Probabilistic Robotics Course

INTRODUCTION

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- all emails you send us and concerning the course should have **[prob-rob]** as first string in the subject.

Teaching Material

- The primary source of information for the course is this web page

  https://sites.google.com/dis.uniroma1.it/probabilistic-robotics

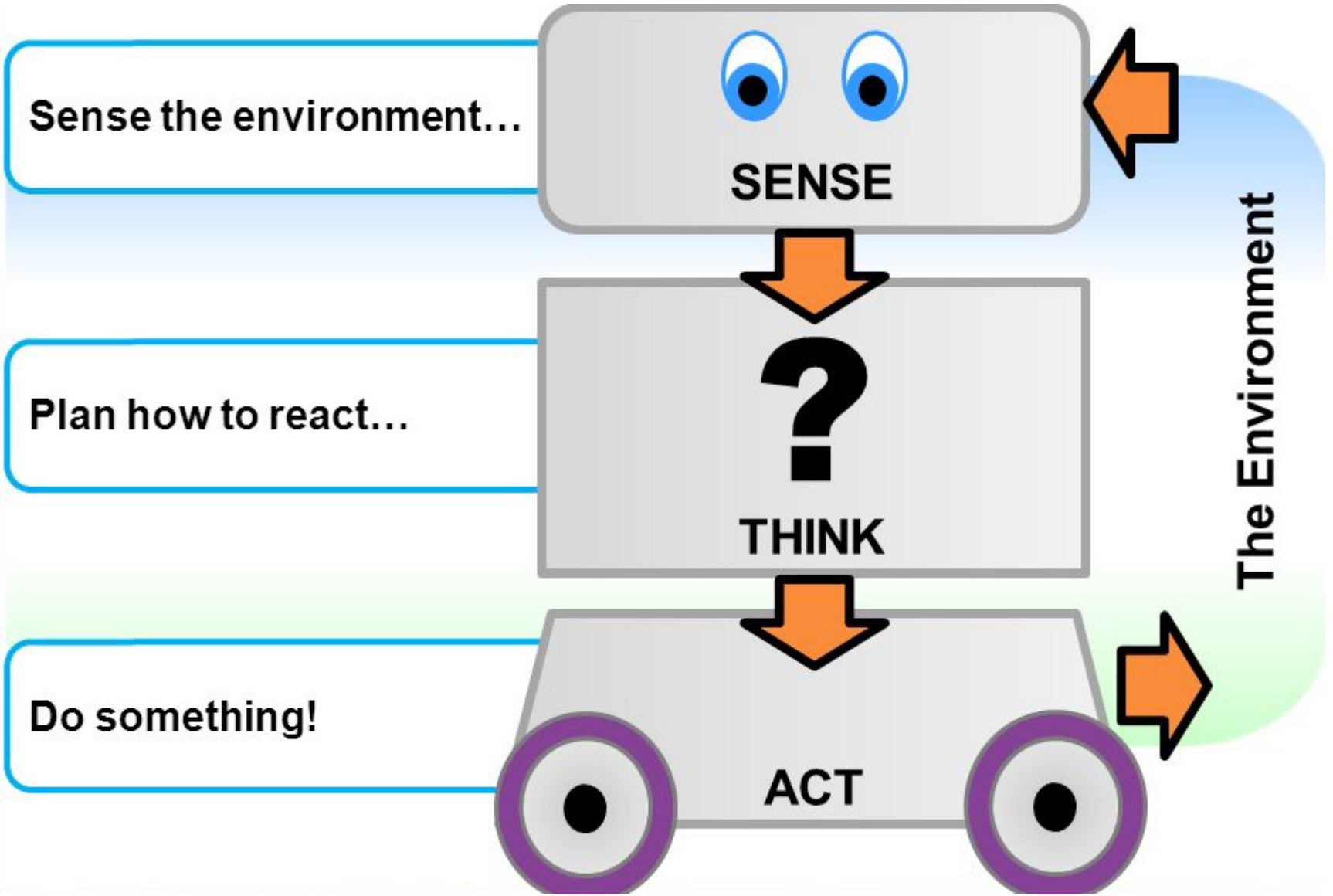
- The material
  - Slides
  - Source code for practicals

  Is also available at the following repository

  https://gitlab.com/grisetti/probabilistic_robotics_2017_18

Robots Have to Work

Sense-Plan-Act



State in Robotics

Model of the world

- Geometry
- Traversability
- Other moving objects
- …

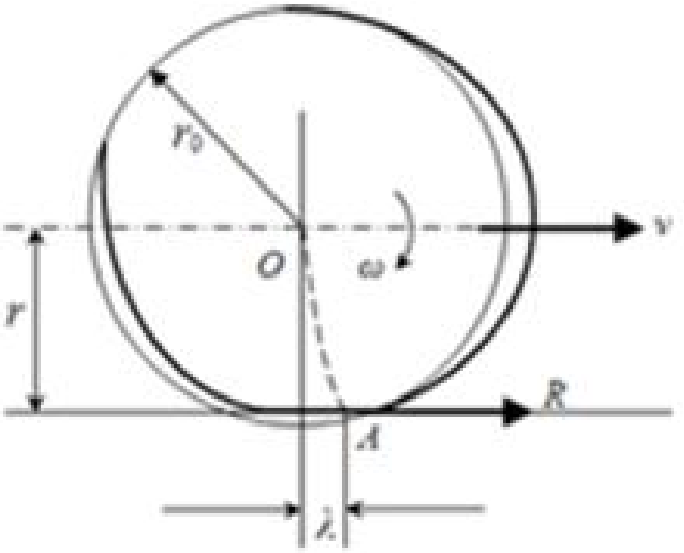
Robot configuration

- Kinematics
- Dynamics
- State of batteries

…

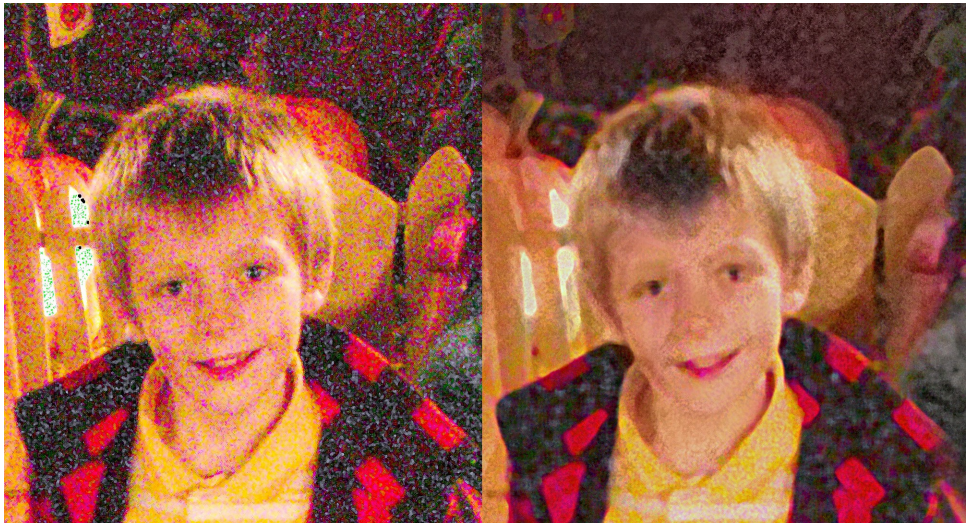
Probability and Robotics

The model of a system is typically an abstraction of a more complex real entity



Disturbances affect the measurements and the system

Measurement might be poorly informative



The predicted behavior different from the observed one

Probability and Robotics

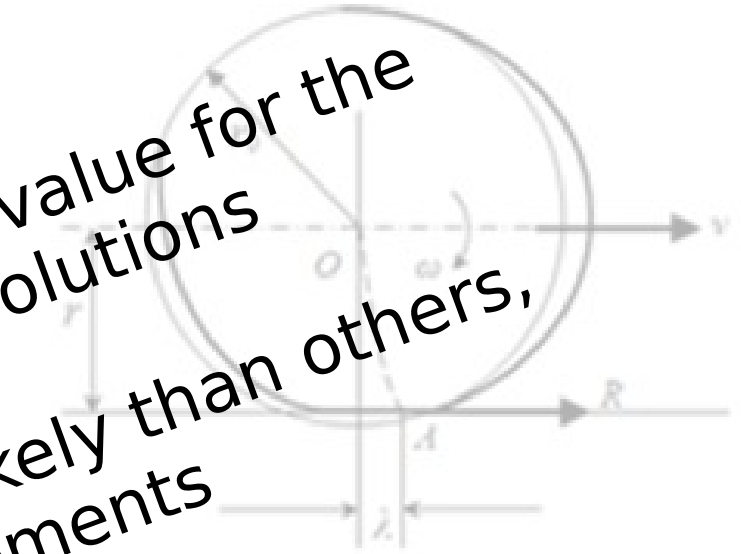
The model of a system is typically an abstraction of a more complex real entity

Disturbances affect the measurement and the system

Measurement might be poorly informative

The predicted behavior different from the observed one

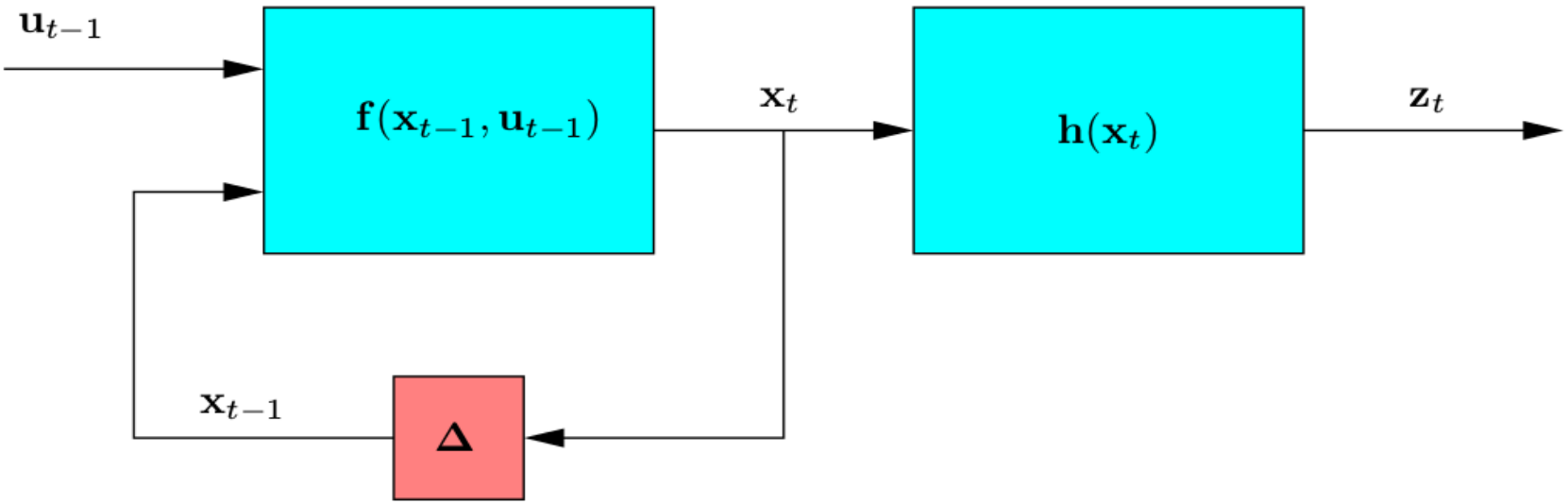
There is not a single possible value for the state, but a set of potential solutions



Some solutions are more likely than others, given the current measurements

We will use probabilistic inference

System Model



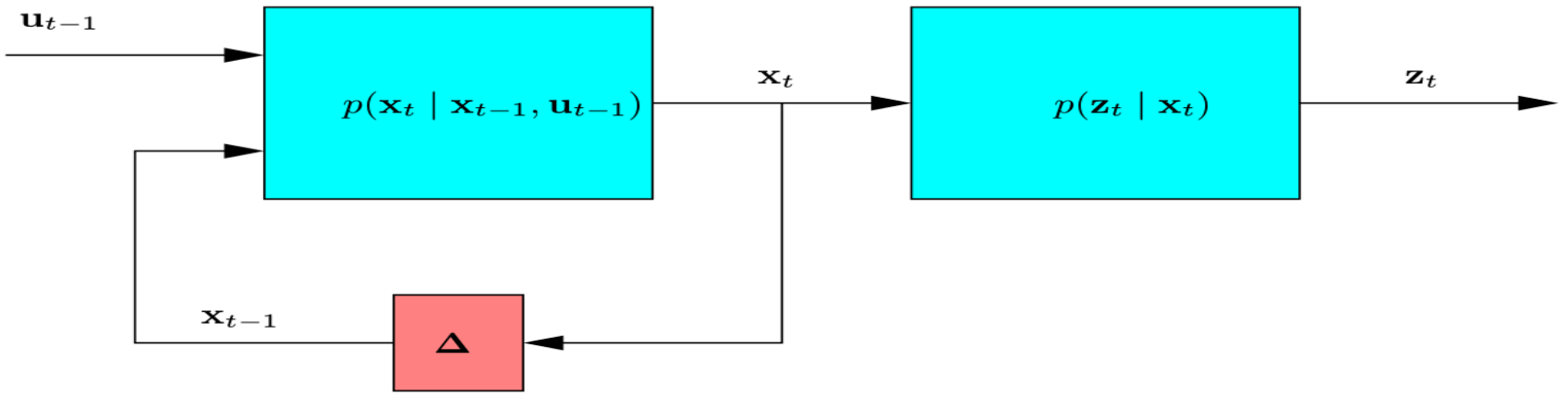
Notation:

- **u**: controls
- **x**: state
- **z**: measurement
- **f**: transition function
- **h**: observation function

Perfect knowledge of

- inputs
- measurements
- transition model
- observation model

System Model



Probablistic model

- The variables become stochastic (uncertain)
- The transition function is replaced by a transition model, that describes a conditional probability distribution over the next states as a function of the previous states
- The observation function is replaced by a conditional probability describing the distribution of possible observations as a function of the current state
- If no uncertainty is present the probabilistic models degenerates to the deterministic model

What will I learn?

Tools

- Filtering tools
  - Discrete
  - Gaussian
  - Particle
- Maximum Likelihood Estimation
  - Gauss-Newton
  - Sparse Least Squares
- Data Association
  - Greedy
  - Voting Schemes
  - Spectral Methods

Applications

Calibration

Tracking

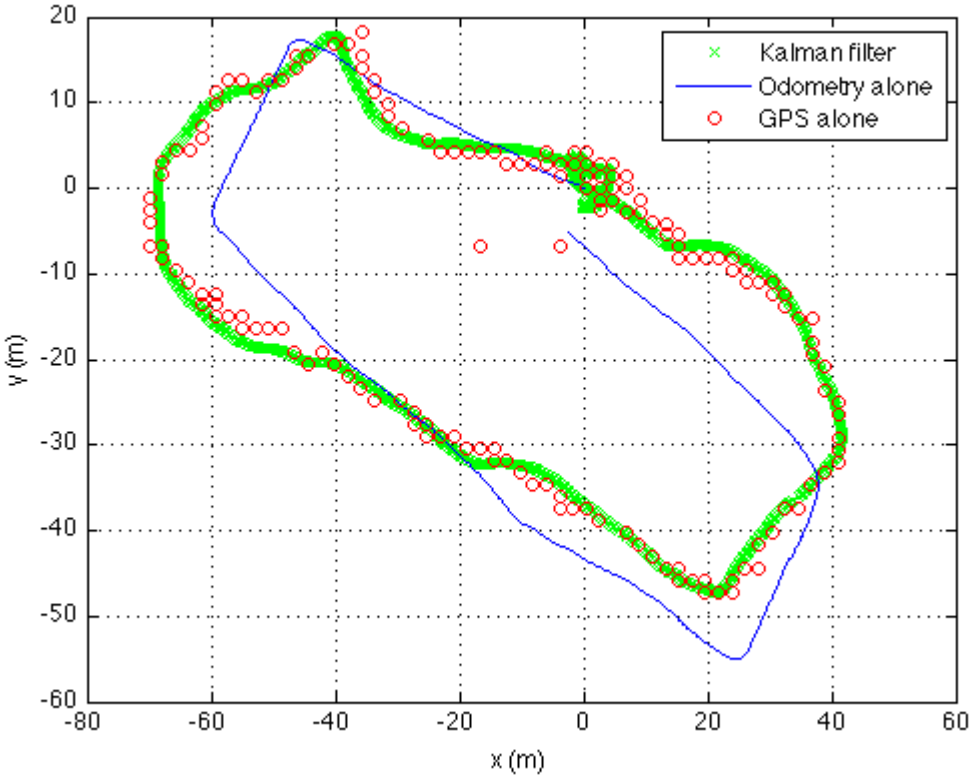
Localization

Mapping

SLAM

Filtering

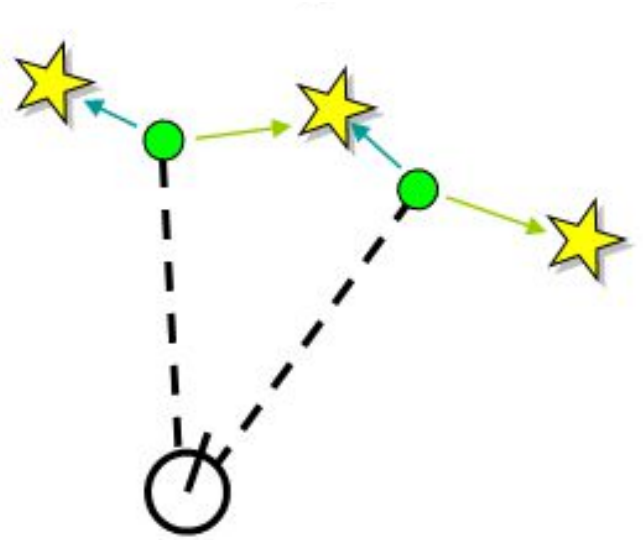
Filtering is the process of estimating the distribution over the possible **current** states of a dynamic



In doing so we have access to

- the controls
- the measurements

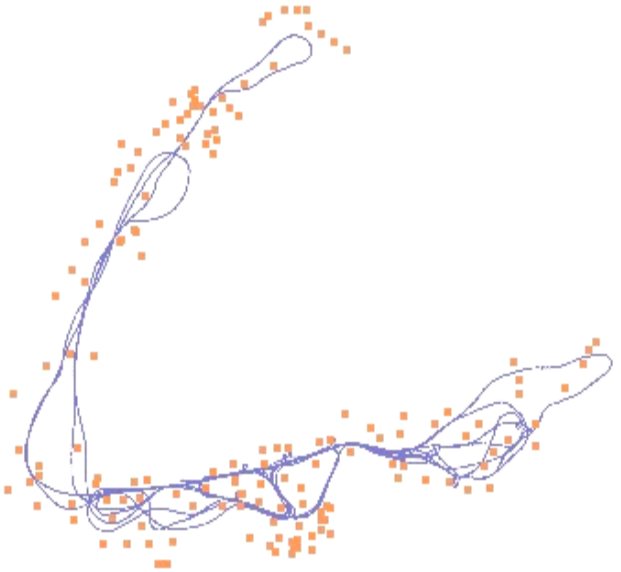
Data Association



Determine which state variable (if any) is responsible of a measurement, based on:

- the current estimate of the state
- the history of measurements

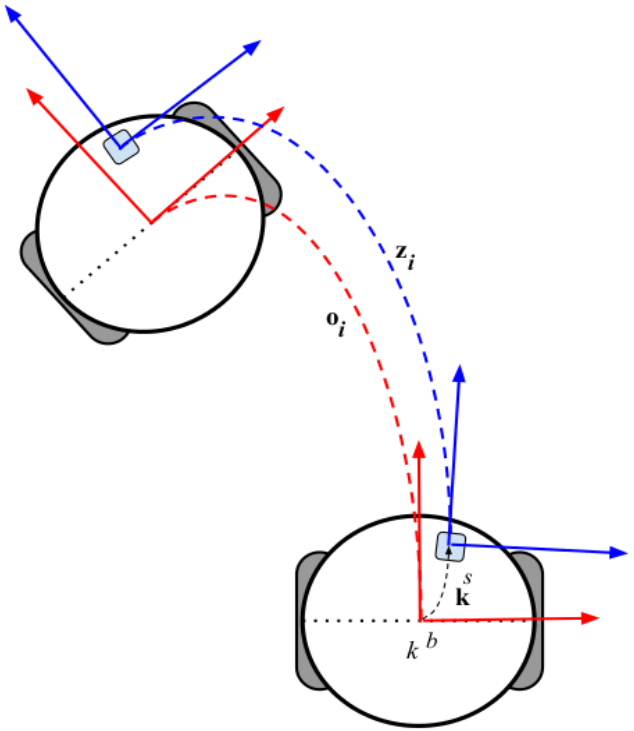
Maximum Likelihood Estimation

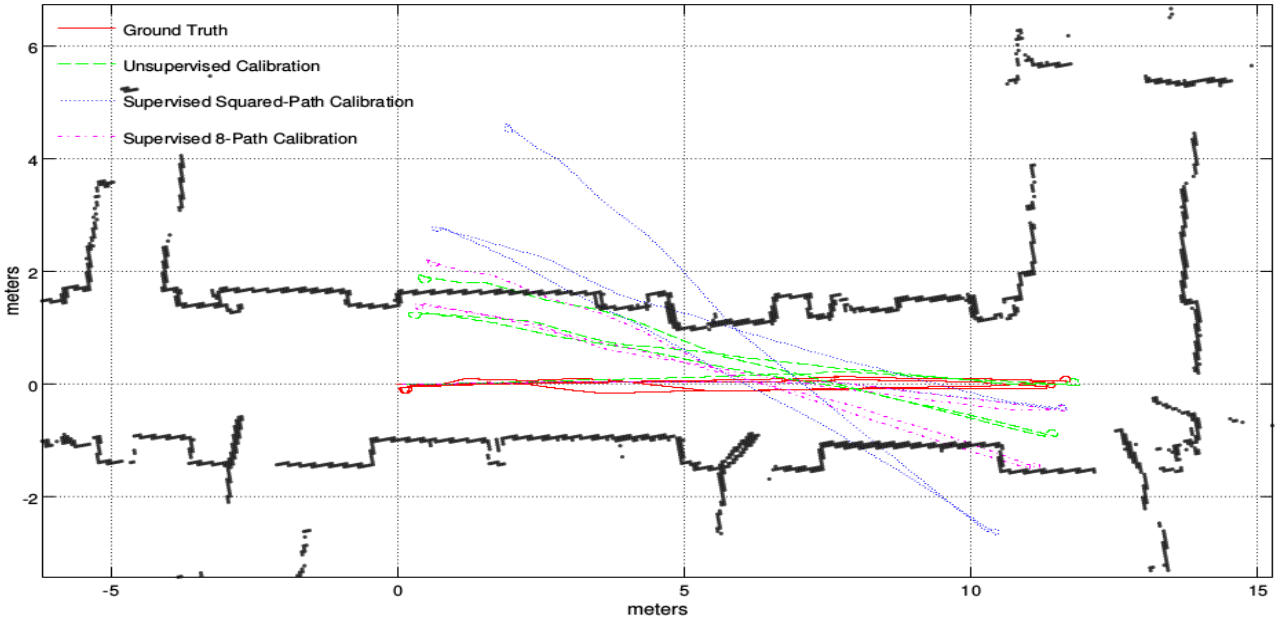


Estimate the most likely trajectory of the system's state given all measurement so far

In case of stationary system, the trajectory degenerates to a single state

Calibration

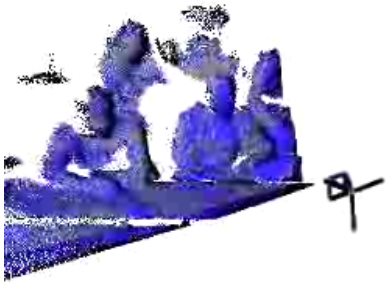




Determining the kinematic parameters of a robotic system given

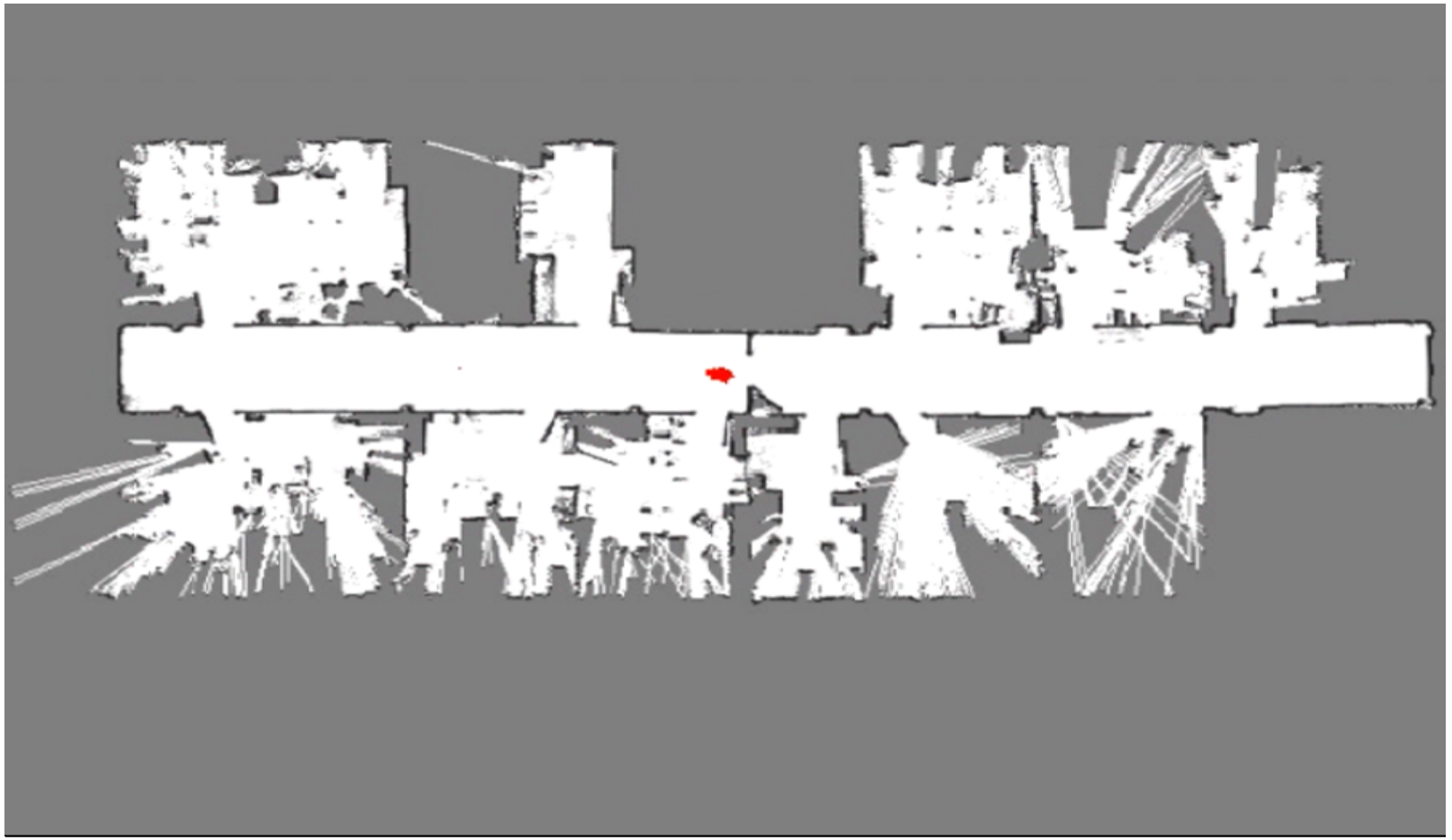
- trajectory of the sensors (externally measured)
- encoder readings

Tracking



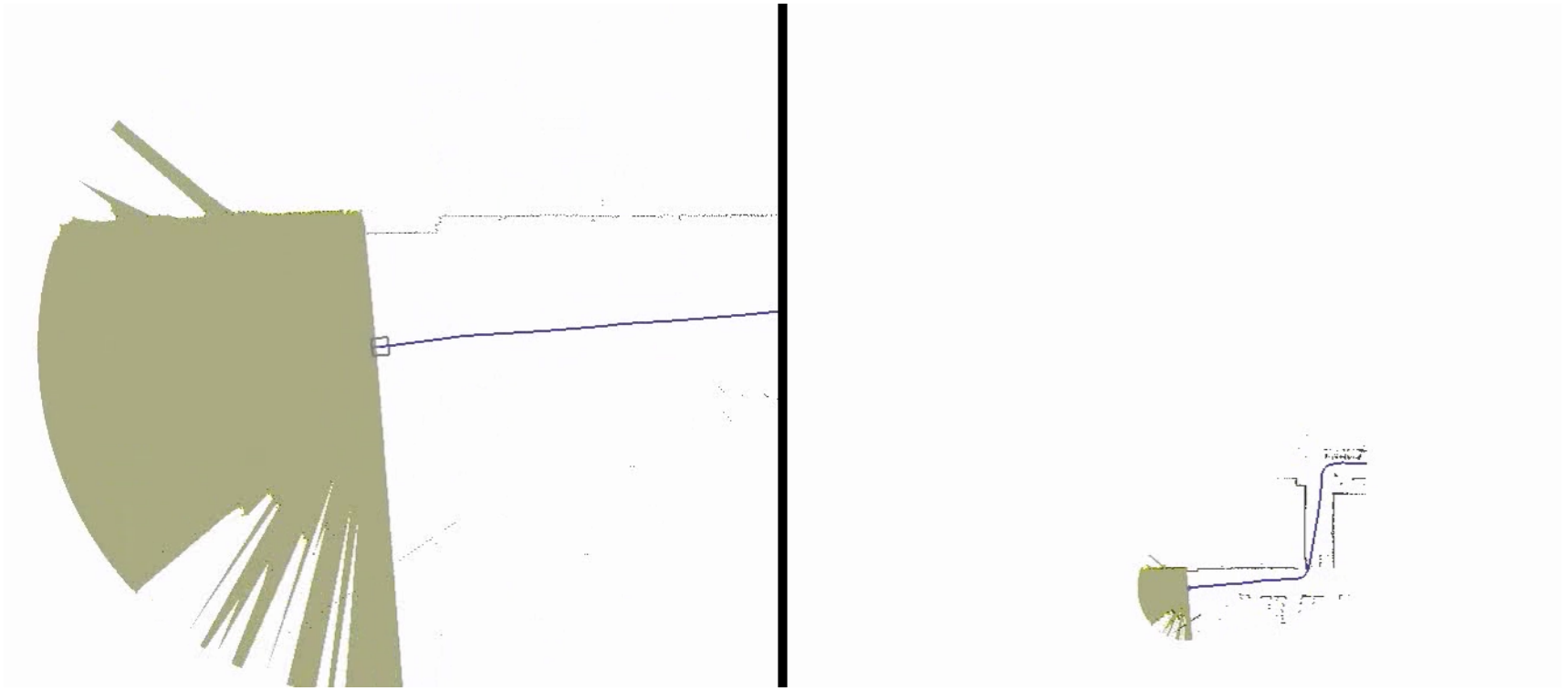
Track the position of a moving sensor by estimating the motion between the previous and the current views

Localization



- Determining the current position of a robot, given
  - The knowledge of the map
  - All sensor measurements up to the current time

SLAM



Determine the robot position AND the map, based on the sensor measurements

Tools

- Linux (Ubuntu)
- C/C++ (gcc)
- g2o (https://github.com/RainerKuemmerle/g2o)
- ROS (www.ros.org)
- Octave (sudo apt-get install octave)
- V-REP (http://www.coppeliarobotics.com/index.html)

Exam

- An individual project
- Oral exam (with written exercises)
- Note
  - The students that already gave LAS or the elective in SLAM (but not both of them) might take the exam in probabilistic robotics
  - For these students there will be an extended part of the program, to be discussed with the teacher