Robots and

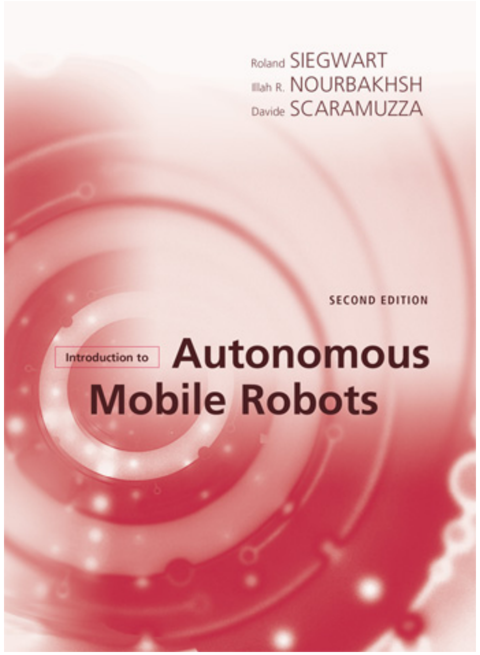
People

Vlad Estivill-Castro (2016)

Robots for People

--- A project for intelligent integrated systems

What is the course about?



- textbook
- **Introduction to Autonomous Robots**
- second edition

  Roland Siegwart, Illah R. Nourbakhsh, and Davide Scaramuzza

The three key questions in Mobile Robotics

- **Where am I ?**
- **Where am I going ?**
- **How do I get there ?**
  - To answer these questions the robot has
    - to have a model of the environment (given or autonomously built)
    - perceive and analyze the environment
    - find its position/situation within the environment
    - plan and execute the movement

Robots and people

This course will deal with Locomotion and Navigation

- Perception
- Localization and Mapping
- Planning
- Motion Generation

Course Content

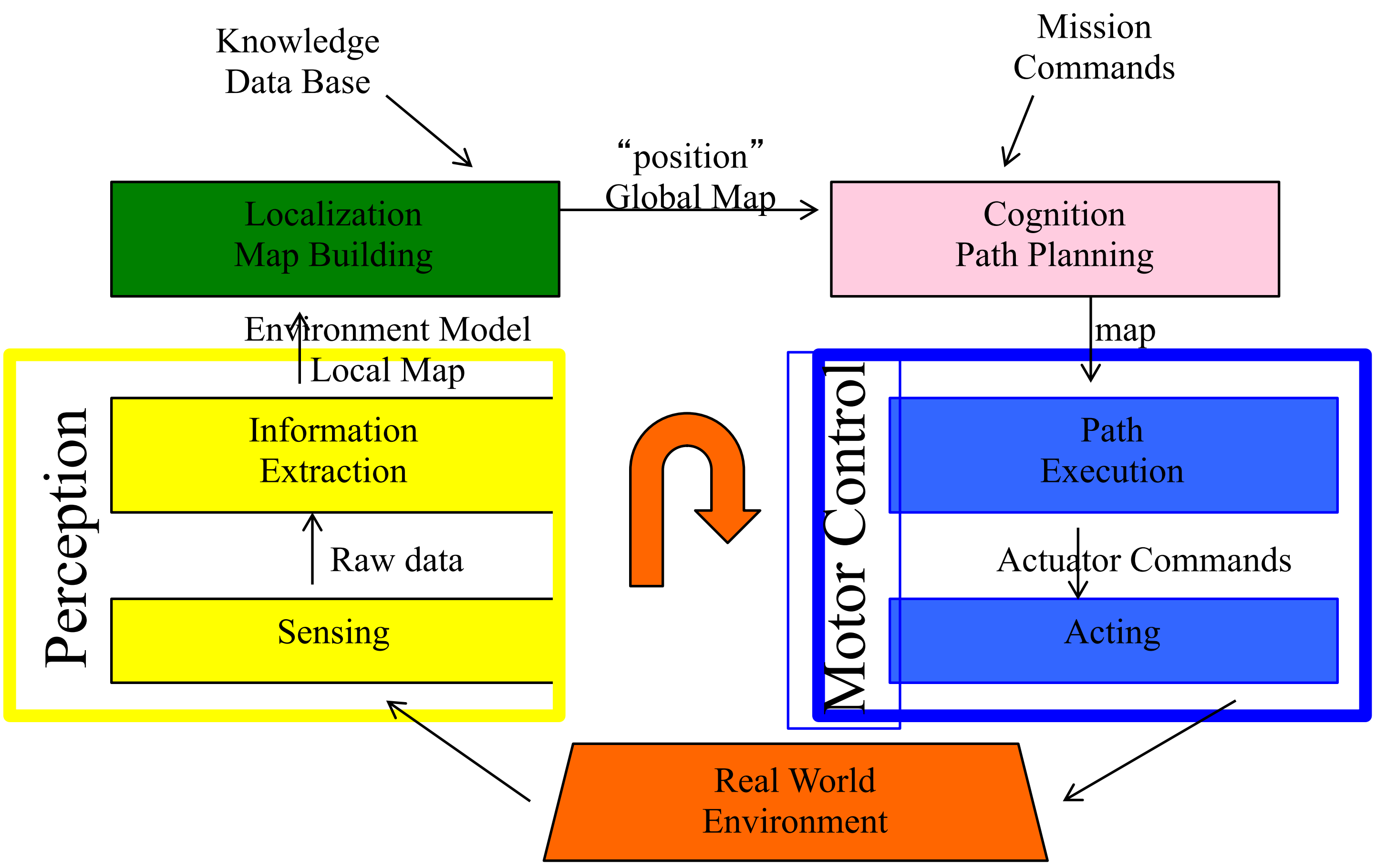
- ***Introduction***
- ***Locomotion (little)***
- ***Mobile Robot Kinematics***
- ***Perception***
- ***Mobile Robot Localization and Mapping***
- ***Planning and Navigation***

- ***- a spin to useful techniques for Humanoid Robots, RoboCup, Nao***

Robots and people

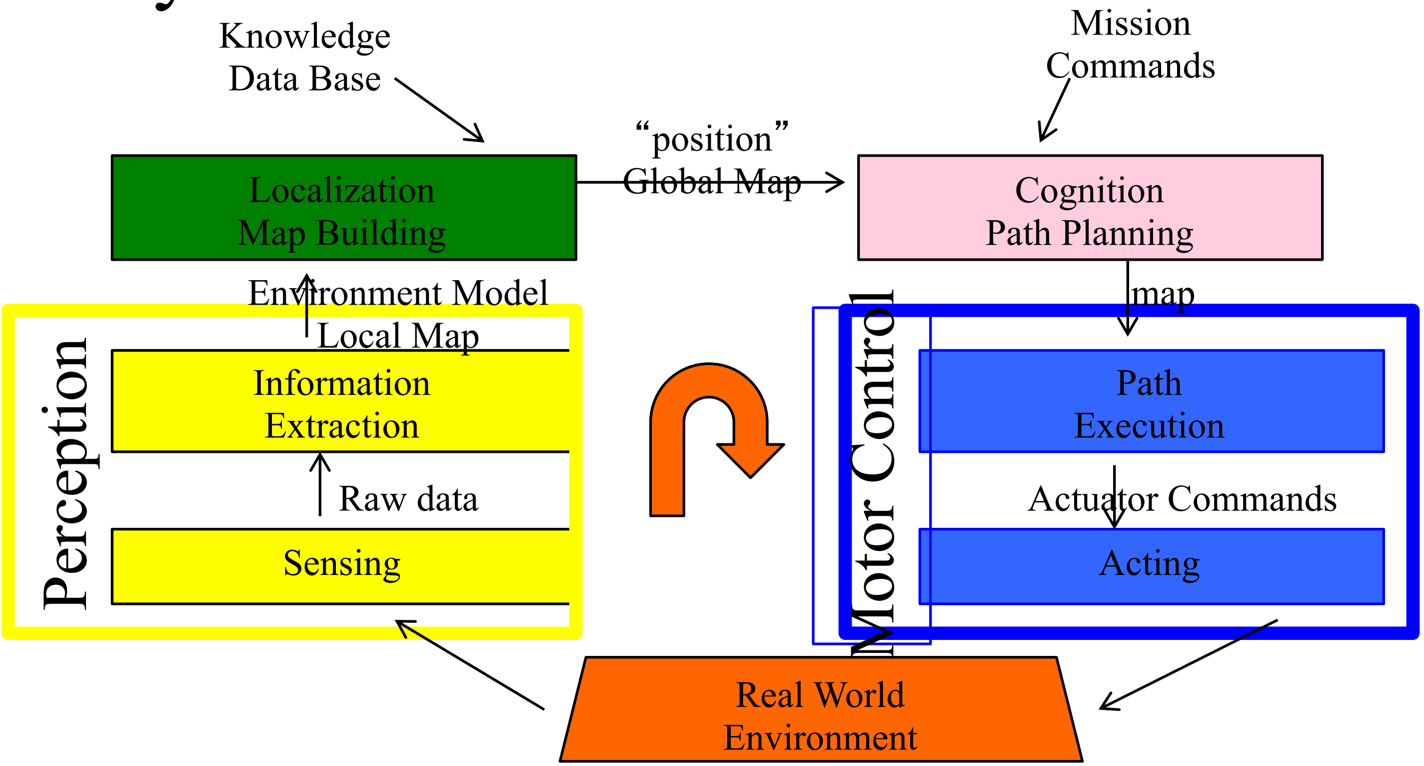
General Control Scheme for Mobile Robot Systems

- (Roland Siegwart, Illah Nourbakhsh, Davide Scaramuzza)



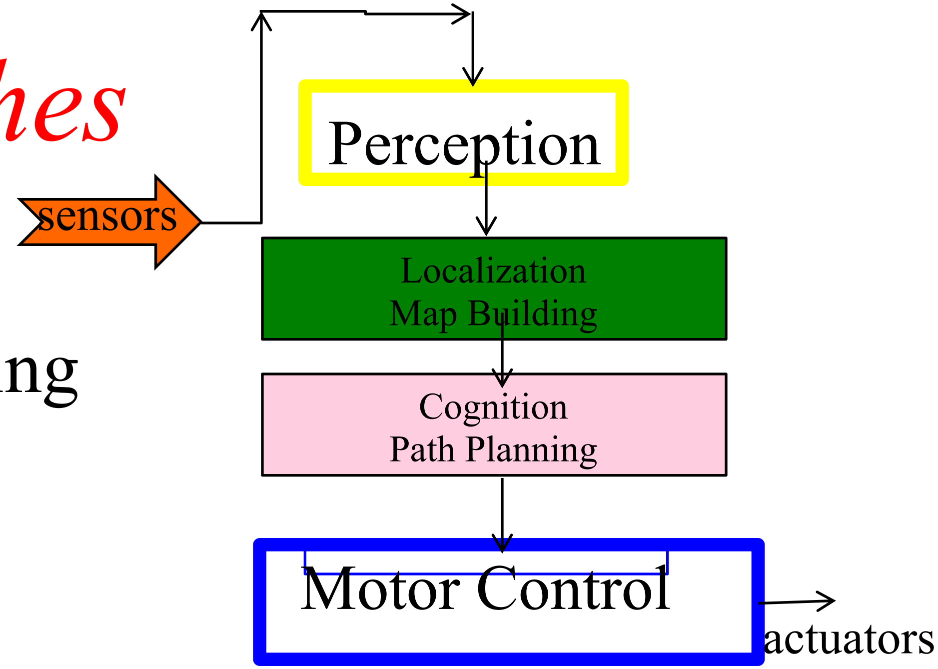
Control loop

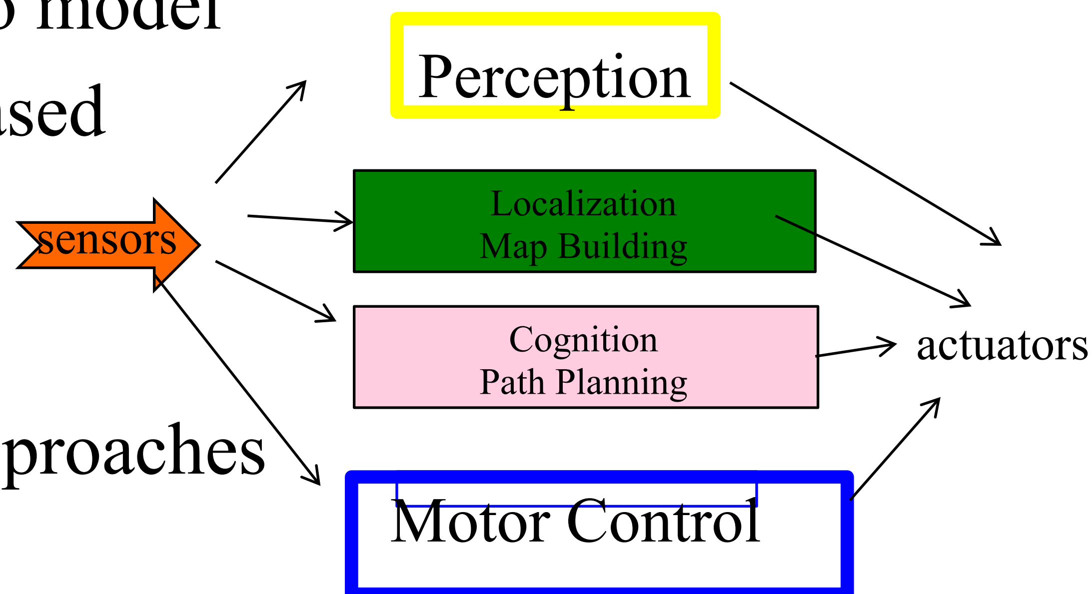
- dynamically changing
- no compact model available
- many sources of uncertainties



Two approaches

- Classical AI
  - complete modeling
  - function based
- New AI
  - sparse or no model
  - behavior based
- Solution
  - combine approaches





The Key for Autonomous Navigation

- Environment Representation
  - continuous metric -> $x, y\ \Theta$
  - Discrete metric -> metric grid
  - Discrete Topological-> topological grid
- Environment Modeling
  - Raw sensor data
    - large volume, low distinctiveness
  - Low level features
    - medium volume of data, some distinctiveness
  - High level features
    - low volume data high distinctiveness

Environment representation

- Odometry
  - follow directions/commands like Navigator
  - follow a treasure
- Modified Environments
  - very specific/encoded information
- Feature based
  - Landmarks, Affordances of the environment

Human navigation

- Topological and conceptual maps
  - the dimensions of Australia, and what is close, north, south
  - number of buildings vs name of buildings
- Relations at different scales

The Map Categories

1. recognizable landmarks
2. topological maps (graph model)
   - games like snakes and ladders
3. metric topological maps
   - edges have weight equal to distance
4. Full metric maps
   - nodes are geo-positioned

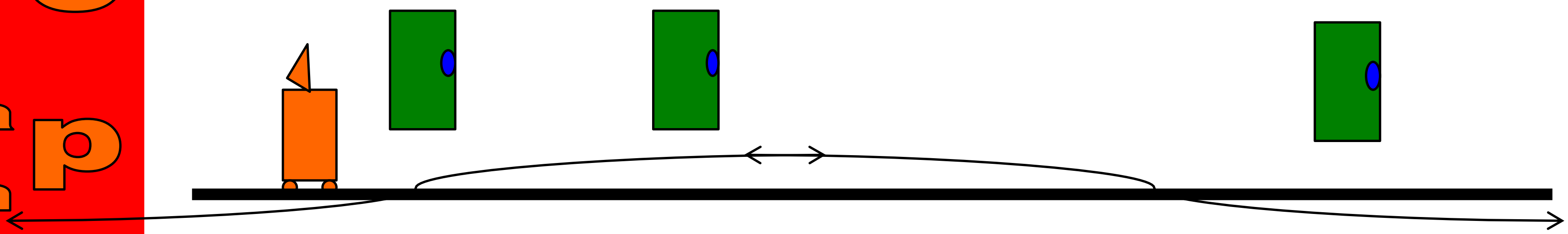
Understanding --- Probabilistic reasoning (Bayesian inference)

- Reasoning in the presence of uncertainties and incomplete information
- Combining preliminary information and models with learning from observed data
- $P(A|B) = P(B|A)\,P(A)/P(B)$
  - the probability that the new situation is A once I observed B is related to the chances of noticing B when in situation A and the ratio of oberving A with the chances of observing B

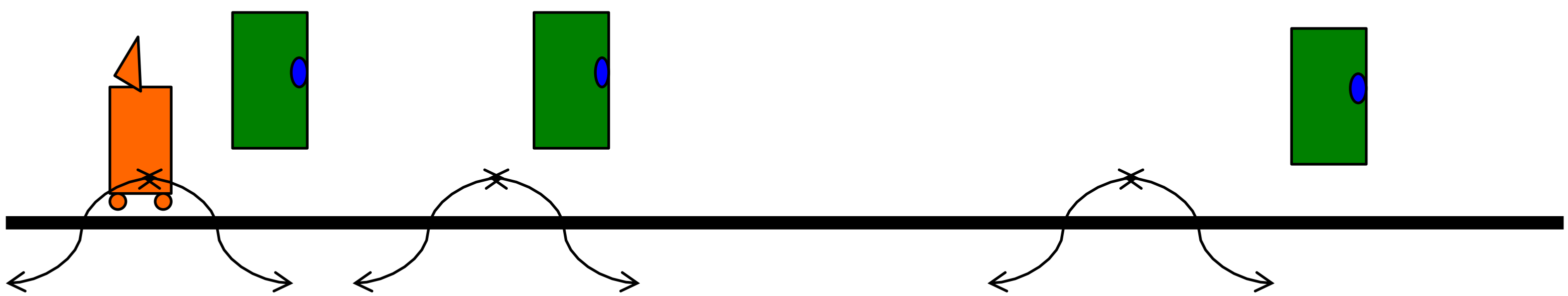
Reducing Uncertainties

- Where can I be?

- Anywhere

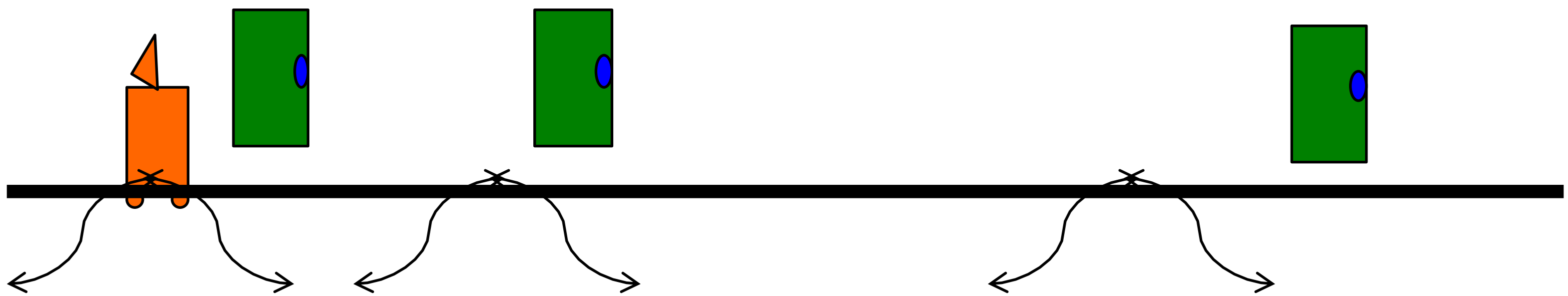


- Observe a door

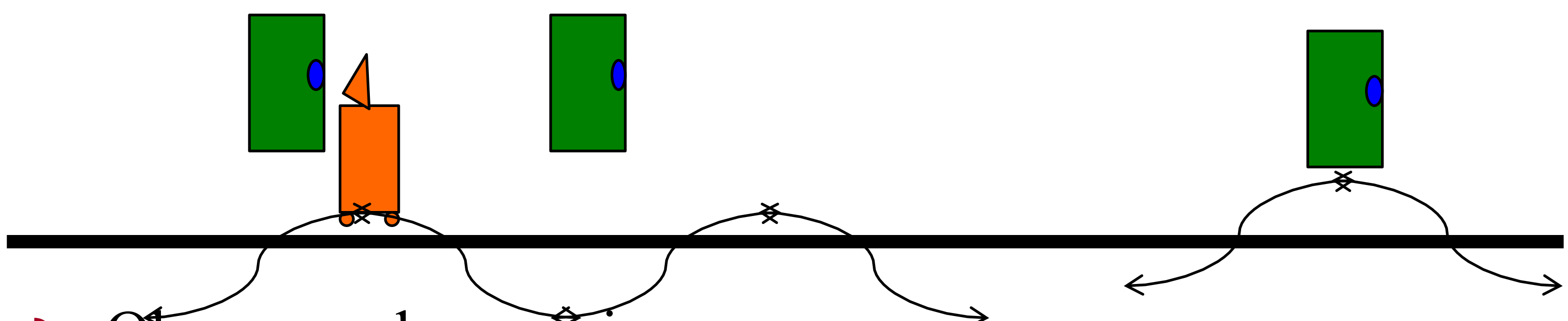


Reducing Uncertainties

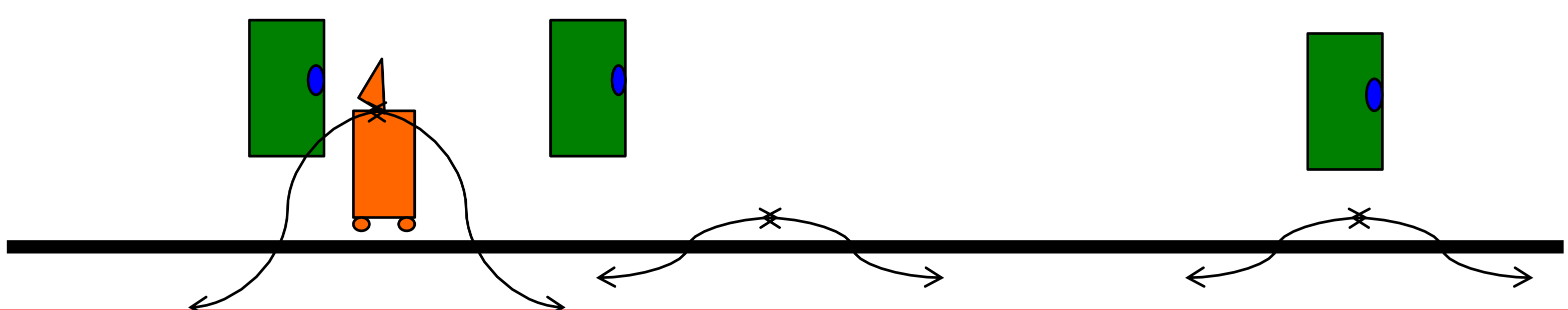
- Observe a door



- Walk a bit



- Observe a door again



Robots and people

Metric Navigation: Probabilistic Position Estimation (Kalman Filter)

- Continuous, recursive and very compact
  - ACT PHASE
    - state prediction via a motion model
      - obtain $x(k+1 \mid k)$ and $P(k+1 \mid k)$ given $x(k|k)$ $P(k|k)$
  - SEE PHASE
    - Balance the advice of where I am (result of the motion model) and the advice of where I am (result of the sensor)
    - Depending on how much I trust each

State prediction: odometry

- Incrementally (dead reckoning)
  - There is a discrepancy into the real trajectory and the belief of where I have been
  - DRIFT
    - cumulative error
- Under no error, current position is accurate

Methods for Localization

∴Quantitative Metric Approach

1. A priori, know your environment
   - in graph, map
2. Extract features (line segments, landmarks)
3. Match them with location in map
4. Estimate your position
   - Kalman filter, Markov filters (particle filters)
   - Balance observations with your belief
   - issues:
     - estimation of uncertainties
     - weights to prior statistics

Belief Representation

- Well known probability models
  - mixture of multi-variate normal distribution
- Descriptive statistics
  - Histograms

Probabilistic SLAM

- **Simultaneous localization and mapping (SLAM)**
  - **first characteristic question**, *What does the world look like?*
  - **second characteristic question**, *Where am I?*
- The robotics community claims to have solved the SLAM problem
  - *lots of variations on the assumptions / sensors/ motions*
  - *issues of complexity*
  - *quality*

Summary

- Mobile robotics
  - the most challenging type of robotics
    - robots are anywhere in the world
- Many architectures, some well accepted but found insufficient, new approaches discussed
- Large body of techniques
  - feature extraction
  - sensor fusion
  - mapping, tracking and/or localization

Robots and people

THANK YOU