

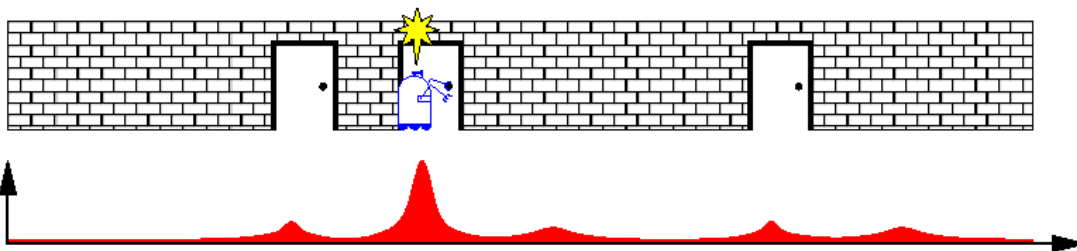
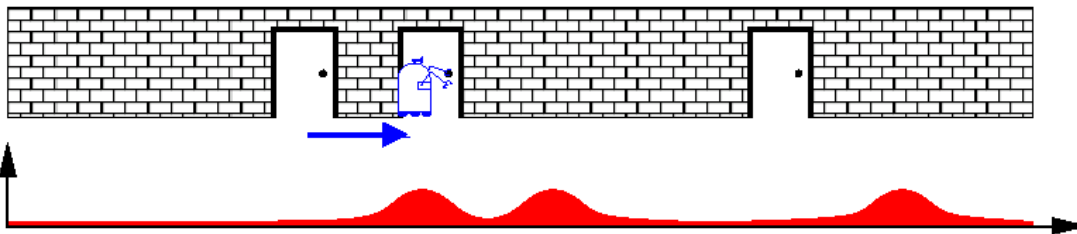
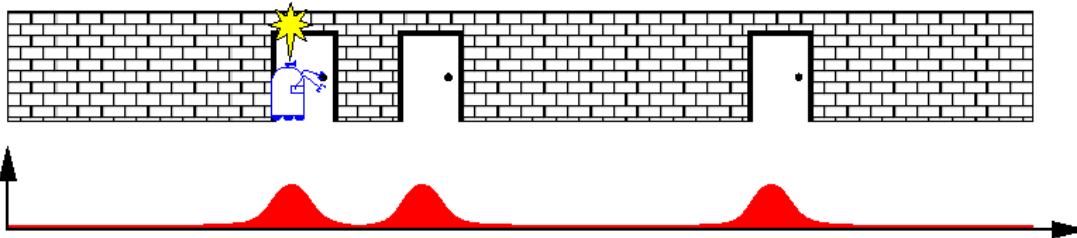
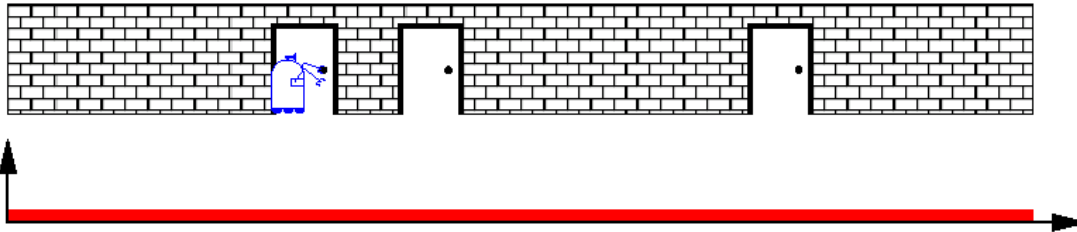
Introduction to Mobile Robotics

Bayes Filter – Discrete Filters

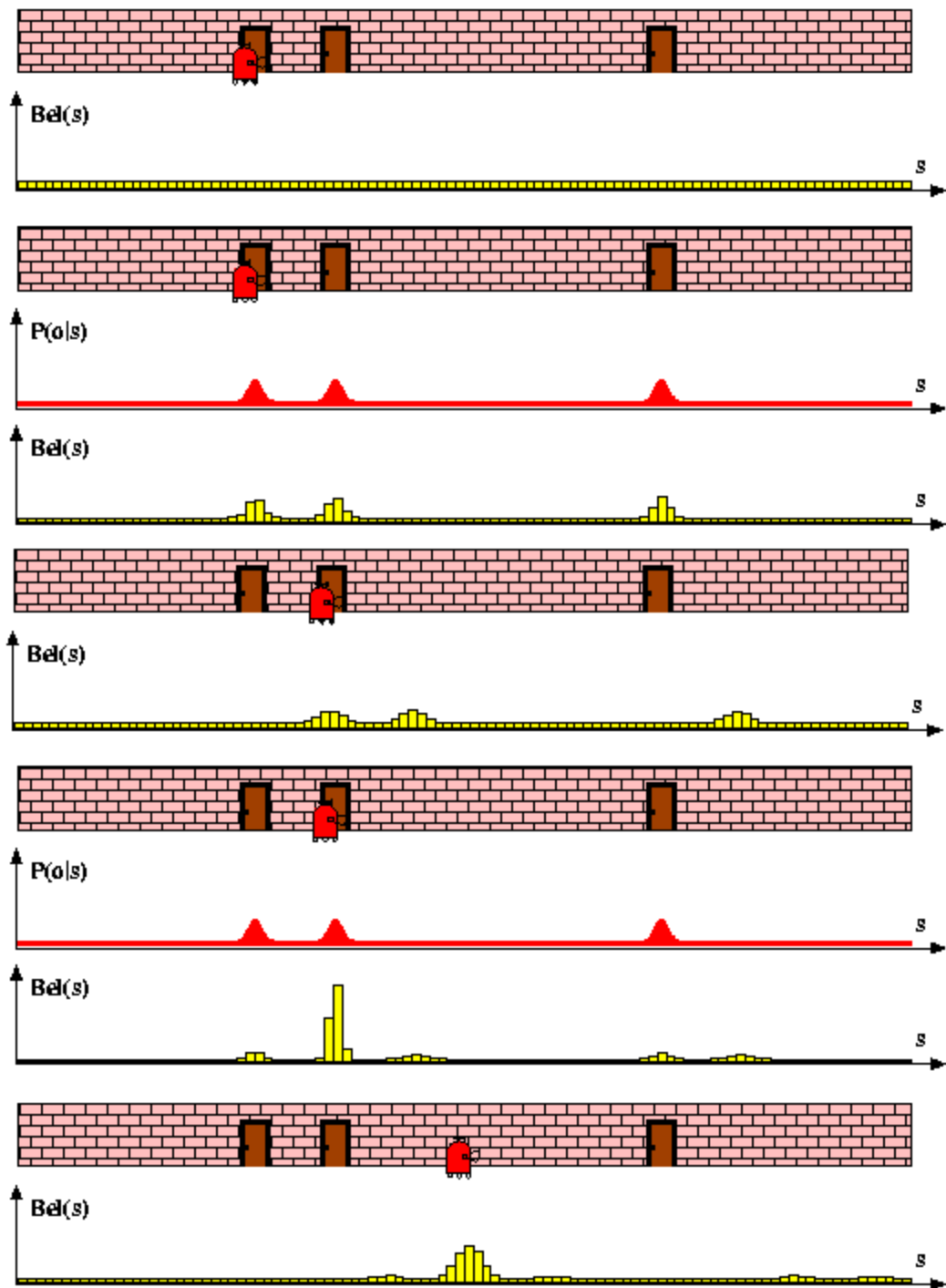
Wolfram Burgard, Diego Tipaldi



$$Bel(x | z, u) = \alpha p(z | x) \int_{x'} p(x | u, x') Bel(x') dx'$$



Piecewise Constant

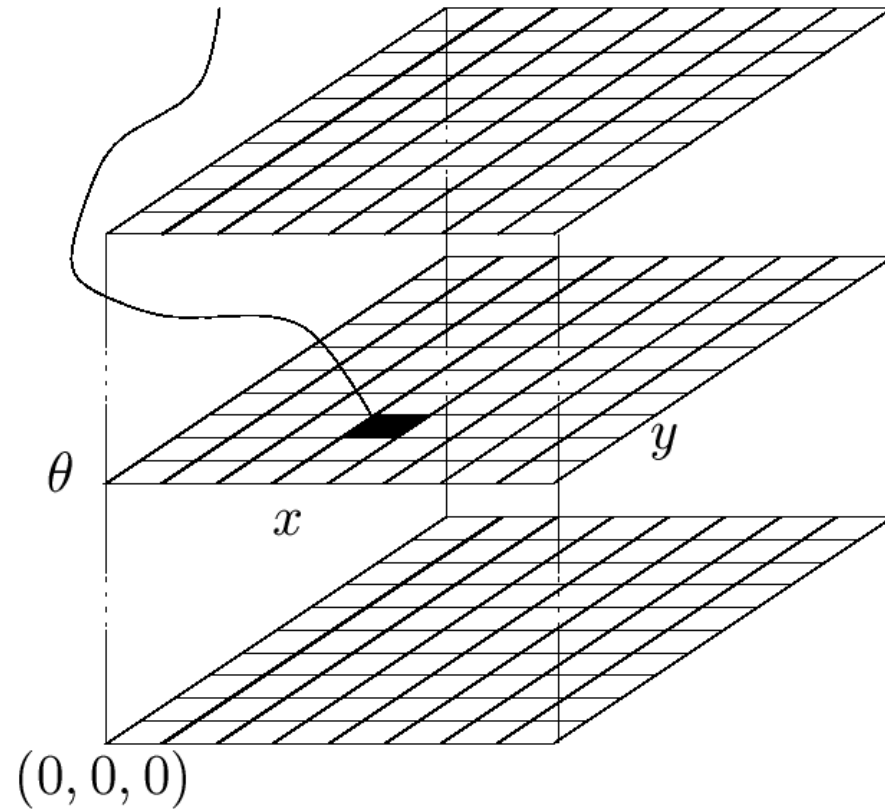


Discrete Bayes Filter Algorithm

1. Algorithm **Discrete_Bayes_filter**($Bel(x), d$):
2. $\eta = 0$
3. If d is a perceptual data item z then
 4. For all x do
 5. $Bel'(x) = P(z | x) Bel(x)$
 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. $Bel'(x) = \sum_{x'} P(x | u, x') Bel(x')$
12. Return $Bel'(x)$

Piecewise Constant Representation

$$Bel(x_t = \langle x, y, \theta \rangle)$$



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

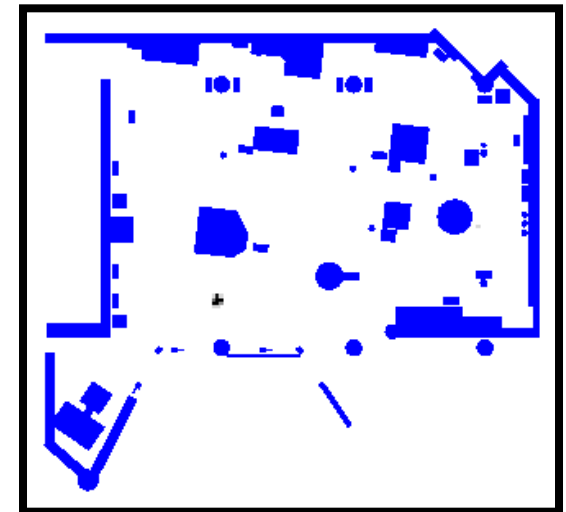
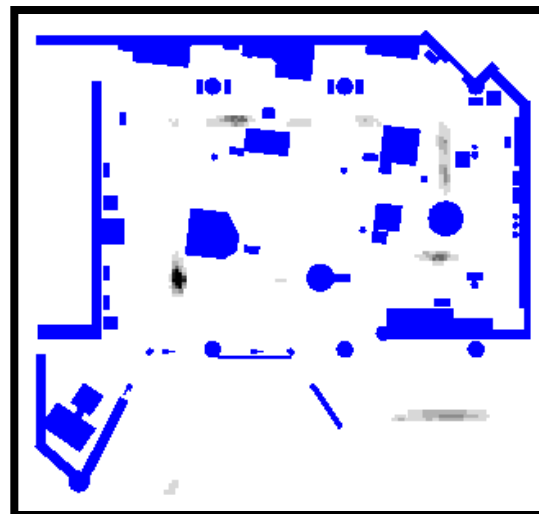
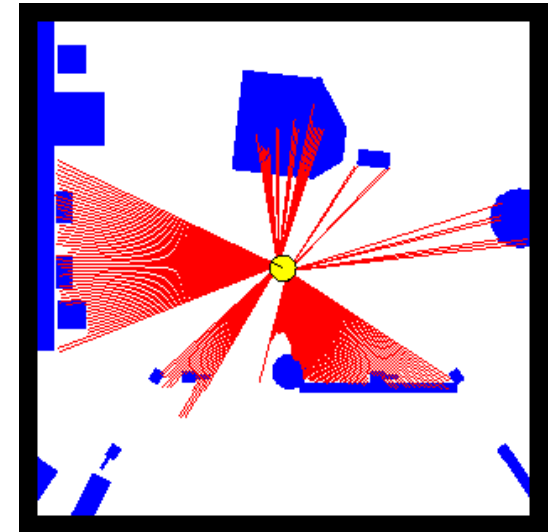
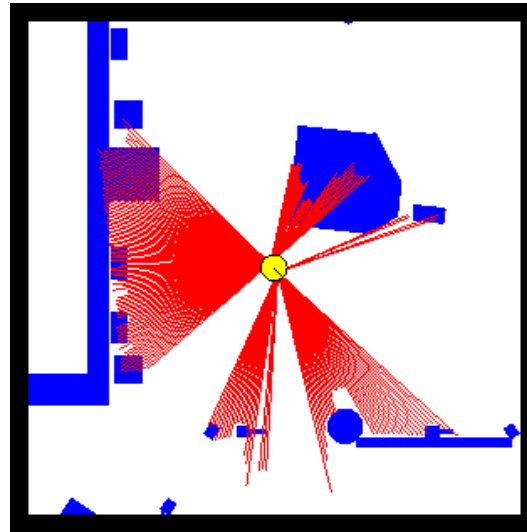
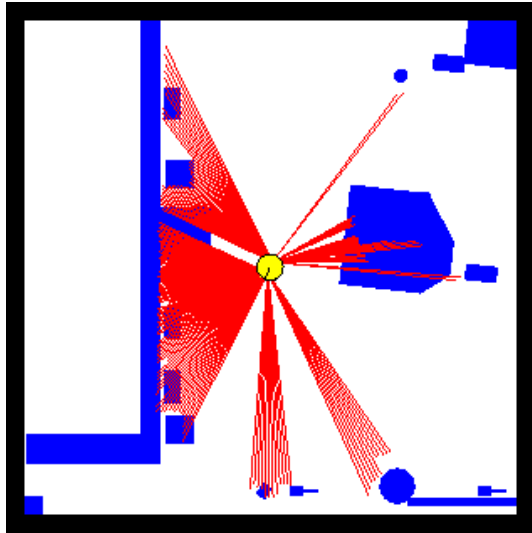
1/4
1/2
1/4

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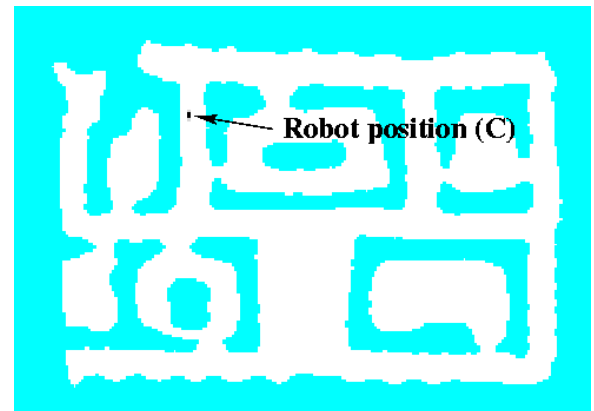
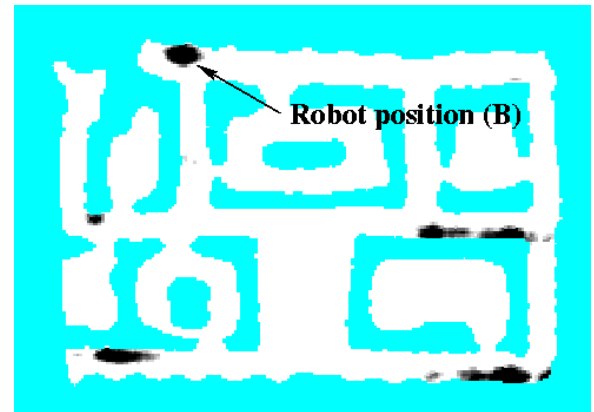
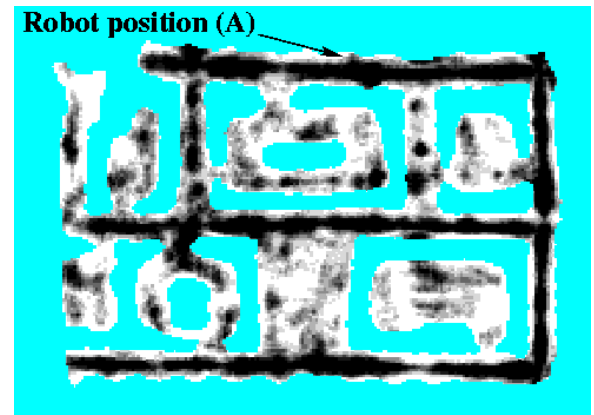
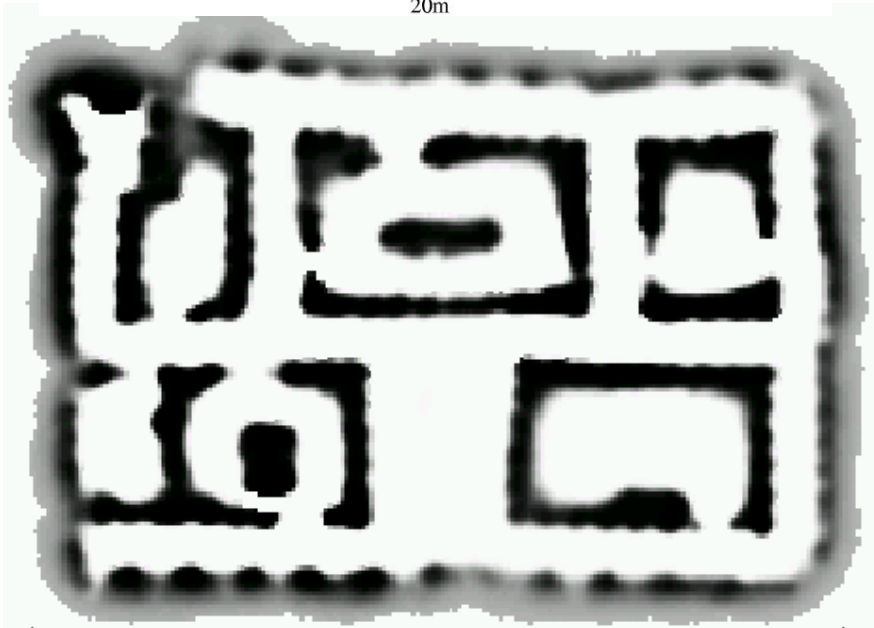
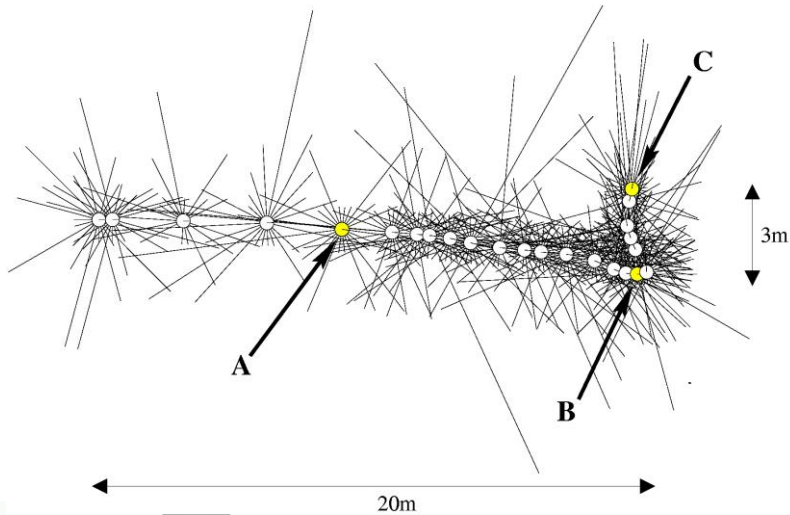
1/4	1/2	1/4
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- Fewer arithmetic operations
- Easier to implement

Grid-based Localization

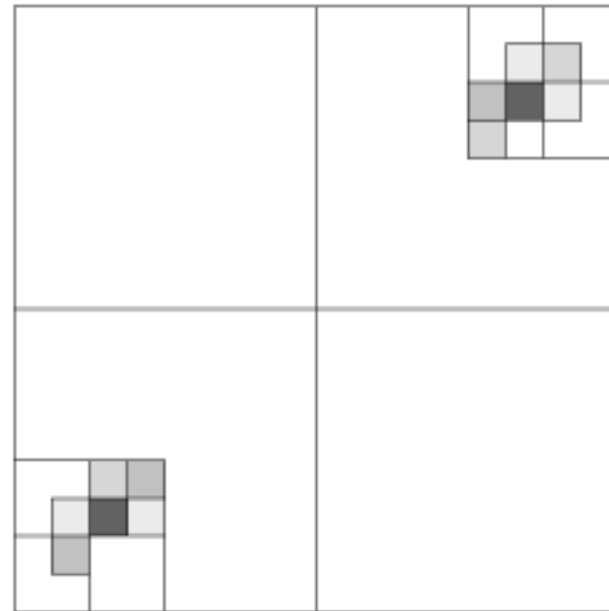
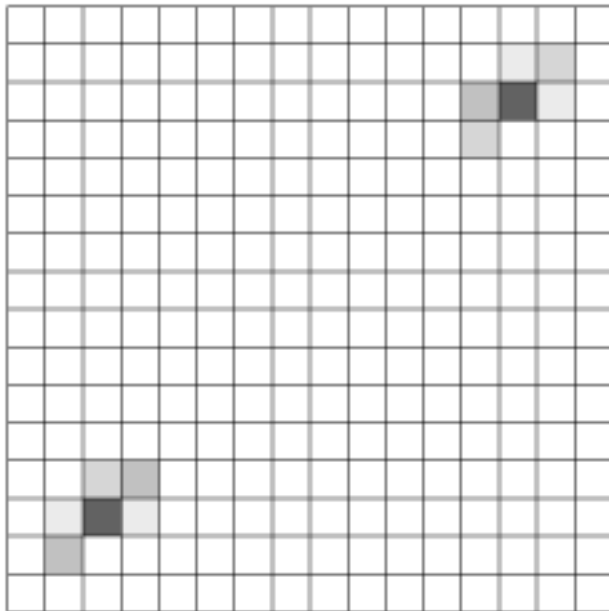


Sonars and Occupancy Grid Map



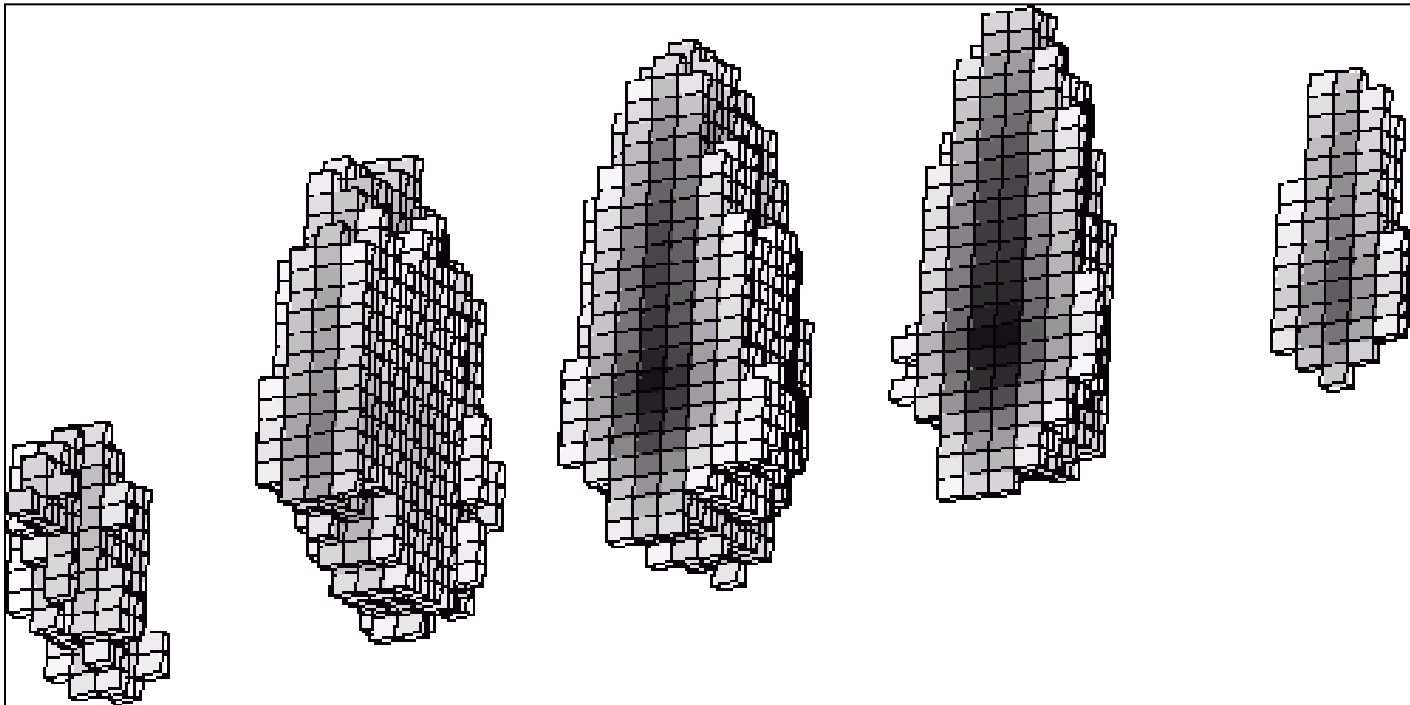
Tree-based Representation

Idea: Represent density using a variant of octrees



Tree-based Representations

- Efficient in space and time
- Multi-resolution



Summary

- Discrete filters are an alternative way for implementing Bayes Filters
- They are based on histograms for representing the density.
- They have huge memory and processing requirements
- Can easily recover from localization errors
- Their accuracy depends on the resolution of the grid.
- Special approximations need to be made to make this approach having dynamic memory and computational requirements.