Introduction to Robotics

Lab Instructor: Miss Sadaf Sheikh
Group Members:
Course Instructor: Dr Basit Memon

LAB 02-GETTING FAMILIAR WITH ARM HARDWARE

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Contents

1 Task 2.1 Model of the arm (25 points)

1.1 (a) Mark all the joints and links in Figure 2.1 or any other image of the arm

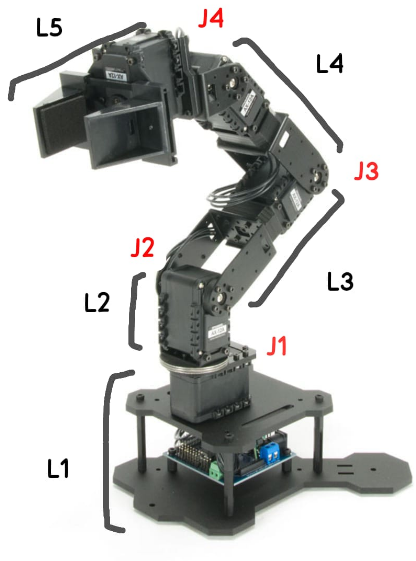


Figure 1: Labelled arms and joints of the robotic arm

1.2 (b) How many joints and links are in this arm? Note that the motor attached to the gripper is only responsible for opening and closing the gripper.

- Links = 5
- Joints = 4

1.3 (c) What is the joint type? Provide a symbolic representation of the kinematic chain corresponding to this arm. Recall that a kinematic chain is symbolically represented as a sequence of joint symbols.

All 4 joints are revolute joints, providing 1 degree of freedom.

1.4 (d) How many degrees of freedom does this arm possess? Hint: You can use Grubler's formula from the class slides.

Using Grubler's formula : DOF = m(L - 1 -J) + $\sum_{i=1}^{J} f_i$
6(5 - 1 -4) + 4(1) = 4

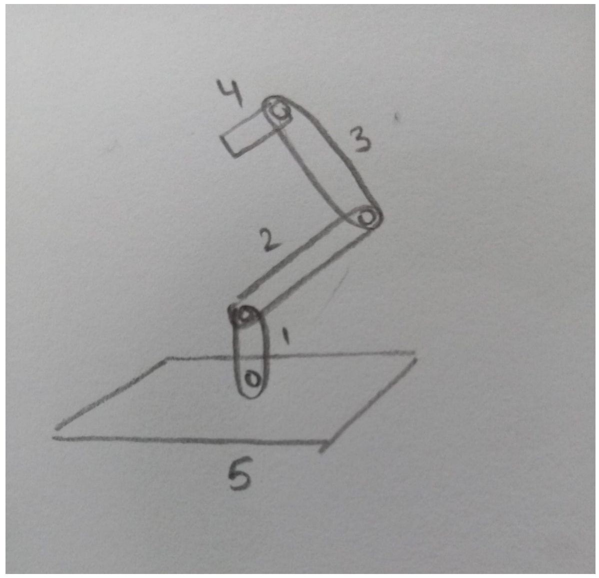


Figure 2: Enter Caption

1.5 (e) Will you be able to arbitrarily position and orient this arm within its workspace?

The workspace is the specification of all possible points that the end effector of a robot can reach.
While working with the hobby arm, we observed that the end effector of the arm can't reach near it's base, which could serve as a limitation while defining the workspace.

2 Task 2.2 Configurations Exploration (15 points)

2.1 (a) Think about a configuration in which the arm reaches the farthest possible point. Move the arm to verify. Draw this configuration as a diagram. In this diagram, links can be represented by line segments and revolute joints by circles.

When all the joints are at 90deg with the x axis along the base, the arm is at the farthest possible point.

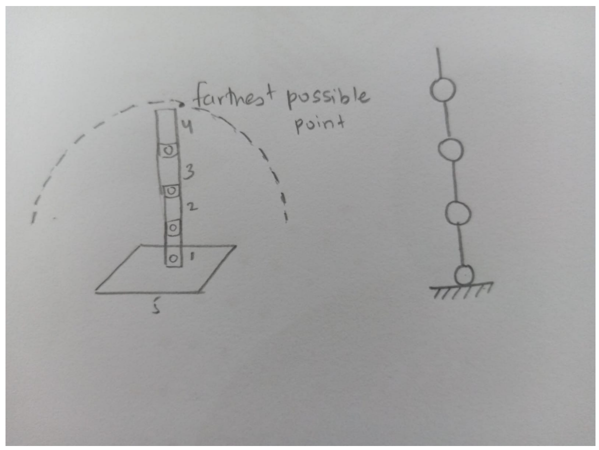


Figure 3: Farthest possible point

2.2 (b) In Cartesian mode, move the robot to an arbitrary (x, y, z) location. Change the wrist angle from the panel and observe what happens to the other joints of the arm. Document your observations and comment on the reasons behind what you observe.

The angles of the shoulder, elbow and wrist all change such that the tip of the gripper (end-effector) still points at the same coordinates. This happens because no changes have been made to the (x,y,z) location, so the end-effector still points there. However, we may want to reach that point from different angles, (like pick a box from above or from the side) so for that we change the wrist angle.

2.3 (c) [*]a The coordinates in the Cartesian or Cylindrical mode describe task space locations. Task space can be used to describe tasks to be carried out by the manipulator, e.g. grabbing a water bottle. Give an example of a task that can be described better in Cartesian coordinates, and a task, which is best expressed in cylindrical coordinates

Any task that involves motion in a linear manner is easy to achieve using Cartesian mode. This could involve reaching out to pick things, and for example designing an electronic chip that requires picking and placing of components on a plane.

Tasks that involve rotation are better executed using Cylindrical mode. It simplifies the description of movements along curves or circular surfaces and can involve tasks such as drawing circles etc.

3 Task 2.3 Coordinate Axes (20 points)

3.1 (a) Determine the directions of positive x, y, and z axes and mark them on paper, in relation to the asymmetric shape of the black base.

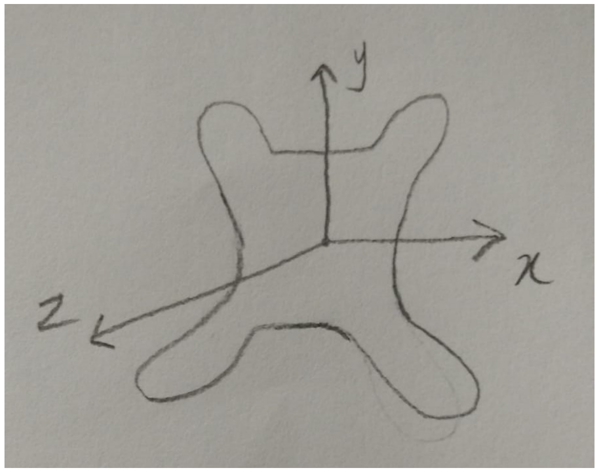


Figure 4: Directions of coordinate axis

3.2 (b) We'll set the origin of the x and y axes at the center of the shaft of the first motor, and the origin of the z axis at the level of the wooden baseboard. If 1 unit in the ArmLink system corresponds to 1 unit in the real world, identify the units being utilized in the real world and the point on the arm corresponding to these coordinates.

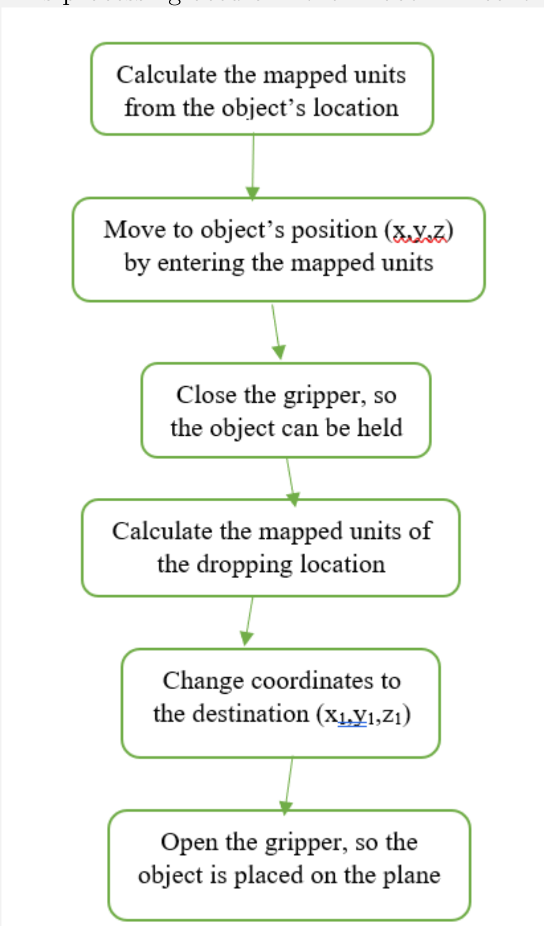
After some testing through the armlink we observed that 30 units on armlink corresponded to 10 boxes in x and 11 boxes in y of the graph paper. This means that for one unit of movement in x in armlink, the effector moved 0.33 boxes in the x coordinate, and one unit movement in y in armlink, the effector moved 0.36 boxes in the y coordinate.

4 Task 2.4 Manipulation (5 points)

4.1 Grab one each of the provided objects. In this task, you'll place each of these objects at a fixed location in your workspace, move the arm using ArmLink in Cartesian mode to that location, pick the object with the arm, and place it at another location. A ruler may be of help to you.

(a) Describe the steps taken as a block diagram. How is the real world environment being sensed in this case? How is the arm motion being adjusted based on the received sensing data? Where is this processing happening?

The environment is being sensed though our eyes, the feedback and input both are being given through our eyes. Using camera is a sensor is also an option for automating this process. Forward kinematics is being applied, and the angles of the base, shoulder and elbow joints are being calculated, so that the tips of the gripper (the end-effector) reach the desired coordinates. This processing occurs in the Arbotix-M controller in the ARM robot.



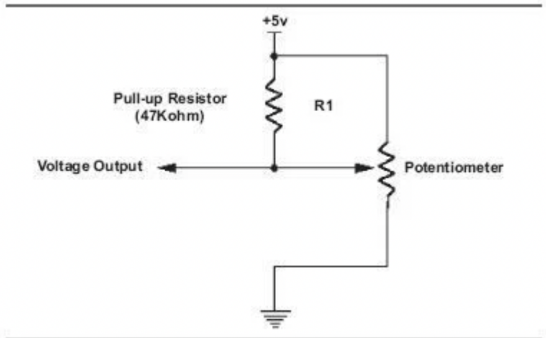


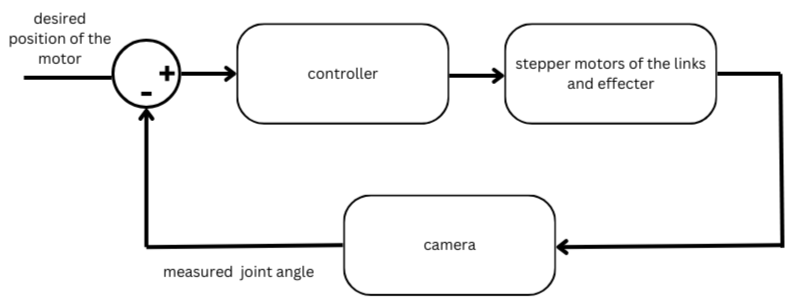
Figure 5: Enter Caption

5 Task 2.5 Design of vision-based system (20 points)

5.1 (a) [*] Figure 2.10 suggests that a potentiometer is being used as the shaft position sensor. Research and describe how can a potentiometer be used for this purpose.

a. Potentiometer can be used as a sensor that basically maps the rotation to certain resistance values, which can then be translated into voltage values. Most potentiometers rotate to 270 degrees and a 1:1 ratio gear can be used to measure movement from 0 to 270 degrees. To compute angle more than 270, we can use a ratio other than 1:1.

5.2 (b) You're now aware that the servomotors installed in the arm expect the desired joint angle as input. Furthermore, imagine that you now have an overhead camera available to you and you'll not use the Armlink software. Draw a block diagram of a robotic system for a pick and place task. Each block's text should describe the block's function. Try to add as much detail as you can to your diagram.



- Input: User provides information about the object's desired pick-up and placement location (e.g. coordinates in real axis)
- Camera as the sensor: Captures real-time video of the workspace and objects. Uses computer vision algorithms (object detection) to identify the object and determine its position and orientation in the image. Also continuously monitors the object and workspace for confirmation of successful pick-up and placement and detection of any unexpected changes or disturbances.
- Planning: The controller implements the trajectory for the arm keeping start end points and joint angle constraints in consideration.
- Actuator: The motor in the links of the robot arm execute the planned movement, following the trajectory and adjusting for any minor real-time changes detected by the camera and the gripper opens and closes at the designated point to pick up and place the object.

5.3 (c) [*] Identify and list all the sensors and actuators in your complete robotic system.

- Actuators: Servo Motor + Gripper Motor
- Sensor: Camera Sensor

6 Task 2.6 Motor Specifications (15 points)

6.1 (a) Find the angle rotation limits, resolution (see the definition below), speed limit, and torque limits of AX-12A servo.

- Stall Torque 1.5 [N.m] (at 12 [V], 1.5 [A])
- Resolution 0.29 [°]
- No Load Speed 59 [rev/min] (at 12V)

6.2 (b) [*] Will this motor resolution limit the possible Cartesian resolution of the end-effector? If yes, why?

As observed from the data sheet, the resolution of the servo angle is 0.29 degrees, which would directly correspond to the cylindrical coordinates, where the smallest rotation can be of 0.29 degrees.
When we convert this cylindrical theta value(and r , which could be the length of the link) to the Cartesian system, using x= r cos theta and y = r sin theta then as a result the resolution of cartesian will be impacted by same ratio.

6.3 (c) Will you be able to pick an object placed in any configuration in the robot's workspace? Justify your response.

The AX-12A motor resolution might not limit object grasping entirely. Gear reduction in joints and coordinated movement of multiple joints can compensate for limited resolution, allowing the robot arm to reach various configurations. However, precise grasping of delicate objects or achieving perfect alignment might be challenging due to the limited number of discrete positions the servo can reach.