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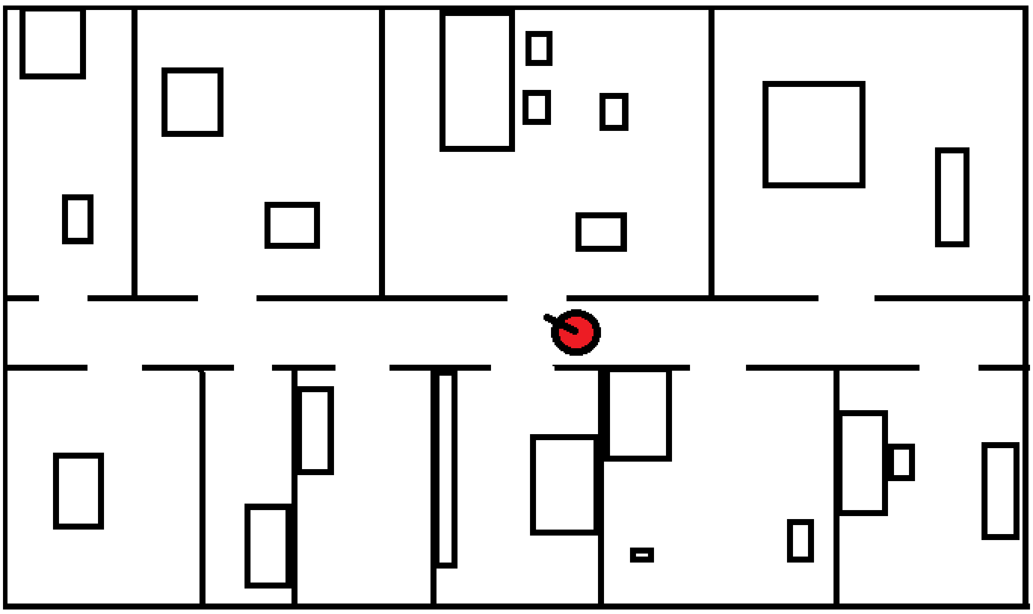
Cognitive Robotics

Assignment 4

Due Tuesday, November 14

Note: If you submit your solutions via e-mail, then please submit a single PDF file containing all solutions for the exercise sheet, write your name on the first page, and name the file after your name.

4.1) In the lecture materials directory, you will find the following 2D grid map as an image with a resolution of 4cm x 4cm per pixel:



Given the current robot pose $x = (x, y, \theta)$, write a program that uses ray casting to generate laser-range measurements

$z = (z_{-125°}, z_{-123°}, \dots, z_{+123°}, z_{+125°})$ for an opening angle of 250° (125° left and right of the heading direction), with a resolution of 2°. Use a maximum measurement range of 12m.

10 points

4.2) Now assume that you don't know the robot's pose and would like to compute the measurement likelihood for the scan generated in 4.1) for all possible robot poses $x = (x, y, \theta)$ within the map boundaries.

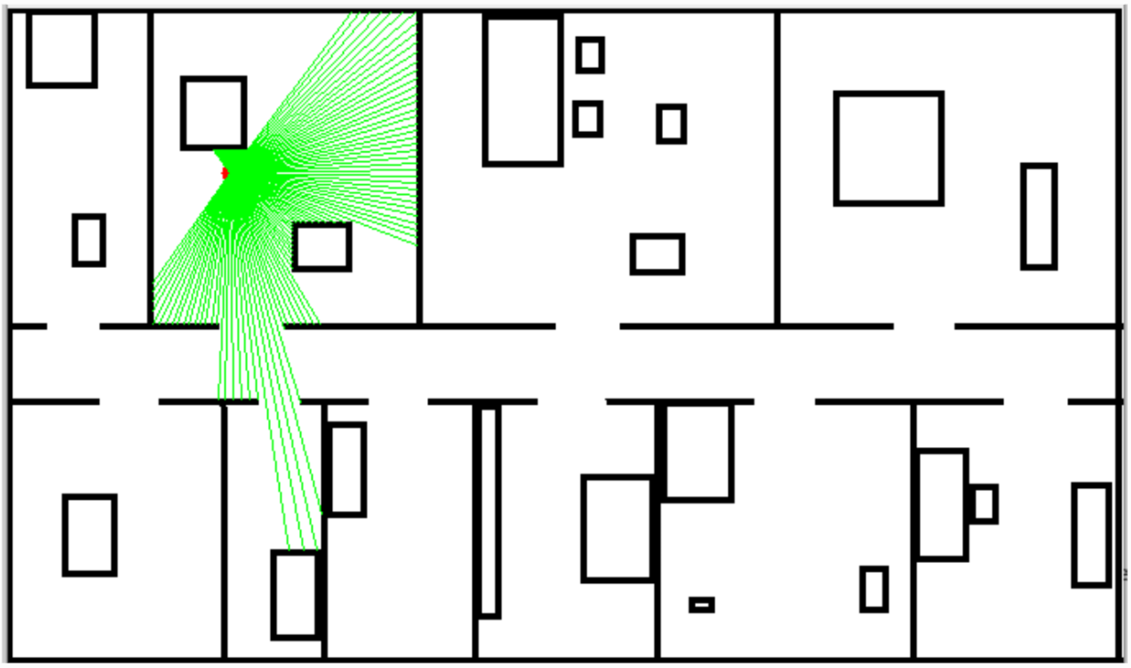
Implement the endpoint model for laser-range measurements. Pre-compute the likelihood field for $\sigma = 0.35m$.

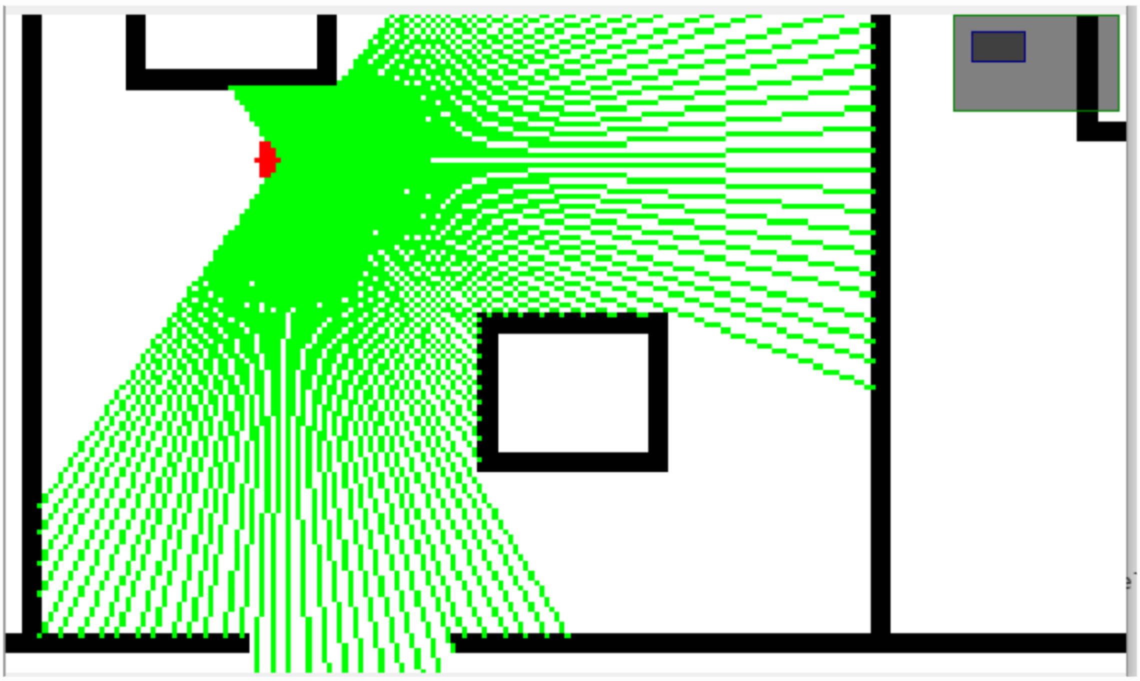
For each possible discretized pose of the robot and the given laser scan z, compute the measurement likelihood $P(z|x, m)$ given that pose and the map.

Visualize the likelihood $P(z|x,m)$ in a 2D map as a grayscale value by taking the highest likelihood over all orientations θ.

10 points

① Using the map, some random robot pose, and a fact that sensor has limited range measurement of 12 meters, we obtained following results for generating laser-range measurements based on ray-casting technique :





② End-Point Model

→ Idea of computing $P(z \mid x, m)$ using End-Point Model is following:

1) Compute Likelihood Field map:

→ For each pixel, we found nearest pixel/cell neighbour that is occupied

→ To that pixel/cell we assign following value:

$$\frac{1}{\sqrt{2\pi\sigma}} \exp \frac{-(d-0)^2}{2\sigma^2}$$

d → distance between pixel/cell and its NN

2) Compute $P(z = z^* \mid x, m)$

→ z^* is some measurement that was obtained in "reality" from some pose in the map (we do not know that pose)

→ For each possible pose in the map X_i we will compute $P(z = z^* \mid X_i, m)$ and then using Bayes rule we can compute

$$P(X_i \mid z = z^*, m) = P(z = z^* \mid X_i, m) \cdot P(x) \simeq P(z^* \mid X_i, m)$$

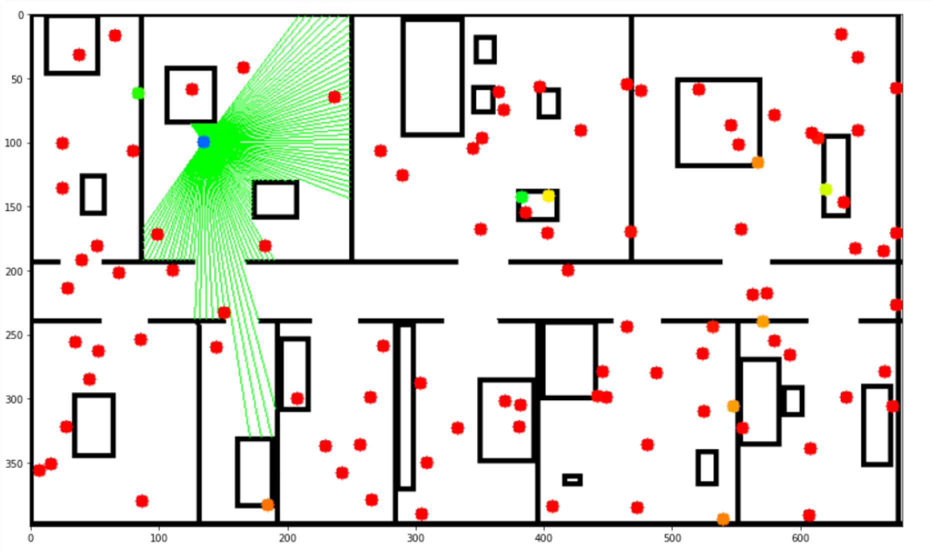
where prior $P(x)$ is uniformly distributed

→ z^* is in our example the measurement that you can see in Task 1

→ Results that we obtained for Task 2 are:

1) Likelihood Field Map

2) $P(z = z^* \mid x = x_i, m)$ for 100 random poses in the map



→ Purely red points are points with low $P(z|x,m)$

→ Blue point is real pose from which measurement was taken ⇒ $P=1$

→ Other color points are points with some value of $P(z|x,m)$

→ Conclusion: It is possible to find robot pose (from which scan was taken)
based only on map and that 1 scan.
But it will probably lead to wrong and ambigous results,
That is why we use Recursive Bayes Filter → to utilaze many measurements
(and controls)