Semester Schedule

C++ and Robot Operating System (ROS)

Learning to use our robots

Computational Perception

Developmental Robotics

Human-Robot Interaction

You are here
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Today

• Reading Discussions

• Where in the world is the robot?
  – a.k.a. Robot Mapping and Localization

• Overview of Homework 5


“Since the article focused on a robot with one arm, how would the robot's “understanding” sort of apply if it had multiple appendages?

Why do they dislike “kinematic models” for this?”

- Jonathan
Fig. 1. Line drawing of the robot’s current mechanical design.
“The robot used in the experiment, Nico, did not seem to have any means of moving its entire body from place to place. I have to wonder if a moving robot would have had the same success with the given method.”

- Aylish
“... if there were multiple robots that performed the same action as a certain robot, would that robot perceive the others to be itself? And if it did so, how would this impact its "thinking" when the others no longer behaved in the same way as itself? What possible methods are there to avoid crashes or failures that could result from this?

- Justin
Reading Discussion

“What is image differencing?”

- Kathryn
Reading Discussion

Input Stream → BG Differencing → BG Model → Threshold → Output Masks

[http://dparks.wdfiles.com/local--files/background-subtraction/FrameDifferencing.jpg]
Reading Discussion

Frame 1

Frame 10

Difference of Two Frames

http://image.slidesharecdn.com/rti3final-120605105222-phpapp01/95/real-time-object-tracking-14-728.jpg?cb=1338893663
Reading Discussion

“A question I have is: how long is the time delay and how does it compare to the time delay that humans experience when learning about our own self-awareness during infancy? Surely it should be much faster for the robot with all that processing power.”

- Hector
Reading Discussion

Fig. 4. Timeline showing relevant events for the measurement of $t_1$ and $t_2$. 
Further reading:


Readings for this week

Rekleitis, I., “A Particle Filter Tutorial for Mobile Robot Localization”


Ch.1, “Probability and Random Variables” from “Introduction to Random Signals and Applied Kalman Filtering”
Robot Localization
Robot Localization

• Main problems:
  – How should the robot represent the map of the world?
  – How should the robot use existing sensory data, combined with knowledge of its own movements, to figure out where it is in the map?
2D Laser Scan for Localization
Using Ceiling Maps for Localization
3D Laser Mapping

http://www.cc.gatech.edu/aimosaic/robot-lab/research/3d/
3D mapping

[ Michael Kaess, Georgia Tech]
3D mapping

[ Michael Kaess, Georgia Tech]
Robot Localization

Why is it not enough to simply keep track of the robot's movements relative to the starting point in the map?
Odometry Motion Model
Sampling From the Odometry Model
Uncertainty accumulates after multiple movements.
Localization using Sonar
Figure 7.4 Example environment used to illustrate mobile robot localization: One-dimensional hallway environment with three indistinguishable doors. Initially the robot does not know its location except for its heading direction. Its goal is to find out where it is.
Initially we don’t know the location of the robot so we have particles everywhere
Next, the robot senses that it is near a door
Since there are 3 identical doors the robot can be next to any one of them.
Therefore, we inflate balls (particles) that are next to doors and shrink all others.
Therefore, we grow balls (particles) that are next to doors and shrink all others.
Before we continue we have to make all balls to be of equal size. We need to resample.
Before we continue we have to make all balls to be of equal size. We need to resample.
Resampling Rules

\[ \text{Basketball} = \text{Tennis Balls} \]

\[ \text{Tennis Balls} = \text{Tennis Balls} \]

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Resampling

• **Given**: Set $S$ of weighted samples.

• **Wanted**: Random sample, where the probability of drawing $x_i$ is given by $w_i$.

• Typically done $n$ times with replacement to generate new sample set $S'$.  

[From Thrun’s book “Probabilistic Robotics”]
Next, The robot moves to the right
... thus, we have to shift all balls (particles) to the right
… thus, we have to shift all balls (particles) to the right
... and add some position noise
... and add some position noise
Next, the robot senses that it is next to one of the three doors
Next, the robot senses that it is next to one of the three doors
Now we have to resample again
The robot moves again
... so we must move all balls (particles) to the right again
... and add some position noise
And so on ...
Localization using Sonar
What does this look like on a real robot?
Using Ceiling Maps for Localization
Vision-based Localization

\[ P(z|x) \]

\[ h(x) \]
Under a Light

Measurement $z$: $P(z|x)$:
Next to a Light

Measurement $z$:

$P(z|x)$:
Elsewhere

Measurement $z$: $P(z|x):$
Global Localization Using Vision
Example in RoboCup
Example in RoboCup
How does all of this work in ROS?

- ROS package for “Adaptive Monte-Carlo Localization” with 2D laser readings: \textit{amcl}
- ROS package for building 2D maps: \textit{gmapping}
Overview of Homework 5

• Due March 22nd
THE END