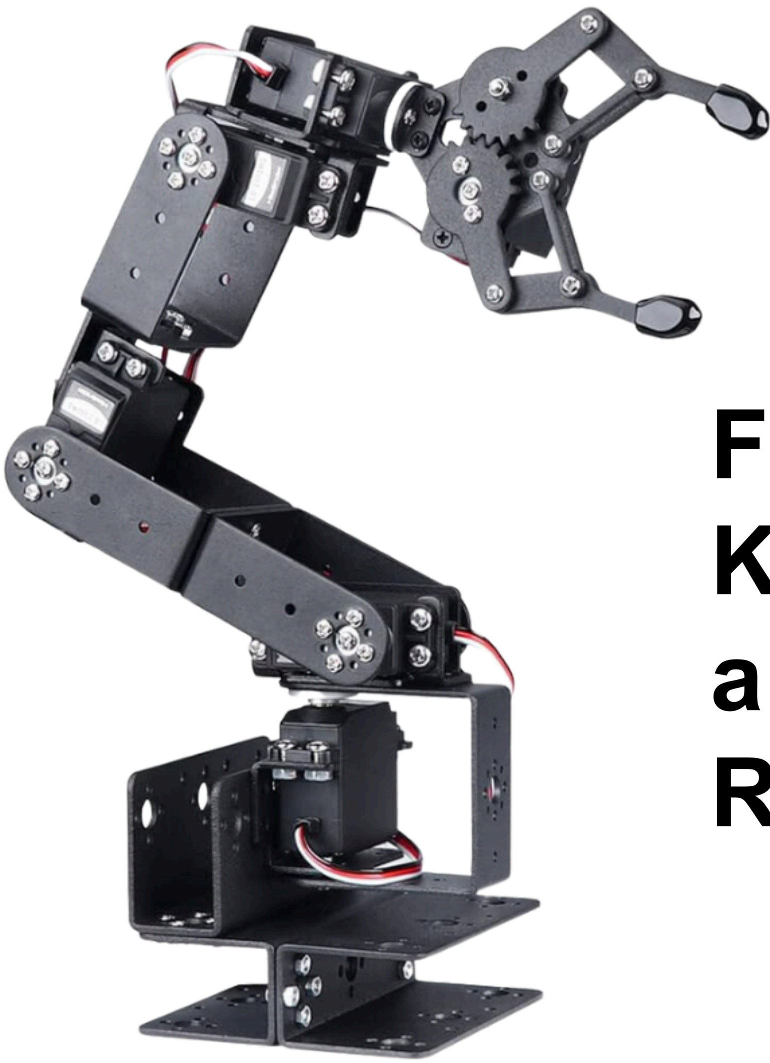

Forward Kinematics of a 6-DOF Rot3u Robotic Arm

Code Link: [Github Repository - Arduino Sketch]
Code Link: [Github - Python Scripts]

The Cartesian Choreographers Team Members:

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1. Introduction

This report details the forward kinematics analysis performed on a 6-DOF Rot3u robot. Forward kinematics determines the end-effector position and orientation of a robot manipulator based on the joint angles. This information is crucial for robot control and path planning applications.

2. Denavit-Hartenberg (DH) Parameters

The analysis utilizes the DH convention to establish a systematic approach for calculating the robot's forward kinematics. The DH table includes the following parameters for each joint:

- α (alpha): Angle of rotation about the previous x-axis. This twist aligns the previous z-axis with the current z-axis.
- a (a): Offset distance along the previous x-axis between the previous and current joint axes.
- θ (theta): Joint angle variable (rotational).
- d (d):Distance along the previous z-axis from the previous origin to the current origin.

i	a	α	d	θ
0	0	0	0	θ_0
1	0	90	0	θ_1
2	10.5cm	0	0	θ_2
3	10cm	0	0	θ_3
4	0	0	0	θ_4

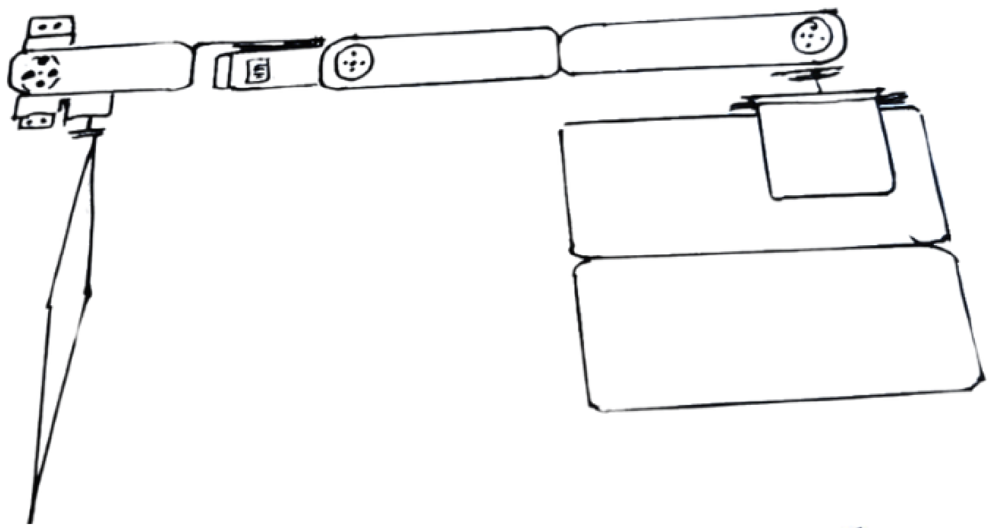
From the DH table the Transformation matrices from base frame 0 to frame 4 were calculated using the python script, then the resultant matrix was multiplied by the last transformation of frame 4 to 5 shown below which gave us the final transformation from base to the end effecter 4x4 transformation Matrix from frame 4 to frame 5 is given below in tabular form:

${}^4T_5$ =

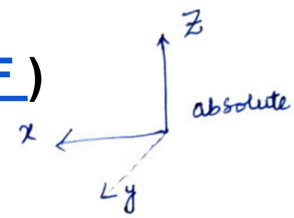
1	0	0	-2.5cm
0	$Cos90^0$	$-Sin90^0$	-16.8cm
0	$Sin90^0$	$Cos90^0$	0
0	0	0	1

3. Initial Configuration

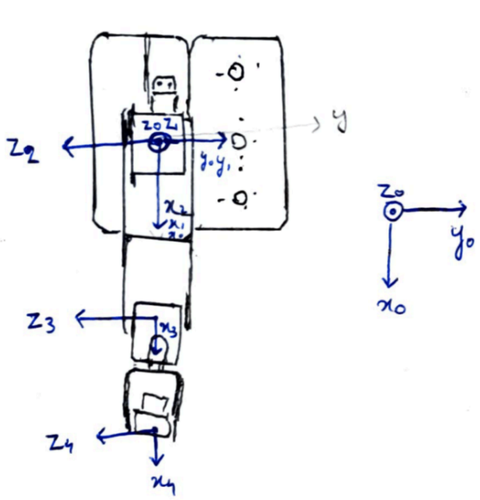
The initial configuration of the robot, including the joint angles (θ values = 0) for each joint, is specified. This serves as the starting point for the forward kinematics calculations.

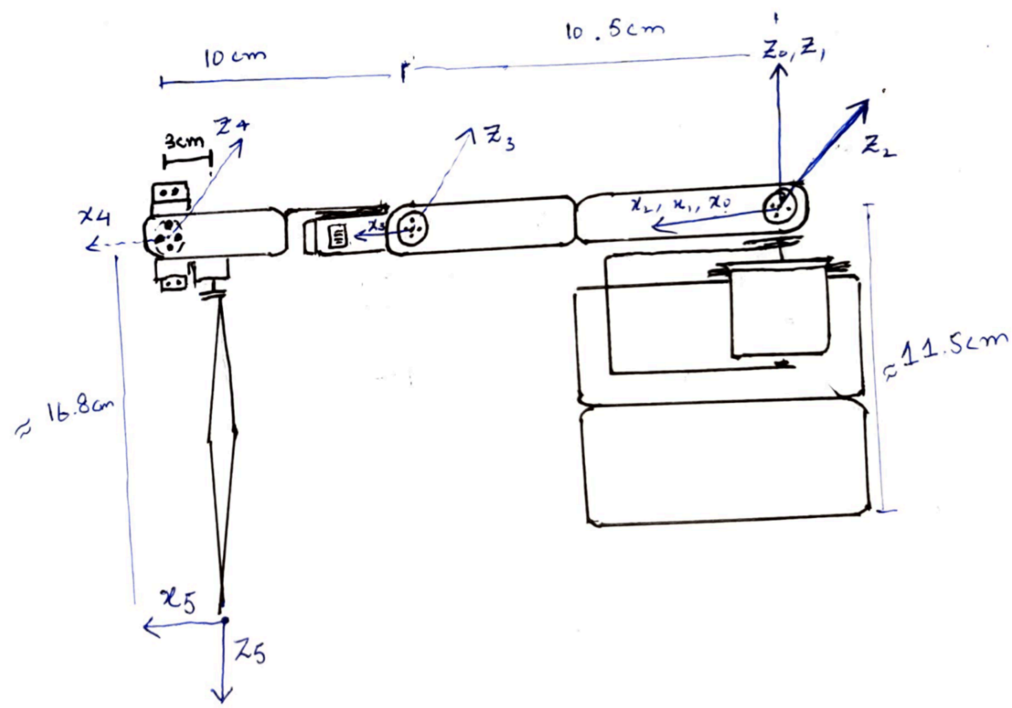


3. Frame assignment (Frames PDF)



Top view.





4. Distributed Forward Kinematics Implementation for Rot3u Robot with Arduino Uno and Python (Code Implementation)

System Architecture

The system comprises two primary components:

1. **Arduino Uno: Responsible for low-level motor control based on received commands.**
2. **Python Script: Handles forward kinematics calculations, user interaction and serial communication with the Arduino.**

Communication Protocol

Serial communication via the `pyserial` library in Python establishes a communication channel between the Python script and the Arduino. The Python script transmits angle values as a series of bytes, which the Arduino receives and interprets to control the robot's joints.

Code Breakdown

1. Python Script:

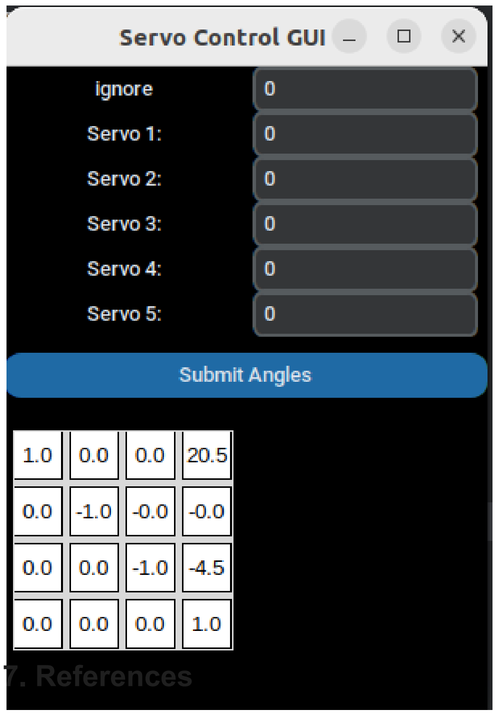
- **Forward Kinematics Function: This function implements the forward kinematics algorithm using the DH parameters and received joint angles. It likely utilizes libraries like `numpy` for matrix operations. The function calculates the final homogeneous transformation matrix representing the end-effector pose.**
- **GUI Implementation: `Tkinter` and `customTkinter` is used to create a user interface for controlling the robot. The user can interact with input fields to specify desired joint angles, which are then sent to the Arduino.**
- **Serial Communication: The `pyserial` library is employed to establish a serial connection with the Arduino at the specified baud rate. The script transmits the calculated joint angles (converted to bytes) through the serial port.**

2. Arduino Uno Code:

- **Serial Communication Setup: The Arduino code initializes the serial communication library to receive data from the Python script.**
- **Motor Control: Based on the received angle values (interpreted from bytes), the Arduino code controls the movement of each joint using dedicated PWM Servo Control Library `Adafruit_PWMServoDriver.h`**

Benefits of Distributed Approach

- **Offloading Computation: Python, on a PC, handles the computationally intensive forward kinematics calculations, freeing the Arduino for real-time motor control.**
- **Flexibility: The Python script offers flexibility for implementing a user interface**
- **Modular Design: The separation of concerns between control and computation simplifies code maintenance and future modifications.**



References and Special thanks

- [Gemini]
- [How to Build a DIY Aluminium 6-DOF Robotic Arm From Scratch – Automatic Addison]