Cognitive Robotics

Assignment 3

RHEINISCHE FRIEDRICH-WILHELMS-UNIVERSITÄT BONN
COMPUTER SCIENCE VI
AUTONOMOUS INTELLIGENT SYSTEMS
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Friedrich-Hirzebruch-Allee 8

Due Tuesday, November 7th, before class.

3.1) Let a robot be equipped with wheel encoders and on-board software that transforms the physical measuring data into time-discrete odometry measurements $\langle \hat{\delta}_{rot_1}, \hat{\delta}_{trans}, \hat{\delta}_{rot_2} \rangle$.

Let the robot start at pose $\langle x, y, \theta \rangle = \langle 3m, -2m, -30° \rangle$ and obtain the following subsequent odometry measurements:

Motion 1	Motion 2
$\hat{\delta}^1_{rot_1} = -20°$	$\hat{\delta}^2_{rot_1} = 20°$
$\hat{\delta}^1_{trans} = 10m$	$\hat{\delta}^2_{trans} = 3m$
$\hat{\delta}^1_{rot_2} = 10°$	$\hat{\delta}^2_{rot_2} = -30°$

Calculate the resulting pose of the robot, assuming exact measurements!

5 points

3.2) How would your pose estimate for the Motion 1 look like under the following simple error model?

$$
\begin{aligned}
\hat{\delta}_{rot_1} &= \delta_{rot_1} \pm \varepsilon_{rot_1}, \qquad \varepsilon_{rot_1} = 10° \\
\hat{\delta}_{trans} &= \delta_{trans} \pm \varepsilon_{trans}, \qquad \varepsilon_{trans} = 0.5m \\
\hat{\delta}_{rot_2} &= \delta_{rot_2} \pm \varepsilon_{rot_2}, \qquad \varepsilon_{rot_2} = 5°
\end{aligned}
$$

Please draw the movements for noise $+\varepsilon_{movement}$ and $-\varepsilon_{movement}$ and the resulting eight pose estimates into one diagram!

5 points

3.3) Visualize the likelihood of positions (x, y) after
- Motion 1,
- Motion 1 followed by Motion 2,
- Motion 1 followed by Motion 2, followed by Motion 1

with the error model from 3.2) by computing the likelihoods on a grid (x, y, θ) and marginalizing out the heading direction θ!

5 points

3.4) Initialize 100 samples at $\langle x, y, \theta \rangle = \langle 3m, 2m, -30° \rangle$.

Show the (x, y) positions of the samples after
- Motion 1,
- Motion 1 followed by Motion 2,
- Motion 1 followed by Motion 2, followed by Motion 1

by applying a sampling-based motion model with parameters from 3.2)!
Compare your results to 3.3)!

5 points

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Calculate the resulting pose of the robot, assuming exact measurements!

5 points

$$X_1 = X_0 + \hat{\delta}_T^{\hat{1}} \cdot \cos(\theta_0 + \hat{\delta}_{R1}^1) = 9.42\ m$$

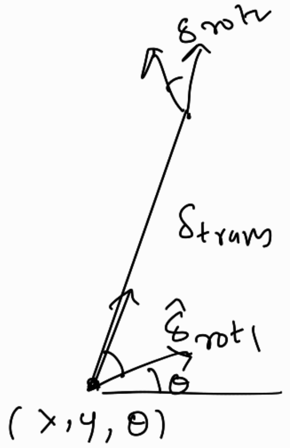
$$Y_1 = Y_0 + \hat{\delta}_T^1 \cdot \sin(\theta_0 + \hat{\delta}_{R1}^1) = -9.66\ m$$

$$\theta_1 = \theta_0 + \hat{\delta}_{R1}^{\hat{1}} + \hat{\delta}_{R2}^1 = -40°$$

$$X_2 = X_1 + \hat{\delta}_T^2 \cdot \cos(\theta_1 + \hat{\delta}_{R1}^2) = 12.25\ m$$

$$Y_2 = Y_1 + \hat{\delta}_T^2 \cdot \sin(\theta_1 + \hat{\delta}_{R1}^2) = -10.69m$$

$$\theta_2 = \theta_1 + \hat{\delta}_{R1}^2 + \hat{\delta}_{R2}^2 = -50°$$



$$x + \delta_{trans} \cos(\theta + \delta_{rot1})$$

$$y + \delta_{trans} \sin(\theta + \delta_{rot1})$$

$$\theta + \delta_{rot1} + \delta_{rot2}$$

(2)

1) + + +
2) + + -
3) + - +
4) - + +
5) + - -
6) - + -
7) - - +
8) - - -

→ These are all possible combinations for error

Please check the implementation in .ipynb for results and plots

(3)

Please check the implementation in .ipynb for results and plots

(4)

Please check the implementation in .ipynb for results and plots