

CS 369: Introduction to Robotics

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Outline for today

- Configuration space
- Motion planning
- World representation

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The World consists of...

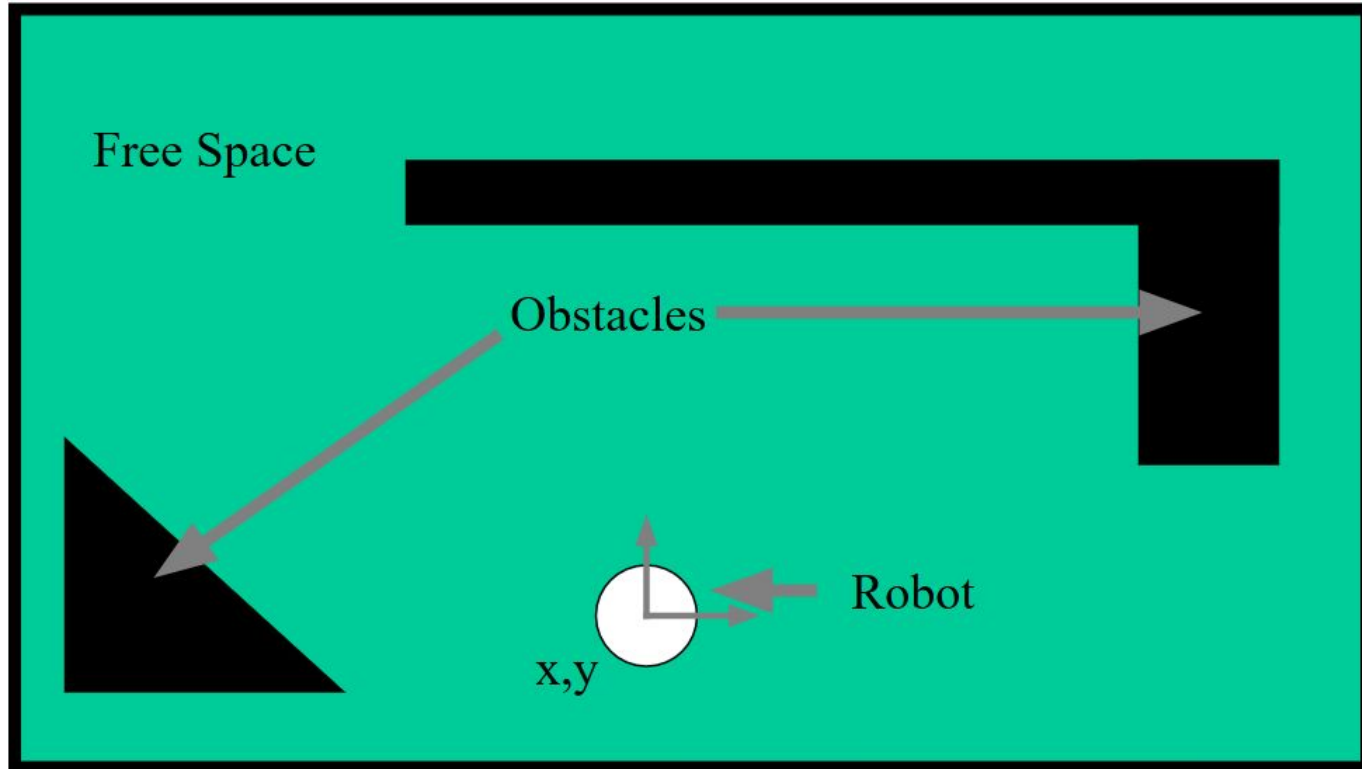
Obstacles

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

Free Space

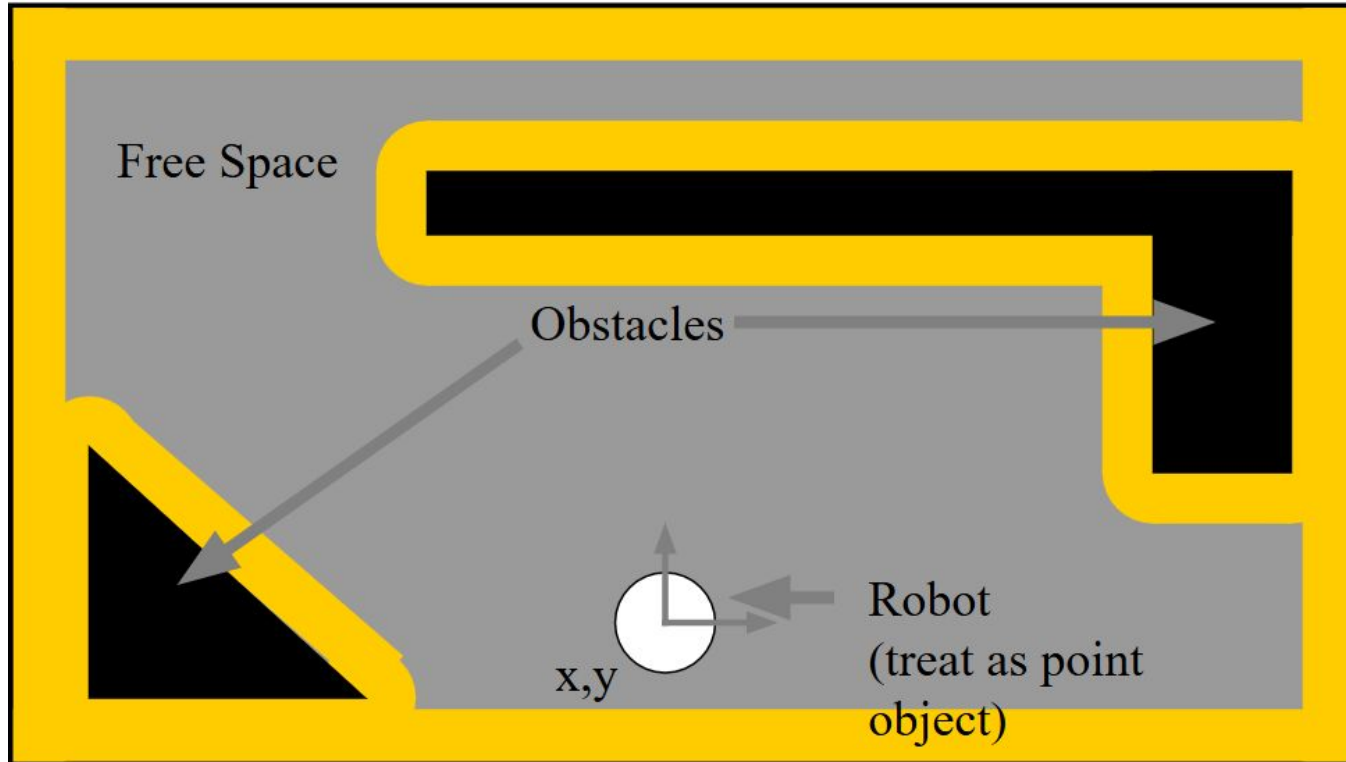
- Unoccupied space within the world
- Robots “might” be able to go here
- To determine where a robot can go, we need to discuss what a *Configuration Space* is

Example of a world (and robot)



Configuration space

accommodate robot size



Configuration space

What it is

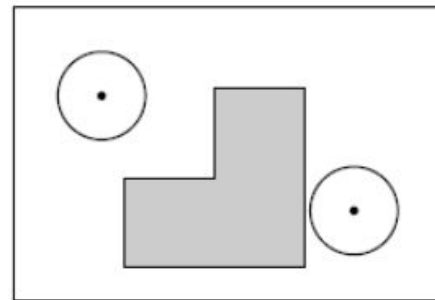
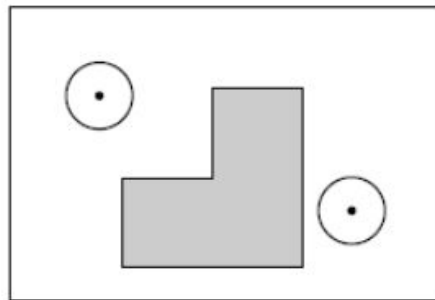
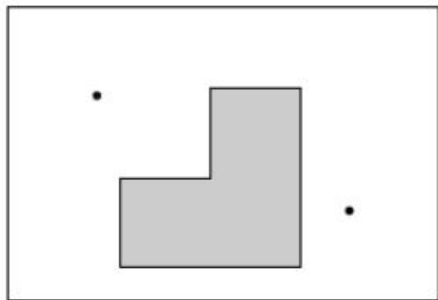
- A set of “reachable” areas constructed from knowledge of both the robot and the world

How to create it

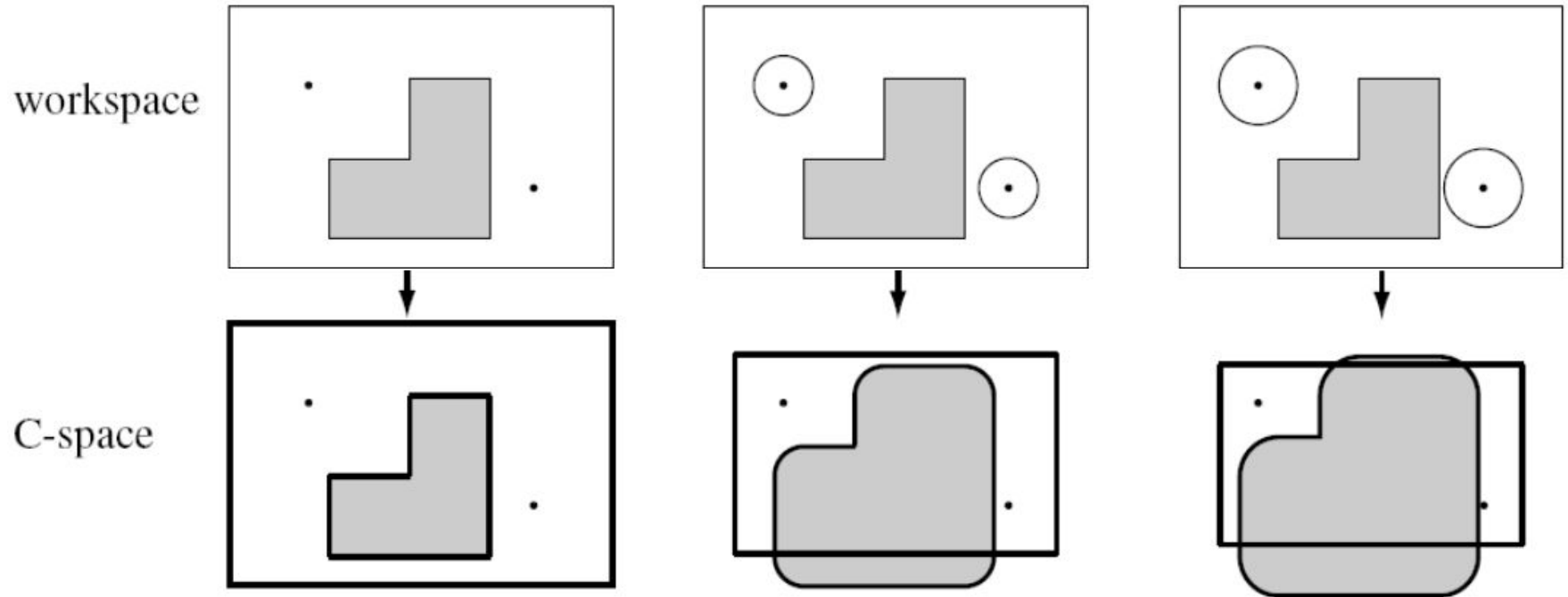
- First abstract the robot as a point object. Then, enlarge the obstacles to account for the robot’s footprint and degrees of freedom
- In our example, the robot was circular, so we simply enlarged our obstacles by the robot’s radius (*note the curved vertices*)

Practice

workspace



Practice



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Motion planning

- Process of finding a feasible path from the start to goal configuration
- If \mathbf{C}_{free} denotes the robot's configuration space,
then a path $\mathbf{p} = (\mathbf{c}_0, \dots, \mathbf{c}_n)$ where $\mathbf{c} \in \mathbf{C}_{\text{free}}$, \mathbf{c}_0 is $\mathbf{q}_{\text{start}}$ and \mathbf{c}_n is \mathbf{q}_{goal}

Evaluation

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

Distance metrics

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

L1 Metric

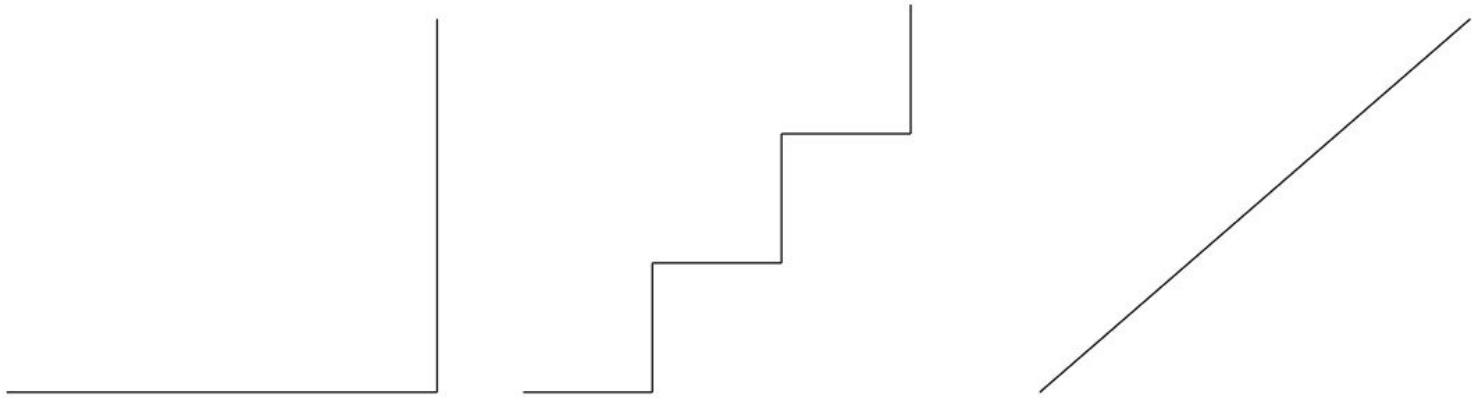
$$d(a,b) = |a_x - b_x| + |a_y - b_y|$$

L2 Metric

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

Path length

Which is shortest?



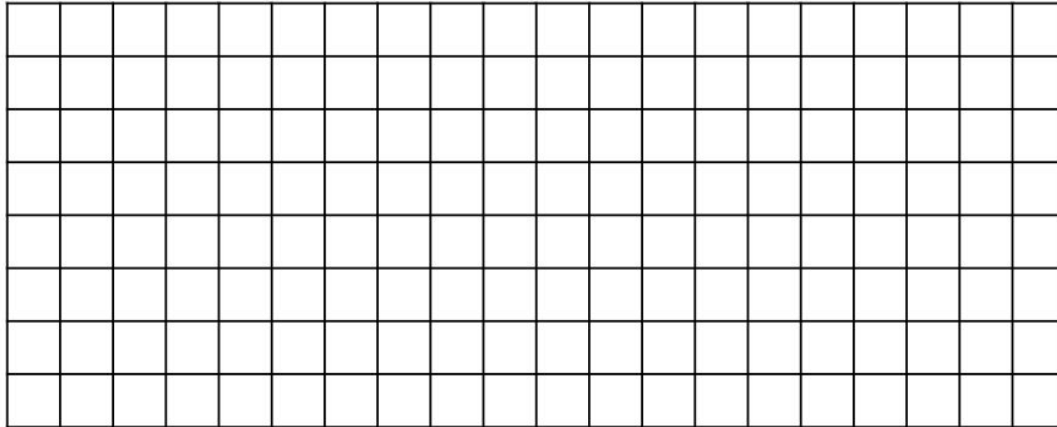
depends on the metric

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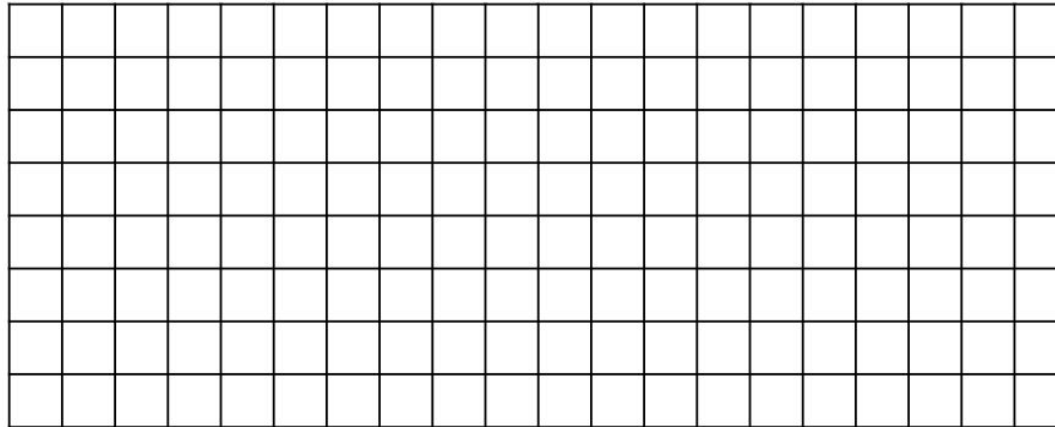
World representation

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



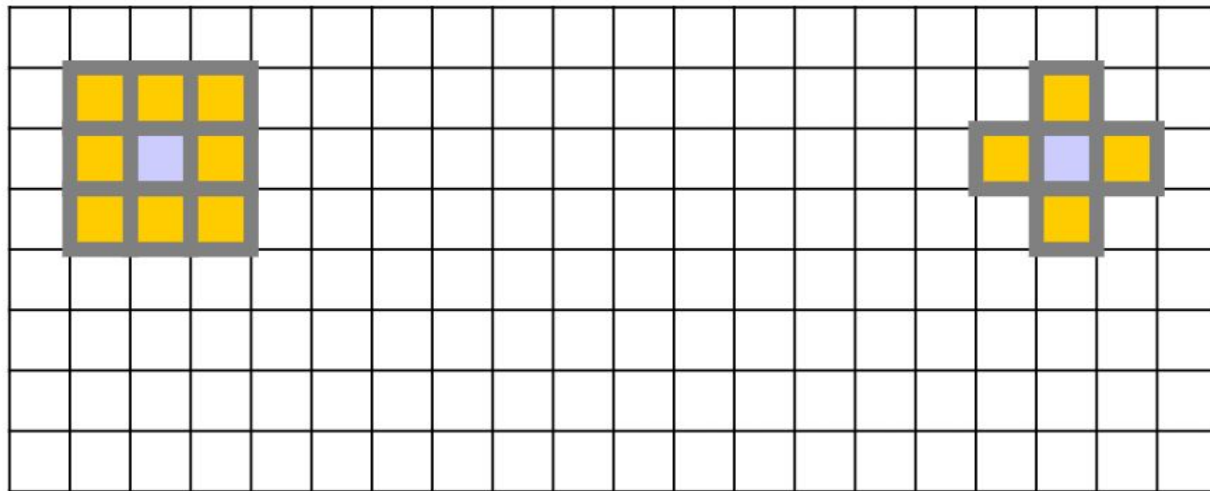
Grid representation

- 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

