Teaching materials
Guide notes 1. Grasping with a robotic hand

MISCE project

Mechatronics for Improving and Standardizing Competences in Engineering

Competence: Robotics

Workgroup: Universidad de Castilla-La Mancha
Universitat Politècnica de València

This document corresponds to the first lecture for the competence ‘Robotics’ using the ‘hand platform’

Version: 1.0

Date: October 5th, 2023

Visit https://misceproject.eu/ for more information.

Index of contents

Index of figures

1 Objective

The main objective of this lesson is to experimentally evaluate the grasping capabilities of a robotic hand when mounted on an industrial robotic arm. Students will perform pick-and-place tasks using predefined gestures of the hand, focusing on the interaction between object geometry, grasp type, and manipulator motion.

The practice aims to develop a practical understanding of robotic manipulation, including concepts such as end-effector orientation, grasp strategy, and workspace planning. Although the hand lacks sensors, the integration with an industrial robot allows a hands-on exploration of real-world manipulation tasks.

Additionally, students will reflect on basic kinematic principles by identifying feasible robot configurations and orientations that ensure effective object grasping and placement.

2 Experimental setup

The robotic hand is pre-mounted on the wrist of an industrial robotic arm. The hand is connected to an Arduino-based control unit, which receives a digital signal from the robot controller to trigger a predefined grasp gesture.

Three objects of varying shape and size, as illustrated in Figure 1, Figure 2, and Figure 3, are placed at predefined positions within the robot's workspace, see Figure 4 and Figure 5. The objective of the activity is to successfully pick and place each object using a robot program that satisfies both grasp and kinematic constraints.

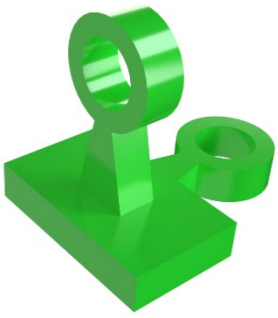

Figure 1. Object type 1

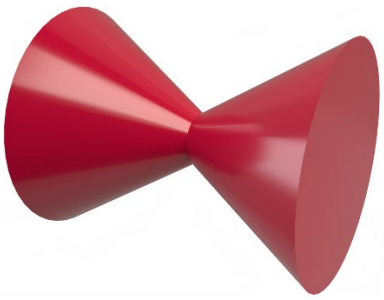

Figure 2. Object type 2

Figure 3. Object type 3

Figure 4. Initial location of the object

Figure 5. Final location of the object

The grasp gesture must be selected in advance using the graphical interface provided in the MATLAB app. There are six different poses that the student can use from the application, as shown from Figure 6 to Figure 11, but it is easy to implement additional poses in the program if the instructor wants to change the type of object or the grasping pose itself.

Figure 6. Pose 1

Figure 7. Pose 2

Figure 8. Pose 3

Figure 9. Pose 4

Figure 10. Pose 5

Figure 11. Pose 6

When the robot reaches the grasping pose, it sends a digital output to the Arduino to activate the selected gesture. Once the gesture has been executed, the Arduino sends back a confirmation signal to the robot, indicating that the hand has closed and that the robot can proceed with the task.

Students are responsible for:

- Selecting the appropriate grasp gesture for each object.
- Planning the robot trajectory considering object location, reachability, and orientation.
- Avoiding collisions and ensuring a stable grasp during transport.
- Executing the movement and evaluating task success.

This setup enables the integration of real-time robotic manipulation, trajectory programming, and open-loop end-effector control, while introducing basic concepts of inter-system communication.

2.1 Considerations about the industrial robot

Since the robotic hand is designed to be mounted on different industrial robots (by adapting the wrist flange), this activity is compatible with any manipulator available in the lab. For that reason, this guide does not include specific programming or safety instructions for a particular brand or model.

However, the instructor is encouraged to dedicate some time before the activity to reviewing basic concepts of robot operation, including:

- Safe startup and emergency stop procedures
- Coordinate systems and reference frames
- Joint and Cartesian control modes
- Manual movement and robot programming basics (e.g., using digital outputs)

This introduction will help students better understand robot behaviour and will reinforce the Robotics skills related to safe operation and behavioural programming.

3 Robotic hand grasping task

The assessment of this activity is based on three main aspects:

1. **Execution and performance:** The student must demonstrate the ability to execute the grasping task successfully. This includes correctly picking up and placing the object using the robotic hand, selecting a suitable grasp gesture from the MATLAB interface, and ensuring the robot performs smooth and safe movements. Particular attention should be paid to proper end-effector orientation, absence of collisions, and control coordination between the robot and the hand.

2. **Planning and reasoning:** Students are expected to justify their decisions regarding the grasping strategy and robot configuration. This involves explaining why a particular gesture was chosen based on the object's geometry and position and evaluating whether the robot's pose and trajectory were appropriate and feasible. Proper understanding of the hand-robot interaction and signal triggering process (from the robot to the Arduino) is also part of this evaluation.

3. **Documentation (individual report):** Each student must complete a brief but coherent report that includes the required photographs, the name of the selected gesture, and a clear explanation of their grasping strategy and execution outcome. The report should reflect their understanding of the task and allow the instructor to verify the reasoning and effectiveness behind their choices.