SLAM

Simult. Localiz. and Mapping

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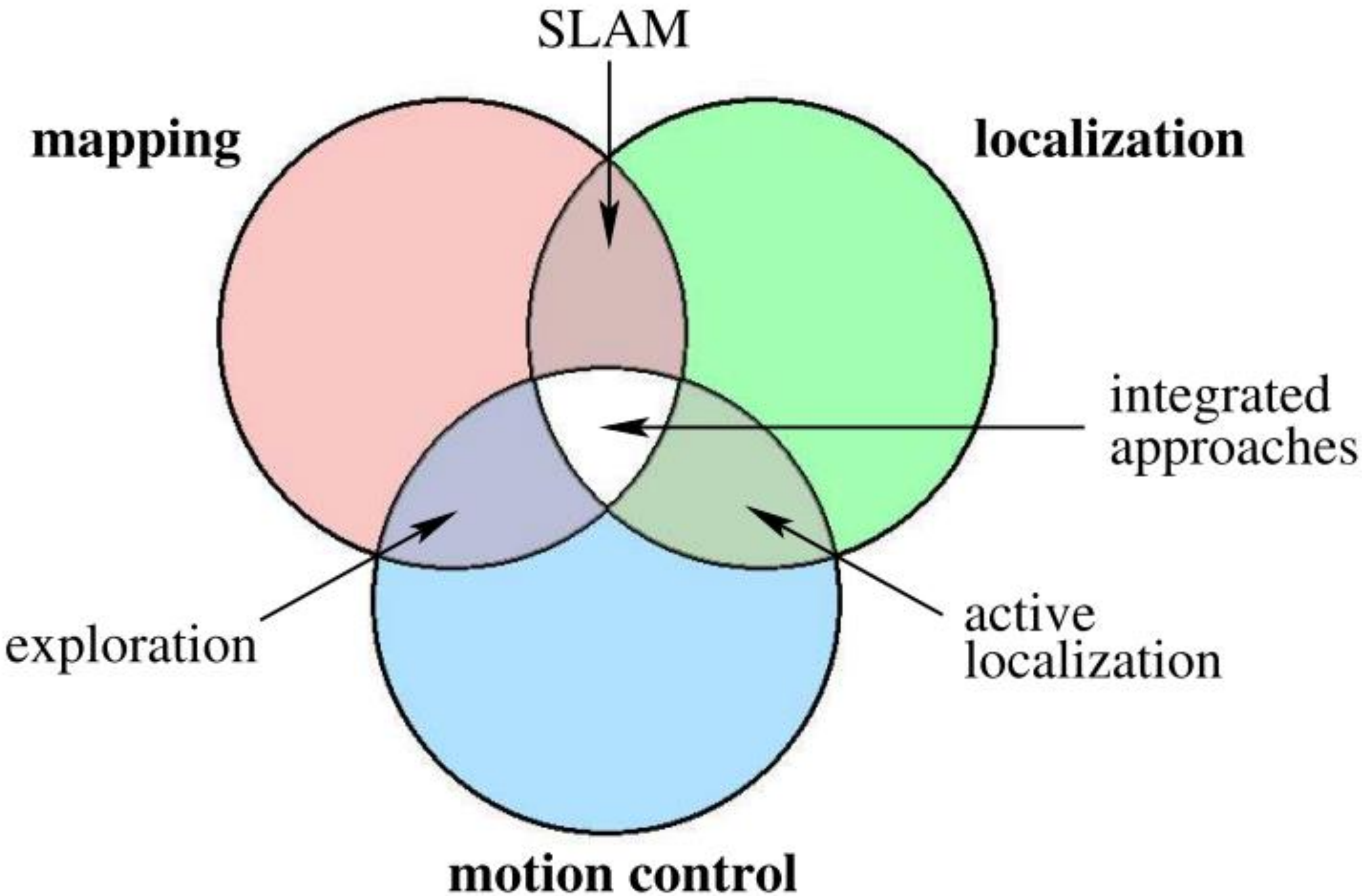
Background

- **Localization** – Where am I?
- **Mapping** – My (dynamic?) surroundings
- **Navigation** – How do I get where I want to go?
- **SLAM –**
  Simultaneous Localization and Mapping

SLAM

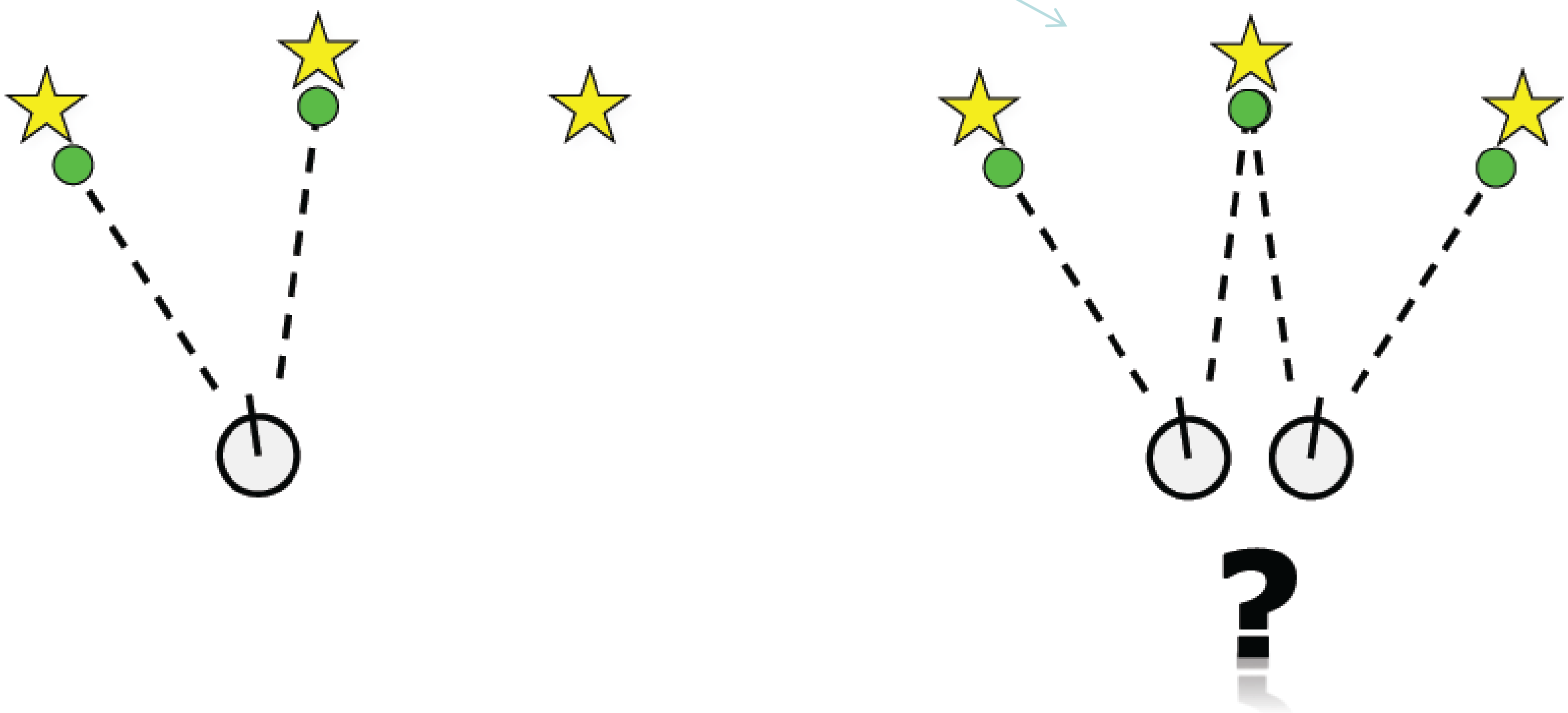
- **SLAM =**
  Simultaneous Localization and Mapping

- **=> Cycle through both!**


SLAM
mapping
localization
integrated
approaches
exploration
active
localization
motion control

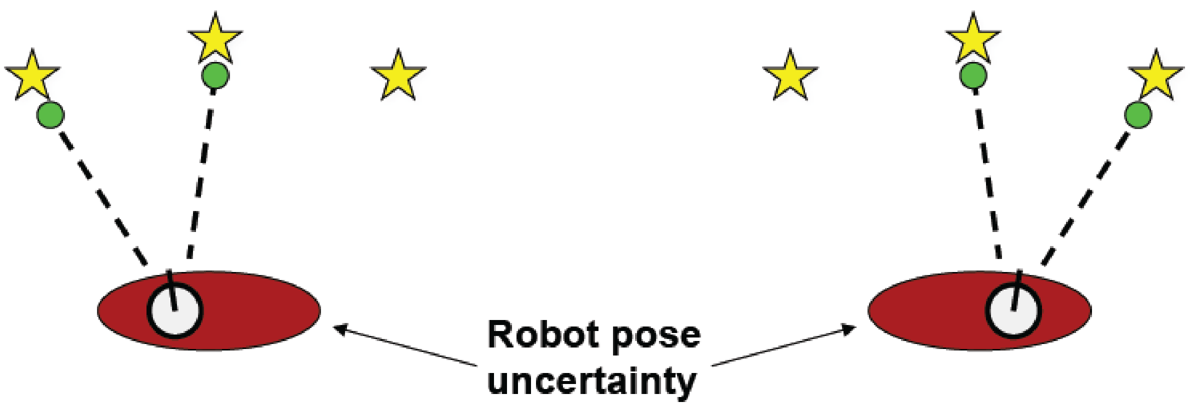
Taxonomy of the SLAM Problem

Known vs. unknown correspondence



Uncertainty…

- The **mapping between observations and the map is unknown**
- Picking **wrong** data associations can have **catastrophic** consequences (divergence)



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Given

- The robot's controls

$$u_{1:T} = \{u_1, u_2, u_3 \ldots, u_T\}$$

- Observations

$$z_{1:T} = \{z_1, z_2, z_3 \ldots, z_T\}$$

Wanted

- Map of the environment

$$m$$

- Path of the robot

$$x_{0:T} = \{x_0, x_1, x_2 \ldots, x_T\}$$

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SLAM

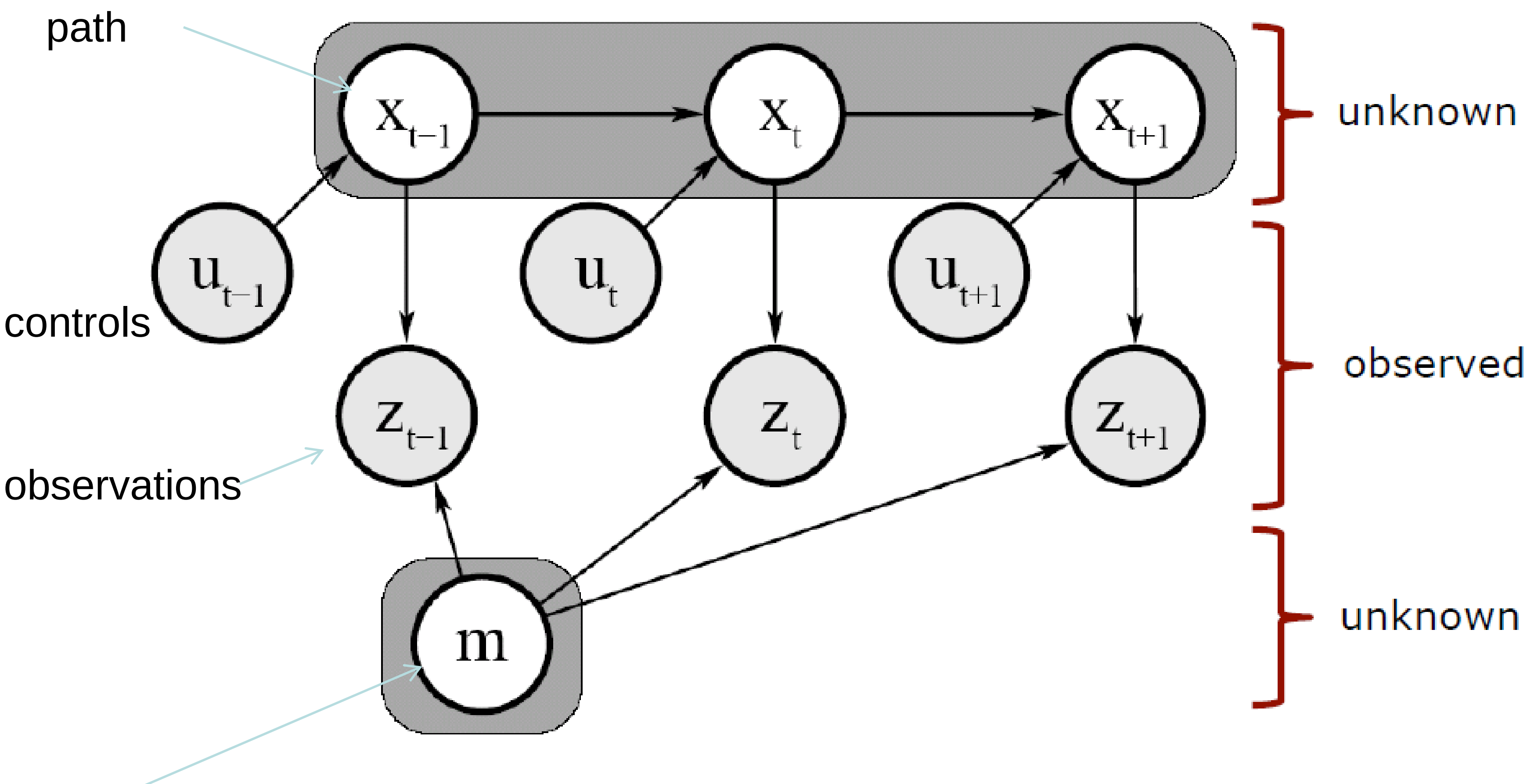
In Probabilistic Terms

Estimate the robot's path and the map

$$p(x_{0:T}, m \mid z_{1:T}, u_{1:T})$$

distribution path map given observations controls

SLAM



$$p(x_{0:T}, m \mid z_{1:T}, u_{1:T})$$

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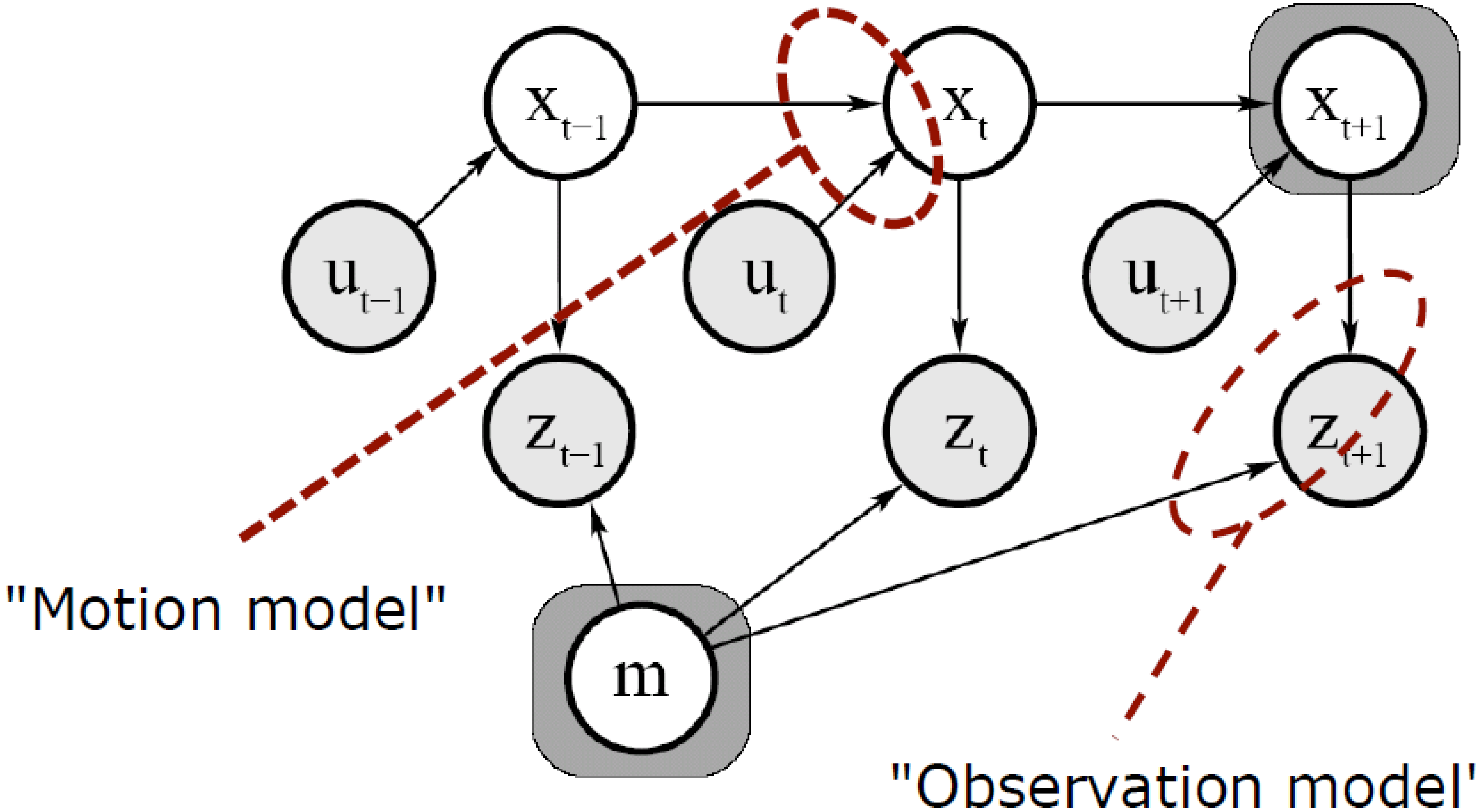
Motion (=System) Model + Observation (=Sensor) Model



MOTION MODEL

- The motion model describes the relative motion of the robot

$$p(x_t \mid x_{t-1}, u_t)$$

distribution new pose given old pose control

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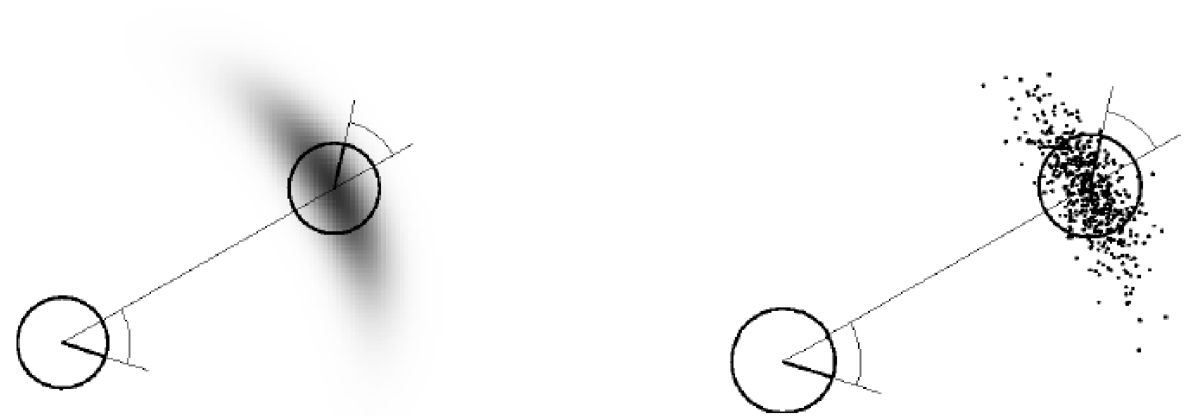
MOTION MODEL example

- Gaussian model

- Non-Gaussian model



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Observation Model

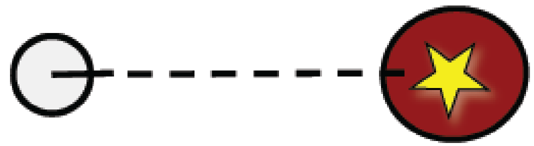
- The observation or sensor model relates measurements with the robot's pose

$$p(z_t \mid x_t)$$

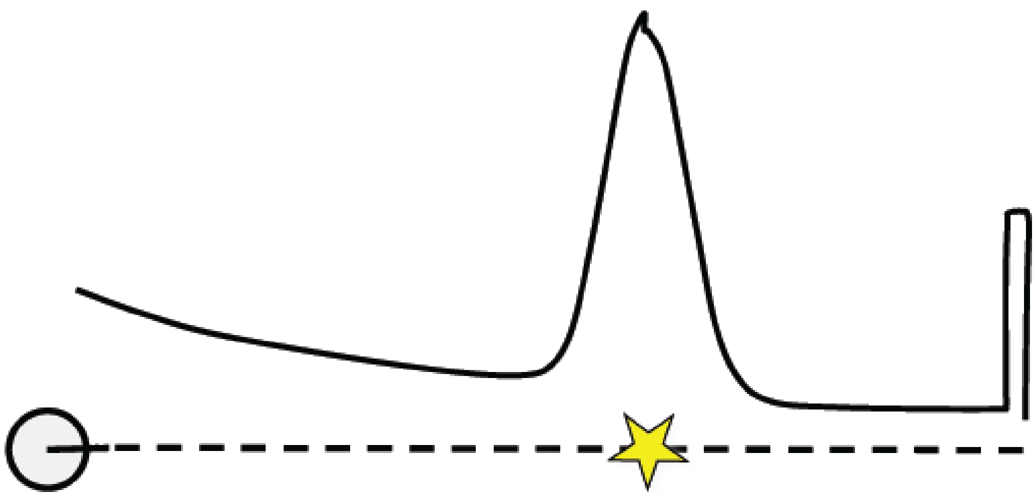
distribution observation given pose

Observation Model example

- Gaussian model



- Non-Gaussian model



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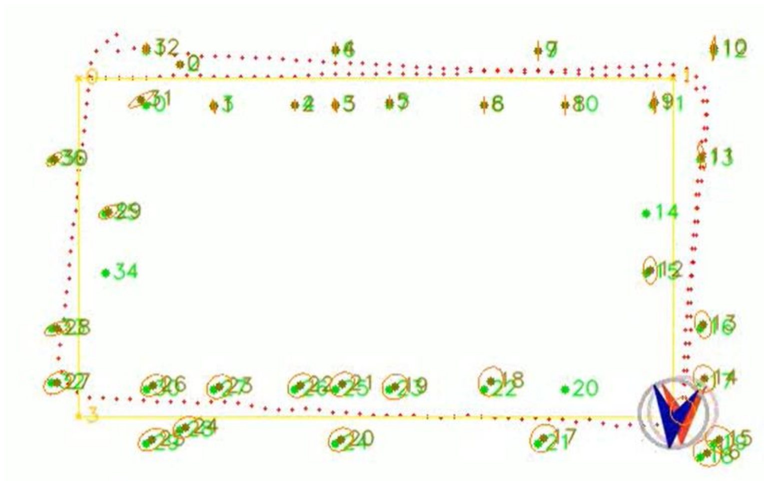
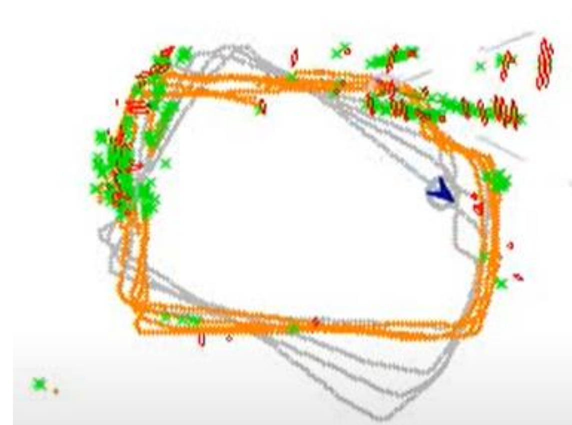
Loop Closure



https://youtu.be/BaqSRf5pAZ0

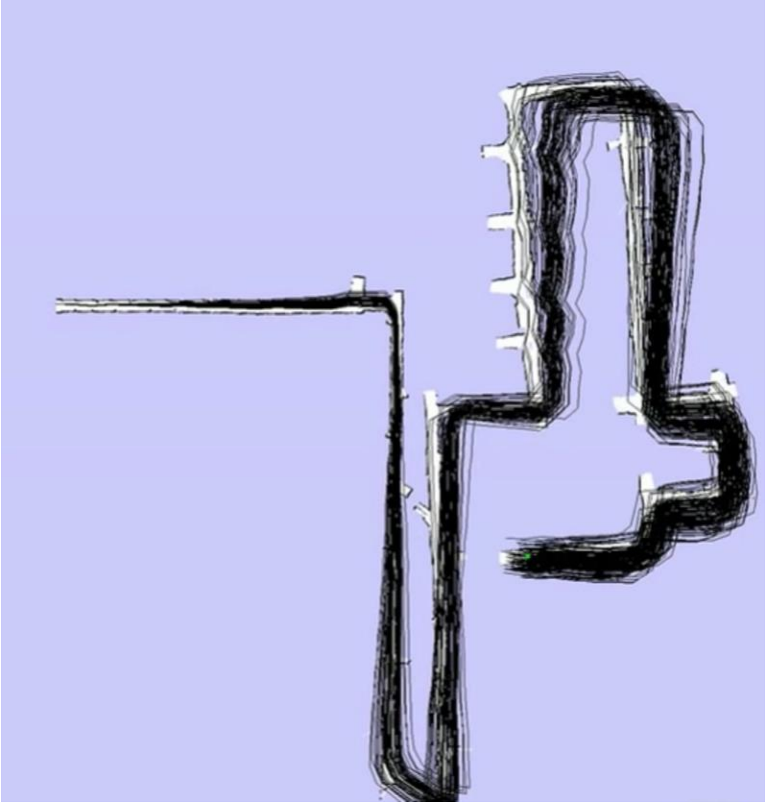


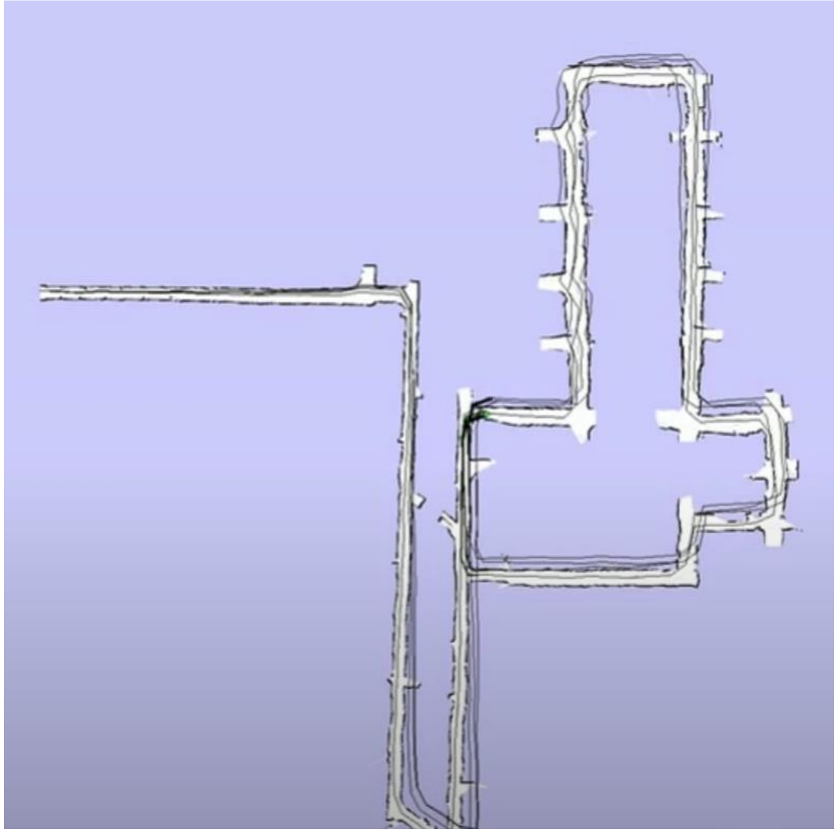
https://youtu.be/WXeWFIUFTC4

The blue arrow is the 'odometric' robot position (where the robot 'thinks' it is).
The red arrow is the 'corrected' robot position.
The ellipses represent the uncertainties of the positions of the landmarks. The smaller the ellipse, the more certain the robot is about the position of the landmark.

SLAM simulation by Sjoerd de Jong
under supervision of Gert Kootstra.
Department of Artificial Intelligence
University of Groningen

Loop Closure

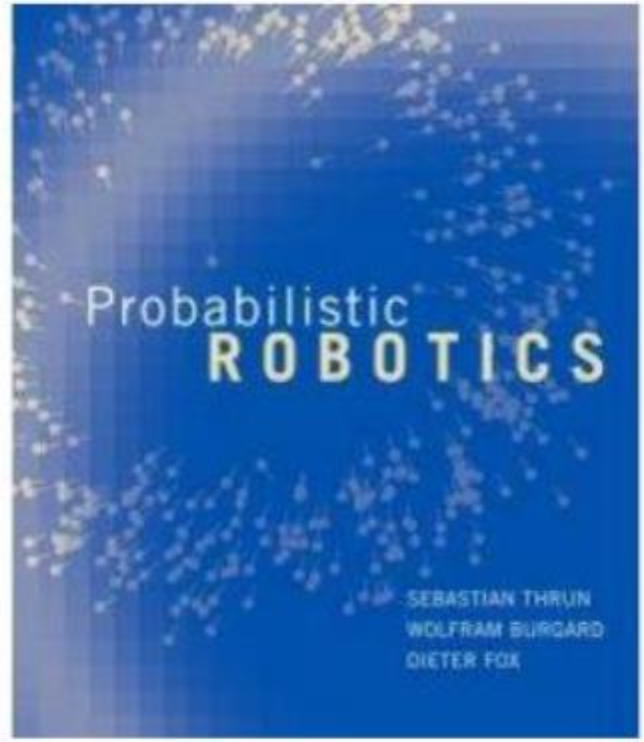




https://youtu.be/O5Zu19-tjY8?t=45

Probabilistic Robotics

- Authors:
  - Sebastian Thrun
  - Wolfram Burgard
  - Dieter Fox
- Publisher:
  - MIT Press, 2005.



Sources

- **Video Class -** Introduction to Robot Mapping
  https://www.youtube.com/watch?v=wVsfCnyt5jA

- **Extra**
  - SLAM - Artificial Intelligence for Robotics
    https://youtu.be/O5Zu19-tjY8?t=22
  - RPLidar and Hector SLAM for Beginners | ROS #8
    https://youtu.be/Qrtz0a7HaQ4

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