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Gesture Controlled Wireless Robotic Arm

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Abstract
The aim of the "Hand Gesture Controlled Wireless Robotic Arm" is to design a robotic arm whose gripping movements shall be controlled by sensors mounted on finger gloves on the Master side. The rotational movements of the motors attached to the metallic platform on which the arm would be installed, shall be configured with code-defined readings corresponding to the alignment of a accelerometer sensor mounted on the wrists of the controlling user at the Master side. The master side is mounted on the glove. The two motors attached to the metallic platform shall be driving four wheels. Whereas three motors on the arm shall drive the arm movements and its gripping control mechanism as per the input from the Master side. The Arduino on the transmitting side will be the Master and on the receiving side, it will be the Slave i.e. the robotic arm. For wireless communication between Master and Slave Bluetooth module is used for communication. Other components of our project include Battery, Signal Conditioning Circuits, Motor-driver IC, etc. Wireless Robotic Control gives an optimal method to govern a robotic arm using accelerometer and flex sensor, which is simple and lucid to work. Other than that, providing the ability to administer a robot by other wireless means is done. Working in this system, robotic arm controller makes the movements seem natural. Applications requiring precision and high level of accuracy can be performed using the robotic arm. And it gives us reliable, flexible control mechanism. The robotic arm may be helpful for the industry automation, military purpose and various other applications for automation activities.

Keywords: *Microcontroller, Accelerometer, Gesture Recognisation, Bluetooth module, Robot, Motor driver.*

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I. INTRODUCTION

In this era of globalization, automatic systems are part of our daily lives. Innovative products have been designed and are available in the market to help the physically challenged and senior citizens in the tasks that seem arduous to them. The precision and accuracy acquired by the performance of automated systems make them useful in vulnerable and critical operations on failure results in financial or human loss. A robotic arm consists of several sections connected with each other by links that assist the arm to move exactly in a designated pattern, with sensors making sure that all movements are exactly of the similar pattern. Several degrees-of-freedom are present for the motor actions of robotic arm, giving them the independence to move in multiple directions through various angles with extreme simplicity. In this project there is a set-up is designed such that that any movement or motion of the human fingers and wrist is reflected by the robotic hand. Sensors such as flex sensors and accelerometer are used. The data transmitted from finger movement and wrist movement to the receiver section i.e. to the arm wirelessly. The wireless transmission is done using Bluetooth.

II. PURPOSE

The motivation behind doing the project titled "Hand Gesture Controlled Wireless Robotic Arm" was to develop some effective technological solution that could help in making mechanical tasks easier with the assistance of electronic automation. The target audience was also extensive, as the robotic arm can be utilized anywhere from household chores to military purposes, from manufacturing plants to automation industries and also in sophisticated medical surgeries.

Various concepts from peers studying in mechanical engineering branch of college for our robotic arm design were learnt. An amalgamation of electronics, embedded processors and communication sub-systems, was an interesting opportunity to work on the studied subjects in previous semesters. Going through all these subjects, various related papers and journals on Internet, our team finalized this proposal for project. The aim of this is to complete project closer to being a prospective commercial product.

III. ITERATURE OF SURVEY

WIRELESS ROBOTIC HAND FOR REMPOTE OPERATYIONS USING FLEX SENSORS

A wireless controlled robotic system is used for surgical tool handling (pick and place). In this, three different fingers position of hand to control the robotic system with the help of flex sensor movement. According to different positions of the finger, resistance of the flex sensor changes, this change in the resistance is used to move the shaft of servo motor that moves the robotic arm as per position of a flex sensor in wireless environment using Zigbee technology.

The system design module divided into two sections, transmitter and receiver. Transmitter section includes flex sensor, voltage divider circuit, microcontroller and Zigbee module. Receiver section includes Zigbee module. Microcontroller and servomotor based robotic hand.

One flex sensor is used to control opening and closing gripper movement. Second flex sensor is used to move the robotic system up and down position. And third flex sensor is used for circular movement of robotic system. Controlling position of robotic system through flex sensor is done wirelessly using Zigbee technology.

ACCELEROMETER BASED CONTROL OF AN INDUSTRIAL ROBOTIC ARM:

An accelerometer based gesture control system is designed. Two 3-axis accelerometors are used, on the right arm and left arm. The Artificial Neural network(ANN) used back propogation algorithm is used to identify the gestures of human arm and the postures.3-axis accelerometer fixed to the right arm is used to identify the gestures. Communication of accelerometers is done with the computers via wireless communication module i.e. Bluetooth. The system receives the data from accelerometer of the left arm. The accelerometer on the left arm is used to activate and deactivate the system. If the communication fails robot stops. The robot is controlled wirelessly via the Ethernet. The achieved solution was to send to the robot only one pose increment that will move the robot to the limit of the field of operation. The increment calculation is also given.

The robot operates along X, Y and Z axes one at a time. Artificial Neural Networks (ANN) that is used to recognize gestures inputs the signals i.e. the acceleration data. The input signals are in vectors and outputs are given of neurons. The back propagation algorithm is used to determine the weights of whole system which are adjusted to minimize error. The whole system has response time of 160 milliseconds. By this procedure overall quantitative study for the recognition rate for each gesture and posture is illustrated.

MOBILE QUAD CONTROLLED WIRELESS ROBOTIC ARM:

The wireless working of the Quad-Controlled Robotic Arm is done through two modes of communication which are Wi-Fi and Bluetooth. These two technologies increase the reliability. Each of them can fulfil for the constraints of others .Bluetooth is preferred when transferring information from one device to other that are near each other without the requirement of a common network. But Wi-Fi is better choice for operating full-scale networks as it makes a faster connection; better range from the base station; and better wireless security.

Four control mechanisms are used for the control of robotic arm. The mechanisms of voice control, tilt control, remote control and hand gesture control are implemented. Voice Control is implemented by using the Google web speech API in the android phone. The Voice commands such as up, down, etc. is used to control the Quad-Controlled Robotic Arm. The phone tilt control works as the changes in tilt direction of the phone which is measured by the inbuilt accelerometer in the mobile phone. The tilt detected by the accelerometer will be transmitted via Blue tooth or Wi-Fi wirelessly to the micro-controller and the corresponding movement with respect to the received data will take place.

This also shows remote control as the controlling mechanism. The simple interface of touch button on the mobile app will control the robot. This information is transmitted via Bluetooth on the mobile phone. The final mechanism is Hand Gesture Recognition, which is implemented by using MATLAB language integrated with Arduino IDE. The Principal component Analysis algorithm is used to implement this mechanism

GESTURE CONTROLLED MOBILE ROBOTIC ARM USING ACCELEROMETER

A robotic arm control model is presented to control via human gestures by using accelerometer. 3 axis accelerometer is mounted on human hand to control the robotic arm according to the movement of hand. Th accelerometer is interfaced to the Atmega 16 Microcontroller which is programmed to take analog readings from accelerometer, process them and transmit the data through the RF transmitter to the receiver i.e. robotic arm. Movements of the robotic arm are achieved through Servo-Motor and they are used to position and hold some object. The arm has with a gripper for the pick and place facility. The whole assembly is placed on a platform with wheels that make the movement from one place to another which can be controlled using a wireless remote control that is in form of push buttons in the system itself.

The model consist of transmitter and receiver sections. The transmitter unit contains an accelerometer, a microcontroller and a RF transmitter to transmit codes against different ADC values from micro- controller.

The ADC values are being sent wirelessly at receiving end, which consists of a RF receiver, & a microcontroller for controlling servo motors.

The whole arrangement is placed on a platform with wheels for the movement from one place to another. This system provides a better way to control a robotic arm using accelerometer which is more and easy to work, also offer the possibility to control a robot by other wireless means

FLEX SENSOR BASED ROBOTIC ARM CONTROLLER USING MICROCONTROLLER:

The wearable data glove controller, processing unit and the servo controlled robotic arm is used.Here wired data transmission is done. flex sensors one for finger movement and other for wrist movement, a signal conditioning circuit and 3-axis accelerometer, processing unit consists of microcontroller (P89V51RD2), analog to digital converter (ADC0809) are used at one side. At other side a 3 degree of freedom robotic arm is built using 4 servo motors, a stepper motor driver (ULN2803AG) and one stepper motor are used.[5] A hardware and software design of robotic arm controller using four servo motors including the micro controller is implemented.

BLUETOOTH COMMUNICATION CONTROLLED ROBOT BASED ON GESTURE RECOGNITION:

Two approaches have been proposed, first is that the cell phone itself acts as processing unit and its inbuilt accelerometer for gesture recognition and Bluetooth for wireless transmission of processed data. Apart from this, another solution is where an external accelerometer for gesture recognition is used along with Arduino as processing unit and a Bluetooth module as a transmitter. The Bluetooth module is interfaced with microcontroller using UART protocol. UART protocol used 2 lines namely transmit and receive lin

Atmega328P a high performance 8-bit AVR RISC-based microcontroller is used. Its USART feature is used in interfacing Bluetooth with microcontrollers. Atmega328 has 6 hardware PWM pins. It's most important feature which is used for speed control of robots. In this application, two 8-bit PWM pins have been used for variable speed control.

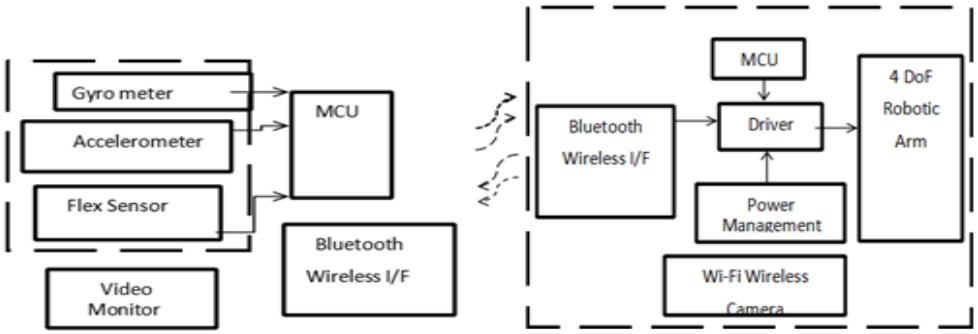

Fig.1 Bluetooth communication controlled robot based on gesture recognition

GESTURE BASED WIRELESS ROBOTIC ARM CONTROL FOR AGRICULTURAL APPLICATIONS:

The system architecture of the glove, harvester and interface. The transmitter i.e. the glove is the Human Control Interface (HCI) of the system. The user wears the gloves which includes the accelerometer, gyro meter and flex sensors. The accelerometer provides the acceleration and tilt and the gyro meter provides the angular velocity and orientation to the robotic arm that is being designed. The harvester is the rover fixed to the arm. The sensors are attached in the hand glove and are interfaced to the Microcontroller unit (MCU). Three accelerometers are used to control the 3 links of the arm and two flex sensors to control the cutter are attached to the glove. The model consisted of a 4 DoF robotic arm constructed with light weight metal aluminium The cutter is attached at the last link. The user wears the glove with the sensors and MCU setup.

A survey of all recent works is done on the wireless robotic arm using hand gestures. There are a lot of ways of implementing a wireless robotic arm design. This provides an idea that a system of wireless robotic arm using simple gestures of hand can be designed in a cost effective manner using flex sensors for the movement of arm based on the fingers and an accelerometer as a tilt sensor that will be mounted on a glove. The wireless communication i.e. transmission of commands from the gloves and reception of that data can be done using Bluetooth.

IV. SYSTEM DESIGN:

INTRODUCTION:

This chapter describes about the proposed system architecture of Hand Gesture Controlled Wireless Control Robotic Arm for pick and place operation using flex sensor and accelerometer and is done wirelessly using the Bluetooth Module.

BLOCK DIAGRAM:

Figure 2 illustrates the system design module of the glove i.e. the block diagram of the transmitter side.
The transmitter section includes:

- Sensors
- Signal Conditioning Circuit
- Accelerometer
- Arduino Uno
- Bluetooth Device. (HC05)

Figure 3 illustrates the system design module of Robotic Arm i.e. the block diagram of the receiver side.
The Receiver Section includes:

- Bluetooth Device
- Arduino Nano
- Servo Motor Mounted On The Robotic System
- DC Motors For The Basement

BLOCK DIAGRAM:

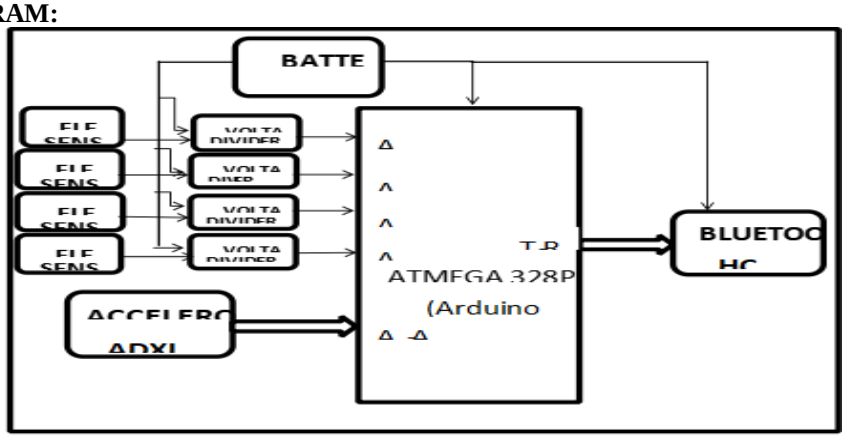

Fig 2 Block diagram of the transmitter side

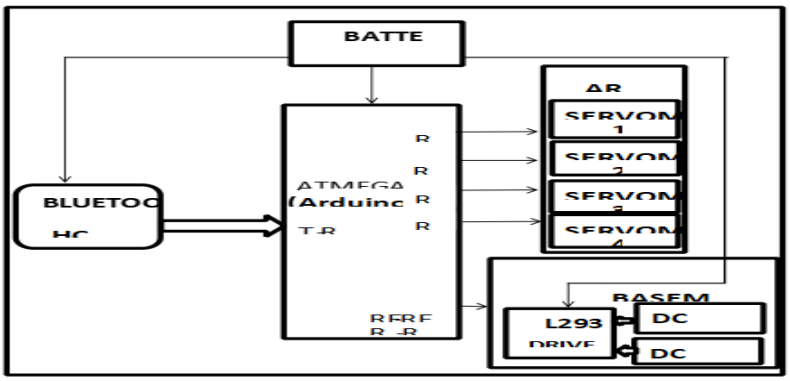

Fig 3 Block diagram of the receiver side

WORKING OF PROJECT

1. The movement of the Arm will be monitored by the sensors.
2. Any change in the fingers will change the resistance introduced by the sensors which will lead to change in voltage due to voltage divider. Thus, several binary combinations can be formed to define commands for the wireless robotic arm.
3. Also the accelerometer is used on the glove. Accelerometer is used for the movement of the basement on which the arm is mounted.
4. The direction in which the glove is to be tilted correspondingly the instructions will be given to the Arduino .
5. The Arduino will serve as the processing unit of the model. The analog signals from the sensors will be converted to digital through the in-built ADC of the controller.

6. It will instruct the Slave device through the Bluetooth module. Bluetooth Module (Master) will be connected to another Bluetooth Module (Slave).
7. This will lead to rotation of the required servo motors for performing various actions, according to the finger control accessed by the user wearing the hand gloves.
8. The receiver is configured as slave and to pair with the transmitter automatically which makes it easy for the user from the burden of configuring the Bluetooth modules separately.
9. The arduino at the receiver side receives the information from the Glove via Bluetooth and further instructs the motors to work accordingly.
10. The output from the Arduino as a PWM signal is given to the servo motor as an input. The gripper action and the Arm movement will be controlled by the servomotor.
11. Two DC motors are used at the back wheels of the basement. For the front two wheels we have attached 2 dummy shafts.

DESIGN OF VARIOUS BLOCKS:

HARDWARE SECTION

The transmitter side that will be mounted on the glove and will further instruct the arm. The above schematic consist of

TRANSMITTER SECTION

Power supply: A 9V power adapter is connected at the transmitter side and the further power supply is designed to get a constant output of 5V

Flex sensors: Connectors are connected in the above diagram for fixing the flex sensors. Flex sensors are used to instruct the arm. The variations in the bend of these sensors are sensed and further sent to the receiver via Bluetooth module.

Accelerometer: The changes in the tilt of the accelerometer will tend to move the basement in forward, backward, left and right directions.

Arduino Uno : ATmega328P a is used for processing the data from the sensors and send the instructions via Bluetooth

BLUETOOTH:HC05 Bluetooth module is used to send data processed in the microcontroller to the receiver side wirelessly.The interfacing is done through UART

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RECEIVER SECTION:

The receiver side that will be mounted on the arm and will further perform the instructions that are given by the glove. This will result in corresponding movement of the arm. The above schematic consist of

Power Supply: A 12V 8 AH battery is used at the receiver. The power supply is designed which gives the output of 5V

Bluetooth: HC05 Bluetooth module is used for receiving the data from the transmitter.

Arduino Uno: Controller is used to process the information coming from the Bluetooth module and further instruct the motors to work accordingly.

Servo Motors: These motors provide enough torque to move the arm as desired. These motors are mounted on the arm assembly.

L293D: This is a driver IC that drives the DC motors.

DC motors: DC motors will be connected to the Arduino via the driver IC. These motors are used for the movement of the basement in desired direction that will be instructed via the Arduino .

HARDWARE TESTING

Flex Sensor: Flex sensors convert the bend in the sensor to a resistance change which means it converts a physical energy into an electrical one. This sensor behaves as a variable resistor. They have a wide range of applications.

There are 3 types of flex sensors

1. Conductive ink based.
2. Fiber optic.
3.Polymer based.

This system has been implemented with the conductive based flex sensors by Spectra Symbol FLX01.

These sensors were first tested with Arduino.

The signal conditioning circuit used for the flex sensor is shown in figure 4.2. It is a simple voltage divider circuit where one resistance is fixed whereas the other is the flex sensor.

The resistance R2 is calculated by finding the average of flat resistance of flex sensor and extreme bend resistance of flex sensor. Thus this value comes out to be 47Ω.

Bend degrees	resistance(in Ohm)	Voltage(in volts)
0	23236	3.21
4	28189	3.13
10	30748	3.02
16	33218	2.93
21	35706	2.84
30	39492	2.72
36	41988	2.64
41	44881	2.58
46	46307	2.52
50	47966	2.48
55	50666	2.41
59	52074	2.38
67	55450	2.30
72	57451	2.25
78	60005	2.20
85	62937	2.26
88	64206	2.12
90	65243	2.10

Flex sensor resistance and corresponding voltage divider output. The above table shows the flex sensor readings by interfacing it with Arduino. This data is used while implementing a system. Average is calculated after observing the data for 50 times. The corresponding ADC values are calculated. Range of certain values is selected in the code. For example, for ADC values greater than 480, the servomotor is in stop state or it stops after attaining the value for 1st flex sensor. For ADC values between 400 and 480, the servo motor moves forward and for values less than 400, the servo motor moves backward. This refers to the clockwise and anticlockwise rotation of the motor.

ACCELEROMETER :

Accelerometer is a device that is an electromechanical device which measures acceleration of a device. With a wide range of applications like mobile phones, video games, measuring vibration in cars, measuring seismic activity and many more. Here an accelerometer is used like a tilt sensor. ADXL335 accelerometer is used for implementing the system. It is a 3-axis accelerometer which is designed to measure acceleration within range ±3g in x, y and z axis. It has a poly-silicon surface-micro machined sensor and signal conditioning circuitry. This accelerometer was also interfaced to the Arduino. Several readings were taken. The analog values when the accelerometer was interfaced with the microcontroller were noted and taken for further implementation.

TESTING:

Fig 4 Transmitter Robotic Assembly

Receiver Section PCB

Above Figure is the transmitter section PCB. It contains a controller, connectors for senser.This PCB is first tested by mounting components

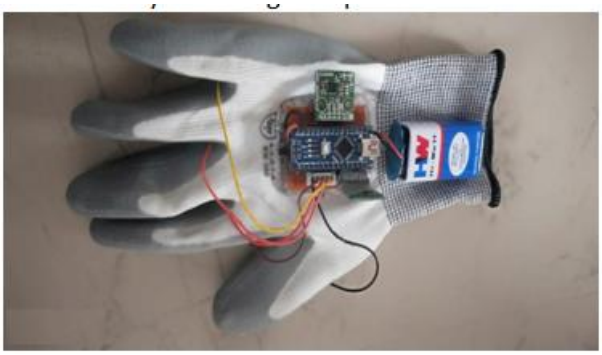

Fig 5 Entire Receiver Robotic Arm Assembly and the Transmitter Glove

Figure 5 shows the entire assembly of receiver robotic arm and transmitter glove. The motors' functioning was individually tested. After that the servomotors and dc motors were mounted onto the assemblyone by one and tested according to the movement of flex sensors and accelerometer respectively. Functioning of all the motors all together were tested and controlled with the help of flex sensors and accelerometer.

V. RESULT & CONCLUSION

RESULT

The Hand Gesture Controlled Wireless Robotic Arm project was proposed and implemented. At first the component selection was done. After going through numerous of references and different components, the final components were selected. The components were individually tested with Arduino Uno development board. Different set of readings were obtained. The testing of servomotors was done by interfacing with Arduino and flex sensor. The testing of dc motors was done by interfacing with Arduino and accelerometer. First Bluetooth was not used. After that testing was done for wireless data transmission via Bluetooth and testing of motors was observed. After that the servomotors and dc motors were mounted onto the assembly one by one and tested according to the movement of flex sensors and accelerometer respectively. Functioning of all the motors all together were tested and controlled with the help of flex sensors and accelerometer. The arm functioned according to the desired actions except the basement attached servomotor. Also the system yet needs to work on making the project model run on portable power supply. The motors are utilizing large power as compared to the expected power due to the load they are bearing.

CONCLUSION

The Hand Gesture Controlled Wireless Robotic Arm project can be installed in locations which demand performance of basic mechanical activities, but where human stationing is impossible, owing to harsh climates or life threats. The robotic arm which is mounted on a metallic platform can move around freely in the range of communication. It can pick up objects lying on floor, hold onto them while moving to another location

and place that object at the desired destination. A systematic approach was followed from planning the project to the final implementation, which helped in making tasks simpler. An effort was made to keep the incurred costs minimum, without compromising on the functionality or efficiency of the project. A lot of tricky situations were faced while working on the hardware of the project. It also helped in developing a good troubleshooting aptitude. Different parameters were studied, compared and learnt while selection of the correct components. Using simulation software, PCB designing and simulation was also done after which PCBs were fabricated for installation on devices.

VI. FUTURE SCOPE:

The Hand Gesture-Controlled robot designed in this work has many future scopes. The robot can be used for security and surveillance purposes. The robot can be applied to a wheelchair, where the wheelchair can be driven by the gestures of rider's hands and fingers. Wi-Fi can be used for communication, instead of Bluetooth, to access it from longer distances. Edge sensors can be incorporated to it, to prevent the robot from falling from any elevated surface. Some cameras may be installed, which can record and send data to the nearby computer or cellphone by wireless communication. It can be implemented on a watch, or in any home appliances like room heaters. Gesture control mobile robotic arm can help the scientists performing hazardous experiments in safer ways, by using robotic arm to pick the dangerous liquids. This can also help scientists to perform experiments with the chemicals which are highly inflammable in nature. It can also be used for military operations to carry out mission on explosives, as gesture controlled robotic arm can also help the bomb squad to detonate or defuse the bomb without involving risks to their lives. It can also help the astronauts to repair or pick up objects in zero gravity without going outside the space craft, where movements of human beings are quite difficult and may prove fatal for human life.

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