Simultaneous Localization and Mapping

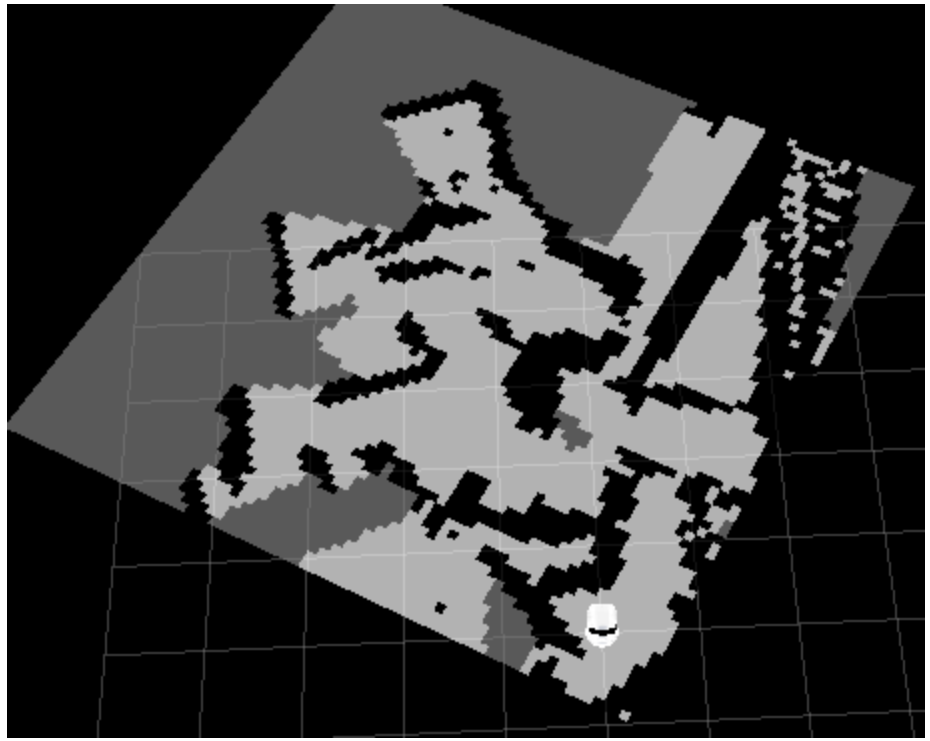
Mapping with known robot locations

Mapping without localization

What does the mapping problem look like **if localization is not an issue**?

Occupancy grid representation:

$$m_\ell = \begin{cases} 1 & \text{if cell } \ell \text{ is obstacle} \\ 0 & \text{if cell } \ell \text{ is free} \end{cases}$$



We want the probability that each cell is occupied, given the robot's position history and sensing history:

$$P_{\ell,k} = P(m_\ell = 1 \mid x_1, \ldots, x_k, y_1, \ldots, y_k)$$

Updating occupancy grid probabilities

1. **Initialization:** Start with some **prior** distribution P_0:

$$P_{l,0} = P_0$$

This could be an naive assumption (say, $P_0 = 0.5$) or from some other partial map.

Updating occupancy grid probabilities

2. **Update**, given a new x_k and y_k:

$$P_{\ell,k} = \left[1 + \left(\frac{P(m_\ell = 0 \mid x_k, y_k)}{P(m_\ell = 1 \mid x_k, y_k)}\right)\left(\frac{1 - P_{\ell,k-1}}{P_{\ell,k-1}}\right)\right]^{-1}$$

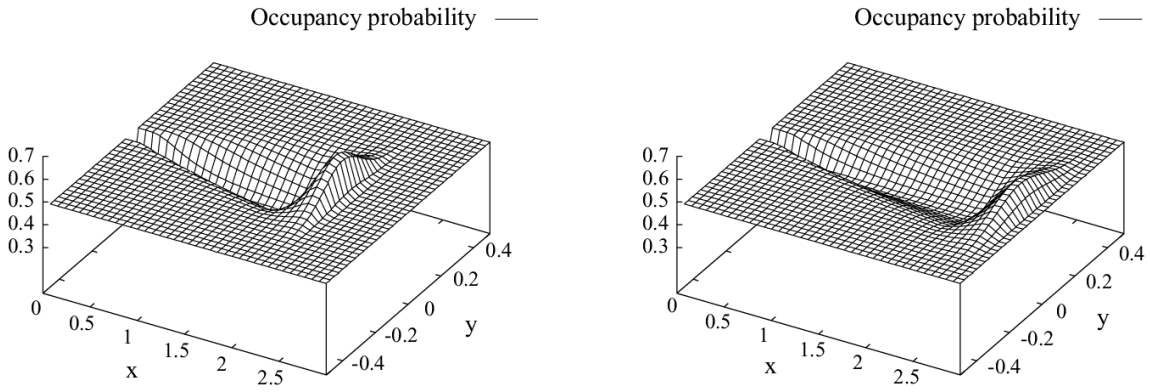
This depends on:

- An observation model, describing the likelihood of a given cell being free or obstacle, given the robot's current location and its observation.
- The occupancy probability, given the history at the previous stage.

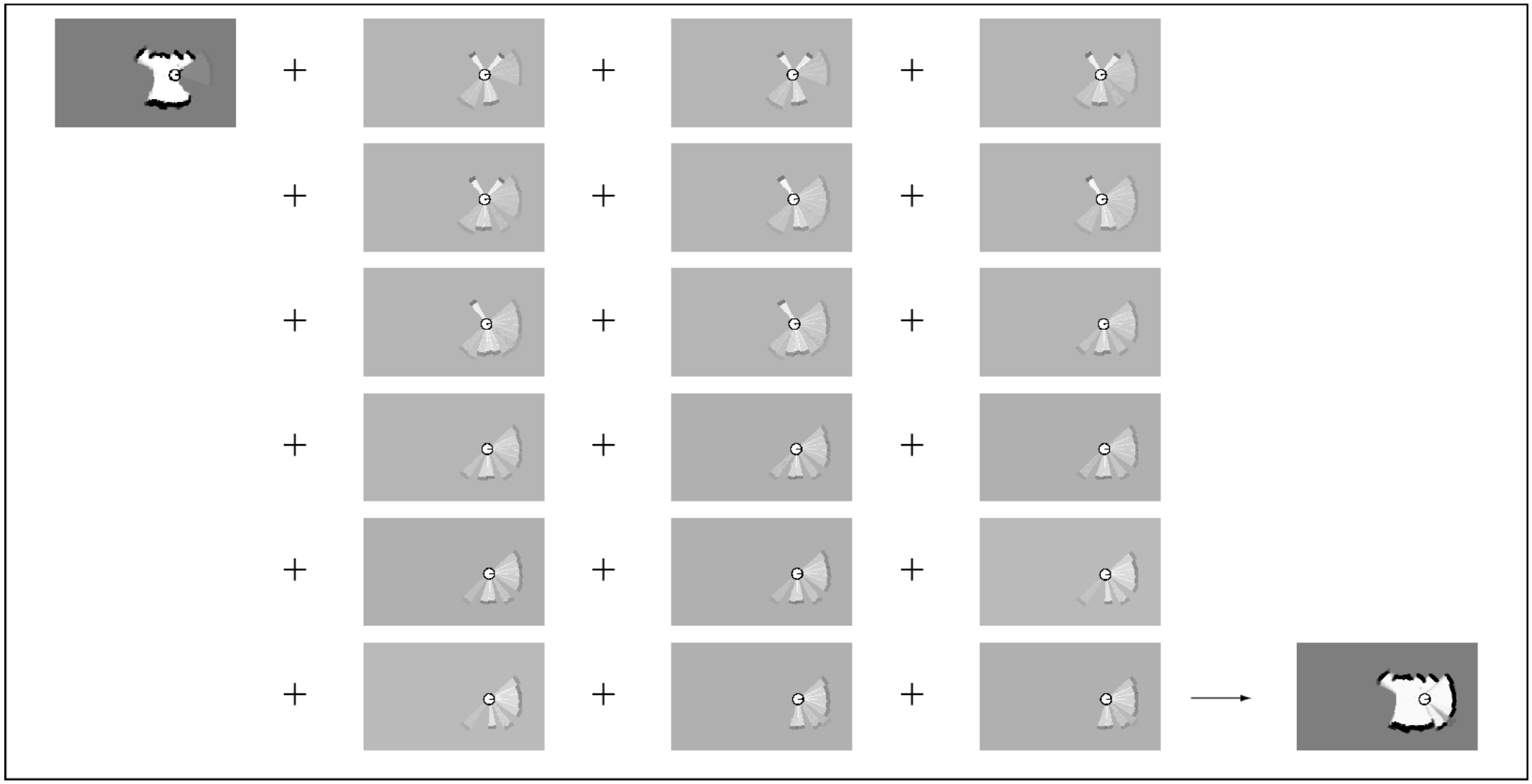
Observation model example

For an ultrasonic range sensor, the observation model depends on:

- the measured distance,
- the angle between the occupancy grid cell and the sensor's emitter, and
- the distance from the occupancy grid cell to the sensor's emitter.



Occupancy Grid Mapping Examples



Occupancy Grid Mapping Examples