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5 Degrees of Freedom Robotic Arm controlled using PS/2 Mouse

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***Abstract*— Basic and contradictory needs of an industrial process are repetitive tasks and high accuracy. Hazardous working conditions may also limit productivity to a great extent. The remote controlled robotic arm may act as a solution to such problems. It can work tirelessly and much more efficiently than a human worker. When programmed to, it can also perform a specific set of tasks repetitively. The assembly of the arm consists of 5 servo motors with different torque ratings for every joint of the arm, for smooth movement and to minimise the cost. Two servo motors are placed at the shoulder (base) joint, one at the elbow joint and two at the wrist joint for the gripper. Servo motors can be programmed to rotate to a specific angle within 0 to 180 degrees. The miscellaneous parts of the arm have been constructed using wooden ply for reducing the weight of the arm. An optical PS/2 mouse is used, because clock and data signals can be directly obtained from the connector pins without having to decode the signals as opposed to a USB mouse. Also, a computer mouse is a device which is very widely used and any layman has expertise over its usage. Hence, we have built a robotic arm controlled using computer mouse.**

***Index Terms*—Arduino, PS/2 mouse, Servo motors.**

I. INTRODUCTION

This project deals with the design, fabrication and control of a robotic arm having features like grip, mobility and placement, with high accuracy and speed. A Robotic Arm, having 5 Degrees of Freedom, is controlled by the 5 functions, using a PS/2 Mouse. These 5 functions are: x-y movements of mouse, left click and scroll, right click and scroll, and scroll. It is implemented using an Arduino microcontroller board. This board controls the servo motors and also responds to the PS/2 mouse. These servo motors can rotate maximum 180 degrees.

The position of these 5 motors is at:

1. Base: for horizontal movement of the arm
2. Shoulder: for vertical movement of upper arm
3. Elbow: for vertical movement of lower arm
4. Wrist: for moving the wrist in clockwise and anticlockwise direction
5. Grip: for opening& closing of the palm.

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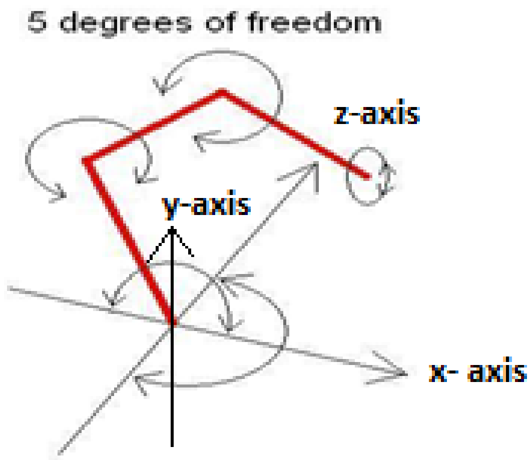


Fig.1 Positions of servo motors and their rotation angles.

The objective of this Robotic Arm is to easily transport objects, held in the gripper, from one place to another, with accuracy and speed. The main feature of this project is, that it works with only one Arduino board which replaces USB Host Shield and Servo Motor Driver boards. This has reduced the overall bulkiness and the cost of the project.

II. CONSTRUCTIONAL DETAILS

The project comprises of three main sections; viz. Mouse, Microcontroller Unit and Robotic Arm assembled using servo motors.

1. A simple Logitech PS/2 mouse with an optical wheel is used to attain desirable accuracy, with minimal cost. The PS/2 mouse has 6 input pins, out of which Vcc, Ground, Data and Clock are used in the connections.

Fig. 2 Pin diagram of PS/2 Mouse

2. To acquire high computational speeds for quick response and functionality, an Arduino Duemilanove board, with ATmega 328 microcontroller, is used. It has 14 digital I/O pins, out of which 6 are Pulse Width Modulation (PWM) pins, to have effective control on the Servo Motors. Other 6 are analog input pins, having clock speed of 16MHz with 2KB SRAM and 1KB EEPROM. It has an operating voltage of 5V.

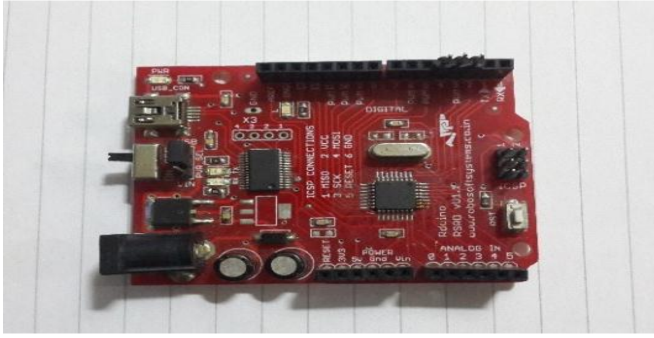


Fig. 3 Arduino Duemilanove board

3. Different types of servo motors, with specific torque ratings for each joint in the arm, are used for achieving expected results at minimal cost.

Fig. 4 Servo motor

Two Metal Gear Servo motors, each having torque up to 10 kg-cm, are used at the base for x-y movements. Two more Metal Gear Servo motors, each having torque up to 7 kg-cm, are used at elbow and wrist. The gripper has a resin gear motor having 5 kg-cm torque. These torque requirements at each joint, have been optimised for stable and accurate performance of the robotic arm. Each of these motors has an operating voltage between 4.5V to 6V and the total current required is around 2A. As Arduino Board cannot provide the required power, an external power supply of 6V, 2A is used to operate these motors.
Servo motors provide the necessary gear locking mechanism and 180 degrees of rotation. The gripper mechanism comprises of two parts, viz. gears and components from 'Mechanix' kit.

III. Connections

The design layout is completed by calculating the lengths of different segments of arm, based on the torque values that are required at respective joints. Every servo motor has three inputs viz. VCC, ground and signal.
VCC input of every servo motor is connected to the positive terminal of the power supply (6V). VCC pin of the PS/2 mouse is connected to the VCC pin of the Arduino, in order to give 5V power supply to the mouse. The ground pins of all the servo motors, PS/2 mouse and Arduino are connected to the negative terminal of the power supply. The signal pins of every servo motor are connected to the PWM pins of the Arduino. The data and clock pins of the PS/2 mouse are connected to the pins 2 and 4 of the Arduino. The wires from the servo motors are soldered on a separate Printed Circuit Board, ensuring firm connections as shown in fig. 5. The motors have been properly positioned on the arm with a reset angle of zero degrees and the degree of rotation is controlled through the code.
The Robotic Arm is placed on a dead load (at the shoulder position) to prevent it from toppling, when it crosses the topmost point.

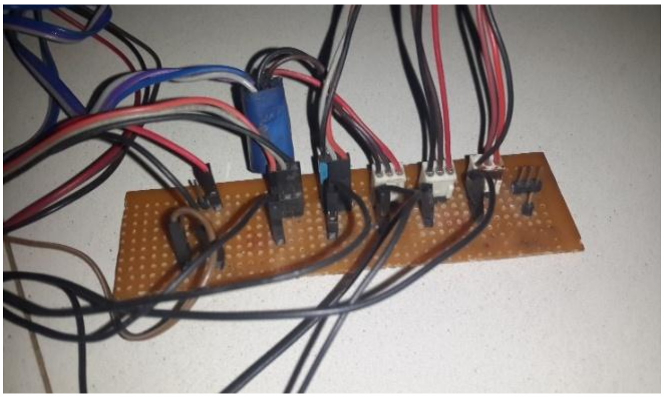


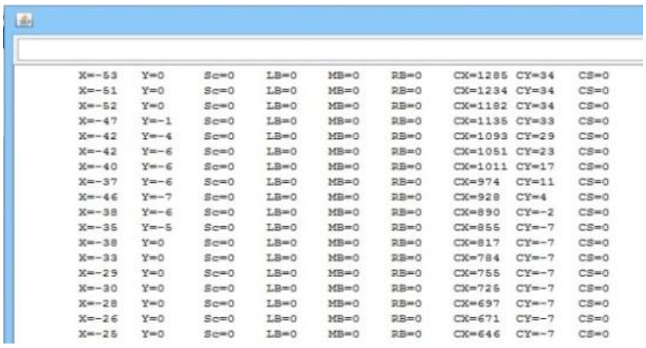
Fig. 5 External connections of servo motors to the Arduino board

IV. Working

The signal from PS/2 mouse is converted into binary data which is assigned to the servo motors at different joints to perform the required function. The commands, that are controlling the servo motors from the mouse are, X-movement, Y-movement, Left click & scroll, Right click & scroll, and Scroll. Each command controls a single joint of the arm (i.e. one servo motor each).
1. The X-movement controls the Base servo motor1 (Shoulder joint for rotation along the X-Z plane).
2. The Y-movement controls the Base servo motor2 (Shoulder joint for rotation along the Y-Z plane).
3. Left click and scroll controls the Elbow joint of the arm.
4. Right click and scroll controls the Wrist joint of the arm.
5. Scroll controls the Gripper of the arm.

V. Software

A major part of the project comprises of coding. Arduino 0023 is used for this purpose, as it provides appropriate libraries, like the PS/2 (ps2.h) and servo (Servo.h). The movement of the mouse can be monitored via the Serial Monitor and values are displayed using the **serial.print()** function. The X column returns a positive value when the mouse is moved in the positive direction of the x-axis and a negative value if it is moved in the negative direction of the x-axis. The click and scroll functions of the mouse, returns different range of values for predefined variables.
Fig.6 below, shows the serial monitor with variables like X, Y, Sc(scroll), LB(left button), MB(middle button), RB(right button), CX(cumulative X values), CY(cumulative Y values), CS(cumulative Sc values). X changes its value when mouse moves in left/right direction for controlling the clockwise and anti-clockwise directions of the shoulder motor, Y changes when mouse moves in forward and backward direction for allowing the up and down movement of the shoulder servo motor, Sc changes when scrolled for enabling the gripper to open and close, LB changes when left click and scroll are used, for controlling the elbow motor, RB changes when right click and scroll are used for wrist movement, CX, CY, and CS are cumulative X, Y, Sc values respectively.



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X=-51  Y=0   Sc=0  LB=0  MB=0  RB=0  CX=1234 CY=34  CS=0
X=-52  Y=0   Sc=0  LB=0  MB=0  RB=0  CX=1182 CY=34  CS=0
X=-47  Y=-1  Sc=0  LB=0  MB=0  RB=0  CX=1135 CY=33  CS=0
X=-42  Y=-4  Sc=0  LB=0  MB=0  RB=0  CX=1093 CY=29  CS=0
X=-42  Y=-6  Sc=0  LB=0  MB=0  RB=0  CX=1051 CY=23  CS=0
X=-40  Y=-6  Sc=0  LB=0  MB=0  RB=0  CX=1011 CY=17  CS=0
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X=-26  Y=0   Sc=0  LB=0  MB=0  RB=0  CX=671  CY=-7  CS=0
X=-25  Y=0   Sc=0  LB=0  MB=0  RB=0  CX=646  CY=-7  CS=0
```

Fig. 6 Serial monitor

PS/2 mouse is interfaced with the servo motors through the Arduino board using the commands available in the PS/2(ps2.h) library of the Arduino 0023. Servo motors are interfaced with the Arduino board via PWM pins 3, 5, 6, 9 and 10. The servo motors are assigned variables, which are used to attach the mouse movements using **servo.attach()** command**.**

e.g. Servo servo1

servo1.attach(3)

Here servo1 is the variable assigned to base servo motor1.

The angle of rotation of the servos is controlled using **servo.write()** command. It is further used for incrementing/decrementing the angle of rotation of the arm, using 'if' loop.

Applying the same logic and syntax to remaining functions of the mouse, we can control different servo motors and hence different joints of the Robotic arm.

VI. Advantages

Robotic arm is controlled by mouse, so it has many movements compared to the one controlled with ordinary remote. Also a remote is required to be at line of sight with the robotic arm, which is not required for the wireless mouse. The Robotic Arm can cover a distance of more than a foot in x direction with 180 degrees rotation, allowing it to pick up objects. The controls of the robotic arm are simple to understand and implement. Other advantages are simple kinematic model, easy to visualize, good access into cavities and machine openings, and very powerful when hydraulic drives are used. The kinematic structure of the robotic arm allows us to position its gripper at any (x, y, z) location in the 3D space within a specific range.

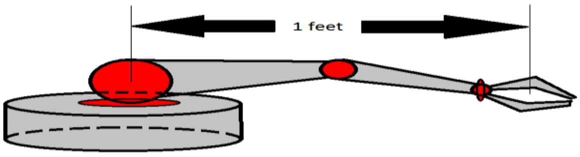

Fig. 7 Range of 5 DoF Robotic Arm

VII. Limitations

The Mouse Controlled Robotic Arm has a limited range over which it can access objects. The accuracy of the movements of the arm can be increased, by reducing the number of degrees the servo rotates when a function is triggered, but it will reduce the speed of operation of the arm. Hence a balance needs to be maintained between them.

VIII. Practical Applications

1. Mechanical: The robotic arm can have a variety of applications in mechanical field. It can be used for welding at high temperature environment usually dangerous for a human to work. It is used by many automobile industries for transport and placement of automobile parts.
2. Medical: Robotic arm finds a number of applications in this field. Surgeons use artificial robotic hands for performing surgeries requiring high precision and stability. They are useful in removing tumours and for performing cataract operations.
3. Space: Remote Manipulator System has robotic arms with many degrees of freedom, used for performing inspections by cameras and sensors attached at the gripper end. These Robotic Arms can be autonomous or manually controlled.
4. Household: Robotic Arms are not only useful in industries but also find a variety of applications in household. Using a cordless mouse, they can be accessed from a distance, thus proving beneficial at household chores like cleaning, placing objects in the shelf, etc.

IX. Conclusion

Mouse controlled Robotic Arm aims at providing assistance to industry as well as domestic applications. We present a cost effective, easy to operate, and having good range, Robotic Arm. In conclusion, we propose an efficient artificial machine, in flow with the recent developments in the robotics field. It can be improved further to upgrade the standard of living of human beings.

Fig. 8 Final setup of 5 DoF Robotic Arm controlled using PS/2 Mouse

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