Robotic Valve Turning: Axial Misalignment Estimation from Reaction Torques

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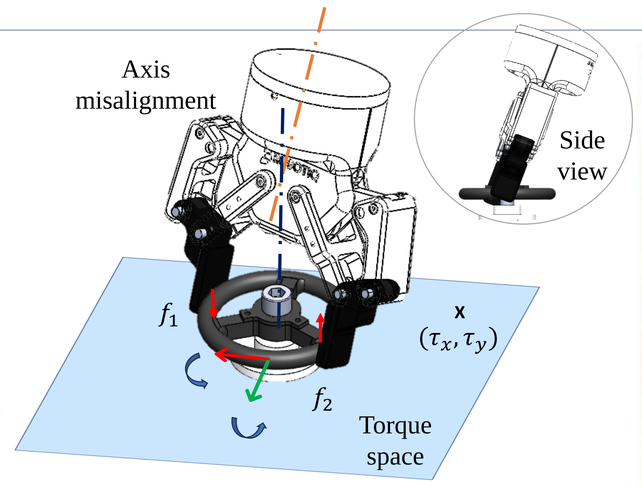
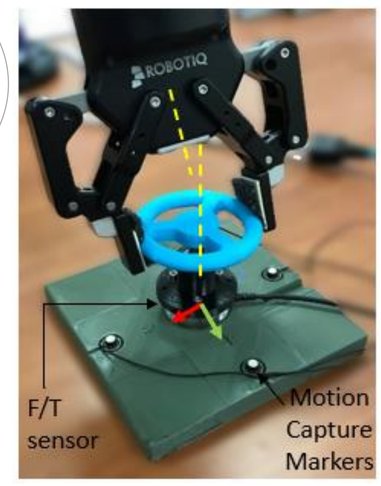
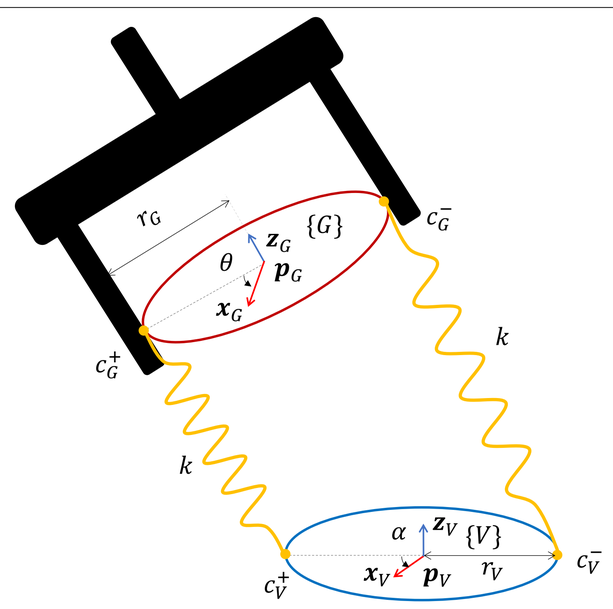
Aim

- Humans easily adapt to **axis misalignments** in tasks like turning a doorknob or twisting a bottle cap.
- When a similar task has to be automated, e.g. a motor is to be connected to a valve or a wheel, a **flexible coupler** is typically used to absorb misalignments as misalignment, albeit small, is unavoidable.
- We **predict axial misalignment** between the valve and the gripper from the reaction torques produced at the base of the valve.

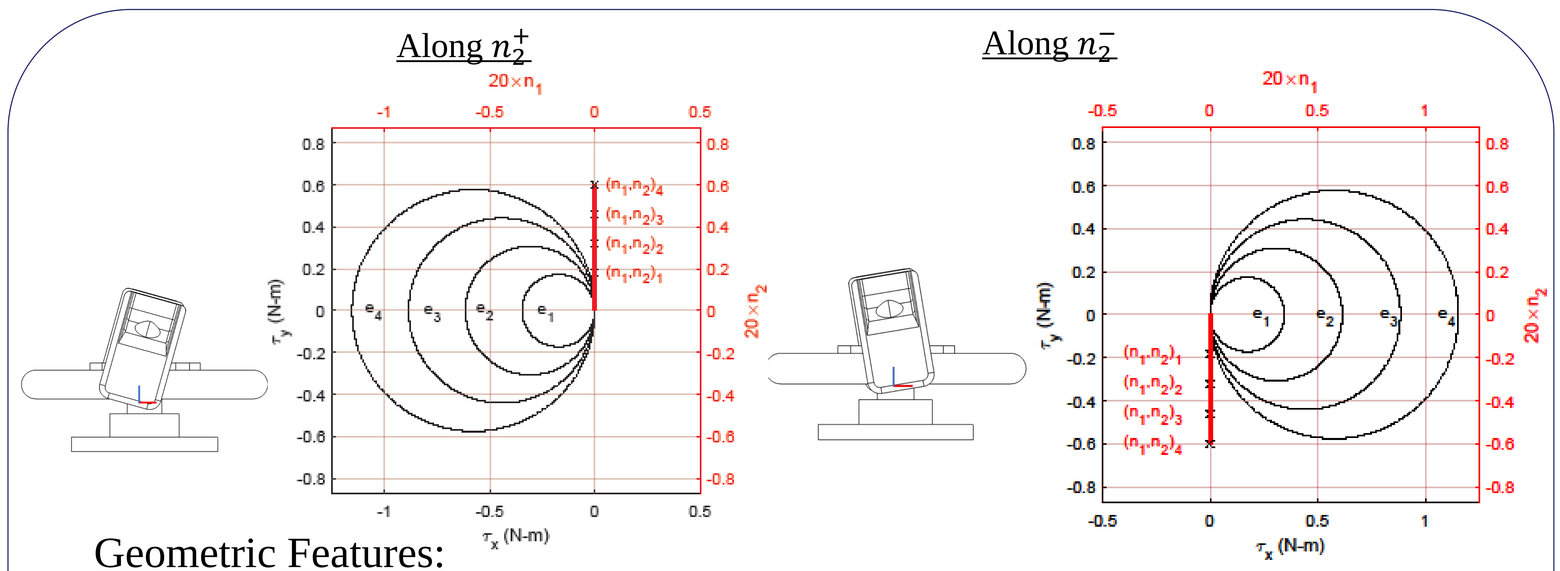




Quasi-static Model and Expected Results



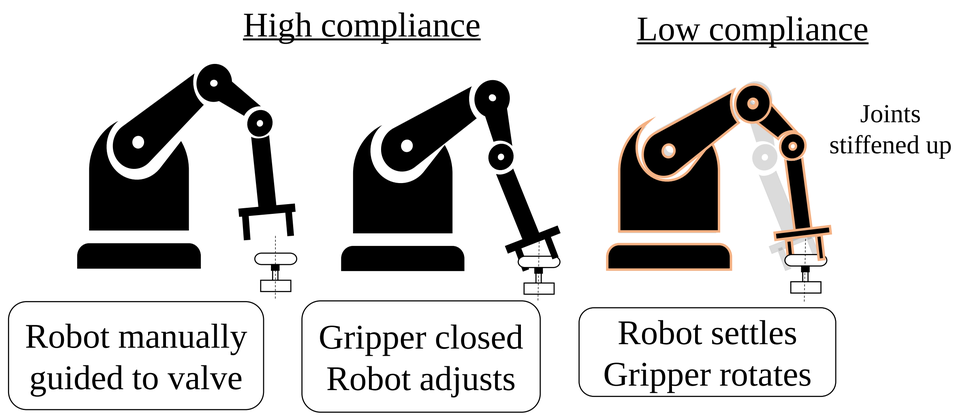
Evaluating reaction torques under quasi-static conditions



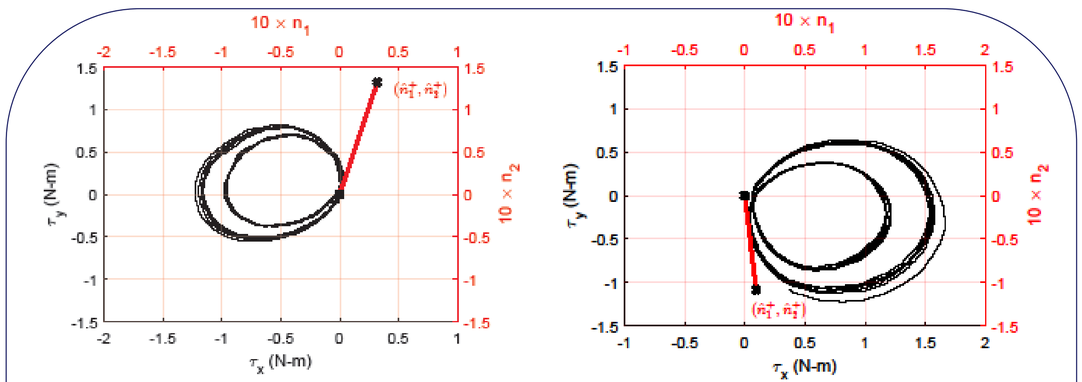
Geometric Features:

1. One torque space ellipse = half rotation of valve
2. Ellipse area $\propto$ misalignment
3. The vector is always tangent to the ellipse.

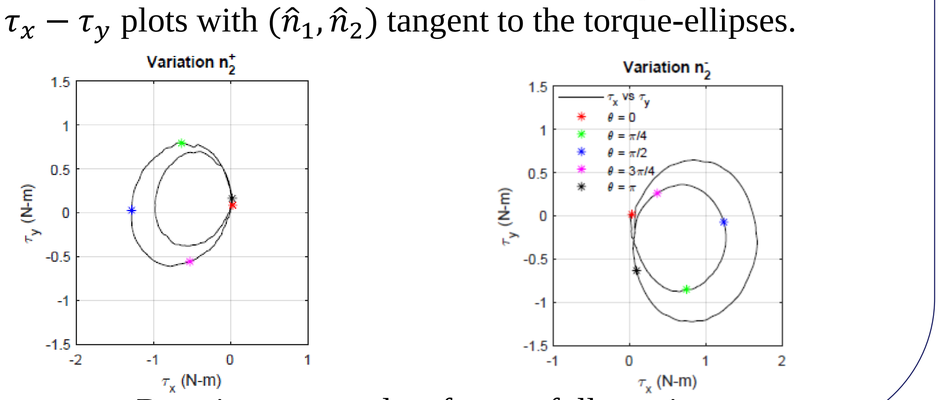
Experimental Validation



- In **high compliance mode**, the robot's joints adjust to equilibrium as the gripper closes.
- Robot set to **low compliance mode**, gripper rotates valve (torque control), reaction torques are recorded and gripper disengages safely.



$\tau_x - \tau_y$ plots with $(\hat{n}_1, \hat{n}_2)$ tangent to the torque-ellipses.



Reaction torque plots for one full rotation

Conclusion

Learned about geometric features that are indicative of axial misalignment by modeling reaction torques during valve rotation.

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