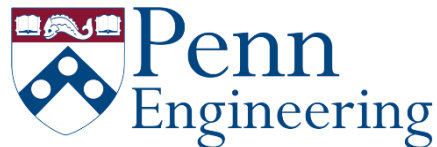


Robotics

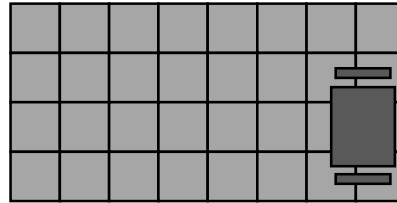
Estimation and Learning
with Dan Lee

Week 3. Robotic Mapping

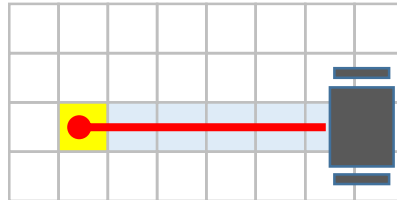
3.2 Occupancy Grid Mapping
3.2.3 Handling Range Sensor



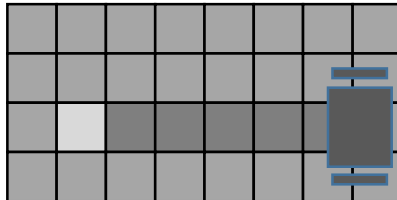
Map at t_0



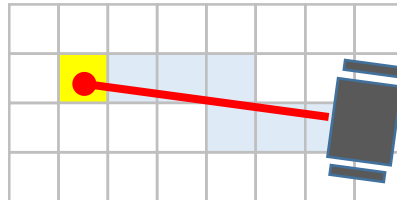
Measurement



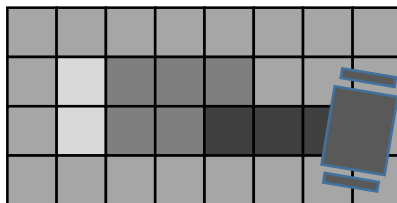
Map at t_1



Measurement

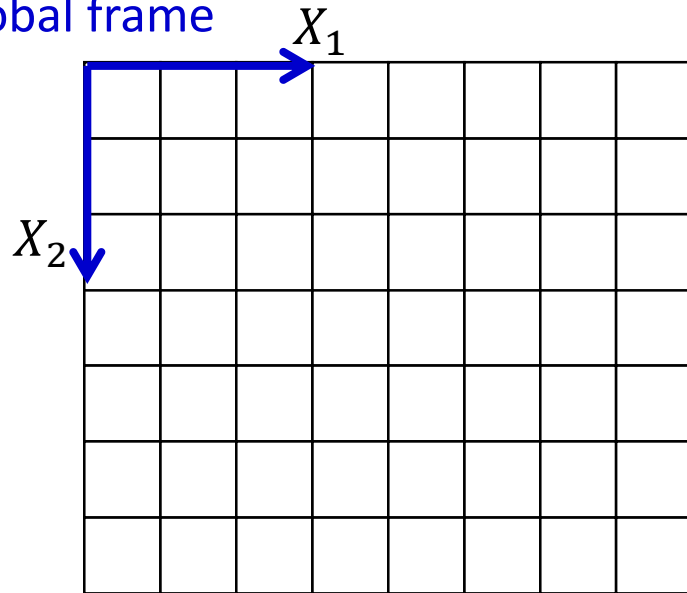


Map at t_2



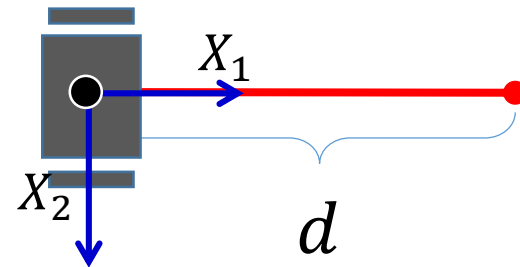
Handling Range Measurement on Grid

Global frame



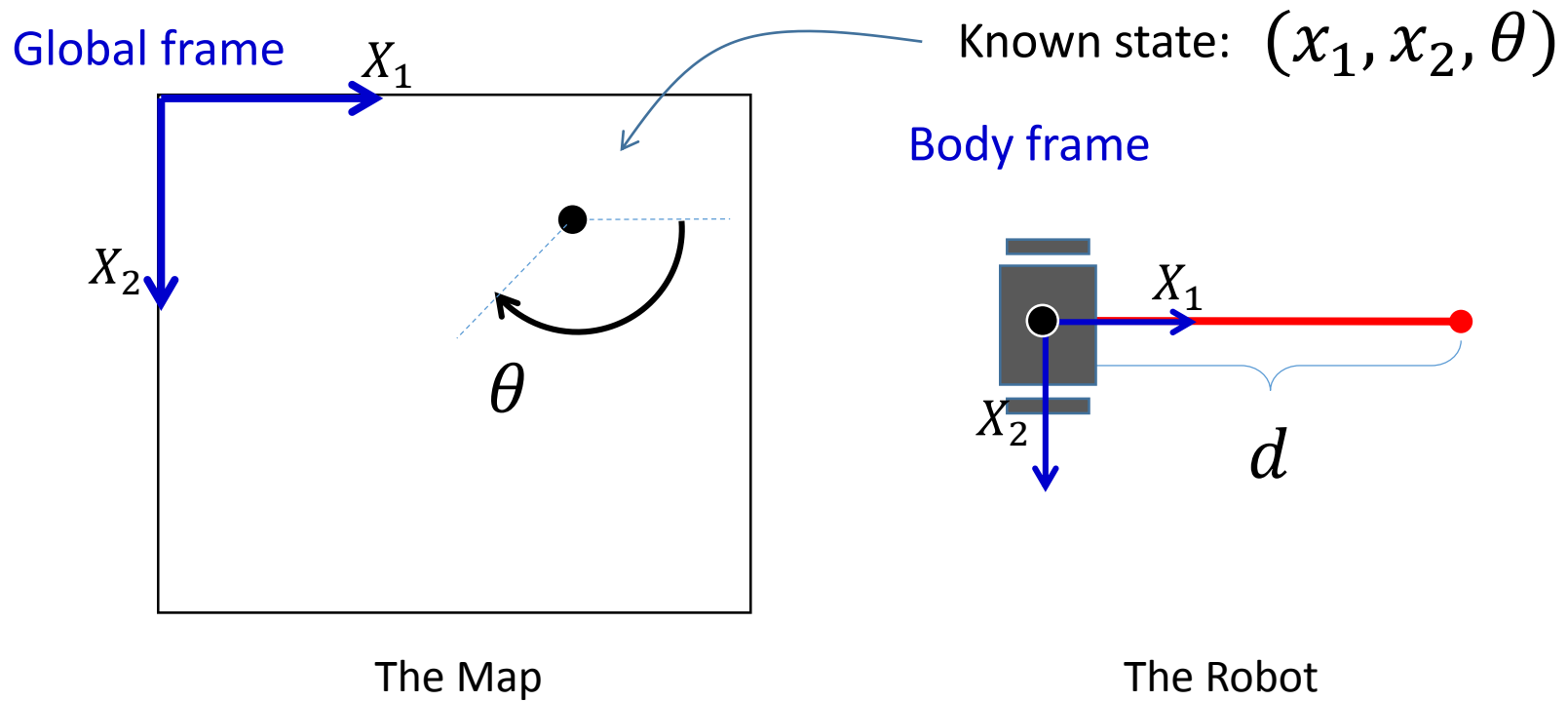
The Map

Body frame

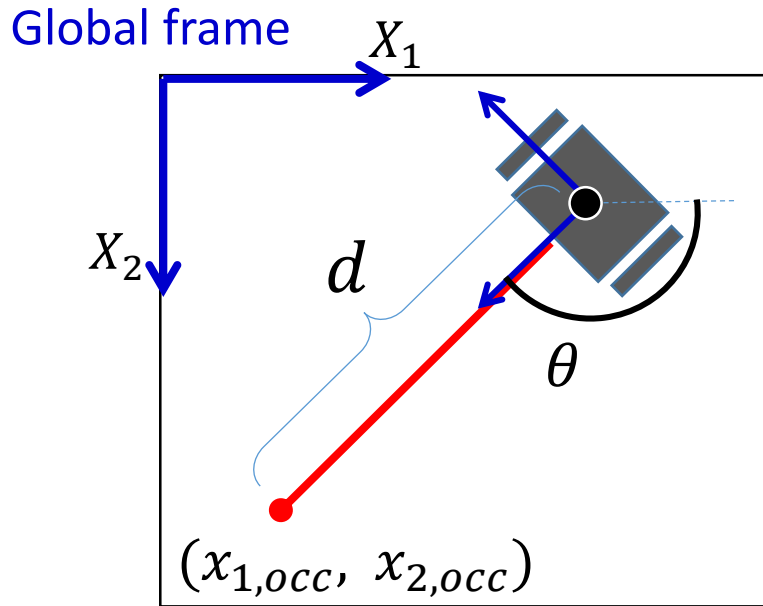


The Robot

Handling Range Measurement on Grid



Handling Range Measurement on Grid



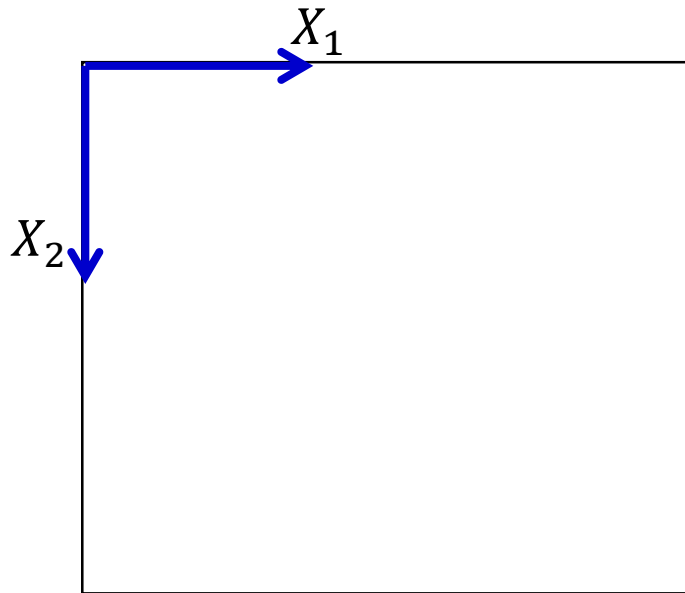
The Map

Distance measurement: d

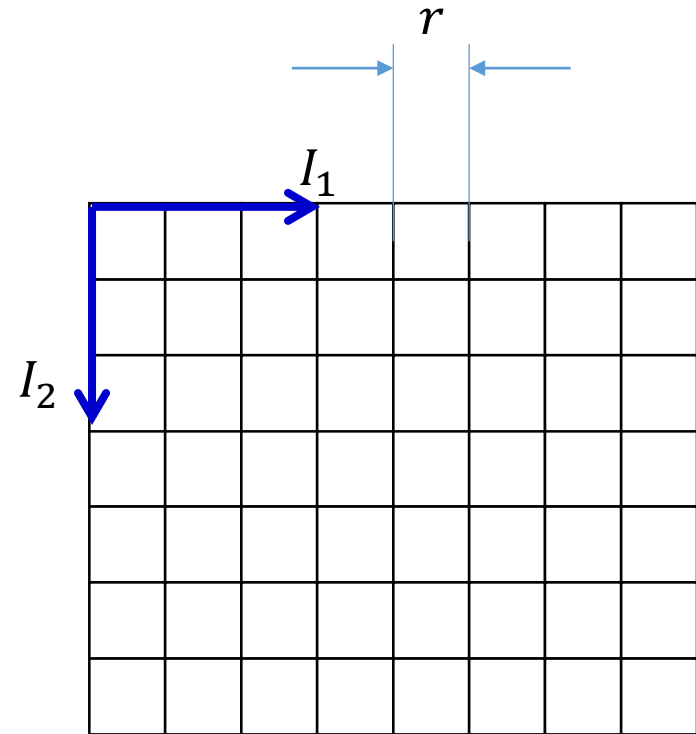
Known state: (x_1, x_2, θ)

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

Handling Range Measurement on Grid



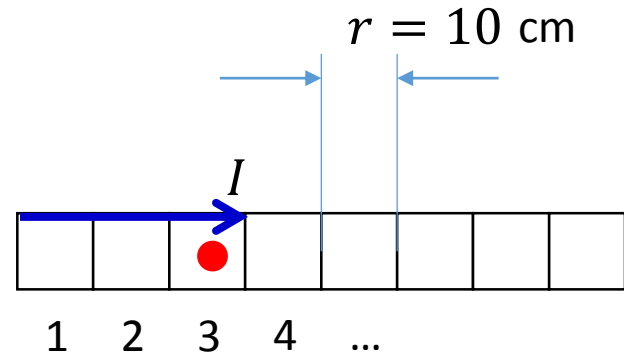
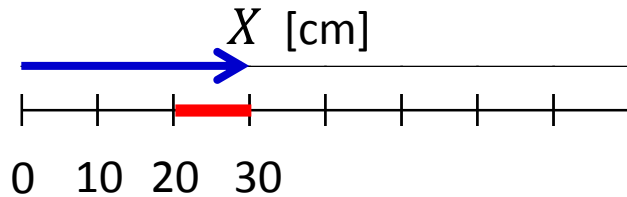
The (Continuous) Map






The **Discretized** Map

Handling Range Measurement on Grid

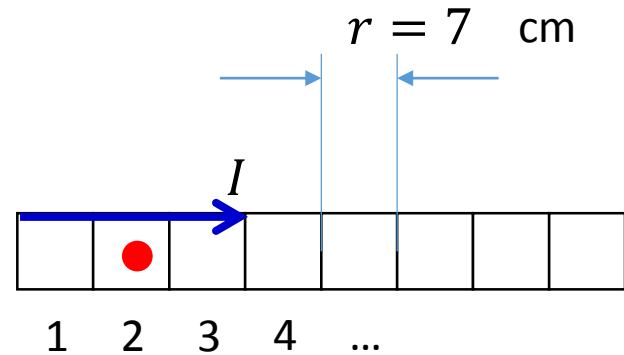
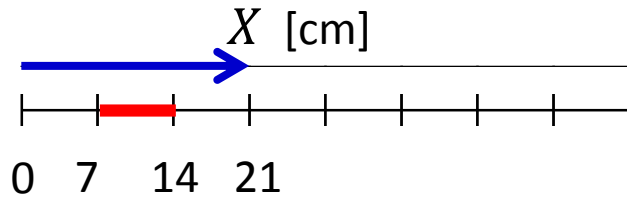
- Example





[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

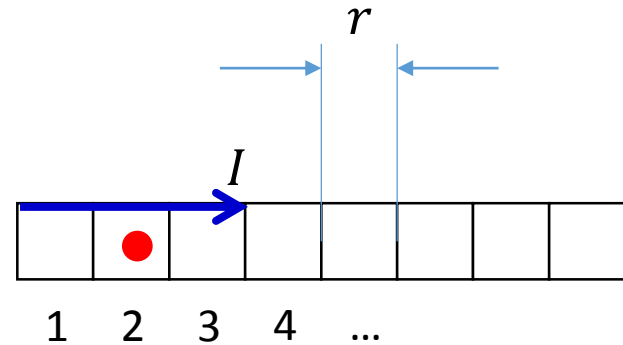
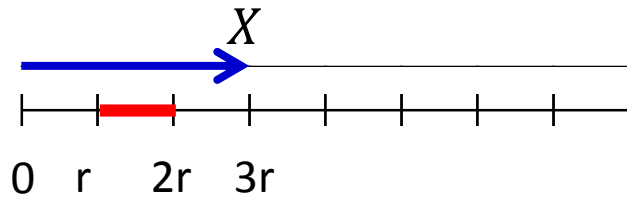
- Example



[cm]	$0 < x \leq 7$		$i = 1$	[index]
	$7 < x \leq 14$		$i = 2$	

Handling Range Measurement on Grid

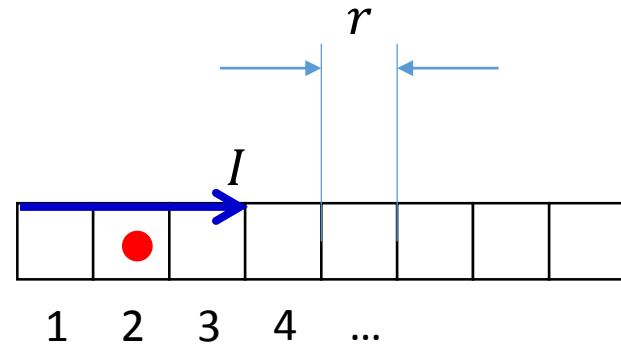
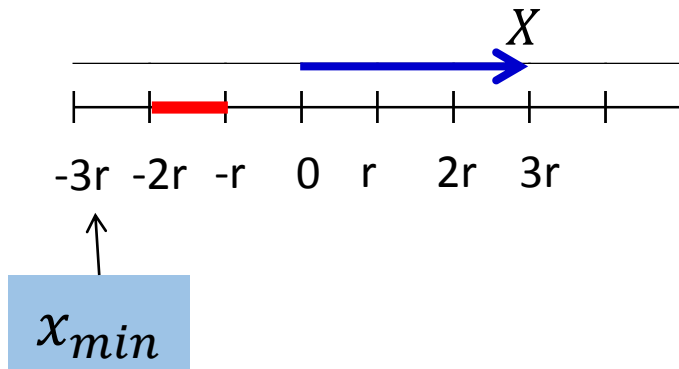
- Example



$$i = \text{ceil}(x/r)$$

Handling Range Measurement on Grid

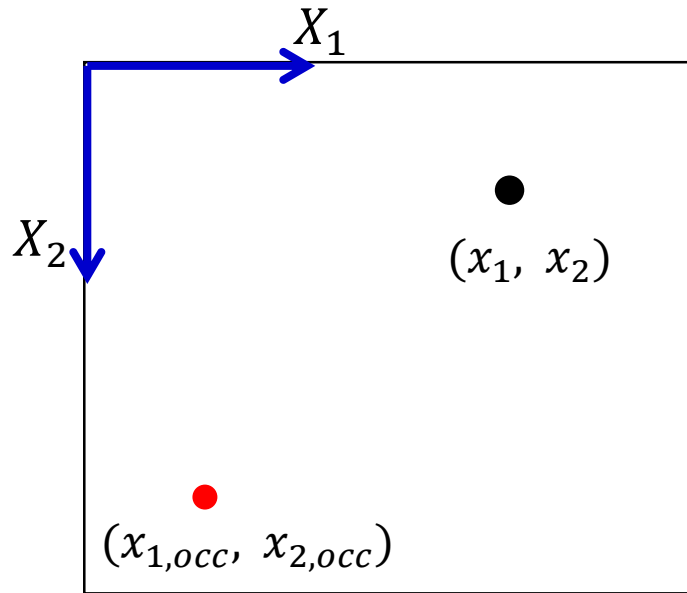
- Example



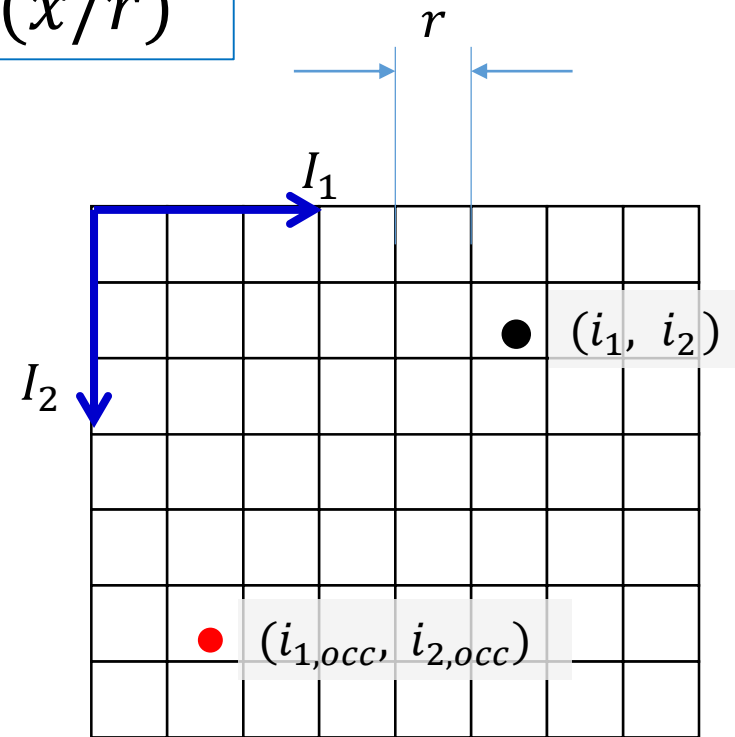
$$i = \text{ceil}((x - x_{min})/r)$$

Handling Range Measurement on Grid

$$i = \text{ceil}(x/r)$$

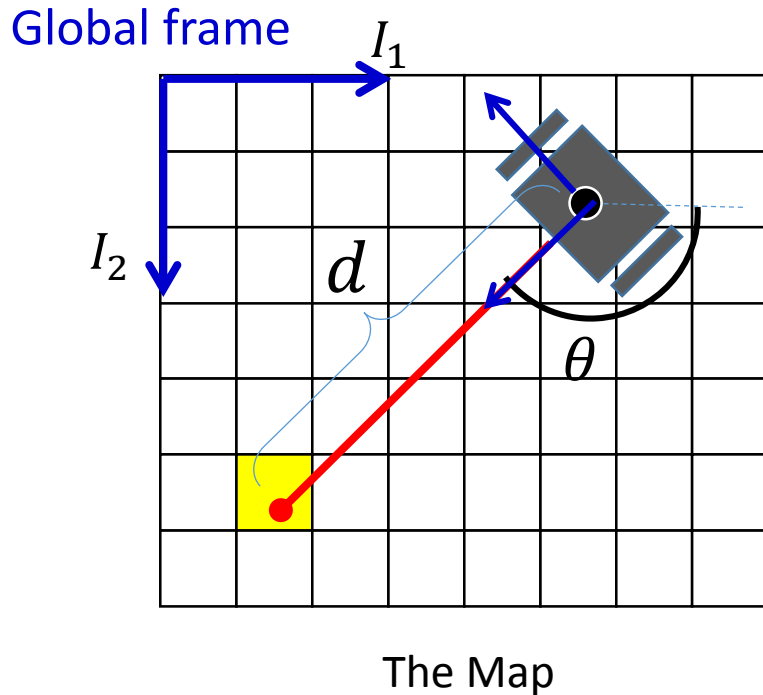


The (Continuous) Map



The **Discretized** Map

Handling Range Measurement on Grid



Distance measurement: d

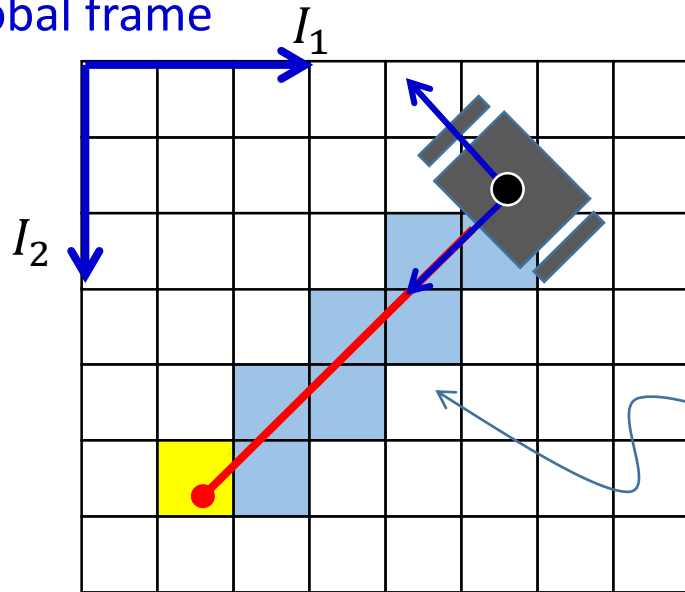
Known state: (x_1, x_2, θ)

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

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

Handling Range Measurement on Grid

Global frame



The Map

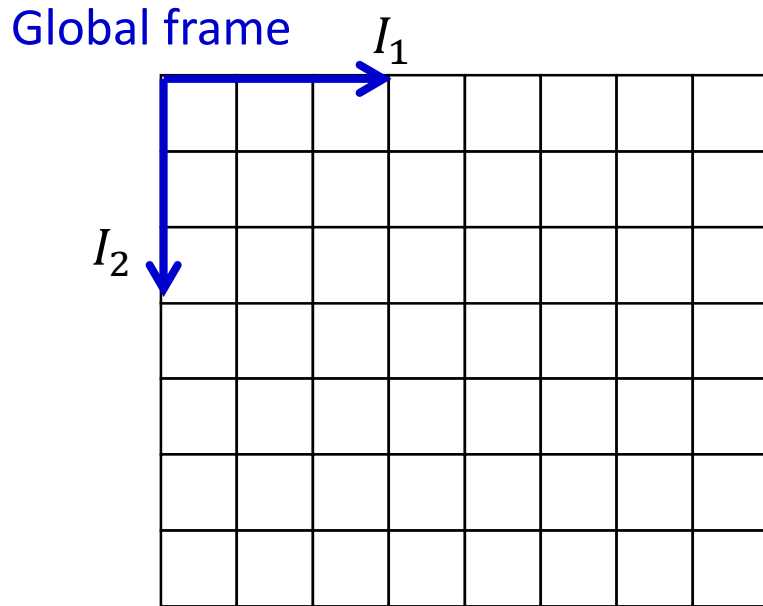
Distance measurement: d

Known state: (x_1, x_2, θ)

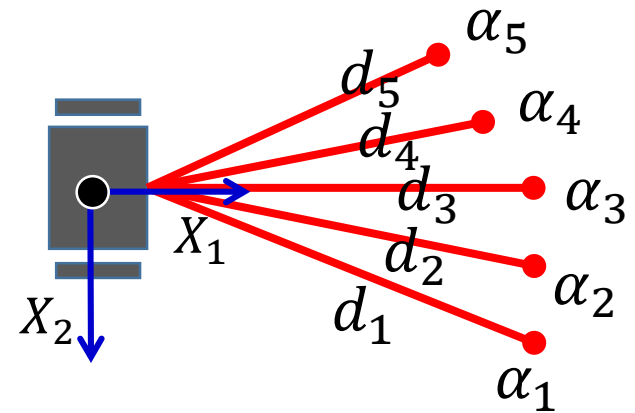
Occupied cell: $(x_{1,occ}, x_{2,occ})$

***Bresenham's line algorithm**

Handling Range Measurement on Grid



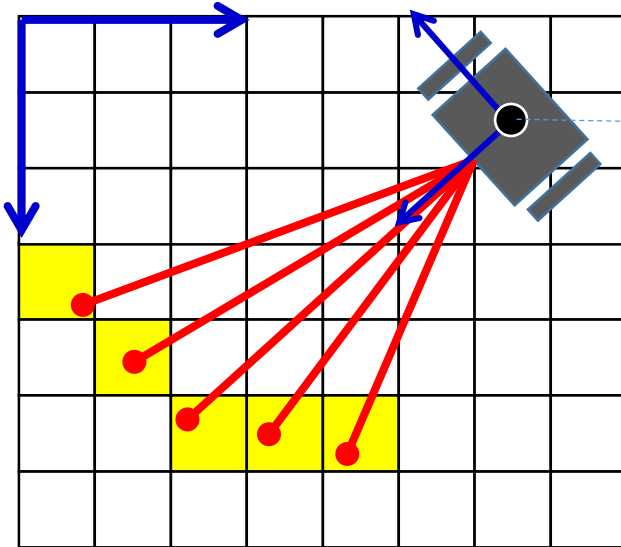
The Map



The Robot

Handling Range Measurement on Grid

Global frame



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)

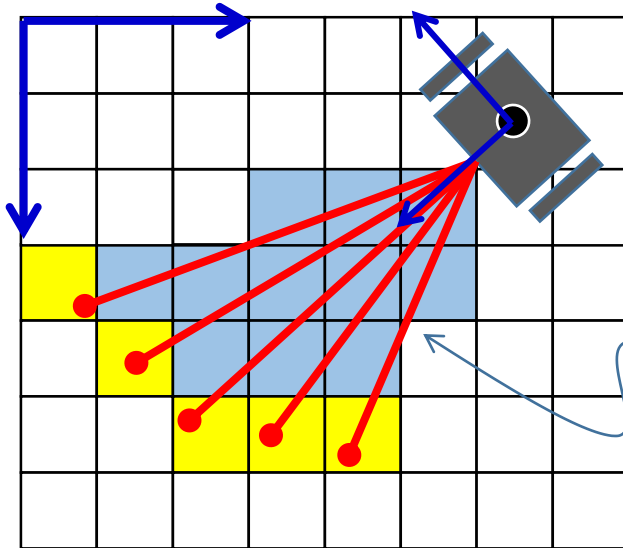
For k -th occupied cell:

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

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

Handling Range Measurement on Grid

Global frame



The Map

***Bresenham's line algorithm**