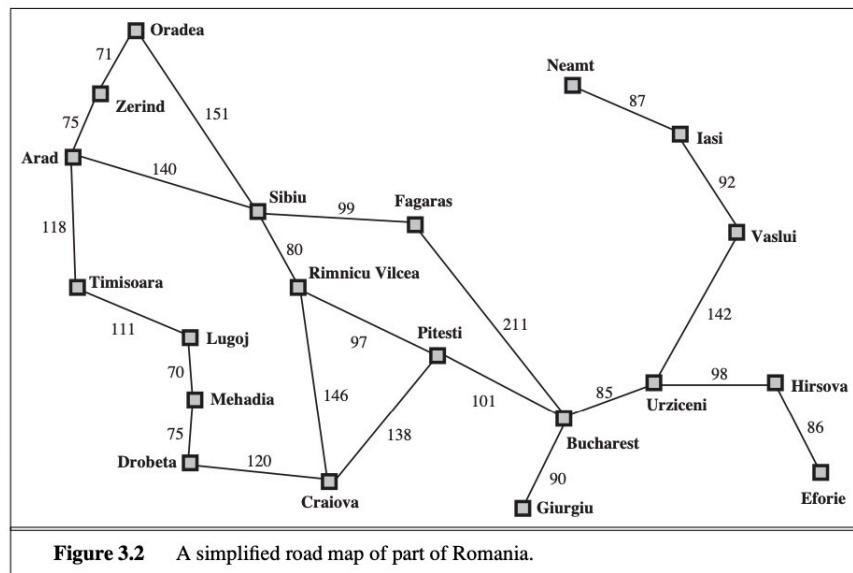


# ROB 422 - Assignment 3

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Q1.)



(AI book, Ex.: 3.3)

Figure 3.2 A simplified road map of part of Romania.

Ans:

- a.) \* Let  $S$  be a set of all cities  $S = \{C_1, C_2\}$  where  $C_1$  is the city where friend 1 is located and  $C_2$  is where friend 2 is located.
- \* Our goal is to minimize the maximum time it takes for both friends to reach same city. i.e.  $C_1 = C_2$
- \* Transition Function, is the possible transitions of moving from  $C_i \rightarrow C'_i$  and  $C_j \rightarrow C'_j$ , where  $C'_i, C'_j$  are neighboring cities.
- \* Thus,

$$\text{cost}(S, S') = \max(d(C_1, C'_1), d(C_2, C'_2))$$

b)  $D(i, j)$  is the admissible

heuristic  $h_1(i, j) = D(i, j)$  (straight-line distance)

$2 \cdot D(i, j)$  is not admissible

heuristic  $h_2(i, j) = 2D(i, j)$  (overestimation of actual cost)

$1/2 D(i, j)$  is admissible

heuristic  $h_3(i, j) = 1/2 D(i, j)$  (underestimation of actual cost but not optimal)

c.) No, there is no completely connected map for which no solution exists.

d.) Yes, it is possible. This can happen when the map has narrow corridors or cyclic patterns.

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Q2.) (AI book, Ex. 4-1)

a.) Hill Climbing (also Greedy Search)

b.) Breadth-First Search (BFS)

c.) Hill Climbing

d.) Random Walk

e.) Hill Climbing

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Q3.) (LeValle book, Ch. 4 Ex. 5)

$$C\text{-space} = \mathbb{R}^3 \times S^2$$

Dimension of C-space is the sum of dimensions of  $\mathbb{R}^3 \times S^2$ :  $3+2=5$ ,

The rod has 3 translational degree of freedom ( $\mathbb{R}^3$ ) and 2 rotational degrees of freedom ( $S^2$ ).

Q4.) (LaValle book, Ch.4 Ex.16)

Each polyhedral body have 5 independent bodies, with translation space  $(\mathbb{R}^3)^5$

This corresponds to 3 translational DOF,  $3 \times 5 = 15$  DOF

Rotating DOF is denoted by  $SO(3)$  with 5 independent bodies

Therefore the config. space is  $(SO(3))^5$

This corresponds to 3 rotational DOF,  $3 \times 5 = 15$  DOF

Total dimension of C-Space is:

$$C\text{-Space} = (\mathbb{R}^3)^5 \times (SO(3))^5$$

dim of  $(\mathbb{R}^3)^5$  is 15.

dim of  $(SO(3))^5$  is 15.

Thus the dimension of C-Space is 30.

Q5.) Searching an implicit, High-Resolution Grid.

→ C-Space is divided into a regular, pre-defined grid, with each grid representing a possible config.

→ High-resolution means smaller grid cell, which capture details of the config. space.

→ Computationally expensive in higher dimensions.

→ BFS and DFS explore this grid by moving from one grid to next.

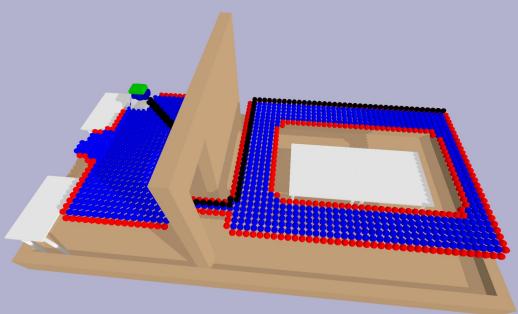
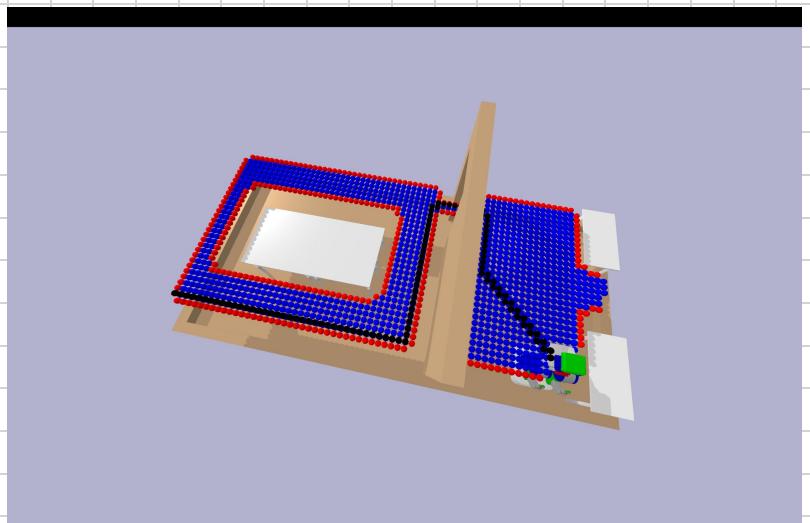
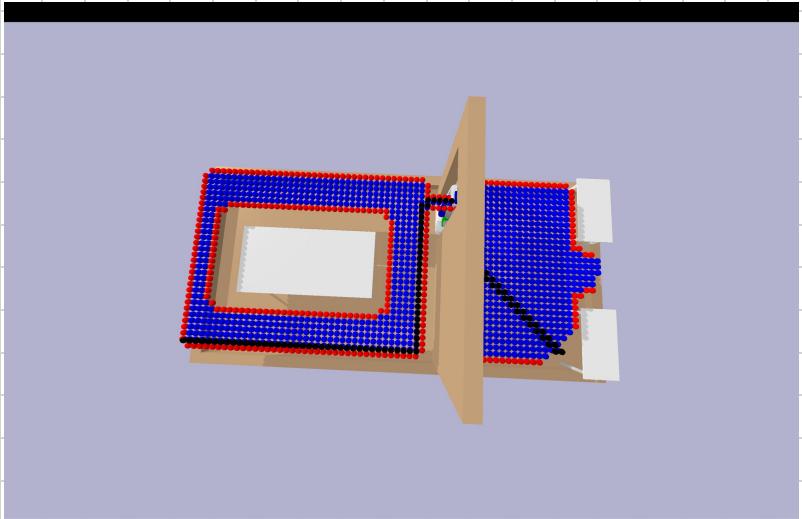
→ A\* can be applied on heuristic estimate to search grid.

## Growing Search trees directly on C-Space (without grid)

- Suitable for high-dimensional spaces & offer more flexibility.
  - Rapidly-exploring Random Trees (RRT) and Probabilistic Roadmaps (PRM) are two common tree-based algos.
  - Explores Space without discretizing into grid.
  - Grows dynamically.
-

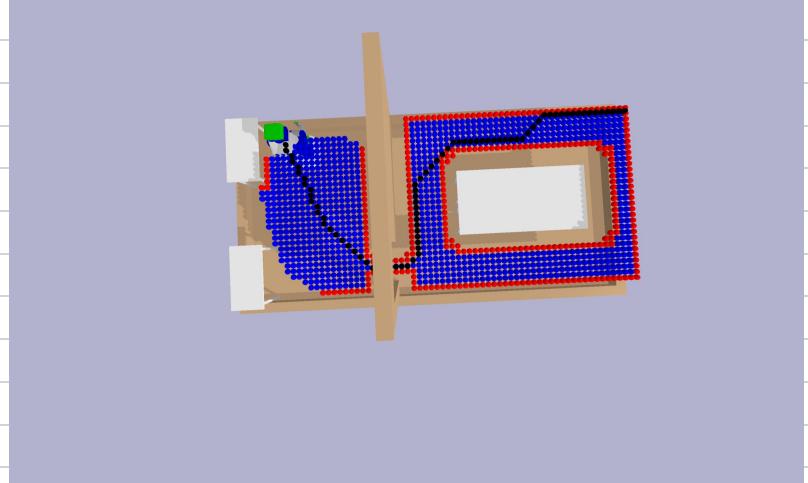
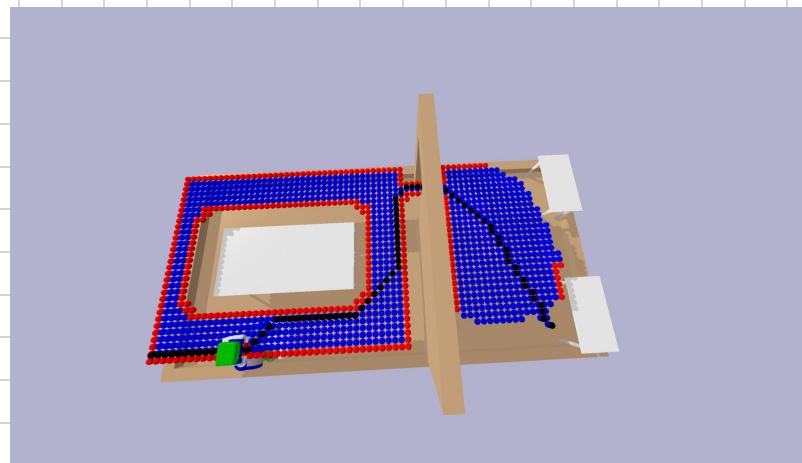
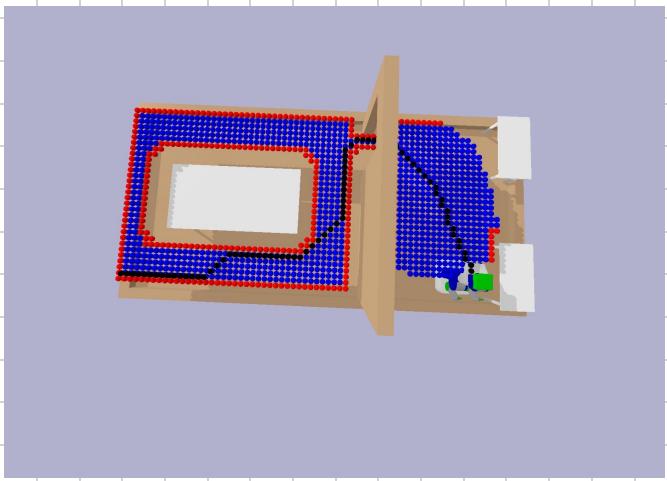
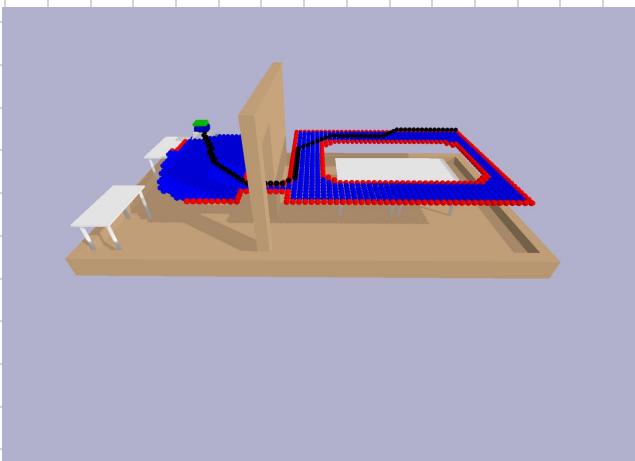
# Implementation

Q1.) a). H- Connected.



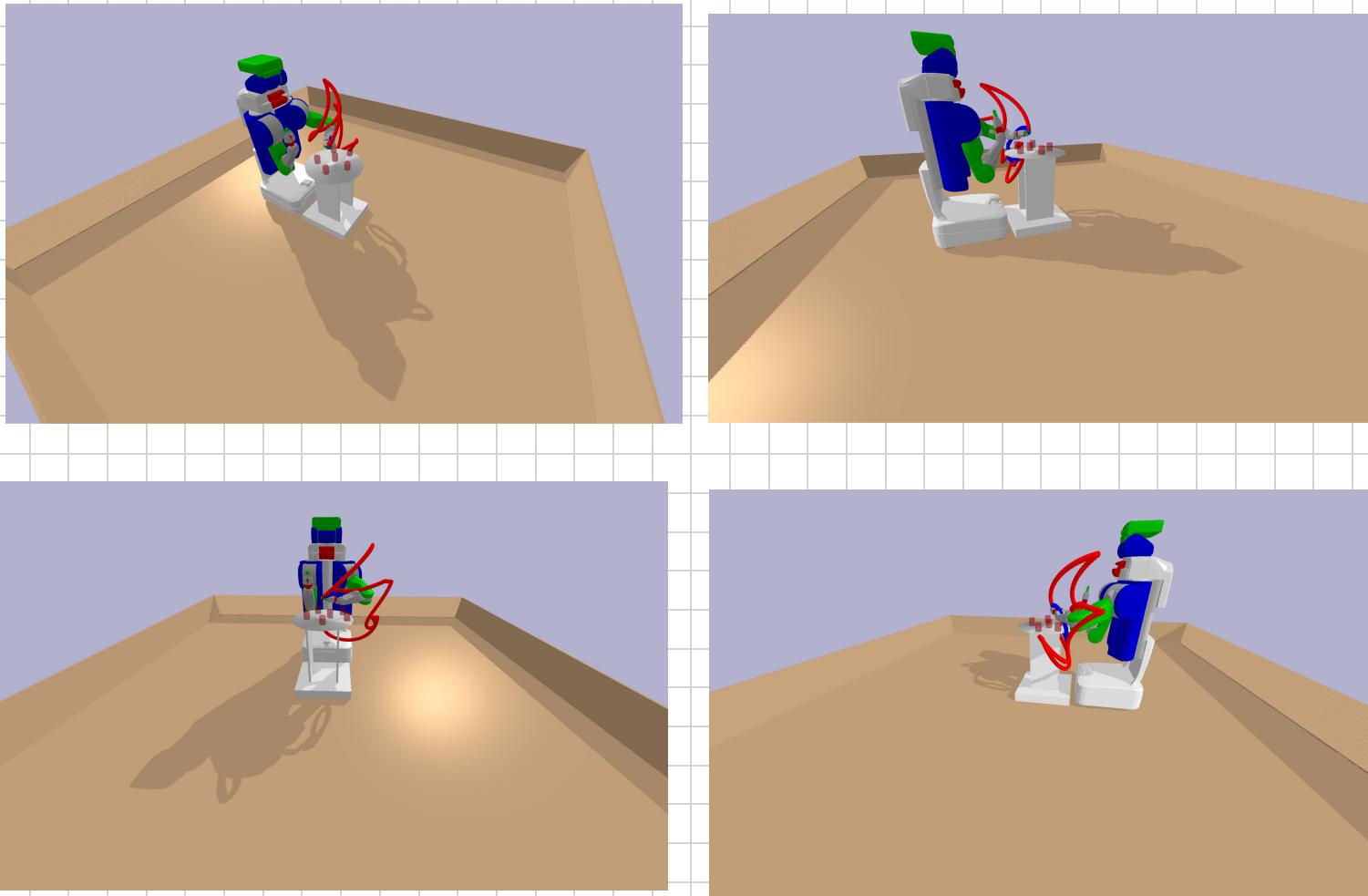
Path cost: 12.470796326794868  
Planner run time: 530.155889749527  
Executing trajectory  
Finished

b) 8 - Connected.



```
Path cost: 10.69552629433298  
Planner run time: 268.8535099029541  
Executing trajectory  
Finished
```

Q2.)



Planner run time: 1.6527538299560547  
Executing trajectory  
Finished

X