ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Vol 6, Issue 8, August 2021

Design & Manufacturing of Robotic Arm for Spray-Painting Application with 5 DOF

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***Abstract*--- This report will give us a brief information about a robotic arm with 5 DOF, in order to deal with this report first of all let us know what a robotic arm is ? A robotic arm is an artificial arm to achieve desired tasks. Now a day, there is a more and more purpose to develop artificial arms for various non-human situations where human communication is impossible. Human's pickups stuff without considering the steps involved, and using wired and wireless, robotic arm is controlled manually. This paper focuses on design, and to control the robotic arm's angle by using Cortex ARM M3 LPC1768 Microcontroller including ultrasonic sensor and a digital controller using computer system. [9].**

The robotic arm can move freely having 5 Degrees of Freedom (DOF) with a Servo motor situated at each joint. The function of Servo motor is position-controlling using a microcontroller. With the help of this Servo motor, Robotic Arm can position the link that required at the particular angle. By using rotary-encoder the feedback of the angle can be measured. The purpose of this paper is to introduce the level of intelligence that can be implemented to industries in order to reduce the human errors as well as enhance the quality and rapid production in manufacturing and processing. The major advantage of the Robotic Arm is that it can work in hazardous circumstances such as high temperature, pressure which is not suitable for the humans. The Robotic Arms can be update and modify easily. Robotic Arm reduces the overall cost and risk associated with the injuries of workers. The operation of designed robotic arm has been experimentally verified. [9].

***Index Terms*— Robotic Arm, servo motors, Spray-Painting**

I. INTRODUCTION

Nowadays, robots are more and more being integrated into working tasks to supplant people particularly to play out the tedious job . Usually, robotics is often divided into two parts, industrial and service robotics. International Federation of Robotics (IFR) characterizes a service robot as a robot which works semi- or fully individually to do services helpful to the prosperity of people and equipment, barring fabricating activities. At present these robots are utilized in numerous fields of applications including office, military undertakings, medical clinic tasks, hazardous condition, and farming. Also, it may be tricky or hazardous for people to do some particular works like grabbing dangerous substances, defusing bombs or in a most dire outcome imaginable to pick and place the bomb some place for regulation and for rehashed pick and spot the activity in ventures. So a robot can be supplanted human to do work .

A robotic arm is a robot controller, generally programmable, with comparative capacities to a person arm. The associations of such a controller are coupled by joints permitting either rotational movement, (for example, in an articulated robot) or translational (direct) displacement. The connections of the controller are often thought-about to frame a kinematic chain. The kinematic chain of the controller in the business end known as the end effectors and it is undifferentiated from the human hand. The end effectors care often intended to play out any ideal work, for example, welding, grasping, turning, and so on., contingent upon the application .

The Robot has significant role in modern era, since; it has ability to perform in various conditions which is not possible for human. The robotic arm besides provides advantage in industrial level by increasing the speed, accuracy. So to attain a complex task, a robot often employed to emulate the human behaviour . Human gets tired and emotionally breakdown in harsh environment, but a Robot can easily utilized without getting tired and face commands emotionally. The advancement in computer technology and programming makes the robot more sophisticated that are expected to obey and perform repeated task continuously. The robotic arm has changed the shape of the industry . The enhancement of robotic technology by pretends the human activities have opened the door for extensive use of robotic technology in various field. The robotic technology and AI has changed our daily life. The main philosophy of creating a robot is to design a robot that can be utilized in our daily. The utility of the Robot is also significant in health care sector and minimize the risk of human errors. At present, the uses of industrial

ISSN (Online) 2456-1290

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robot can be seen in many industries that manufacture vehicles, tools, electronic devices, cuisine and many more .
In many industries the implementation of robot assembly lines has made the operation, processing and production faster and accurate than before. Recently, robot is capable to perform almost all kind of repeated task that usually done by the humans . The implementation of robotic technology in industry has facilitated the industry by reducing the risk of accident and human error. So, more time is available for human to spend on skilled professions such as programming and development planning. There are various areas where a robot has already replaced the human and reduced the health hazard and accidental risk. Particularly in automotive and metal industries the role of robot has increased tremendously. In aerospace industries, robots are very effective, since it can work in the space, different pressure, underwater and etc .
In many space missions such as mars mission, lunar mission and other space probe, robots are playing significant role which is not possible for human being or if possible the process is highly effective and risky. The modern simulation technology has also made the robotic technology more effective.
The development in artificial intelligence and cognitive science has contributed in making robotic technology more usable and effective. The concept and design of the robotic arm is not a new concept but still a lot of research and development is required to make the robot usable in our daily life. The study and research in the area of circuitry, degree of freedom (DOF), algorithm, programming, metallurgy and system design is necessary for the development of the robotic technology . The challenges with the robotic technology are to make compatible with human task and hand's actions like grabbing, replacement and doing critical task. At present robotic arms are playing role in repeating task but still lot of work needs to be done in order to make robot capable to perform complex task. At present robotic arm has a primary processor – LPC1768 (Cortex Arm M3)Mbedmicrocontrolle. [9]

II. LITERATURE SURVEY

1. Design and fabrication and testing of 6 DOF spot welding robotic arm
Rashmi Shantanu K.Mahale, Ankush A. Mathur, Prasad A. Nandalwar, Nitesh N. Shukla, Vivek S. NarnawareApril 2018 IJSDR | Volume 3, Issue 4This paper tells about the components used in making the welding robotic arm, it also has the calculations of the designing of the components which are been manufactured for making the welding robotic arm. It has the analysis and result of the tests done on the robotic arm.

2. Design and control of 6 DOF robotic manipulator
Muhammad Bilal, Muhammad Osama Khan, Awais Mughal, Noman Ali.. Department of mechatronics & control engineering Faculty of mechanical , mechatronic & manufacturing Engineering. University of engineering and technology Lahor Faisalabad campus. May 2018
Kinematics and Dynamics is been explained in this paper, hardware and the software used for making the robotic arm work is been explained. It has the simulation and implementation of the hardware and software.

3. Six DOF pray Painting Robot Analysis
Om Prakash Gujela, Vidhatri Gujela, Dev Prakash Gujela (An ISO 3297: 2007 Certified Organization) Vol. 4, Issue 9, September 2015.
This paper represents the analysis of a spray painting robot. Calculations and analysis are made to get the position and orientation of end effector. Also the spray painting patch and angles of each joint are calculated in this analysis. Denavit- Hartenberg (D-H) methods are used in forward and inverse kinematic.

III. OBJECTIVE OF THE PAPER

The main objectives of the project are to be able to design and construct a robot arm, and to be able to control the robot arm using a Arduino. The first object is very straightforward it requires the modern designing capacities. The complete robotic arm was first designed and assembled in designing software. The model is designed as per the actual dimensions of the robot.
The main concentration of the work was to make a cost efficient autonomous robotic arm in terms of industrial automation. It is a type of mechanical arm, usually programmable, with similar functions to a human arm; the arm may be a unit mechanism or may be a part of a more complex robotic process. The end effector or robotic hand can be designed to perform any desired task such as welding, gripping, spinning etc., depending on the application.[8]
Our objective is to construct physical parts of the robot and them assemble them as we assembled in the software.
An additional objective will be to program the robot arm to do a simple task. This option, if to be implemented with accuracy and precision, requires a more challenging task of familiarizing the science of kinematics both forward and reverse kinematics. However, the implementation used for the automation of this robot arm is time-based. This means that when automating the robot arm, a program records the length of time of a certain joint from moving from one

ISSN (Online) 2456-1290

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position to another. This kind of automation, however, is not very accurate or precise since it doesn't take into consideration the actual load that the arm is carrying.

1) We are going to design robotic arm with payload capacity of 500gm.

2) We are going to include the manufacturing of parts such as robot base, grasping mechanism etc..

3) We are going to evaluate the performance of our sector through industrial applications such as spray painting and welding

IV. SYSTEM COMPONENTS

The whole system is based on two parts, mechanical part with functioned arm and signal processing part. Signal processing part will process the computing language uploaded to the micro controller and mechanical part is the design concept using mechanics.

Signal processing part is given below:

Arduino Uno R3:

Arduino Uno is a micro controller board based on the ATmega328P. It has 14 digital input/output pins of which 6 can be used as PWM outputs, 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the micro controller.

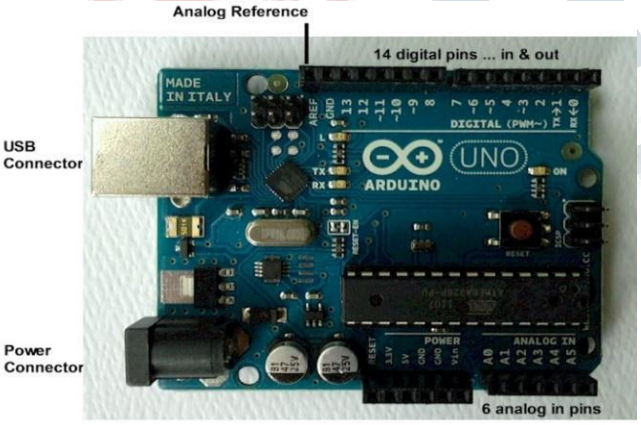


Fig: Arduino Uno r3 microcontroller

Servo motors:

A servomotor consumes power as it rotates to the commanded position but then the servomotor rests.

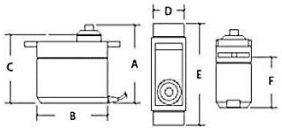
In case of this robotic arm the types of servo motors used are 17 kg torque, 6.8 kg torque and 4.5 kg torque.

Fig: Servo Motor

The servo motor of 17 kg torque will be used at the base. It will rotate the whole base in the desired direction.

Servo 17 Kg Torque:

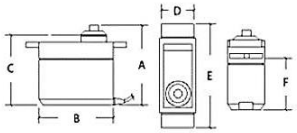
A (mm)	46
B (mm)	40
C (mm)	41
D (mm)	20
E (mm)	55
F (mm)	29



The servo motor of 6.8 kg torque will be used at the 3 links of the robot. So by that we can move the desired arm according to that.

Servo 6.8 Kg Torque:

A (mm)	44.2
B (mm)	40
C (mm)	41
D (mm)	20
E (mm)	55
F (mm)	29



The servo motor of 4.5 kg torque will be used at the last link which is the gripper where there will be the spraying jet gripped by the robotic arm.

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

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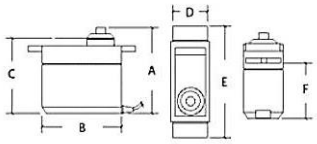
Servo 4.5 Kg Torque (Standard servo):

A (mm)	46
B (mm)	41
C (mm)	42
D (mm)	21
E (mm)	56
F (mm)	29



Selection procedure for standard parts

Servo motors:- load, voltage, current, speed, torque, size, cost, weight, etc.

Arduino Uno :- operating voltage, micro controller, processor, CPU speed, analog I/O, digital I/O, I/p voltage, system voltage, cost, etc

Linkages :- Aluminum has been selected as it is light in weight, corrosive resistant and has moderate strength and malleability

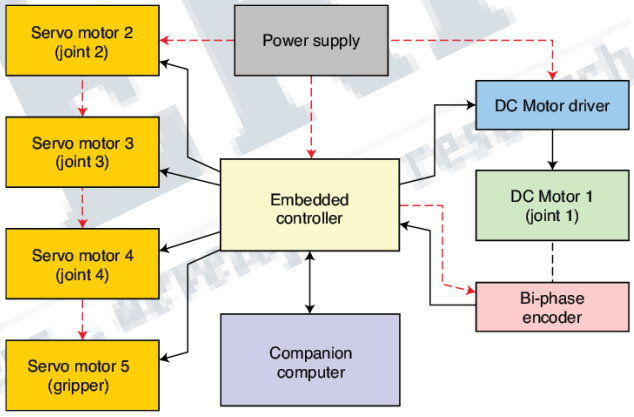
Base plate :- Cast Iron as our Base plate material. As it will take up the whole load of the robotic arm. Also it is cost effective.

V. WORKING

The robotic arm works on the principle of electrical input energy to perform some mechanical works effectively with the help of some automation and program based operations. The pick and place robotic arm consist of major hardware components such as strips & motors and arm gripper, switches, battery, piece of metal, and other discrete mechanical and electrical components. This project is designed for Spray-painting Application robotic arm with a soft catching gripper. This soft catching gripper is used for safely handling an object carefully while Catching and placing. The robotic arm consists of servo motor which is used for angular rotations of the arm for catching items (to hold items, to release, to rotate, to place). This servomotor used is works on the principle of Fleming's left-hand rule and is controlled using Arduino circuit board.

The movement from the servo motor to the tool holding assembly or gripper is transmitted through the various linkages. The design of linkages is such that the power is transmitted with minimum load on the servo motor .the linkage design is made very light weight by using the proper material. The basic concept behind using the links instead of rigid parts is to avoid waste of energy required to perform the motion of the arm. The links in the arm are made from the aluminum Alloy 6061

To effect motion of the links of a robotic arm, an actuator is fixed at each joint of the arm. The actuator applies torque at the joint to overcome the resistance of the link to motion. Resistance of any link to motion is due to gravity and inertia effects. The effect of gravity on any link of the robot is to pull and accelerate it towards the centre of the earth due to its own weight, thus exerting a resistive torque on it. Therefore, a portion of the torque generated by the actuator is needed to overcome this resistive torque (due to gravity). It was necessary to calculate the value of the gravity-induced resistive torque acting on each link of the arm, so that an actuator with sufficient torque rating could be selected for each joint. The resistive torque exerted on a joint due to gravity acting on the robot depends very strongly on the robot's pose. Intuitively the torque on the shoulder joint is much greater when the arm is stretched out horizontally. So, in order to calculate the torque required at each joint, the worst case scenario (arm completely stretched out) was chosen. The arm is subjected to the highest torque when the arm is stretched horizontally.



Block diagram showing the main components of the robotic arm. The embedded controller determines the pose of the robotic arm by commanding each of the four joint motors to the desired angles. It implements a serial command interface with a very simple ASCII string protocol for receiving target angles from the companion computer. It also implements a pid control loop for controlling the rotation angle of the DC motor at joint 1.

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

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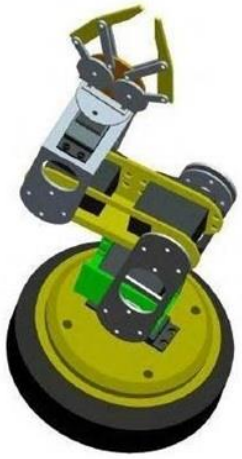

To do so, it reads the current motor position from the bi-phase encoder attached to the DC motor, and computes the required pid output signal to drive the motor to the target angle. The servo motors are handled much more easily by using only an open-loop control scheme.There are five degrees of freedom, corresponding to these 5 main joints respectively: The joints can be found in shoulder, base, wrist, elbow, and slider as well as in gripper.

The robot will drive these five degrees of freedom to complete the job with three independent motors, and the base is used to support the three-joint manipulator. The base is fixed on the ground, with its upper end connected to the waist parts by a flange plate, and its lower end equipped with actuators and driving devices. The big arm, driving rocker, connecting rod and small arm constitute a four-link mechanism.

The arm is driven by the rocker, which can increase the accuracy and stability of the movement. The wrist is the part that connects the arm and the forearm, and the forearm is a moving part that supports the end effector and adjusts its orientation and posture. The material of the upper arm of the painting robot is made of aluminium alloy to reduce the weight and the moment of inertia of each component, thereby improving the stability and dynamics ofthe robot during movement; and as the base carrying the spraying robot, it requires high rigidity and strength. So, structural steel is selected as the material.

The robotic arm mechanics were expected to create issues like spraying the paint away from the target, to keep the harmful things away from the user in a fast paced environment. The arm was made successfully and helps to control the robots movement easily.

VI. CONCLUSION

Based on observation, it became clear that it is perfect and easily manageable as well as easy to operate. The main aim of this work has been achieved that is it can hold a spray gun with payload capacity of 500gm,and even it fulfills the demand of application such as spray painting.

To conclude, we tried to cover all the aspects of design and structural analysis in our work. But there is still a large chance of upgrading the machine, as a future scope the arm can be developed further using better technology, perfect design and made to order for disabled people within heavy industries.

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