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MEEN 537 Advanced Mechanisms Robotics

Project Abstract

Soft robot task space accuracy and repeatability are affected by dynamic and kinematic model error. At the start of this project, the RaD Lab utilized joint space controllers to control desired joint angles; however, due to kinematic modeling uncertainty, these desired joint angles did not result in accurate cartesian end effector positions. We found that the cartesian end effector position error when controlling in joint space alone was on the order of 15 cm (using a slightly outdated set of DH parameters). In order to decrease this error, we implemented a cartesian controller using an HTC Vive virtual reality system for end effector position feedback. Our algorithm consisted of the following steps:

1. Set a reachable x_{des}
2. Calculate the initial joint angles (q_{cmd}) to command using TracIK (an inverse kinematics library in python)
3. Send q_{cmd} to the existing PID joint space controller and wait for steady state to be reached
4. Once steady state is reached, output the actual end effector position (x_{act}) from the vive and calculate $\Delta x = x_{des} - x_{act}$
5. Calculate the Jacobian (J_A) using sympybotics (a python robotics library)
6. Calculate a Δq using a numerical inverse kinematics approximation $\Delta q = (J_A)^T * K * \Delta x$
7. Calculate a new commanded joint angle to the PID controller $q_{cmd}(t_{k+1}) = q_{cmd}(t_k) + \Delta q$
8. Repeat steps 3-7 until Δx is within a desired tolerance

Using this algorithm, we were able to drive the cartesian end effector position to less than 1 cm of error.