“Wenchoi”, a 3DOF Robotic Arm

ME134 HW #2 Final Prototype

By: Jacob Choi, Wenchang Gao

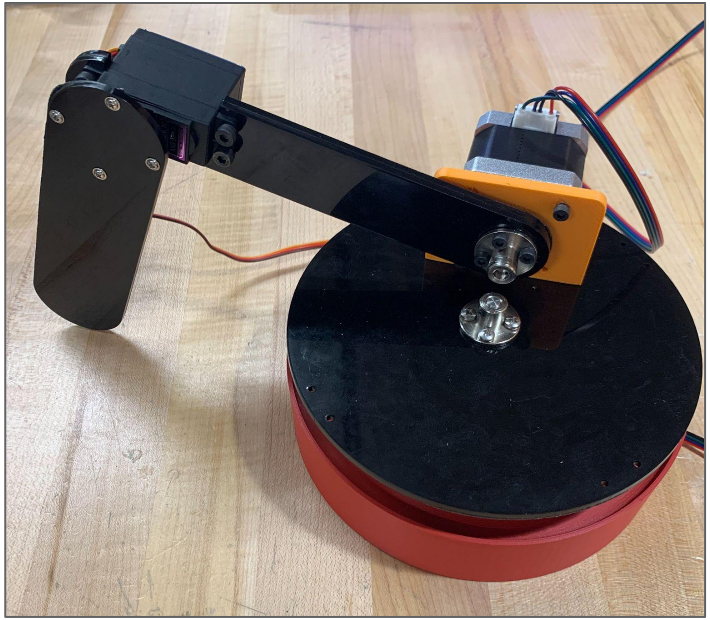
Sales Pitch

Functional Flexibility:

- 3 DOF and arm-like design
- 360° action space
- Potentials beyond writing letters

Computational Flexibility:

- Trajectory and inverse kinematics computed remotely
- Few data stored on ESP32



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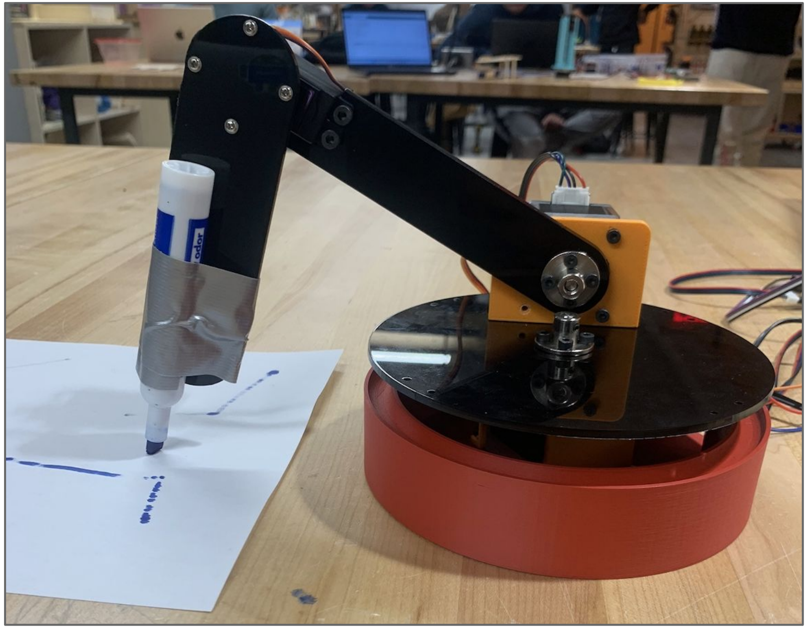
Sales Pitch



- Lightweight and portable design
- Multiple user interfaces
- Hands-free writing with facial recognition

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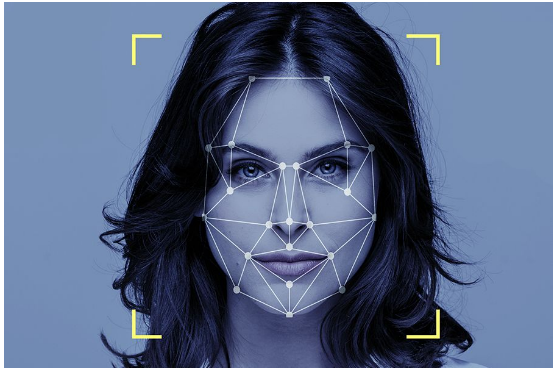
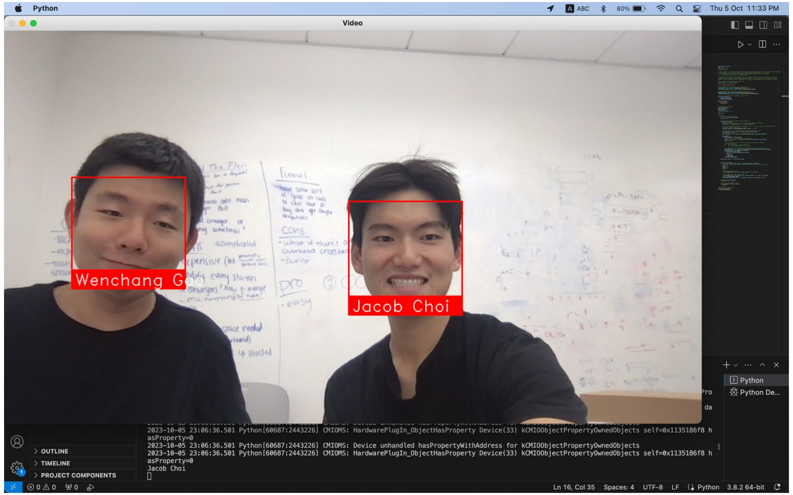
Sales Pitch



- Remembers your name and your face
- Automatically writes your initials when finds you



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2023-10-05 23:06:36.501 Python[60687:2443226] CMIOMS: HardwarePlugIn_ObjectHasProperty Device(33) kCMIOObjectPropertyOwnedObjects self=0x1135186f8 h
asProperty=0
2023-10-05 23:06:36.501 Python[60687:2443226] CMIOMS: Device unhandled hasPropertyWithAddress for kCMIOObjectPropertyOwnedObjects
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asProperty=0
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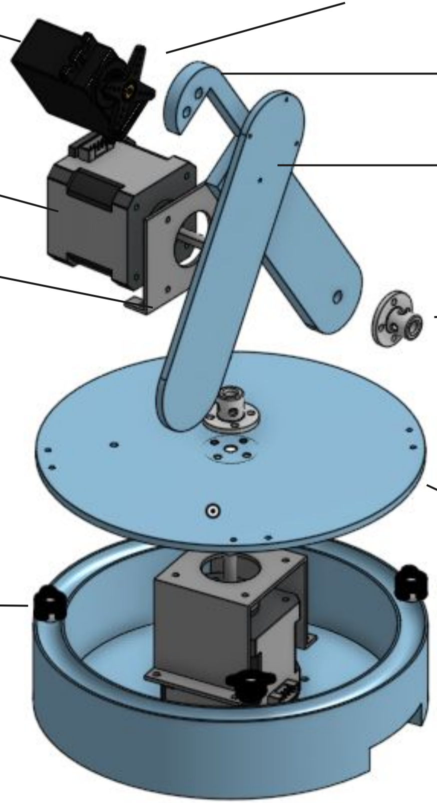
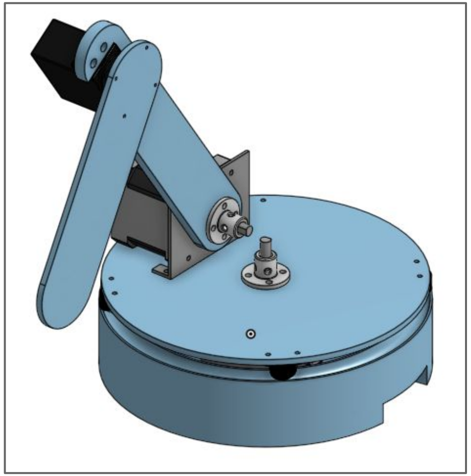
CAD Review





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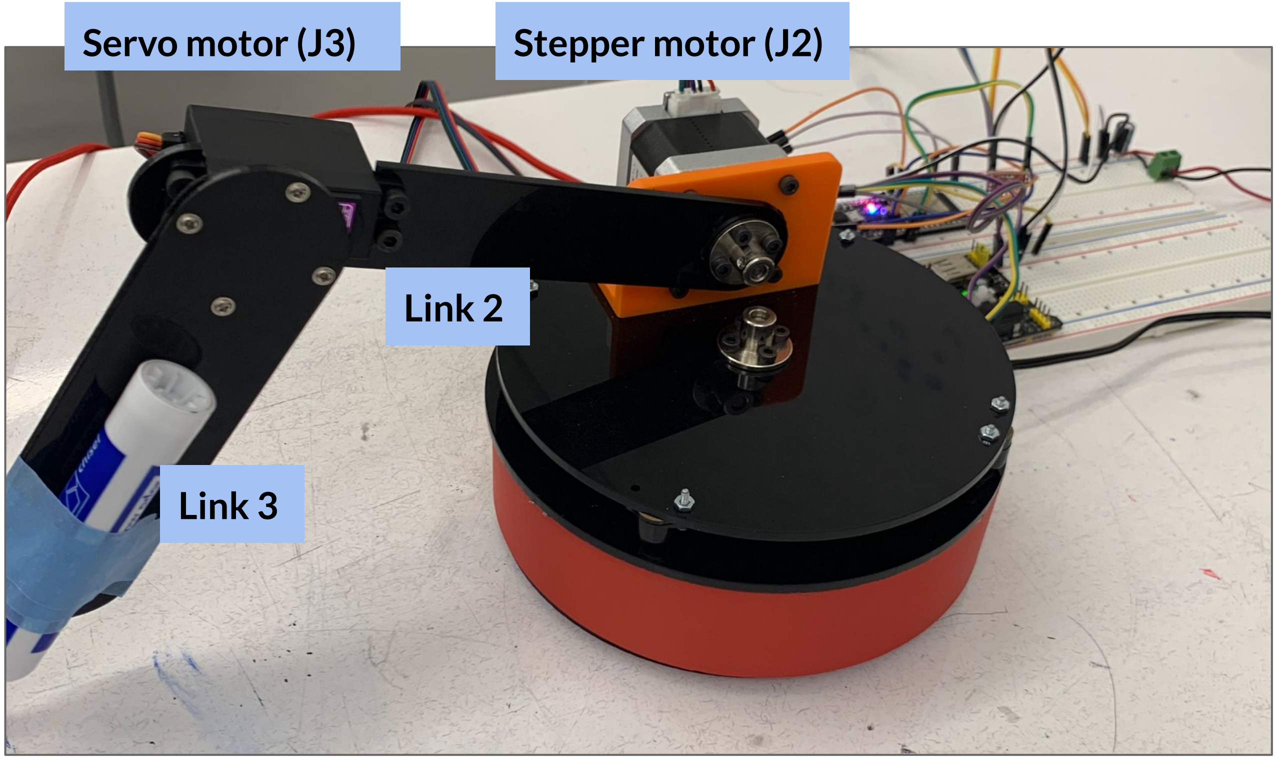
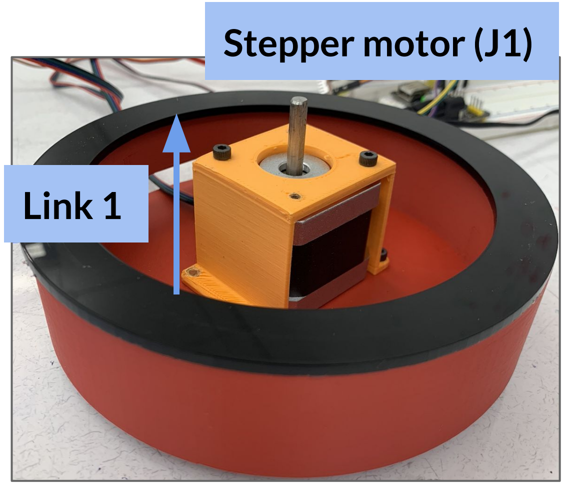
Overview





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Stretch Goal | Creativity & Innovation

Stretch goal: to automatically write initials based on facial recognition and pre-trained object detection models.

Demo video:

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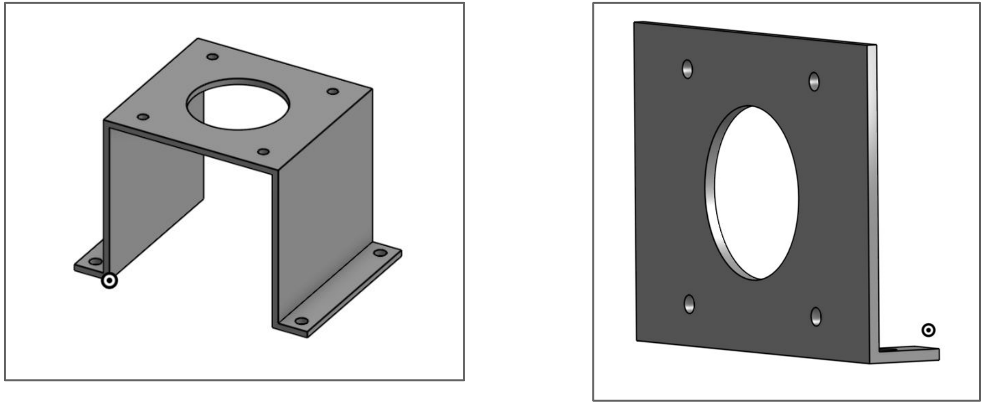
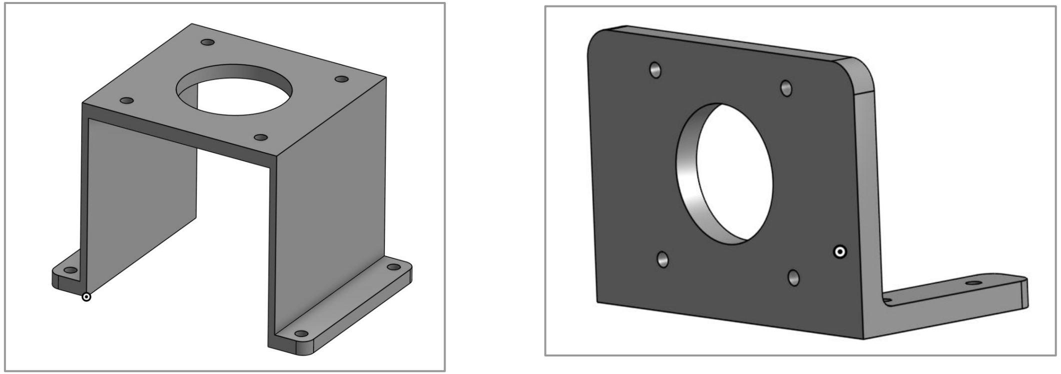
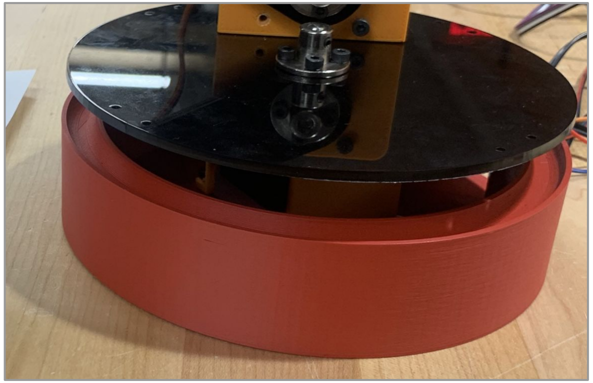
Mechanical Updates



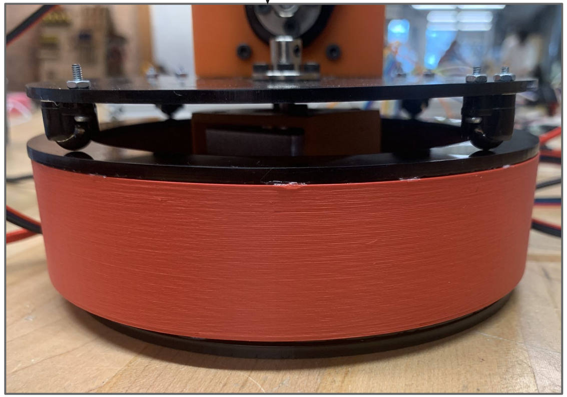
Structurally weak mounts



Thicker mounts



Unstable, unsupported base rotation



Reduced deflection, controlled base rotation

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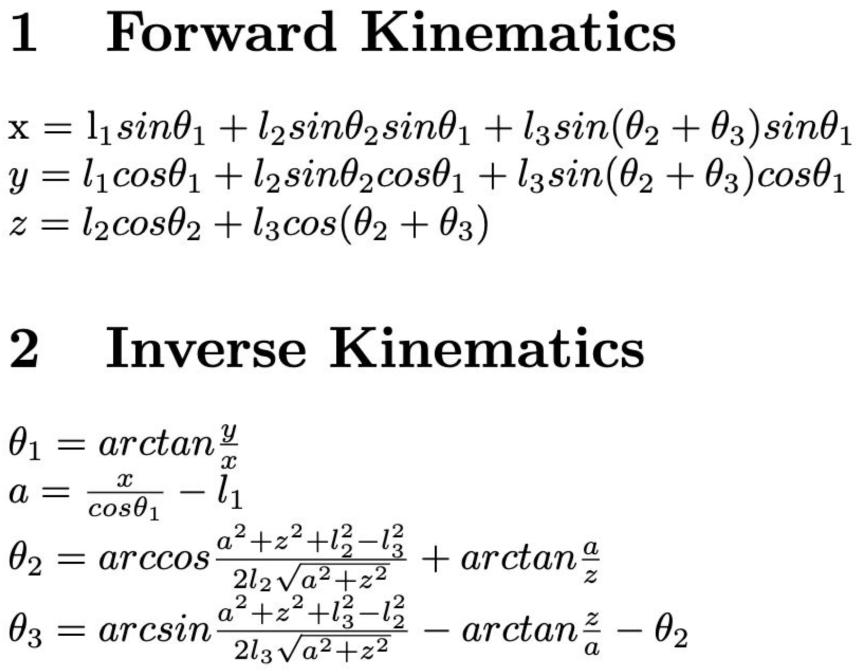
Mathematical Reasoning



1 Forward Kinematics

$$\mathrm{x} = \mathrm{l}_1 sin\theta_1 + l_2 sin\theta_2 sin\theta_1 + l_3 sin(\theta_2 + \theta_3) sin\theta_1$$
$$y = l_1 cos\theta_1 + l_2 sin\theta_2 cos\theta_1 + l_3 sin(\theta_2 + \theta_3) cos\theta_1$$
$$z = l_2 cos\theta_2 + l_3 cos(\theta_2 + \theta_3)$$

2 Inverse Kinematics

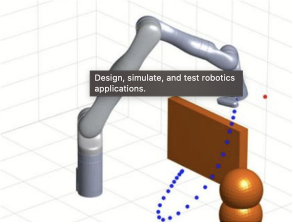
$$\theta_1 = arctan\tfrac{y}{x}$$
$$a = \tfrac{x}{cos\theta_1} - l_1$$
$$\theta_2 = arccos\tfrac{a^2+z^2+l_2^2-l_3^2}{2l_2\sqrt{a^2+z^2}} + arctan\tfrac{a}{z}$$
$$\theta_3 = arcsin\tfrac{a^2+z^2+l_3^2-l_2^2}{2l_3\sqrt{a^2+z^2}} - arctan\tfrac{z}{a} - \theta_2$$

Scientific Reasoning

$$x = x_1 + t(x_2 - x_1) \qquad (Line)$$

$$x = o + \begin{bmatrix} cos\theta \\ sin\theta \\ z \end{bmatrix} \qquad (Circle)$$

Using parametric equations, we can discretize lines and circles in Cartesian.



Using Robotics System Toolbox in MatLab, we can safely calculate the inverse kinematics.

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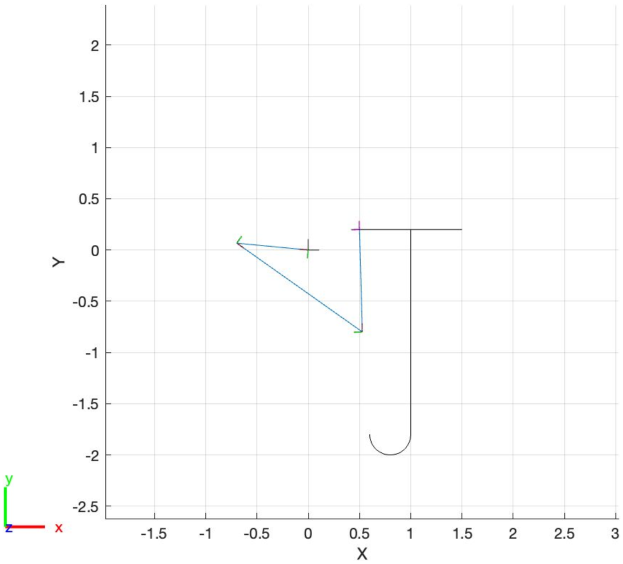
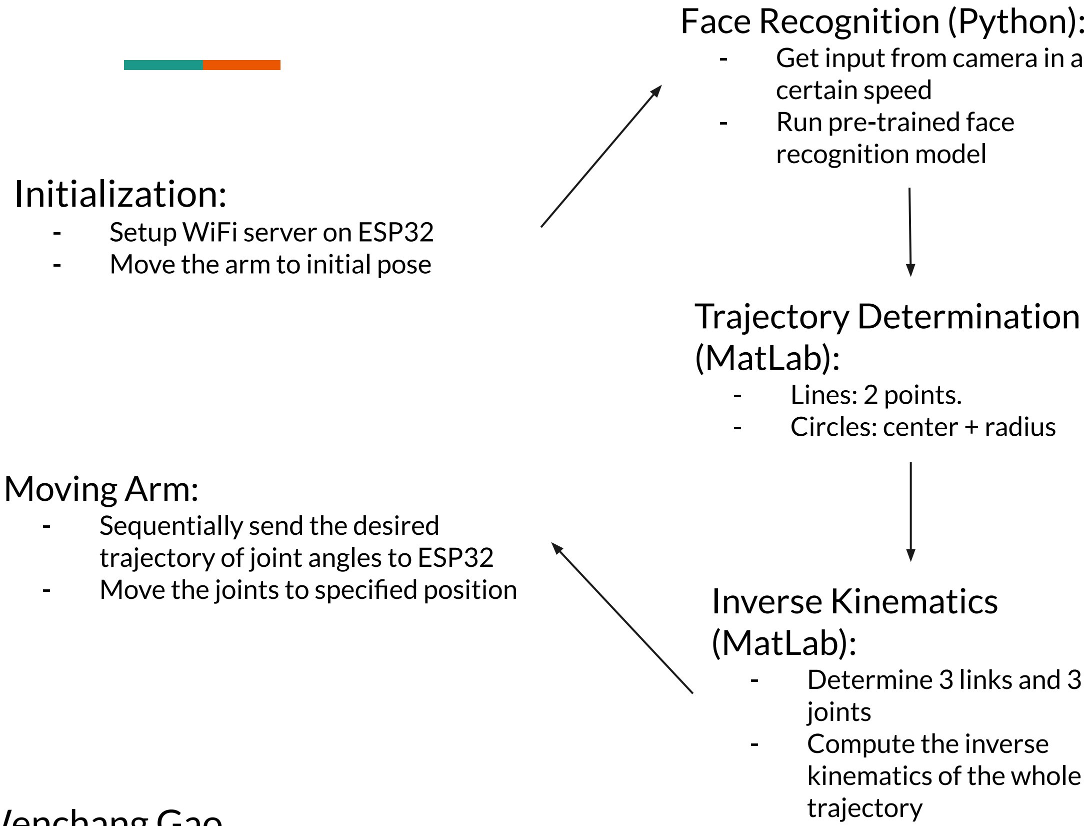


Calculating the inverse kinematics trajectory of letter ‘J’ in matlab.

This letter is combined with 3 lines and 1 half circle

Code Flow



Initialization:

- Setup WiFi server on ESP32
- Move the arm to initial pose

Face Recognition (Python):

- Get input from camera in a certain speed
- Run pre-trained face recognition model

Trajectory Determination (MatLab):

- Lines: 2 points.
- Circles: center + radius

Inverse Kinematics (MatLab):

- Determine 3 links and 3 joints
- Compute the inverse kinematics of the whole trajectory

Moving Arm:

- Sequentially send the desired trajectory of joint angles to ESP32
- Move the joints to specified position

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Thank you for listening!

Any questions?