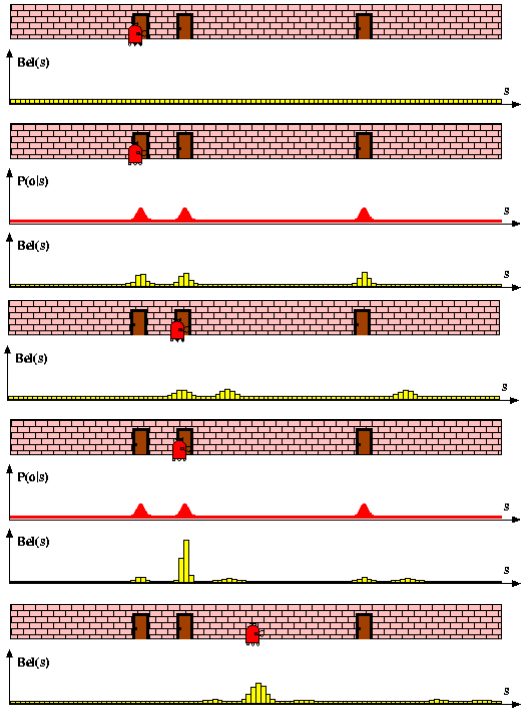
Introduction to Mobile Robotics

Bayes Filter Implementations

Discrete filters

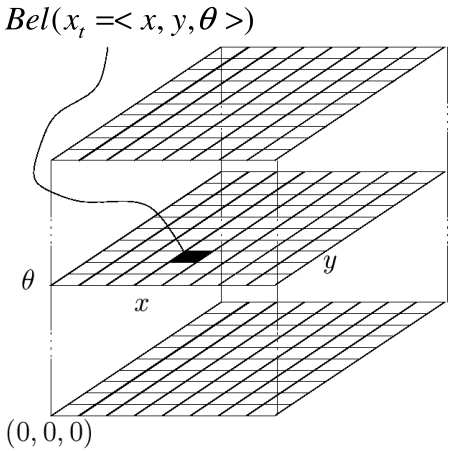
Piecewise Constant



Discrete Bayes Filter Algorithm

1. Algorithm **Discrete_Bayes_filter**(*Bel(x),d*):
2. η=0
3. If *d* is a perceptual data item *z* then
4. For all *x* do
5. $Bel'(x) = P(z \mid x) Bel(x)$
6. $\eta = \eta + Bel'(x)$
7. For all *x* do
8. $Bel'(x) = \eta^{-1} Bel'(x)$
9. Else if *d* is an action data item *u* then
10. For all *x* do
11. $Bel'(x) = \sum_{x'} P(x \mid u, x') \, Bel(x')$
12. Return *Bel'(x)*

Piecewise Constant Representation



Implementation (1)

- To update the belief upon sensory input and to carry out the normalization one has to iterate over all cells of the grid.
- Especially when the belief is peaked (which is generally the case during position tracking), one wants to avoid updating irrelevant aspects of the state space.
- One approach is not to update entire sub-spaces of the state space.
- This, however, requires to monitor whether the robot is de-localized or not.
- To achieve this, one can consider the likelihood of the observations given the active components of the state space.

Implementation (2)

- To efficiently update the belief upon robot motions, one typically assumes a bounded Gaussian model for the motion uncertainty.
- This reduces the update cost from $O(n^2)$ to $O(n)$, where n is the number of states.
- The update can also be realized by shifting the data in the grid according to the measured motion.
- In a second step, the grid is then convolved using a separable Gaussian Kernel.
- Two-dimensional example:

1/16	1/8	1/16
1/8	1/4	1/8
1/16	1/8	1/16

$\cong$

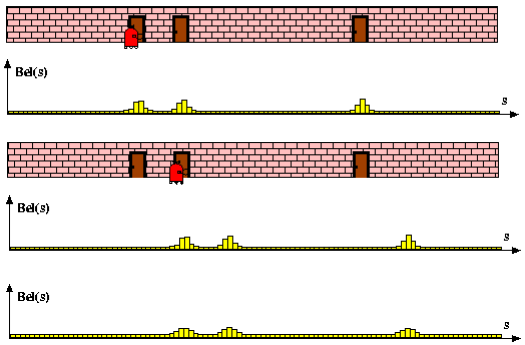
1/4
1/2
1/4

$+$

1/4	1/2	1/4

- Fewer arithmetic operations
- Easier to implement

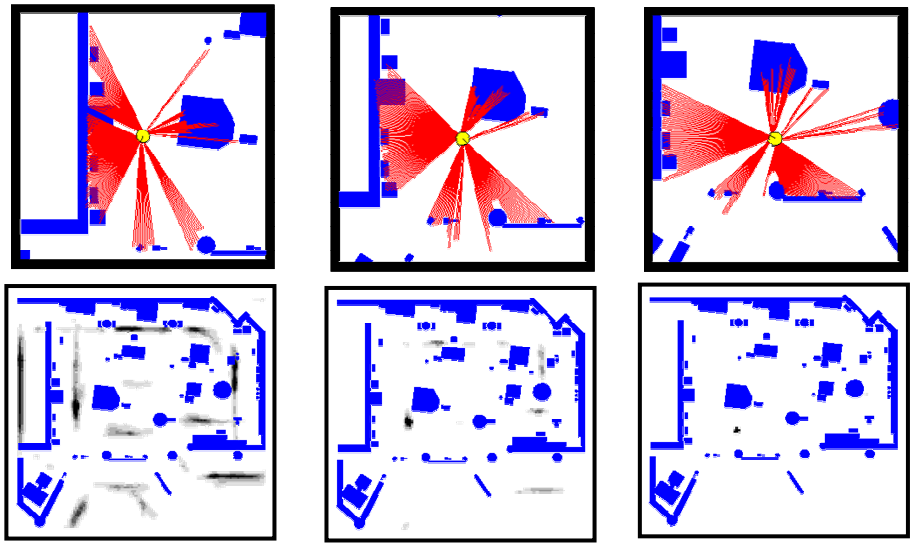
Efficiently Updating a Grid upon Movements



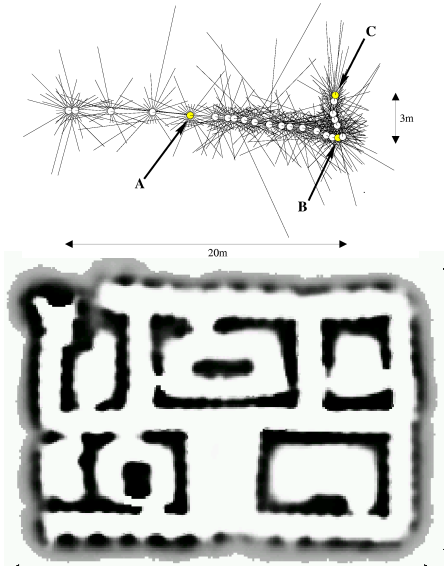
Shifting operation

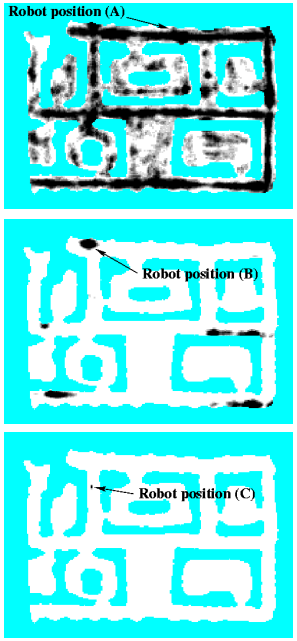
Convolution

Grid-based Localization



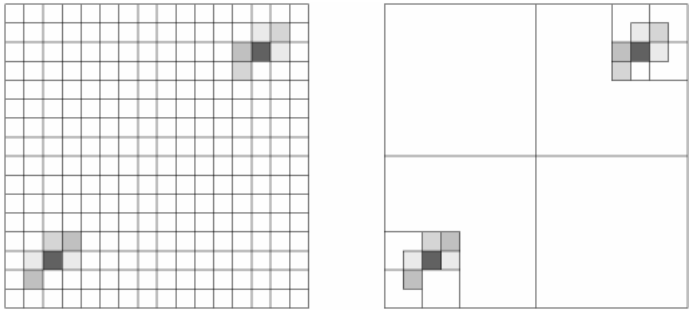
Sonars and Occupancy Grid Map





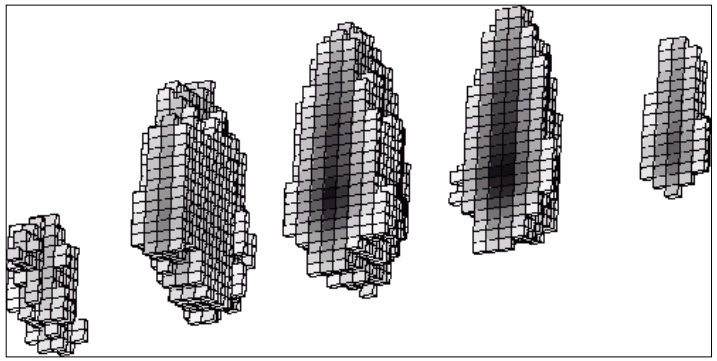
Tree-based Representation

Idea: Represent density using a variant of octrees

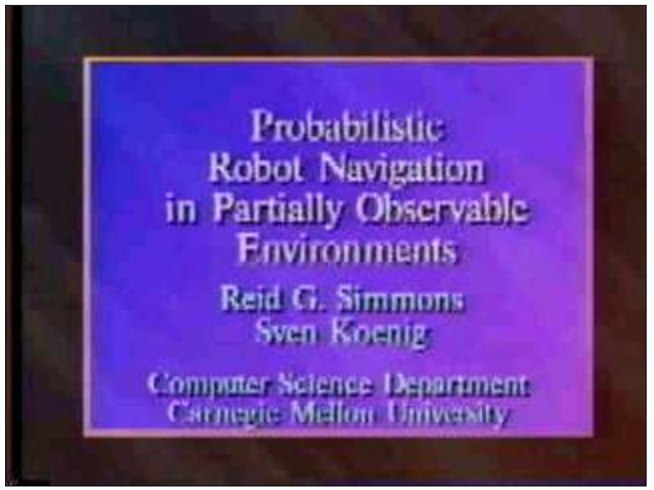


Tree-based Representations

- Efficient in space and time
- Multi-resolution



Xavier:
Localization in a Topological Map



Summary

- Piecewise constant functions (histograms) are a natural way to represent posteriors and likelihood functions.
- They can be easily updated upon sensory input.
- For the incorporations of movements bounded Gaussians can be used to reduce the computational complexity.
- Selective updating techniques (update the grid only at places with a sufficient probability mass) can lead to a speed-up.