Qualitative study of the different types of Robot Arms and their specific applications.

GROUP - 8

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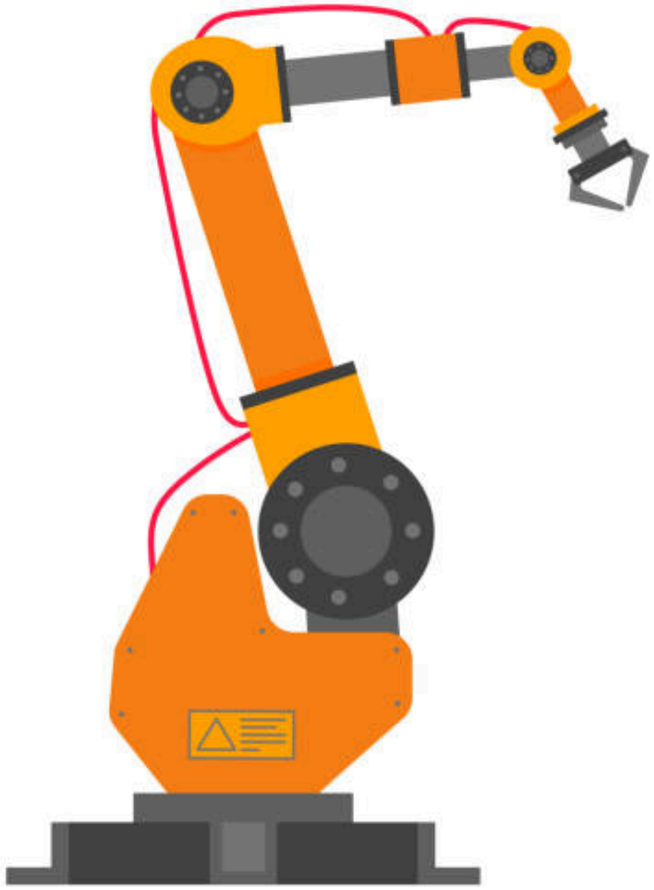
Overview

- Introduction
- Motivation
- Methodology
- Experimental results
- Simulation
- Conclusion

INTRODUCTION



Robot arms are machines designed to perform tasks that require precision and consistency. They are used in many industries to help with jobs like assembling products, welding parts, or painting objects. Just like our own arms, robot arms can move in different ways to do different tasks.

In this case study, we will look at five main types of robot arms:

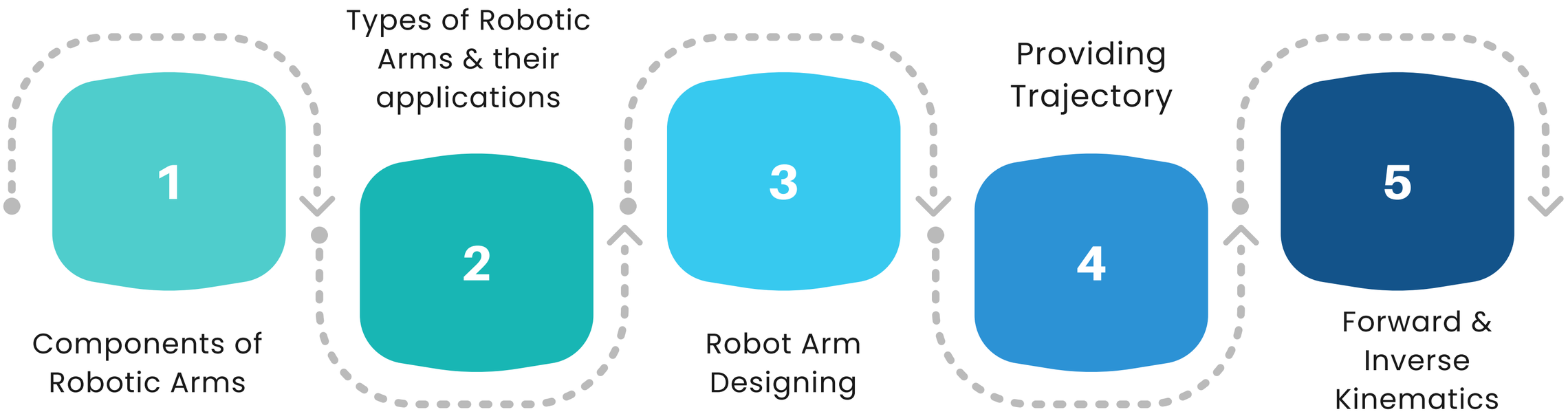
1. Cartesian Robots
2. Spherical Robots
3. Cylindrical Robots
4. Articulated Robots
5. SCARA Robots

Motivation

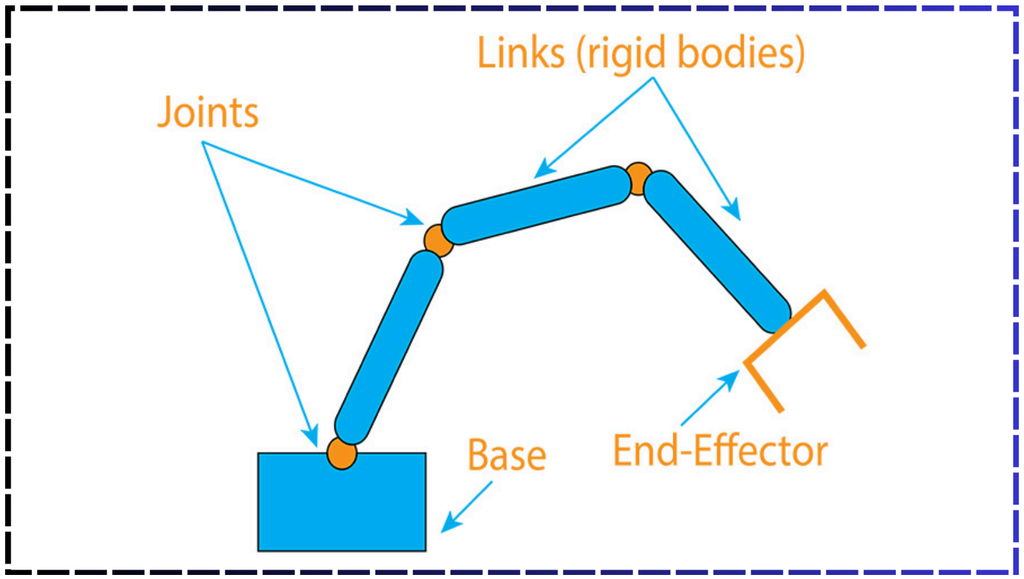
Why Study Robot Arms?

- Help People: Robot arms can do jobs that are boring, hard, or dangerous for people. This helps keep workers safe and makes their jobs easier.
- Precision and Consistency: Robot arms can do tasks very accurately and the same way every time. This is important in making things like cars, electronics, and even in medical surgeries.
- Efficiency: Using robot arms can speed up production and reduce mistakes. This saves time and money for companies.
- Innovation: Understanding different types of robot arms helps us create new and better robots for future needs.
- Learning and Growth: Studying robot arms helps us learn about new technologies and how we can use them in different industries.

METHODOLOGY



Components of a Robotic Arm



Base

The base serves as the foundation of the robotic arm, providing stability and support. It houses the motors and mechanisms necessary for rotational movement along the horizontal axis ensuring the arm position accurately.

Link

Links are the segments or sections that connect the robotic arm’s joints. These links are typically rigid structures made of metal or composite materials, providing structural integrity and motion between joints.

Joint

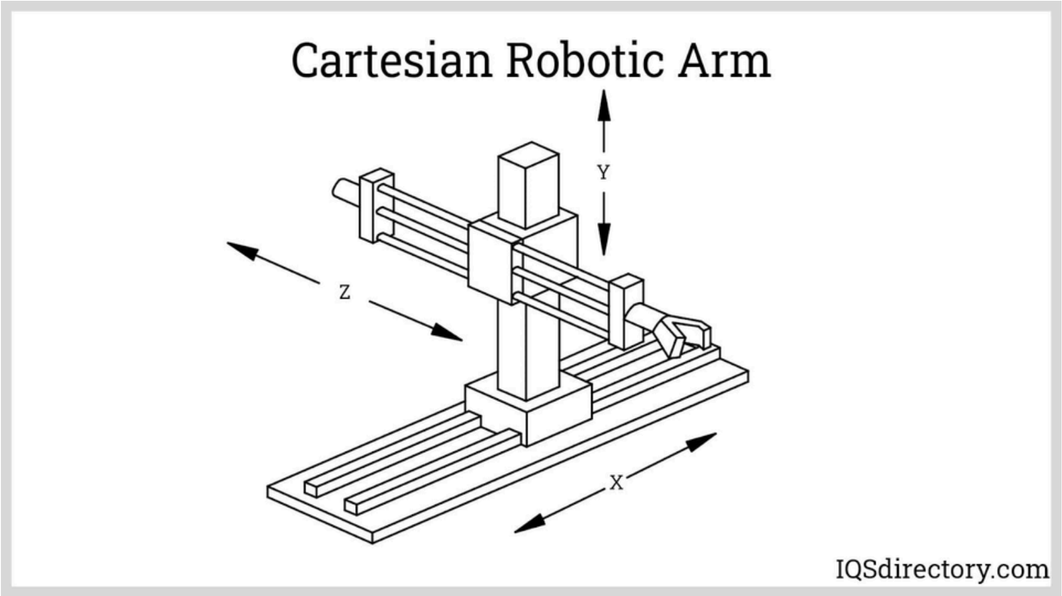
Joints are points along a robotic arm where movement occurs. Robotic arms can have different types of joints, such as revolute (rotational) and prismatic (linear), allowing for a wide range of motion.

End Effector

The end effector is the tool at the robotic arm's end that performs specific tasks. It can be a gripper, suction cup, welding torch, cutting tool, or specialized sensor, depending on the application.

TYPES OF ROBOTIC ARMS & THEIR APPLICATIONS

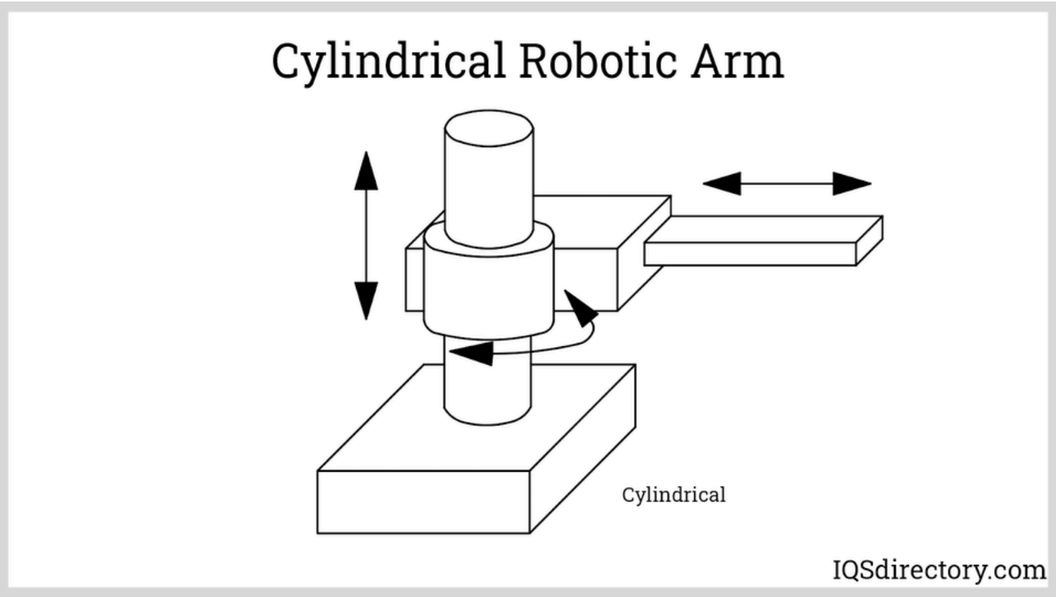
1.CARTESIAN ROBOTIC ARM



Cartesian robot arms are also known as linear robots or gantry robots. These are the types of industrial robots that work on three linear axes using the Cartesian coordinate system (X, Y, and Z).
This means they move in straight lines on three different axes (up and down, in and out, and side to side). This is why this type of robotic arm is quite popular amongst industrialists and manufacturers who are looking for higher flexibility in their configurations.

MANIPULATOR: LOO (L: Linear, O: Orthogonal)
MOTIONS: 3 Linear
WORK ENVOLOPE: Rectangular
APPLICATIONS: Assembly, Palletizing Machine Tool Loading

2.CYLINDRICAL ROBOTIC ARM

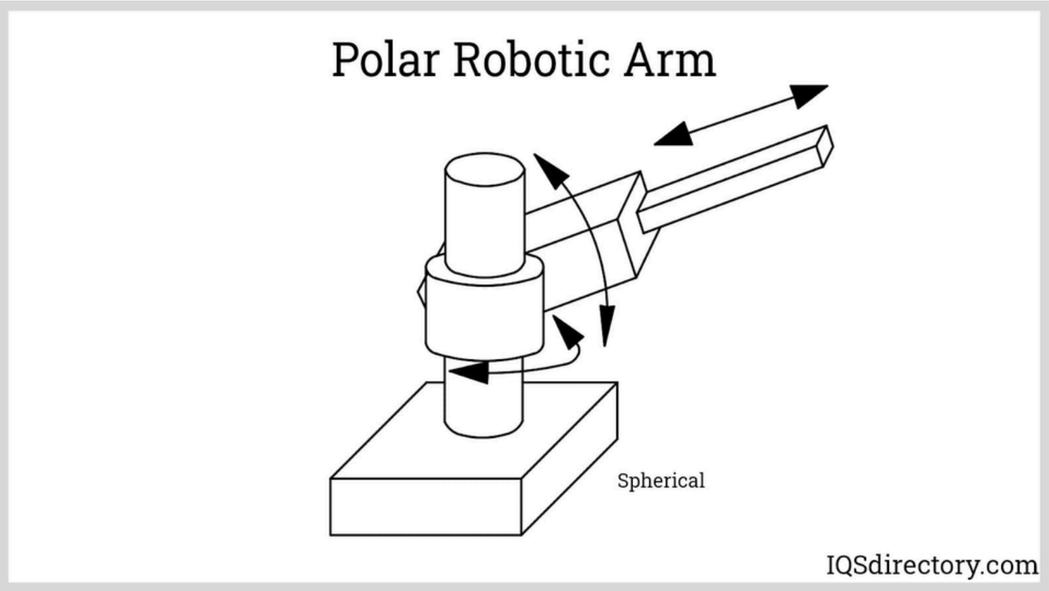


Cylindrical robot arms are industrial robots that operate within cylindrical coordinates. These robots have movements along radial, angular, and vertical axes, allowing them to move in and out, rotate around their base, and move up and down. This type of motion makes cylindrical robots well-suited for tasks that require a combination of linear and rotational movements.

They are popular in industries where moderate reach and flexibility are needed, such as in assembly, machine tending, and material handling.

MANIPULATOR: TLO (T: Twisting, L: Linear, O: Orthogonal)
MOTIONS: 2 Linear, 1 Rotatory
WORK ENVOLOPE: Cylindrical
APPLICATIONS: Loading & Unloading on Machine Tools

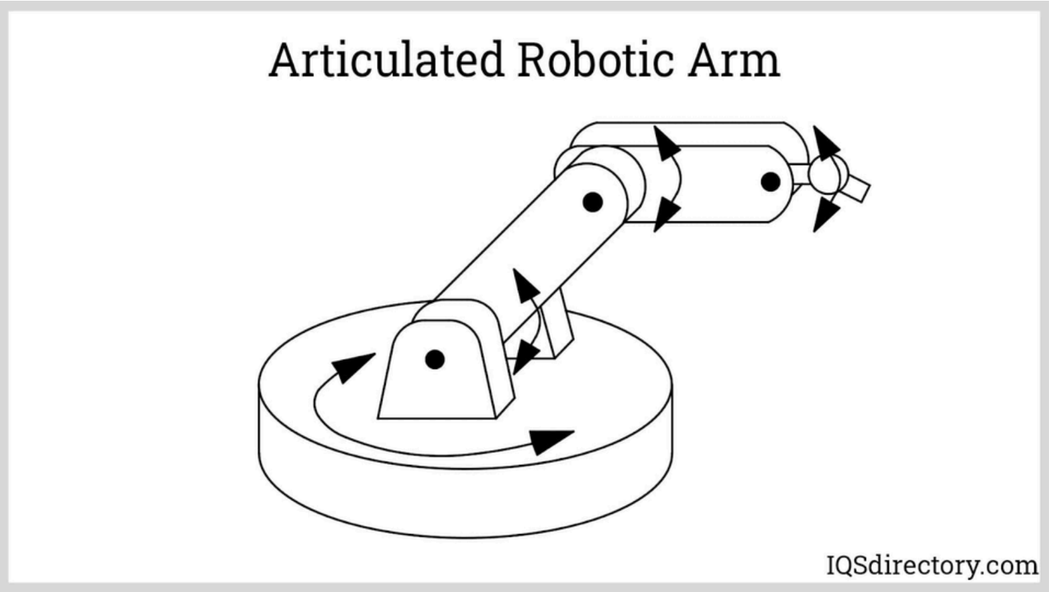
3.SPHERICAL/POLAR ROBOTIC ARM



Spherical robot arms, also known as polar robots, are industrial robots that operate using spherical coordinates. They have three types of movement: radial (in and out), polar (around the base), and vertical (up and down). This setup allows them to cover a wide spherical area around the base, making them versatile for various applications.
One of the first industrial robot categories to ever be created is the Polar Robot. Die casting, injection moulding, welding, and material handling are popular uses for polar robots.

MANIPULATOR: TRL (T: Twisting, R: Rotational, L: Linear)
MOTIONS: 1 Linear, 2 Rotatory
WORK ENVOLOPE: Spherical
APPLICATIONS: Spot Welding, Handling of Heavy Loads.

4. ARTICULATED ROBOTIC ARM

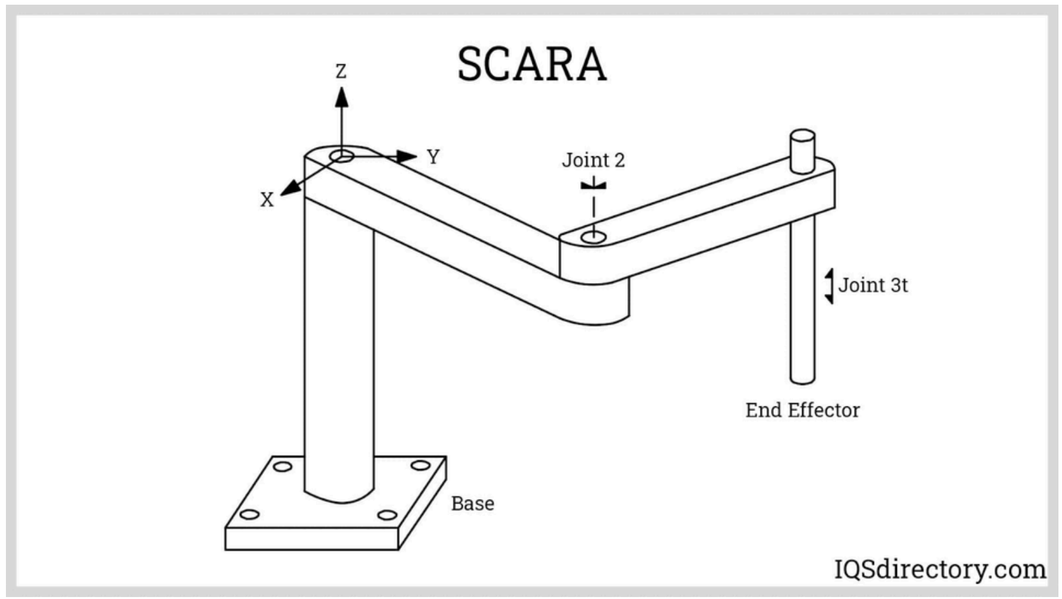


Articulated robot arms, also known as robotic arms or multi-joint robots, use multiple rotational joints to mimic human arm movements. These joints provide flexibility and a wide range of motion, enabling the robot to perform complex tasks.

An articulated robot arm resembles the human arm and allows mechanical movement and configuration. It is one of the most common types of robotic arms for industrial automation.

MANIPULATOR: TRR (T: Twisting, R: Rotational)
MOTIONS: 3 Rotatory
WORK ENVOLOPE: Spherical
APPLICATIONS: Spray Painting, Seam Welding, Spot Welding, Assembly, Heavy Material Handling.

5. SCARA ROBOTIC ARM



SCARA Robot Arms are industrial robots that use a unique combination of two rotational joints and one prismatic joint to perform tasks with high speed and precision. SCARA stands for Selective Compliance Assembly Robot Arm, reflecting its design for both rigidity in the vertical direction and compliance in the horizontal plane.
Compared to Cartesian robots, SCARA robots perform better in lateral motions, move more quickly, and integrate more readily. SCARA robots are typically employed for biomedical applications, palletizing, and assembling.

MANIPULATOR: VRO (V: Revolving, R: Rotational, O: Orthogonal)
MOTIONS: 1 Linear, 2 Rotatory
WORK ENVOLOPE: Cylindrical
APPLICATIONS: Assembly Operation, Biomedical applications.

ROBOT ARM DESIGNING

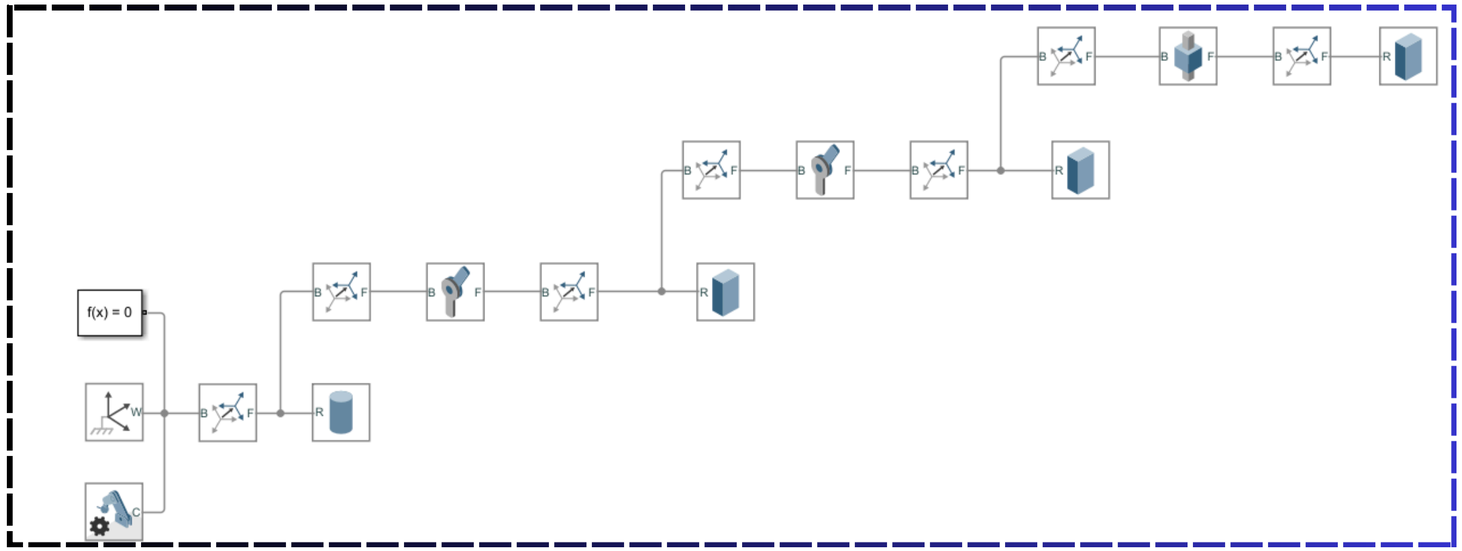
Simulation in Simscape

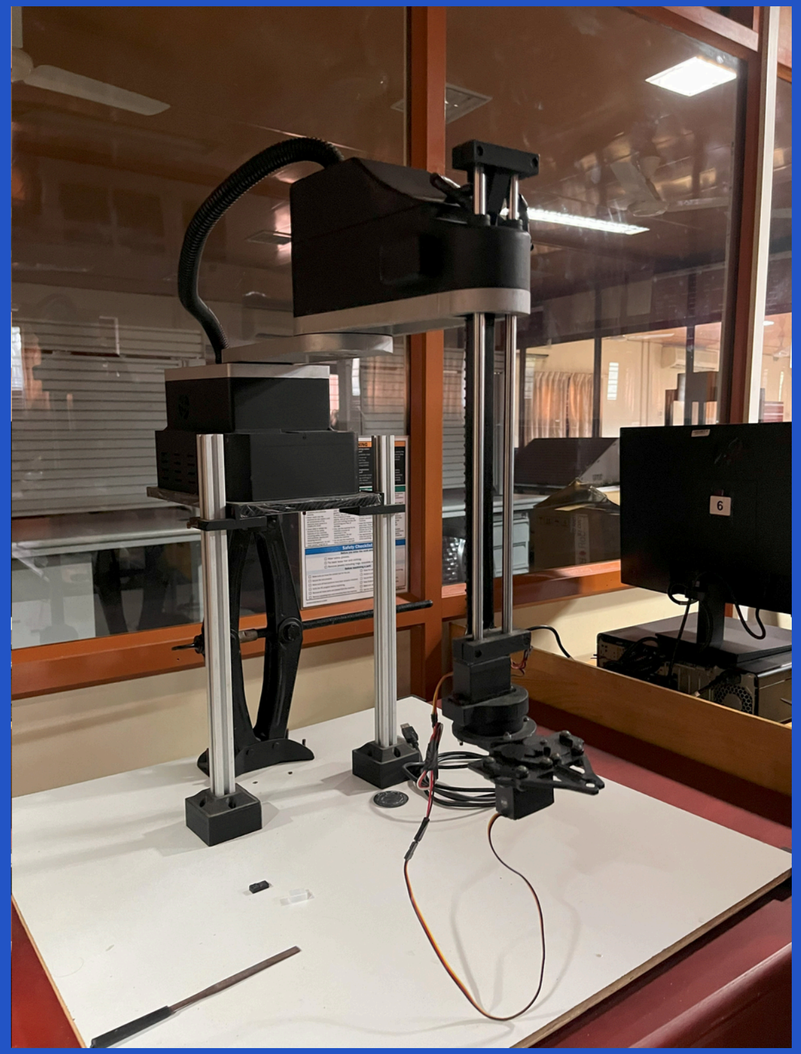
- We used MATLAB's Simscape environment for our simulations.
- Our focus was on designing and analyzing different types of robot arms.

Scara Robot Simulation

SCARA Robot Design

- Started with the SCARA robot model available in MATLAB.
- Analyzed its structure and motion.
- Learned about the SCARA robot’s specific configurations and applications.



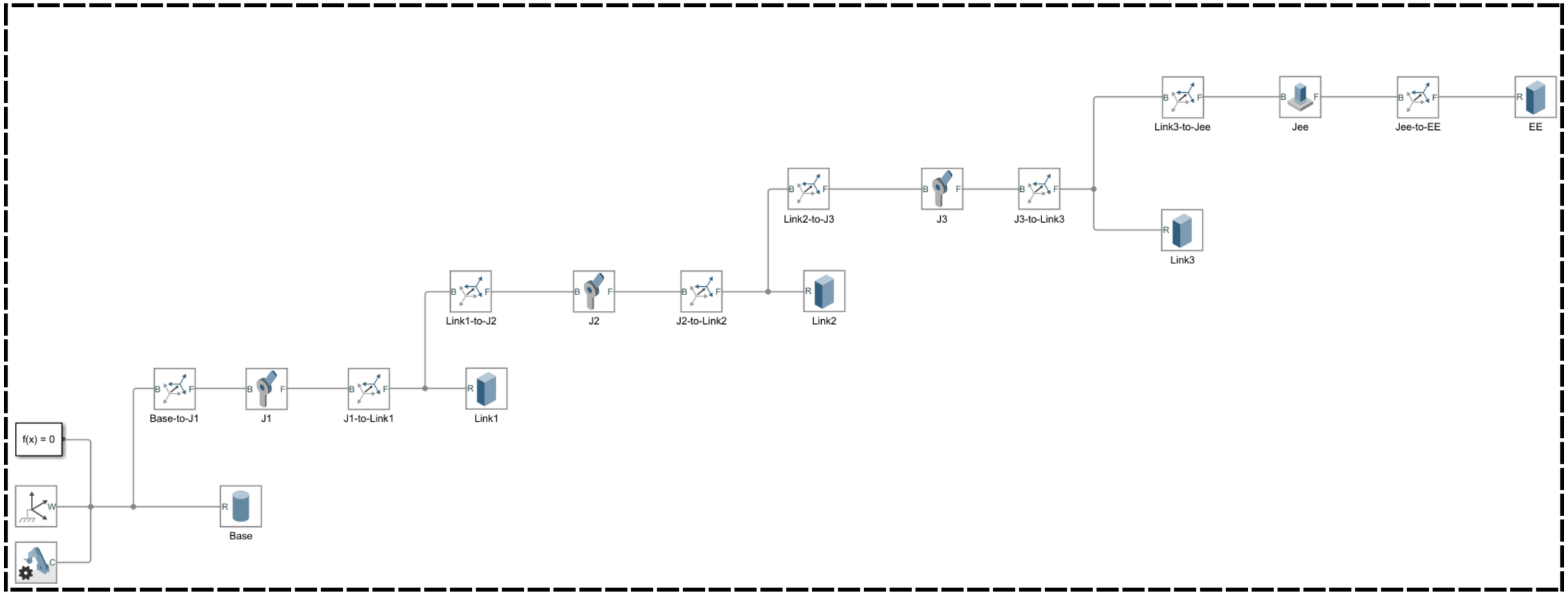


SCARA ROBOT

Articulated Robot Simulation

- In this project, we designed and simulated a 3-degree of freedom (DOF) articulated robot arm in MATLAB, focusing on creating a 3D model with three revolute joints and analyzing its kinematics.
- The robot features a light blue cylindrical base, three links of varying colors and lengths, and a red end-effector.
- We employed MATLAB Simulink for the simulation, using essential components such as the Solver Configuration and Multibody Elements to build the kinematic chain and visualize the robot's movements.
- Kinematic Chain: Base → Joint 1 → Link 1 → Joint 2 → Link 2 → Joint 3 → Link 3 → End-Effector
- Components Used:
    a. Solver Configuration: Essential for simulation
    b. Multibody Elements: Base, links, joints
    c. Signal Builder: For providing joint angles
    d. Forward Kinematics Block: Computes the end-effector position

Articulated Robot Design



FORWARD KINEMATICS
VS
INVERSE KINEMATICS

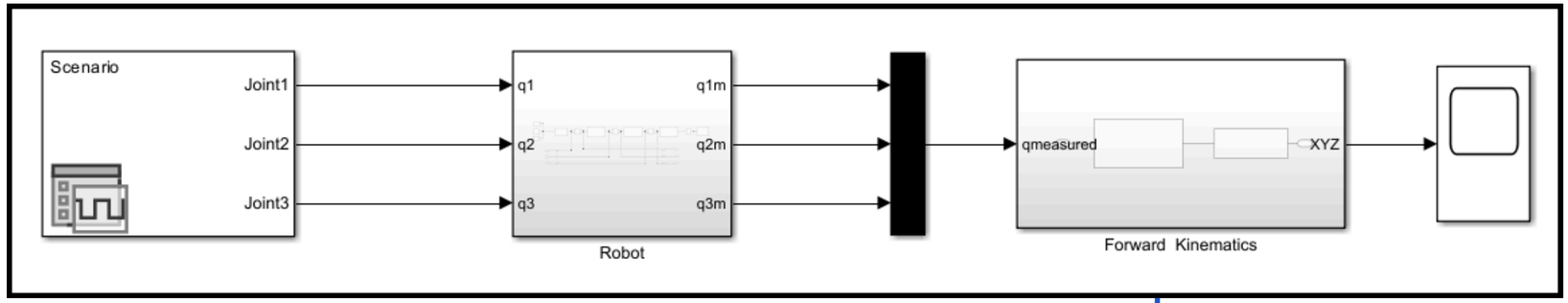
Forward Kinematics

Definition:

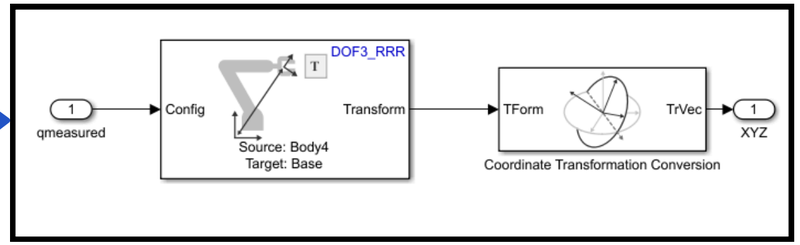
Forward kinematics is the process of calculating the position and orientation of the end-effector (e.g., robot hand, tool) based on given joint parameters (angles for revolute joints, lengths for prismatic joints).

How It Works:

- Input: Joint parameters (angles or displacements).
- Process: Apply the kinematic equations and transformation matrices to compute the end-effector's position and orientation.
- Output: End-effector's position in the Cartesian space (x, y, z).



Articulated Robot



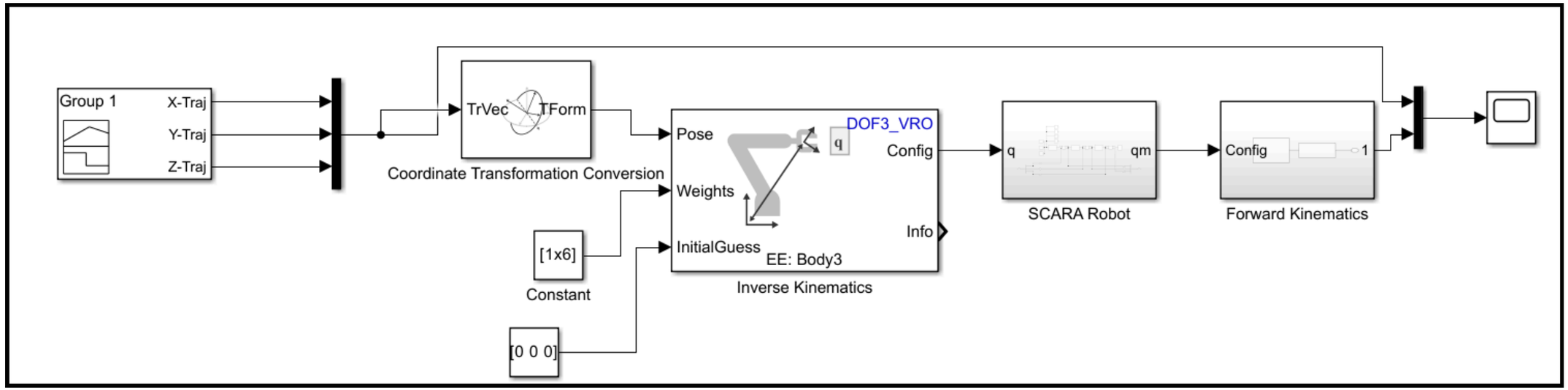
Inverse Kinematics

Definition:

Inverse kinematics is the process of determining the required joint parameters to achieve a desired position and the orientation of the end-effector.

How It Works:

- Input: Desired position and orientation of the end-effector.
- Process: Solve the kinematic equations to find the joint parameters.
- Output: Joint angles or displacements.



SCARA ROBOT

EXPERIMENTAL RESULTS

DH PARAMETERS

DH PARAMETERS

Denavit-Hartenberg (DH) parameters are a method to describe the positions and movements of a robot arm's parts. Each part is defined by four parameters:

1. θ (theta): Rotation around the z-axis.
2. d: Shift along the z-axis.
3. a: Shift along the x-axis.
4. α (alpha): Rotation around the x-axis.

Using these parameters, one can create a transformation matrix for each joint, which describes the position and orientation of one link relative to the previous link. The series of these transformations can be used to derive the forward kinematics of the robot, determining the end-effector position and orientation based on the joint variables.

```
>> dh_parameters
DH Parameters Table for SCARA Robot:
theta (rad),   d (m),   a (m),   alpha (rad)
          0     0.3250     0.1000           0
          0          0     0.5000           0
          0          0     0.5000           0
          0     0.0500          0           0
```

```
>> dh_parameters
DH Parameters Table for ARTICULATED Robot:
theta (rad),   d (m),   a (m),   alpha (rad)
          0     0.0250          0     1.5708
          0          0     0.1000           0
          0          0     0.2000           0
          0     0.0750     0.0150           0
```

SIMULATION

SCARA ROBOTIC ARM

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Current Folder

Name

- resources
- slprj
- DOF3_VRO_Video.slx
- DPF3_VRO_Video.slx
- IK_SCARA_drive.slx
- IK_SCARA_drive.slx.r2021b
- IK_SCARA_drive.slxc
- license.txt
- Robot_Movement.slx
- SCARA.slx
- start_file.m

IK_SCARA_drive.slx (Simulink Model)

Workspace

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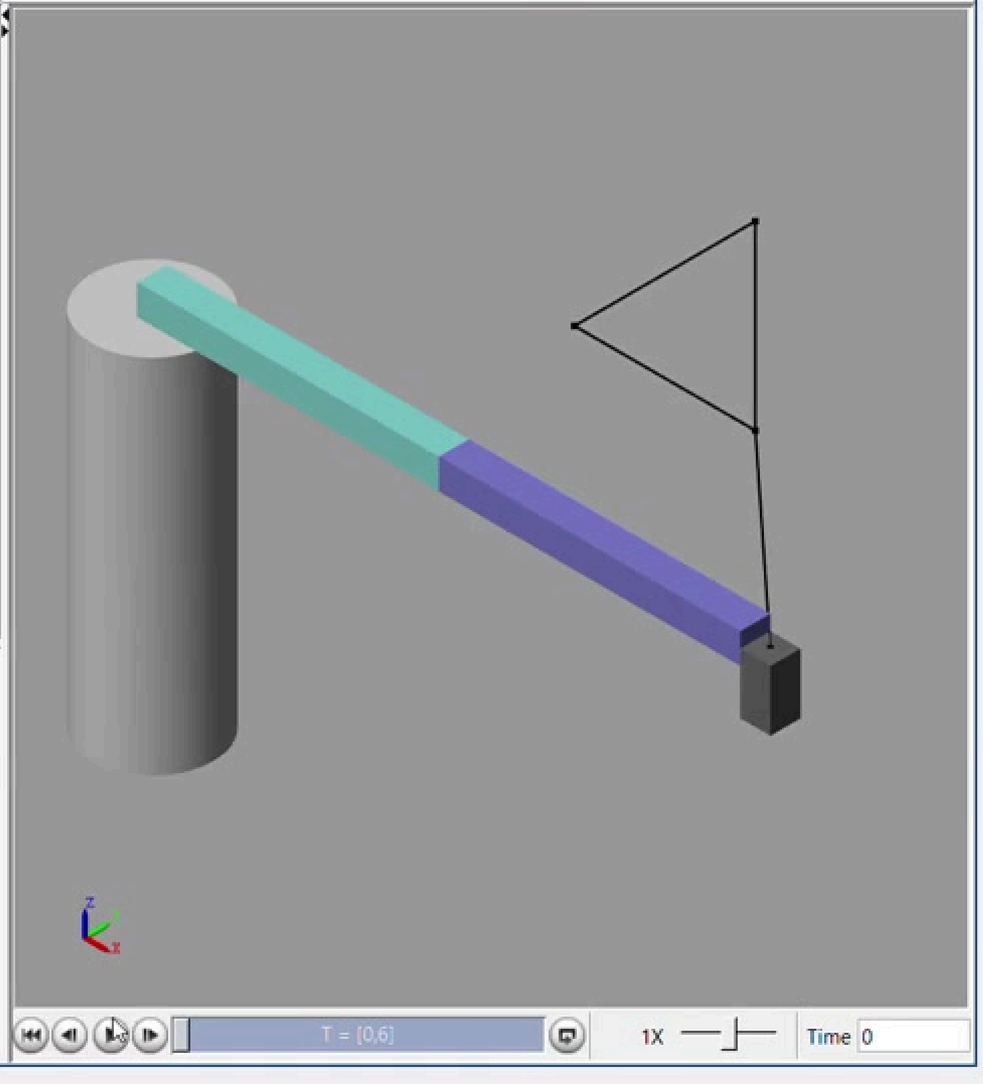
Editor - start_file.m

Mechanics Explorer-IK_SCARA_drive

- IK_SCARA_drive
- SCARA_Robot

Mechanics Explorers - Mechanics Explorer-IK_SCARA_drive



Command Window

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>> start_file
>>
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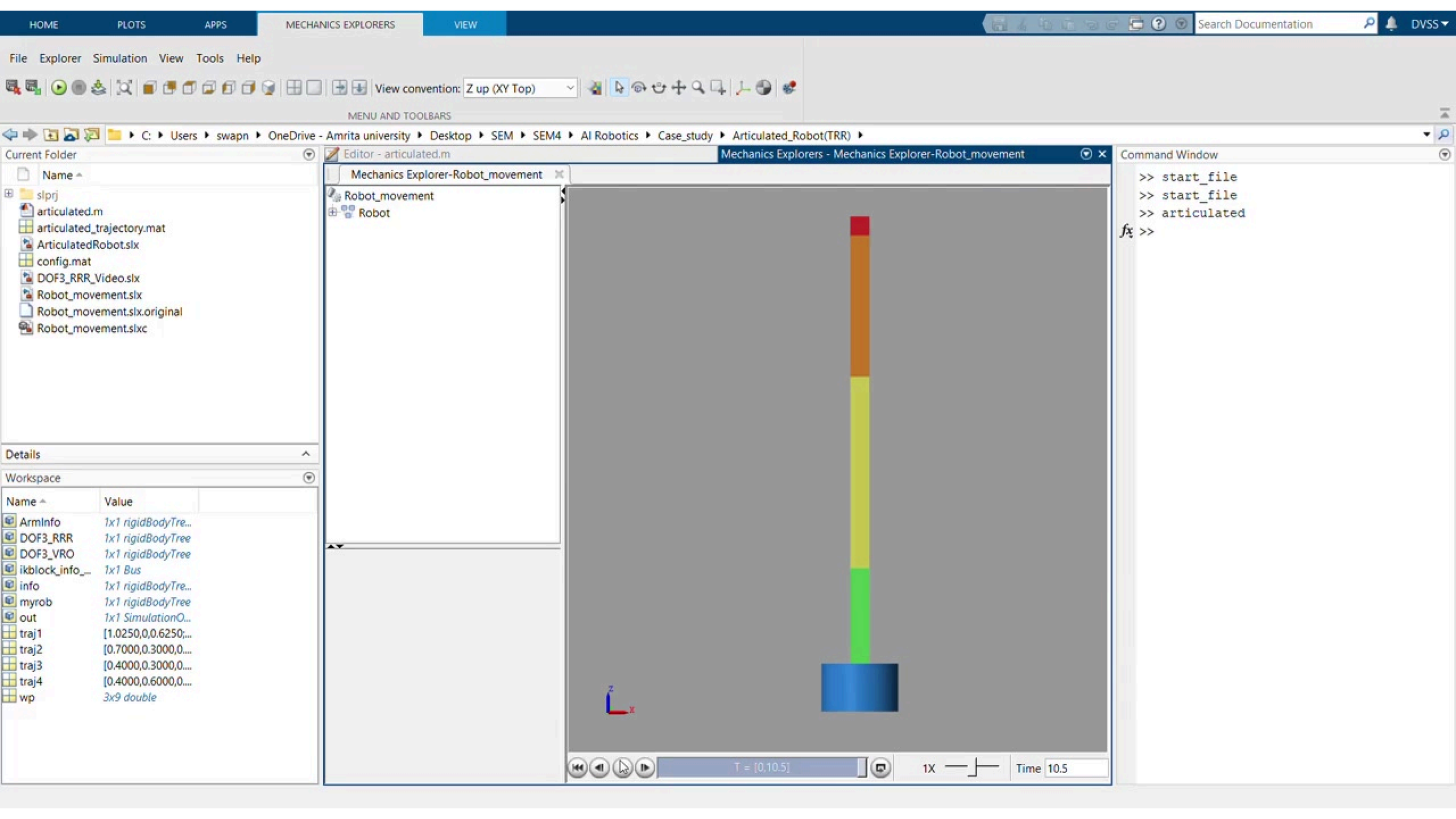
ARTICULATED ROBOTIC ARM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articulated.m
articulated_trajectory.mat
ArticulatedRobot.slx
config.mat
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Robot_movement.slx.original
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info 1x1 rigidBodyTre...
myrob 1x1 rigidBodyTree
out 1x1 SimulationO...
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traj2 [0.7000,0.3000,0....
traj3 [0.4000,0.3000,0....
traj4 [0.4000,0.6000,0....
wp 3x9 double
Editor - articulated.m
Mechanics Explorers - Mechanics Explorer-Robot_movement
Mechanics Explorer-Robot_movement
Robot_movement
Robot
T = [0,10.5]
1X
Time 10.5
Command Window
>> start_file
>> start_file
>> articulated
>>

Conclusion

Robot arms are like helpful tools that can do many different jobs. They are used in factories and other places to help people with tasks that need to be done carefully and over and over again. There are many different kinds of robot arms, each with its own special way of moving and its own special jobs to do. Some robot arms move in straight lines, while others can move in circles or even more complicated ways. Some robot arms are good at putting things together, while others are good at painting or welding. By understanding the different types of robot arms and what they can do, we can use them to make our work easier and more efficient.

Thank You