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1a Joint-space DOF of 1,2,3,4 respectively

1b Operational space DOF of 3,3,3,3 respectively

2

6 DOF since there is one DOF for x,y,z axis and then roll, pitch, yaw which are all rotations around those axis

3a

7: wrist has 3 DOF, elbow has 1 DOF, shoulder has 3 DOF

3b

Redundancy is when robot DOF > environmental DOF. This means there is one or more joints for a single DOF which makes that joint redundant

3c

Yes, the DOF of the arm(7) > environmental DOF(6). The redundancy is in the wrist and shoulder

3d

Redundancy makes it easier for a robot to move into any given position and allows more ways for the robot to move into any given position. The downside is that it makes the robot more complicated.

4

Both of the given vectors are in the x-y plane and are both in length since the sides are .5 in length and it is a perfect triangle. Thus, to make a coordinate system with them it needs to be just in the z direction with a magnitude of the same size.

5

I used the convenient solution showed in lecture slides to solve this using only two matrices. I put in the coordinates of the car and target and the angle.

For theta we can just add them to get 2pi/3. Final answer x,y,theta =

6

I will use the 3d rotation matrix shown in class. To find the angle between the axis’s I just use the right-hand rule.

7a

Again, using the 3d rotation matrix from class I get

7b

For theta it is the same except in the epuck’s frame theta is orientated around the y axis.

x, z, theta (.33, -.1, .47)

7c

Instead of radius, I can just use the speed since it is proportional to it. For axle length I’m using 53mm as posted on piazza. After calculating the change I add it to the starting point and I get the final answer.

X,Y,theta in i frame = (.06, .41, -1.79)