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AIS Autonomous Intelligent Systems

Least Squares and SLAM *Intro*

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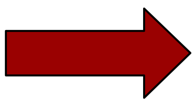
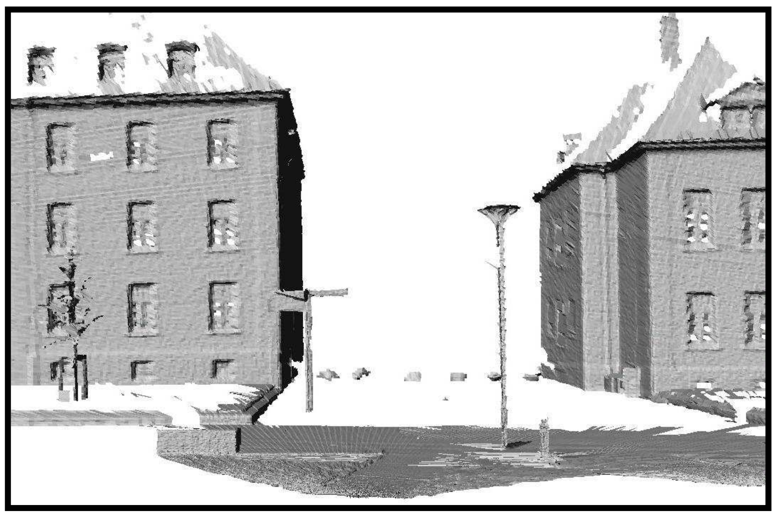
Part of the material of this course is taken from the Robotics 2 lectures given by G.Grisetti, W.Burgard, C.Stachniss, K.Arras, D. Tipaldi and M.Bennewitz

SLAM

- SLAM= Simultaneous Localization and Mapping
- Estimate:
  - the map of the environment
  - the trajectory of a moving device

using a sequence of sensor measurements.





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- Estimate:
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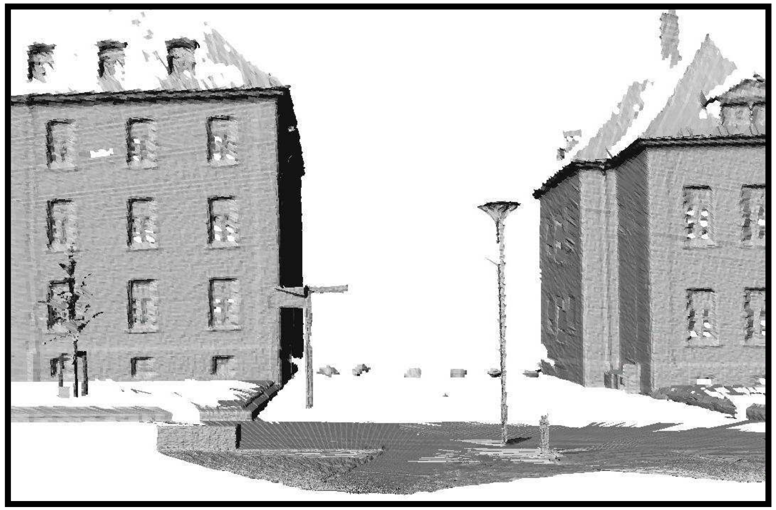
these quantities are correlated



Why SLAM is so Important?

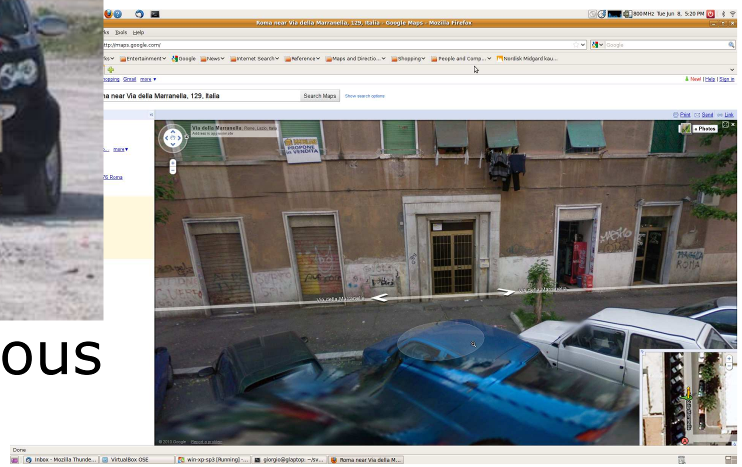
- Most applications require to localize a device in a map.
- A map cannot always be provided.
- Do **SLAM**!

service robotics

industrial applications

autonomous cars

Google street view



History

time and size of the environment

1960 Bundle Adjustment (~10
images)
1970 Recursive Partitioning (~1000 images)

1990 (SLAM is born)

1993 Scan-Matching, Iconic maps

1997 Graph-SLAM

2000 Modern Sparse Matrix Techniques for BA

2002 FastSLAM

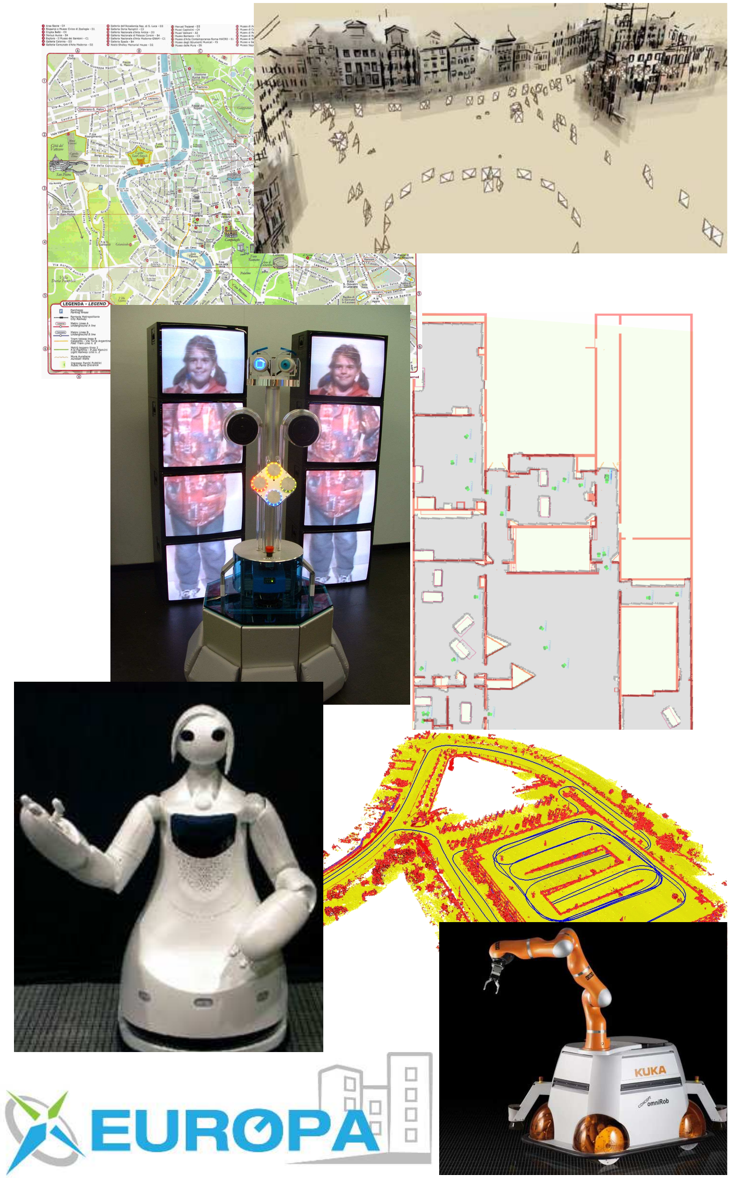
2003 ESDF, Treemap,
TJTF

2005
SAM

2006 Appearance-Based Localization

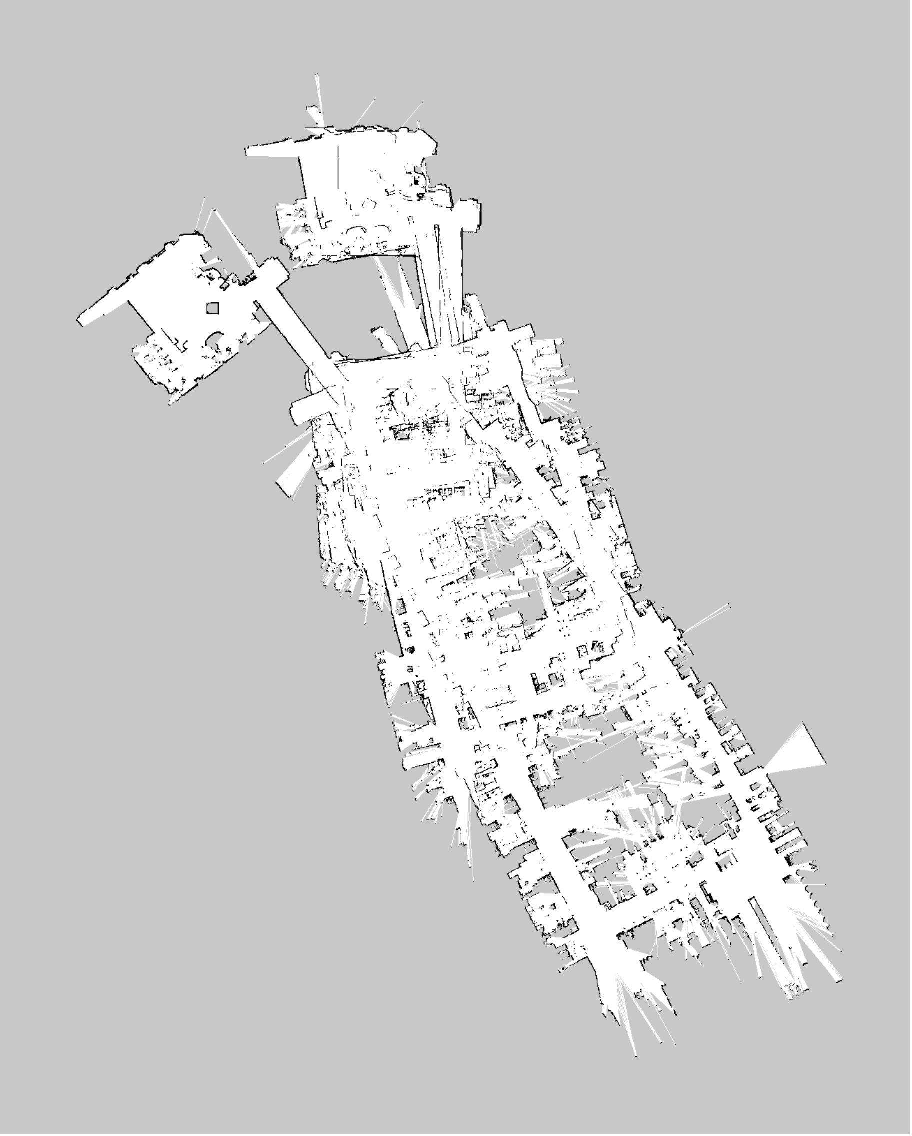
2006 Efficient Graph-Based SLAM

2010 Towards the unification of BA and SLAM



Graph-based SLAM in a Nutshell

- Node:
  - robot position and
  - laser measurement.
- Edge:
  - spatial transformation between nodes
  - depends on the matching of scans



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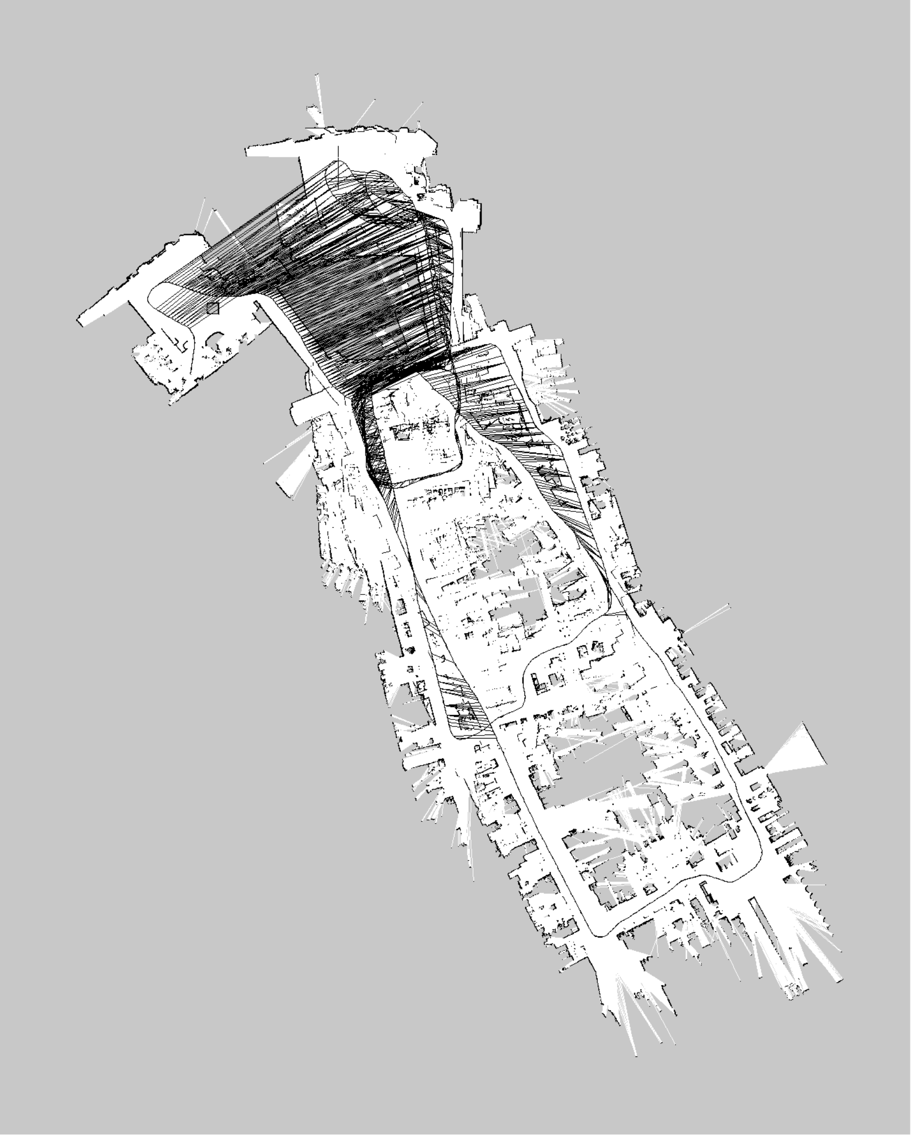

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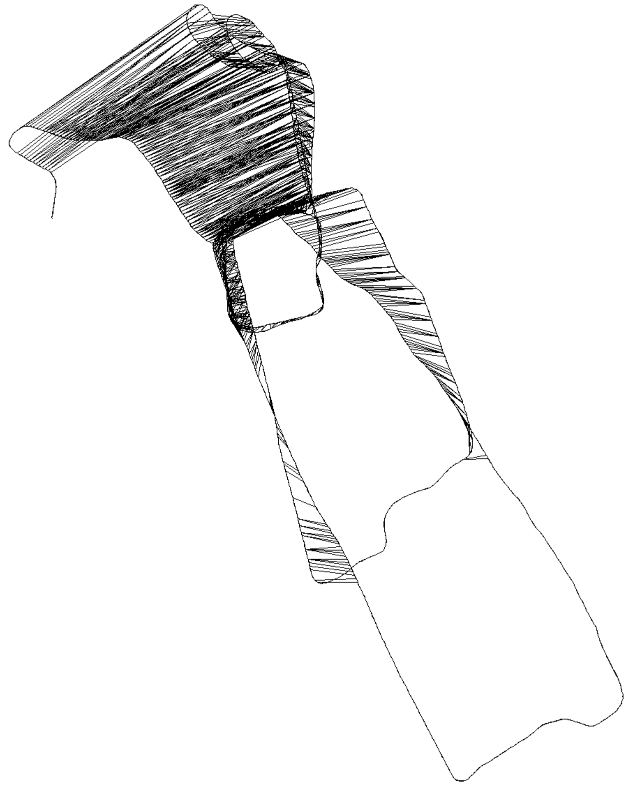
Graph-based SLAM in a Nutshell

- The graph "abstracts away" the measurements
- The most likely is trajectory obtained by optimization.



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Graph-based SLAM in a Nutshell

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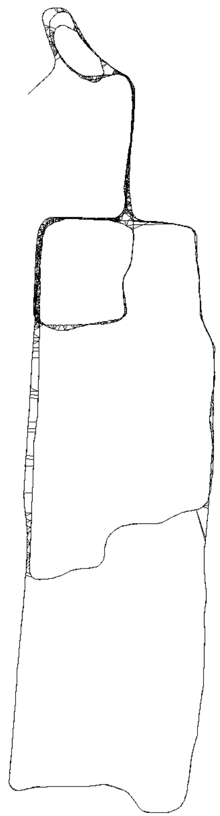
- The most likely is trajectory obtained by optimization.
- … like this



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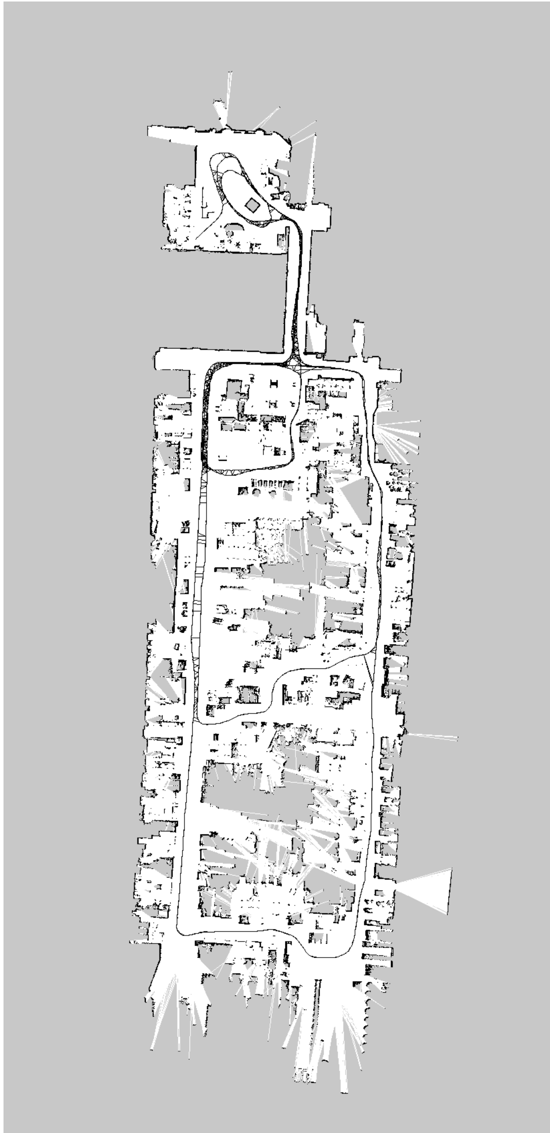
Graph-based SLAM in a Nutshell

- … and thus the map.



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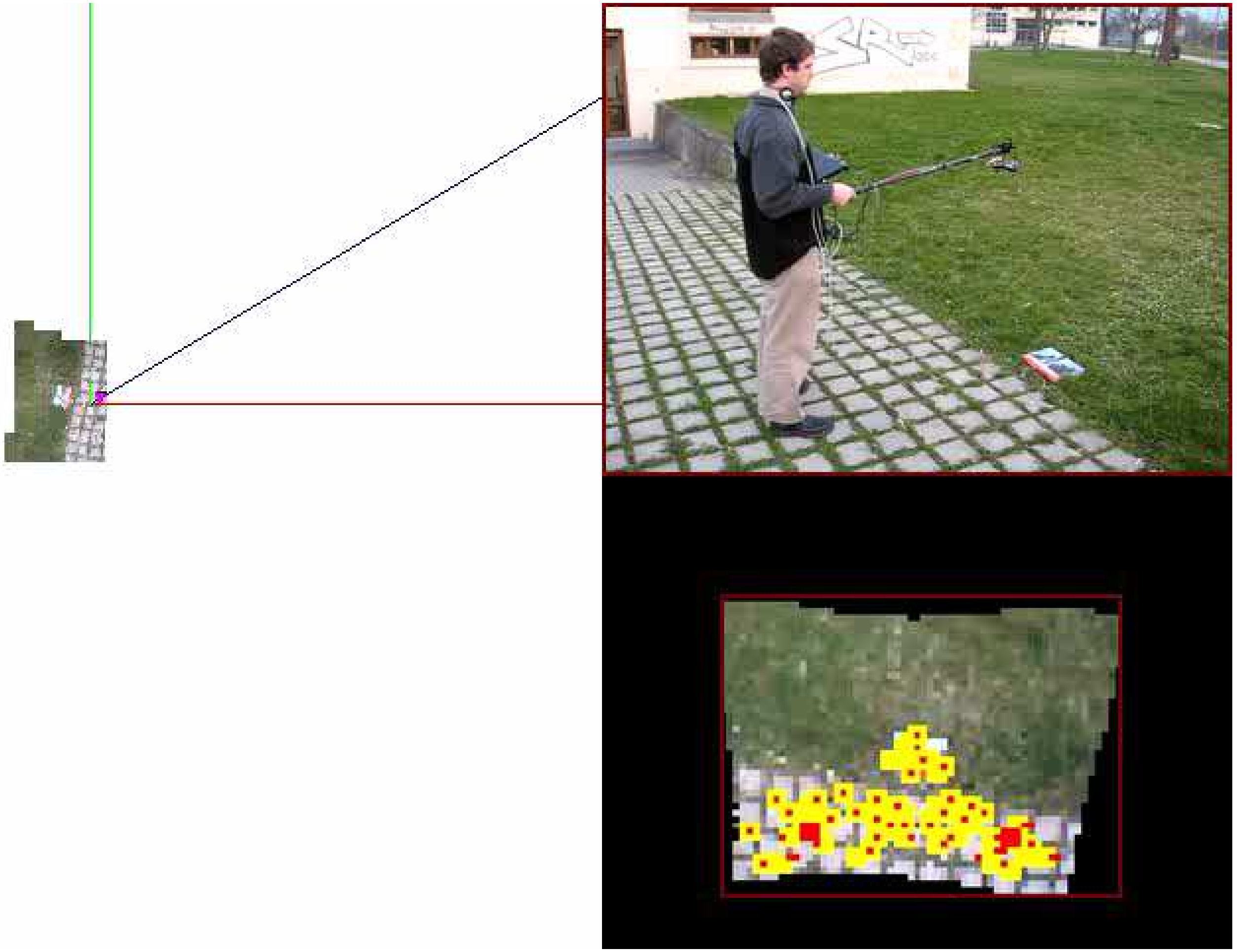
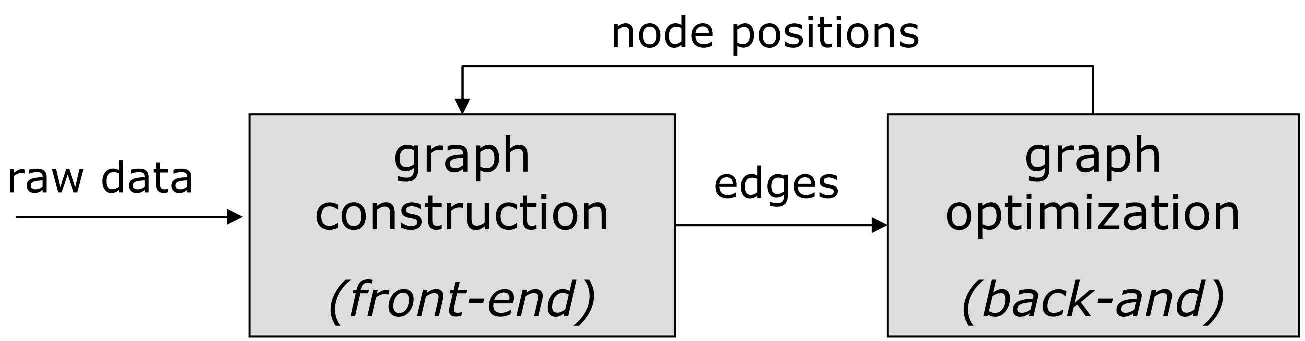
An Example using Lasers

... or Vision



Front-end and Back-end

- **Front-end**: extracts constraints from the sensor data
- **Back-end**: optimizes the pose-graph to reduce the error caused by the constraints



Insight: intermediate solutions are needed to make good data associations

Front-end and Back-end

- **Front-end**
  - This part is sensor dependent
  - We will discuss robots equipped with:
    - laser range finders
    - odometry
- **Back-end**
  - We will discuss how to solve this problem with efficient least-squares approaches that exploit the problem's structure.
- **Calibration**
  - A working system needs to be accurately tuned, and we will show how to do this with LS.

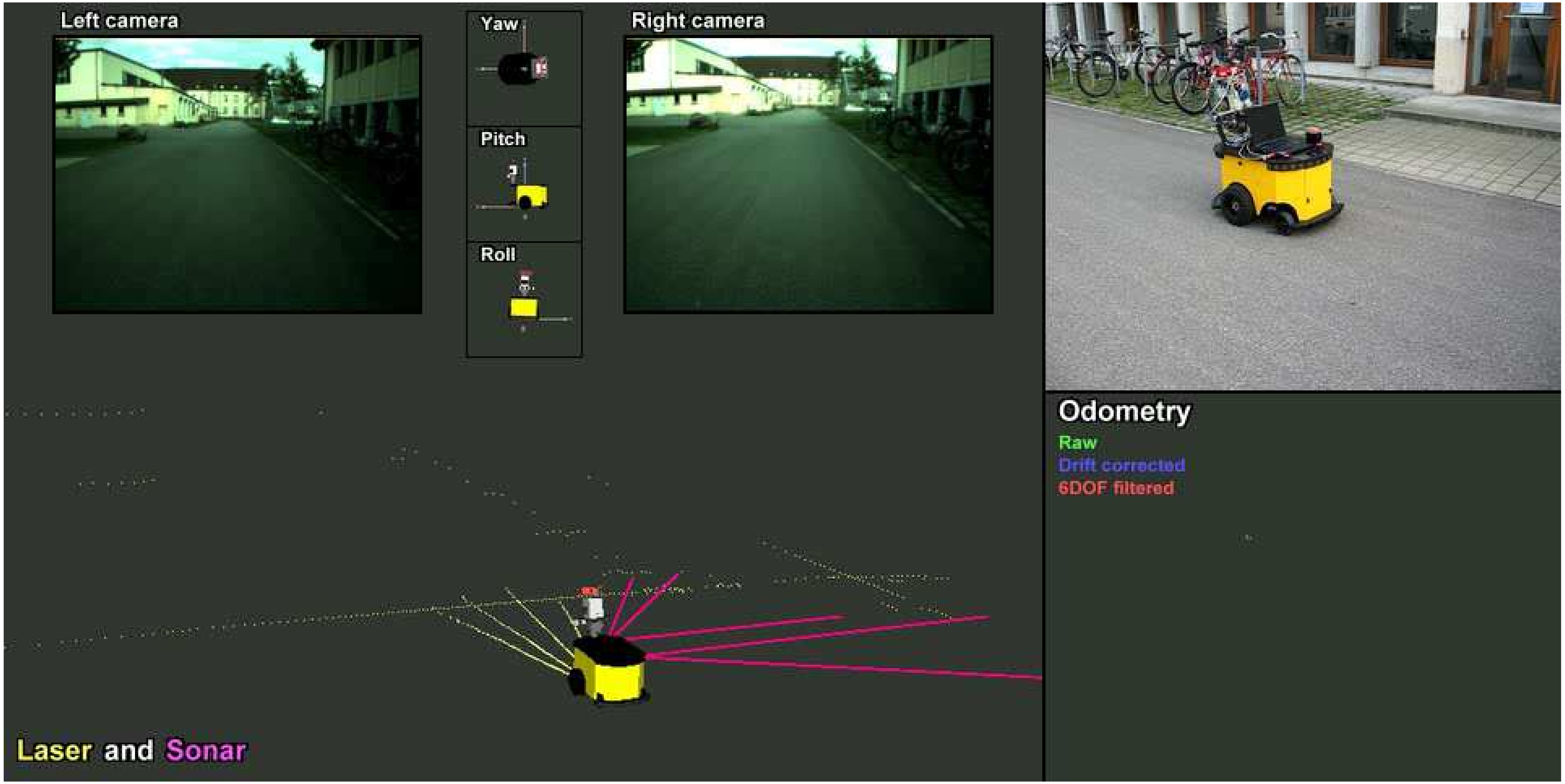
Outline of the Course

- A (short!) refresher of linear algebra
- Introduction to Octave/Matlab
- Robot and sensor models
- Probability theory
- Particle Filtering and Localization
- Scan Matching (ICP)
- Least squares estimation
- Odometry calibration (and practical)
- Pose-graph optimization (and practical)
- Landmark-graph (and practical)

Goals of the Course

- Get into LSE
  - You should be able to construct an LS estimator for typical problems
- Get some insights on SLAM and Filtering in this context
- See running systems and construct your own.
- Have access to real robot data.
- Have fun.

Real Data



Left camera
Yaw
Pitch
Roll
Right camera
Odometry
Raw
Drift corrected
6DOF filtered
Laser and Sonar

Some Applications