Transform the force-torque (FT) output of the load cell (LC) to the tool coordinate system (CS), either by using the load cell’s software or by the following transformation:

For force vector: where *F* is the force vector *F*=(*Fx , Fy , Fz*)

For torque vector: where *Torq* is the force vector *Torq*=(*Torqx , Torqy , Torqz*)

Now the FT output is relative to the tool CS.

We need to get a transformation of the current tool’s pose (ti) to a new tool pose (ti+1) relative to the base frame which reduces the FT. This is:

Thus, we need a transformation that represents the new tool pose (ti+1) relative to the current tool pose (ti). This will be constructed from the FT transformation above.

Say the rate of correction is set at 1 mm/N for forces and at 1°/Nm for torques. Then,

For forces: and similarly for the y and z directions. Note the (-) sign which denotes correction in the opposite direction of the force. Also note that the rate can be different for each direction. It can also be given a lower threshold to remove jitter near zero, and an upper limit to avoid large corrections.

For torques: and the same notes apply similarly as for corrective translations.

Now build a rotation R matrix from *Rotx, Roty,* and *Rotz* using the equations of the Craig text according to the fixed-axis method.

Now build the T matrix using R and the translations *Transx, Transy,* and *Transz*

The final T matrix represents the small translations and rotations needed to correct counter the forces and torques at the tool’s coordinate system. This is suitable for the matrix needed for the tool CS transformation above.

The load cell should be zeroed in order to ignore preloads. This this way, the above will provide reference following. For a pre-planned navigation path, a different treatment may be needed.