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"Design and Fabrication of Pick and Place Robotic Arm with 4DOF"

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Abstract - *The more increase in the number of industries in developing countries, the more workers are required. To reduce the cost of the labor force and to increase the manufacturing capacity of industries, advanced robot arms are more needed. This paper aims to eliminate the control of the robotic arm for picking and placing the required object. The arm is constructed with four links and four servo motors to drive the robot arm. Arduino Nano is been used to generate the required control signals for servo motors. The robot is to be developed for assisting/replacing workers in a factory involving material handling of small components such as electronic items, nuts and bolts, small mechanical components, etc.*

***Key Words*: Robot arm, Industries, Control, Manufacturing, Arduino nano , Servo motors.**

1.INTRODUCTION

The pick and place robotic arms handle repetitive tasks while making it available to human workers to focus on more complicated work. Robotic arms are usually mounted on a stable stand, pick and place robotic arms are positioned to reach different areas to perform work. For, example in order to fulfillment applications in which items are placed onto a conveyor, picking bin or directly into a packaging container, the robot should come with four to five axes. This project is been designed the robotic arm with four degree of freedom which will assist/replace workers in the industry. The main objective of the project is to design and fabricate the robotic arm which may perform various operations in industry such as pick and place the object, material handling, which can be controlled automatically and manually. The robotic arm may be classified into four parts:

- Base
- Servo shoulder
- Arm
- Gripper

The pick and place robotic arm has a base which is stationary and has joints with servo shoulder. There are four servo motors for the smooth operation of robotic arm. Ankle and servo shoulder is the main part to assist gripper for the working of robotic arm. The main functioning of the robotic arm is handled by the sensor technology which is been used for the smooth operation to pick the object from one position and place it over desired position. This project is such designed it is highly secure and cost effective as HC05 Bluetooth module is being used. Android application is being developed for the prototype and it is been designed in "MIT app inventor" which is open online platform to design android app having block coding system (drag and drop).

2. PROBLEM STATEMENT

To design a robotic arm suitable to work with 4DOF and which is not too bulky and also compatible to use. This arm should be encrypted wireless controllable according to the applications to be used for. Automatically obtained its initial position. Develop arm which can be operate remotely at hazardous workplaces.

3. OBJECTIVE

To design and develop a system of robotic arm that can perform various operations in industry such as to pick the object from one position and place it over desired position, handle the material effectively, which can be controlled automatically and manually. Following are the main objectives of this project:

- To reduce human efforts to some extent.
- To reduce time consumption.
- To remain unaffected by all weather conditions.
- Operate from 1 meter distance.
- End to end encrypted operation.

4. MATERIAL SELECTION

The material properties were taken into consideration during the material selection process: strength, lightness, availability and Ease of cutting. The material should possess sufficient strength so it will ensure that each link of the arm is able to bear the load imposed on it by motors, other attached links and the payload. Lightness of the material reduces the torque requirement of the robotic controllers, thus minimizing the cost. The material needs to be readily available and easy to cut because the fabrication of some parts of a robotic arm involves the cutting of intricate shapes which will go for laser cutting. The main objective is to have mild steel as selection for arm and servo brackets because it may sustain the force exerted by servo and also it is easy to do laser cutting operation as its thickness is less. The main objective is to select aluminum for gripper because it is lightweight and can handle the weight concentration properly.

Table -1: Material Selection

Component	Material	Reason
Arm	Mild Steel	Can sustain force exterted by servo, sheet metal component so easy to mfg.
Servo brackets	Mild Steel	Can sustain the force exterted by servo.
Gripper	Aluminium	Strong,light weight,readily available.

5. CALCULATIONS

The criteria chosen for the designing of the robot size was designed as per the maximum pay load and on the application of the robot for industry use. The robot is such a design that it will assist/replace workers in a factory involving material handling of small components such as electronic items, nuts and bolts, small mechanical components, etc.So, the maximum payload carrying capacity is taken into consideration is 350g.

Torque Calculation for maximum load:-

At Gripper: The gripper is the main component for the smooth operation of the robotic arm.

Moment arm = 13.2cm

Load = 0.350kg

Torque = 4.55kg.cm

At Elbow: The elbow is the component which will assist the gripper for the movement from one place to another.

Moment arm = 11.5cm

Load = 0.4kg

Torque = 4.6kg.cm

At Shoulder and Yaw: The shoulder and yaw is joint with the elbow for the smooth functioning of the robotic arm.

Moment arm = 25cm

Load = 0.6kg

Torque = 15kg.cm

DOF Calculation:- Using following Kutzbach criteria equation to calculate DOF of robotic arm,

DOF = 3(L-1) – 2j – h

Where,

L= No. Of Links

j= Lower pairs

h=Higher pairs

Here in this project,

No. of links = 5

No. of lower pairs = 4

No. of higher pairs = 0

Thus, by calculating the degree of freedom using Kutzbach criteria equation,

DOF = 3(L-1) – 2j – h

DOF = 3(5-1) – 2(4) – 0

DOF= 4

Thus, required torque of every motor and calculated DOF of th project is 4.

6. SENSOR TECHNOLOGY

i) Adafruit Servo module:- Adafruit servo module allows easy to write Python code that controls servos and PWM with this breakout.

ii) Arduino Nano:- Arduino Nano is a flexible, low cost and easy-to-use programmable open-source microcontroller board that can be integrated into a variety of electronic projects. This board can be interfaced with other Arduino boards, Arduino shields, Raspberry Pi boards and can control relays, LEDs, servos, and motors as an output.

iii) HC05 Bluetooth Module:- HC-05 Bluetooth Module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. Its communication is via serial communication which makes an easy way to interface with a controller or PC.

iv) Jumper wires:- Jumper wires typically come in three versions: male-to-male, male-to-female and female-to-female. The difference between each is in the end point of the wire. Male ends have a pin protruding and can plug into things, while female ends do not and are used to plug things into.

v) MG995 Plastic Gear Servo Motor:- The servo motor is specialized for high-response, high-precision positioning. As a motor capable of accurate rotation angle and speed control, it can be used for a variety of equipment. A rotation detector (encoder) is mounted on the motor and feeds the rotation position/speed of the motor shaft back to the driver.

vi) Power source:- The actual supply from switch board is 230 volt which is so much excess for our requirement it can blast our system hence a 5 V transformer we have added in system which can convert 230 v into 5v which we required in DC current form.

vii) Android development :- Android application is being developed for the prototype and it is been designed in "MIT app inventor" which is open online platform to design android app having block coding system (drag and drop)

7. ANSYS ANALYSIS

The analysis of the robotic arm was done on ANSYS workbench software. Boundary conditions: Base plate is fixed and load is applied at the gripper, ankle and shoulder.

Meshing: General

Force 1= 3.43N

Force 2= 3.924 N

Force 3 = 5.886 N

Hence, the experimental validation of the robotic arm done manually and the analysis was performed with the ANSYS software.

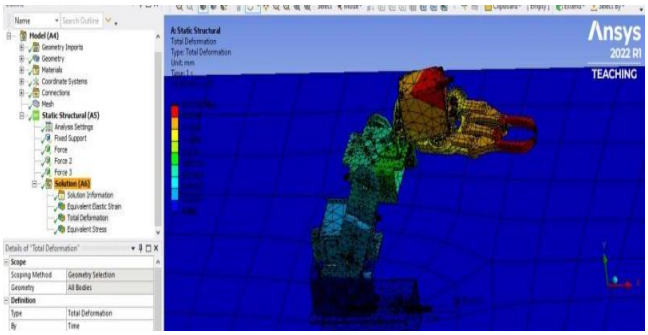

Fig -1: Ansys Simulation

8 EXPERIMENTAL VALIDATION

The experimental validation of robotic arm was done by performing manually and automatically with 0.35kg load.

Fig -2: Picking the object

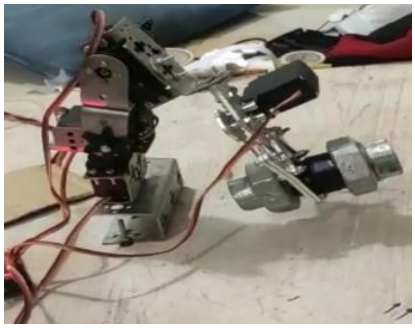

Fig -3: Movement of object

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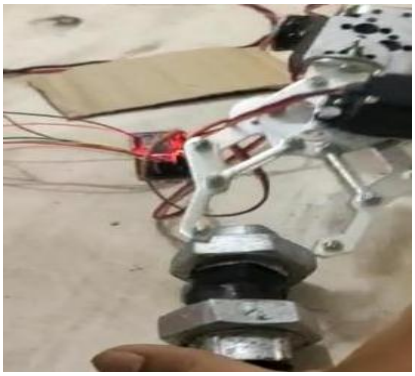

Fig -4:Placing the object

8. ACTUAL PROJECT

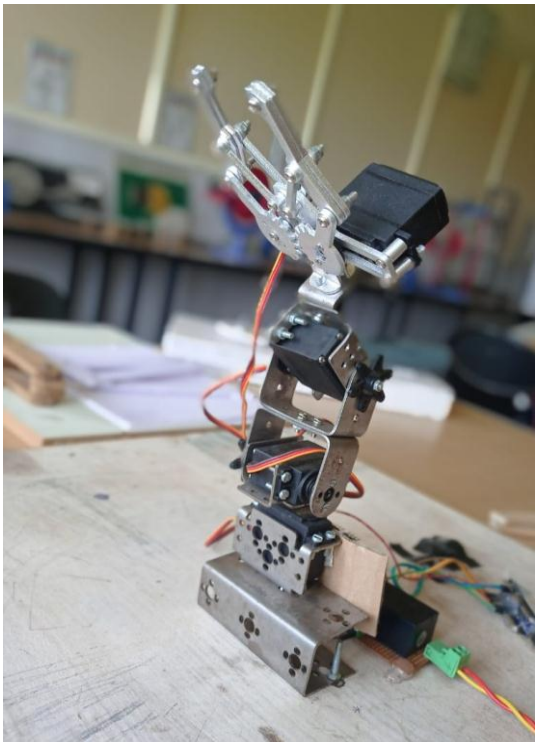

Fig -5: Actual Project

10. CONCLUSIONS

Thus by experimental validation and by testing. It can lift 350 Gram object effectively and can be operated from 1m distance. We can increase its weight capacity by changing servo motor and part dimensions. In hazardous location where human existence not possible there robotic arm can reach. In repetitive work where human can be fatigue due to repetition of work and can't perform efficiently. At assembly line to pick and place various Parts within short span of time and on desired time.

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