Autonomous Mobile Robotics

Robot Localization

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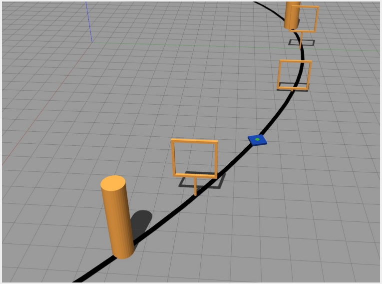

Robot Localization

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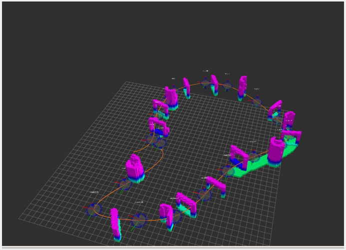


A Taxonomy of Localization Problems

- Local Versus Global
  - Position tracking where initial position is known (local tracking)
  - Robot position is unknown, initially has to assume that pose of robot is uniform in the most of the cases (global)
  - Kidnapped robot problem; anytime robot can be moved to different location without prior knowledge (global)
- Static Versus Dynamic Environments
  - In static environment, robot's pose is only the variable quantity
  - Dynamics environment, whole configuration can be changed over the time
- Passive Versus Active Approaches
  - In passive, robot is controlled through some other means, robot motion is not aiming at facilitating localization

Markov localization

Algorithm Markov_localization($bel(x_{t-1}), u_t, z_t, m$**):**

for all x_t *do*

$$\overline{bel}(x_t) = \int p(x_t \mid u_t, x_{t-1}, m)\, bel(x_{t-1})\, dx$$

$$bel(x_t) = \eta\, p(z_t \mid x_t, m)\, \overline{bel}(x_t)$$

endfor

return $bel(x_t)$

- Markov localization is derived from the algorithm Bayes filter
- However, it requires information about the map to estimate the measurement model $p(z_t|x_t, m)$
- Markov localization addresses the global localization, the position tracking, and the kidnapped robot problem in static environment

Markov localization

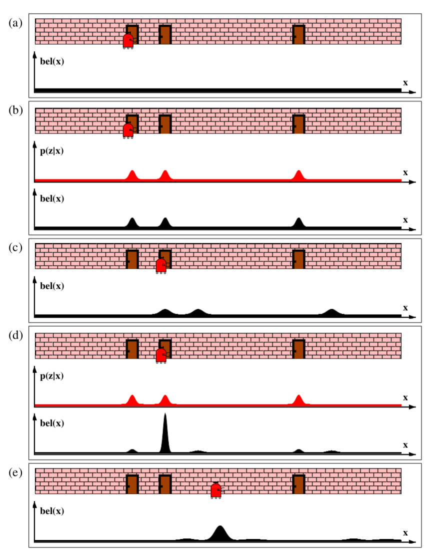
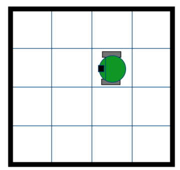


Illustration of the Markov localization algorithm, Thrun, Sebastian. "Probabilistic robotics." Communications of the ACM 45.3 (2002): 52-57.

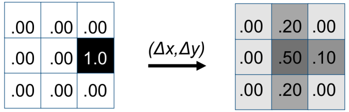
Grid-based localization



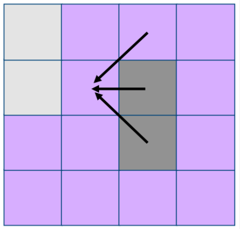
.02	.05	.05	.05
.02	.05	.18	.05
.05	.05	.18	.05
.05	.05	.05	.05

robot initial belief

- The map is discretized into 16 cells, each of which has an area of $1m^2$
- Consider the initial belief of the robot position is given
- If control command to the robot is given by $\delta x, \delta y$ = -1.0 cells, 0.0 cells, what is the probability that robot be in the position (2,3)
- The following outcomes are possible when the control command is being applied



- How many possible ways to get to (2,3)?



  - Prediction step

$$p(x_k|z_{1:k-1}, u_{1:k-1}) = \Sigma_{x_{k-1} \in X}\ p(x_k|x_{k-1}, u_{k-1}) p(x_{k-1}|z_{1:k-1}, u_{0:k-1}) \quad (1)$$

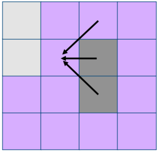
  - Correction step

$$p(x_k|z_{1:k}, u_{0:k-1}) = \frac{p(z_k|x_k)p(x_k|z_{1:k-1}, u_{0:k-1})}{p(z_k|z_{1:k-1}, u_{0:k-1})} \quad (2)$$

, where

$$p(z_k|z_{1:k-1}, u_{0:k-1}) = \Sigma_{x_k \in X}\ p(z_k|x_k)p(x_k|z_{1:k-1}, u_{0:k-1})$$

- How many possible ways to get to (2,3)?



  - Prediction step

$$
\begin{aligned}
p(x_{i,t}|u_t) &= \Sigma_{j=1}^{n} p\left(x_{i,t}|x_{j,t-1}, u_t\right) p\left(x_{j,t-1}\right) \\
&= p\left(x_{i,t} = (2,3)|x_{j,t-1} = (3,3), u_t = (-1,0)\right) p\left(x_{j,t-1} = (3,3)\right) \\
&+ p\left(x_{i,t} = (2,3)|x_{j,t-1} = (2,3), u_t = (-1,0)\right) p\left(x_{j,t-1} = (2,3)\right) \\
&+ p\left(x_{i,t} = (2,3)|x_{j,t-1} = (3,2), u_t = (-1,0)\right) p\left(x_{j,t-1} = (3,2)\right) \\
&+ p\left(x_{i,t} = (2,3)|x_{j,t-1} = (3,4), u_t = (-1,0)\right) p\left(x_{j,t-1} = (3,4)\right) \\
&= 0.5 \cdot 0.18 + 0.1 \cdot 0.05 + 0.18 \cdot 0.2 + 0.05 \cdot 0.2 \\
&= 0.141
\end{aligned}
$$

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