NTUST

Final Project

6 R Screw Assembly Robot

15 December 2025

Introduction To Robotics

Group B1

Overview

Introduction

6R Robot in Screwing Assembly Line

We introduce a highly versatile 6-axis robot tailored for screw-based assembly applications. Built to adapt to changing environmental constraints, our system focuses on delivering fast and precise execution for lightweight product manufacturing.

Problem Statement

01

Error Rate in Manual Assembly:
The precision required for small, delicate, and lightweight parts often results in costly quality control due to human error.

02

Inconsistent Throughput and Bottlenecks:
Manual assembly processes create variable cycle times, leading to inconsistent production rates and significant bottlenecks in continuous production lines.

03

High Automation Barrier:
Traditional, large industrial robots are cost-prohibitive for small and medium-sized enterprises (SMEs) and specialized production, forcing continued reliance on inefficient manual labor.

Objectives &Constraints:

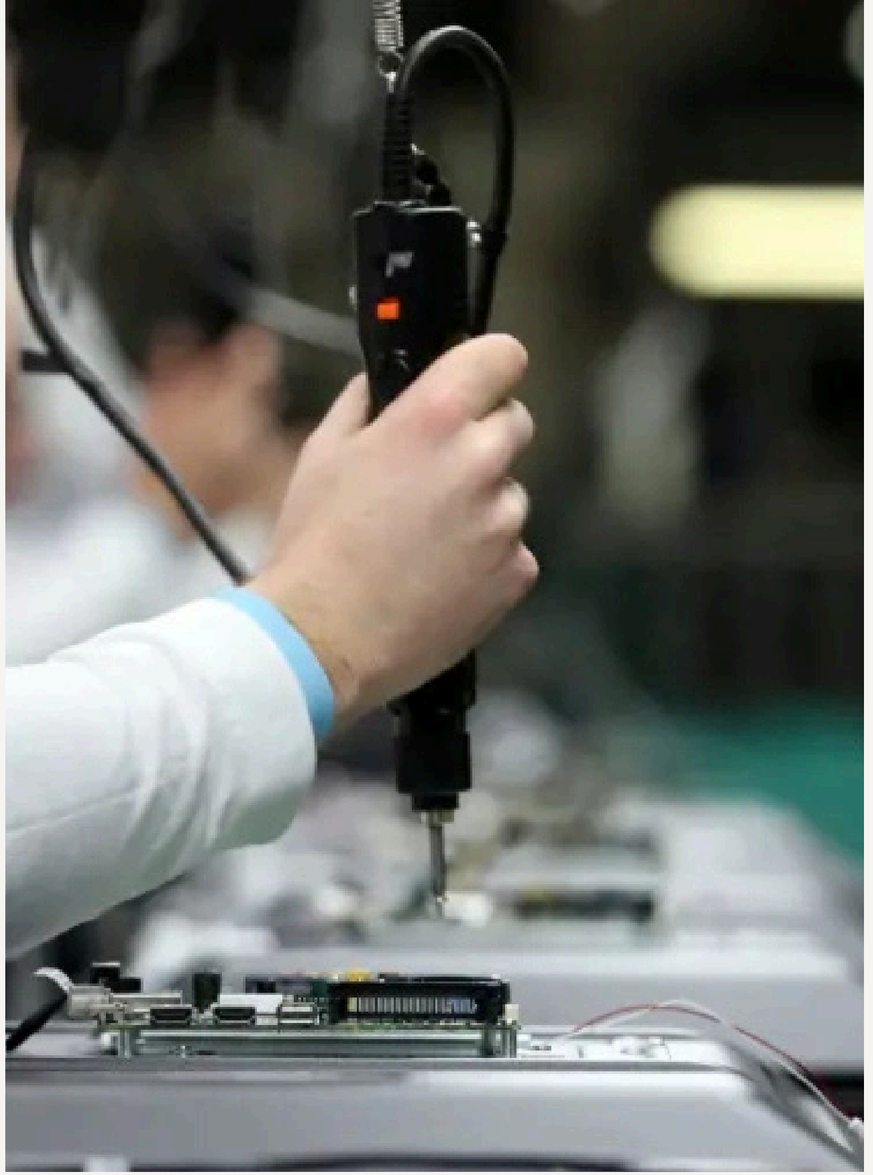
01 **Acceptable Tolerance:** ±0.02mm

02 **Workpace:** Maximum Velocity of 1000 mm/s. Precision Velocity: 50mm/s

03 **Reachable Workspace:** 0.57 m^3

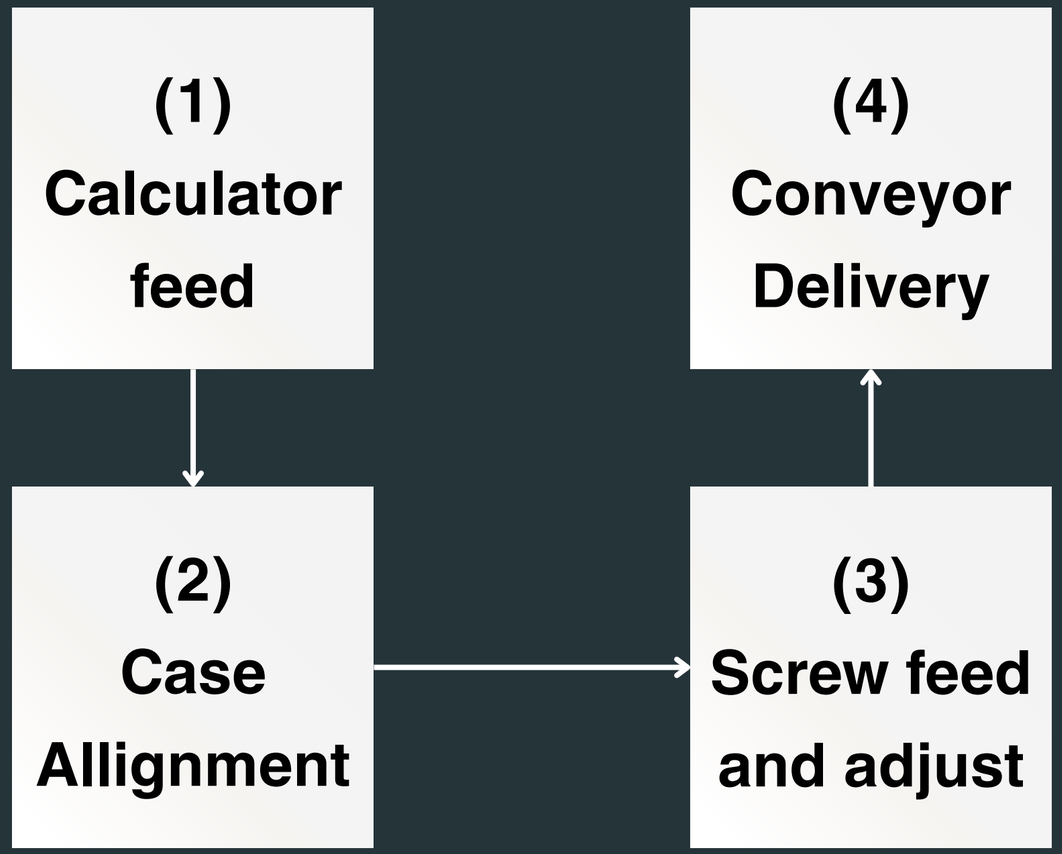
04 **Payload:** 1kg maximum

05 **Accesibility:** Light Material (aluminum 2014 - t6 and steel aisi 2010)

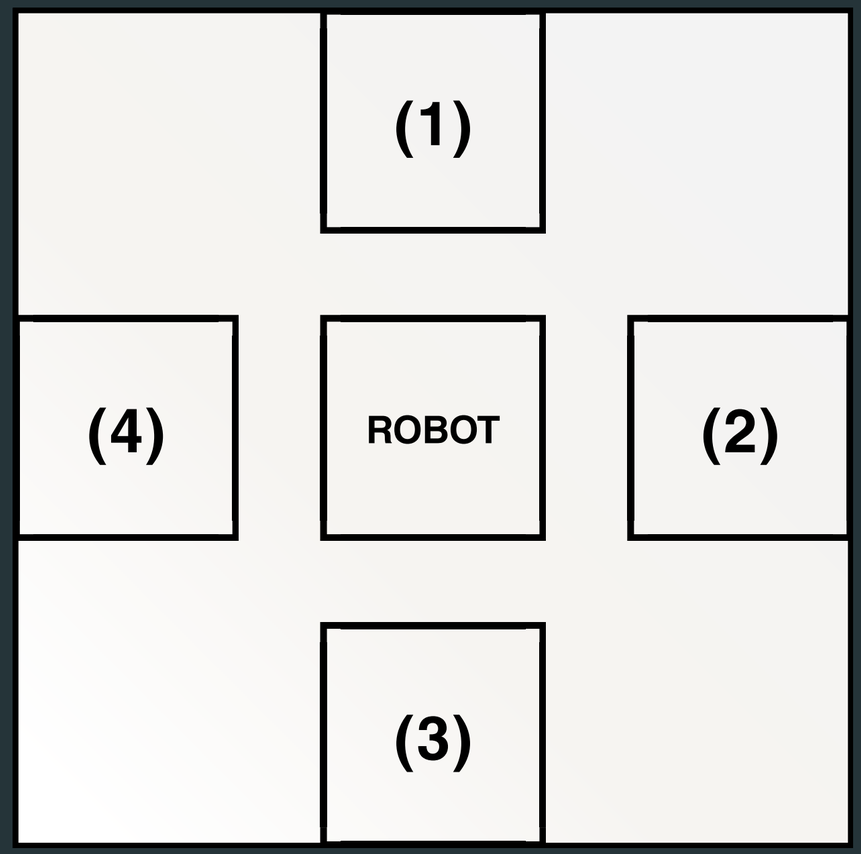


Design Specifications

WorkFlow Diagram

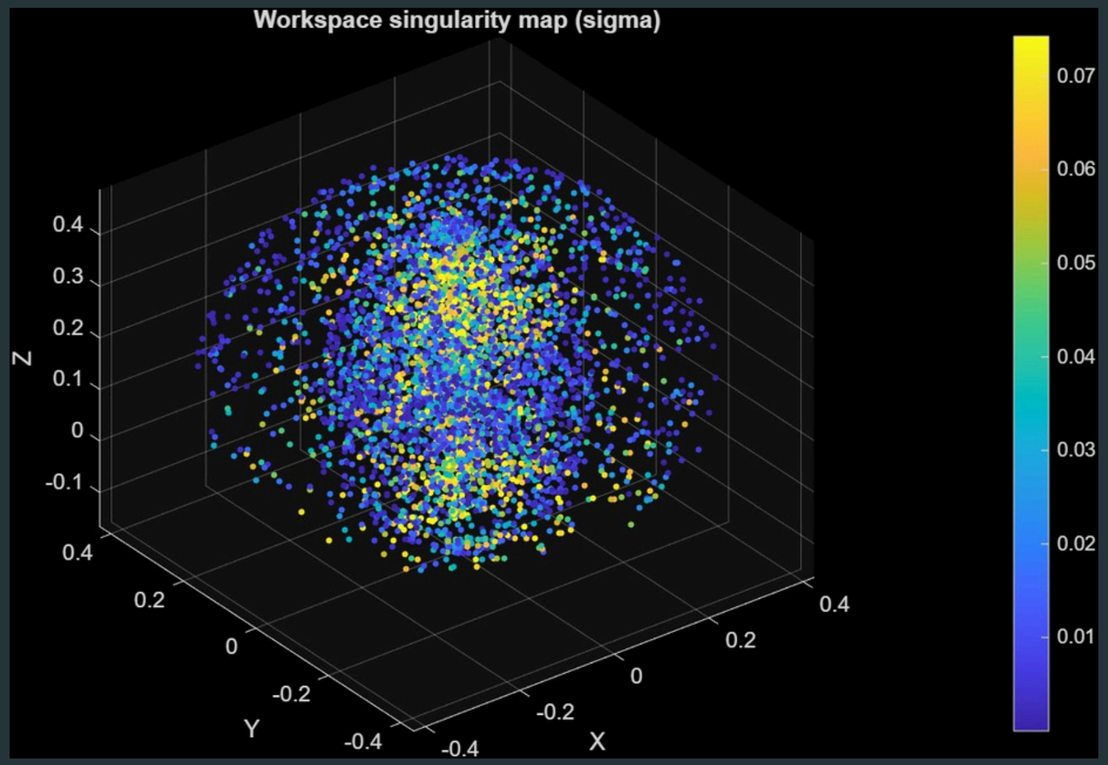


Tabletop workcell

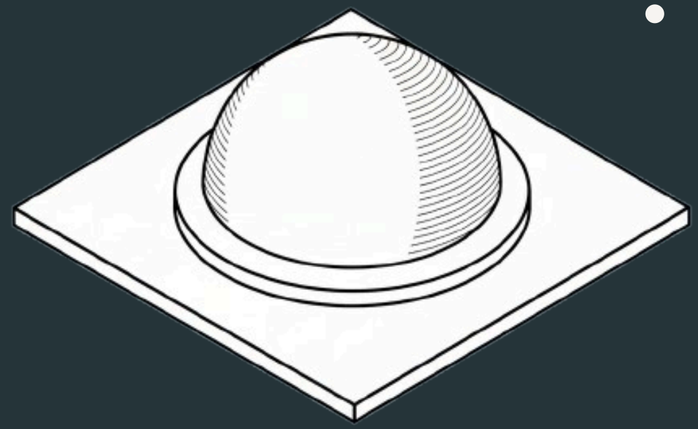


Design Specifications

Workspace and singularity analysis

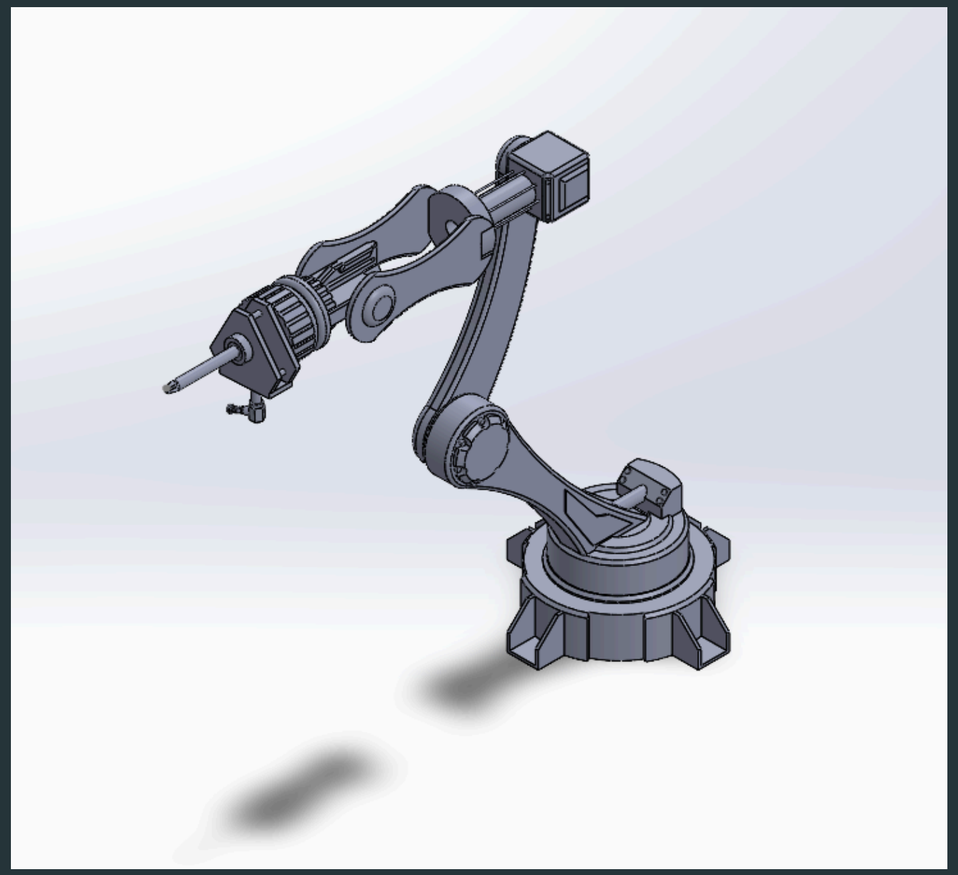


- Workspace ~ 0.57 m^3
- Semi - Spheric
- 650 mm tabletop reach

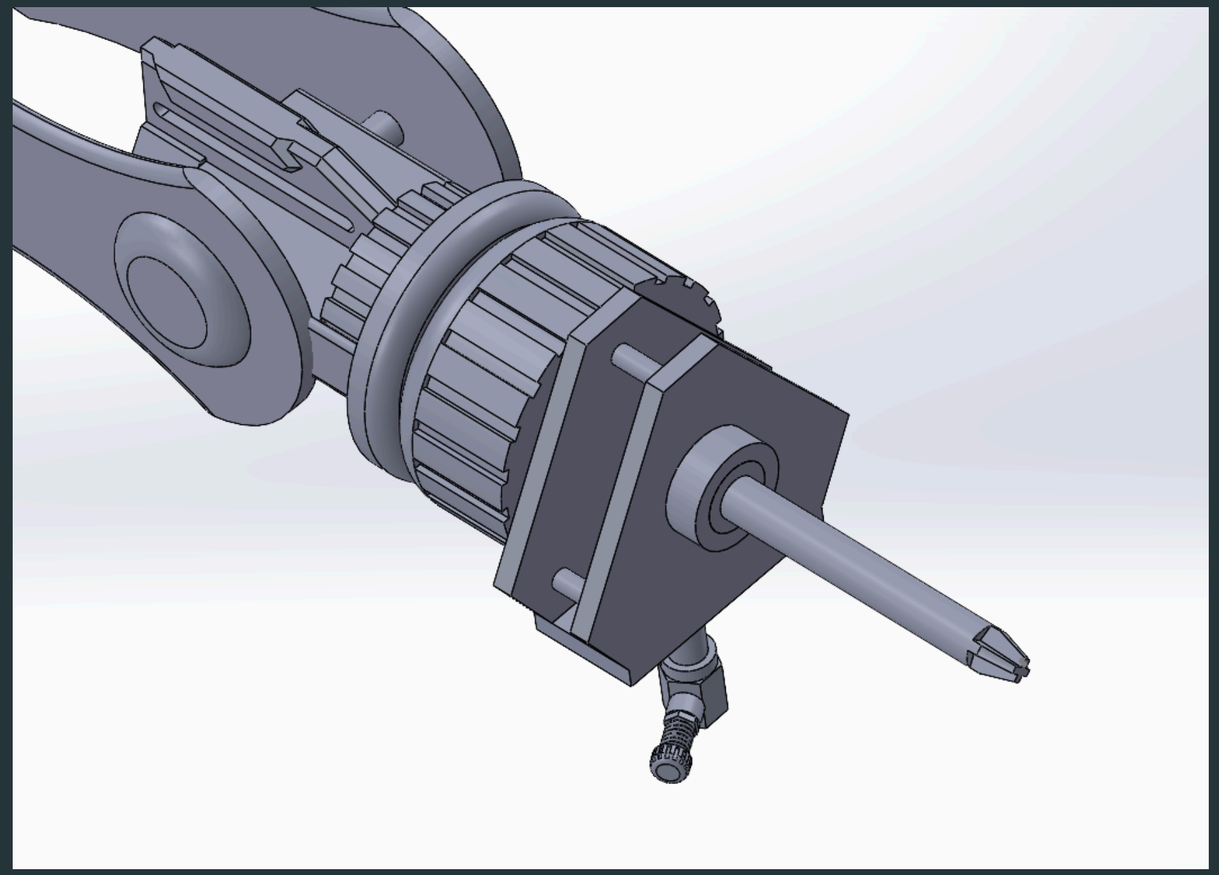


→ Compact radial layout, minimizing joint travel distances between the Screw Feeder, Parts Feeder, and Assembly Area, optimizing cycle time.

CAD Models

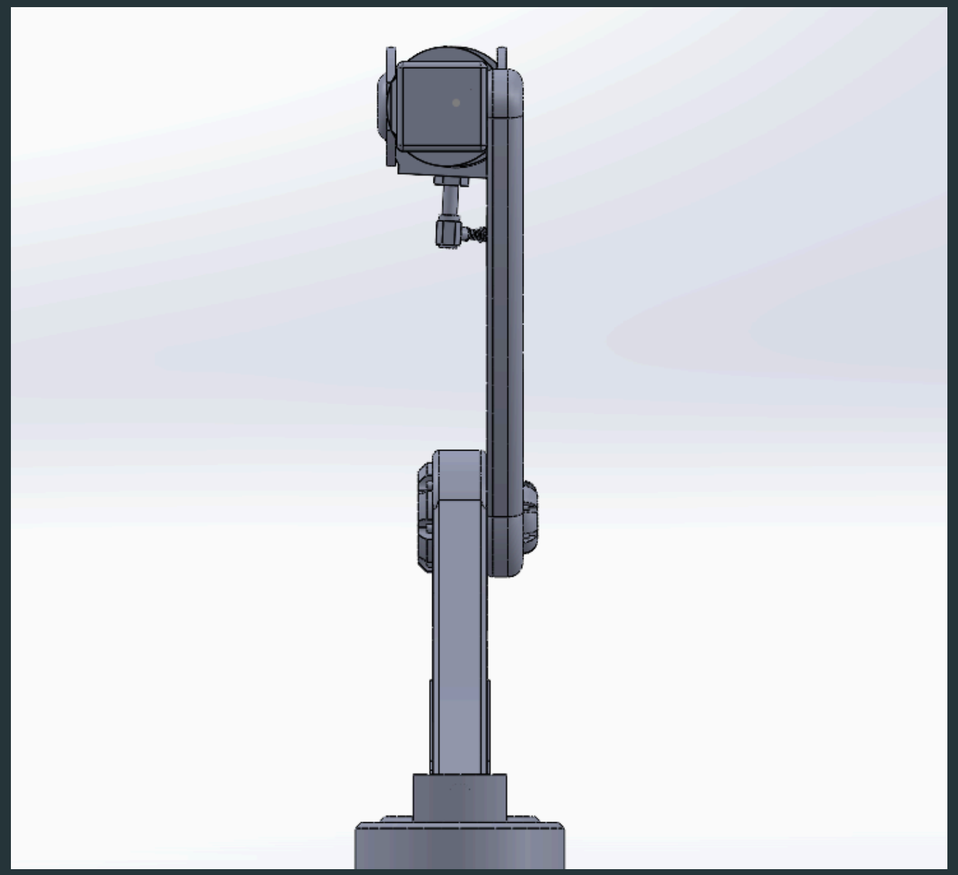


Isometric view

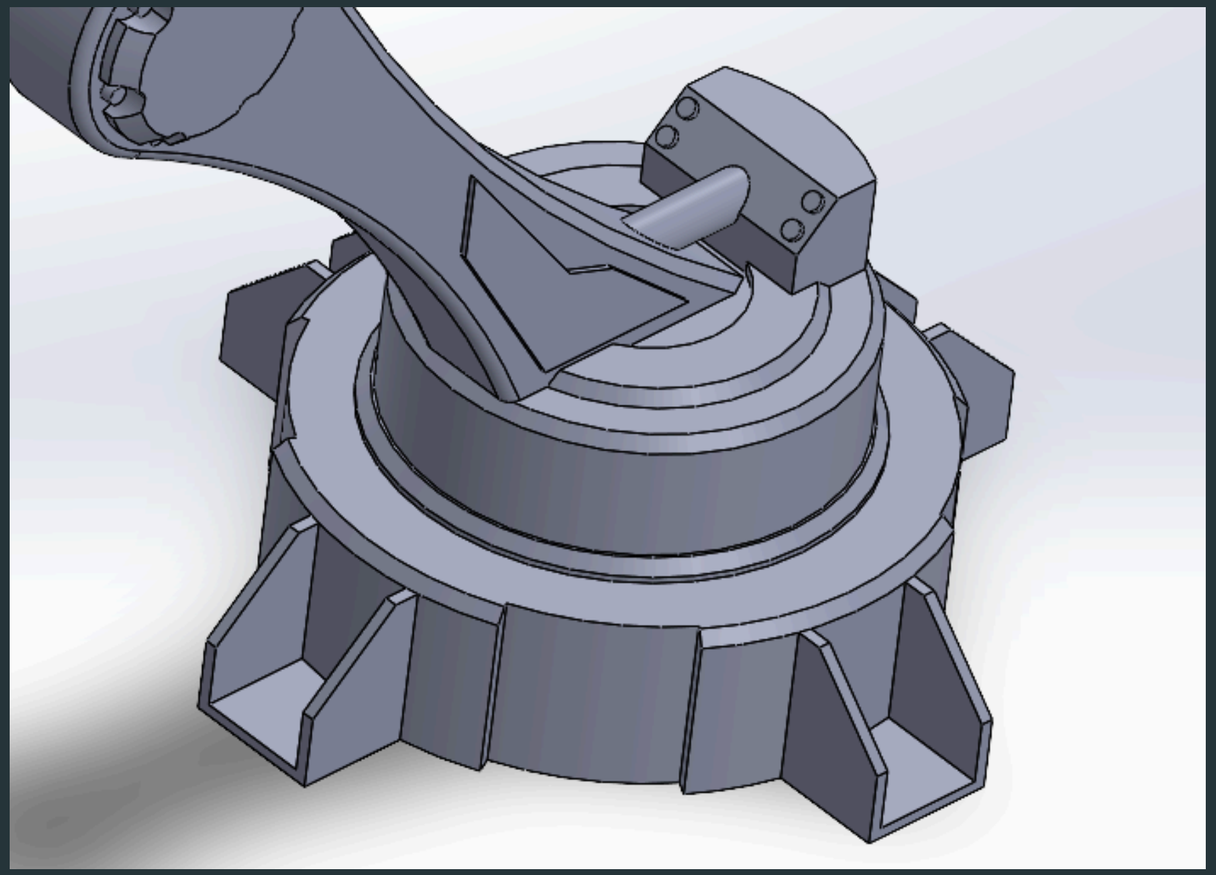


Tool close-up

CAD Models



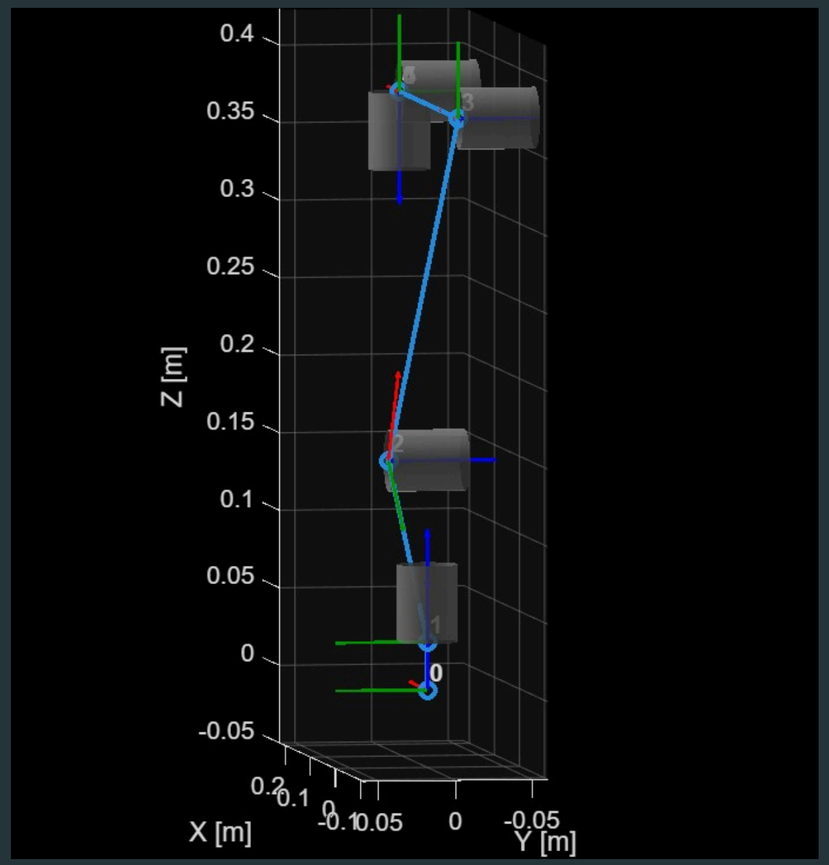
Link connections



Base close-up

Mathematical Models

Kinematic diagram and DH Parameters



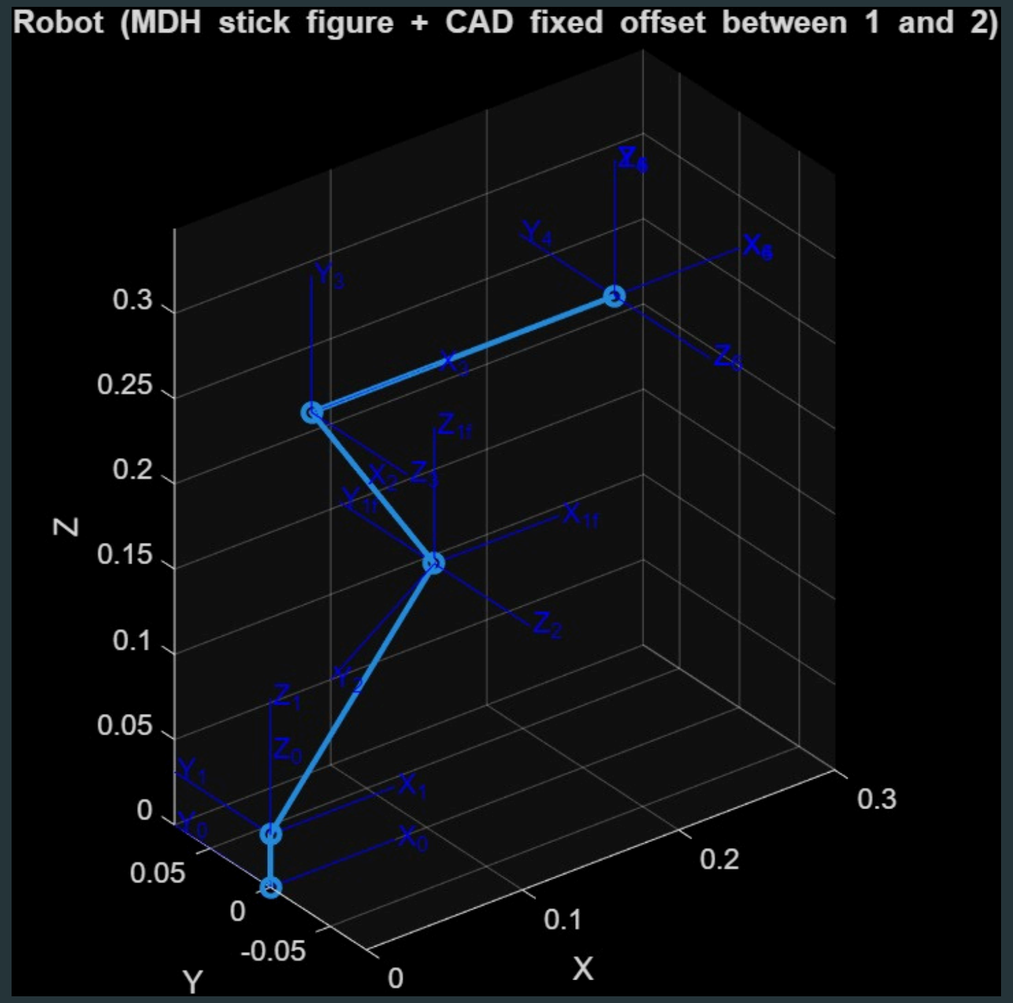
DH Parameters				
i	θi-1	di	ai-1	αi-1
1	0	0.03	0	0
2	0	0.02	0.145	90°
3	0	0.01	0.28	0
4	0	0	0.235	90°
5	0	0	0	-90°
6	0	0	0	90°

Foward Kinematics Transformation Matrices

$$T_{tool} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0.0001 & 0 & 1 & 0.085 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

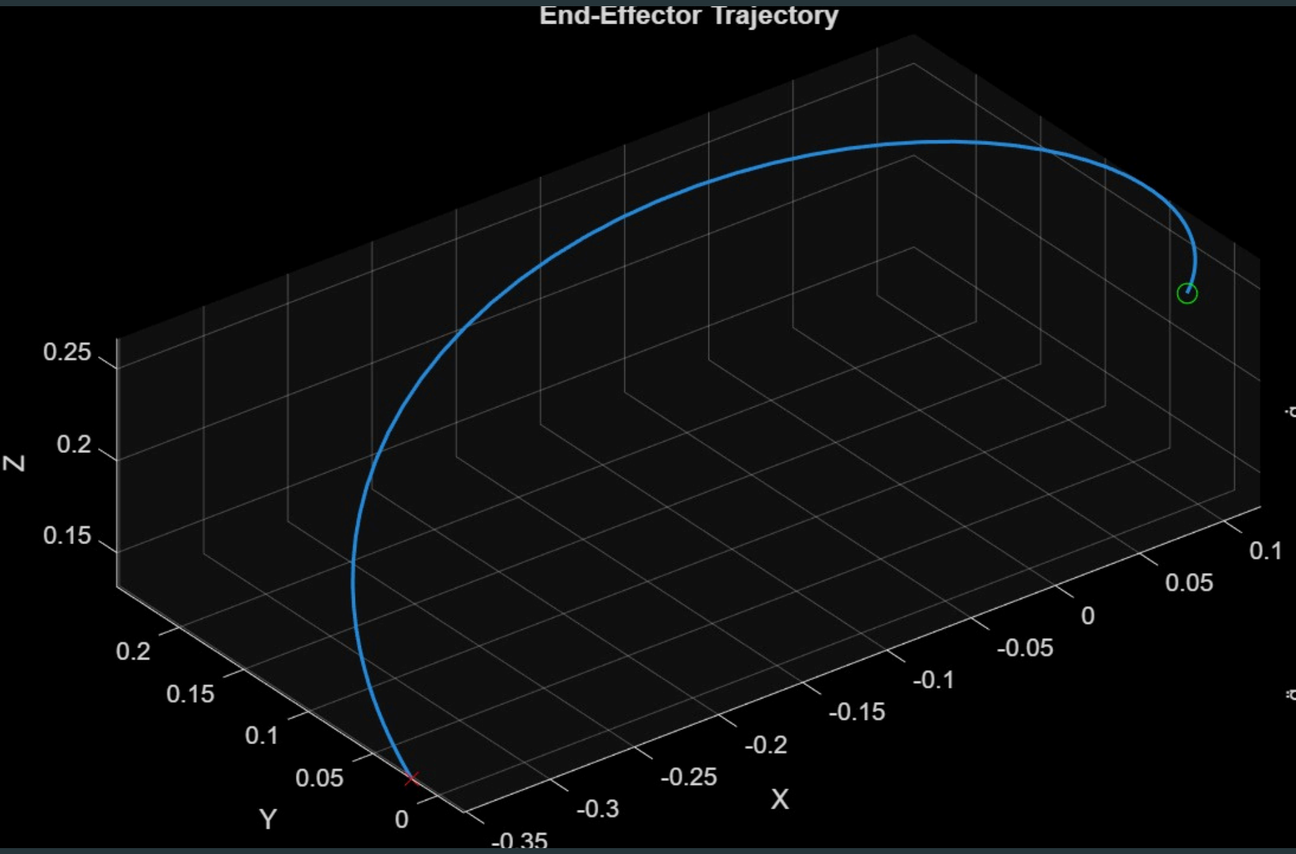
$$T_{06} = \begin{bmatrix} 1 & 0 & 0.0001 & 0.0782 \\ 0 & -1 & 0 & -0.02 \\ 0.0001 & 0 & -1 & 0.1780 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

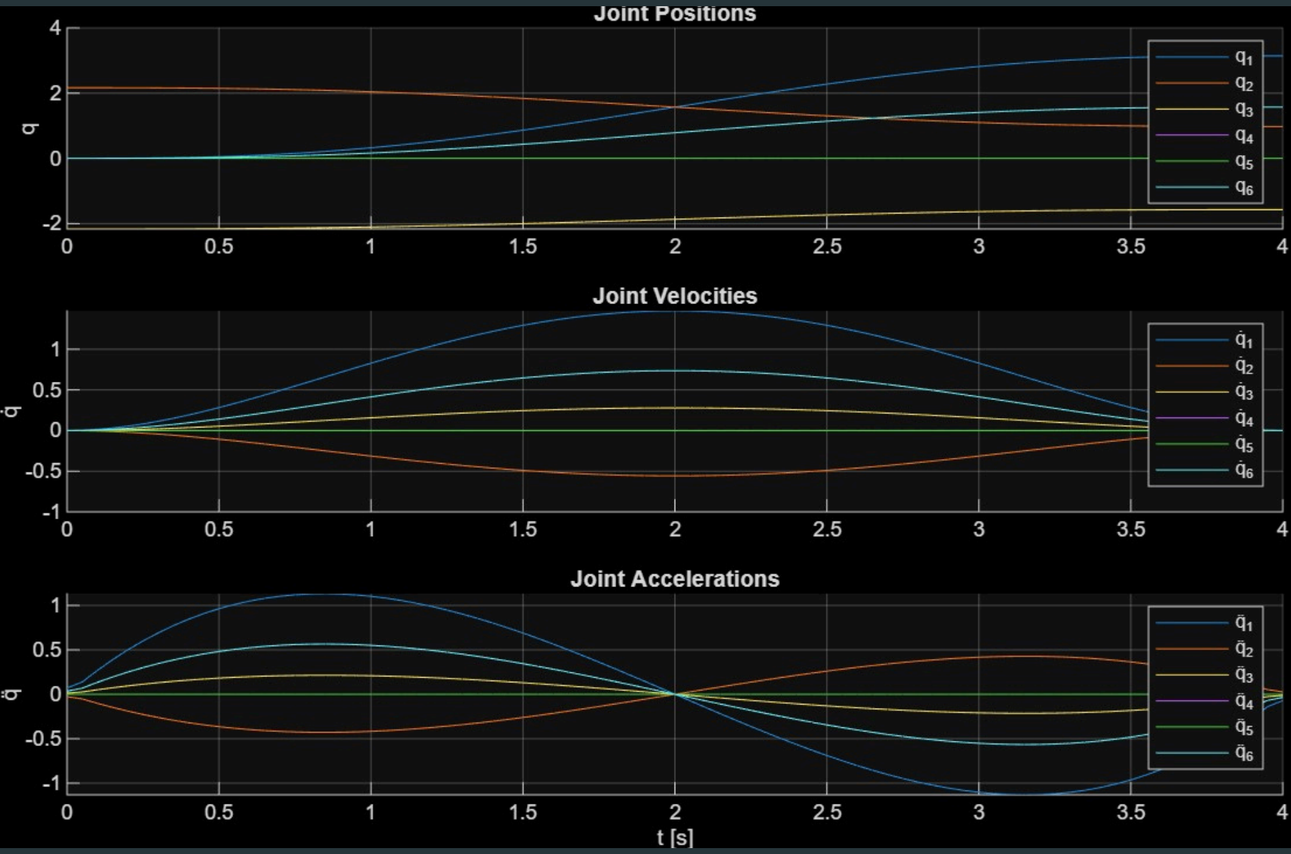
$$T_{12\text{Fixed}} = \begin{bmatrix} 1 & 0 & 0 & 0.0946 \\ 0 & 1 & 0 & 0.01 \\ 0 & 0 & 1 & 0.1099 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$



Mathematical Models

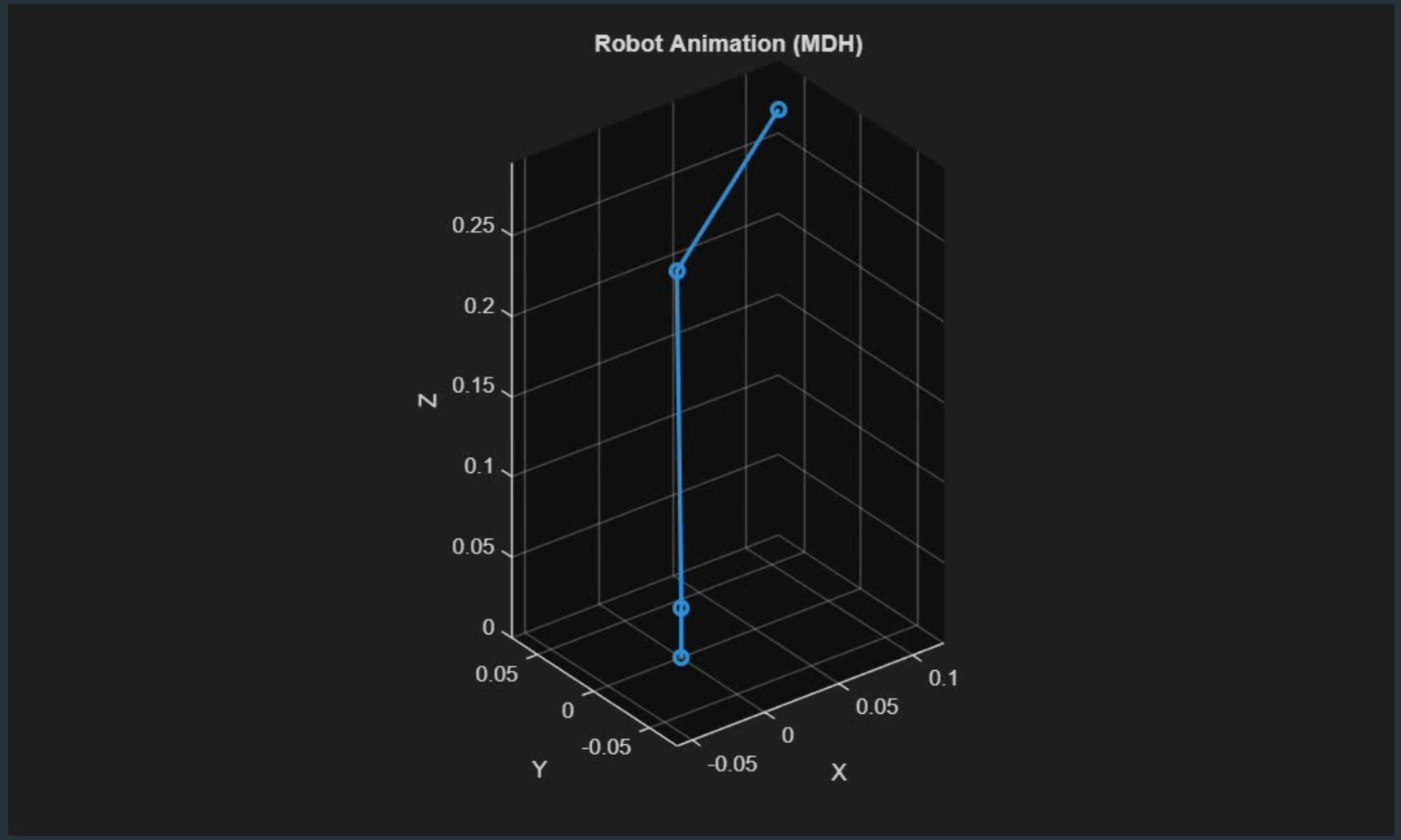
Trajectory Generation





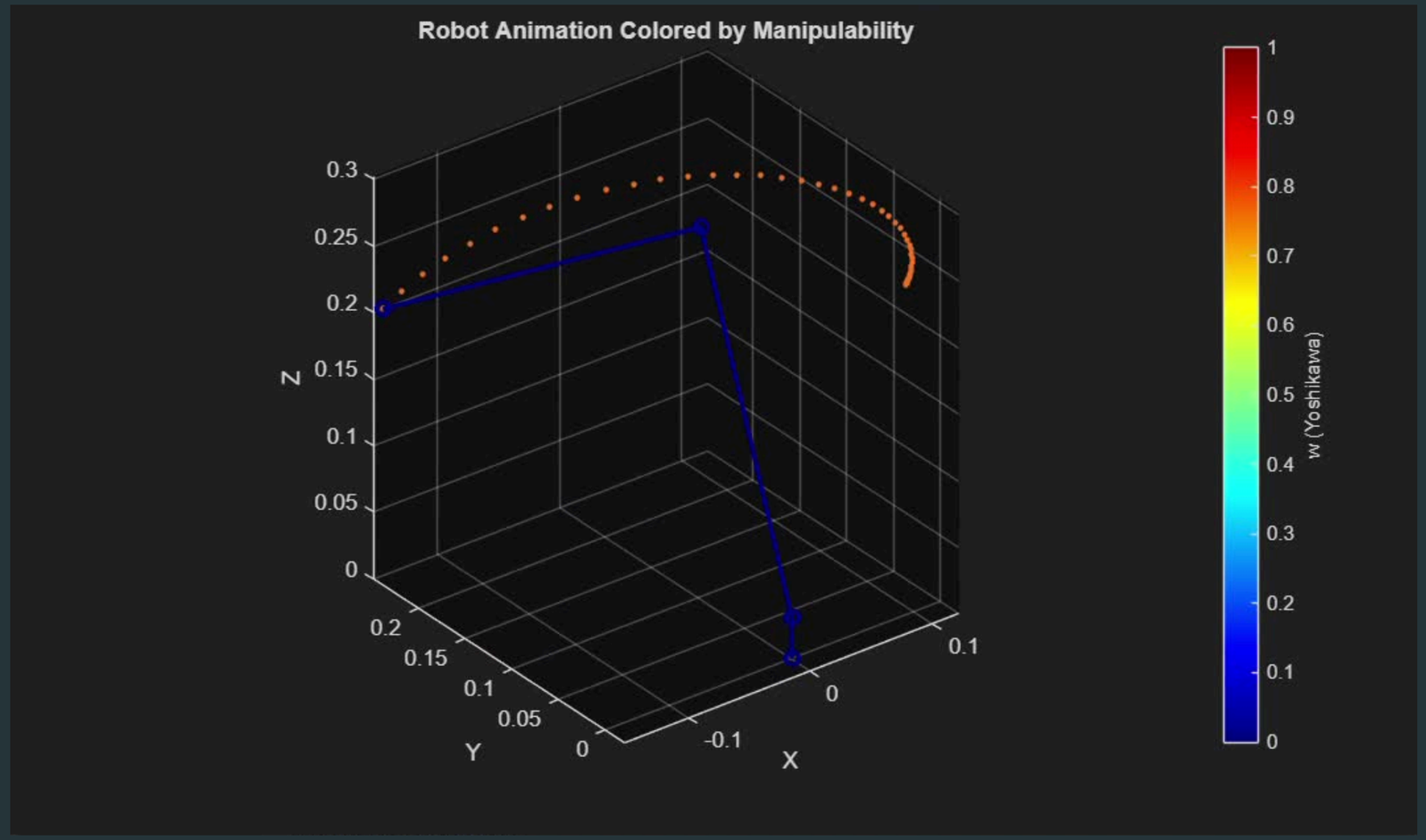
Mathematical Models

Trajectory Generation



Mathematical Models

Trajectory Generation



Mathematical Models

Torque analysis

Masses and payload:

Link 1 = 13kg
Link 2 = 11 kg
Link 3 = 9 kg
Link 4 = 3.25 kg
Link 5 = 2.25 kg
Link 6 = 1.4 kg

Payload = 1 kg

	q0 (Rad)	qf (Rad)
1	0	3.1416
2	2.1651	0.9766
3	-2.165	-1.5708
4	0	0
5	0	0
6	0	1.5706

Joint Torque vector modelled by:

$$\tau(q, \dot{q}, \ddot{q}) = M(q)\ddot{q} + C(q, \dot{q})\dot{q} + g(q) + \tau_{\text{payload}}(q, \dot{q}, \ddot{q}) + \tau_{\text{ext}}$$

Gravity torque obtained by:

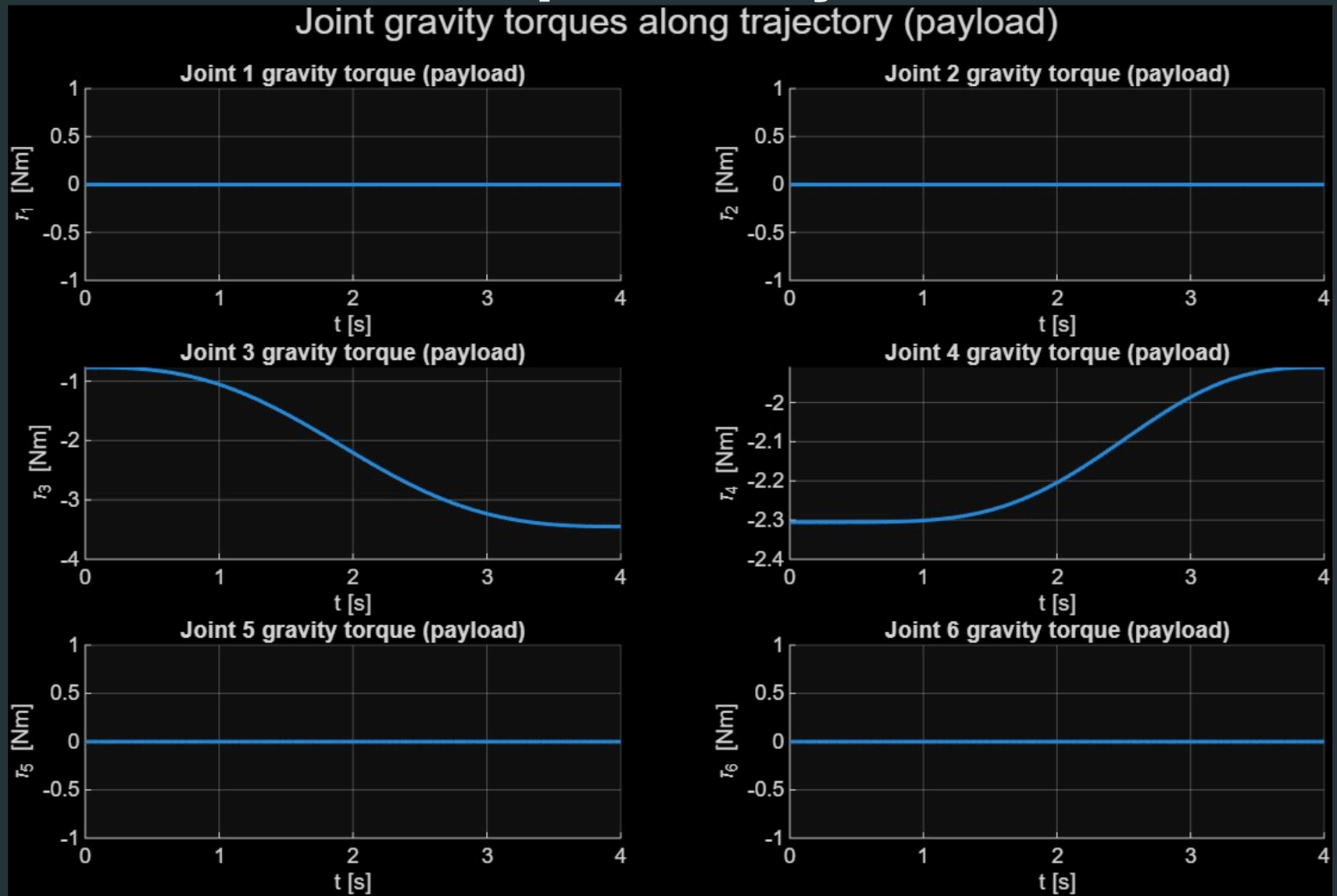
$$\tau_g(q) = \tau(q, \dot{q} = 0, \ddot{q} = 0)$$

$$g_0 = [0, 0, -9.81]^T \, \text{m/s}^2$$

Safety Factor: 1.8

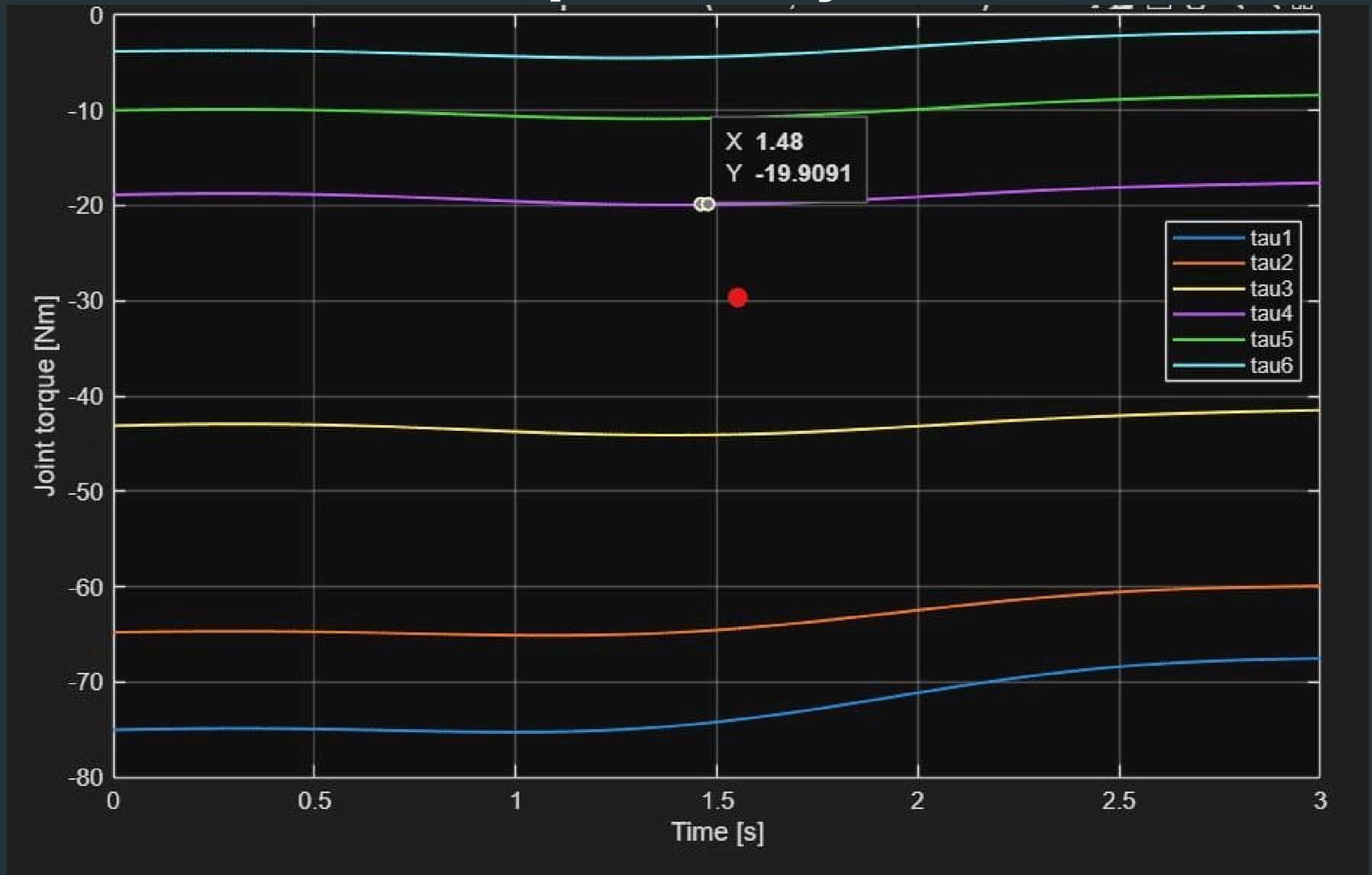
Mathematical Models

Torque analysis



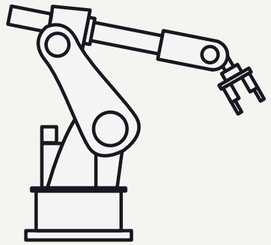
Mathematical Models

Torque analysis



Summary

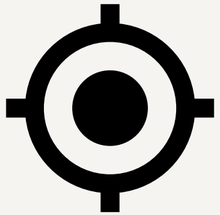
01



Smooth Performance & durability

A robust 6-axis solution that prioritizes smooth kinematics to reduce wear and guarantee durability.

02



Precision & Efficiency

Delivers high-precision screwdriving with ±0.02mm repeatability and rapid cycle times, eliminating bottlenecks and quality errors in delicate assemblies.

03

Accessible Automation

Offers a low barrier to entry with high adaptability, ensuring fast return on investment and a future-proof path for specialized production lines.

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Thank You

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