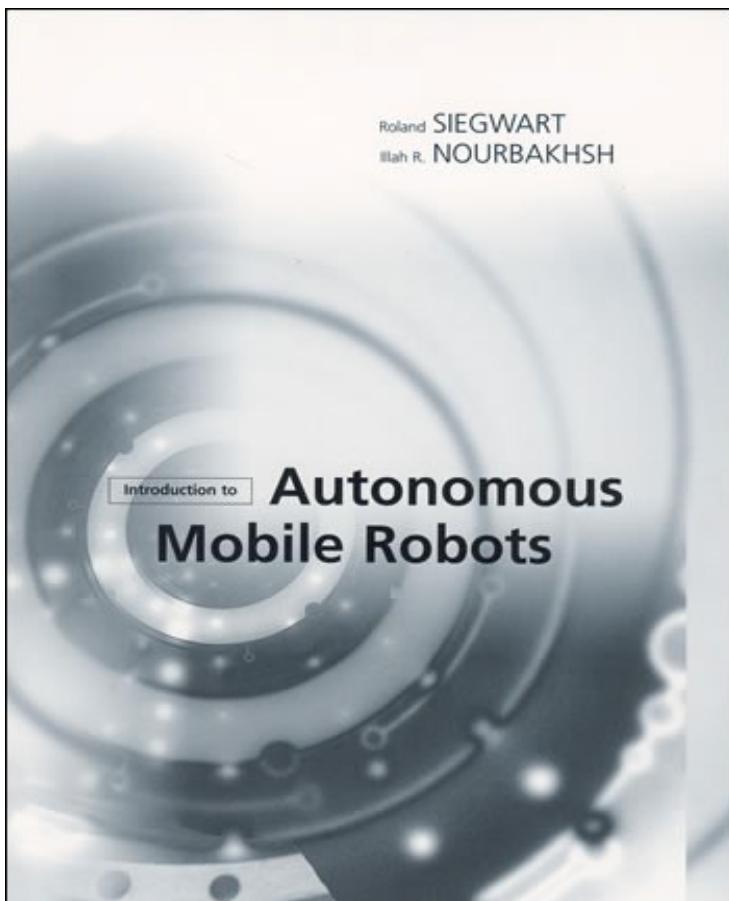
- Learning from demonstration (supervised learning).
- Semi-supervised learning.
- Unsupervised learning & reinforcement learning.
- Object & visual learning.
- Developmental robotics.
- Evolutionary Robotics.
- Etc.



# Readings

Siegwart & Nourbakhsh Chapter 1.

(Introduction)



“When we try to pick out anything by itself  
we find that it is bound fast by  
a thousand invisible cords that cannot be broken,  
to everything in the universe.”

John Muir  
Ecologist

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# Review

- What is a robot?
- What was the first robot?
- What is the difference between reactive robotics and cognitive robotics?
- What is “control”?
- What is “kinematics”?
- What is “localisation”?
- What is “soft robotics”?

