PROJECT ON ROBOTICS

APPLICATION OF IMAGE PROCESSING AND 3-DOF SCARA ROBOTIC ARM IN OBJECT CLASSIFICATION BASED ON COLOR

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SUMMARY

Our team successfully completed the design, integration, and testing of a 3-degree-of-freedom (3-DOF SCARA) robotic system combined with image processing. We calculated the size and designed the robot shape using SolidWorks software. The model was controlled on MATLAB via the support package for Arduino microcontrollers.

1. SYSTEM OVERVIEW

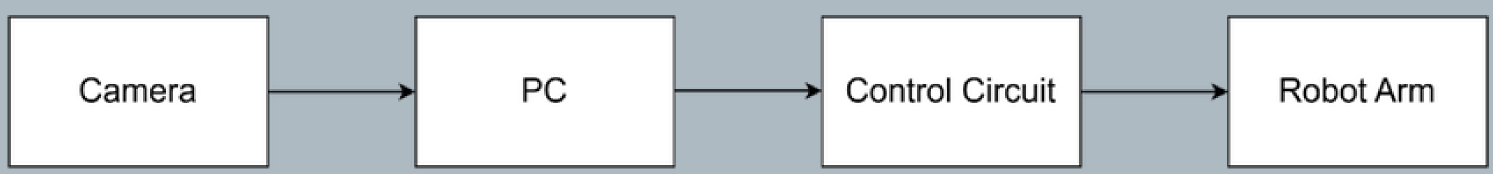

Figure 1: System Block Diagram

2. KINEMATICS EQUATION

SET ROBOT AXIS

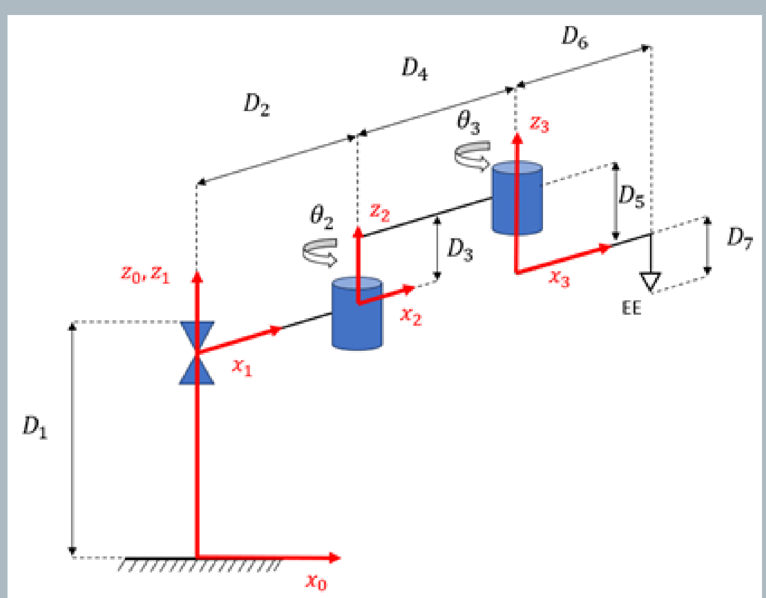

Figure 2: 2D model of 3-DOF SCARA robot model

MODIFY DH TABLE

	i	a_{i-1}	α_{i-1}	d_i	θ_i	
$z_0 z_1 x_0$	1	0	0	D_1	0	$x_0 x_1 z_1$
$z_1 z_2 x_1$	2	D_2	0	0	θ_2	$x_1 x_2 z_2$
$z_2 z_3 x_2$	3	D_4	0	0	θ_3	$x_2 x_3 z_3$

FORWARD KINEMATIC

$$ {}^{0}_{EE}T = {}^{0}_{1}T\,{}^{1}_{2}T\,{}^{2}_{3}T\,{}^{3}_{EE}T $$

$$ {}^{0}_{EE}T = \begin{bmatrix} c_{23} & -s_{23} & 0 & c_{23}D_6 + c_2 D_4 + D_2 \\ s_{23} & c_{23} & 0 & s_{23}D_6 + s_2 D_4 \\ 0 & 0 & 1 & -D_7 + D_1 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

INVERSE KINEMATIC

$$ \begin{cases} \theta_2 = atan2\left(\dfrac{(P_x - D_2)^2 + P_y^2 + D_4^2 - D_6^2}{\sqrt{(2D_4P_y)^2 + (2D_4(P_x - D_2))^2}}; \sqrt{1 - \dfrac{\left((P_x - D_2)^2 + P_y^2 + D_4^2 - D_6^2\right)^2}{(2D_4P_y)^2 + (2D_4(P_x - D_2))^2}} \right) - \alpha \\ \theta_3 = \theta_{23} - \theta_2 \\ D_1 = P_z + D_7 \end{cases} $$

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3. 3D DESIGN

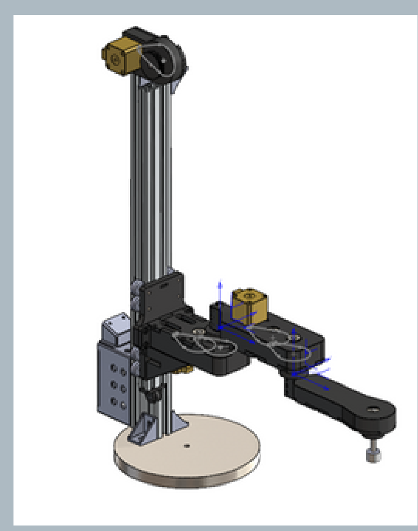

Figure 3: 3D Robot model in SolidWorks

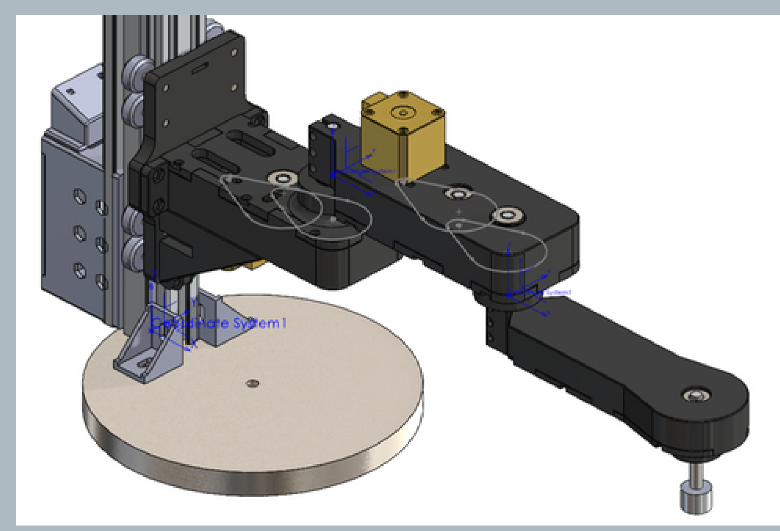

Figure 4: Setting up axis in SolidWorks

4. ALGORITHM

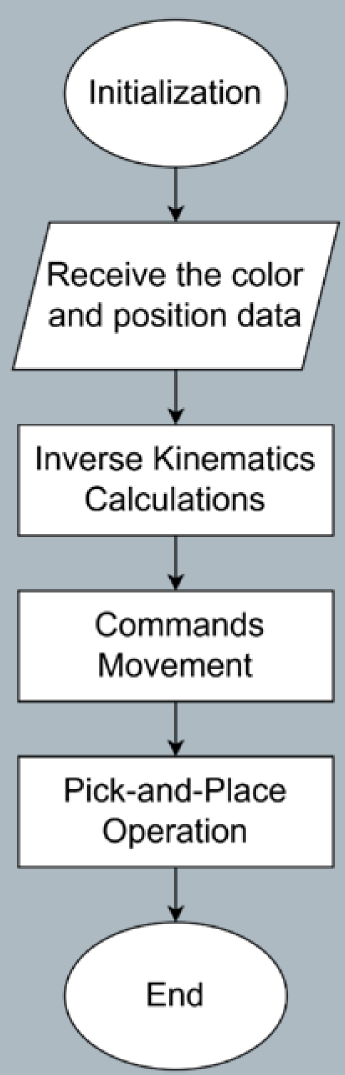

Figure 5: Robot control algorithm

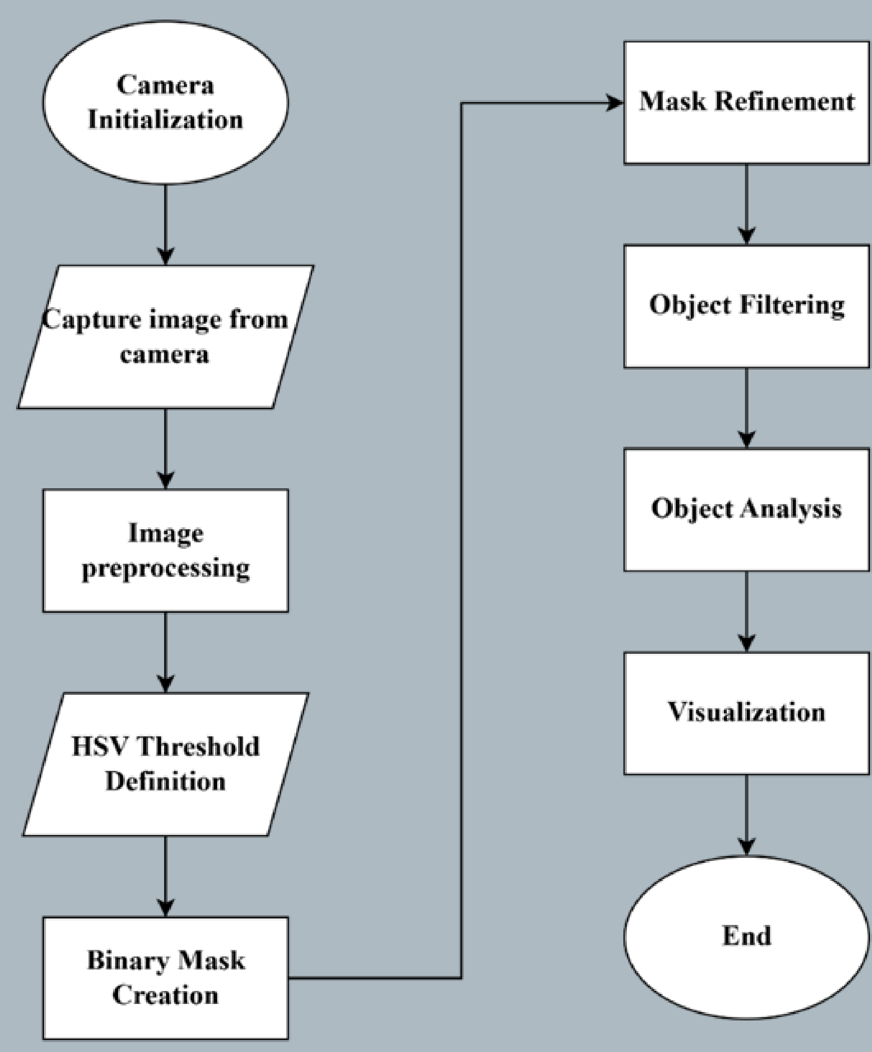

Figure 6: Image processing algorithm

5. EXPERIMENT RESULT

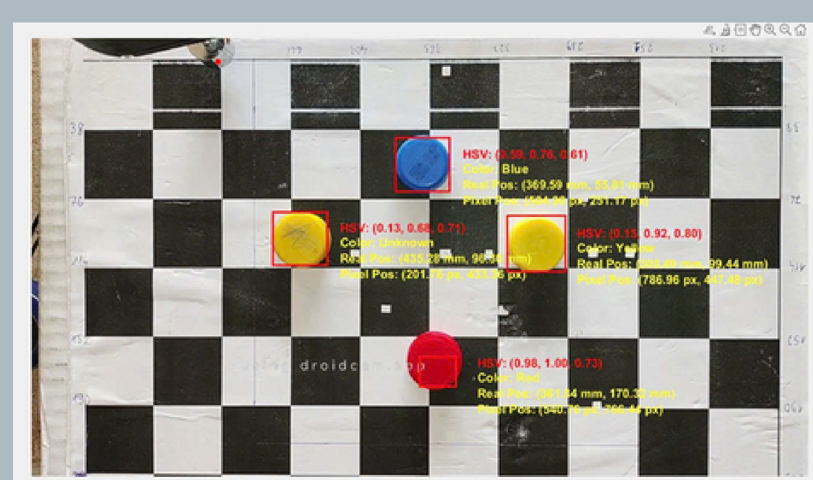

Figure 7: Classify color and determine position of each bottle cap

Figure 8: Robot sorting bottle cap

6. CONCLUSION

In this project, we have successfully:

- **Calculated Forward and Inverse kinematics**
- **Designed a 3D robot model on Solidworks**
- **Created a program used to classify 3 colors and determine positon**
- **Controlled the hardware model using MATLAB**