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Robotic Arm Aimed to Replace Cutting Processes

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Abstract : *Small to medium scale industries waste resources on cutting operations, this article presents a study of a robotic arm aimed to replace cutting operations in industries. Control of Robotic arm was made by interfacing Matlab with Arduino. The concept of this arm is same as that of a plotter. The arm works in 2 parts, firstly forming a binary image and secondly finding out the pixelinfo and plotting according to the generated pixels.*

Keywords: *Interfacing, Binary Image, Pixelinfo.*

I. Introduction

A robotic arm is a mechanical arm which has similar functions to a human arm and in the case of this project (and usually), is programmable. Robotic arms consist of a series of connected links of either revolute or prismatic joints which form a kinematic chain. The end of the kinematic chain, termed the end effecter, is where the tool is located and is analogous to the human hand. Revolute joints allow rotational motion about an axis, while prismatic joints allow linear translation along an axis.

The project involves the design and implementation of an articulated robotic arm with 2 degrees of freedom (DOF) capable of plotting commands sent by matlab codes onto a flat surface. The project consists of a number of stages [3], namely conceptualisation, system design, component selection, mathematical modelling of the arm, coding of the control hardware, implementation of control hardware, performance analysis and conclusion.

There have been many designs of 2-DOF robotic arms and they all vary in construction and size and what their final goals are. Most of the are 2-DOF arms programmed using inverse kinematics[2], controlled by external input such as a potentiometer [1], or similar type of master/slave interface. They are built using a mainly servos and stepper motors for actuation.

II. Mechanical Design

The mechanical design of the system includes the arm construction and platform holding the base of the arm as well as the motors.

A. *ARM:* The arms needed to be light weight in order to minimise the inertial load reflected to the motors through the coupling systems but also strong enough to hold any other forces in the system without much buckling, bending or large deflection due to weight. The robot consists of 2 arms, L1 and L2. For reference, arm L1 is coupled to the shoulder drive motor, while arm L2 is connected at the elbow, to which the end effector (the pen) is connected.

B. Kinematics: To solve the angles the arms need to be at in order to achieve a desired location of the end effector (pen), inverse kinematics is used. Inverse kinematics calculates the required angles of the arms, theta 1 and 2, in order for the end effector to reach its desired coordinate point.

A simple diagram for the robot arm is given, where the end effector is represented by the orange circle. (x0,y0) is the coordinate frame for arm l1, and (x1,y1) the coordinate frame for arm l2.

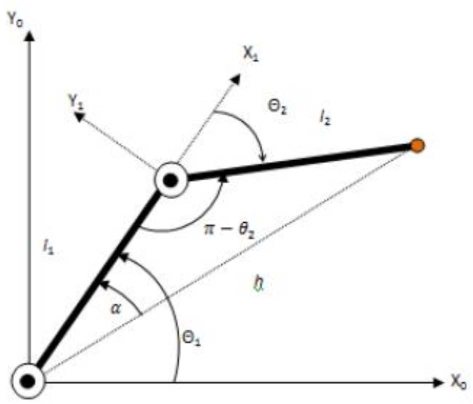

Figure 1 diagram of the system

Solving kinematic equations we get,

$$\theta_2 = \pi - \cos^{-1}\left(\frac{L_1^2 + L_2^2 - h^2}{2L_2L_1}\right) \qquad (1)$$

$$\Theta_p = \text{atan2}(x_p, y_p) \qquad (2)$$

Where,

$$\theta_1 = \Theta_p + \alpha \qquad (3)$$

$$\alpha = \cos^{-1}\left(\frac{L_1^2 + h^2 - L_2^2}{2L_1h}\right) \qquad (4)$$

C. Dynamic solution:

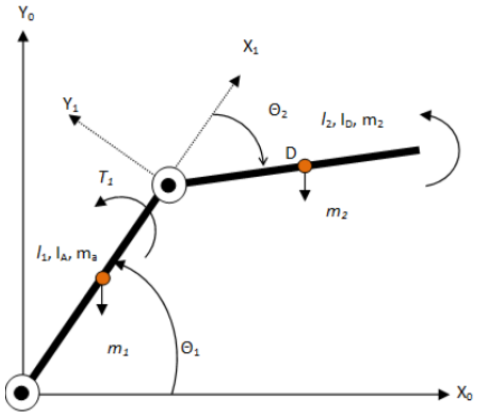

Figure 2 Dynamic system

$$\tau_1 = \ddot{\theta}_1\left(\frac{1}{2}I_A + \frac{1}{2}I_D + \frac{1}{2}m_2l_1{}^2 + m_2l_1l_{m2}c_2 + \frac{1}{2}m_2l_{m2}{}^2\right) + \ddot{\theta}_2\left(\frac{1}{2}I_D + m_2l_1l_{m2}c_2 + \frac{1}{2}m_2l_{m2}{}^2\right)$$

$$\tau_2 = \ddot{\theta}_2\left(\frac{1}{2}I_D + \frac{1}{2}m_2l_{m2}{}^2\right) + \ddot{\theta}_1\left(\frac{1}{2}I_D + m_2l_1l_{m2}c_2 + \frac{1}{2}m_2l_{m2}{}^2\right)$$

………….. (5)

…......…….(6)

It is clear from these equations, that the torque is dependent on the acceleration/deceleration as well as the mass, lengths of certain mass moment points away from other points and inertia of the arms.

MODELLING

Modelling of Robotic arm:

Modelling was performed in SolidWorks 2013 using solid part modelling.

The model designed has 2 links and a path in shape of a t-shirt on which the end effector was animated to simulate motion.

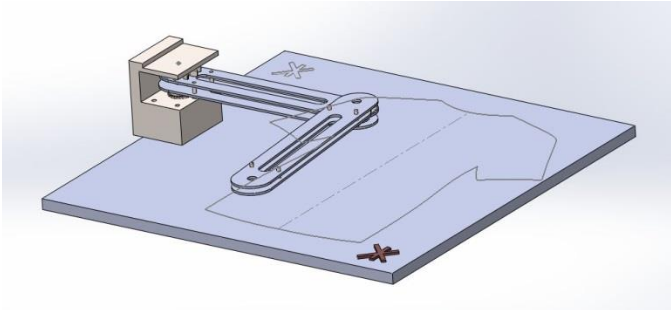

Figure 3 Screenshot of robot with path

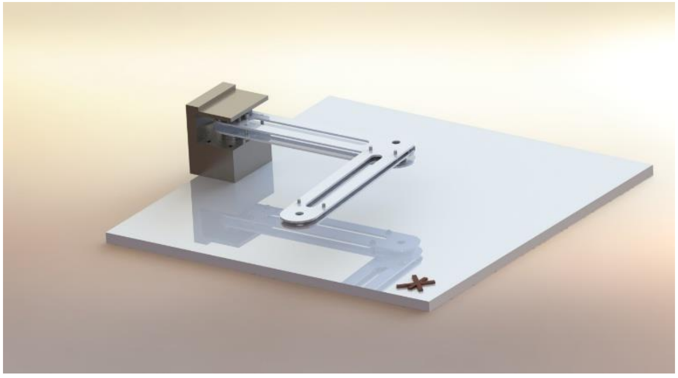

Figure 4 After rendering the model

III. RESULTS

To get converted image consisting of pixel information of all the detected 1's the input image is first converted to .png extension. Then the image is placed in Matlab directory after the program is run, the program first finds the edges in the image then converts it into binary form, pixels (coordinates) of 1's in the image are found out then the converted image is displayed in computer's screen, the pixel information is then sent to arduino board via AB type serial cable.

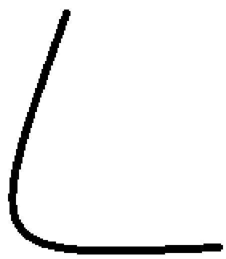

Figure 5 Input image in .png extension

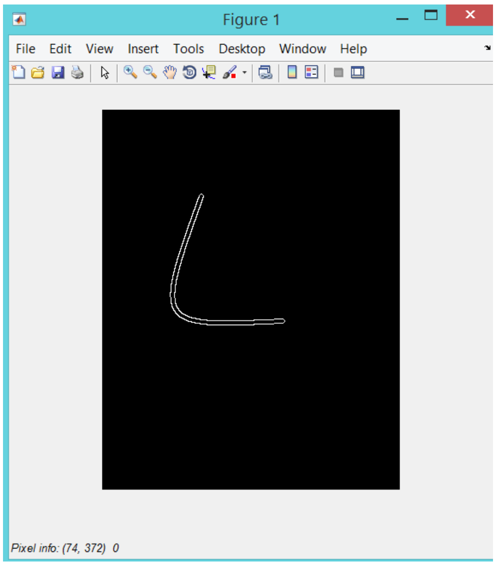

Figure 7 Output

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