Robot Learning and Sensorimotor Control

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1 Part A

1.1 1.1-1.2

The requested table with the costs is table 1. The starting pose was always

$$q = (\frac{\pi}{4}, 0, 0, \frac{\pi}{2}, 0, 0, 0, 0, 0, -\frac{\pi}{4}, 0, 0, \frac{\pi}{2}, 0, 0, 0, 0, 0)$$

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2 Part B

2.1 2.1-2.2

We used as target position the first given: $y^* = (0.46, 0.275, 1.29)$ and for each setting we computed the following norm:

$$\|q_{start} - q_{final} - h\|_W^2$$

where $h = 0$ for the case where we use the minimum norm and $h = q_{comf} - q_{final}$ for the case where we use the comfortable pose for redundancy resolution. We summarize the results in table 2. In the simulation we observed that the solutions for the minimum norm seem random joint movements, whereas for the null space redundancy resolution, all final poses are similar to the comfortable pose. Since we constrain the joint movement, we expect to have higher cost. This is expressed in the norm because in the minimum norm case, the difference depends on the final pose, whereas in the null space case the cost depends not on the final, but rather on the comfortable pose:

$$q_{start} - q_{final} - h = q_{start} - q_{final} - (q_comf - q_{final}) = q_{start} - q_{comf}$$

Table 1: Weighted distance cost of calculated final poses and start pose 1. The highlighted cells indicate the configurations with minimum cost.

	Comf. 0		Comf. 1	
Target	Right	Left	Right	Left
0	3.995	3.565	1.678	1.523
1	3.778	3.500	1.554	1.476
2	3.534	3.426	1.463	1.423
3	3.279	3.308	1.374	1.384
4	3.052	3.192	1.292	1.333
5	2.818	3.062	1.224	1.294
6	2.576	2.919	1.191	1.252
7	2.319	2.764	1.197	1.221

Table 2: Distance cost for null space and minimum norm redundancy resolution.

	Minimum norm	Comf. 0
q_start1	1.418	2.916
q_start2	0.626	2.713
q_start3	0.744	6.403

3 Part C

3.1 3.1-3.2

We gather the poses and perform principal component analysis. The resulting eigenvalues of the covariance matrix of the poses are:

$$0.2243, 9.622e-4, 8.491e-05, 2.3598e-05, 6.2664e-06, 8.7920e-07, 2.0045e-14$$

Therefore, the underlying dimensionality of the space is 1. The remaining principal components are due to the redundant degrees of freedom that Baxter's arm has for reaching the target.

4 Demo video

We selected the right arm to perform the demonstration video.