Robotic Valve Turning: Axial Misalignment Estimation from Reaction Torques

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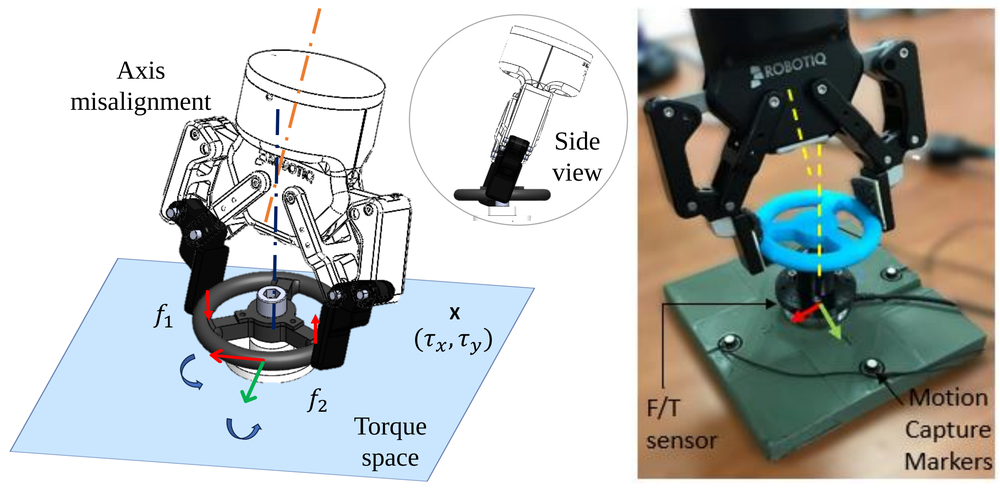
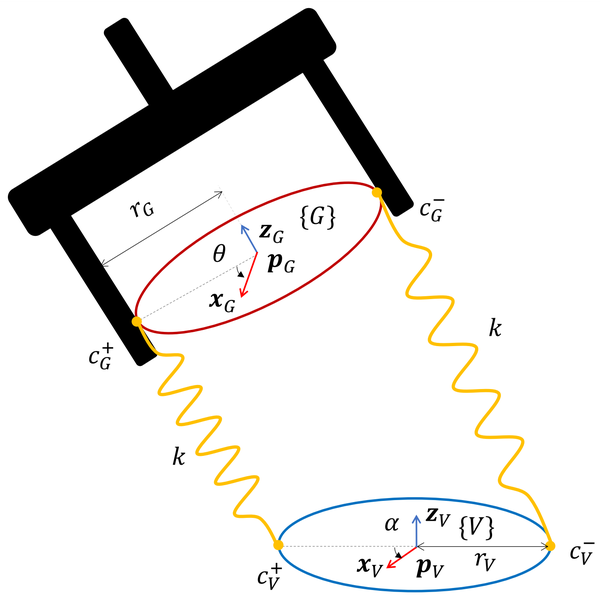
Aim

- 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.



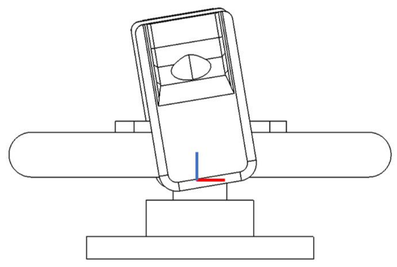
Quasi-static Model and Expected Results



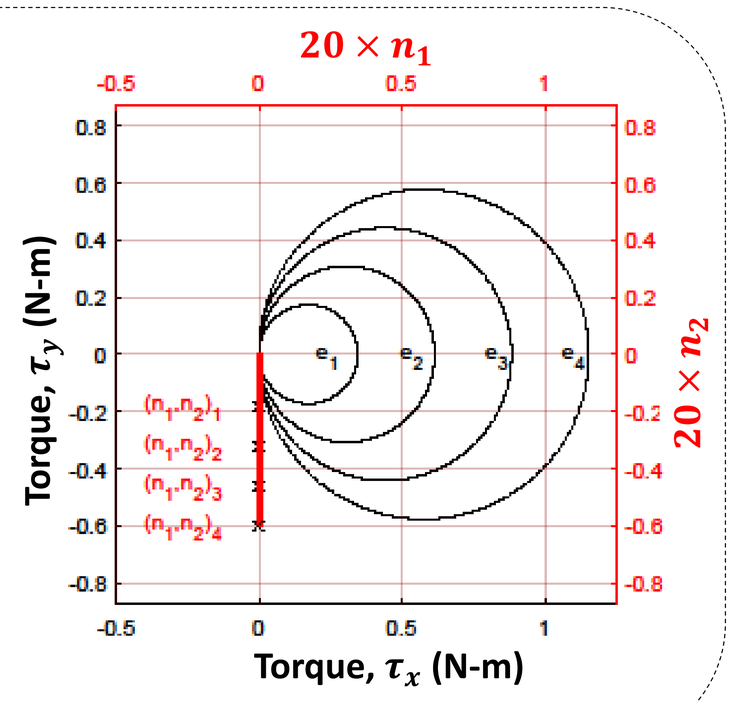
Evaluating reaction torques under quasi-static conditions.

Geometric Features:

- 1 torque space ellipse = 1/2 valve rotation
- Ellipse area ∝ misalignment
- The vector is always tangent to the ellipse.



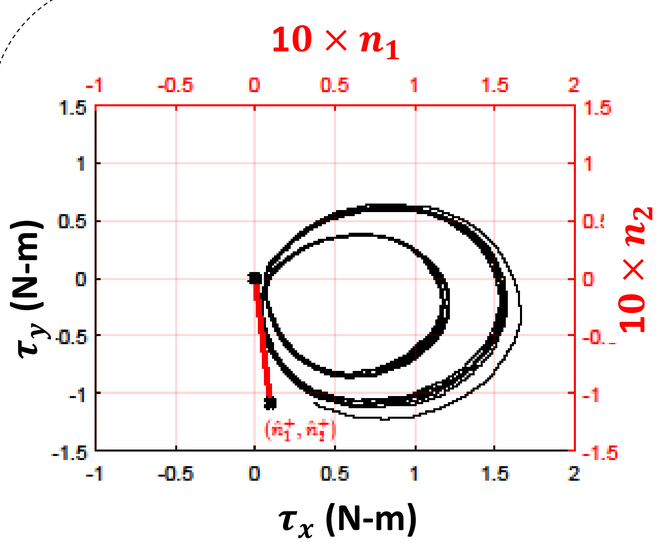
Gripper configuration: misaligned along n_2^-



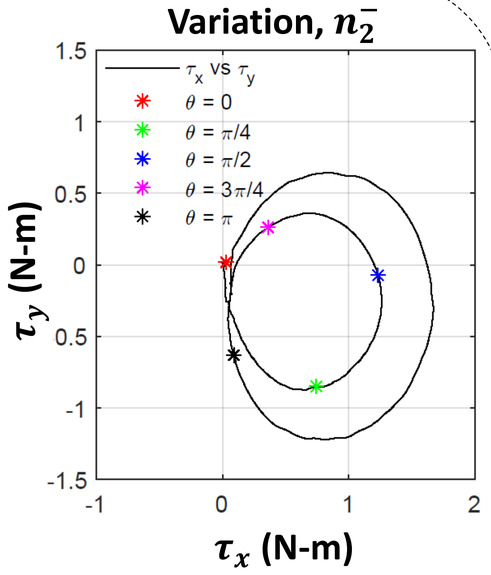
Experimental Validation

High compliance *Low compliance*

- 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

Axial misalignment can be predicted from reaction torques under quasi-static assumptions.

This research is supported by the National Research Foundation, Singapore, under the NRF Medium Sized Centre scheme (Centre of Advanced Robotics Technology Innovation, CARTIN)