Lab 5: Localization

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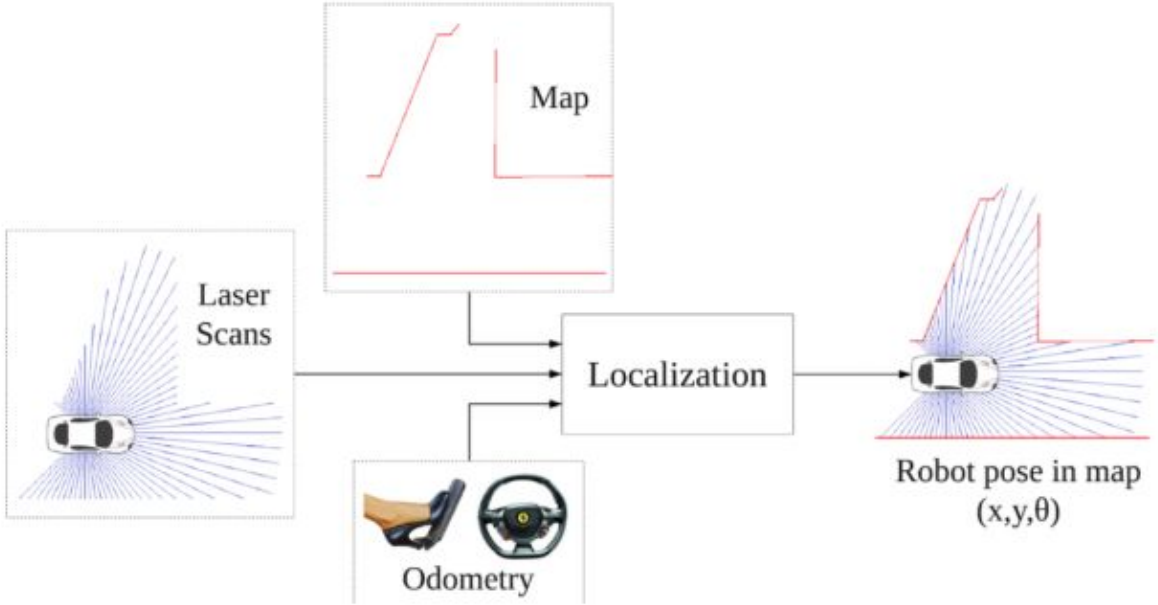
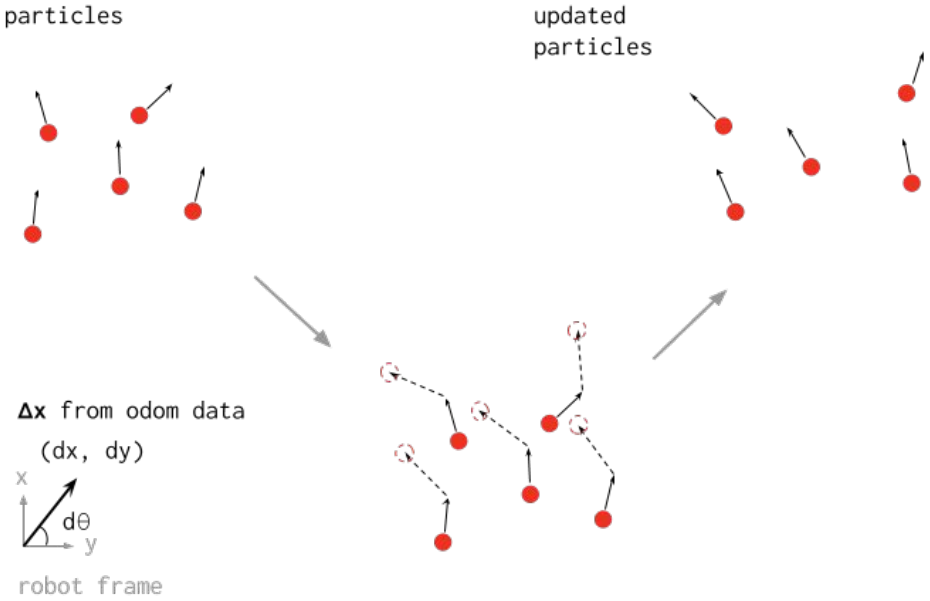
Kevin Carlson, Susan Ni, Talia Pelts, Jonathan Samayoa, Vlad Seremet

Localization Goals: Determine the robot's orientation and position in a known environment

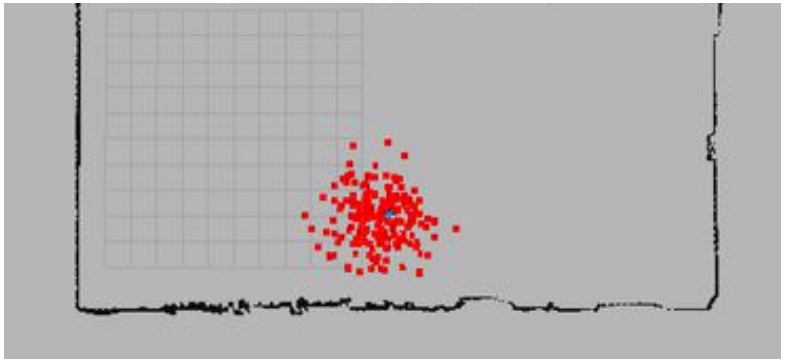


Motion Model

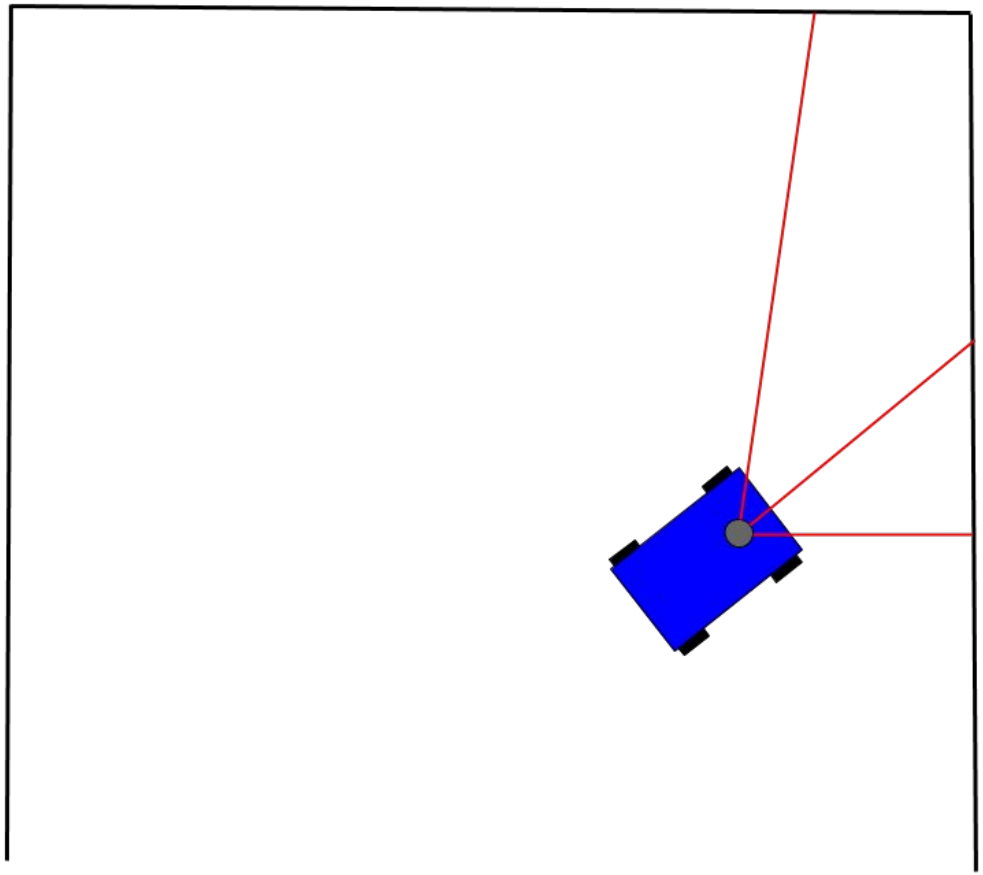
The motion model updates particle positions using odometry data that is rotated into the particle's coordinate frame

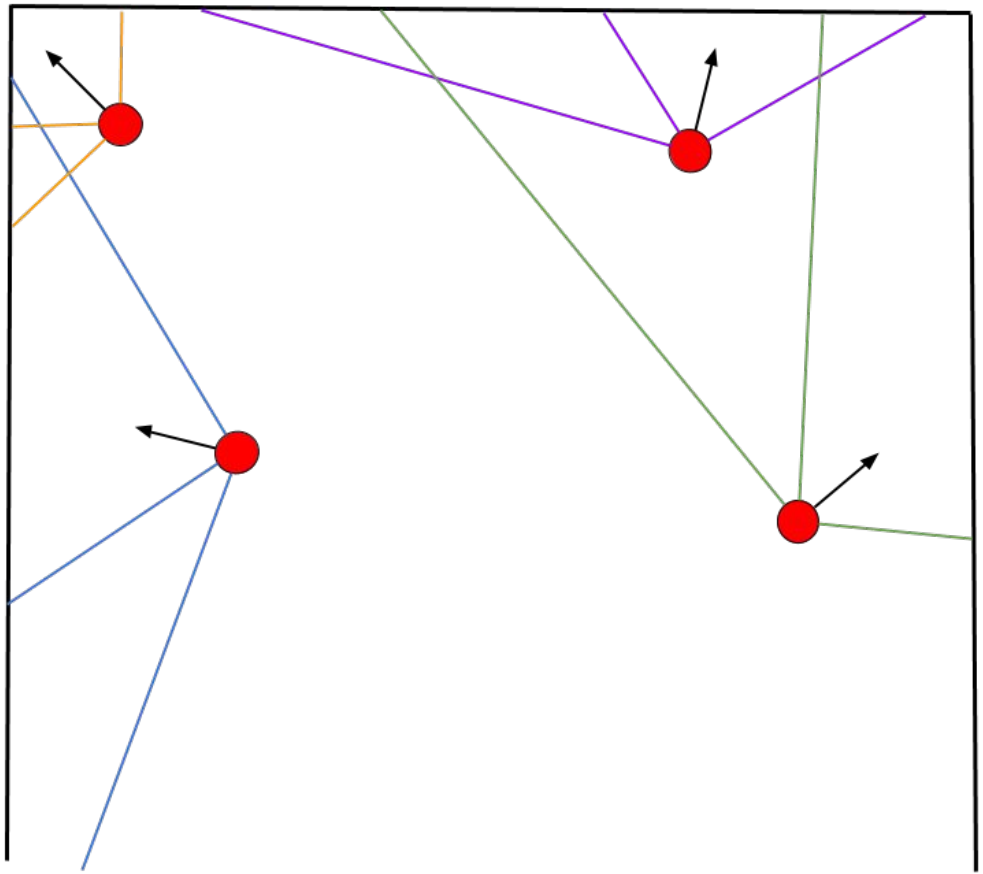


$$\begin{bmatrix} dx' \\ dy' \end{bmatrix} = \begin{bmatrix} \cos(d\theta) & -\sin(d\theta) \\ \sin(d\theta) & \cos(d\theta) \end{bmatrix} \begin{bmatrix} dx \\ dy \end{bmatrix} = \begin{bmatrix} dx * \cos(d\theta) - dy * \sin(d\theta) \\ dx * \sin(d\theta) + dy * \cos(d\theta) \end{bmatrix}$$



Sensor Model





4 cases for our lidar model

1. Probability of detecting a known obstacle in the map

$$p_{hit}(z_t|x_t, m) = \begin{cases} \eta \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left(-\frac{(z_t - z_t^*)^2}{2\sigma^2}\right) & \text{if} \quad 0 \le z_t \le z_{max} \\ 0 & \text{otherwise} \end{cases}$$

2. Probability of a short measurement

$$p_{short}(z_t|x_t, m) = \frac{2}{z_t^*} \begin{cases} 1 - \frac{z_t}{z_t^*} & \text{if} \quad 0 \le z_t \le z_t^* \\ 0 & \text{otherwise} \end{cases}$$

3. Probability of a very large measurement

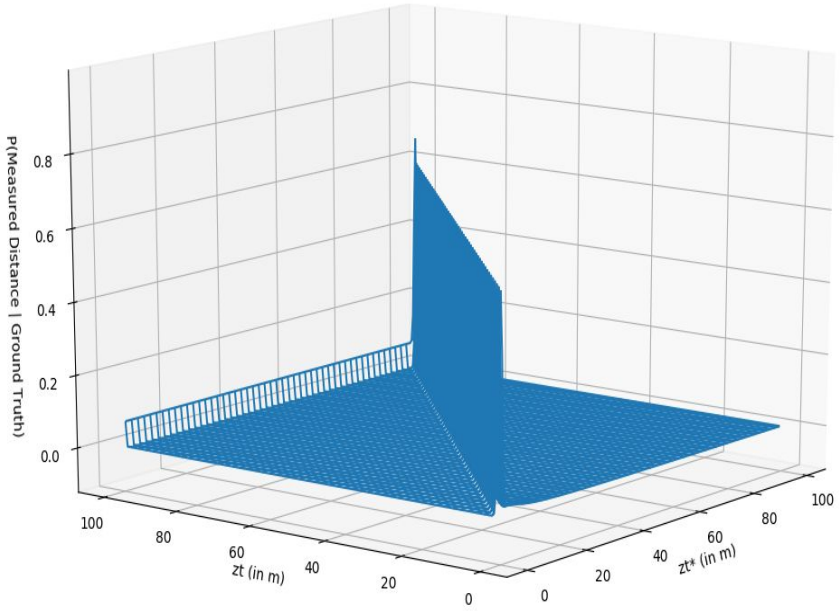
$$p_{max}(z_t|x_t, m) = \begin{cases} 1 & \text{if} \quad z_t = z_{max} \\ 0 & \text{otherwise} \end{cases}$$

4. Probability of a random measurement

$$p_{rand}(z_t|x_t, m) = \begin{cases} \frac{1}{z_{max}} & \text{if} \quad 0 \le z_t \le z_{max} \\ 0 & \text{otherwise} \end{cases}$$

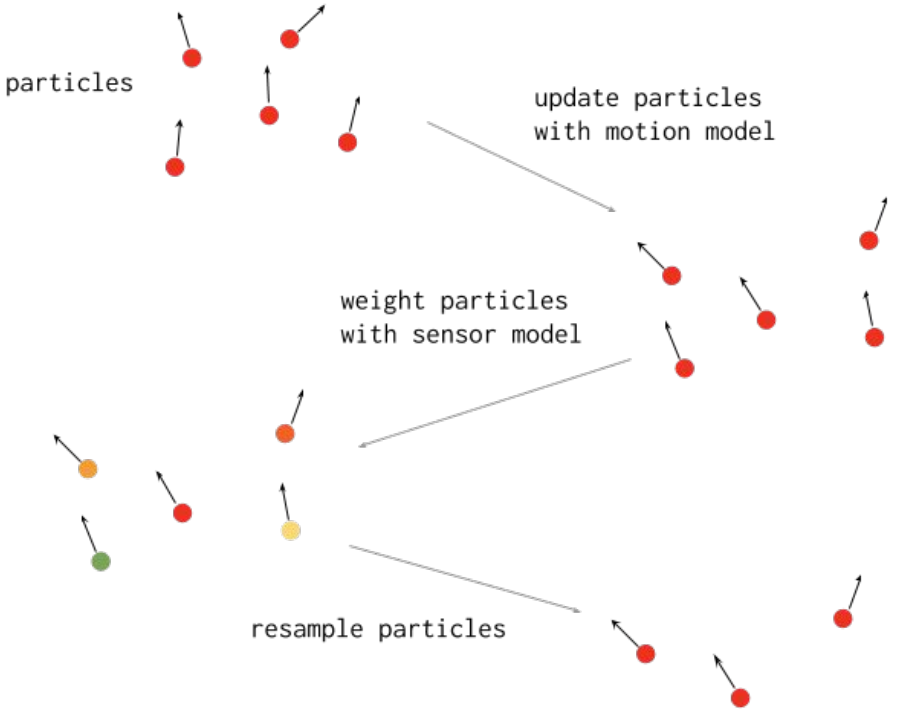
*combined via a weighted average

Probability distribution over measured distance and ground truth

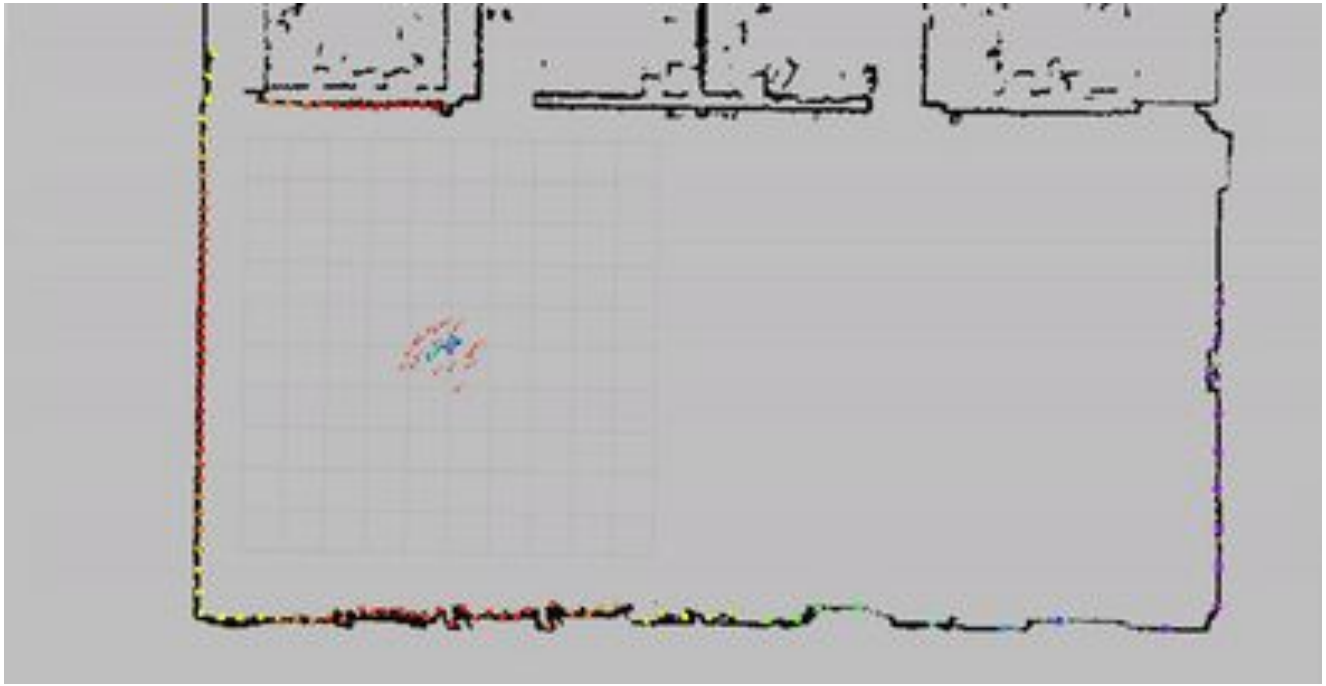


Particle Filter

The particle filter updates particles positions with the motion model and resamples particles with the sensor model

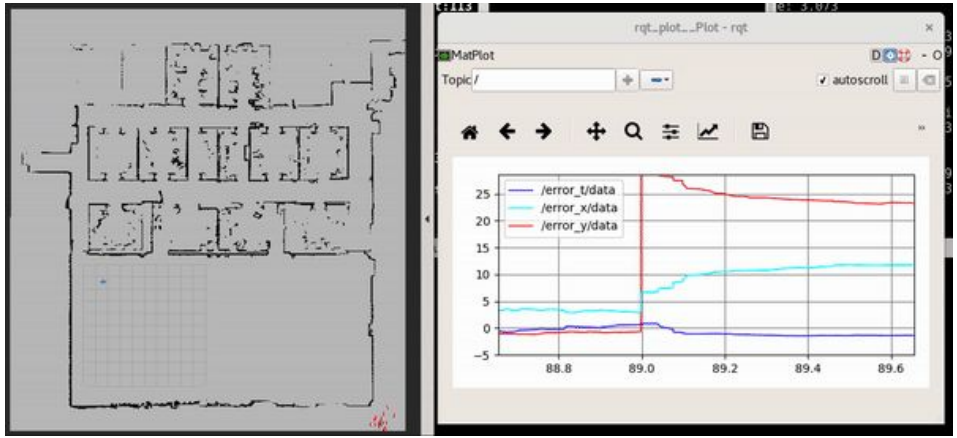


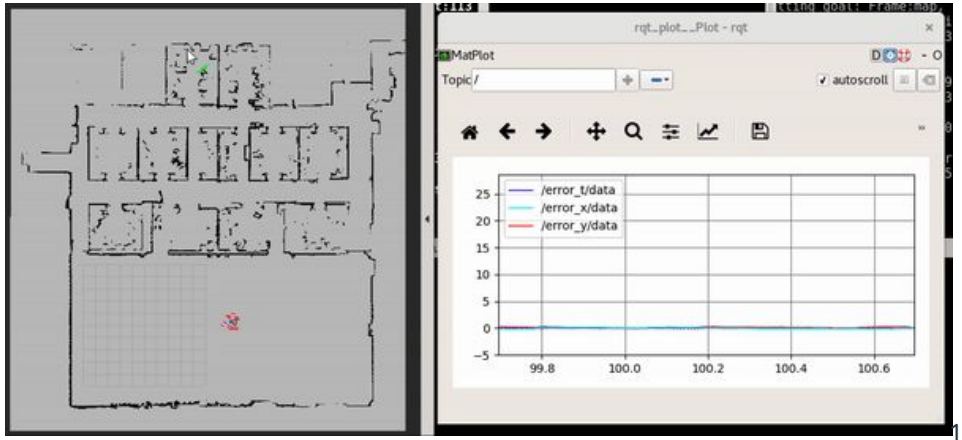
MCL in rviz, including particles, inferred pose, and laser scan visualization



Particle Filter Convergence Times in Simulator

Simulation 1: 2.7 s
Simulation 2: 4.5 s

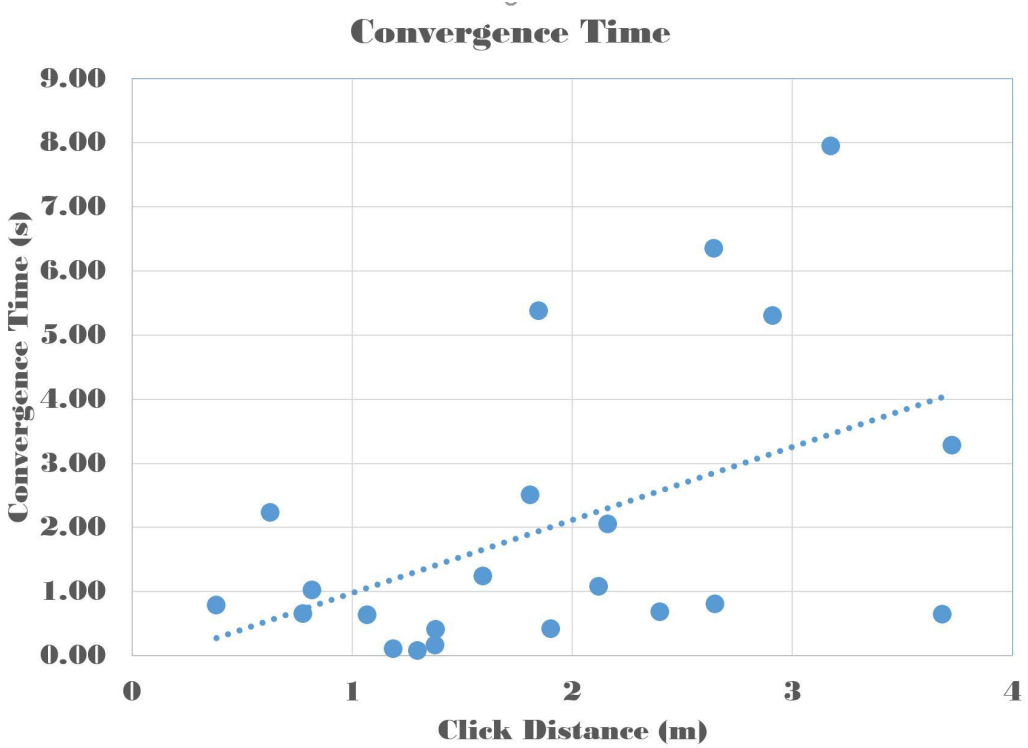




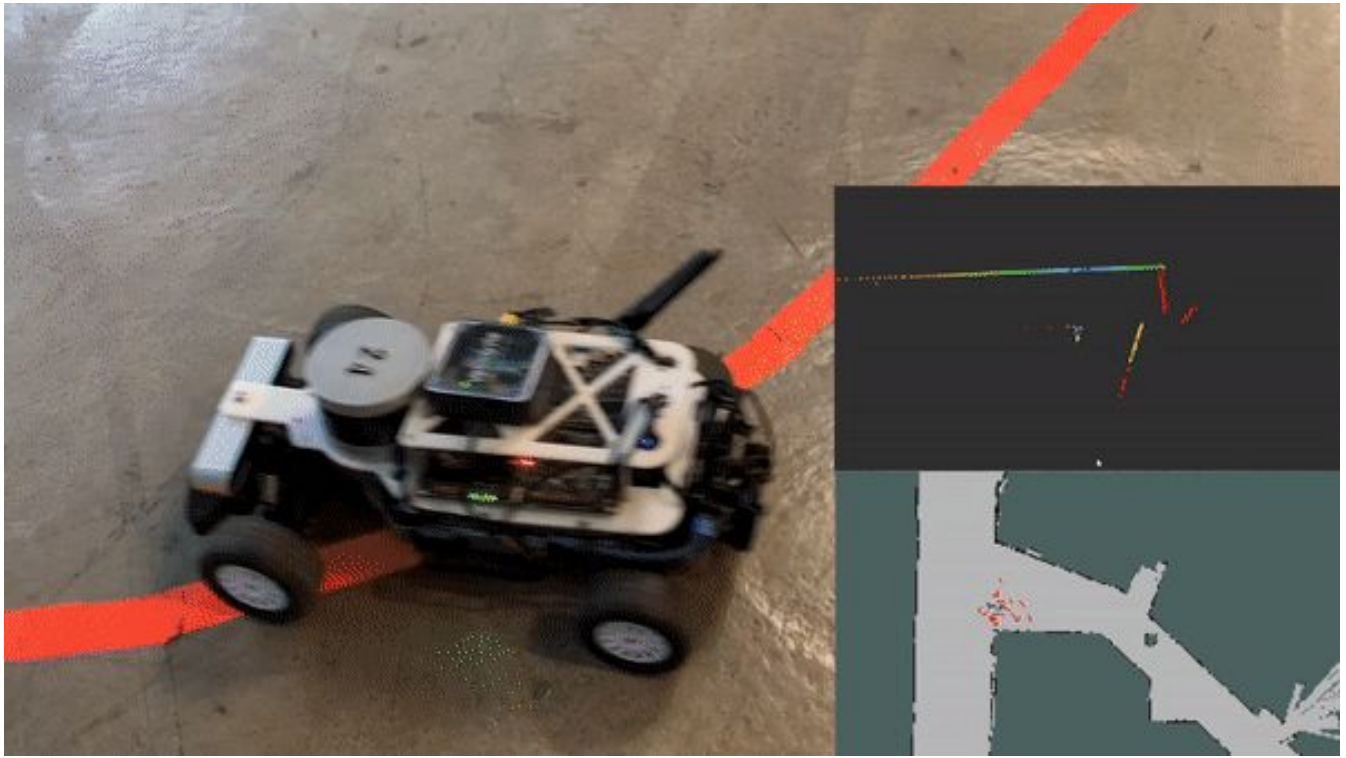
Particle Filter Convergence Times in Simulator

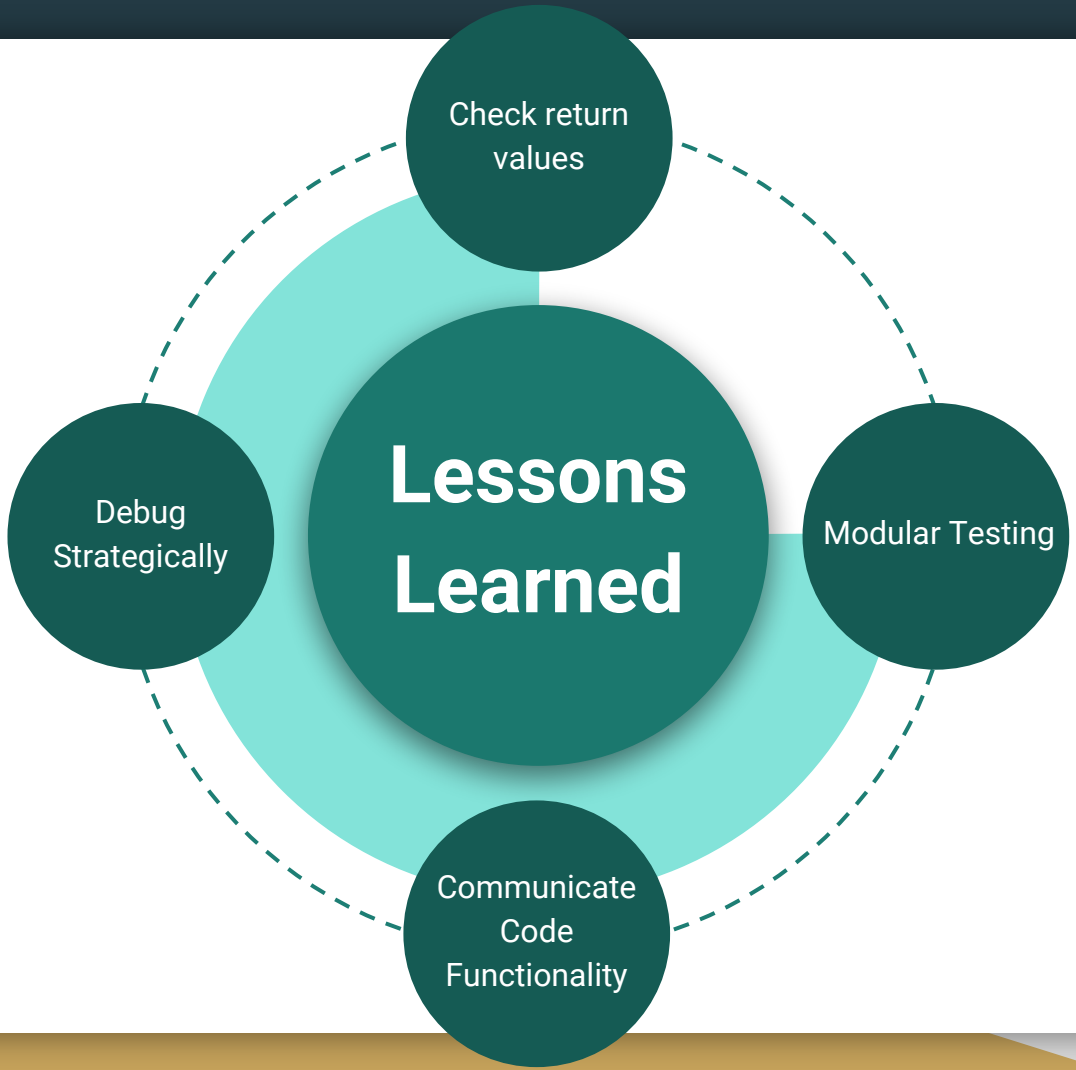
23 Trials

- Average Convergence Time of 1.99 s
- Average Convergence Rate of 3.11 m/s



MCL on real robot with rviz and laser scan visualization




Check return values
Debug Strategically
Lessons Learned
Modular Testing
Communicate Code Functionality

Future Steps

Refine & Improve

dgf

Implement for Path Planning

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Apply Systematic Testing

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Something

Questions?