PacBot

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Summary

- **Motivation**: Let the robot tracks and chases RFID tags

- **Sparse & noisy sensor**: RFID antennas deployed in the CSE building
  - 36 Antennas at fixed location
  - Read “RFID Tags”

- **Particle filter**
System Design

RFID Centralized system

Antenna 1
Antenna 2
Antenna N

Server

Tag Reads
Discrete (X, Y)
Fixed rate

Example data:
t=1, (10,40)
t=2, (10,40), (14,78)
t=3, N/A

Python (particle filter)
Java (RFID server)
Platform: Linux & Robot operating system (ROS)

Particle Filter

Tag Location
Navigation

Static map
System Design

RFID Centralized system

Antenna 1
Antenna 2
Antenna N

Server

Tag Reads
Discrete (X, Y)

Particle Filter

Tag Location

Navigation

Python (particle filter)
Java (RFID server)
Robot operating system (ROS)
Particle Filter

- Tag Reads $Z$
- Fixed rate (i.e. @10 Hz)
- Time Update
  - Motion Model $P(X'|X)$
- Sensor Update
  - Emission (Sensor) Model $P(Z|X)$
- Belief (particles) $X$
Evaluation: Tracking error

- Track a RFID tag on the robot
- Use the robot’s localized coordinate as the ground truth
- Find the error: the distance from the maximum in the particles belief
- Compute the average error over a trial
Update Rate

1 Hz
Sensor model $\sigma = 4$
Average error = 9.08 (m)

10 Hz
Sensor model $\sigma = 4$
Average error = 2.93 (m)
Motion Model

- (1) Random movement
  Gaussian \((\mu, \sigma)\) distribution centered at each particle

- (2) Velocity Model

With Velocity Model
1 Hz update rate
Sensor model \(\sigma = 4\)
Average error = 2.756 (m)
Sensor Model

Emission (Sensor) Model \( P(Z|X) \)

(1) Single reads

(2) Shifted gaussian

(3) Collect sensor model from data

<table>
<thead>
<tr>
<th></th>
<th>Average Error (m)</th>
<th>Standard deviation (m)</th>
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<tbody>
<tr>
<td>(1) Bimodal Gaussian</td>
<td>1.688</td>
<td>0.079</td>
</tr>
<tr>
<td>(2) Shifted Gaussian</td>
<td>1.716</td>
<td>0.041</td>
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A : Antenna
Conclusion

- Implemented and tested a system using particle filter to track RFID tag
- Learn to apply particle filter to real data and real world system
- Evaluated Accuracy of different Sensor and Time updates

Team Work

- Liang-Ting Jiang: System design and implementation, robot integration, data collection
- Alex Takakuwa: Sensor model, motion model design, implementation, and verification