CS 560 Introduction to Computational Robotic

Homework #2

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Problem 1

Because in such situation, we don't really need an absolute coordinate, instead, we need a relative coordinate based on the tall building. Two people only need to know which side of the building they are facing, like the front side or the left side and roughly how far are those two people from that building.

Problem 2

The size of state space:

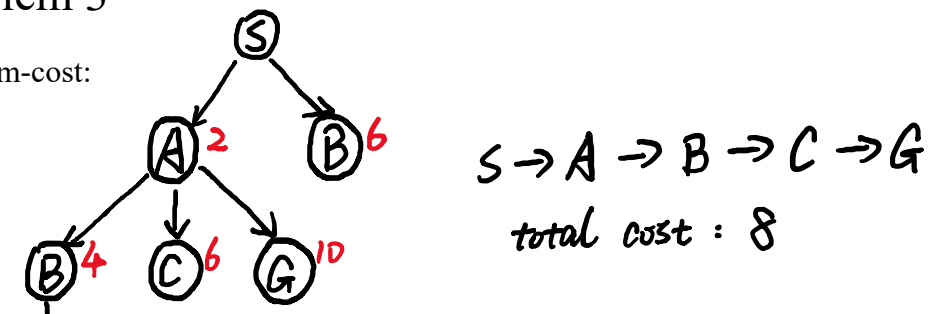
$$\frac{9! - 8!}{2}$$

Explanation:

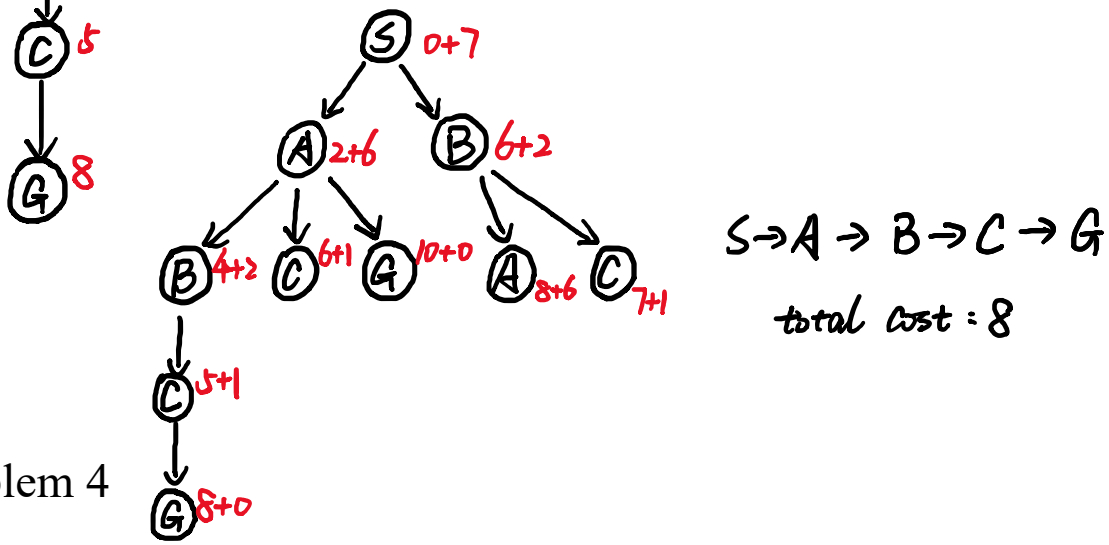
We have 6 pieces labeled and two labeled as *, including the empty space, there are 8 different type of spaces. Considering 8 empty spaces needed to be filled with 8 different pieces, we have 8! different possibilities to fill these. Now consider we have another extra piece and it can insert in any these 8 spaces and the rest pieces will move backward for one space, which makes it total 9 spaces to be filled. In this situation, we have $8! \times 8$ possibilities. However, we also need to consider in what situations we cannot make it happen by simply move an empty space. Since moving an empty space will not cause a reverse order of adjacent spaces, this means that the transformation by moving an empty is symmetrical, which gives us total $\frac{8! \times 8}{2} = \frac{9! - 8!}{2}$ possibilities.

Problem 3

Uniform-cost:



A*:



Problem 4

Even if we consider earth as a perfect ball, a car is way smaller than the earth, which make the earth surface that a car can cover a space that so small we can treat it as flat surface. Therefore, in this situation, C-space for the car is same as three-dimensional C-space for flat surface, which is (x, y, θ) where $x, y \in \mathbb{R}^2, \theta \in S$.

Problem 5

Grübler's formula: $DOF = m(N - 1 - J) + \sum_{i=1}^{J} f_i$

a) $m = 3, N = 10, J = 12$
$DOF = 3 \times (10 - 1 - 12) + 12 = 3$

b) $m = 3, N = 14, J = 18$
$DOF = 3 \times (14 - 1 - 18) + 18 = 3$

f) $m = 3, N = 7, J = 9$
$DOF = 3 \times (7 - 1 - 9) + 9 = 0$

Problem 6

a) $m = 6, N = 8, J = 9$

$DOF = 6 \times (8 - 1 - 9) + 21 = 9$

b) $m = 6, N = 2n + 2, J = 3n$

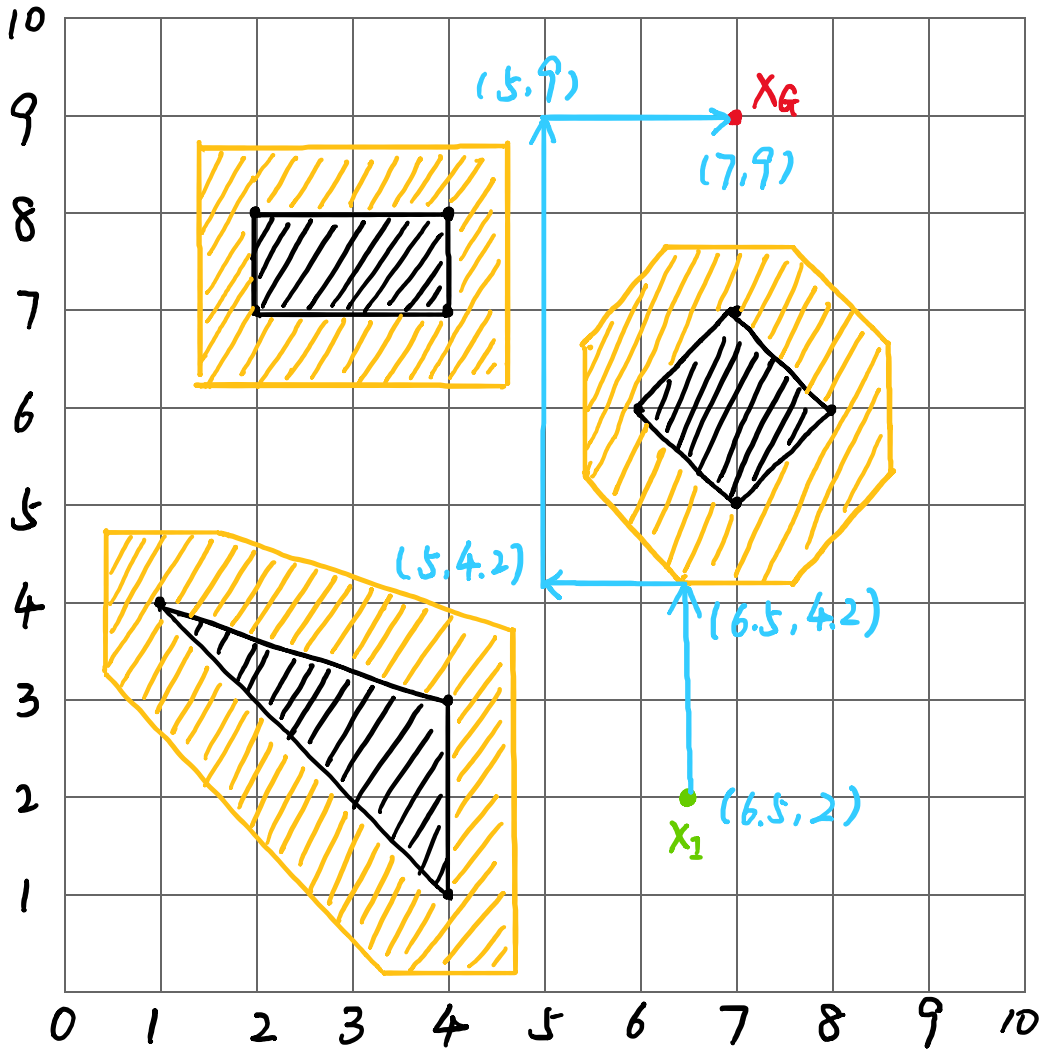
$DOF = 6 \times (2n + 2 - 1 - 3n) + 7n = n + 6$

c) $m = 6, N = 2n + 2, J = 3n$

$DOF = 6 \times (2n + 2 - 1 - 3n) + 5n = 6 - n$

Problem 7

1. Obstacles are **BLACK**, C_{obs} are **YELLOW**.



2. See above.

   The C_{free} is connected.

3. See above.
   x_I is **GREEN**, x_G is **RED**, the path is **BLUE**.

Problem 8

1. $T = \begin{bmatrix} \cos\Delta\theta & -\sin\Delta\theta & \Delta x \\ \sin\Delta\theta & \cos\Delta\theta & \Delta y \\ 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} \cos 40° & -\sin 40° & 3 \\ \sin 40° & \cos 40° & 4 \\ 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 0.767 & -0.643 & 3 \\ 0.643 & 0.767 & 4 \\ 0 & 0 & 1 \end{bmatrix}$
2. A(8.879, 12.212) E(9.774, 11.321)
3. Transformed rigid body will collide with the polygon at the edge AE.
4. $T' = \begin{bmatrix} 0 & -1 & 17 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}$