Robotics

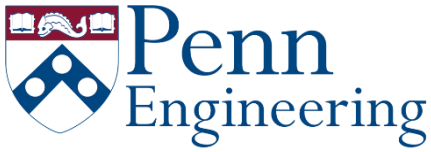
Estimation and Learning
with Dan Lee

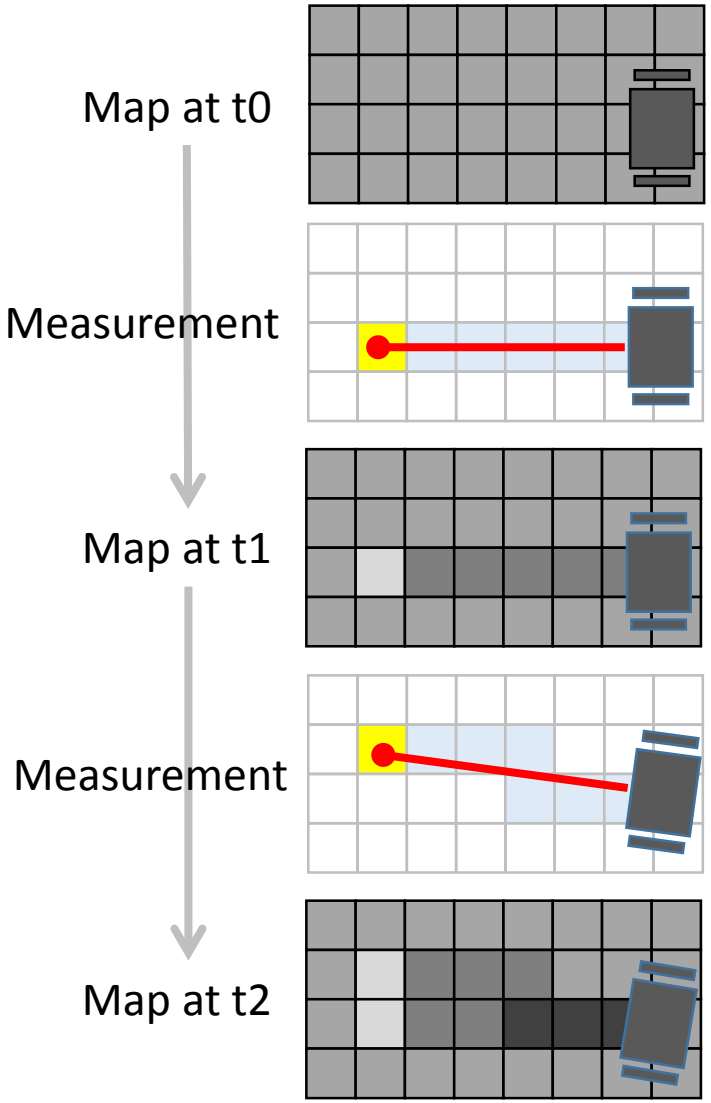
Week 3.

Robotic Mapping

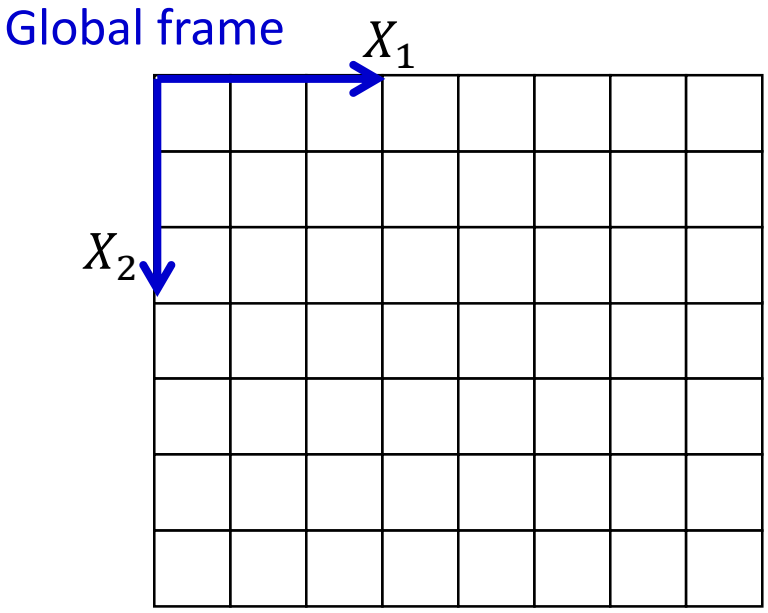
3.2 Occupancy Grid Mapping

3.2.3 Handling Range Sensor

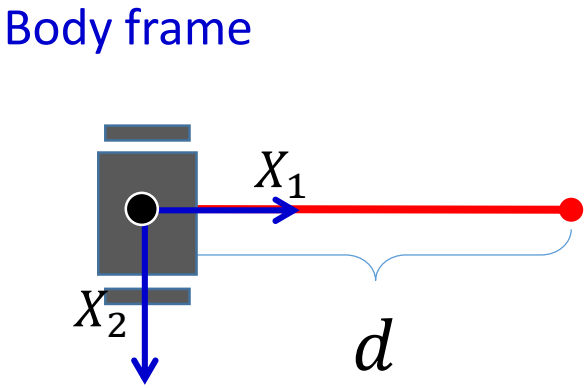



Map at t0
Measurement
Map at t1
Measurement
Map at t2

Handling Range Measurement on Grid

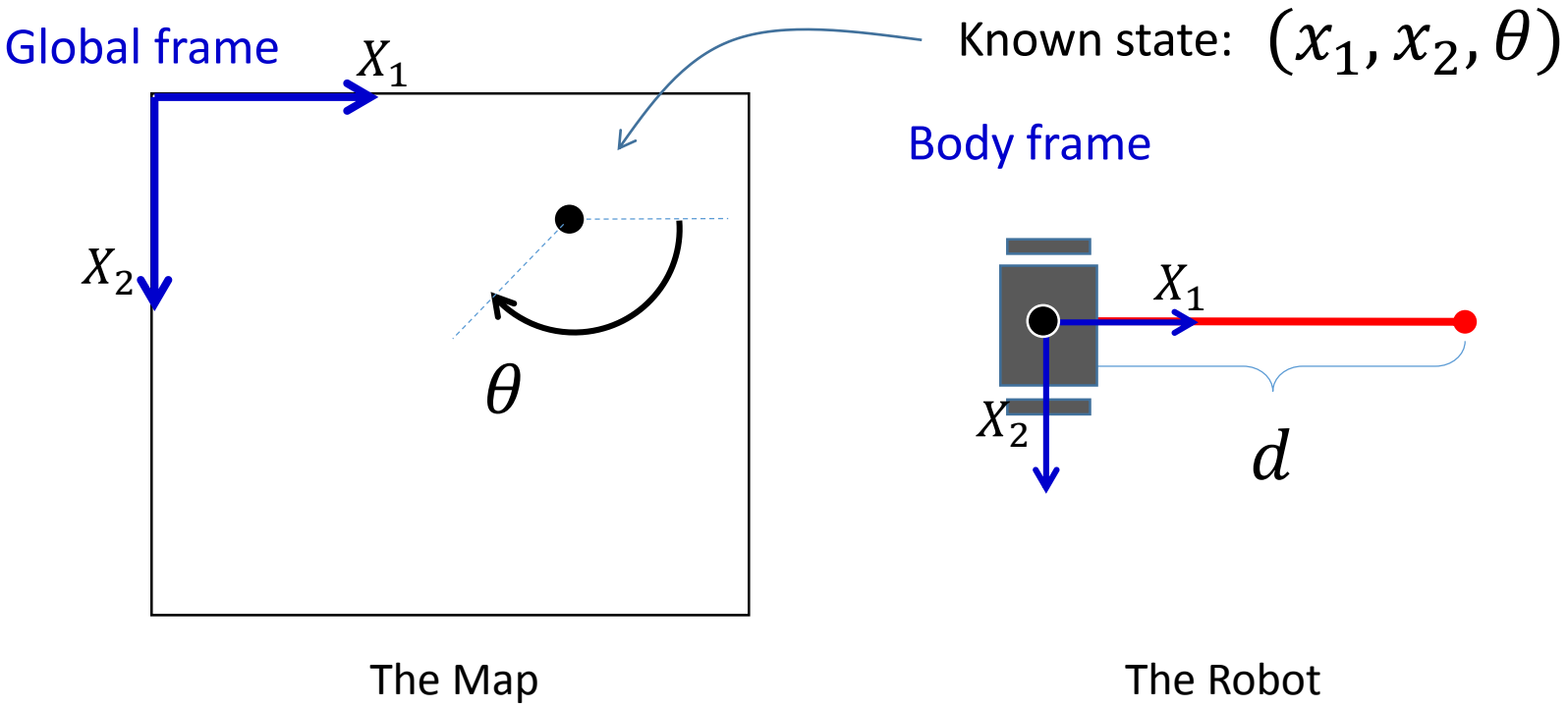


The Map

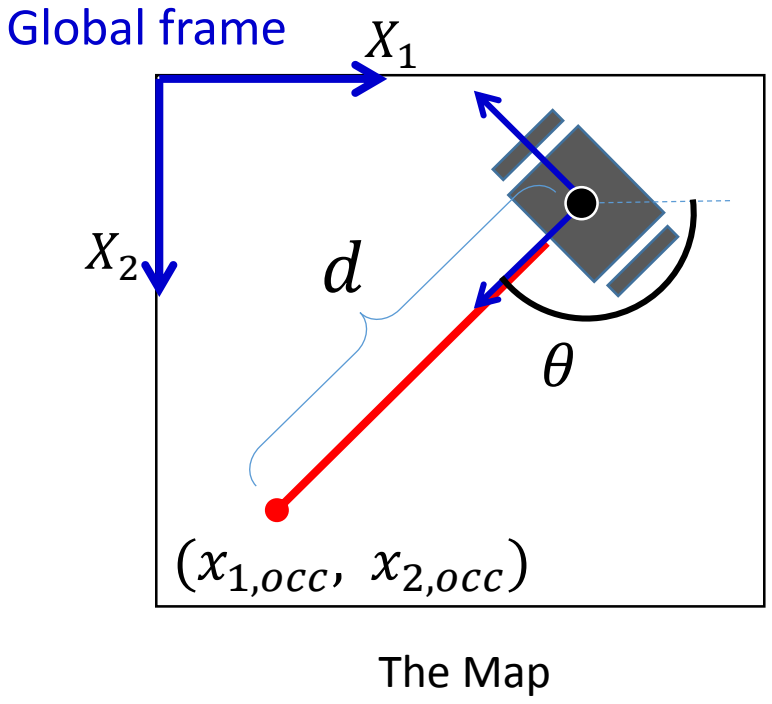


The Robot

Handling Range Measurement on Grid



Handling Range Measurement on Grid



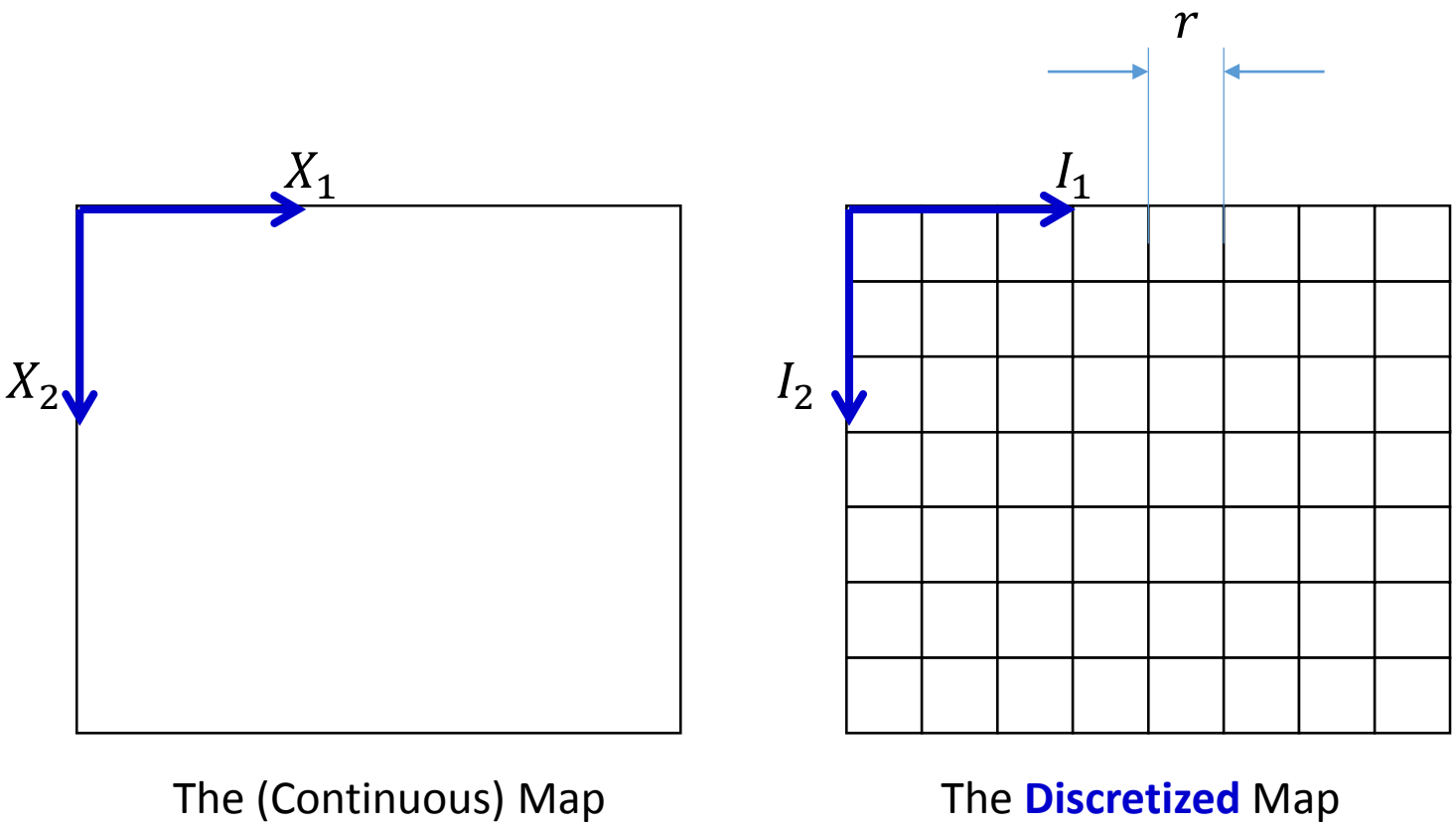
The Map

Distance measurement: d

Known state: (x_1, x_2, θ)

$$\begin{bmatrix} x_{1,occ} \\ x_{2,occ} \end{bmatrix} = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} d \\ 0 \end{bmatrix} + \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

Handling Range Measurement on Grid

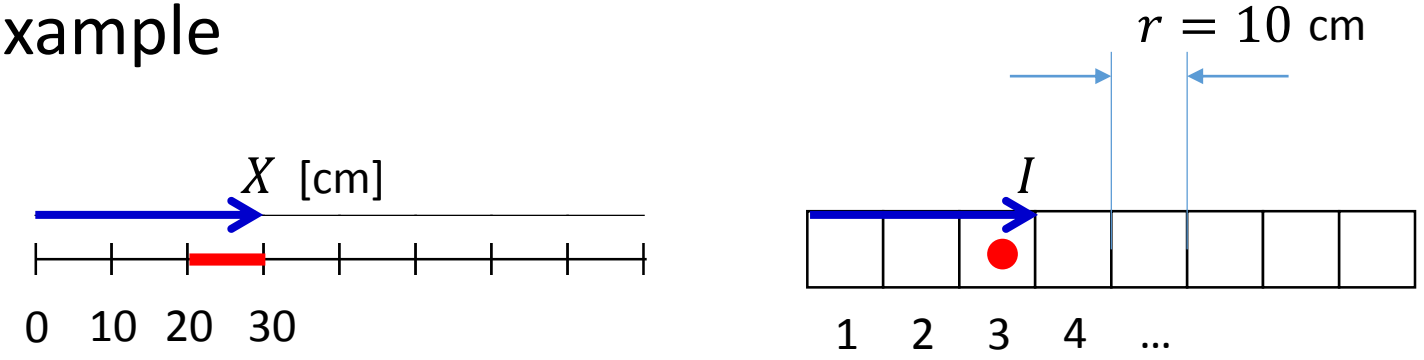


The (Continuous) Map

The **Discretized** Map

Handling Range Measurement on Grid

- Example



[cm] $0 < x \leq 10$ ⇨ $i = 1$ [index]

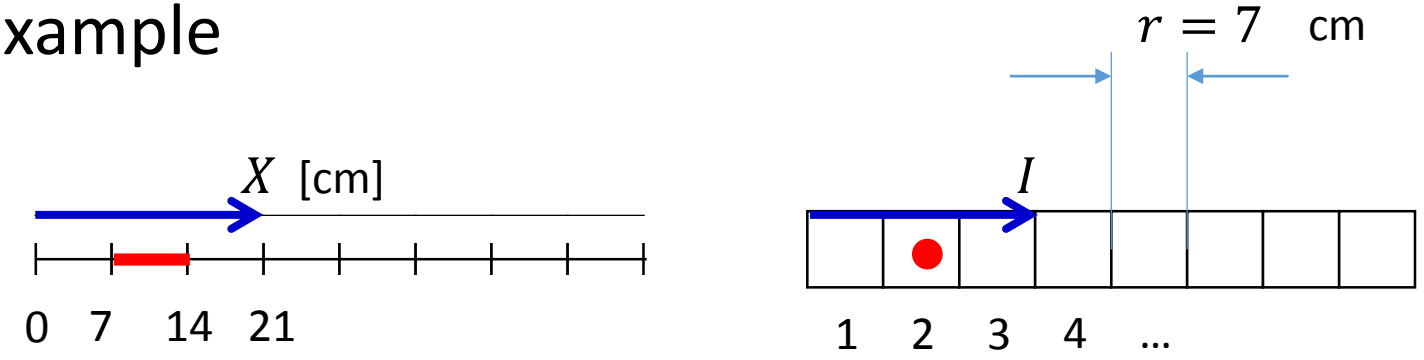
$10 < x \leq 20$ ⇨ $i = 2$

$20 < x \leq 30$ ⇨ $i = 3$

$\vdots$ $\vdots$

Handling Range Measurement on Grid

- Example

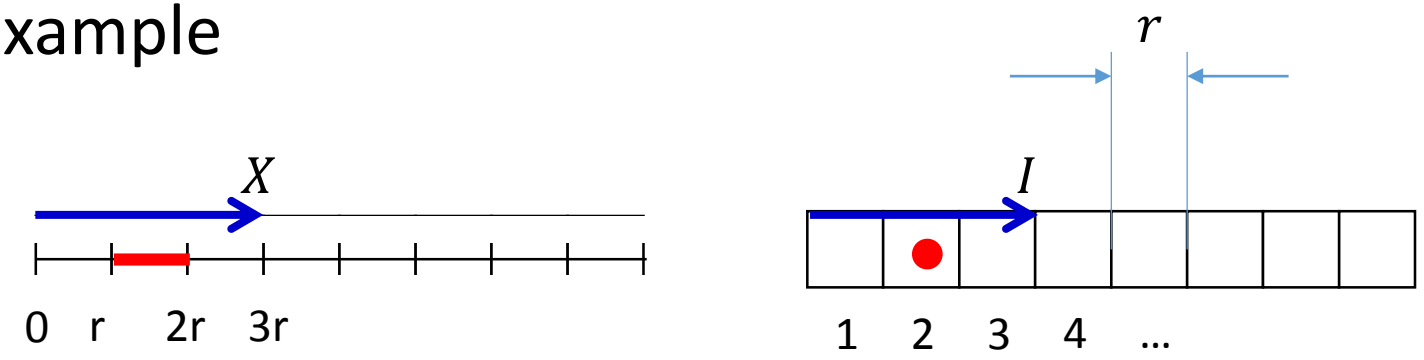


[cm] $0 < x \leq 7$ ⇨ $i = 1$ [index]

$7 < x \leq 14$ ⇨ $i = 2$

Handling Range Measurement on Grid

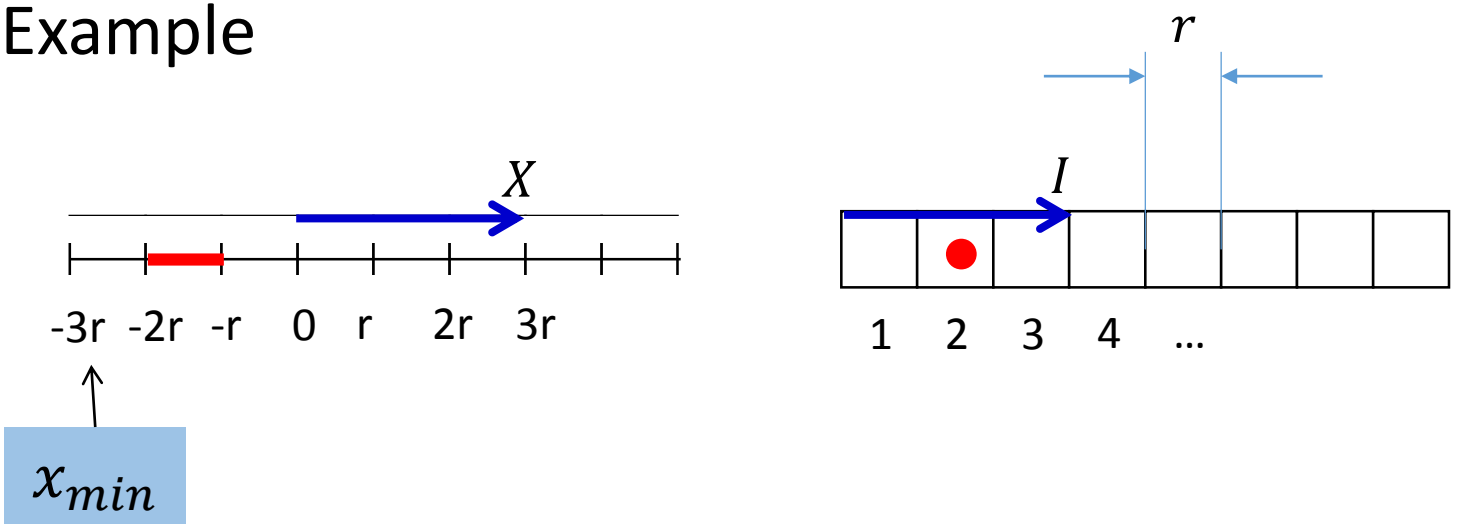
- Example



$$i = ceil(x/r)$$

Handling Range Measurement on Grid

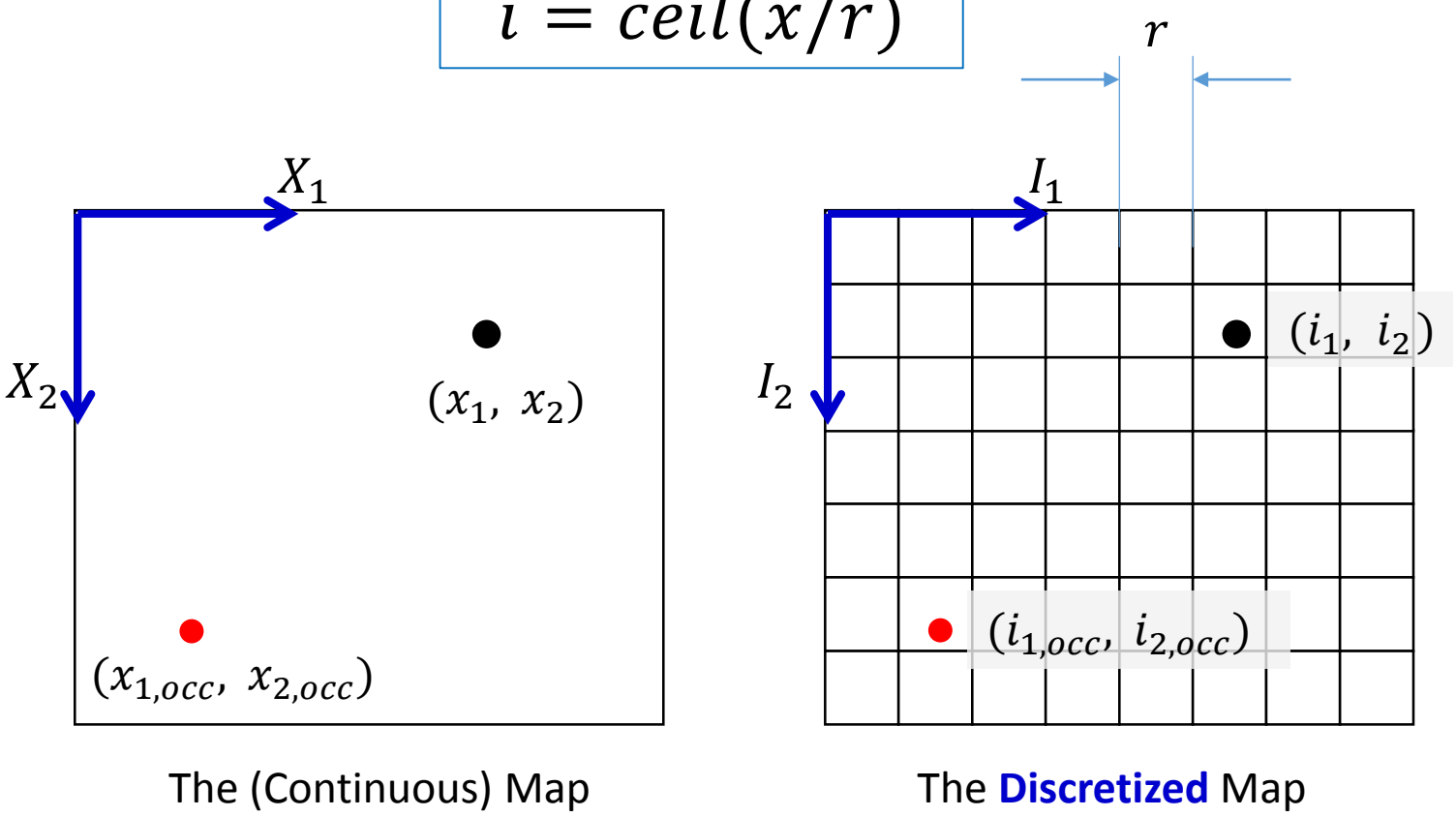
- Example



$$i = ceil((x - x_{min})/r)$$

Handling Range Measurement on Grid

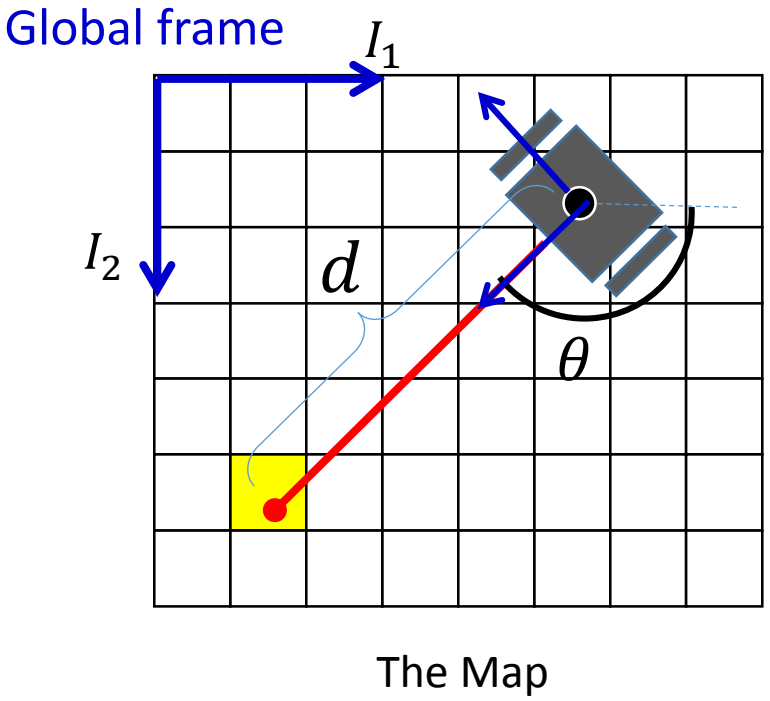
$$i = ceil(x/r)$$



The (Continuous) Map

The **Discretized** Map

Handling Range Measurement on Grid



The Map

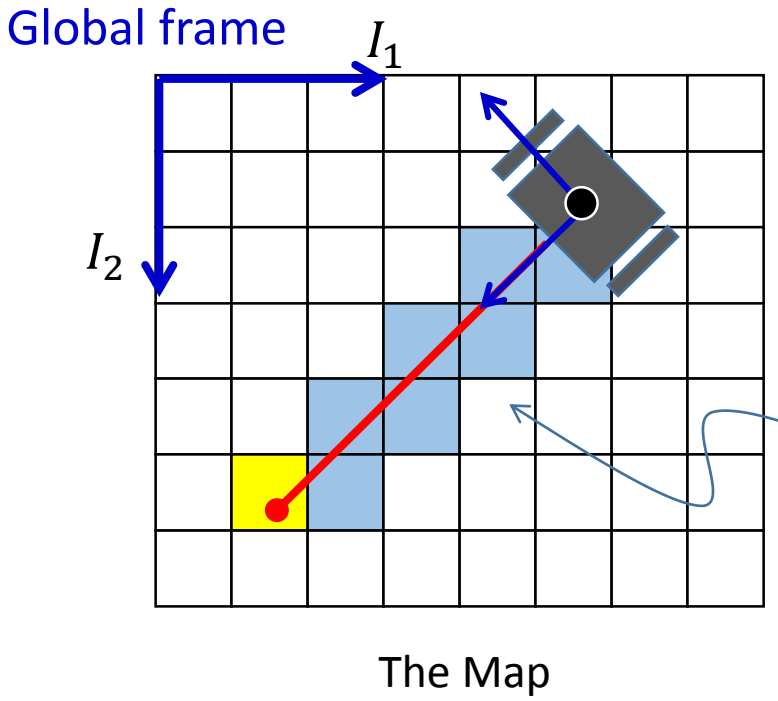
Distance measurement: d

Known state: (x_1, x_2, θ)

$$\begin{bmatrix} x_{1,occ} \\ x_{2,occ} \end{bmatrix} = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} d \\ 0 \end{bmatrix} + \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

$$\begin{bmatrix} i_{1,occ} \\ i_{2,occ} \end{bmatrix} = ceil\left(\frac{1}{r}\begin{bmatrix} x_{1,occ} \\ x_{2,occ} \end{bmatrix}\right)$$

Handling Range Measurement on Grid



The Map

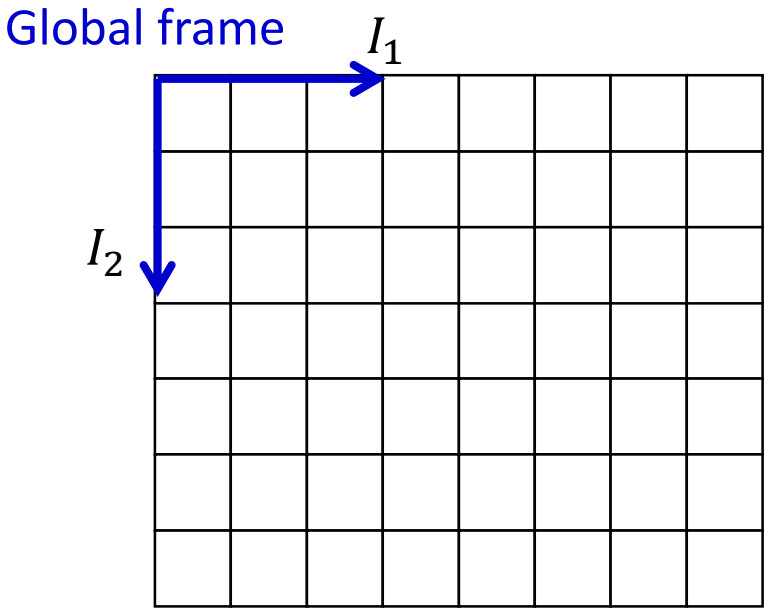
Distance measurement: d

Known state: (x_1, x_2, θ)

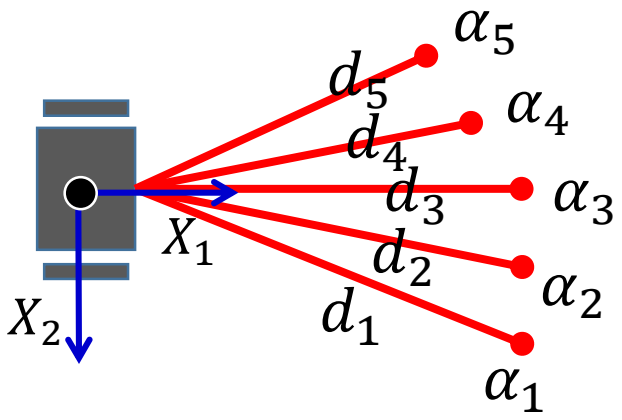
Occupied cell: $(x_{1,occ}, x_{2,occ})$

***Bresenham's line algorithm**

Handling Range Measurement on Grid

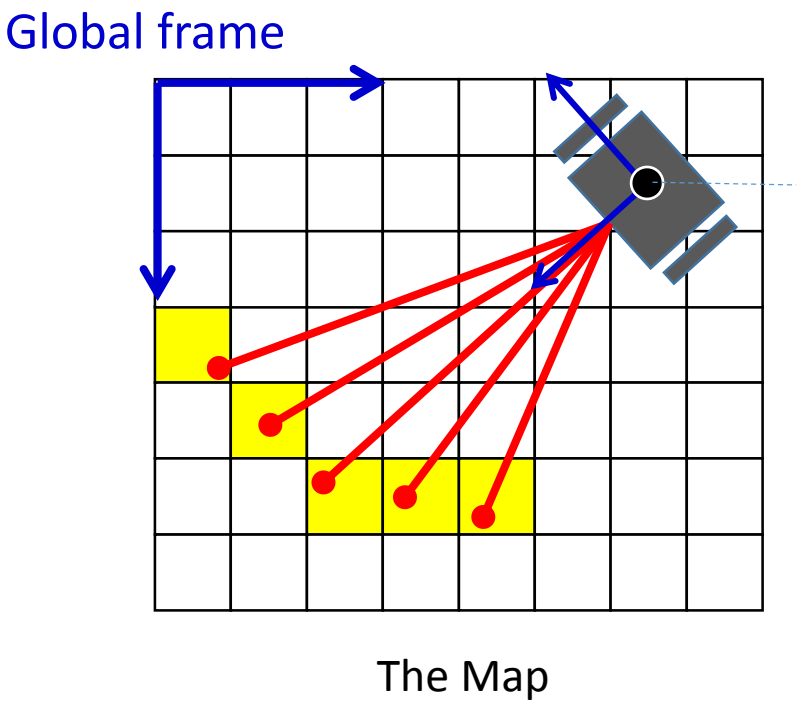


The Map



The Robot

Handling Range Measurement on Grid



The Map

Distance measurement:

$$(d_1, d_2, d_3, d_4, d_5)$$

Directions of rays:

$$(\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5)$$

Known state: (x_1, x_2, θ)

For *k*-th occupied cell:

$$\begin{bmatrix} x_{1k} \\ x_{2k} \end{bmatrix} = \begin{bmatrix} d_k \cos(\theta + \alpha_k) \\ -d_k \sin(\theta + \alpha_k) \end{bmatrix} + \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

$$\begin{bmatrix} i_{1k} \\ i_{2k} \end{bmatrix} = ceil\left(\frac{1}{r}\begin{bmatrix} x_{1k} \\ x_{2k} \end{bmatrix}\right)$$

Handling Range Measurement on Grid