Kia Cooperative Systems Summer High School Outreach Module 4

PI: Solmaz Kia
Graduate Students: Donipolo Ghimire
Mechanical and Aerospace Engineering Department
University of California Irvine
Summer 2021

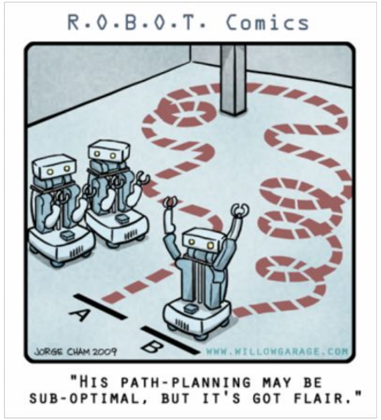
Why do we care about robot motion planning?

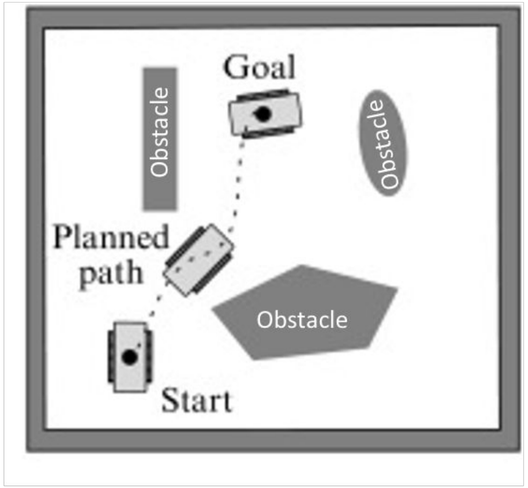
Regardless of the form of the robots or the task it must perform, robots must maneuver through the world.

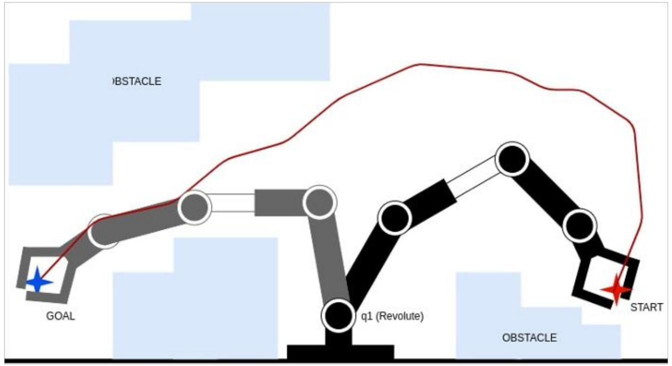
Motion planning is the problem of finding a robot motion from a start state to a goal state in a cluttered environment to achieve various goals while avoiding collisions.

In its simplest form, the motion planning problem is:

how to move a robot from a "start" location to a "goal" location avoiding obstacles.







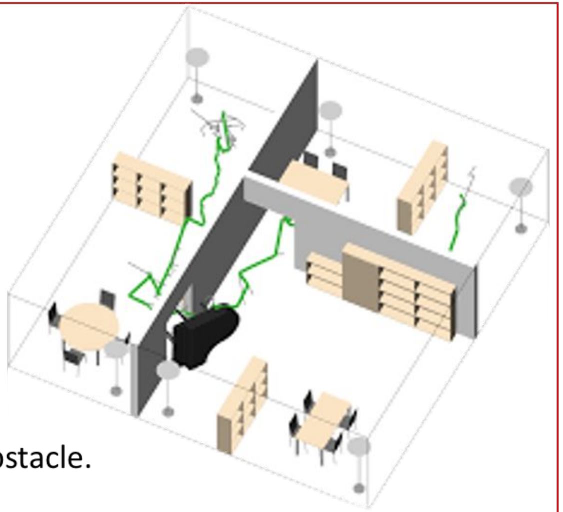
Motion Planning: Problem Formulation

The problem of motion planning can be stated as follows:

Given:

- ❑ A start pose of the robot
- ❑ A desired goal pose
- ❑ A geometric description of the robot
- ❑ A geometric description of the world

Find a path that moves the robot gradually from start to goal while never touching any obstacle.

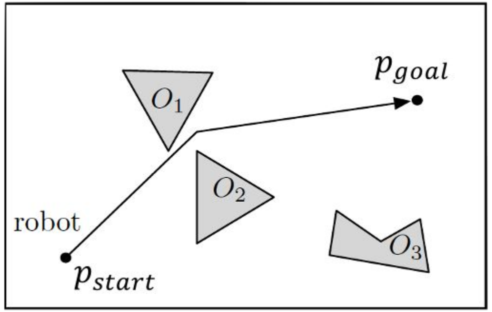


https://youtu.be/HdfAzUXvmOQ

This problem is sometimes referred to as the "move from A to B" or the "**piano movers problem**" (how do you move a complex object like a piano in an environment with lots of obstacles, like a house).

Motion Planning: Workspace

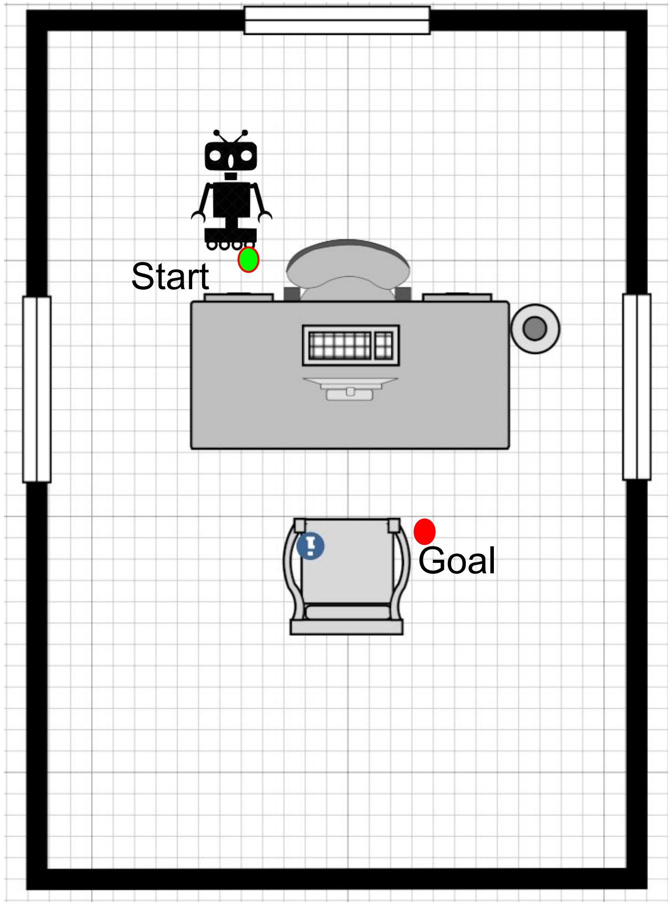
a robot described by a moving point (that is, the robot has zero size).



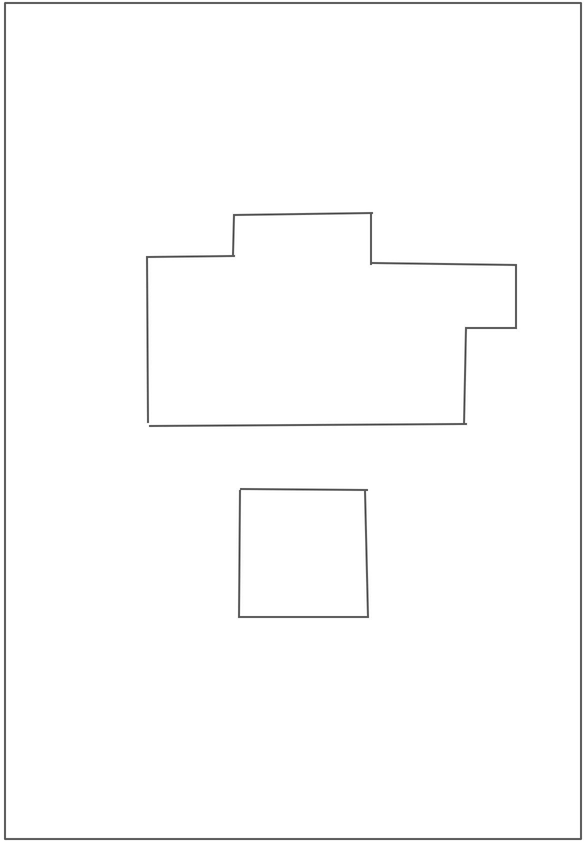
- A workspace $W \subset R^2$ or R^3, often just a rectangle;
- Some obstacles $O_1, O_2, \cdots, O_n$;
- A start point p_{start} and a goal point p_{goal};

free workspace: $W_{free} = W \backslash (O_1 \cup O_2 \cup \cdots \cup O_n)$: the set of points in W that are outside all obstacles.

Motion Planning



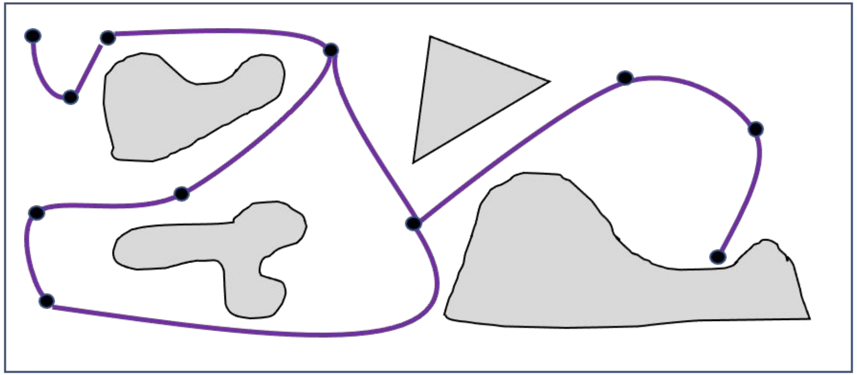
Representing the Obstacles as polygon

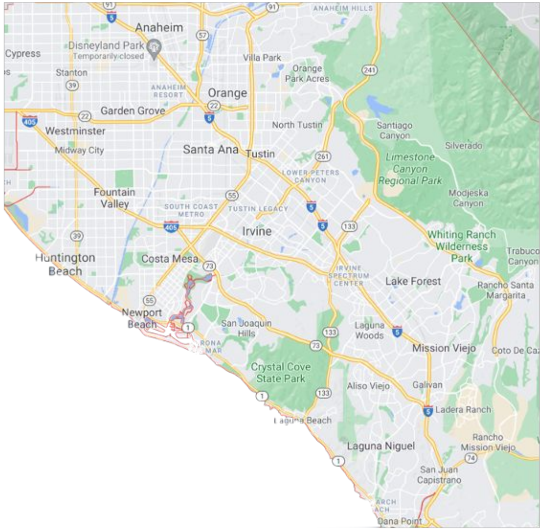


Roadmaps

A roadmap is a collection of locations in the configuration space along with paths connecting them.

- With each path, we associate a positive weight that represents a cost for traveling along that path, for example, the path length or the travel time.
- Think of a roadmap as a weighted graph $G = (V, E, w)$, where w is a function that assigns the weight (e.g., path length) to each edge in E.





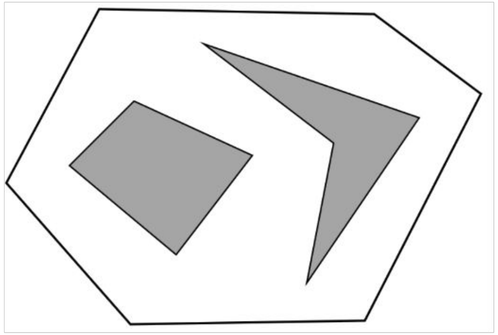
Motion Planning Using Visibility Graph

Visibility roadmaps: the visibility graph $G = (V, E, w)$, is defined as

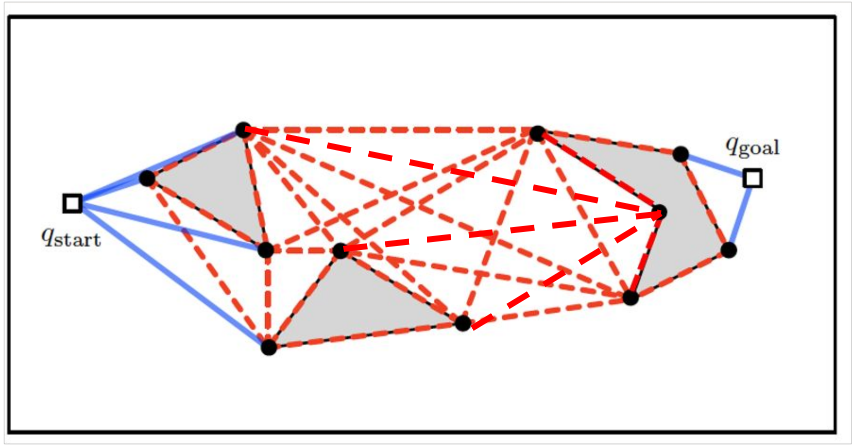
i. the nodes V of the visibility graph are all the vertices of the polygons $O_1, \cdots, O_n$,

ii. the edges E of the visibility graph are all pairs of vertices that are visibly connected. That is, given $u, v \in V$, we add the edge $\{u, v\}$ to the edge set E if the straight-line segment between u and v is not in collision with any obstacle, and

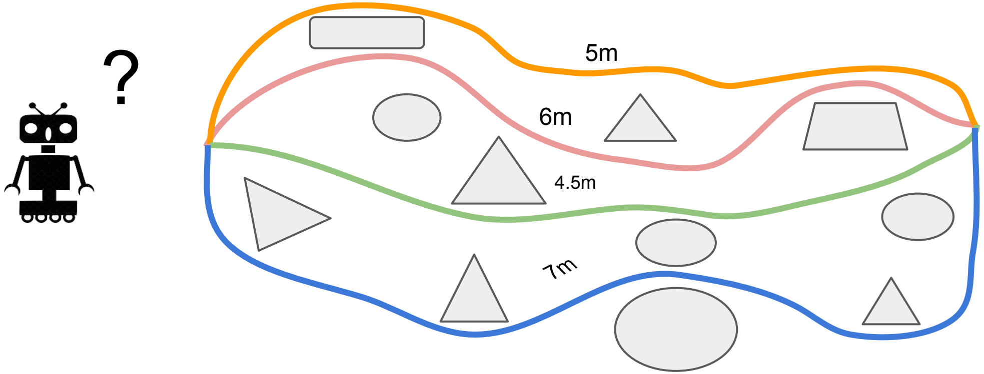
iii. the weight of an edge $\{u, v\}$ is given by the length of the segment connecting u and v.



environments with polygonal obstacles.



How to represent my problem for computer programming



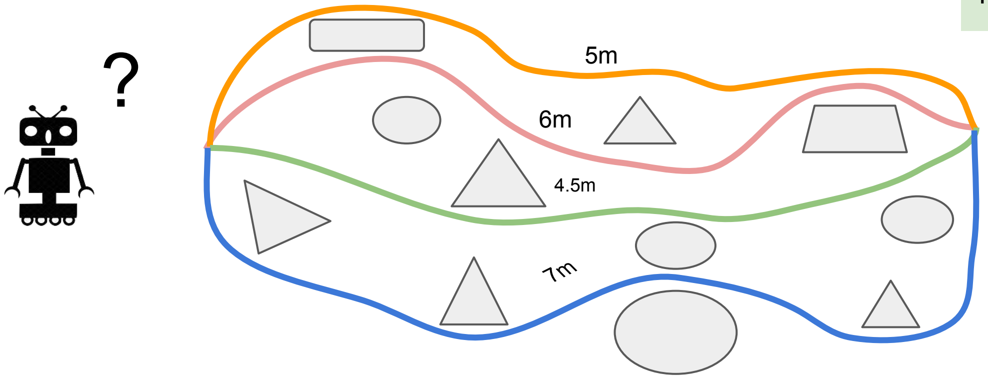

```
Input: an array
Initialize maximum_element with a[0], i.e, maximum_elemen=a[0]
for i=1 to length(a)-1
      if maximum_element<a[i]
                maximum_element=a[i]
      End if
End for
Return maximum_element
```

Array representation of data

a[0]	5
a[1]	6
a[3]	4.5
a[4]	7

According to Wikipedia:pseudocode, "pseudocode is compact and informal high-level description of a computer programming algorithm that uses the structural conventions of a programming language, but is intended for human reading rather than machine reading." see also https://www.geeksforgeeks.org/how-to-write-a-pseudo-code/

How to program my problem in Python



How to write a program for the robot to choose the shortest path?

```
### KCS LAB
## finding the shortest path in the array

import numpy as np
paths = np.array([5,6,4.5,7])
# initializing the first item to be the miniimum
min = paths[0]
# for loop to run through every elements in the list
for i in range(len(paths)):
  # comparing minimum values with the elements in the
list
  if  min >= paths[i]:
    # update the minimum value
    min = paths[i]
print('The shortest path is:', min)
```

Output : The shortest path is: 4.5

Assignment 1, Problem no 1

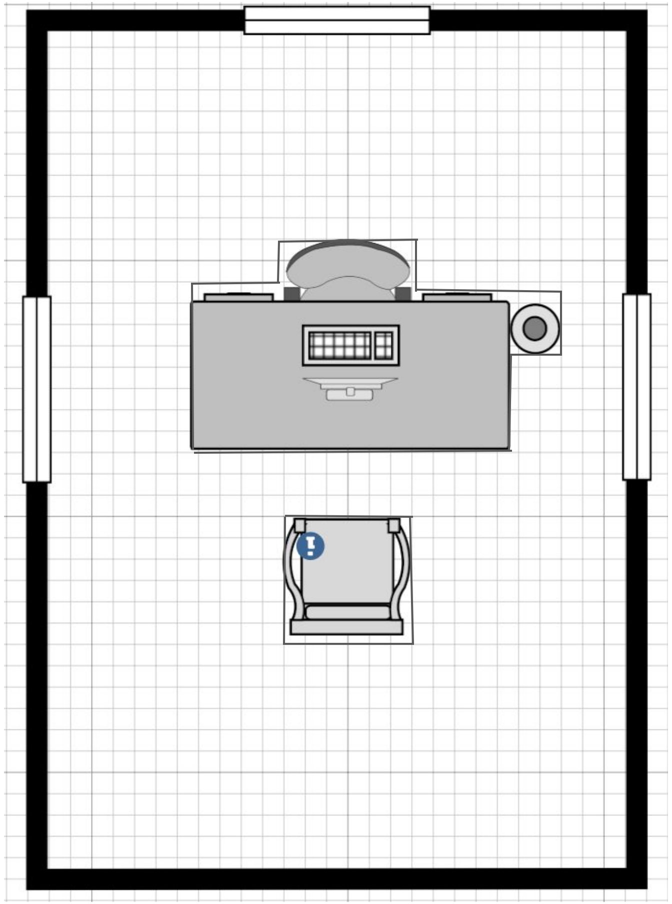
Write a program to sort the list of distances stored in an array in descending order?

Example : Input : distances = [9,6,7,1,4,5,8]
Output : distances = [9,7,8,6,5,4,1]

You can also find the code here:

https://colab.research.google.com/drive/1BLfoWaeBplJTPb2w_0ahmMewdmTtrJ-f?usp=sharing

Motion Planning via Visibility Graph



- Create the visibility graph: clearly show the vertices and edges and write the distance between visible vertices as weights on the edges

- Use Dijkstra algorithm to find the shortest path from the show start point to the shown goal point.

Sponsors

NSF

UCI Center for Educational Partnerships