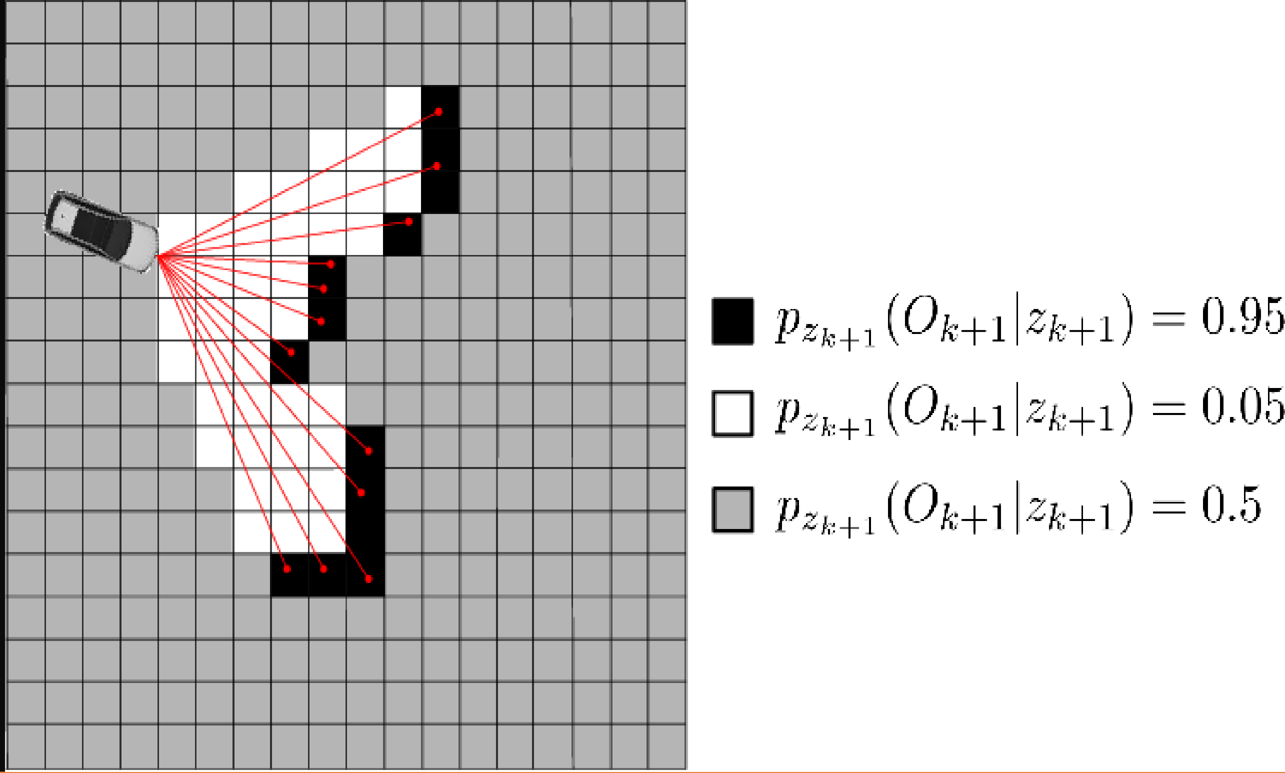
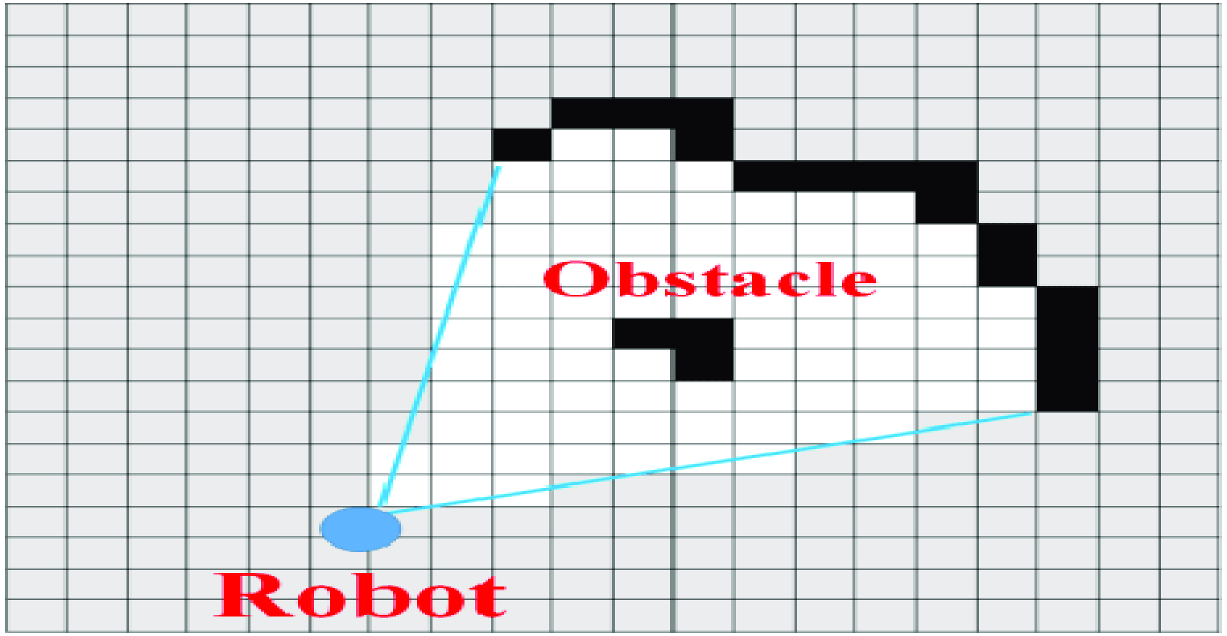
Introduction to Mapping| Occupancy Grid Mapping



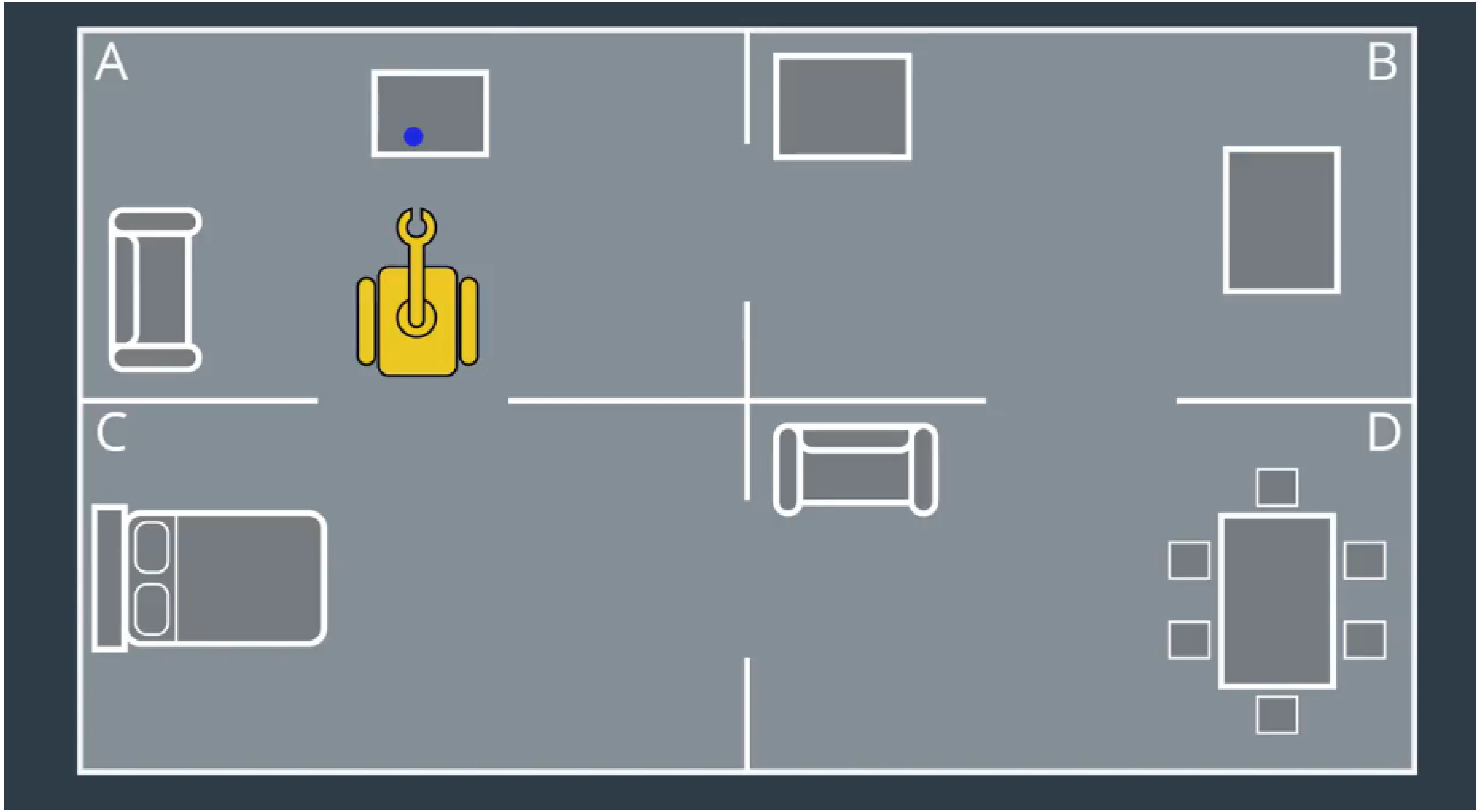
Prepared By: Youssef Hindawi



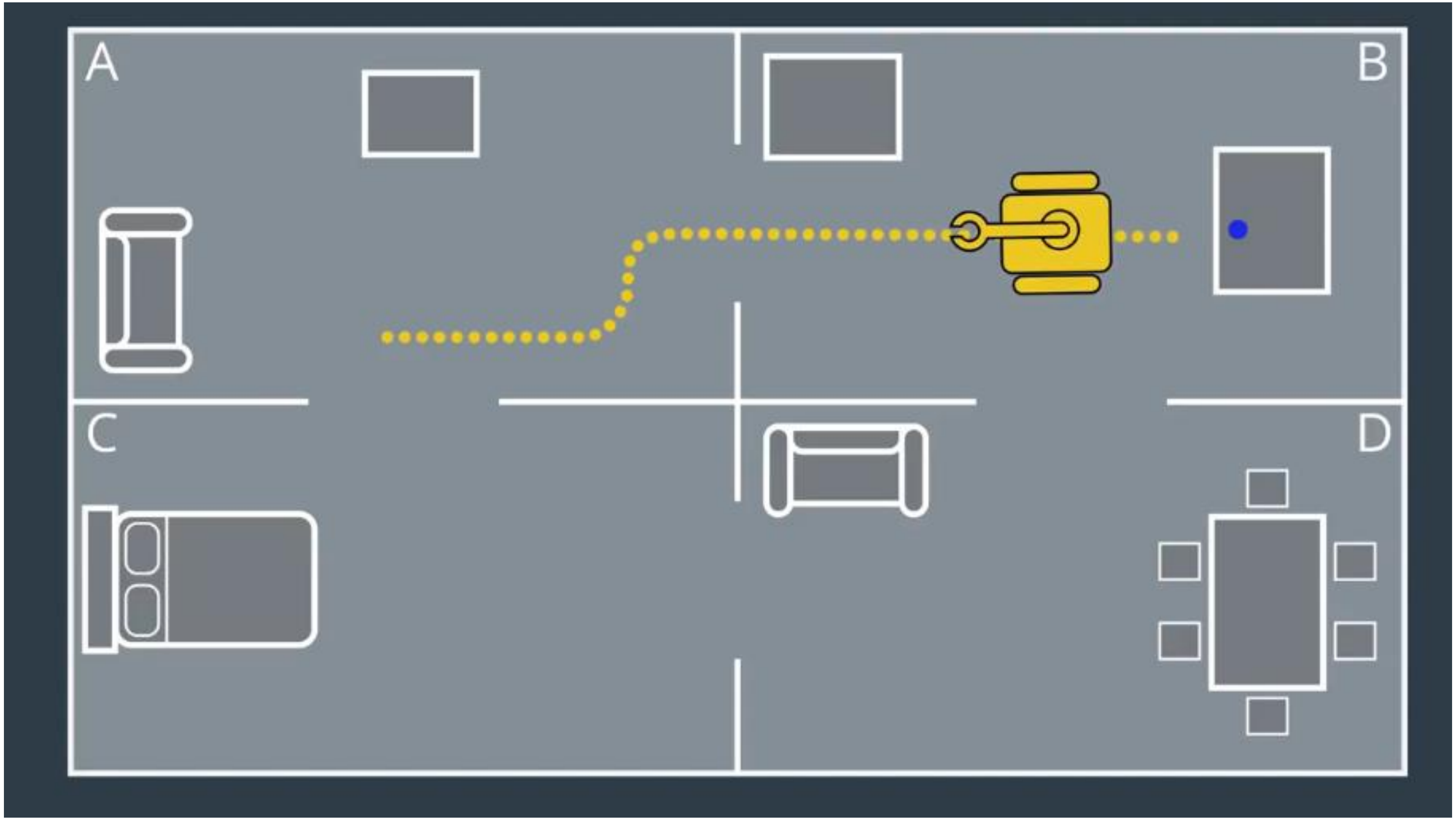
By the end of this Presentation, you will be able to:

- Know occupancy grid mapping and its data type
- Introduction to occupancy grid mapping algorithm
- Relate between occupancy grid mapping and use with Bayesian filter
- Know the steps involved for occupancy grid mapping
- Know different types of mapping and its performance

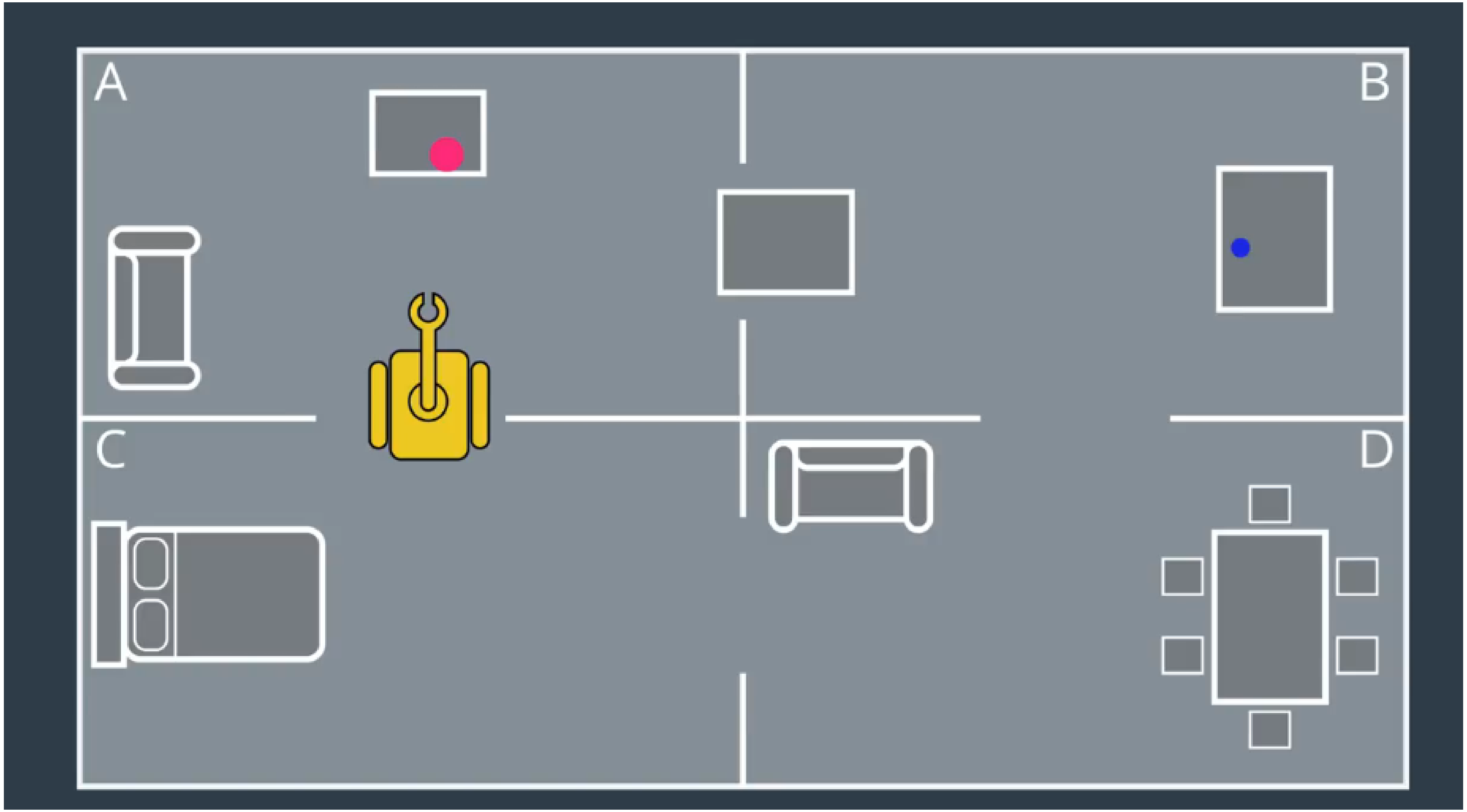
Occupancy Grid Mapping | Problem Statement



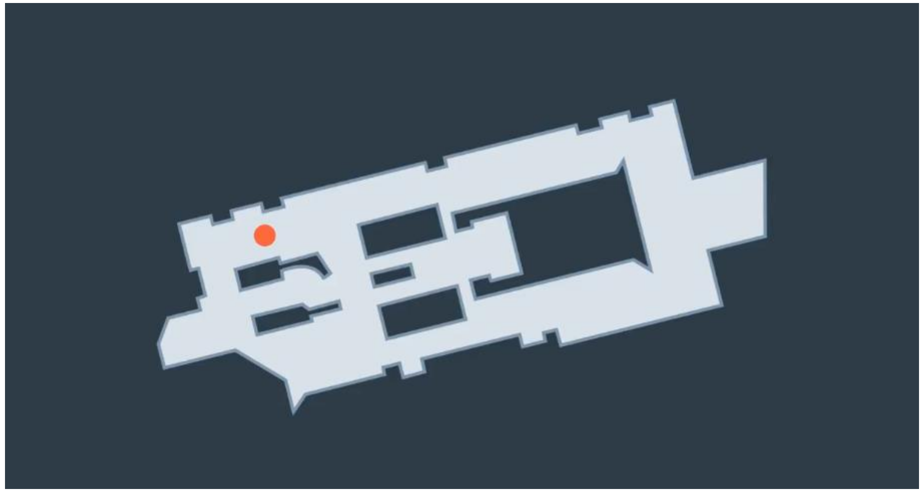
Occupancy Grid Mapping | Problem Statement

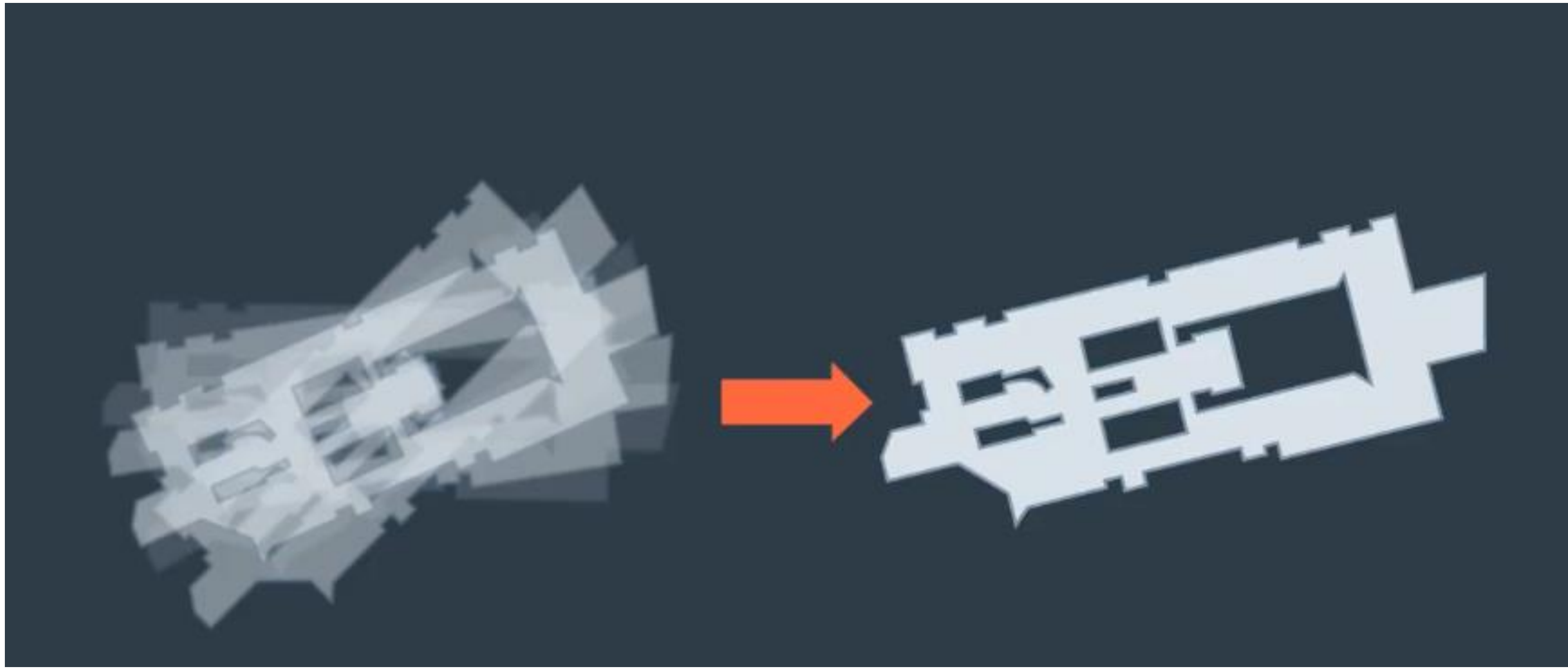


Occupancy Grid Mapping | Problem Statement



Occupancy Grid Mapping | Problem Statement

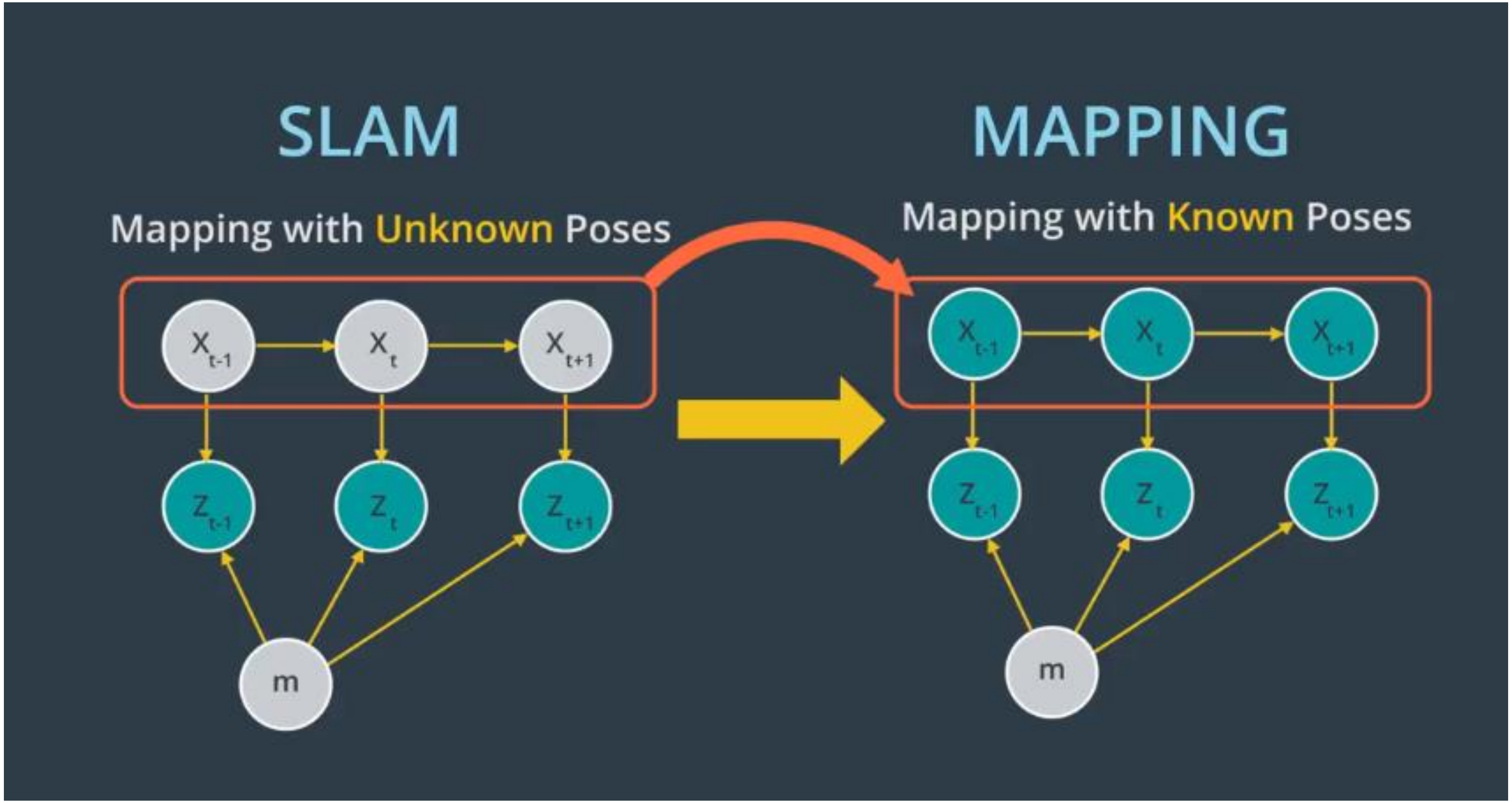




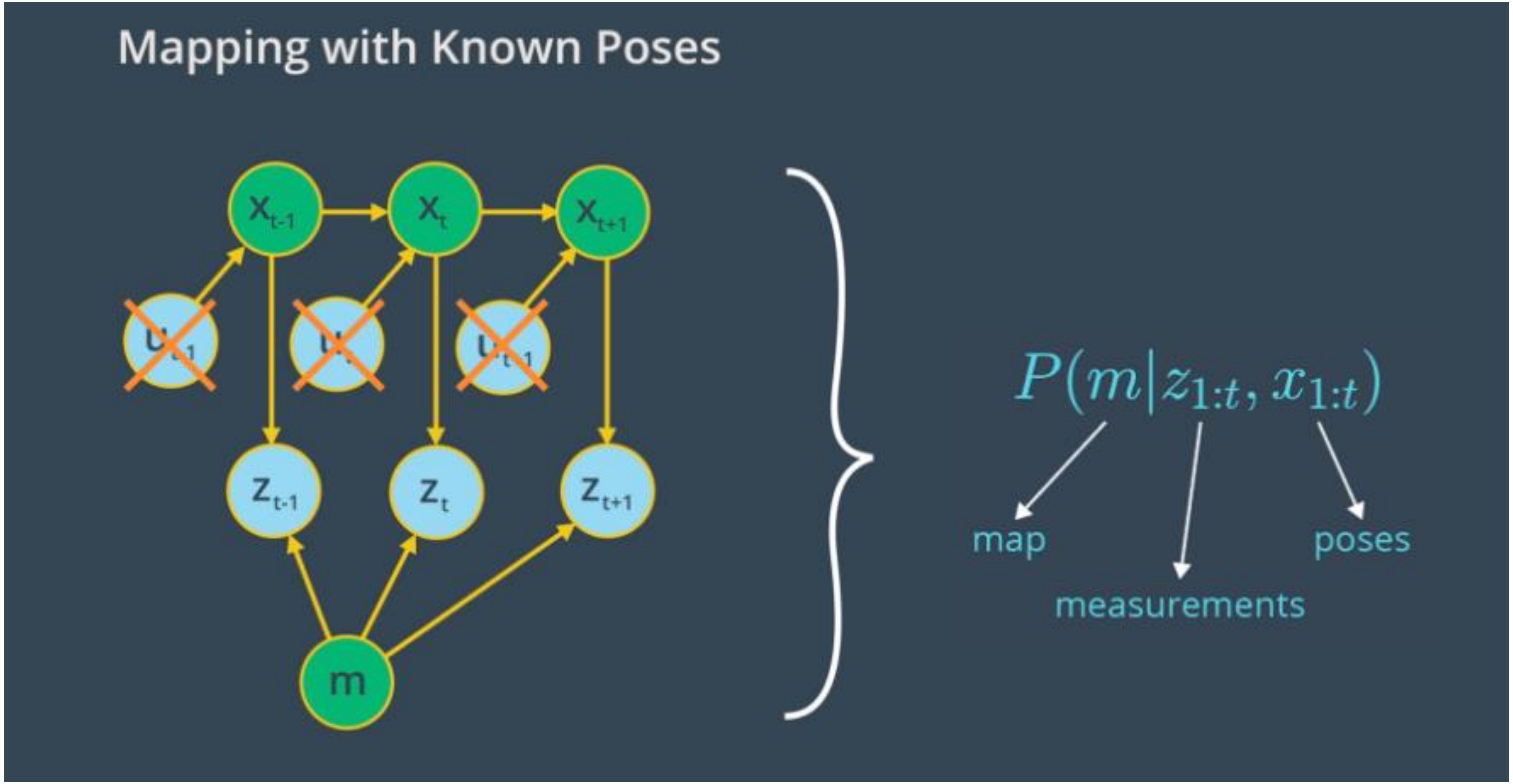
Mapping | Introduction

- Estimating Map with known poses
- Estimating Map and the poses (SLAM)
- Mapping is a process for building a map
- Consideration for mapping
    - Map representation
    - Available sensors
    - Purpose of mapping

Mapping | Introduction



Mapping | Introduction



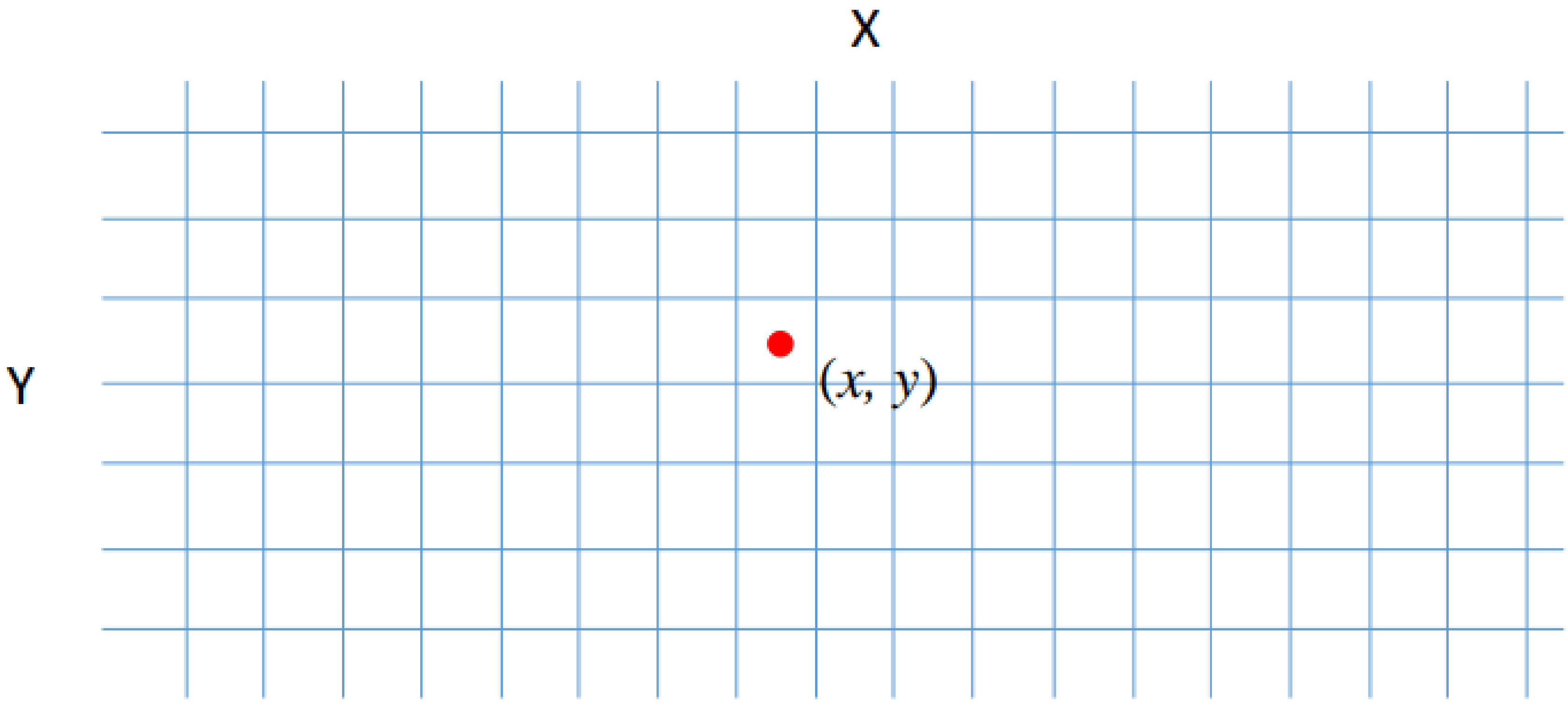
Mapping | Challenges

- Size
- Noise in sensors
- Perceptional Ambiguity
- Cycles
- Motion involved
- Change over time

Mapping | Types of Map

- Metric Map
- Topological Map
- Semantic Map

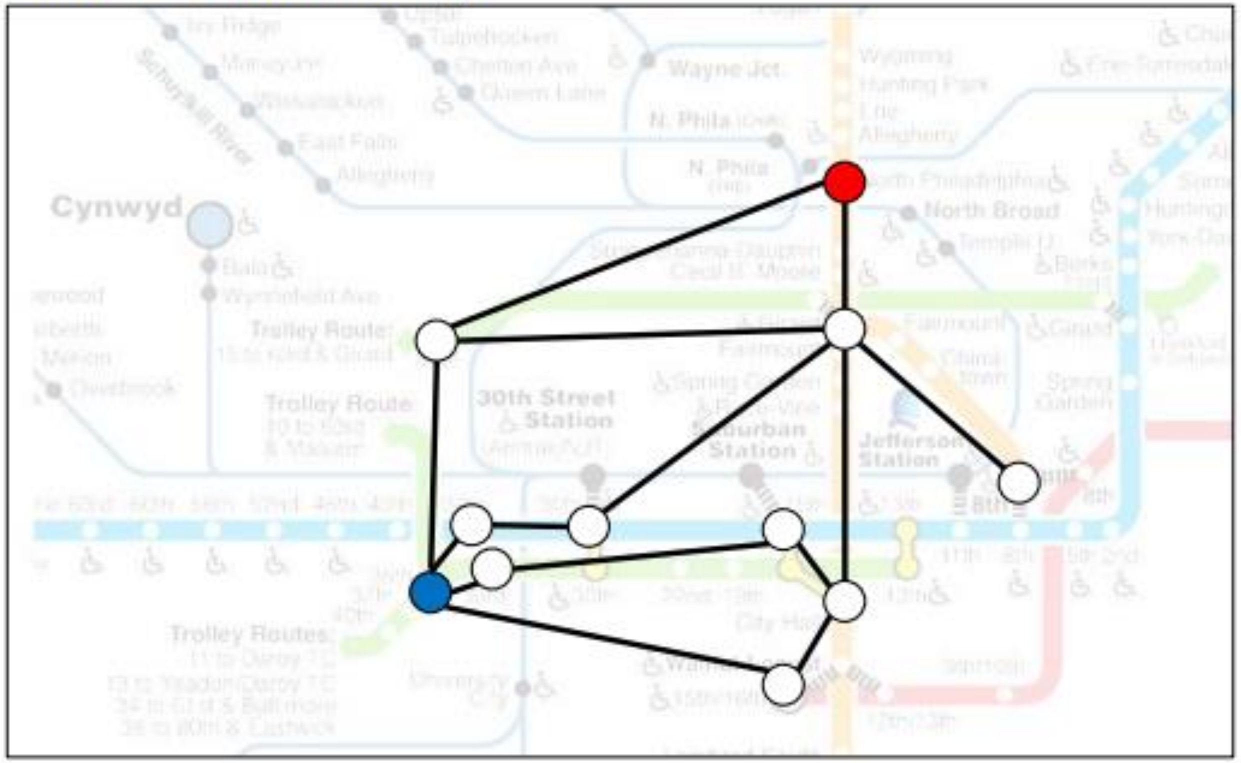
Mapping | Metric Map



A location is represented as a coordinate.

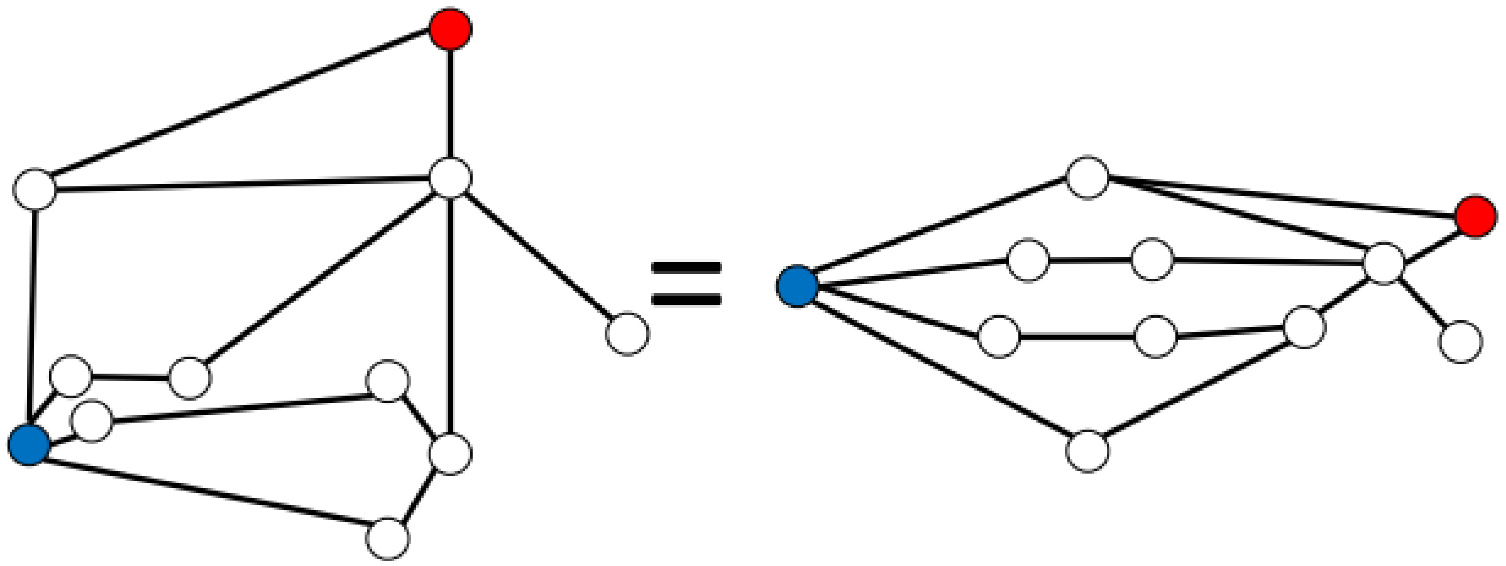
Mapping | Topological Map

Part of SEPTA Train Map



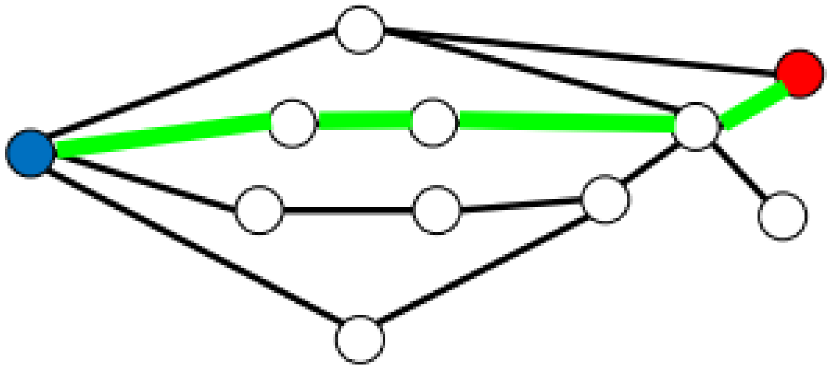
Locations are represented as nodes and their connectivity as arcs.

Mapping | Topological Map



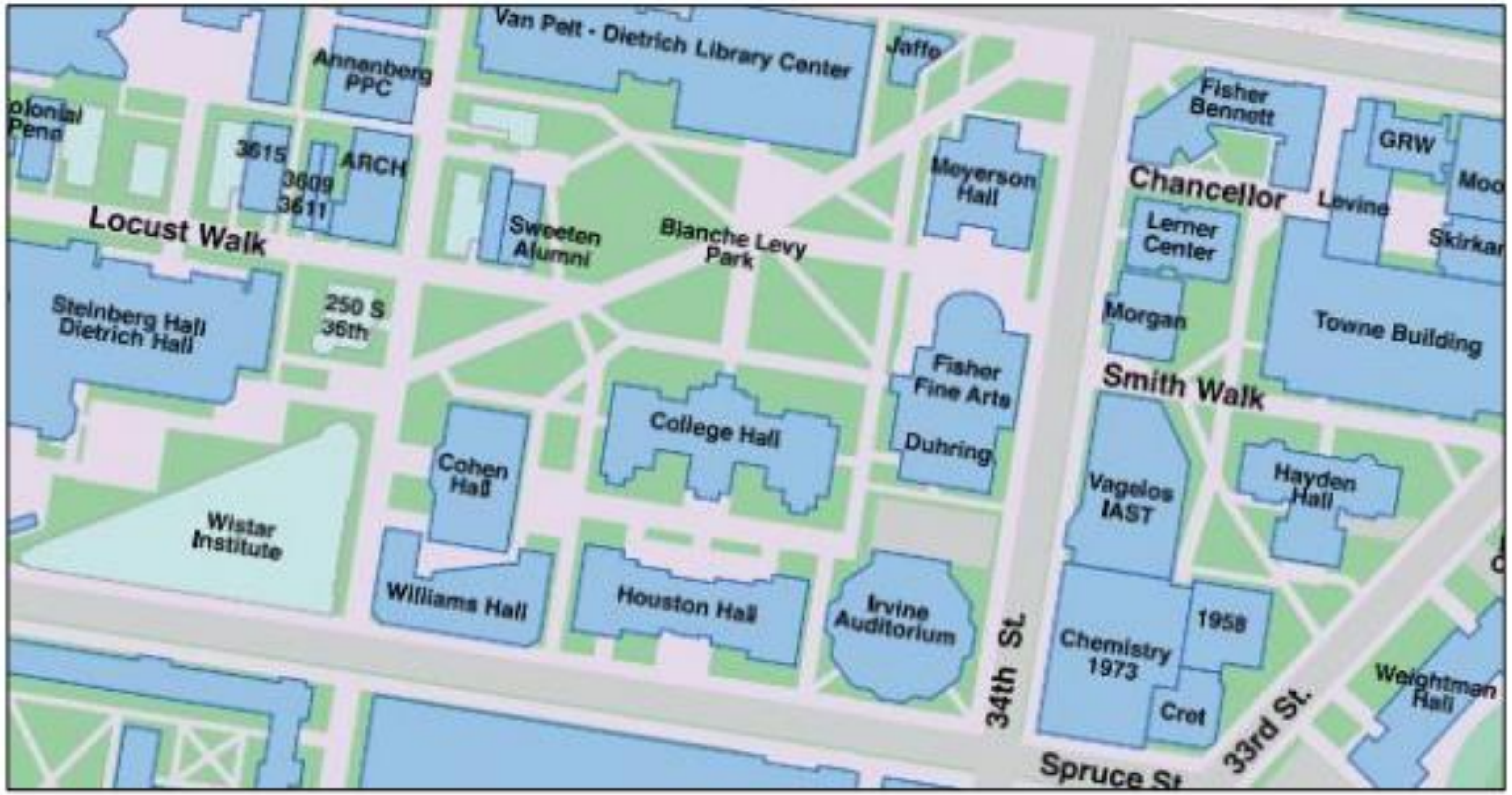
Only the connectivity between nodes matter.

Mapping | Topological Map



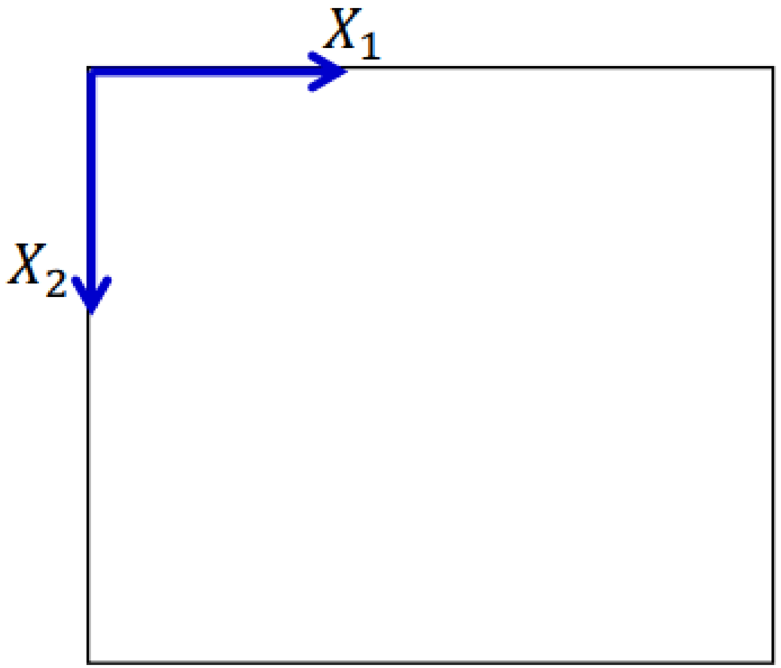
Graph representation is useful for path planning.

Mapping | Semantic Map

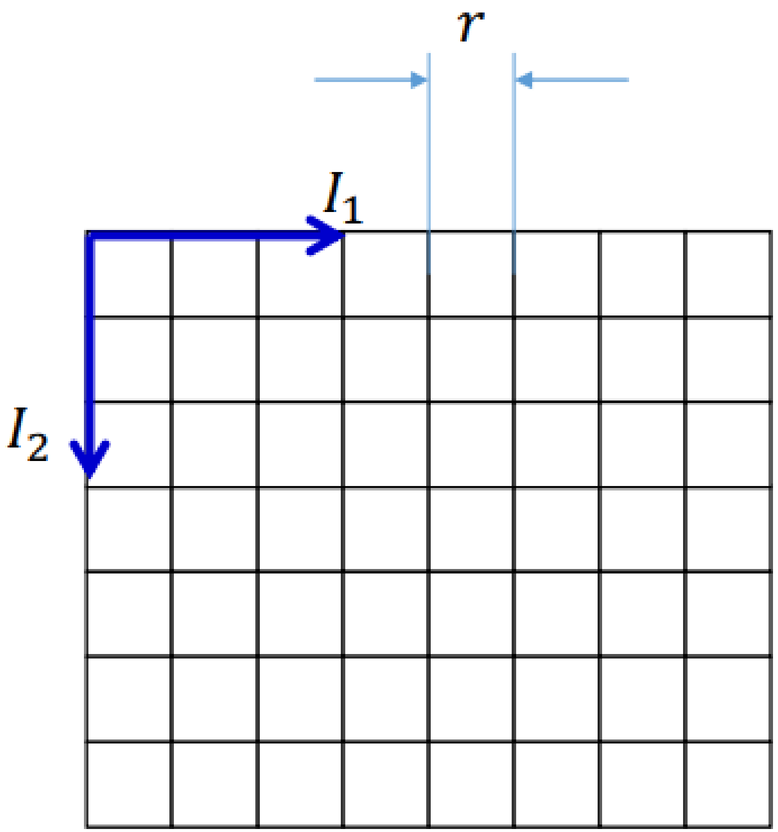


Semantic map is a map with labels.

Mapping | Grid Cells



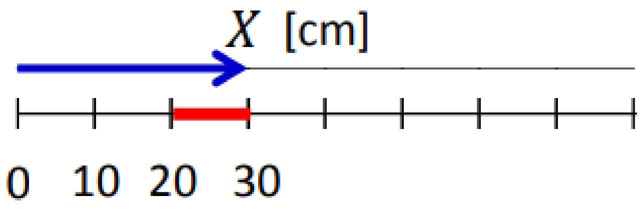
The (Continuous) Map

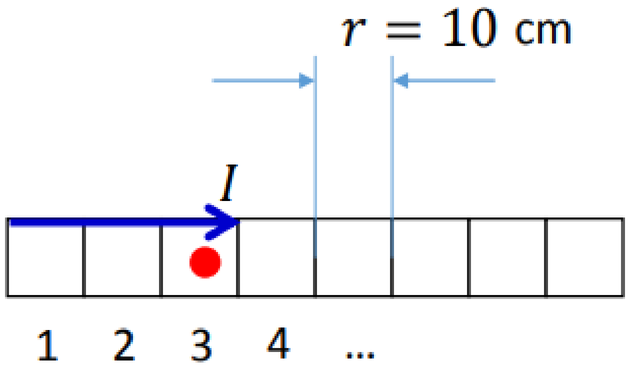


The **Discretized** Map

Mapping | Grid Cells

- Example

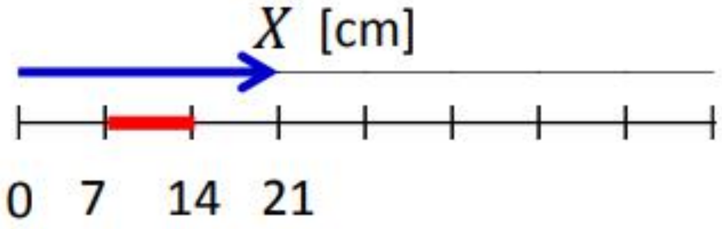


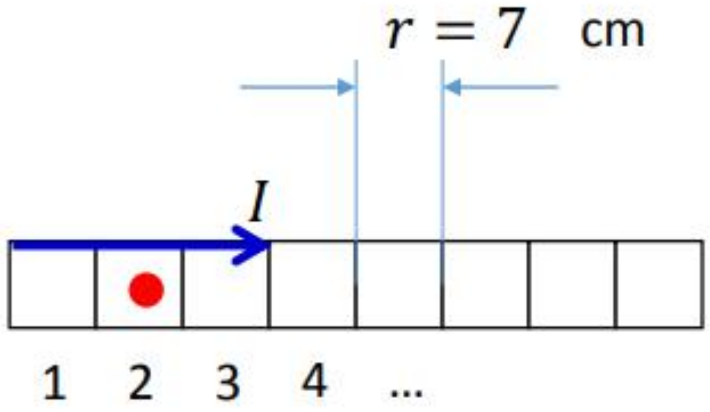


[cm]	$0 < x \leq 10$	$\Rightarrow$	$i = 1$	[index]
	$10 < x \leq 20$	$\Rightarrow$	$i = 2$	
	$20 < x \leq 30$	$\Rightarrow$	$i = 3$	
	$\vdots$		$\vdots$	

Mapping | Grid Cells

- Example



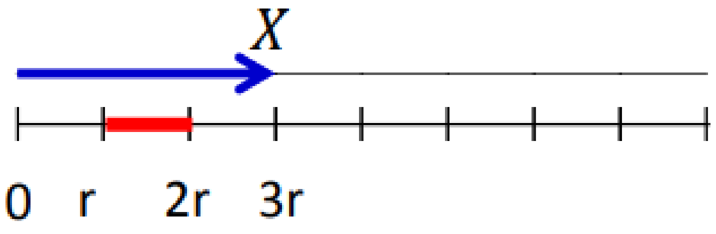


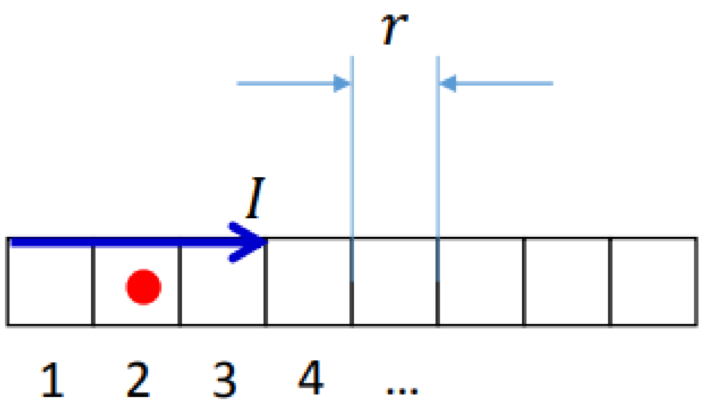
[cm] $0 < x \le 7$ $\Rightarrow$ $i = 1$ [index]

$7 < x \le 14$ $\Rightarrow$ $i = 2$

Mapping | Grid Cells

- Example

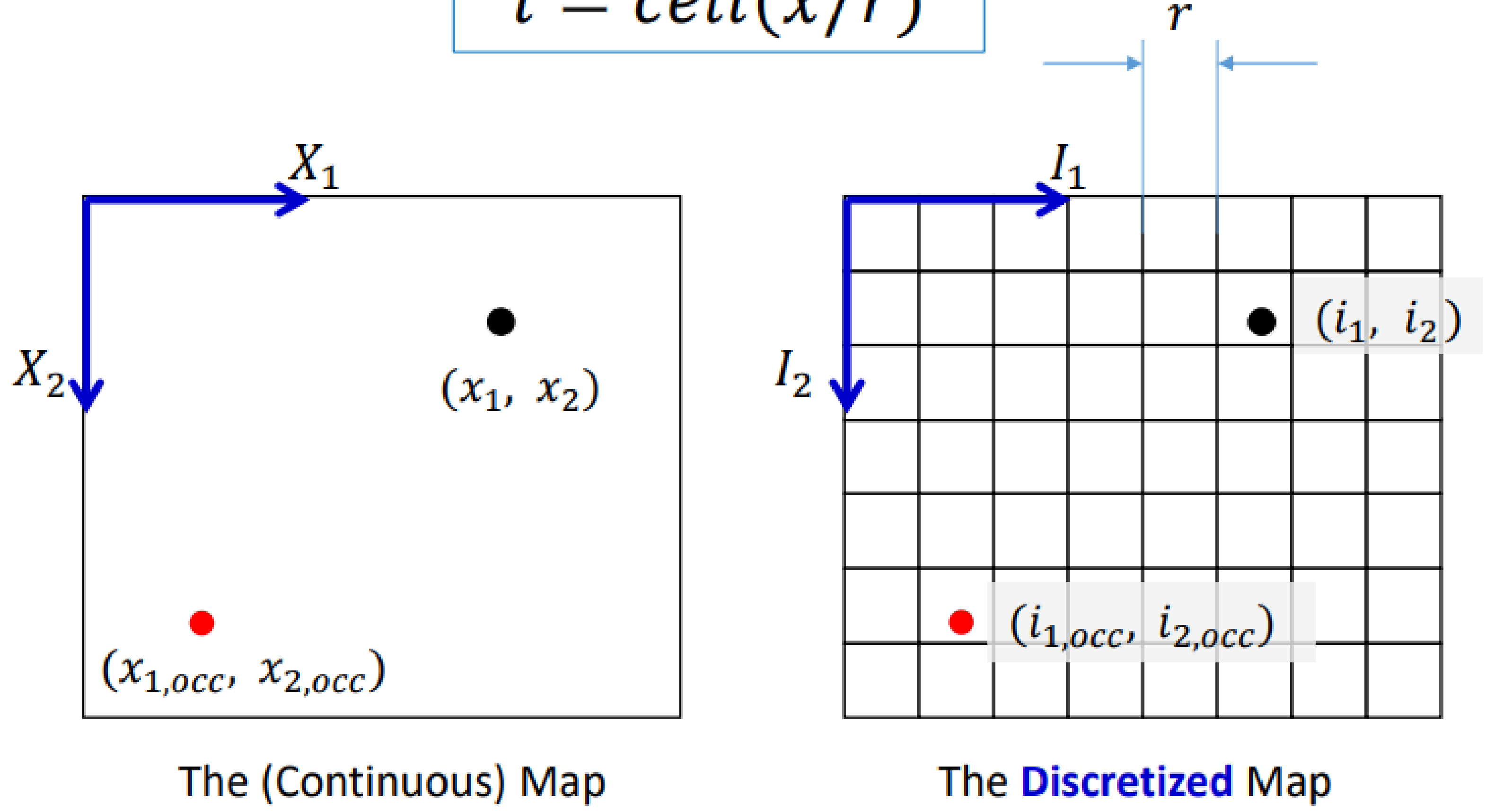




$$i = ceil(x/r)$$

Mapping | Grid Cells

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



Mapping | Grid Maps

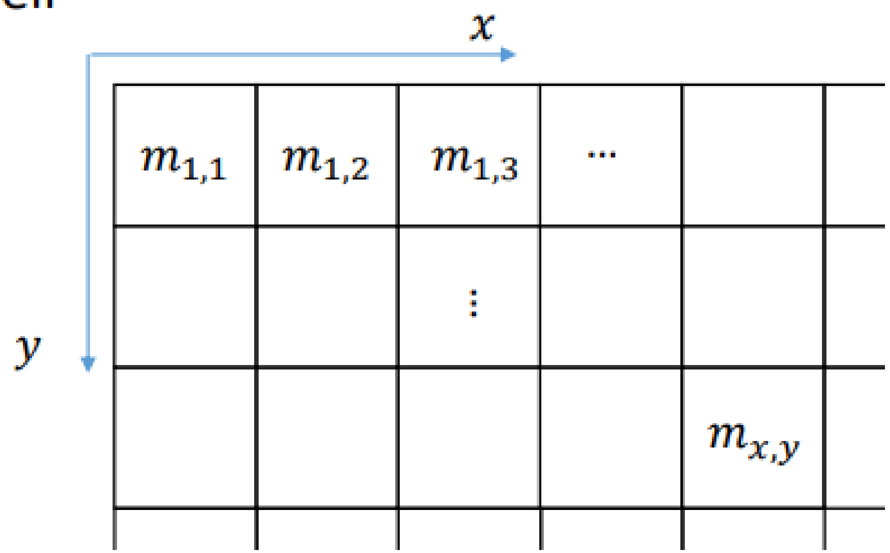
- Occupancy grid mapping represents discrete approximation of the map!
- Discretize the world into cells
- Each cell is assumed to be occupied or free space
- Non-parametric model
- Large maps require substantial memory resources
- Do not rely on a feature detector
- Grid structure is rigid

Mapping | Explanation

- Occupancy: binary R.V.

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

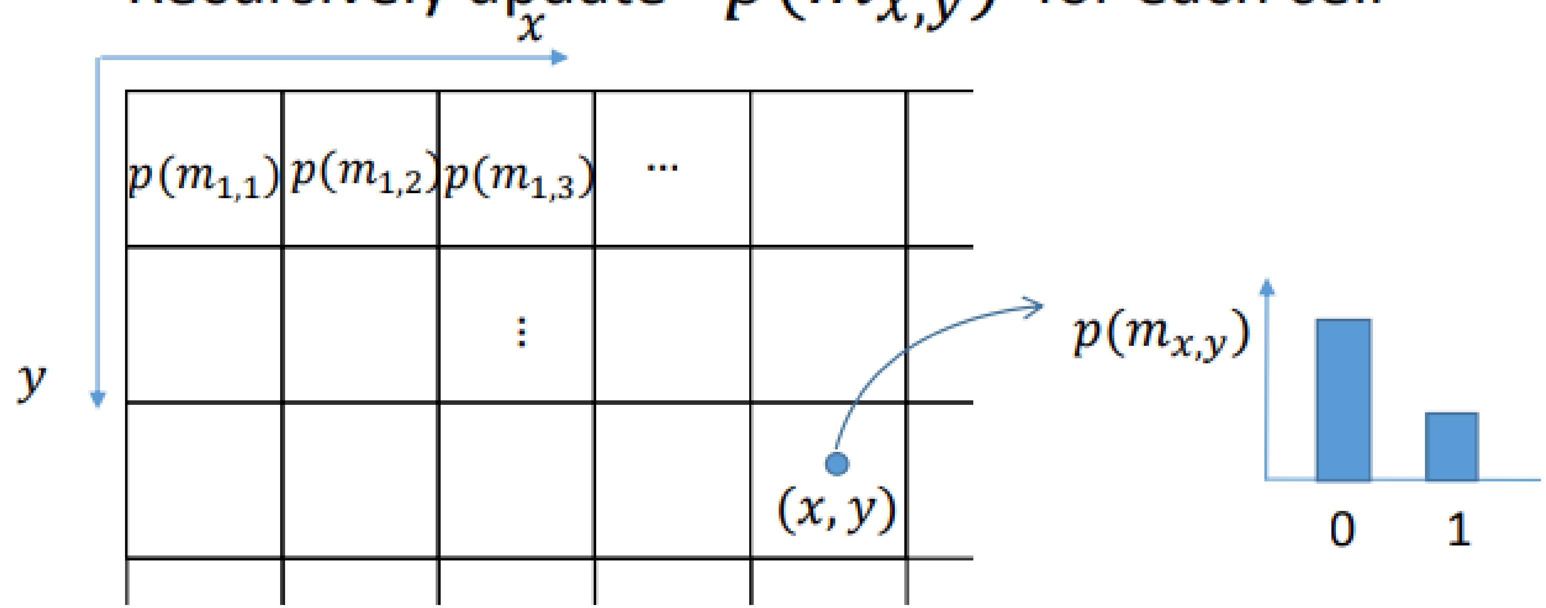
- Occupancy grid map
  : fine-grained grid map where an occupancy variable associated with each cell



Mapping | Explanation

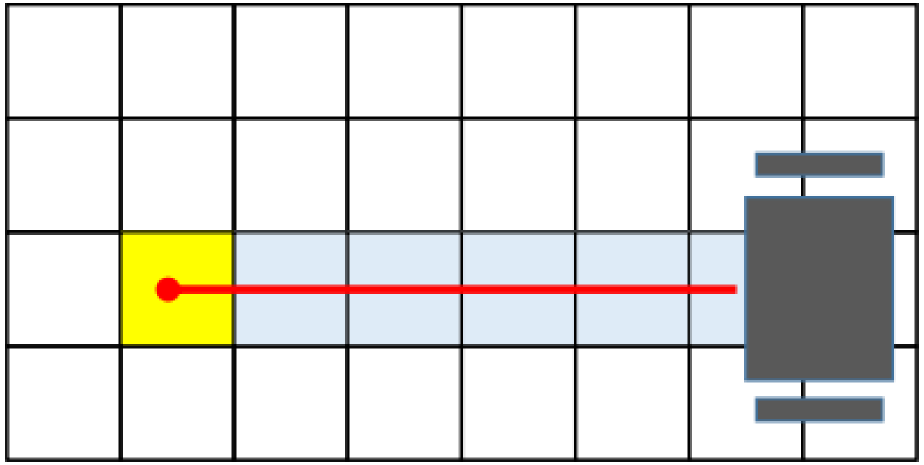
: A Bayesian filtering to maintain a occupancy grid map.

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



Mapping | Explanation

- Measurement



a range sensor

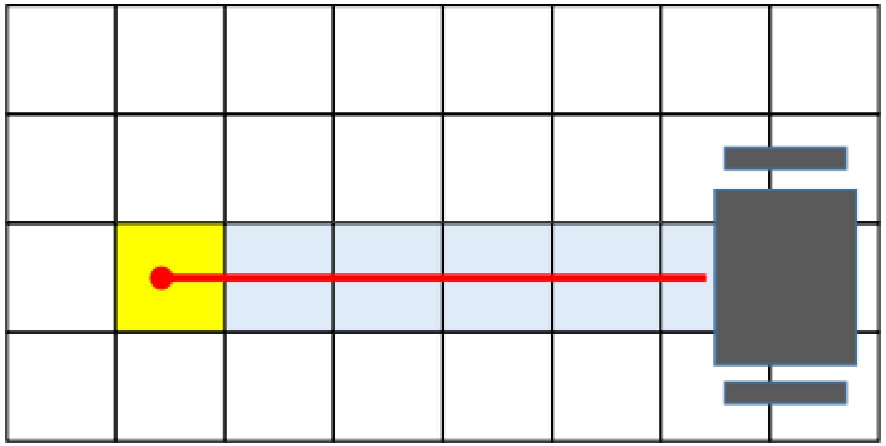
Mapping | Explanation

- Measurement

Free

Occupied

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



a range sensor

Mapping | Explanation

- Measurement

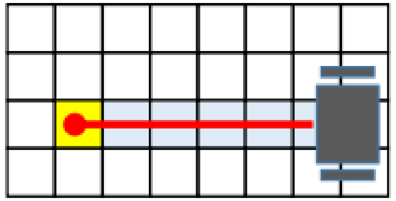
Free

Occupied

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

- Measurement model

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



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

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

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

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

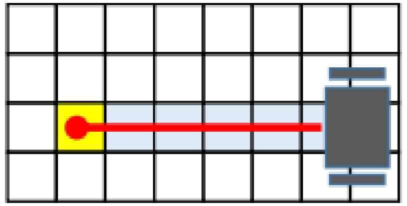
Mapping | Explanation

- Measurement

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

Free

Occupied



- Measurement model

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

[Review – Into Probability]

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

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

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

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

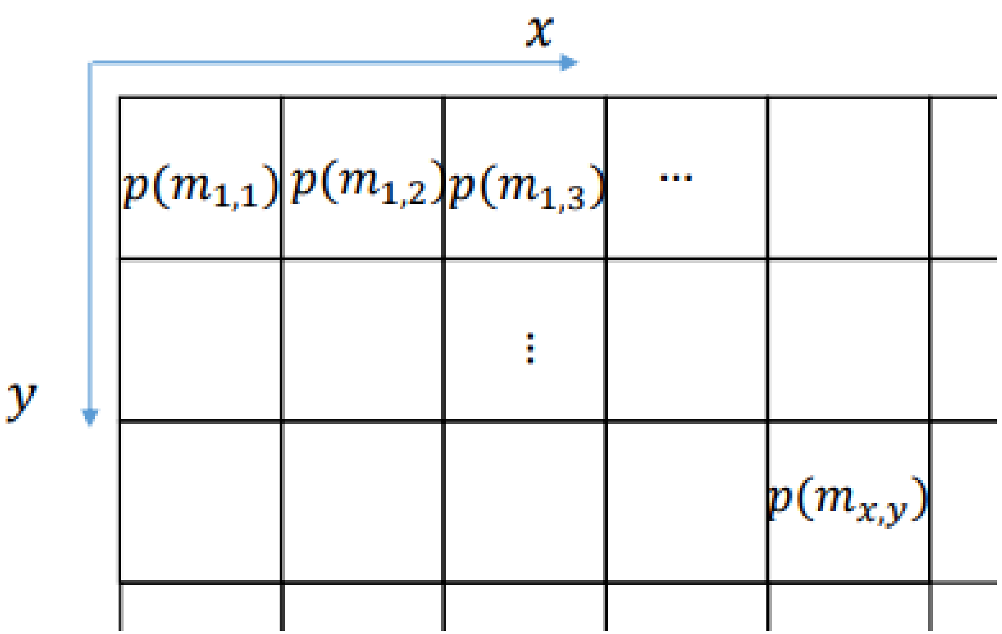
$$p(z = 0|m_{x,y} = 0) = 1 - p(z = 1|m_{x,y} = 0)$$

Mapping | Explanation

Measurement Model

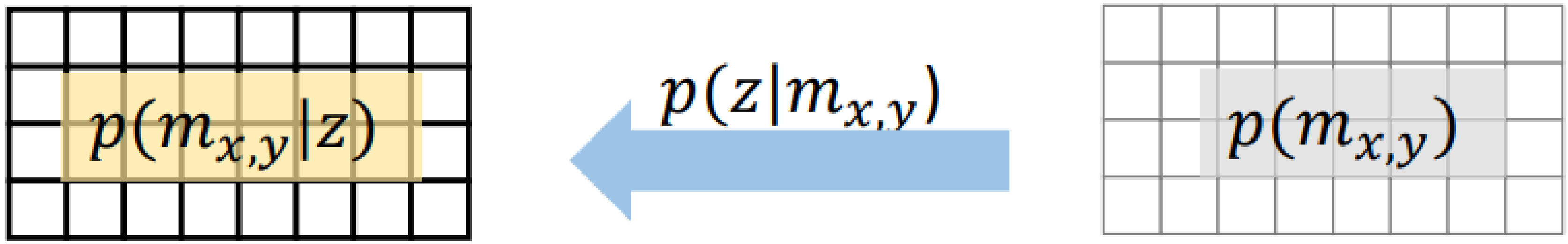
$$p(z|m_{x,y})$$

Map



Mapping | Explanation

Posterior Map **Measurement Model** **Prior Map**



Likelihood Prior

Posterior

$$\underbrace{p(m_{x,y}|z)}_{\text{Posterior}} = \frac{\overbrace{p(z|m_{x,y})}^{\text{Likelihood}}\overbrace{p(m_{x,y})}^{\text{Prior}}}{\underbrace{p(z)}_{\text{Evidence}}}$$

Evidence

Review

- Occupancy grid data type and how it is represented in ROS
- Occupancy grid resolutions
- Probability for grid maps
- Introduction to Bayesian filter to the map

By the end of this session you should be able to:

- Know how continuous maps are represented using grid maps
- Probabilities represented for occupied and unoccupied region
- Types of map
- Known position of the robot