Tutorial 2 – Parameterization of a robot for TMS

This tutorial deals with the parameterization of the supporting structure and the calculation of the elementary transformations.

Figure 3 extends the parameterization proposed in the previous tutorial.

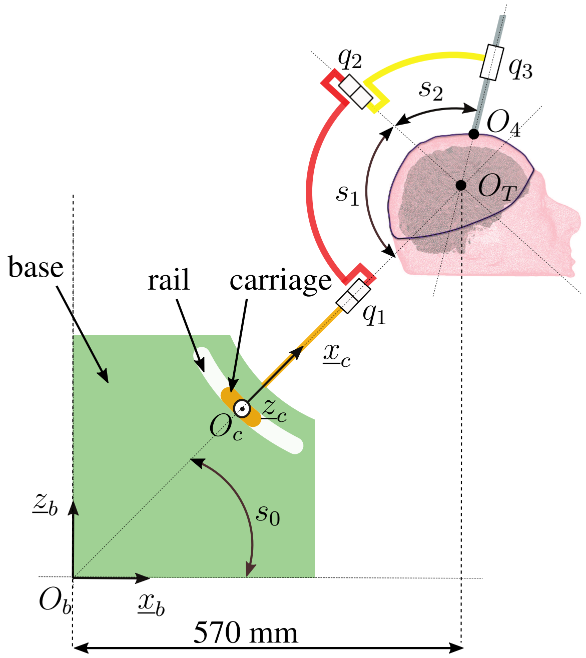

Figure 3: Supporting structure in a planar (sagittal) configuration.

The system parameterization will be performed using a printed version of Figure 4, provided by the teachers during the tutorial. The system has two circular s_1 and s_2 long segments. The angle s_0, which defines the rotation of the first body of the supporting structure, with respect to the robot base, is still considered as fixed in the present tutorial.

The frames $\mathcal{F}_b = (O_b, \underline{x}_b, \underline{y}_b, \underline{z}_b)$ and $\mathcal{F}_c = (O_c, \underline{x}_c, \underline{y}_c, \underline{z}_c)$ defined in Figure 3, are respectively attached to the robot base and the carriage on which the robot arm is mounted. Note that these two frames are *imposed* in this problem. At the contrary, the parameterization of the supporting structure has to follow the rules presented during the course, and is therefore free of any other constraint.

Questions

1 Why is Figure 4 appropriate for parameterization?

2 In Figure 4, place the frames $\mathcal{F}_i = (O_i, \underline{x}_i, \underline{y}_i, \underline{z}_i)$, for $i = 0, \ldots, 3$ using Denavit-Hartenberg modified parameters convention. Please, do not represent the $\underline{y}_i$ axes as recommended.

3 Fill in the Denavit-Hartenberg modified parameters table.

4 Calculate the homogeneous transformation matrices $T_{i-1,\,i}$ for $i = 1, \ldots,\ 3$.

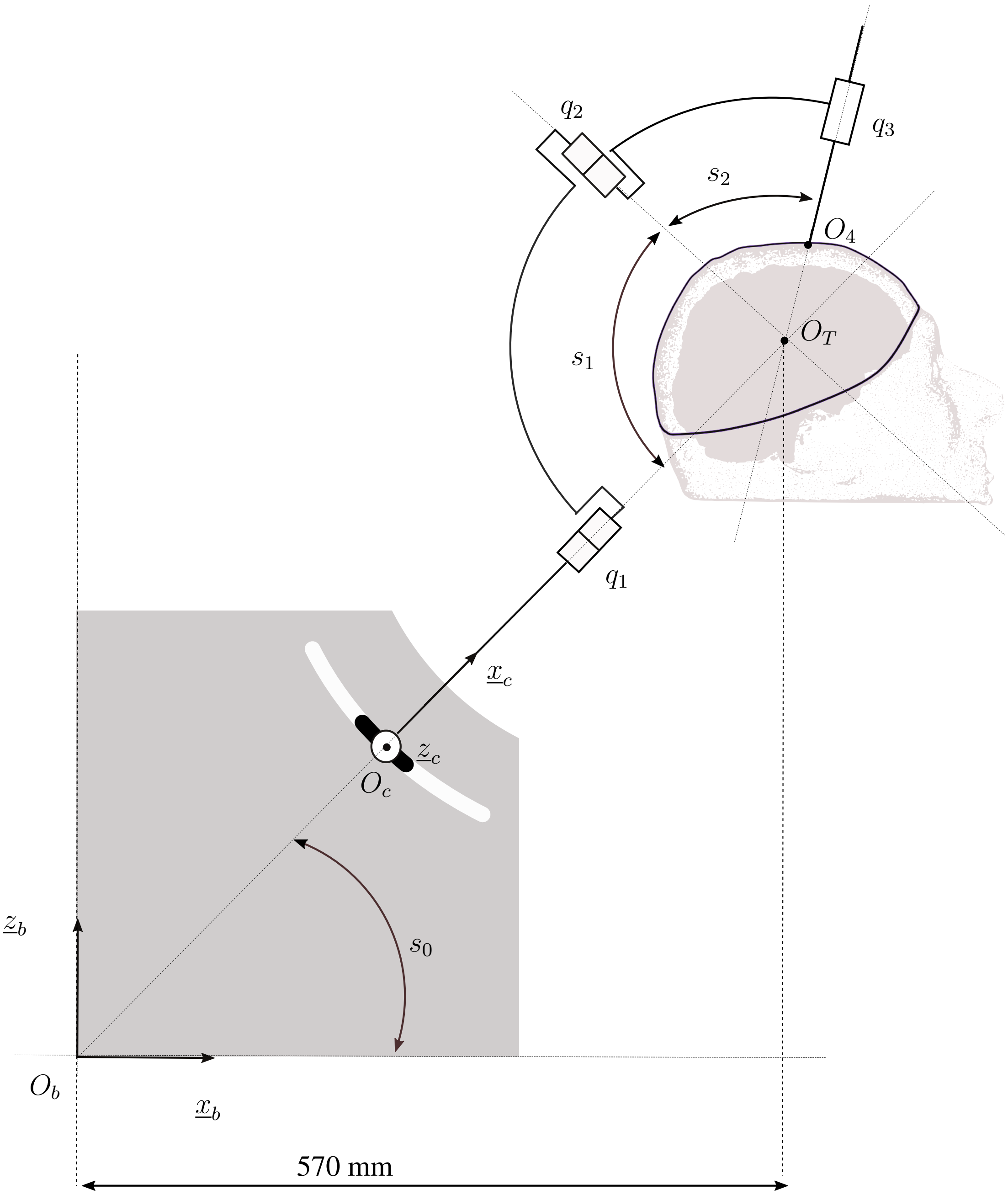

Figure 4: Supporting structure in planar sagittal configuration for parameterization.

Tutorial 2, homework – Simulation of the TMS robot

This homework aims at checking Tutorial 2 calculations.

Work to be done

In the previous tutorial, you have determined all the homogeneous transformation matrices $T_{i-1,\ i}$ for $i = 1, \ldots,\ 3$. They are useful to compute the Forward Kinematic Model (see next tutorial), but also to plot the robot links in a correct way.

0 Have a look at Tutorial 1 to check:

1. that you have already computed $T_{b,\ 0}$: recall the expression.
2. that you are therefore able to express all the links positions in $\mathcal{F}_b$ when you know the transformation with respect to $\mathcal{F}_0$

1 From the calculations made in Tutorial 2, program with MATLAB the transformations that have to be applied to represent the robot links. To that purpose, study the proposed functions: `modeling.m` (for programming) and `circular_arc.m` (the latter should not be modified). Note that the calls to the plot functions have been already been defined, but that the homogeneous transformation matrices computation has to be programmed.

2 Take some examples to check if everything is correct, e.g. $s_1 = s_2 = \frac{\pi}{2}$ and some well chosen values for q_1, q_2 and q_3, like $q_1 = q_2 = q_3 = 0$ or $q_1 = \frac{\pi}{2}$, $q_2 = -\frac{\pi}{2}$ and $q_3 = 0$.

3 When you will be working hard on the topic, for instance for the exam, check that you understand all the MATLAB code that has been implemented[1]. In particular, observe how `circular_arc.m` was modified, compared to the previous tutorial, in order to plot the robot links in a more generic way. Also observe how the last link is defined in the code: it can help you understand the respective positions of O_3 and O_4 in Figure 4 .

[1] and of course report any bug :-) to the professor