

# RCS Project

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Course: *Robotic Control Systems* – Professor: *Anastasios Natsakis*

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## Robotic Platform Description

The chosen robotic platform for this project is the Universal Robot UR5, a highly flexible robotic arm designed for repetitive tasks. With a carrying capacity of up to 5 kg and a radius of 850 mm, this robot is well-suited for light applications, such as packaging, assembly and testing. The UR5 is easy to program, having a user-friendly programming interface. The ease of programming, combined with its safety features, makes the robot an ideal candidate for replacing humans in hazardous work environment.

## Task Description

The task executed on the UR5 robotic arm involves trajectory planning and execution with waypoints. The implemented code defines a sequence of waypoints, guiding the robot through the predefined trajectory.

The initial configuration of the robot is  $[0.0, 0.0, 0.0, -\pi/2, 0.0, 0.0]$ , indicating that it starts from the *home* pose and then aligns itself parallel to the x-axis. The trajectory follows four waypoints that can be seen in the figures below. Then the robot retraces the same waypoints in reverse order, finally returning to the *home* pose, completing a full cycle of the trajectory execution.

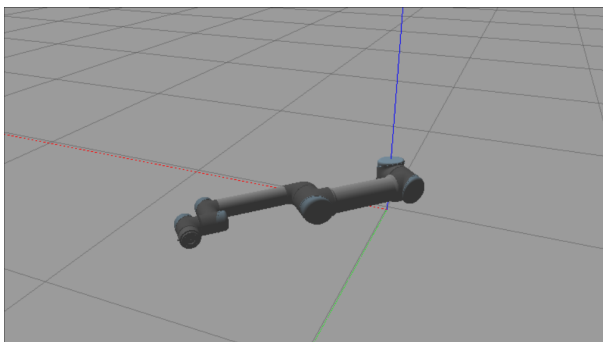


Figure 1: First Waypoint

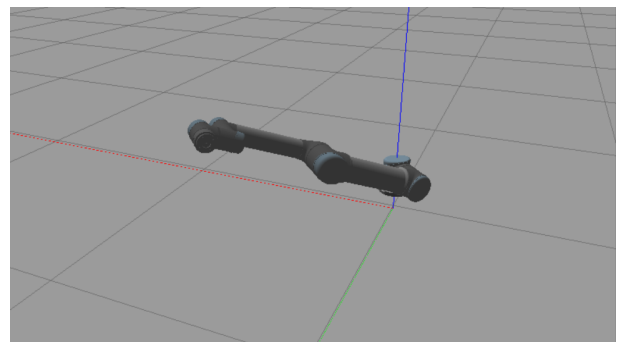


Figure 2: Second Waypoint

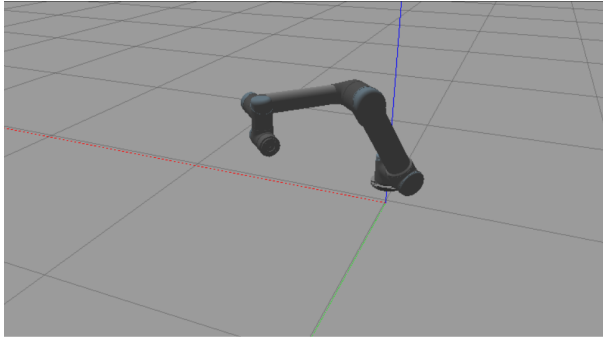


Figure 3: Third Waypoint

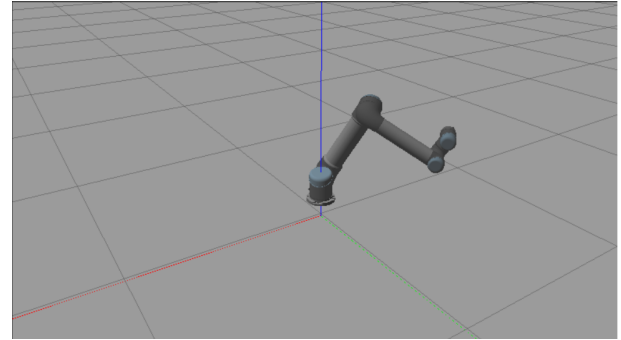


Figure 4: Fourth Waypoint

### Implementation Performance

1. **Task Performance Time:** The trajectory planning and execution with waypoints task was successfully completed with a measured time of approximately 45.7 seconds, acknowledging the possibility of an increase in this value for certain simulations.
2. **Limitations:**
  - (a) The environment is considered to be collision-free.
  - (b) Explicit joint checks were not implemented, but the selected joint configurations fulfil the range of motion of the robot.
  - (c) The robot has no load capacity.
  - (d) The robot may not adapt to changes in the environment.
  - (e) The accuracy of the robot's movements may be limited.
3. **Specifications**
  - (a) **Degrees of freedom:** The robot has 6 DOF.
  - (b) **Payload Capacity:** The UR5 has a maximum payload capacity of 5kg.
  - (c) **Reach:** The robot has a radius of 850mm.
  - (d) **Easy to Setup:** The UR5 is quick to setup, in less than half a day.
  - (e) **Easy to Program:** The robot offers ease of programming, supporting movements via a touchscreen tablet.
  - (f) **Weight and Space Considerations:** The Universal Robots have a light weight and they can be repositioned easily without the need of changes in the production space.
  - (g) **Safety:** The safety features are certified by TUV, minimizing the risk of accidents.
  - (h) **Reuse of Programs:** The robot can reuse programmed tasks for recurrent applications, contributing to efficiency in repetitive tasks.

## Resources

1. Universal Robot U5
2. Wired Workers - Universal Robots UR5
3. Universal Robot GitHub Repository
4. ROS MoveIt Commander Documentation
5. MoveIt Python Interface Tutorial