Robot end effector orientation and distance compensation

The main task of this part is to maintain the robot end effector at a certain distance from the intended wall at the proper perpendicular orientation, this will allow the correct measurements from the sensor placed on the end effector of the robot.

The approach is based on the distance data (d_A, d_B, d_C) from three non-colinear sensors located at given known positions on a plate mounted on the end effector. These three sensors form a triangle on a plane and ideally all three maintain the same desired distance reading *d* from the wall, ensuring a proper distance and orientation of the plate with respect to the wall.

$$\boldsymbol{w}_A = \boldsymbol{p}_A + \boldsymbol{d}_A$$

$$\boldsymbol{w}_B = \boldsymbol{p}_B + \boldsymbol{d}_B$$

$$\boldsymbol{w}_C = \boldsymbol{p}_C + \boldsymbol{d}_C$$

With the known positions of the sensors and the corresponding measured distances to the wall, we can obtain the position vectors of the projected points on the wall. Once these intersection points are obtained, two vectors ($\boldsymbol{v}_1$ and $\boldsymbol{v}_2$) that belong to the plane on the wall can be obtained, and the cross products between them will give us the normal vector of the wall with respect to the plate $\boldsymbol{n}_W$, which ideally should be parallel to the plate's normal vector.

$$\boldsymbol{v}_1 = \boldsymbol{w}_B - \boldsymbol{w}_A$$

$$\boldsymbol{v}_2 = \boldsymbol{w}_C - \boldsymbol{w}_A$$

$$\boldsymbol{n}_w = \boldsymbol{v}_1 \times \boldsymbol{v}_2 = \begin{bmatrix} w_x \\ w_y \\ w_z \end{bmatrix}$$

Once this vector is obtained, we can compute the pitch and yaw angular errors through its components

$$\beta = \tan^{-1}\left({}^{w_x}/_{w_z}\right)$$

$$\gamma = \tan^{-1}\left({}^{w_y}/_{w_z}\right)$$

With these angular errors we can compensate for the errors at the end effector level of the robot. Once the plate is correctly aligned with the wall, the distance can also be compensated directly in the z direction of the end effector according to the measurements.

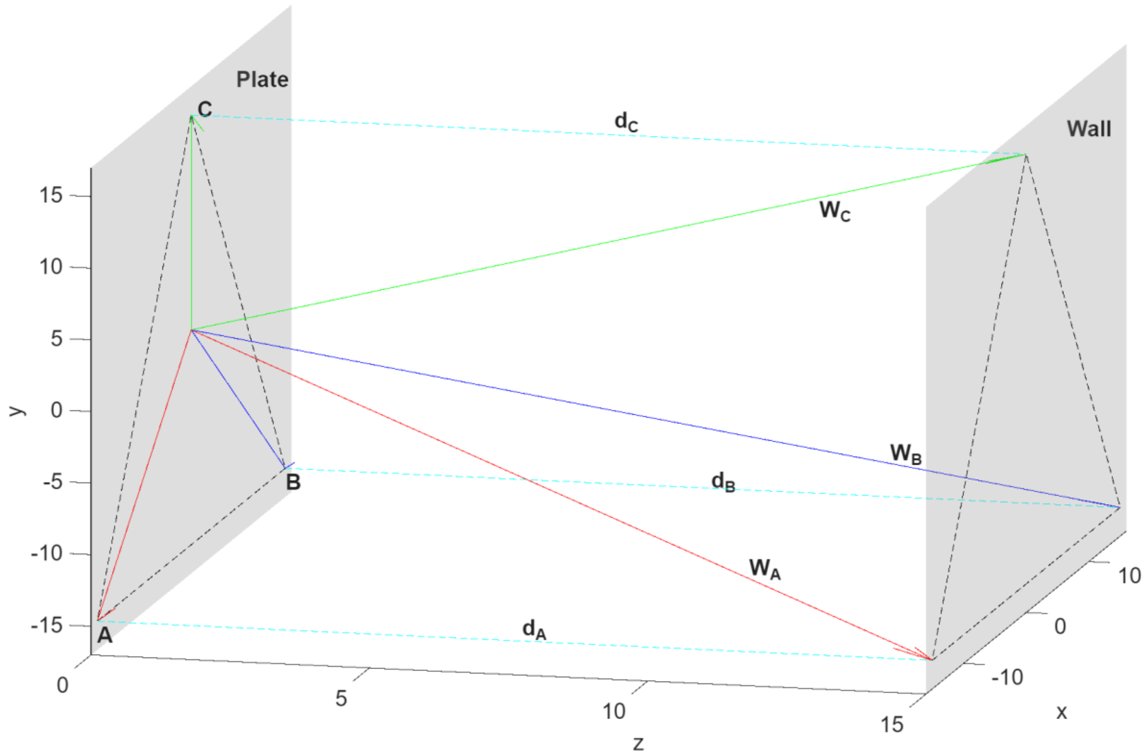

Plate
Wall
C
B
A
d_C
d_B
d_A
W_C
W_B
W_A
y
z
x
15
10
5
0
-5
-10
-15