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Design, Manufacturing and Analysis of Robotic Arm with SCARA Configuration

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Abstract - *This paper deals with the "Design, Manufacturing and Analysis of Robotic Arm with SCARA Configuration". In the modern world, robotics has become popular, useful and has achieved great successes in several fields of humanity. Every industrialist cannot afford to transform his unit from manual to semi-automatic or fully automatic as automation is not that cheap in India. The basic objective of this project is to develop a versatile and low cost robotic arm which can be utilized for Pick and Place operation. Here controlling of the robot has been done by using servo drives and arduino microcontroller. This robot is having 4 DOF and controlled by android app with Bluetooth interfacing. This Robotic arm can be used in number of applications by changing the program of controller and end effector, so that it would be used mainly in the automatic assembly lines.*

Key Words: **SCARA, Degree of Freedom (DOF), Arduino, Bluetooth Interfacing, Design, Manufacturing, Analysis.**

1.INTRODUCTION

The purpose of using robotic arm is to reduce errors and human efforts. As the robotic field is having an application in various department of engineering such as production, inspection, material handling etc. This type of robotic arm is famous for its characteristics like high speed, good accuracy, less maintenance and repeatability in pick and place operation which is required in assembly. This case study is concern with design, manufacturing and analysis of mechanical structure of SCARA. The SCARA stands for Selective Compliance Assembly Robot Arm having 4 degrees of freedom in which one is linear motion and three rotational motions.

This robotic arm is electrically actuated by using DC servo motors for achiving three rotational motions and one DC geared motors for linear vertical motion. These motors are controlled by C-programming language in Arduino Genuino 1.8.5 software as required for pick and place operation of object having dimensions 20x20x50mm. To command the robotic arm by using mobile android app, Bluetooth module HC05 is used which make it user friendly and ease of giving task.

2. LITERATURE REVIEW

1. Design and Fabrication of Pick and Place Robot to be used in Library by Anusha Ronanki, M. Kranthi:

The use of robots in library is becoming more popular in recent years. The trend seems to continue as long as the robotics technology meets diverse and challenging needs in educational purpose. The prototype consists of robotic arm along with grippers capable of moving in the three axes and an ATMEGA 8 microcontroller. Software such as AVR Studio is used for programming, PROTESUS is used for simulation and PROGISP is used for dumping the program. RFID is used for identifying the books and it has two IR Sensors for detecting the path. This robot is about 4 kg in weight and it is capable of picking and placing a book of weight one kg.s.

2. ROBOT ARM CONTROL WITH ARDUINO By Abdellatif Baba

Today, technology is developing in the same direction in line with rapidly increasing human needs. The work done to meet these needs makes life easier every day, and these studies are concentrated in robotic arm studies. Robot arms work with an outside user or by performing predetermined commands. Nowadays, the most developed field of robot arms in every field is the industry and medicine sector. Designed and realized in the project, the robot arm has the ability to move in 4 axis directions with 5 servo motors. Thanks to the holder, you can take the desired material from one place and carry it to another place, and also mix it with the material it receives. While doing this, robot control is provided by connecting to the android application via Bluetooth module connected to Arduino Nano microcontroller.

3. Pick and Place Robotic Arm Implementation Using Arduino Ashly Baby1 , Chinnu Augustine2, Chinnu Thampi3, Maria George4 , Abhilash A P5 ,Philip C Jose6

A robotic arm is designed using arduino to pick and place the objects via user commands. It will pick and place an object from source to destination safely. The soft catching gripper used in the arm will not apply any extra pressure on the objects. The robot is controlled using android based smart phones through Bluetooth. Based on the commands given by the user the robot moves accordingly. At the receiver end there are four motors interfaced with the micro controller. Two for the vehicle movement and the remaining two are for arm and gripper movement. Blue control application is used for the controlling of robot. Keywords: Pick and place robotic arm, Blue control app, soft catching gripper

4. Design And Development Of A 4–Dof Scara Robot For Educational Purposes by Ksm Sahari and Hong Weng Khor

Robotics have become a common course in a lot of higher institutions. Although there are many robots available in the market, most of them are for industrial purposes and are costly. There is a need to develop low cost robots for students in higher institutions to learn the elements of robotics such as design, kinematics, dynamics, sensing and control. The aim of this project is to design and develop a mechanical structure of a SCARA robot that can perform certain tasks for educational, research and exhibition purposes such as pick and place operation. The paper discusses the steps used in design and development of a 4 degree of freedom (DOF) SCARA robot which includes specification definition, conceptual design, product development, and testing. In specification definition phase, the specifications of the SCARA robot are first determined. After that, the best conceptual design of the SCARA robot is chosen after making concept evaluation in the conceptual design phase. Then, in third phase which is the product generation, the chosen design of the SCARA robot is fine-tuned. Stress analysis using finite element analysis is carried out before a prototype is developed. The direct and inverse kinematics, dynamics of the robot are then modeled. Off shelf parts are also selected based on the derived parameters from calculations. Electronic parts such as sensors and dedicated controller using low cost microcontroller are then developed. Finally, the developed SCARA robot is tested to see whether it fits the targeted specifications.

5. Auto & Manual Control of Robotic Arm Using PLC by R. Jagan1 , P.Rana Singh2 , CH .Ashirvadam3 , K .Navitha4

The main objective of this project is to control the Robotic Arm manually and automatically by using Programmable Logic Control(PLC) to pick the moving object on a conveyor belt. In industries highly advanced robots are used, but still the controlling is done by manually or processors like arduino, microprocessors etc. There are several disadvantages by using these processors like micro controllers cannot work in the environments with the high levels of vibrations, corrosion, humidity, and other environmental factors. All these problems are overcome by using Programmable Logic Controller (PLC) which acts as a brain to control the robotic arm. This project focuses to create and build more compact, useful and cheaper robotic arm to perform various functions where human is proven too dangerous to perform a specific task and also to eliminate human errors to get more precise work.

6. Review on Development of Industrial Robotic Arm by Rahul Gautam1, Ankush Gedam2, Ashish Zade3, Ajay Mahawadiwar4

The use of industrial robots is increasing in areas such as food, consumer goods, wood, plastics and electronics, but is still mostly concentrated in the automotive industry. The aim of this project has been to develop a concept of a lightweight robot using lightweight materials such as aluminum and carbon fiber together with a newly developed stepper motor prototype. The wrist also needs to be constructed for cabling to run through on the inside. It is expensive to change cables and therefore the designing to reduce the friction on cable, is crucial to increase time between maintenance. A concept generation was performed based on the function analysis, the the specifications of requirements that had been established. From the concept generation, twenty-four sustainable concepts divided into four groups (representing an individual part of the whole concept) were evaluated.

3. PROBLEM STATEMENT

The problem is to design a robotic arm with SCARA configuration having 4 DOF which is used for pick and place operation of an object having dimensions 20x20x50mm and payload capacity of 0.150kg. The aim of this study is to provide Robotic arm as a learning material to Engineering colleges at lowest possible cost.

4. METHODOLOGY

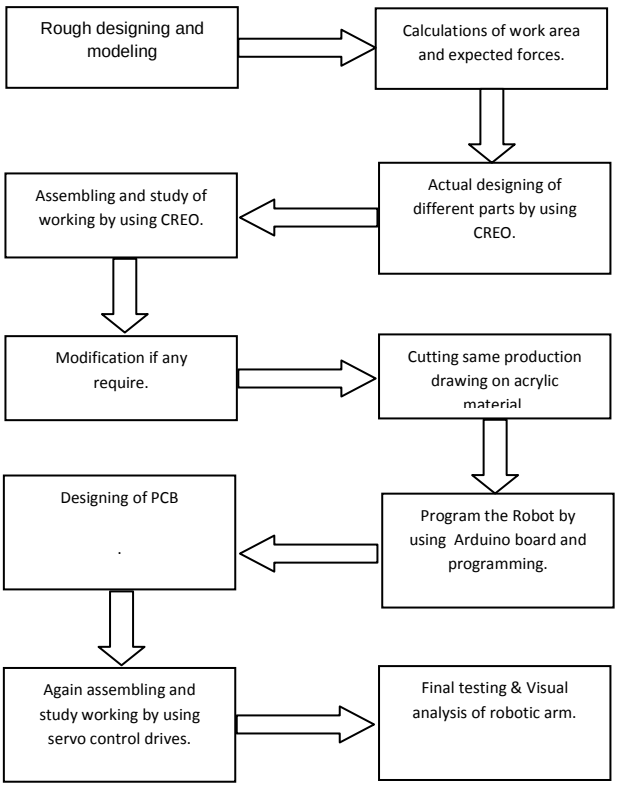

Chart -1: Rough model

5. EXPERIMENTAL SETUP

Starting with rough drawings of robotic arm and by using a Cardboard material model is created to find its working area, movements and degrees of freedom. The designed model working has been studied by moving all links with respect to its motions(Linear and Rotary) with the help of DC servo motors. During this experimental study it is found that the model is working as per the required movements and motions of the links and end effector successfully. The type of parts required, quantity of motors and location where motor is to be fitted can be identified from experimental model.

Fig -1: Rough model

6. DESIGNING OF ROBOTIC ARM

The designing of robotic arm was done in CREO 2.0. The various components part drawings are created separately and by using this parts assembly is created.

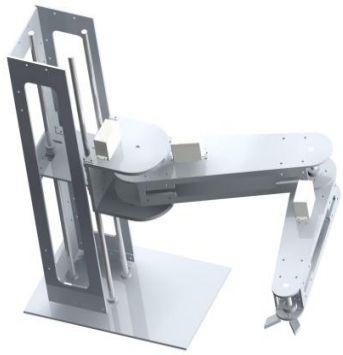

Fig -2: Assembly in CREO 2.0

To known the working of various linkages of assembly drawing an animation is created by taking care of its various constraints. This animation provides nature of behaviour of each links in its working envelope.

7. ANALYSIS

To analyze links under various stress, strains, internal as well as external loading conditions, importing of CREO drawings in ANSYS files has been done by converting it into IGES format. Ansys software uses the displacement formulation of the finite element method for calculate component displacements. The geometry under analysis is discretized using tetrahedral (3D), triangular (2D), beam elements and solved by direct sparse or iterative solver.

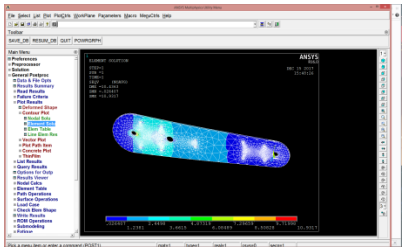

Fig -2: Element solution lower arm

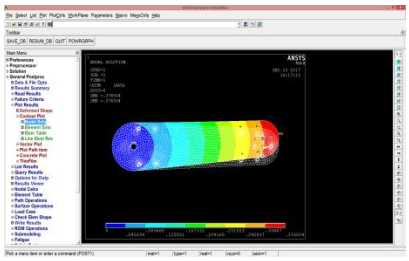

Fig -3: Nodal solution lower arm

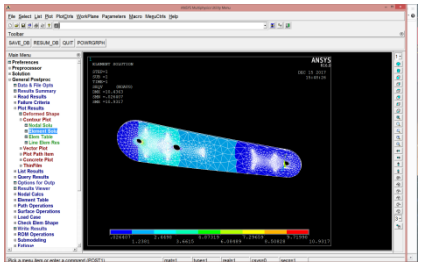

Fig -4: Element solution upper arm

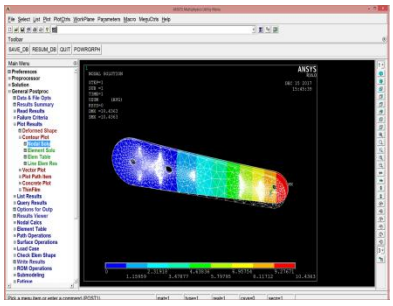

Fig -5: Nodal solution upper arm

8. MANUFACTURING & ASSEMBLY

The Acrylic material is selected based on its properties like high density, light weight and transperancy so that it helps to understand the actual working of robotic arm. By using LASER cutting machine various linkage, parts, grippers, spasers cut from production drawing. After cutting assembly is done with the help of adhesive, screws, nuts and spacers. DC servo motors and gear motor are used to provide motion to different links by supplying power through 12v SMPS.

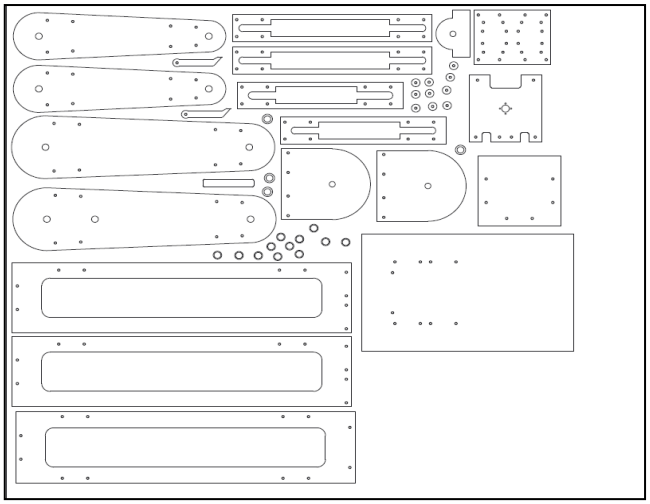

Fig -6: Production Sheet

9. TESTING

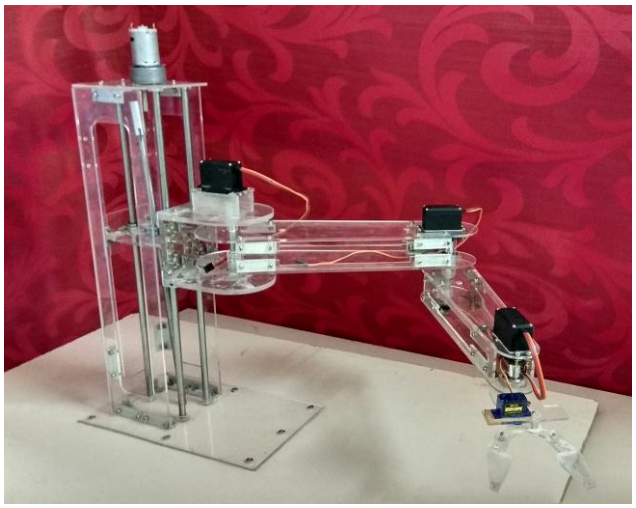

Fig -6: Final Assembly

By using arduino programming robotic arm tested for designed load at various working conditions and it was found that it worked properly.

10. SPECIFICATIONS

1. Degree of Freedom: 4
2. Payload Capacity (Fully Extended): 200-250gm
3. Maximum Reach (Fully Extended): 560cm
4. Rated speed (Adjustable): 0-80 rpm
5. Hardware interface: USB/Bluetooth
6. Control Software: computer interface (GUI)
7. Shoulder spin: 180°
8. Elbow spin: 180°
9. Gripper spin: 180°
10. Gripper opening: 60°

11. CONCLUSION

Designed, manufacturing and analysis of SCARA configuration robotic arm has been successfully completed. It is concluded that this robotic arm is working properly under the specified working envelope and at a given speed with good accuracy. It is successfully able to carry defined payload. This can be used for pick and place operation required in assembly line which will be helpful to increase productivity.

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