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Design, Simulation and Control of 5 Degree of Freedom Manipulator Using Mobile Application

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Abstract— *Recent Years, Robots play an important role in our daily life. Neverthless it is important to control these robots which could serve in various applications such as Pick and Place, Spot Welding, Arc Welding, Drilling etc. As popular are Robots so are the Mobile apps and in this scenario we will see the design and control of 5 DoF Manipulator using Mobile application. We Used Lynxmotion 5 DoF manipulator with appropriate controller namingly SSC-32 which is interfaced with PC through Arduino with the help of Bluetooth module.This mobile application can be customized for various hardware platforms such as Bipeds,Hexapods,Tripods etc..*

Keywords—*Internet of Things(IoT),Mobile Apps, Robotic Arm, Manipulato, Bluetooth Module*

I. INTRODUCTION (COMPONENTS *SELECTION*)

Here we Consider a Robotic Arm with a twisting base, shoulder, elbow, Wrist and a gripper with TRRR Configuration. We use Hi-tech Servos to Design and manipulate the arm. The configuration of Robotic arm considered is as shown below:

Robotic Arm Assembly	Configuration	No. of Servo Motors	Degrees of Freedom
BASE	Twisting	1	1
SHOULDER	Rotational	2	1
ELBOW	Rotational	1	1
WRIST	Rotational	1	1
Gripper	Open/Close	1	1

We select an appropriate SSC-32 Servo Controller which could control up to 32 Servo Motors and HC-05 Bluetooth module which controls the robot interfaced with PC through Arduino Controller board

II. DESIGN AND SIMULATION OF MANIPULATOR

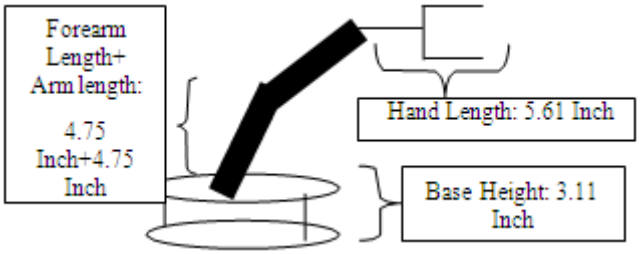
A. Design of manipulator through appropriate CAD Models

A robotic arm was designed through appropriate CAD software like CREO.Direct Kinematics and Inverse Kinematics of the Manipulator was performed through the design model.

Let the twisting angle be α and all the rotational angles be θ_1, θ_2 and θ_3.Computation of Direct Kinematics involves the following equations:

Height Y=L1+L2 *SIN θ_1+ L3 *SIN(θ_1+ θ_2)+ L4 *SIN(θ_1+ θ_2+ θ_3)

Depth X=L1+L2 *COS θ_1+ L3 *COS(θ_1+ θ_2)+ L4 *COS(θ_1+ θ_2+ θ_3)



B. Inverse Kinematics

Inverse Kinematics is to compute the Joint angles given the Height Y and Depth X. Let

X_b=(X - L4 * Cos(β)) / (2 * L2) Where β is the angle of hand from ground.

Z_b=(Z – L1 – L4 * Sin(β)) / (2 * L2)

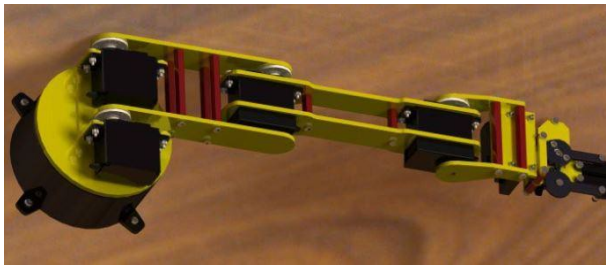
Let Q= sqrt(1 / (X_b^2 + Z_b^2) - 1)

P1= `arctan2(`X_b `- Q *` Z_b`,` Z_b `+ Q *` X_b`)`

P2= arctan2(X_b + Q * Z_b, Z_b - Q * X_b)So Joint angles θ_1= P1 – 90

$\theta_{2=}$ P2 – θ_1
$\theta_{3=}$ β- P2

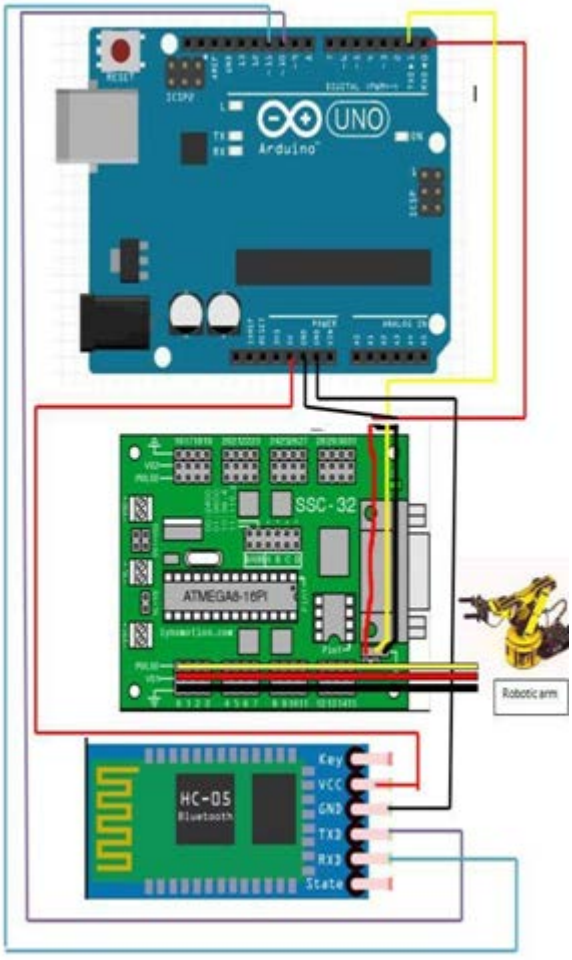
III. SIMULATION DESIGN OF MANIPULATOR



IV. CONTROL OF ROBOTIC ARM

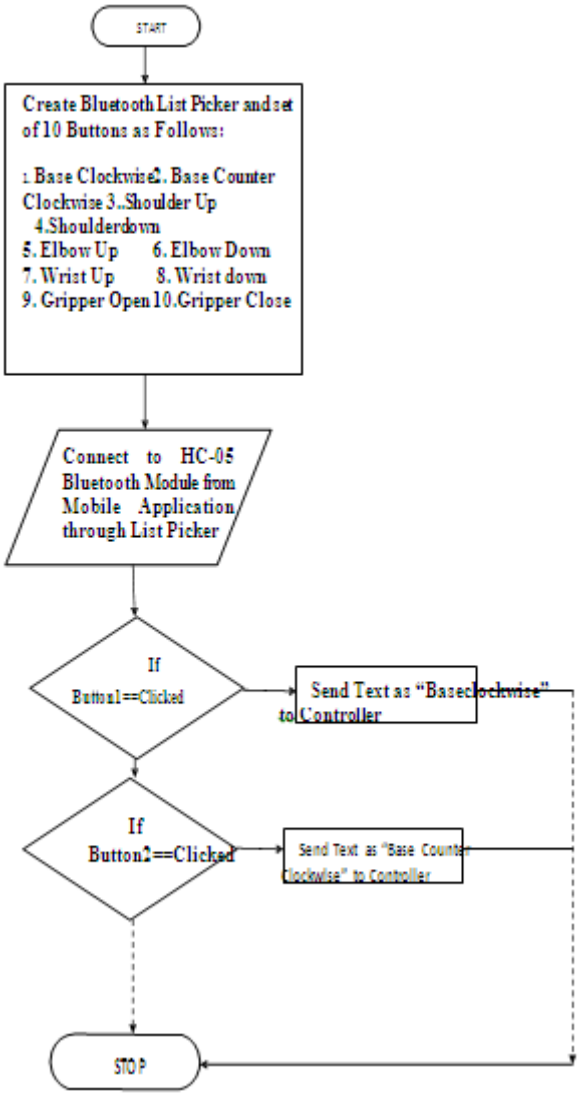
A. CIRCUIT DIAGRAM:

All motors of Robotic arm are powered through SSC-32 which are allowed to operate in the BAUD RATE of 9600 bps.HC-05 Bluetooth module is connected to Pin 10th and 11th of Arduino UNO board. Transmit and Receive pins of Arduino UNO board and SSC-32 Board are interchangeably connected.
The following diagram shows the circuit connected.



B. ANDROID APPLICATION DEVELOPMENT

The flowchart to design an android app is as given below.



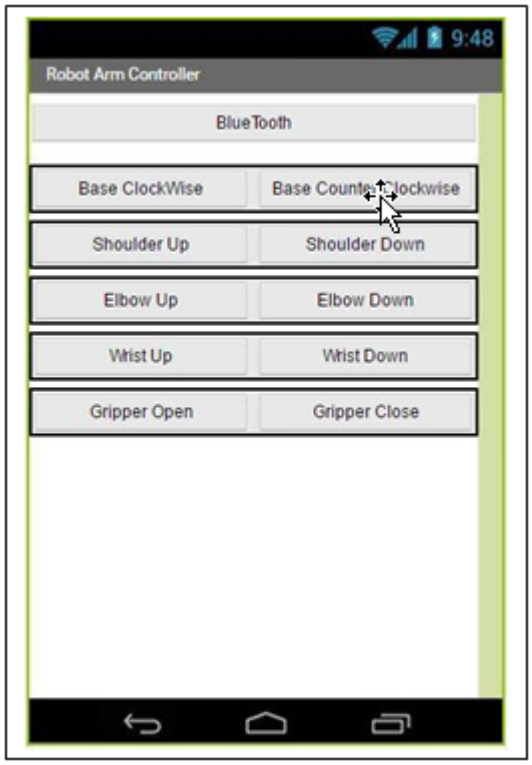
After sending the text serially it is manipulated by Arduino to appropriately actuate the motors of robotic arm. Usually SSC-32 is programmed such that its Servos can be actuated through serial commands.

One example command is #0P1500S0; in general form is #xPωSt. In the command x = {0, 5} is the number of the motor(0 for the base, 1 for the shoulder, 2 for the elbow, 3 for the wrist, 4 for the gripper, 5 for the wrist rotate). Our robot is not equipped with the wrist rotate motor. After the P letter (Pulse), we have the position ω = {500, 2500} of the motor, this way the middle position is ω = 1500. The position of the motor is not set in degrees, but in values from 500 to 2500. To know exactly the angles we can simply calculate with equation

α=dω/180˚=2500-500/180˚=11

So For every 1˚ =11.

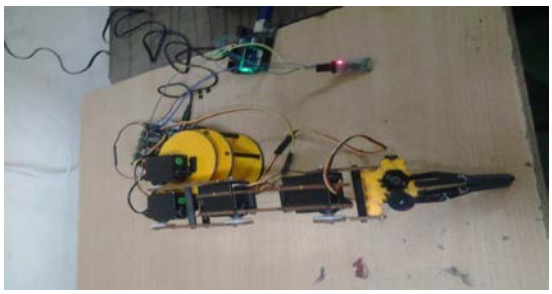
So for each click we move by 20˚. The design screen is as shown below.



V. EXPERIMENTAL RESULT

The five Degree of Freedom Manipulator was controlled by means of Android Application and the same manipulator could be controlled through Speech by means of Google Speech API which also being incorporated in the Android Application. The manipulator was tested to work in any Environment by following the trajectory through the given inputs and thus a Point-To-Point control robot was designed and developed to meet the Industrial needs.

The below figure shows the Experimental Setup to test the 5 Degree of Freedom Manipulator.



The previous figure showing 5 Degree of Freedom Manipulator for Pick and Place Operations controlled by Point-To-Point means by Android Application that could well serve in the field of Industries or for Domestic Purposes.

VI. REFERENCES

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