

# CS 369: Introduction to Robotics

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Spring 2026



# Outline for today

- Configuration space
- Motion planning
- World representation

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# The World consists of...

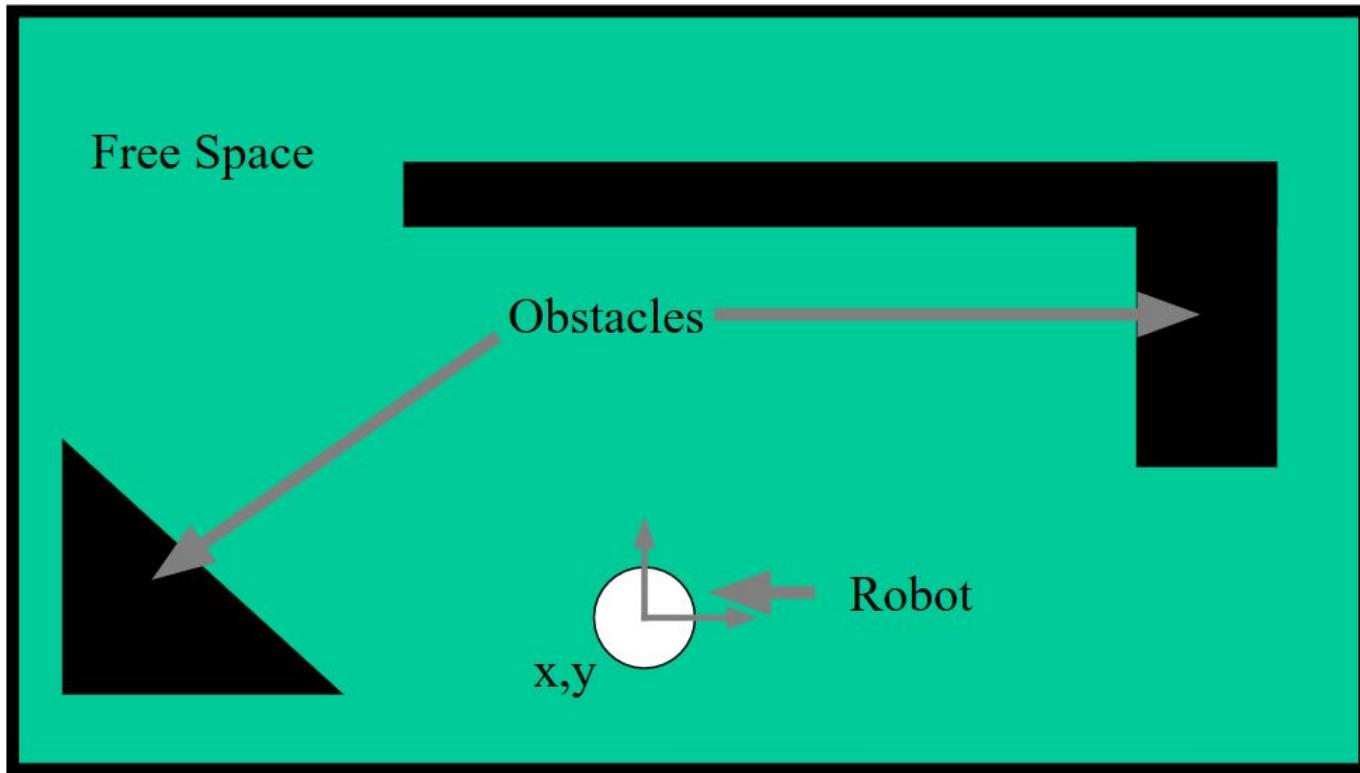
## Obstacles

- Already occupied spaces of the world
- In other words, robots can't go there

## Free Space

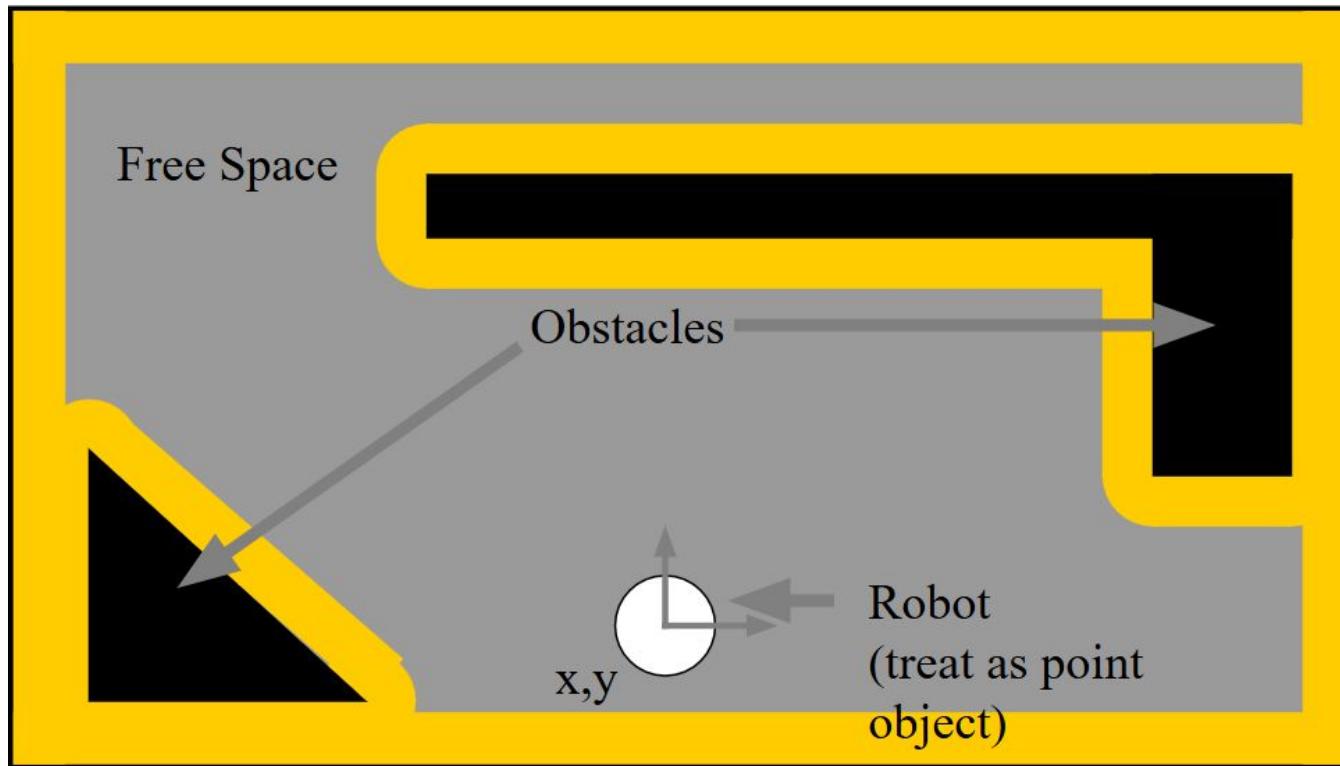
- Unoccupied space within the world
- Robots "might" be able to go here
- To determine where a robot can go, we need to discuss what a *Configuration Space* is

# Example of a world (and robot)



# Configuration space

accommodate robot size



# Configuration space

## What it is

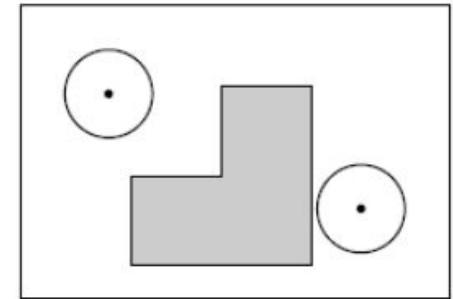
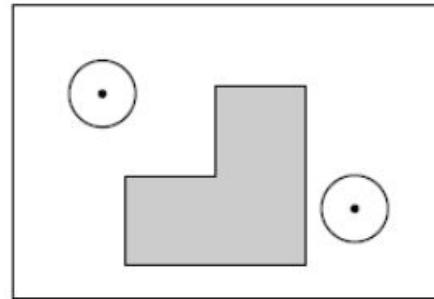
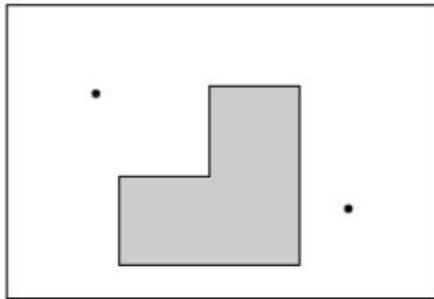
- A set of “reachable” areas constructed from knowledge of both the robot and the world

## How to create it

- First abstract the robot as a point object. Then, enlarge the obstacles to account for the robot’s footprint and degrees of freedom
- In our example, the robot was circular, so we simply enlarged our obstacles by the robot’s radius (*note the curved vertices*)

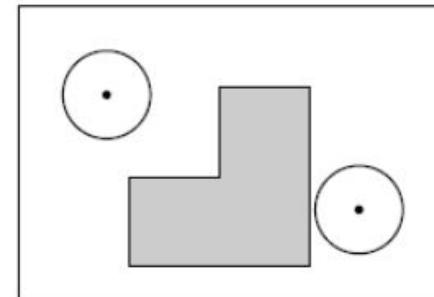
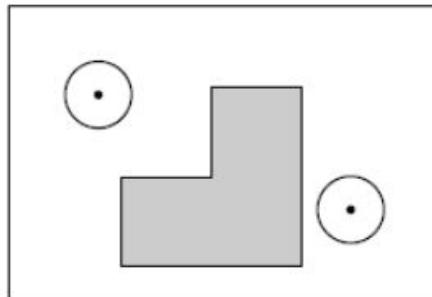
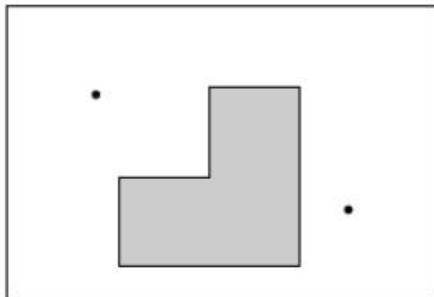
# Practice

workspace

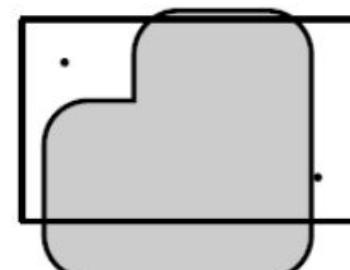
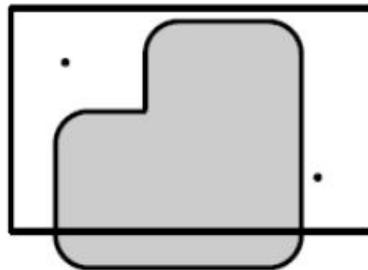
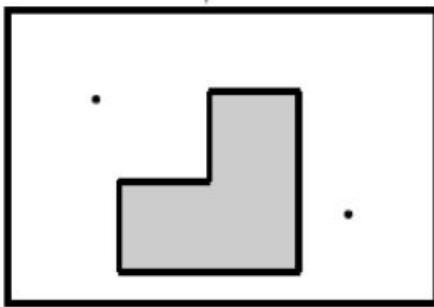


# Practice

workspace



C-space



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# Motion planning

- Process of finding a feasible path from the start to goal configuration
- If  $C_{\text{free}}$  denotes the robot's configuration space,  
then a path  $p = (c_0, \dots, c_n)$  where  $c \in C_{\text{free}}$ ,  $c_0$  is  $q_{\text{start}}$  and  $c_n$  is  $q_{\text{goal}}$

# Evaluation

- Path feasibility
- Distance from obstacles
- Path length
- Planning time

# Distance metrics

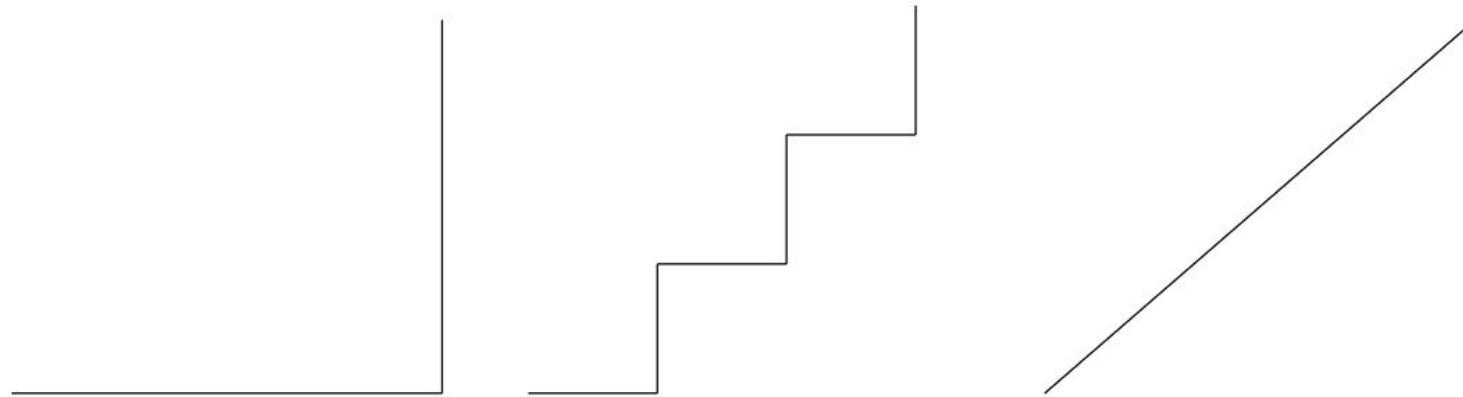
$$d : R^2 \times R^2 \rightarrow R$$

L1 Metric  $d(a,b) = |a_x - b_x| + |a_y - b_y|$

L2 Metric  $d(a,b) = \sqrt{(a_x - b_x)^2 + (a_y - b_y)^2}$

# Path length

Which is shortest?



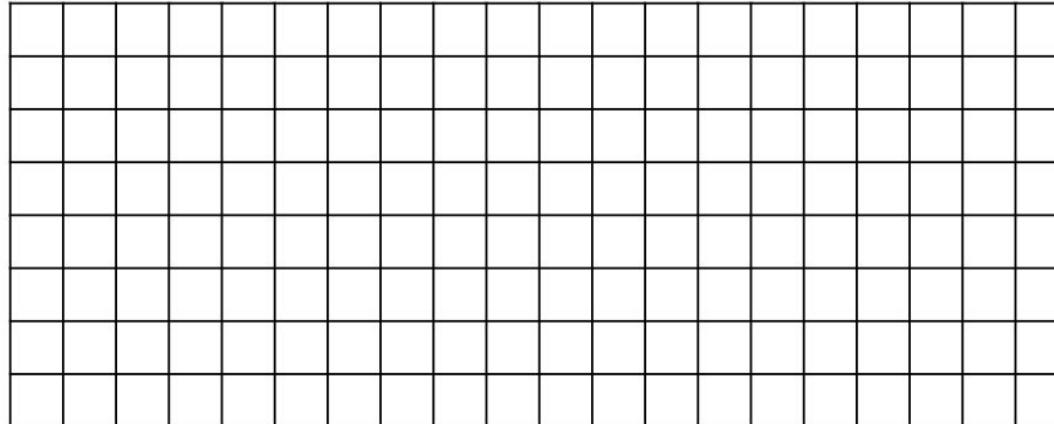
depends on the metric

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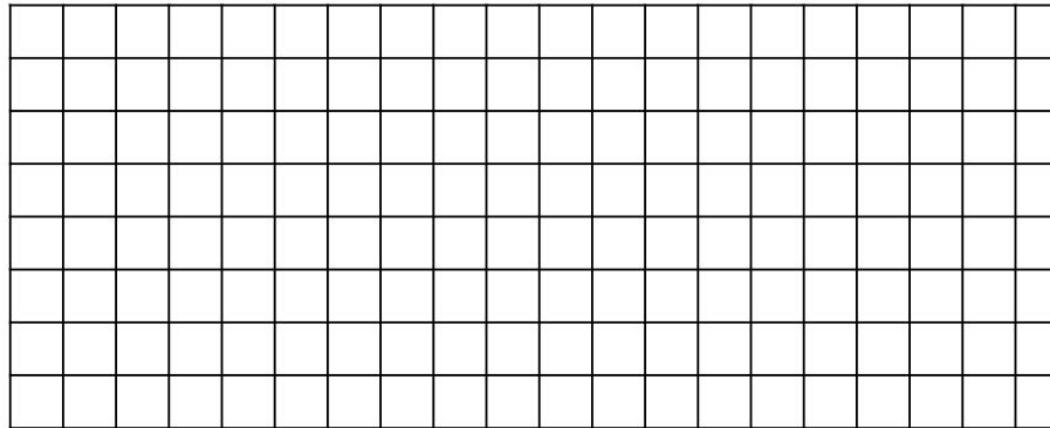
# World representation

- Can always use a continuous representation
- For simplicity, use uniform-sized grid cells



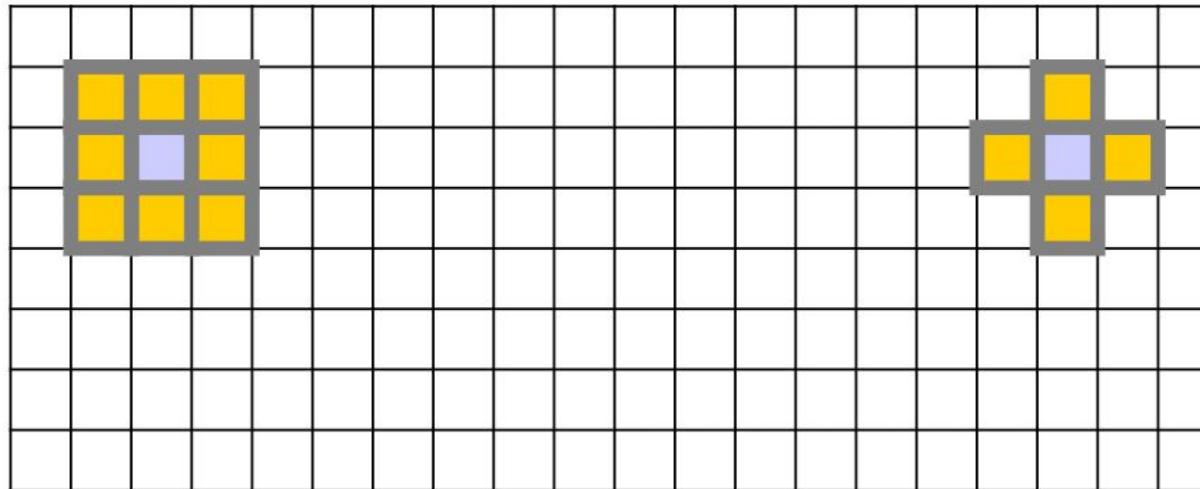
# Grid representation

- Distance is reduced to discrete steps
  - what does it mean for the robot to be inside a grid?
- Direction is now limited from one adjacent cell to another



# Connectivity

- 8-Point Connectivity
- 4-Point Connectivity
  - *(approximation of the L1 metric)*



# Occupancy grid

- A grid where each cell encodes occupancy information
  - Binary: a cell is either occupied (1) or free (0)
  - Probabilistic
- How to determine occupancy?
  - Optimistic
  - Pessimistic

