**ME 5250 – Project Report**

**Name: Sachidanand Halhalli**

**Key Challenges and Solutions**

**Trajectory Planning in Joint Space:** One of the most significant challenges was ensuring the robot moved smoothly and precisely while adhering to the movement threshold. Initially, I attempted a Cartesian space approach, but difficulties with inverse kinematics accuracy led me to shift to a joint space planning method.

* **Solution:** I developed a function to calculate joint space waypoints using linear interpolation, ensuring the distance between consecutive joint configurations did not exceed the specified maximum joint step. This allowed for smooth transitions and avoided overshooting or violating hardware constraints.

**Real-World Testing with the Robot:** Testing the pick\_place.m code with the physical robot introduced new challenges, such as ensuring the set\_joint\_pos function accurately sent joint positions while respecting thresholds.

* **Solution:** I implemented a persistent variable to track the previous transformation matrix (prevTF) for validating movement thresholds and preventing large jumps between waypoints. This also required debugging to ensure all commands worked seamlessly with the robot's hardware.

**Main Contributions**

**Joint Space Trajectory Planning Function:** The trajectory\_plan function was designed to calculate a series of waypoints in joint space between the current and target joint configurations.

**The key steps involved:**

**Waypoint Generation with Interpolation:** The function uses linear interpolation to compute intermediate joint angles, ensuring the distance between consecutive joint configurations (in joint space) does not exceed the maximum joint step (max\_joint\_step). This prevents abrupt movements and keeps the robot's motion smooth.

**Incorporation of Checkpoints:** To ensure a safe and efficient trajectory, intermediate checkpoints were added at critical stages:

1. Hovering Above the Payload: Before approaching the payload, the robot moves to a position directly above it. This allows the gripper to align properly without risking collisions or misalignment.
2. Approach to Payload: From the hover position, the robot moves vertically downward to grasp the payload. This vertical movement ensures precise control during the pickup phase.
3. Lifting the Payload: After securing the payload, the robot moves back to the hover position to ensure it clears any obstacles before starting horizontal movement toward the drop location.
4. Hovering Above Drop Position: Similar to the pickup phase, the robot hovers above the drop location before descending to place the payload.
5. Returning to Home Configuration: After completing the task, the robot executes a smooth trajectory back to its home position, resetting for future tasks.
6. These checkpoints ensure that the robot avoids sudden or diagonal movements, which could destabilize the payload or lead to undesired interactions with the environment.

**Team Synergy**

I worked on the pick\_place.m file and collaborated with a teammate to share debugging tips and ideas for handling the inverse kinematics (IK) solver. While I primarily focused on joint space trajectory planning, I worked with my teammate on the visual simulation of the robotic arm discussing how to plan the trajectory and what method to follow we tried to use the cartesian waypoints method but we were not able to prepare the trajectory properly with this method so we discussed and switched our approach to joint space waypoint method and with this decision we were able to simulate as planned.

**Learning Outcomes**

* **MATLAB and Robotics Programming:** This project enhanced my understanding of MATLAB for robotics, particularly trajectory planning and executing motion using forward and inverse kinematics.
* **Practical Testing with Hardware:** Debugging and testing my code on a physical robot allowed me to bridge the gap between simulation and real-world execution. I learned the importance of threshold-based validation for safe and precise movements.
* **Future Applications:** These skills directly apply to my interest in robotics and automation, especially for motion planning and control in industrial or research settings.
* With this project I got a starting point on building my MATLAB programming and problem-solving skills, I learned how to apply the theoretical knowledge I learned in my lectures in practical conditions.