Robotic Arm Controlling with Image Processing

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Introduction

The aim of this project is to design and manufacture a robotic arm that capable of tightening or loosening metallic Phillips screws by using image processing.

The arm utilizes a video camera that captures images to be processed for screw recognition. Based on these captured images, the algorithm feeds the robotic arm with the corresponding coordinates of the screw and enables the arm to tighten it.

Specifications and Design Requirements

As design requirements robotic arm designed with 6 - Degrees of Freedom rotational joint. End effector must be able to work in 20x20x20 cm cube. Detection and recognition done by image processing algorithm. The detected screws information should sent to the user via Graphical User Interface (GUI).

Solution Methodology

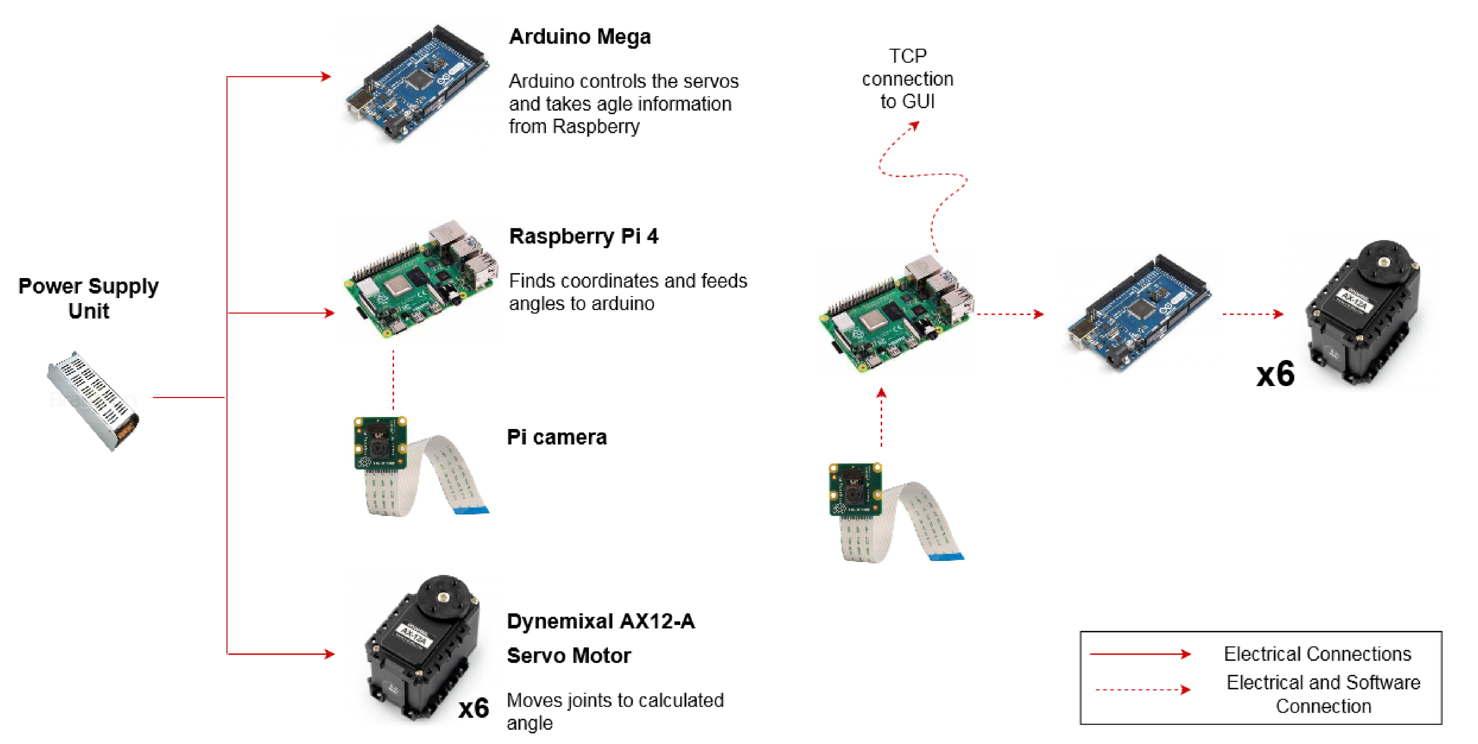


Figure 1: Electrical description of the project components.

Haar-like features are digital image features used in object recognition.By using haar like features of the screw, the classifier trained. After finding location of the screw, using kinematic equations calculated angels are sent to the motors. To increase accurcy pixel tracking algorithm added.

For determining the coordinates or angles inverse and forward kinematic equations are used respectively. Forward and inverse kinematic equation given in below. Here S and C are abbreviations of the sinus and cosine function.

Forward Kinematic Equation:

$$\begin{bmatrix} c_{\theta_i} & -s_{\theta_i}c_{\alpha_i} & s_{\theta_i}s_{\alpha_i} & a_i c_{\theta_i} \\ s_{\theta_i} & c_{\theta_i}c_{\alpha_i} & -c_{\theta_i}s_{\alpha_i} & a_i s_{\theta_i} \\ 0 & s_{\alpha_i} & c_{\alpha_i} & d_i \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Inverse Kinematic Equation:

$$\begin{bmatrix} n_x C_6 - o_x S_6 & o_x C_6 + n_x S_6 & a_x & P_x - a_x d_6 \\ n_y C_6 - o_y S_6 & o_y C_6 + n_y S_6 & a_y & P_y - a_y d_6 \\ n_z C_6 - o_z S_6 & o_z C_6 + n_z S_6 & a_z & P_z - a_z d_6 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Mechanical design is made on SolidWorks.

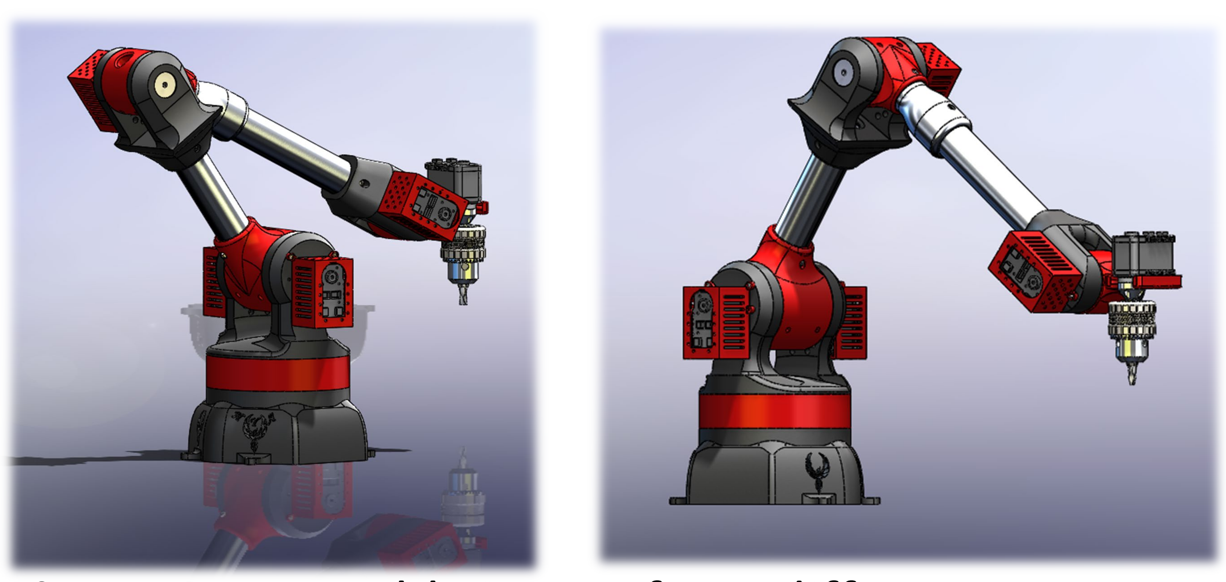


Figure 2: Assembly image from different perspective

Application Areas

- ❖ Defense Industry
- ❖ Automotive Industry
- ❖ Space Technologies
- ❖ Clean Room etc.

Figure 2: Electronic Card Screwdriving

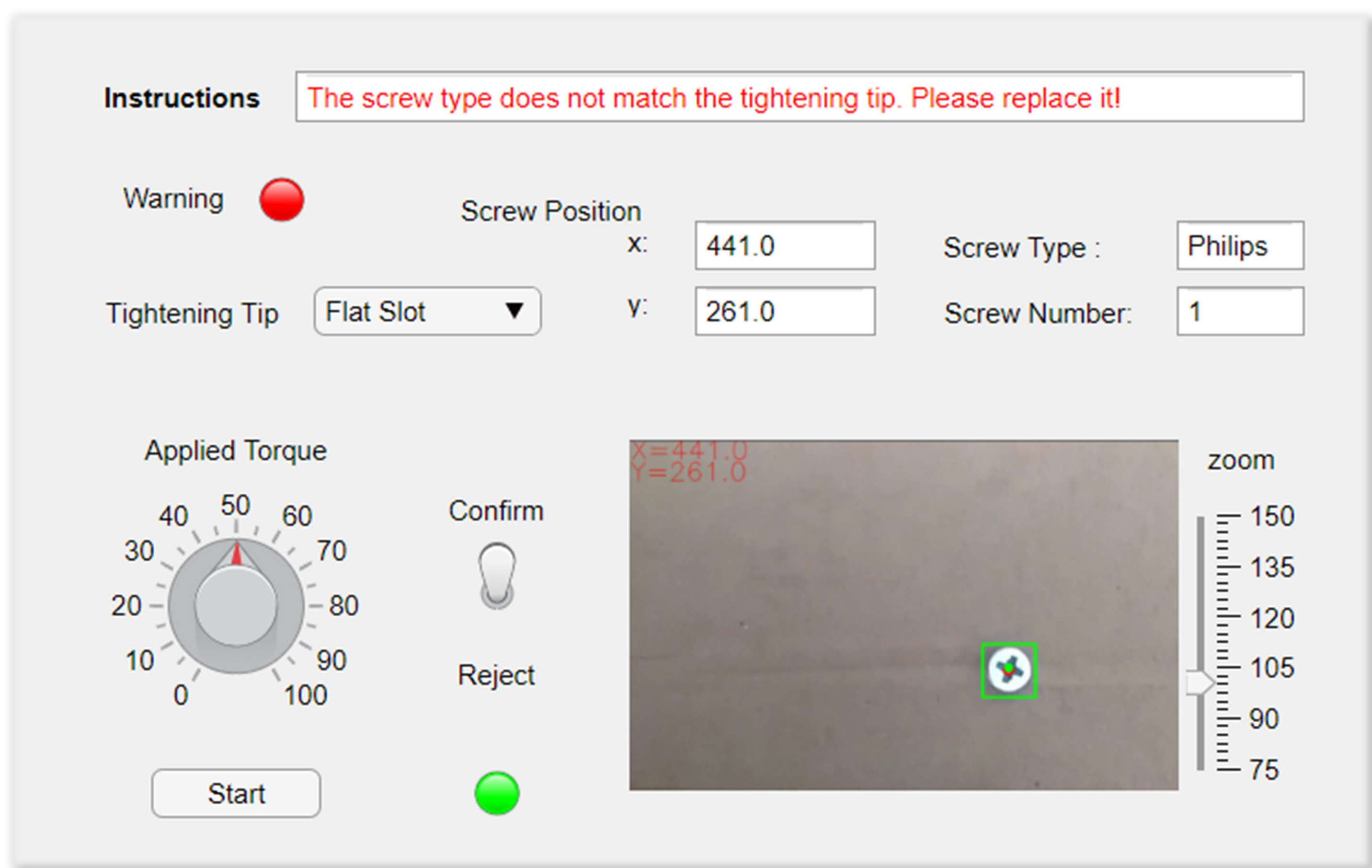
Results and Discussion

For increasing the performance and mobility, Raspberry Pi and Arduino used. Raspberry pi used for Robot Operating System and image processing. Robot Operating System takes information from the Graphical User Interface and transmit to the related parts like Arduino to control servo motors or Raspberry Pi to detect new screw locations.

Algorithm calculates the forward and inverse kinematics using URDF (Universal Robot Description File). So URDF taken from the SolidWorks. Also this file used in Rviz simulation to test whether or not kinematic calculations work properly.

Recognition of the screw worked fine and also tracking algorithm increases the performance. Even if the screw undetected in video frames, screw location is tracked with the help of algorithm.

The interface design communicates remotely with the TCP-IP protocol with the robotic arm. The robotic arm sends the position of the screw , the type of screw (Philips) and its image on the camera to the user interface, and waits for confirmation to start working from the user interface. At the same time, if the screw type does not match with the tightening tip attached on the robot arm, it sends a warning message to the user and waits for replacement.



Acknowledgements

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