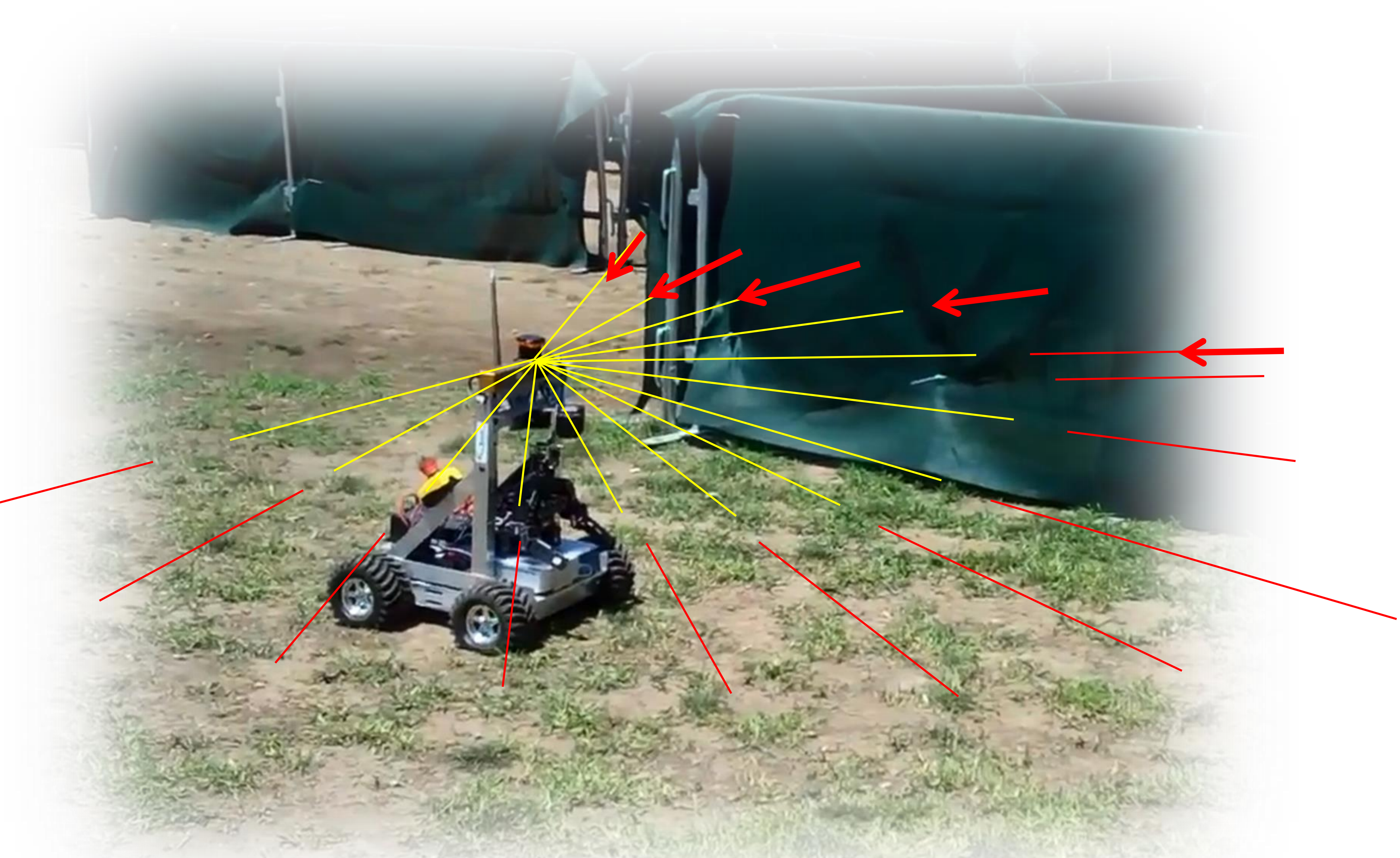
Robotics

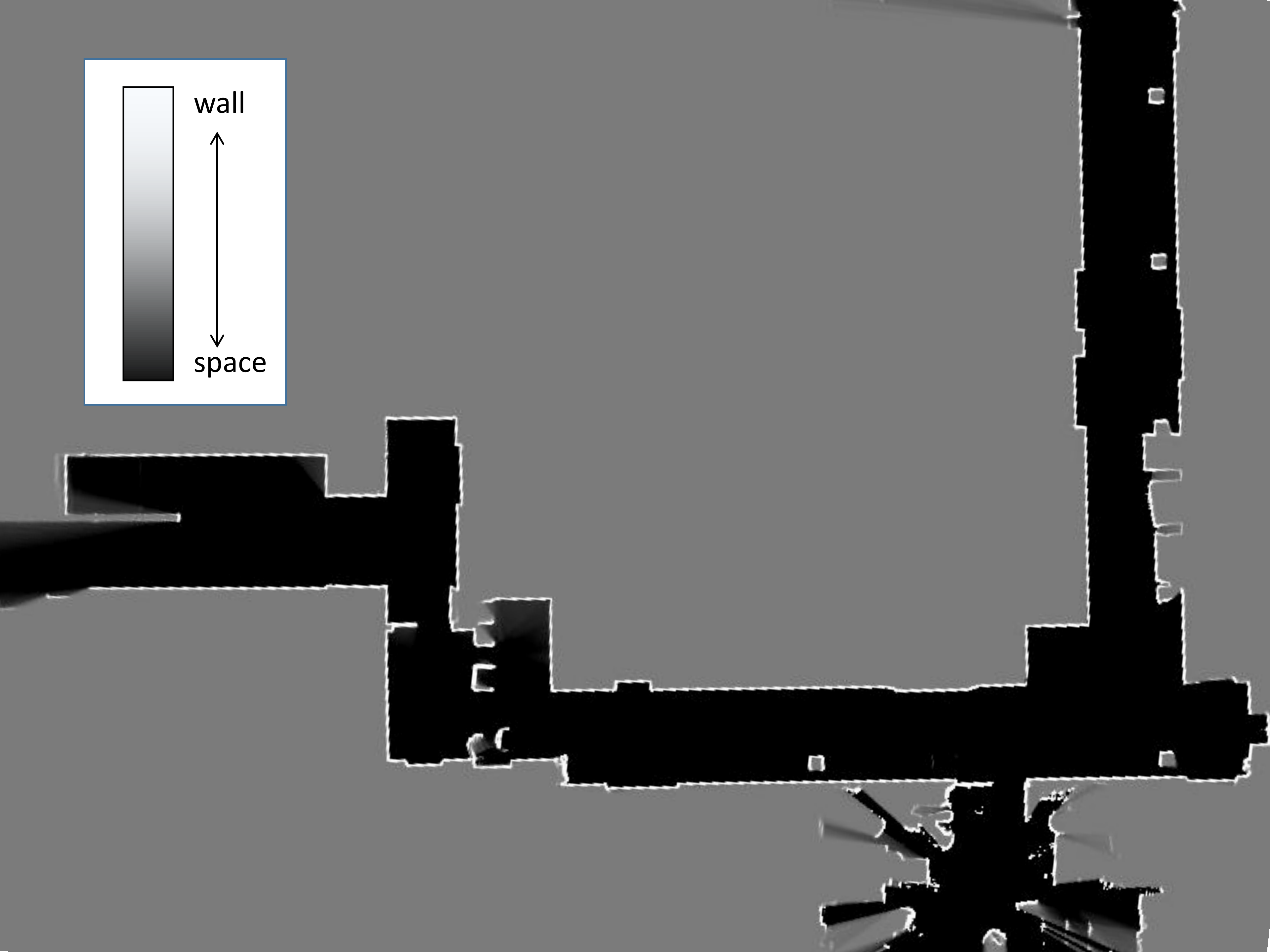
Estimation and Learning
with Dan Lee

Week 3.
Robotic Mapping

3.2 Occupancy Grid Mapping
3.2.1 Occupancy Grid Map

Penn Engineering




wall
space

Occupancy Grid Mapping

- Occupancy: binary R.V.

  $m_{x,y}: \{free, occupied\} \rightarrow \{\,0\,,1\,\}$

[Review – Into Probability]

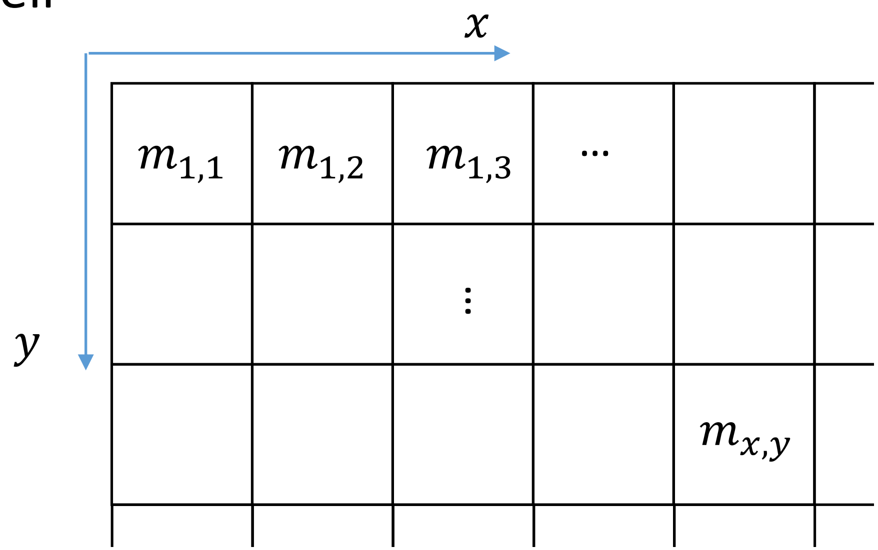
Given some probability space (Ω, P),
a **random variable** $X: \Omega \rightarrow R$ is a *function* that maps the sample space to the reals.

Occupancy Grid Mapping

- Occupancy: binary R.V.

$$m_{x,y}: \{free, occupied\} \rightarrow \{0, 1\}$$

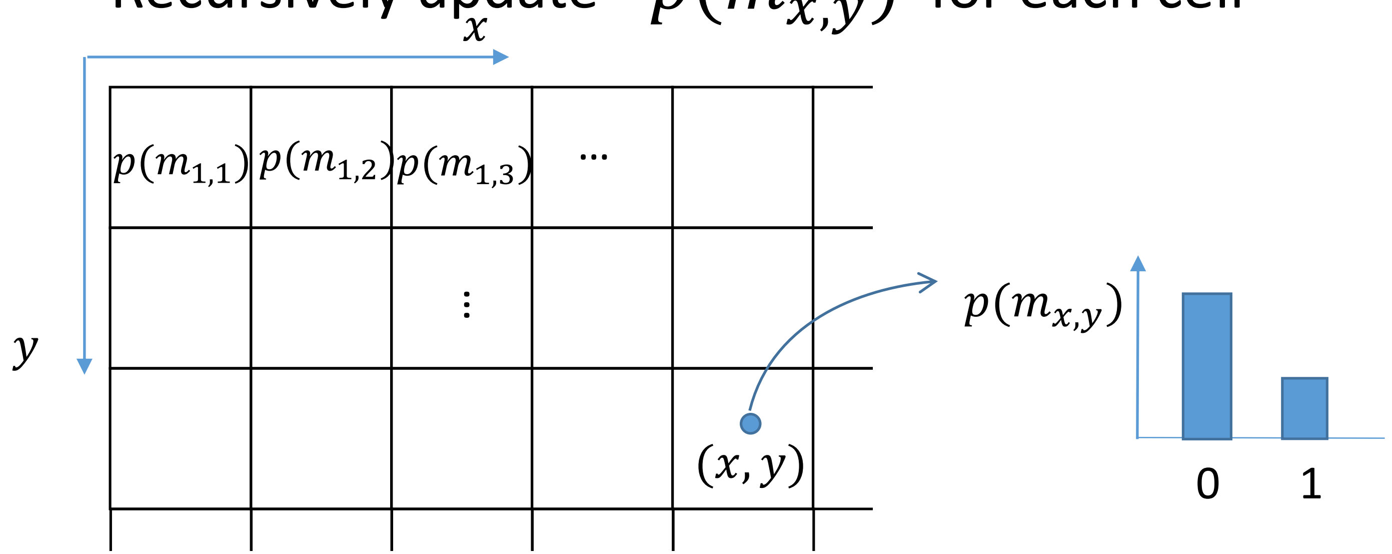
- Occupancy grid map
  : fine-grained grid map where an occupancy variable associated with each cell



Occupancy Grid Mapping

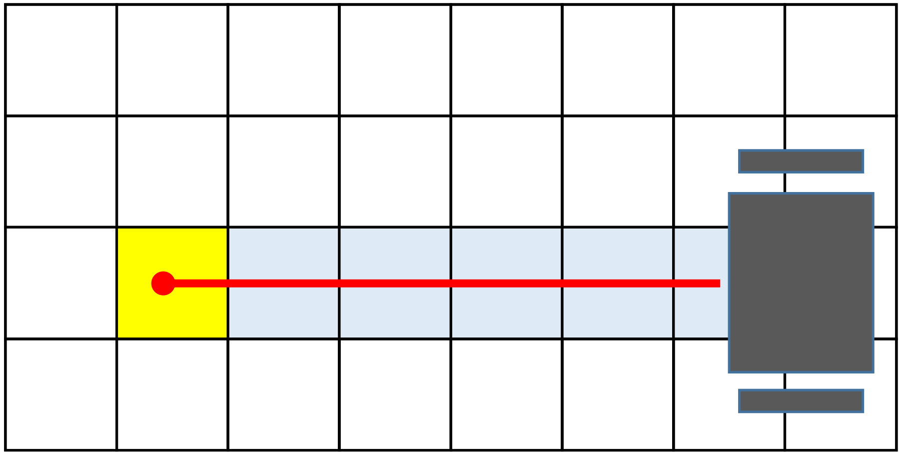
- Occupancy grid mapping
  : A Bayesian filtering to maintain a occupancy grid map.

Recursively update $p(m_{x,y})$ for each cell



Occupancy Grid Mapping

- Measurement

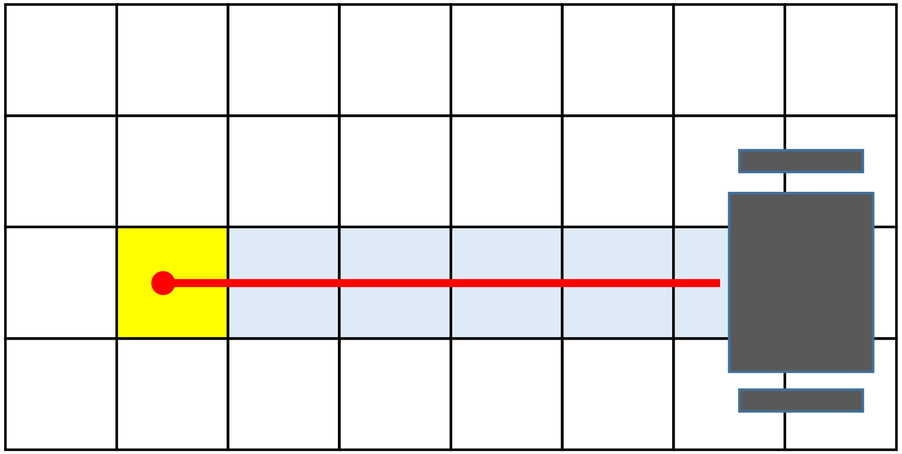


a range sensor

Occupancy Grid Mapping

- Measurement

$$z \sim \{\underbrace{0}_{\text{Free}}, \underbrace{1}_{\text{Occupied}}\}$$



a range sensor

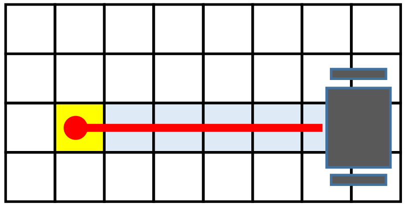
Occupancy Grid Mapping

- Measurement

Free

Occupied

$$z \sim \{0, 1\}$$



- Measurement model

$$p(z|m_{x,y})$$

$p\left(z = 1|m_{x,y} = 1\right)$: True **occupied** measurement

$p\left(z = 0|m_{x,y} = 1\right)$: False **free** measurement

$p\left(z = 1|m_{x,y} = 0\right)$: False **occupied** measurement

$p\left(z = 0|m_{x,y} = 0\right)$: True **free** measurement

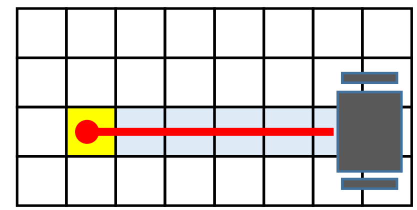
Occupancy Grid Mapping

- Measurement

Free

Occupied

$$z \sim \{\, 0 \,,\, 1 \,\}$$



- Measurement model

$$p(z|m_{x,y})$$

[Review – Into Probability]

$P(A^C|B) = 1 - P(A|B)$

$$\boxed{p\big(z = 1|m_{x,y} = 1\big)}$$

$$p\big(z = 0|m_{x,y} = 1\big) = 1 - p\big(z = 1|m_{x,y} = 1\big)$$

$$\boxed{p\big(z = 1|m_{x,y} = 0\big)}$$

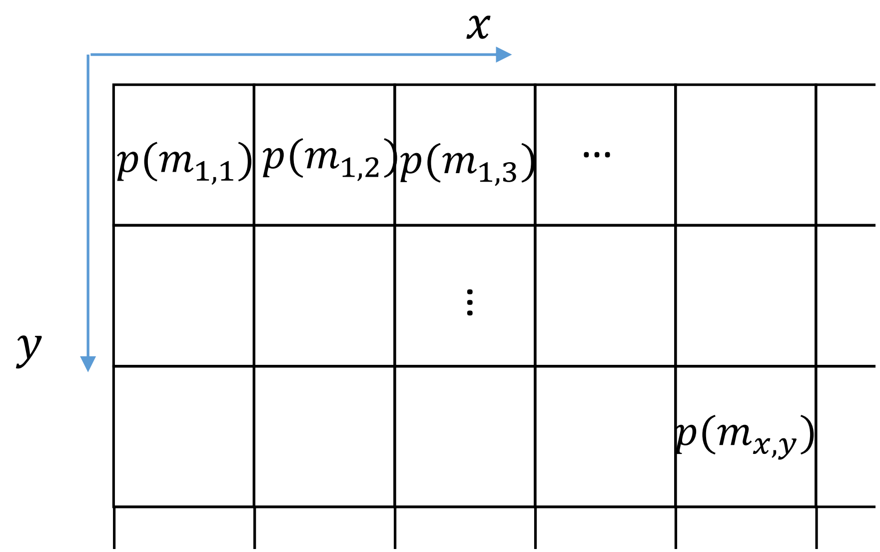
$$p\big(z = 0|m_{x,y} = 0\big) = 1 - p\big(z = 1|m_{x,y} = 0\big)$$

Occupancy Grid Mapping

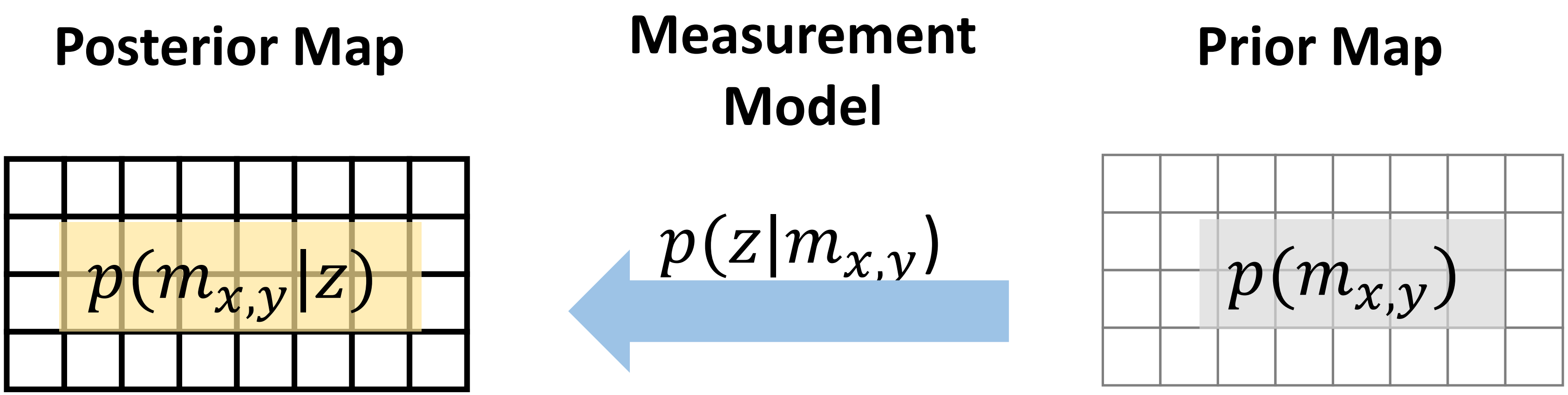
Measurement Model

$$p(z|m_{x,y})$$

Map



Occupancy Grid Mapping



$$\overset{\text{Posterior}}{p(m_{x,y}|z)} = \frac{\overset{\text{Likelihood}}{p(z|m_{x,y})}\,\overset{\text{Prior}}{p(m_{x,y})}}{\underset{\text{Evidence}}{p(z)}}$$