Design and Fabrication of Pick and Place Robotic Arm by Using 3D-Printing Technology

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ABSTRACT: The Main technology of this proposed work was to design and fabrication of pick and place robotic arm by 3d-printing technology. The robot arm will be designed with four degree of freedom and programmed to accomplish accurately simple light material pick and place task to assist in the production line in any industry.3D printing method was used in this project to fabricate the components of the robot arm. Therefore it provided more precise dimensions and huge time and cost saving in fabrication.

The robot arm was equipped with servo motors to link the parts and bring arm movement. ARDUNO an open-source computer hardware and software is applied to control robot arm by driving four servo motors to be capable to modify the position wireless control was done by using a Smartphone with android operating system through a Bluetooth module. The robotic arm working and its performance in execution of pick and place task should be analyzed.

Keywords – Robotic Arm, 3D-Printing, Fabrication.

I.   INTRODUCTION

The 3D printing process can builds a three-dimensional object from a computer-aided design(CAD)model, usually by successively adding material layer by layer, which is why it is also called additive manufacturing, unlike conventional machining, casting and forging processes, where material is removed from a stock item(subtractive manufacturing)or poured into a mold and shaped by means of dies, presses and hammers. the 3D printing techniques covers a various processes in which material is joined or solidified under a computer-aided design to create a three-dimensional object, with material being added together(such as liquid molecules are fused together),typically layer by layer. one of the key advantages of 3D printing is the ability to produce very complex shapes and geometries also producing any 3D Printed part in a digital 3D model or a cad file.3D printing can produce rapid prototype with in a specific time because it have print it.3D printing technology is very ease to operate and also it is safety. Print direction can be xyz directions and also fill in and hallow objects are basic of 3d printing.

GENERAL EXPLANATION OF 3D-PRINTING

A   method of manufacturing known as 'Additive manufacturing'. due to the fact that instead of removing material to create apart, the process adds material in successive patterns to create the desired shape.

3D Printing uses software that slices the 3D model into layers by layer and its thickness(0.01mm thick or less in most cases).Each layer is then traced onto the build plate by the printer,0nce the pattern is completed, the build plate is lowered and the next layer is added on top of the previous one.

Typical manufacturing techniques are known as 'Subtractive manufacturing 'because the process is one of removing material from performed block. processes such as milling, drilling and cutting are subtractive manufacturing techniques this of process creates a lot of waste since the material that is cut off generally cannot be used for anything else and is simply sent out as scrap or it can be waste material.

3D Printing can eliminates such waste since the material is placed in the location that it is needed only, the rest will be left out as empty space

In 1984 year 1st working 3d printer was introduced by Charles   W.Hull then he named it as a machine sterolithgraphy. the technology was very expensive and not suitable for the general market in the early days. As we moved into the 21th century, however, costs drastically decreased, allowing 3-dprinters to find their way into many industries.

TYPES OF 3D-PRINTING TECHNOLOGIES

There are various types of 3d printers .mainly they are

STEREO-LITHOGRAPHY(SLA)

1. It was introduced in 1988 by Charles hull with 3d systems inc., company. .it was the first rapid prototyping process. stereo-lithography is the most widely used prototyping technology. it can produce highly accurate and detailed polymer parts stereo-lithography contains two main families

1. Projet

2. Ipro

Stereo-lithography can break off the thin plastic lattice. Stereo-lithography can builds a plastic parts or objects one layer at a time by tracing a laser beam on the surface of a vat of liquid photopolymer quickly solidifies wherever the laser beam strikes the surface of the liquid and resins. The platform is lowered by a distance equal to the layer thickness(typically0.003-0.002 in)and a subsequent layer is formed on top of previously completed layers. Resolution up to 0.05mm.The self-adhesive property of the material causes each succeeding layer to bond to the previous one and thus forma complete, three-dimensional object out of many layers. Objects which have over hangs or undercuts must be supported during the fabrication process by support structures. these are either manually or automatically designed with a computer program specifically developed for rapid prototyping. once complete the part is elevated above the vat and drained. Excess polymer is swabbed or rinsed away from the surfaces. in many cases a final cure is given by placing the part n a uv oven. after the final cure, supports are cut off the part and surfaces are polished, sanded or otherwise finished. Resolution up to 0.05mm
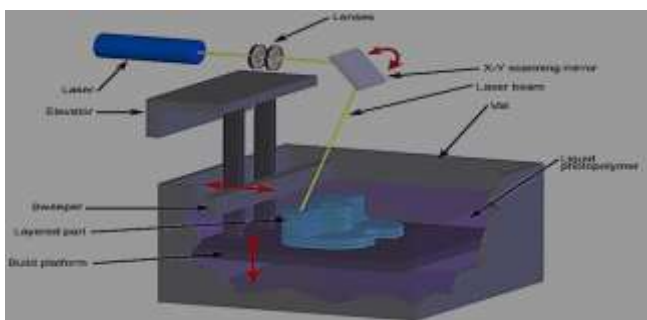
A)STEREO LITHOGRAPHY WORKING

B)COMPONENTS PRINTED USING SLA

FUSED DEPOSITION MODELING(FDM)

It was developed by Scott and Lisa crump's in late 80's century. Fused deposition modeling was trademark by stratasys and developed in Eden prairie ,Minnesota. In this process material is extruded through a nozzle that traces the parts cross sectional geometry layer by layer. Material can be a form of a plastic (or) wax material

FDM is the one of the most widely used additive manufacturing processes for fabricating a rapid prototyping technology and functional parts in common engineering plastics, after stereo lithography. FDM is made up of thermoplastic material, ABS and PLA.fdm is a material extrusion process. A plastic filament is unwound from a coil and supplies material to an extrusion nozzle. The nozzle is heated to melt the plastic and has a mechanism which allows the flow of the melted plastic to be turned on and off. The nozzle is mounted to an x-y plotter type mechanism which traces out the part contours, there is a second extrusion nozzle for the support material. As the nozzle is moved over the table in the required geometry, it deposits a thin bed of extruded plastic to form each layer. the plastic hardens immediately after being squirted from nozzle and bonds to the layer below. The object is built on a mechanical stage which moves vertically downward layer by layer as the part is formed. the entire system is contained within a chamber which is held at a temperature just below the melting point of the plastic. support structures are automatically generated for overhanging geometries and are later removed by breaking them away from the object.FDM will have a traversal speed of 4000mm/min. extruding a layer 0.5 mm wide and 0.2mm thick would allow a build rate of 400 or 1.5 mm3/min

A water-soluble support material is also available for ABS parts. A range of materials are available including ABS Polyamide, polycarbonate ,polypropylene ,and investment casting wax. A large fdm machines have been developed that directly extrude thermoplastic pellets to print larger parts and structures.

A)FUSED DEPOSITION MODELING WORKING

B)COMPONENTS PRINTED USING FDM

SELECTIVE LASER SINTERING(SLS)

This selective laser sintering(SLS) technology was conspicuous in year 1989 and was originally sold by dtm corporation.DTM was acquired by 3d systems in 2001.it is similar to SLA but laser is more powerful.sls is an additive manufacturing method that uses a powder bed fusion process to build 3d parts.

The Thermoplastic powder is spread across a roller over the surface of a build cylinder. the piston is move from one position to another position .A piston cylinder is moving into downward direction then a object layer thickness to accommodate the new layer of powder. a piston moving into upward direction then it results into a incrementally to supply a measured quantity of powder for each layer. a laser beam is target over the surface of this tightly compacted powder to selective melt and joining the grains together to form a layer of the object. the fabrication chamber is maintained at a temperature slightly to a cause sintering-the grains are not entirely melted, just their outer surfaces-which greatly speeds up the process. the process is several times repeated then the layer by layer, will remain until the entire object is formed. after the object is fully formed. the piston is raised. Excess powder is simply brushed away and final manual finishing may be carried out. Machining can be done once at a time.

A)SELECTIVE LASER SINTERING

B)COMPONENTS PRINTED IN SLS

APPLICATIONS OF 3D PRINTING

Main areas of use:
1. Prototyping
2. Specialized parts-aerospace, military, biomedical engineering, dental.
3. Future applications-medical(body parts),buildings and cars

- Biomedical Engineering
- Aerospace And Automobile Manufacturing
- Construction And Architecture
- Product Prototyping
- Dental Industry

II. DESIGN CONSIDERATION

DESIGN OF ROBOTIC ARM

A four degree of freedom manipulator having variable programmed motions and movements to carry out variety of tasks in various environments are taken under consideration. this is a four axis articulate manipulator designed to move material like machine parts tools, specialized devices etc.it is driven by four servomotors and had a gripper as end-effectors. the gripper had fingers for a grasping and manipulation of object.

4 degree of freedom robotic arm

SPECIFICATIONS OF ROBOTIC ARM

SPECIFICATION	VALUE
Number of axes	4
Horizontal reach	
Vertical reach	
Drives	4 servomotors
configuration	4 axes plus gripper All axes completely independent All axes can be controlled simultaneously
Work envelope	a)shoulder rotation:180mm b)elbow rotation:180mm c)wrist rotation:180mm d)gripper rotation:90mm

III. DESIGNING A ROBOTIC ARM IN NX-CAD

There are so many designing software are available .here in this project NX-CAD Software can be preferred. We started the project by using an NX-1o version. The introduction will providing a basics information an CAD software. we will learn the preliminary steps to start ,to understand and use the nx-1o   package for modeling. Assembly drafting etc..

THREE DIMENSIONAL MODELING

In this modeling process we create to robotic arm with a required dimensions in step by step procedure we can select a plane which is xyz-axis to create a sketch on plane. Modeling is beginning from 2D sketch and extrude ,revolve or sweep the sketch to create solids .many complex shapes. some concepts of sketching and then proceed to sketch and model some parts.

Robotic arm is a prototype model and it can be import into a model in a step by step procedure. Here there are 4 major parts while designing

1. Shoulder
2. Elbow
3. Wrist
4. Gripper.

Modeling of a Elbow
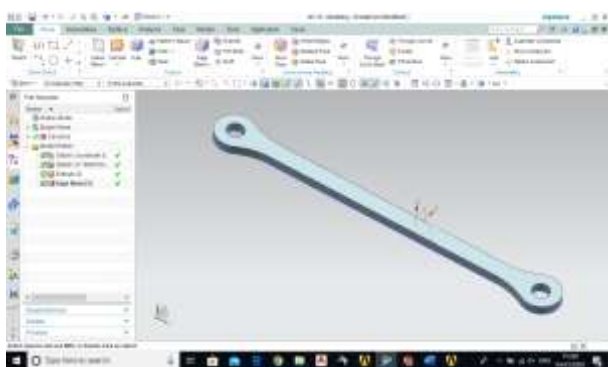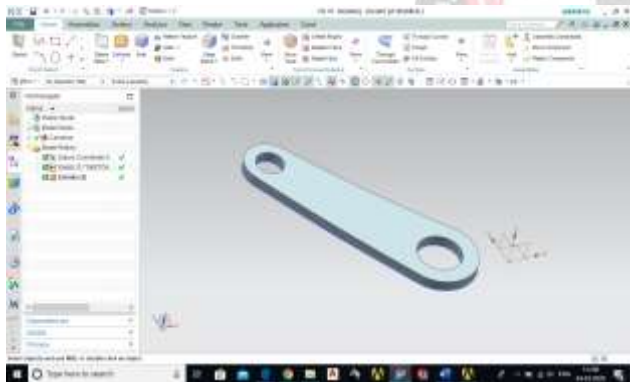
Modeling of a Shoulder Part

ASSEMBLY MODELING

Every product in the word can be created in assembly procedure, A components that are assembled together into one model such as trucks cars, bicycles, and computers. All of these products were created by designing and manufacturing of each and every of individual parts and then assembled   together. The designers can be carefully planed each part so that they all assembled   together perfectly in order to execute   the desired function. In this project robotic arm is a prototype and it can assembled into a step by step procedure format. All the parts are selectable and can be used in the design process for assembling each and every part of robotic arm.

As per all the design factors, dimensions, tool and sketch assignments and sketch constraint operators each and every component should be designed with out any errors. By the selection of line to line, face to face ,circle to circle, like concentric operations, inserting of components one another each by different assembly operations like smart more, rotate, revolue, fit, componential zoom 300m etc.

Mating options should be

1. Coincident
2. Parallel
3. Perpendicular
4. Concentric
5. Fix

Above parts are assembled at different parts mating options in nx-cad on a different distances, different angular placements and multiple tangential and concentric placement origin.

SELECTED SLICER

i)Using Maker ware

Makerware   can   be   downloaded   from: makerbot.com/makerware/

If you open the .stl in Slic3r and see that it is not oriented correctly, you will need to rotate it first.

1. Click and drag your file into makerware or go to file > Open.
2. With the part selected, click on turn and use the buttons until it is placed correctly. It does not need to be centered.
3. Placing the part correctly can often be tricky. Unless it is over a short distance with support on both sides, you do not want to print over air. Rotate your object until it is oriented so that it has the least amount of area where it will print over air. If there is no way to prevent printing over air, you will use supports in Slic3r.
4. Now the file is ready for Slic3r. Save it as a new .STL
5. With the part selected, go to print > Send to 3D printer service.
6. Click on options and make sure that units are set to mm and resolution is set to High.

MAKERBOT EXPLANIATION

It can authorize to view, arrange, orient ,scale, and preview a sliced version of your 3d model. we can be used to work with multiple build plates to view and edit multiple 3d models.

1. Creating a model to print and getting a file ready for printing can be overwhelming the first time around. after attaching to a printer. they can be provide instructions to help for printing required files.
2. Add a model to a virtual build plate.While adding a model to a build plate in some different ways. we can follow the form provided below or go to file>insert file if you don't yet have files of your own to print, you can approach our example sample files to test by going to file>insert example file.
3. Rotating and scaling a model here selecting orient and scale will authorize to change the orientation of required model and let we can allow rescale any model respectively.
4. Settings can be changed for complex models
5. While printing a model we had to select print options it will displays a visualization of a model on a printer. this will show you where the rafts and supports will print as well as provide an estimation printing time. if there are any errors in a print model we will use rescale option.
6. Print your prepared model.

STL file

"STL (an abbreviation of "stereo lithography") it is a file format in the STL which can be used in cad software. STL is a file format to the stereo lithography CAD software. This file format is assisted by so many other software packages. STL files can gives information on the surface geometry of a three-dimensional object without any representation of colour, texture or other common CAD model attributes .it is highly used for rapid prototyping, 3D printing and computer-aided manufacturing.

V. WANHAO 3D-PRINTER AND EXPERIMENTAL SET UP PROCEDURE

3D-PRINTING PROCESS

After completion cad model.it can be converted into a stl file for a printing we must use slicers software which is discussed early topic.

There are different types of 3d-printer in world. depending on our ability we must selected a wanhao dual extruder machine.

### SELECTED 3D-PRINTING MACHINE

WANHAO DUPLICATOR 4S DUAL EXTRUDER

Wanhao duplicator 4s dual extruder is 0ne of 3d-printer.it is based on a FDM Technology. it is having metal frame professional printer. this can be used by professionals, designers, architects, industries etc. build area 225x145x150mm 3d printer gives you the power to transform your imagination and creativity into reality.this 3d-printer comes with dual extruder direct drive system which prints wide range of materials like PLA,ABS,WOOD,NYLON, and even flexiable.

This 3d-printer can print different materials at different temperature examples;

1. ABS MATERIAL is at a 230 degrees temperature
2. PLA MATERIAL is at a 200degrees temperature
3. NYLON MATERIAL is at a 250degrees temperature

These are can print xyz directions so it is called a 3d-printer.it is having feature that can print in

sd card, and connected to the computer
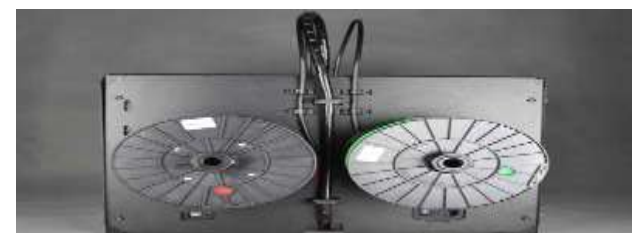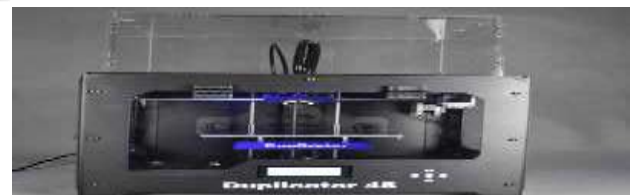
PROPERTIES OF WANHAO 3D-PRINTER

1)MECHANICAL PROPERTY

a) Overall dimensions:320x466x382mm
b) Weight capacity -25kg
c) Linear ball bearings
d) Precision ground 8mm shafts
e) Snap-on'snap-off carriage assemblies

2) ELECTRONICS PROPERTY

a) Duplicator 4s single-piece motherboard
b) 5axis,1/16 microstepping motor controller.
c) Piezoelectric buzzer
d) 4x20 lcd character display and multi-direction control pad.

SOFTWARE:REPLICATORG

a) compatibility:linux.0sx,and windows

b)print from sd card 0r 0ver usb.

c) input file type:stl,gcode.

4) OVERVIEW FEATURES SPECIFICATIONS

a) Build envelope:225 x 145 x 150mm

b) Build volume:about 5liters
c) layer thickness choose 0.1-0.5 mm which is adjustable by software.
d) Speed limit:40mm/s
e) Stock nozzle diameter stock 0.4 mm
f) Extruder temperature recommended upto maximum 230 degrees
g) Heated build platform 120 census maximum
h) Positioning precise 2.5 micron on z-axis
i) 11 micron on xy axis

5) MATERIALS

a) Filament diameter:1.75 mm
b) Works with ABS,PLA AND OTHER MATERIALS

SELECTED MATERIAL

ACRYLONITRILE-BUTADIENE-STYRENE(ABS)

ABS is a common material for 3d-printing.ABS means Acryonitrile-butadiene-styrene is widely used and versatile thermoplastics. ABS is a light weight material.ABS is an amorphous blend consisting of three monomers; acrylonitrile, butadiene, and styrene.

1. Acrylonitrile adding thermal and chemical enhancements.
2. Butadiene donate impact strength and toughness to the plastic.
3. Styrene will added a sleek, glossy surface to the plastic.
   ABS formula((C8H8)X(C4H6)Y(C3H3N)Z)

These three monomers are typically added together in specific portion:15-35%acrylonitrile,5-30% butadiene and 40-60%styrene.a small change in even one of the monomers can create drastic changes in the mechanical and physical properties of abs.in fdm machining abs can melt at 230degrees temperature.ABS is a insoluble in water.

COMPONENTS IN ABS

ABS resins having good ability of injection molding can be used for molding parts requiring close dimensions high impact resistance. in addition, abs has good toughness and rigidity.Abs also has a high abrasion resistance. depending on the percentage of butadiene, abs will have little or no wearing effect when being moved along arough surface for an extended period of time.

Processing the plastic at different temperatures if at higher temperature will create a good surface finish as well as higher heat resistance. At lower temperature it will a result in the form of higher strength and higher impact resistance.

ABS can also be recycled by using a process called" froth flotation" froth flotation is a process that separates high purity plastic from waste streams containing a mixture of plastics. this is the only process which can recover over a 99%purity level from recycled abs.

ASSEMBLING THE 3D-PRINTED ROBOTIC ARM PARTS

It is a step-by-step assembly procedure of the 3D-printed parts of the robotic arm.for assembling robotic arm we can consider mainly degrees of freedom.here we are designing and assembling four degree of freedom.the main parts in four degree of freedom are

a) Base
b) Shoulder
c) Elbow
d) Wrist

the assembling was done with the help of screws, nuts and bolts.the assembly procedure of this arm takes around 2hours when done without any error.the kit has many screws divided in M3 8mm, M3 8mm flat,M3 10mm,and M4 10mm and it is very important to understand where each screw goes in order to guarantee the functionality of arm body.first step is to fix base part and sub part of base related part.second part is to fix shoulder part and third step is to fix the elbow part.final step of robotic arm is to

fix the wrist part.these are step by step procedure for assembling robotic arm with screws and nuts.

SERVOMOTOR

A Servomotor is an electrical device capable of pushing or rotating an object with great precision. it can rotate an object at some specific angles or distance. A servomotor is a rotary actuator or linear actuator that authorize for precise control of angular or linear position, velocity and acceleration. it contain of a suitable motor coupled to a sensor for position feedback. it also requires a relatively sophisticated controller, often an assigned module designed specifically for use with servomotors. We can achieve a very high torque motion in a small and light weight packages.

Servomotors are used in applications

1. Robotics,
2. CNC machinery
3. Automated manufacturing.

SELECTED SERVOMOTORS

MG996R

The mg996r is essential an upgraded version of the famous mg995 servo, the features upgraded shock-proofing and a redesigned pcb and ic control system that makes it much more accurate than its predecessor. The gearing and motor have also been up graded to improve dead bandwidth and centering. This high-torque mg996r digital servo features metal gearing resulting in extra high 10kg stalling torque in a tiny package.This high-torque standard servo can rotate approximately 120degrees(60 in each direction)you can use any servo code, hardware or library to controlling these servos, so it will fit in small places. the mg996r metal gear servomotor also comes with a selection of arms and hardware to get you set up nice and fast.

i) Specifications

1. Weight:55g
2. Dimension:40.7 x 19.7 x 42.9 mm approx.
3. Stall torque:9.4kgfcm(4.8v),11 kgf cm (6v)
4. Operating speed:0.17s/60 (4.8v),o.14 s/60 (6V)
5. Operating voltage:4.8 v a 7.2 v
6. Running current 500ma-900ma(6v)
7. Stall current 2.5A(6v)
8. Dead band width:5
9. Stable and shock proof doubleball bearing design
10. Temperature:0c-55c

SG-90S META GEAR

It is a small and light weight with high power. It rotate approximately 180 degrees(90 in each direction),and works just like the standard type but smaller. you can use any servo hardware or library to control these servos.

i)SPECFICATIONS

1. Speed(sec):o.1
2. Torque(kg-cm):1.8
3. Weight(g):9.o
4. Voltage:4.8-6
5. Gear type: plastic

POWER SUPPLY

The arduino uno board can connected via USB Connection or with an external power supply through switch board.the main reason for power supply is to conversion ac to dc.the arduino board connected a power supply to operate a robotic arm with help of connecting wires.here used power supply is s-60-12 tek

5.6.1)S-60-12 POWER SUPPLY

1. It is a protection from a overload/over voltage/short cut.
2. It is a universal ac input/full range.
3. fixed switching frequency at 50khz
4. It is having a feature of cooling by free air convection.
5. Iron housing
6. Dimensions:16 cm x 9.8 cm x 4.2 cm
7. Weight :397gram
8. Outputted 12v/5a

ARDUINO UNO

Arduino is an point-source platform using for a building electronics projects. arduino contains of a physical programmable circuit board and a piece of software or IDE(integrated development environment)that runs on a computer, which is used for writing and uploading computer code to the physical board. arduino is amalgamation of software and hardware. Arduino uno is a microcontroller board based 0n the ATmega328p.it has 14 digital input/0utput pins , 6 analog inputs ,a 16MHZ quartz crytal, a USB connection, power jack ,reset button. it consists everything needed for support the microcontroller; simply connecting into a computer with a USB cabe or power it with a AC to DC adapter or battery to get started.

There are various models and types of Arduino boards can be available on the market .but selecting a suitable model is required in this project.

According to the selection of materials, Arduino AT mega 328 was selected as main board for the robotic arm. Most of the robotic arms set up on the internet in the research phase were using Arduino UNO, a less powerful board.

Mega328 was taken over UNO because Mega328 is more powerful, it is having a better memory and response time, more pins for wiring and also be used for more complex projects in the future. Jumper wires are used to get connection between the power supply and arduino and Bluetooth.

SPECIFICATIONS

Microcontroller	ATmega328p
0perating voltage	5v
Input voltage	7-12v
Input voltage	6-20v
Digital i/o pins	14
Pwm digital i/o pins	6
Anlog input pins	6
Flash memory	32kb

BLUETOOTH HC-05 MODULE

For operating robotic arm we can use Bluetooth module with the help of android smart phone .Hc-o5 module is an easy to use Bluetooth spp(serial port protocol)module, designed for transparent wireless serial connection setup. serial port Bluetooth module is fully qualified Bluetooth v2.o+edr(enhance data rate)3mbps modulation with complete 2.4ghz radio transceiver and baseband. It use csr blue core 04 external single.

a) Back view

b) Front view

ANDROID APP FOR ARDUINO AND BLUETOOTH CONTROLLED ROBOTIC ARM

For controlling and operating the robotic arm an android app had been designed in form of programming. the arduino uno is a software and hardware device. we had programmed for arduino to operate servomotors. instead of using potentiometers or serial communication through computer, we had distinct to take a further step and designed a simple application for android phones in order to control and operate a robotic arm.

There are 4 pairs of arrows and control keys each pair for base, elbow, shoulder, and gripper servos respectively. there is a program button, using which, we can enable the program mode The following image shows the app layout in a smart phone running android version 6.o.but the app is tested for android version 8.o is worked .

WORKING OF THE ARDUINO AND BLUETOOTH CONTROLLED ROBOTIC ARM

Installing a application in a mobile phone with containing android software which can give responses to Bluetooth module. The android phone can providing a necessary authorization to access the Bluetooth operation. if the Bluetooth module(HC-05) is to paired it. Then opening the app and it will automatically list out the paired Bluetooth devices. Selecting the Bluetooth module and if everything goes well. We can enter into the main control panel. Here we can see controls for the 4 servomotors of the robotic arm that is BASE,SHOULDER,ELBOW AND GRIPPER. using the arrow keys we can be moved our moment of robotic arm which is represent in a diagram. The movement of robotic arm is controlled with help servomotors. This part of the working is the manual operation of the robotic arm, where every movement must be manually adjusted.

Next interesting part is we can see a button in the centre called program at any time of the operation, if you press this button, the robotic arm will reset. in this mode, I can program the robotic arm to execute a series of tasks in form of 4directions that is right and left, forward and backward directions. for pick and place I designed up and down ward direction. for gripper operation I designed open and close grippers. for example, I can pick small objects from one place and place it in another place.

VI. CONCLUSION

The intension of this project is to amalgamation of 3D printing and designing a robotic arm. Here successfully make structural adjustment while designing nx cad software to make it movement for pick and place a light weight object. in this project designed a robotic arm ,3d print it, assemble it. while meeting all eligibility criteria for a model.

3D printing technology a emerging technology for new innovations and new development in production and manufacturing industries.3d printing will have capacity to a make mass production on prototypes .we will make a own manufacturing without a skilled labour. 3d printing will make a less time, waste reduction, cost efficient.

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