Individual Research Project Interim Report

Project Overview:

In modern industrial and research contexts, robotic arms must dynamically adapt to changing tasks and environments. Conventional position-based controllers often lack responsiveness and might not be able to meet real-time precision requirements. Resolved-Rate Motion Control (RRMC) provides a robust alternative by mapping desired end-effector velocities to each joint's velocity command through the Jacobian pseudo-inverse. This project seeks to develop Advanced Velocity Control using the RRMC method. The aim is to enhance adaptability, accuracy, and operational safety in applications such as manufacturing pick-and-place or logistics sorting.

Project Description:

- **Simulation & Modeling**
  - Using Robotics System Toolbox to import a rigidBodyTree model
  - Validating forward and inverse kinematics in Simulink.
- **RRMC Algorithm Development**
  - Defining end-effector velocity targets.
  - Computing the Jacobian each step, then apply the pseudo-inverse.
  - Commanding joint velocities, ensuring enforcement of joint limits and avoiding collisions.
- **Implementation & Testing**
  - Visualising results in Simulink 3D.
  - Collecting data on tracking accuracy and responsiveness.

- Comparing basic RRMC vs. advanced approaches (e.g., QP-based velocity control).

Literature Review:

In the early research of differential kinematics, the major trend is to focus on basic velocity control. However, advanced techniques have emerged, such as using null-space projection for redundancy and optimization of secondary objectives. The recent researches emphasize integrating second-order kinematics for better performance near singularities and for complex motion planning. From two references, the detailed introduction about how RRMC can be extended into a robust closed-loop scheme that accounts for velocity constraints, improving real-time adaptability compared to static IK solutions is presented.   In particular, the pseudo-inverse of the Jacobian is key to converting desired task-space motion into safe and precise joint-space commands.

Future Plan: