Recommended Assessment

Visual Servoing

Image Processing

1. Why is the inverse Jacobian matrix used in visual servoing? How does it help control the manipulator's movement?

   The inverse Jacobian matrix is used in to map the desired end-effector velocities in the image space to corresponding joint velocities. It provides a relationship between the manipulator's joint movements and the changes in the object's position in the camera frame. The system can adjust the joint angles in real-time to minimize the error between the current and target object positions.

2. What differences do you observe when switching from 2-joint tracking to all-joint tracking? Why does this change the manipulator's behavior?

   When using 2-joint tracking, the manipulator tracks the object more accurately because the movement is constrained to key joints, allowing quicker adjustments to changes in the object's position. However, this approach results in a less smooth trajectory due to limited joint flexibility. In contrast, all-joint tracking produces smoother motion by distributing movement across all joints. However, the end effector may continuously adjust to center the object in the camera view, leading to reduced tracking accuracy and potential oscillations if the object moves unpredictably.

3. What limitations might you encounter when tracking objects with different colors or lighting conditions? How could you improve the system's robustness?

   Tracking objects with different colors or varying lighting conditions can be challenging due to changes in saturation, and brightness. Variations in lighting can cause color shifts, making it harder to maintain consistent detection. Similarly, reflective or translucent objects may produce inaccurate color readings. To improve the system's robustness, you could expand the hue, saturation, and value (HSV) range to account for lighting variations and apply additional filtering techniques to reduce noise.

4. If the object moves too quickly or leaves the camera frame, how might the system respond?

   If the object moves too quickly or leaves the camera frame, the system may lose track of it due to the limited frame rate and processing speed. Rapid motion can cause motion blur, reducing detection accuracy, while objects leaving the frame prevent the manipulator from receiving positional updates, causing it to stop or move erratically.