

Robotic Arm Control through Mimicking of Miniature Robotic Arm

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Abstract- In the recent technology advancements, robots are employed to carry out the tasks that are monotonous or that are unsafe for human intervention in the field of medicine, industry, rescue operations and so on. Interaction of humans with robotic arm can yield many advancements and innovations. In this paper we have presented a model to control robotic arm with three degrees of freedom through miniature arm using potentiometer. The wiper of the potentiometer is connected to the Arduino Uno Microcontroller which is programmed to take analog readings from potentiometer and transmit them. Movements of the robotic arm are achieved through Stepper-Motor, which is a brushless DC electric motor that divides a full rotation into a number of equal steps. The arm is also equipped with a universal gripper to facilitate the pick and drop facility. The main aim is to design miniature robotic arm which can make the main robotic arm imitate as it does when the miniature arm is operated by a human operator.

Keywords—ADC, CNC Shield, PWM, Servo motor, Stepper motor, Universal Gripper

I. INTRODUCTION

Nowadays, robots are increasingly being integrated into working tasks to replace humans especially gestures of the operator was created.

The paper 3) studies the to perform a repetitive task. It might be difficult or dangerous for humans to do some specific tasks like picking up explosive chemicals, defusing bombs or in worst case scenario to pick and place the bomb and for repeated pick and place action in industries. Therefore a robot can replace human to do work. A robotic arm is a robot manipulator, usually programmable, with similar functions to a human arm.

Degree-of-freedom is used to describe robotic arms. Robotic arms are usually designed and manufactured based on their purposes. The degree-of-freedom and maximum reachable distances about the X, Y and Z-axis are two important factors that needs to be taken into consideration before and while designing a robotic arm.

There are certain techniques being implemented to control the movement of a robotic arm like Motion sensors & markers, vision systems etc. Use of potentiometer as a gesture recognition device is becoming quite popular The links of such a manipulator are connected by joints allowing rotational

motion. The end effectors can be designed to perform any desired task here it is gripping.

Currently, such robotic arm is controlled using joystick. To make control of an arm more precise like human beings we designed an arm which is synchronized to the model of the human arm and can emulate the movements of a human arm. This method of control allows greater flexibility in controlling the robotic arm rather than using a controller where each actuator is controlled separately.

II. RELATED WORKS

The authors in paper 1) reports the making and testing of a miniature prototype robotic controller arm using Bluetooth wireless technology which can be used to manually control an actual robotic arm that has 3 degrees of freedom. This can be achieved with the help of simple potentiometers at the joints of the miniature arm. The data is exchanged by the miniature robotic arm and the main robotic arm with the help of Bluetooth wireless interface. The servo motor takes the digital inputs from the Arduino board. The gyration of the servo motor is calibrated according to the position of the potentiometer.

In paper 2) the authors presented paper an application on how to control robotic arm with hand movement of the operator. The hand movement gestures were read by accelerometer of the smart phone. This data were sent to the PC through wifi or Bluetooth. The accelerometer actually controls mouse. The software controls robotic arm according to the movement of the arm. Merging two applications robotic arm control through hand movement simulation of a miniature conceptual seven degree-of-freedom (DOF) robotic slave arm that is able to imitate the seven basic motions of a human arm . Based on the simulation results, the miniature robotic arm designed is able to mimic the motion of a human arm.

III. BLOCK DIAGRAM

There are two systems, one master (miniature arm) and another slave (actual robotic arm) and an universal gripper.

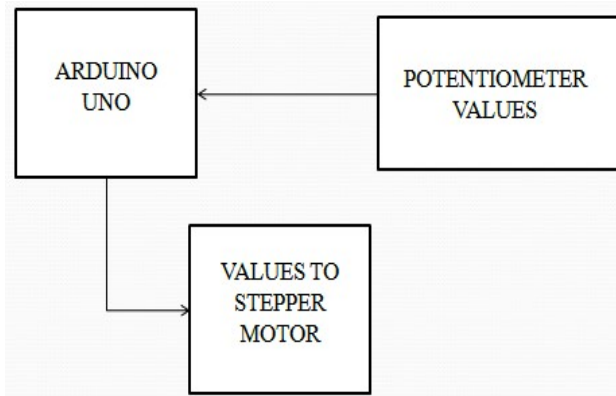


Fig 1: Block diagram of master robot

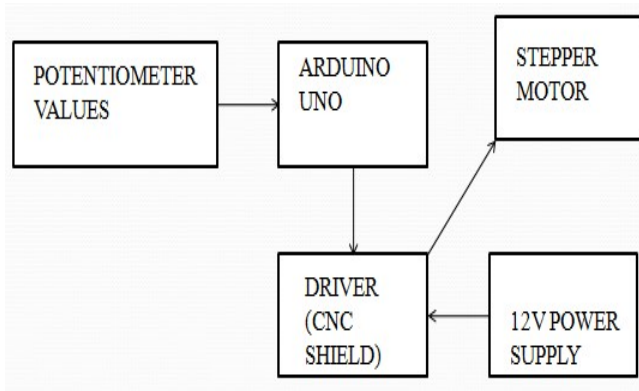


Fig 2: Block diagram of slave robot

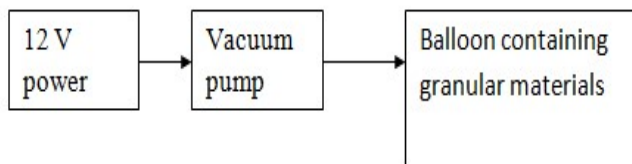


Fig 3: Block diagram of universal gripper

IV. HARDWARE USED

A. MICROCONTROLLER (ARDUINO)

The Arduino UNO is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 Digital pins, 6 Analog pins, and is programmable with the Arduino IDE (Integrated Development Environment) via a type B USB cable.

B. SERVO MOTORS

The servo motor takes the digital inputs from the Arduino board. The gyration of the servo motor is calibrated according to the position of the potentiometer. A Servo motor uses its own position feedback to control its motion and desired

position. This is basically achieved with the help of (feedback) encoders. The feedback from the motor is input to the encoders which then creates an error if the present position is not the same as that of the desired position. This error helps in the direction in which the motor should rotate in order to reach the final position. When the desired position is met, the encoder generates a zero error which stops the servo motor. This is also known as Bang-bang control of the motor. Tower pro MG995 is a high Speed Metal Gear Dual Ball Bearing Servo. This high-speed standard servo can rotate approximately 120 degrees (60 in each direction).

C. STEPPER MOTOR

A stepper motor is a kind of electric motor used in the robotic industry. Stepper motors move a known interval for each pulse of power. These pulses of power are provided by a stepper motor driver and is referred to as a step. As each step moves the motor a known distance it makes them handy devices for repeatable positioning. A full 360° circle divided by the step angle gives the number of steps per revolution.

D. CNC SHIELD

This shield is designed to allow you to control a CNC router or milling machine from an Arduino board. CNC shield is a well designed board which takes the trouble of doing own hardware layout. It contains 4 driver sockets which allows compatible A4988 driver modules to be inserted providing the ability to drive 3 stepper motor axis (X,Y, & Z) plus an optional 4th auxiliary motor. The shield allows external power supply upto 36V for powering powerful motors, Also has the pins for setting up end stops, hold & resume operation.

E. A4988 IC

This is used in CNC Shield as a driver IC. This stepper motor driver lets you control one bipolar stepper motor at up to 2 A output current per coil. Adjustable current control lets you set the maximum current output with a potentiometer, which lets you use voltages above your stepper motor's rated voltage to achieve higher step rates

F. UNIVERSAL GRIPPER

An universal gripper will be able to pick up unfamiliar objects of widely varying shape and surface properties. Individual fingers are replaced by a single mass of granular material (salt), when pressed onto a target object, flows around it and conforms to its shape. Upon application of a vacuum the granular material contracts and hardens quickly to pinch and hold the object without requiring sensory feedback.

The three separate mechanisms that contribute to the gripping force are

- friction
- suction
- interlocking

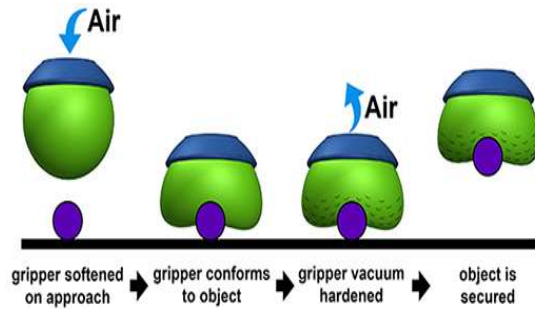


Fig 3: Block diagram of universal gripper

V. IMPLEMENTATION

The miniature arm model shown in Figure 4 was developed with foam board (can be developed with any suitable material which can rotate potentiometer wiper). The potentiometer gave out only a range of values which were eventually mapped from 0 to 180. The voltage given from each potentiometer is fed to the Arduino for processing the raw data. The voltage value that is 0 to 5 volts is mapped to 0 to 1023 value of ADC which is in built in Arduino.

Only integer value is taken into consideration. The robotic arm is suitable to the miniature arm and it is shown in figure 5.

These digital values ($0 - 1023 = 1024$ units) are mapped to stepper motor rotation angle. Robotic arm has three degrees of freedom. Two degree of freedom is provided by stepper motor and one by servo motor. Required degree of rotation at every joint is 180 degrees. NEMA 17 (stepper motor) has 200 steps with 1.8 degree each. 100 steps will provide required degree of rotation that is 180 degree. The 1024 units are mapped to 180 degrees, which can be done in two ways.

- Value of each potentiometer
 $100/1024 = 0.097$ steps
 Potentiometer values are read and multiplied with 0.097 to get number of steps to be taken
- Using the available function in arduino
`[map (potentiometer values, 0 , 1023 , 0 , 180)].`

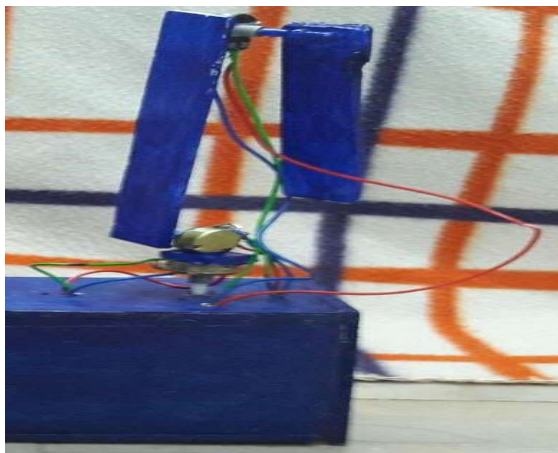


Fig 4: Block diagram of miniature arm

Table 1 is about the dimensions of the parts of the miniature arm as shown in Figures 3 and 4. The arm parts are given their names based on how close they are to the support arm.

	Length in mm	Breadth in mm	Height in mm
ARM1	190	5	1480
ARM2	190	5	1080
ARM3	2600	683	840

Table 1: Dimension of miniature arm

The stepper motor takes those many numbers of steps. If the potentiometer is read in opposite direction then values is multiplied with -1 for getting positive steps and stepper is rotated in opposite direction from which it was rotating earlier. The process is repeated with sufficient delay allowing stepper to move for those many numbers of steps.

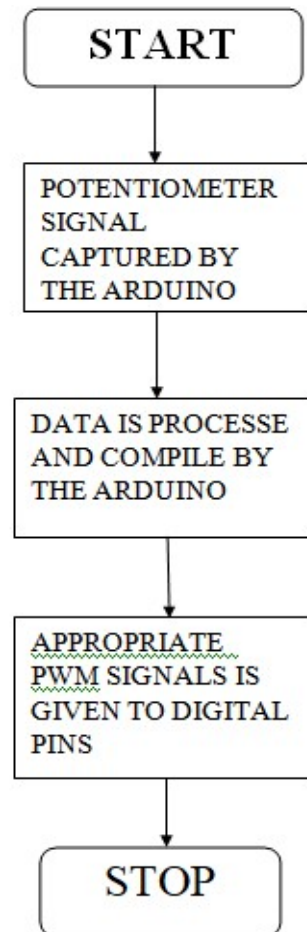


Fig 5: Flowchart of miniature arm

The process of controlling the servo motors actually happens with the help of PWM signals. The values are given as PWM signals to the Servo and the motor rotates to the specified angle

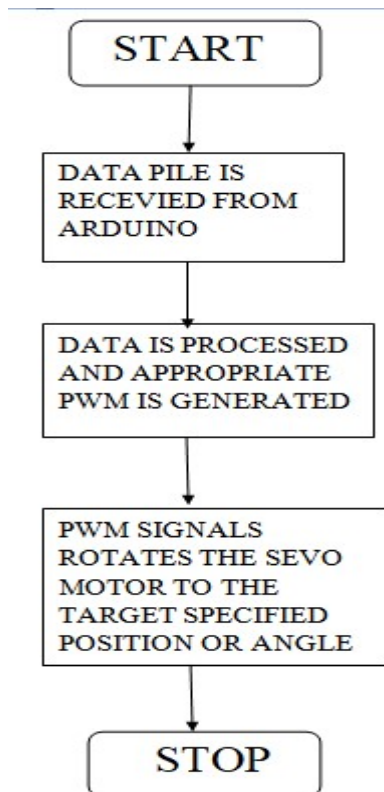


Fig 6: Flowchart of robotic arm

The robotic arm mimics the exact position of miniature arm by taking inputs from arduino on which CNC shield is mounted. CNC shield allows us to control two stepper motors after testing the designed robotic arm, under different

the system is efficient

- 1) The live video feedback is slightly lagging in nature. The response to hand movement by the arms is satisfactory as tested under a wide range of hand gestures including opening and closing of the grips.
- 2) The robot can be controlled inside 1 km of radius which gives a pretty good clearance of the affected rescue zone.
- 3) This is expected from the NRF24I01 module used in this project, which is an ultra-low power 2Mbps RF transceiver IC for the 2.4GHz band and has a range upto 1 kilometer.
- 4) The robotic hand shows an excellent response in picking up and placing a good amount of objects with respect to its load balancing capability. For heavy duty responsibilities; some additions to the existing modular structure or resizing of the existing structure should be sufficient.
- 5) Closed loop control system is adopted for governing of the precise movement of arms, exchange and collaborative handling of objects. However, instability, albeit in a short quantity, is persistent in

the arm response which can be corrected with necessary control mechanisms in place.



Fig 5: Block diagram of robotic arm

VI. EXPERIMENT AND RESULTS

In the Program, we can assign various types for the values, but we are taking in the integer values only. The reason behind this is that the Servo Motor and stepper motor always gives out an integer number feedback.

Sl. No.	Input			Output		
	Pot 1	Pot 2	Pot 3	Stepper 1	Stepper 2	Servo 3
1	0	0	0	0	0	0
2	30	30	30	28	29	29
3	45	45	45	47	47	42
4	90	90	90	91	91	85
5	135	135	135	120	120	120
6	180	180	180	170	167	165

Table 2: Corresponding angles moved by slave arm contributed by master arm

The table 2 values are obtained by measuring the angles manually. This value tells us the deviation of two arms.

Table 3 gives us the time delay between miniature arm and robotic arm. This time delay is measured in milliseconds.

The universal gripper used in this project can pick objects weighing around 50 to 70 grams (tested for objects like screwdriver, capacitor, a small analog watch and resistors).

Figure 6 shows us the universal gripper.

Sl.no	Type of operation	Average time lag measured
1	Joint 1 alone	220 ms
2	Joint 2 alone	350ms
3	Joint 3 alone	550ms

Table 3: Time delay between miniature and robotic arm

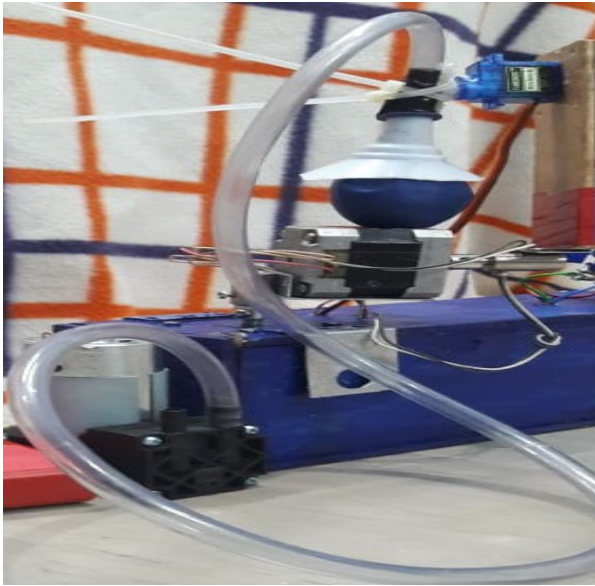
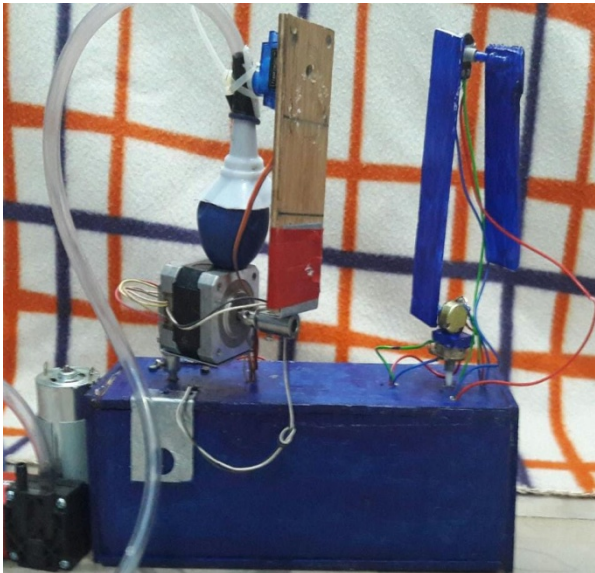


Fig 5: Block diagram of universal gripper

The overall system is wired and robotic arm mimics the positioning of miniature arm efficiently. Figure 6 shows the overall system.



VII. APPLICATIONS

Considering the environment under which arms have to work suitable material is taken during the construction. It can be used to pick and place any objects(should change the dimensions and use a stepper motor with better torque to lift heavier objects). This technology can be further developed. The miniature arm can be made a wearable one which can be worn by a therapist and the main arm can be an exoskeleton robotic arm which can be worn by a patient. Thus, this combination can be used in rehabilitation of stroke patients and other disabled people. This idea can be extended to measure other sensory feedback like vibrations from the robotic arm when it is involved in some operation. This idea with measuring necessary feedback parameters can be used for remote controlled medical operations such as surgeries

VIII. CONCLUSION

The objective of designing a miniature arm which can control the robotic arm using potentiometers has been achieved. The arm has three degrees of freedom. By using Arduino programming, a precise controlling system has been developed. An inference can be made from the observations that the robotic arm mimics the miniature arm movements accurately and precisely. Hence this miniature arm should resolve the issues that arises in the applications of the robotic arms

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