Introduction to Robot Motion Planning & Navigation
Introduction: Probabilistic Robotics

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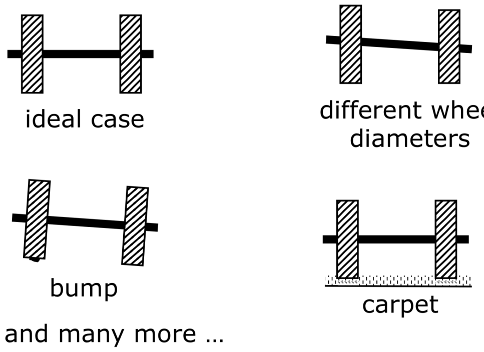
Why Probability in Robotics

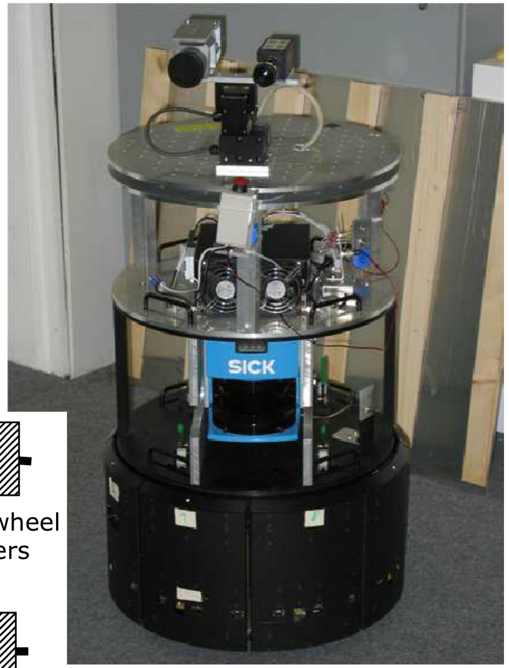
In practice, often the state of the robot and the state of the environment are unknown and only noisy measurements are available.

Example:

- One crude method of mobile robot localization is achieved by simply integrating robot velocity commands from a known starting position.
- Odometry : sensing rotation of wheel, using wheel encoders

If commands executed perfectly and the robot starting position is perfectly known, this method gives a perfect estimate of the position.
In practice this perfect execution does not happen.





B1 robot

actual

Odometry

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Why Probability in Robotics

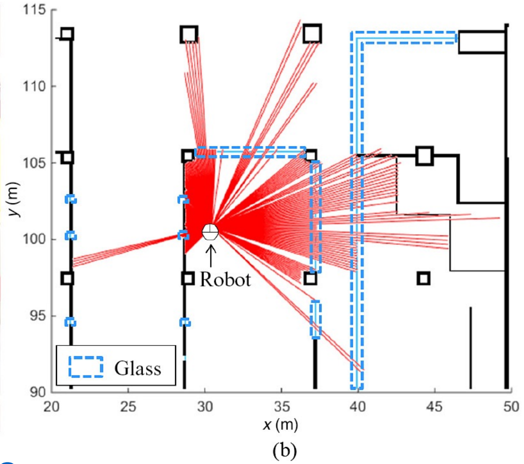
In practice, often the state of the robot and the state of the environment are unknown and only noisy measurements are available.

Example: Mobile robot inside a building
Estimate: position and heading
Sensors:

- Odometry : sensing rotation of wheel, using wheel encoders
- Laser range finder:
  - Measures time of flight of a laser beam between departure and return
  - Return typically happens when hitting a surface thar reflects the beam back to wheel it came from

Dynamics:

- Noise from wheel slippage, unmodeled variation in floor



Courtesy of [10.1109/TIE.2016.2523460](https://doi.org/10.1109/TIE.2016.2523460)

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Why Probability in Robotics

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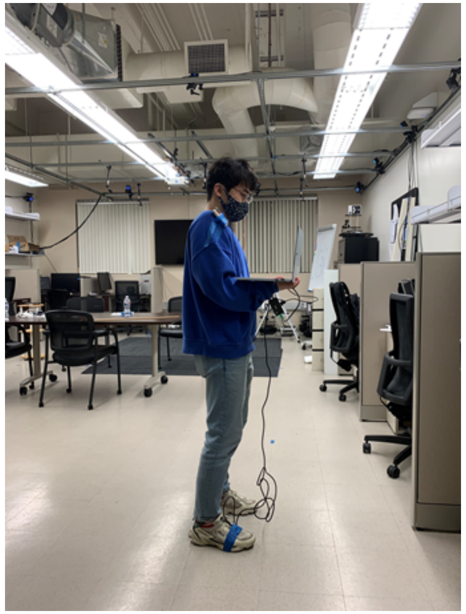
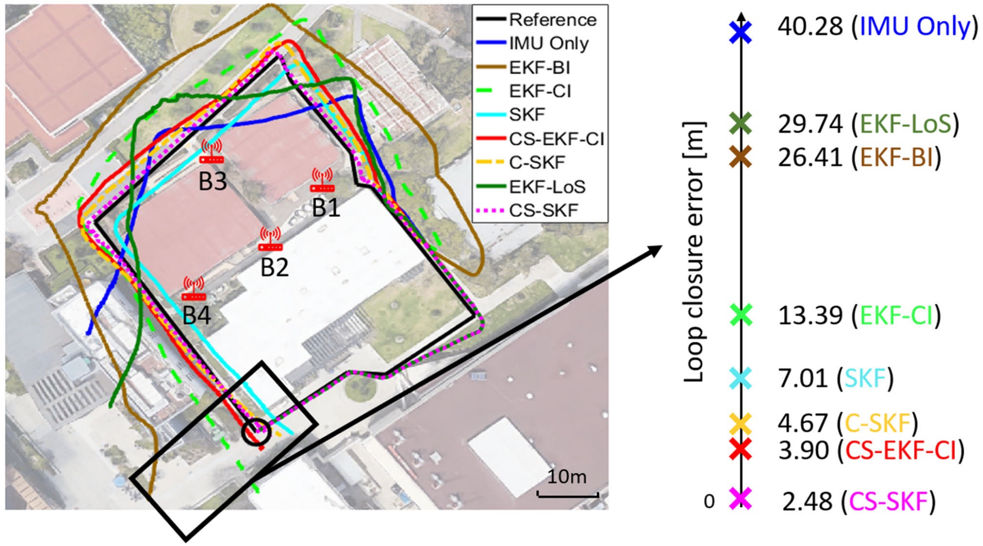
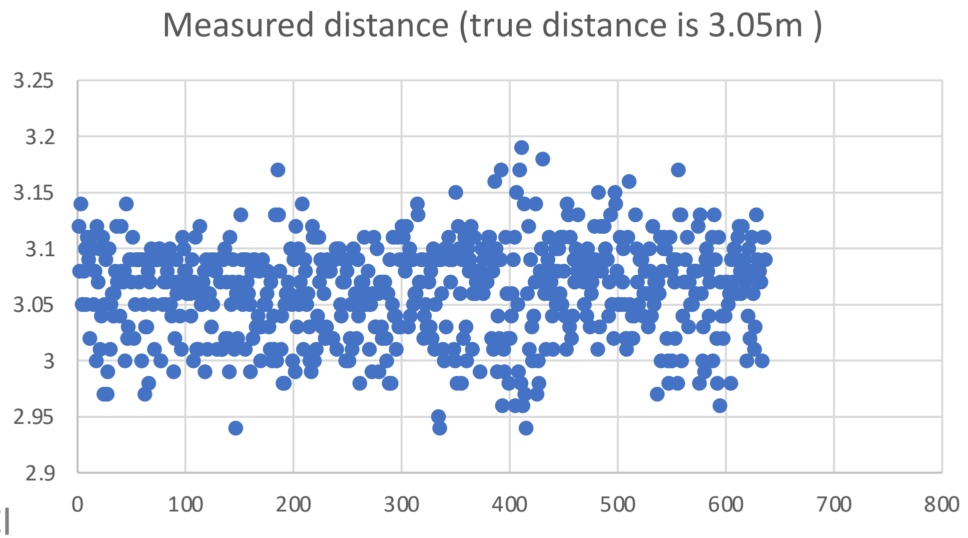
Example: Pedestrian localization
Estimate: position and heading
Sensors:

- Inertial navigation system (INS) : sensing acceleration and rotation using inertial measurement unit (IMU)
- Ultra wind band (UWB) ranging: measures time of arrival of signal sent from the agent to beacon and back time of flight of a laser beam between departure and return





Courtesy of [10.1109/LSENS.2019.2936007](https://doi.org/10.1109/LSENS.2019.2936007)



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Our focus: probabilistic localization

- Instead of of maintaining a single hypothesis as to where in the world a robot might be, probabilistic localization maintains a probability distribution over the space of all such hypothesis
- The probabilistic representation allows for uncertainties that arise from uncertain motion models and noisy sensor reading to be accounted in a principled way.

Probability theory provides a set of tools that can be used to quantify uncertain events.
In robotics, Probability provides a framework to fuse sensory information

Result: probability distribution over possible states of robot and environment

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Some of the material in this note are taken from:
F. H. Choset, K. Lynch, S. Hutchinson, G. Kantor, et al. Principles of Robot Motion, Theory, Algorithms, and Implementations.

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