Introduction to Mobile Robotics

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Some examples of mobile robots

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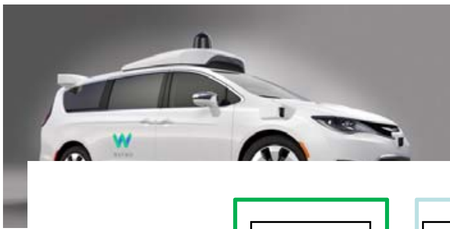
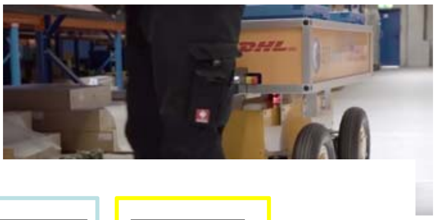
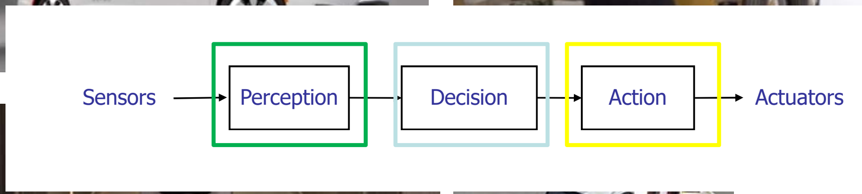
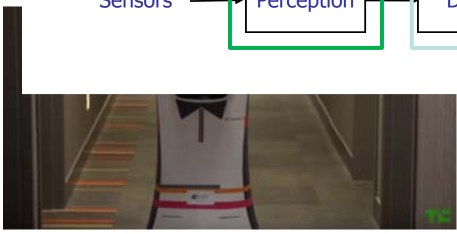
Some examples of mobile robots

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The robot of the day: robair(1/2)

- Robair project: 100% designed, built and developed in the LIG+FabLab Mstic


Research

Public events


Teaching

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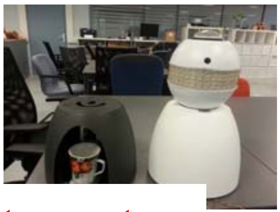
Research



@RobairLig sur tweeter

Teaching

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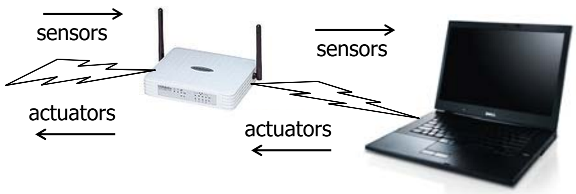
The robot of the day: robair(2/2)



- Sensors
  - 2 laserscanners
- Actuators
  - 2 wheels driven by 2 motors + encoders
- 1 tablet Ubuntu + ROS

- 1 PC Ubuntu + ROS
  - In charge of sensor data acquisition, processing & visualization;
  - In charge of controlling actuators.

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Outline

1. **Sensors + actuators**
2. Perception
3. Decision
4. Action
5. Conclusion

Sensor (1/2)

- **A sensor** is an instrument measuring a physical property of the environment;
- Sensors are imprecise and limited;
- The environment of a robot is generally complex, changing, unpredictable and uncertain;
- Understanding the world in which a robot evolves remains a challenge.

Courtesy of sick

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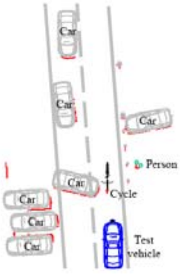

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Sensor (1/2)

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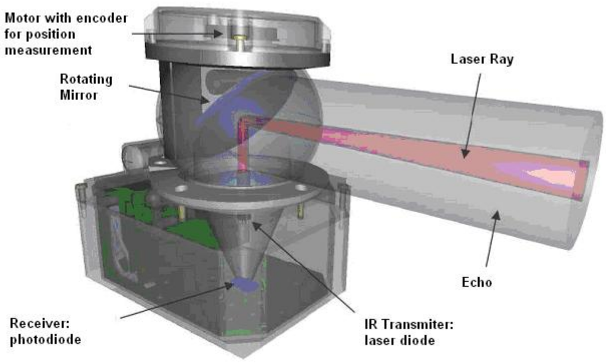

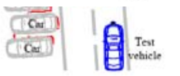

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Sensor (2/2)

- **Robair** is equipped with a 2D laser scanner;
- The laser scanner has:
  - a range of about 5.5 meters;
  - a field of view of 240 degrees;
  - an angular resolution of 1/3 degrees;
  - Frequency: 20-25 hz
- The laser scanner costs about 1200 euros.
- **Output**: a table with 720 elements (r, ϴ)
- Quality of data depends on distance, angle…
- Polar to cartesian:
  - X = r cos (ϴ);
  - Y = r sin (ϴ).

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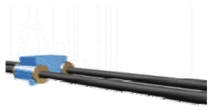
Actuators of a mobile robot

- An **actuator** is a component of a machine that is responsible for moving or controlling a mechanism or system;
- An actuator controls a **degree of freedom** (rotation, translation);

- Actuators could be complex**.**



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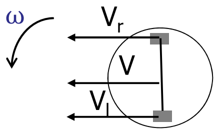
Actuators of robair

- **Robair** has 2 wheels controlled by 2 motors;
- Robair is a differential drive robot;
- Simplest and most used kinematic model of robot.



- Controlling (V_l, V_r), we can determine (V, ω)
  - If $V_l = V_r$ then $\omega = 0$
  - If $V_l = -V_r$ then $V = 0$
- But it is easier and more intuitive to control (V, ω) and determine (V_l, V_r) (inverse kinematic model)
- Combining (V, ω), any motion is possible

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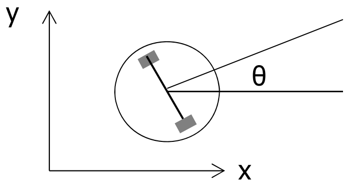
Estimation of motion: encoder/odometer

- While Robair is moving in its environment, we would like to know its position in this environment;
- Its position is determined by its position (x, y) in the environment + its orientation θ: (x, y, θ)



- On each wheel, there is a system (named encoder) able to estimate the distance traveled by each wheel over a short time Δt

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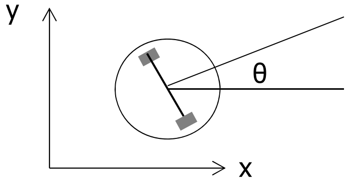

$$x_t = x_{t-1} + \mathrm{d}\cos(\theta)$$
$$y_t = y_{t-1} + \mathrm{d}\sin(\theta)$$
$$\theta_t = \theta_{t-1} + \theta$$

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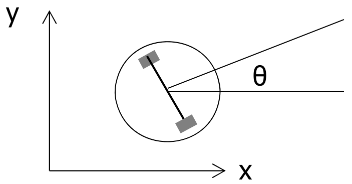

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- On each wheel, there is a system (named encoder) able to estimate the distance traveled by each wheel over a short time Δt
- This is an estimation: with time the error associated to this estimation increases: Drift problem

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Outline

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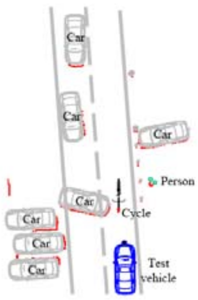
Perception: introduction

Goal

- Robot perception in dynamic environments
- **Laser scanner**
- Speed and robustness



Present Focus: interpretation of raw and noisy sensor data

- Identify static and dynamic part of sensor data
- Modeling dynamic part of the environment
  - Detection And Tracking of Moving Objects (DATMO)
- Modeling static part of the environment
  - Simultaneous Localization And Mapping (SLAM)
  - Not presented today: see lecture on Localization on my web page

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Detection And Tracking of Moving Objects

1. **Cluster data to form objects**
2. **Detection of (moving) objects**
   - **Motion based detection of objects**
   - **Model based detection of objects**
   - **Motion+model based detection of objects**
3. **Tracking of objects**
   - **Detection is never perfect: false alarm, missed detection**
   - **Not only one object is present in the environment**
   - **Integration of detection in time improves robustness**
   - **Some theoretical tools to perform tracking: Kalman filter, particle filter**

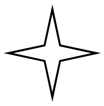
Outline

1. Sensors + actuators
2. Perception
3. **Decision**
4. Action
5. Conclusion

Decision/Plan of future actions

- Most of the time, a mobile robot has to move in its environment:
  - It needs to plan its future actions
- The mobile robot has a map and it knows where it is in the map (position A for instance);
- It should reach an other position in the map (position B for instance)
- **Question**: How to get there ?
- Answer: sequence of actions to go from A to B that is feasible and without collision.

north



West, South, East (12 times), North (6 times), West (twice)

Courtesy of T. Fraichard

Outline

1. Sensors + actuators
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3. Decision
4. **Action**
5. Conclusion

Action/control/navigation

- The mobile robot has a sequence of actions to execute, to reach its goal: it has to execute this sequence of actions;
  - Monitoring of execution: we monitor what happen and react if needed.
    - We need to localize the mobile robot to monitor the actions;
    - Collision detection/avoidance: the mobile robot should be able to detect and avoid collision.

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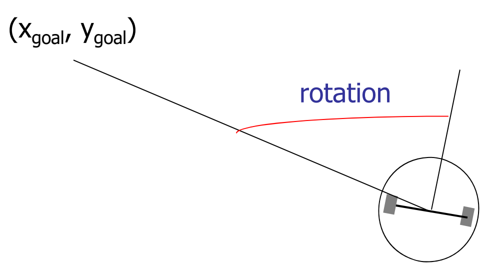
Control of robair

- Robair has to reach a position (x_{goal}, y_{goal}) in its surrounding environment;
  - We determine the translation and rotation to reach (x_{goal}, y_{goal})
  - V is proportional to the translation to do: PID controller
  - ω is proportional to the rotation to do: PID controller
  - We use odometry to monitor the control
  - We combine translation and rotation to have smooth motions



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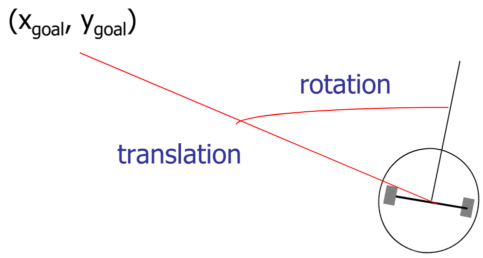
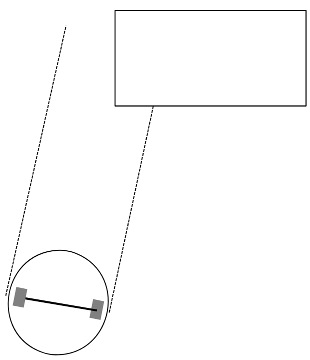


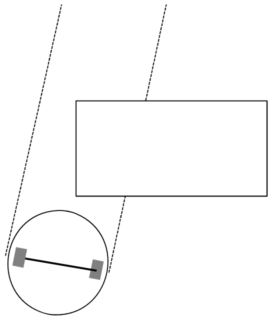
Obstacle detection

- Robair has to detect obstacles while it moves
  - We build a virtual corridor surrounding robair
  - If there is an obstacle in this corridor, we decrease V



Obstacle detection

- Robair has to detect obstacles while it moves
  - We build a virtual corridor surrounding robair
  - If there is an obstacle in this corridor, we decrease V
  - If the obstacle is too close, robair stops



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Summary (1/2)

- A mobile robot is equipped with 2 kind of sensors:
  - **Exteroceptive sensors** that give information about the environment (ie, laser scanner);
  - **Proprioceptive sensors** that give information about the internal state of the robot (ie, odometer);
- A mobile robot is equipped with some actuators characterized by their degree of freedom;
  - Robair is a differential drive robot;
- Sensors and actuators are imprecise and limited;
- The environment of a robot is generally complex, changing, unpredictable and uncertain.

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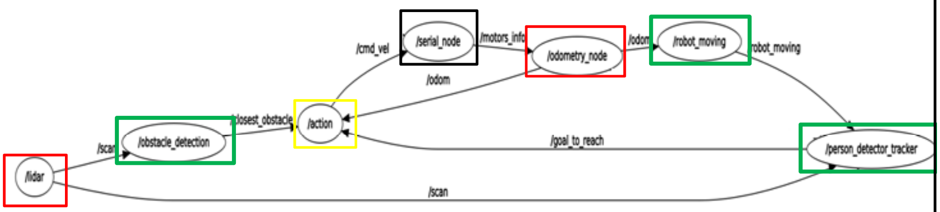
Summary (2/2)

- The link between sensors and actuators is done in 3 steps:

- A mobile robot control architecture is a finite state automaton;
- Architecture of « follow me » behavior.



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