Lecture: Mapping and Perception for an autonomous robot ,0510-7951

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Project 4 A

Topics:

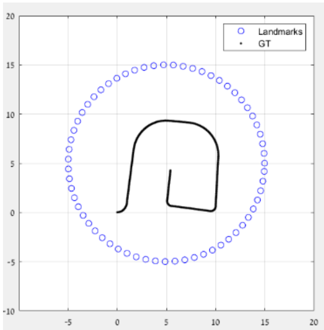
- Particle Filter
- TBD

1. Particle Filter

Particle filters sample a distribution with a collection of *particles*, generate a prediction of the distribution by forward predicting each particle using motion model and then compare and update that prediction using a measurement and its uncertainty characteristics.

a. Load the attached files – (Odometry and GT data) and plot the GT trajectory and landmarks from starting point (x_0=0,y_0=0) based on motion model

$$\begin{pmatrix} x_t \\ y_t \\ \theta_t \end{pmatrix} = \begin{pmatrix} x_{t-1} \\ y_{t-1} \\ \theta_{t-1} \end{pmatrix} + \begin{pmatrix} \delta_{trans}\cos(\theta_{t-1}+\delta_{rot1}) \\ \delta_{trans}\sin(\theta_{t-1}+\delta_{rot1}) \\ \delta_{rot1}+\delta_{rot2} \end{pmatrix}$$



b. Add gaussian noise in the motion model:
c. (σ_{rot1}=0.01, σ_{trans}=0.04, σ_{rot2}=0.01).
d. The starting point of the robot is unknown!
e. Assume spin LiDAR 2D sensor (1 layer, 360 degrees) which in each iteration calculates the range from the all the landmarks.

f. <u>Run Particle Filter!!</u>

- Initialize particles array:
  i. N particles (N=100)
  ii. Position of robot (x_0,y_0) – generate hypothesis pose for each particle randomly only inside the boundary circle (landmarks).
  iii. Initial weight for each particle
  iv. History- remember last positions to draw path of particle.

- Run noise odometry data according to motion model

$$\begin{pmatrix} x_t \\ y_t \\ \theta_t \end{pmatrix} = \begin{pmatrix} x_{t-1} \\ y_{t-1} \\ \theta_{t-1} \end{pmatrix} + \begin{pmatrix} \delta_{trans}\cos(\theta_{t-1}+\delta_{rot1}) \\ \delta_{trans}\sin(\theta_{t-1}+\delta_{rot1}) \\ \delta_{rot1}+\delta_{rot2} \end{pmatrix}$$

- Apply sensor correction (ranged from each landmarks)- find technique to calculate new weight for each particle.

- Perform Resampling and continue to next iteration.

g. Estimate the pose of the robot from the particles. (weighed average from of all the particle or according to the best particle, check both of the options)
h. Analysis Results:
    i. Explain your method to calculate the weight for each particle.
    ii. Show and explain your results. Show the trajectory (final graph, not animation) of the best particle. (weighted average of the particles also possible)
    iii. Show in figures the first initial steps (GT,landmarks, particles and estimate pose) until the robot finds the correct trajectory.
    iv. Find the minimal set of particles which achieve the same performance as in previous section.

Appendix

A. Please be honest, you may automatically lose points if you are caught copying including from the internet (code, results). The work is personal.

B. See instructions about the recorded data in the Appendix.

C. You are required to read the following paper for better understanding.
Vision meets Robotics: The KITTI Dataset/ Andreas Geiger

D. The final grade is given according to the quality of your analyses, descriptions, conclusions, explanations, the form of the results (plot, graphs, animations), understandable code with comments and explanations. It is possible that the final performance and results will not be as perfect as you desired as this is real data and is part of the challenge of the autonomous driving field Feel free to suggest solutions that could improve your results if this is the case.

E. Your final package should contain the following folders:

- Code contains all functions + sub-functions
- Results stores the resulting figures ,movies, etc.
- Please save the package as zip file. The name of the should be your ID.

The report should be separated from the package, please use the attached format and read the comments therein.

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