Technical Documentation

1. Image Processing

Edge detection is implemented using Sobel operators:

$$G = \sqrt{G_x^2 + G_y^2}$$

Binary segmentation isolates structural edges, followed by morphological closing for contour continuity.

2. Coordinate Transformation

Let:

- Image size: Wi,HiW_i, H_iWi,Hi
- Paper size: Wp,HpW_p, H_pWp,Hp

Scaling:

$$S_x = W_p / W_i$$

$$S_y = H_p / H_i$$

3. Workspace Analysis

Maximum reach:

$$R_{max} = L_1 + L_2 = 400 \text{ mm}$$

Minimum reach:

$$R_{min} = |L_1 - L_2| = 0 \text{ mm}$$

Workspace shape: Circular annulus (degenerates into full circle due to equal links).

Reachable drawing area depends on mechanical mounting offset.

4. Control Strategy

- Open-loop PWM control
- No feedback correction
- Manual homing calibration
- Sequential contour following

5. Mechanical Considerations

- Lightweight PLA structure
- Friction at joints
- Servo gear backlash
- Limited stiffness under load