Gesture Control of Robotic Arm for Hazardous Environment

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Abstract—*Gesture controlled robotic arm is proposed to dispose nuclear waste generated in restricted areas like nuclear reactors. Manual labour is not the ideal choice because of the high levels of radiation. Here we use hand gestures to control the robotic arm. Hand gestures are sensed by accelerometer sensors. Servo motors are used as actuators to move the robotic arm. They will replicate the human hand gestures read using the accelerometer sensors. This method is used for replacing damaged parts in the reactor.*

Keywords—*gesture control; hand gestures; accelerometer sensors.*

I. Introduction

Nuclear wastes are nothing but radioactive wastes produced due to the use of nuclear fuel in fission and fusion reactions. Such waste products are usually hazardous. They cause pollution and are a dangerous health risk to living organisms. Control rods used in nuclear power plants must be replaced whenever necessary to avoid the emission of dangerous gases. Sometimes manual replacement of control rods in restricted areas is not possible. Therefore, we use hand gestures to control robotic arm for replacing control rods.

Here, a glove with 5 accelerometer sensors (each one for sensing individual finger movement) is used for providing hand gestures. Servo motors are used for the operation of robotic arm.

This paper explains about the entire process involved in control of hazardous environment. The block diagram is a manifestation of the project. It consists of two main blocks – the transmission side and the reception side.

II. Abbreviations

IOT- Internet of Things

EEPROM- Electrically Erasable Programmable Read Only Memory

RAM- Random Access Memory

SRAM-Static RAM

III. Transmission Side

This side mainly consists of accelerometer sensors feeding their data to the Arduino. This data is processed and sent to ZigBee transmitter.

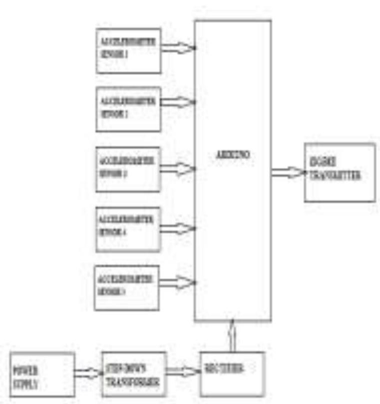

Figure 1. Block diagram of Transmission side

1) ***Accelerometer sensor*:** They are used for measuring acceleration of hand gestures along x, y and z axis.

2) ***Arduino:*** It is a Microcontroller Board that is used for storing and processing data. Here the sensor values are measured, stored and processed in the required format by uploading software code into it.

3) ***Power supply:*** Arduino requires power supply for working. Power supply is given using battery or by means of direct connection from supply board.

4) ***Step down transformer:*** It is used for stepping down the supply value to the required value.

5) ***Rectifier***: It is used for converting ac supply voltage to dc voltage.

6) ***ZigBee:*** It is nothing but communication protocol used for wireless transfer of data.

IV. Reception Side

This side receives the ZigBee receiver and gives input to the servo motors of the robotic arm using the Arduino.

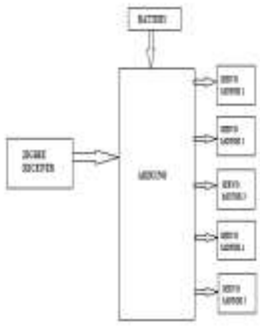

Figure 2. Block diagram of Reception side

1) ***Arduino:*** Arduino in receiver section uses the stored data from cloud and process them into the required format in order to make the robotic arm work as that of hand gestures.

2) ***Servo motors:*** They are used in the robotic arm for the movement of arms' fingers mimicking the human hand gestures. Receiver section Arduino provides the angles to which each and every servo motor should rotate.

V. Existing System

The existing system uses wired connections from transmitter to receiver part for controlling the movement of robotic arm. While using this method distant locations cannot be accessed. Man has to operate the reactor from nearby location which can cause health risk and skin allergy due to various radiations emitted from reactor. The main disadvantages of using this method are:

- Communication with the robot in the reactor area is not stable.
- This increases the overall cost and may have unsafe effects.
- Cooling and shielding are required for significant amount of time for nuclear waste.

VI. Proposed System

Accelerometer sensors used for sensing hand gestures are mounted on glove. The controller on the glove will send data to the ZigBee transmitter. The robot inside the nuclear plant environment will receive the values from ZigBee receiver and based on the values the robot will operate. Totally 2 types of controller exist in this system - one for the gloves and other for operating the robot. The main advantages of using this system are:

- Communication with the robot is done through Internet of Things (IOT) which is efficient and simple. There is no intrusion of human beings.
- This method does not cause any health risk to living organisms
- The use of IOT makes the system to be operated from distant locations.

VII. Detailed Explanation of Components

A detailed explanation of each and every component is done.

A. *Accelerometer:*

The ADXL335 is a small, thin, low power, complete 3-axis accelerometer with signal conditioned voltage outputs. The sensor measures acceleration with a minimum full-scale range of ±3 g. It can measure the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration. The user selects the bandwidth of the accelerometer using the CX, CY, and CZ capacitors at the XOUT, YOUT, and ZOUT pins. Bandwidths can be selected to suit the application, with a range of 0.5 Hz to 1600 Hz for the X and Y axes, and a range of 0.5 Hz to 550 Hz for the Z axis. The ADXL335 is available in a small, low profile, 4 mm × 4 mm × 1.45 mm, 16-lead, plastic lead frame chip scale package (LFCSP_LQ).
Low power: 350 µA (typical)
Single-supply operation: 1.8 V to 3.6 V 10,000 g shock survival Excellent temperature stability BW adjustment with a single capacitor per axis RoHS/WEEE lead-free compliant.

Figure 3. Accelerometer module

B. *Arduino:*

Arduino board uses different microprocessors and controllers. It has 14 digital input/output pins. An Arduino contains 6 analog inputs pins, a 16 MHz resonator, a USB connection, a power jack, 7-12 DC input,14 Digital pins, SCL, SDA, ICSP head and its USB interface,3.3v pin,5v pin. The Arduino provides the Arduino Integrated Development Environment (IDE). It is a platform where the application is written in the form of program.

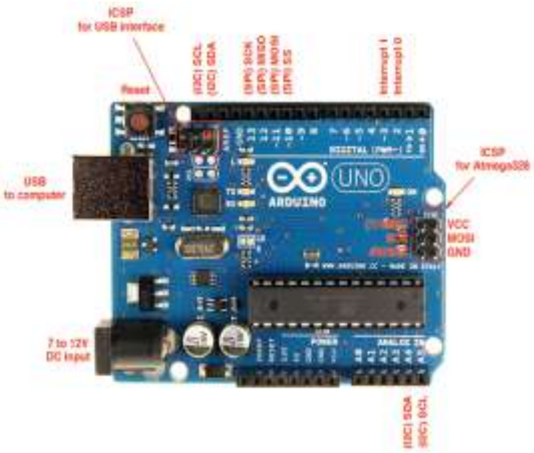

Figure 4. Arduino board

Specifications:
Microcontroller ATmega328
Operating Voltage 5V
Input Voltage (recommended) 7-12V
Input Voltage (limits) 6-20V
Digital I/O Pins 14 (of which 6 provide PWM output)
Analog Input Pins 6
DC Current per I/O Pin 40 mA
DC Current for 3.3V Pin 50 mA
Flash Memory 32 KB (ATmega328) of which 0.5 KB used by bootloader
SRAM 2 KB (ATmega328)
EEPROM 1 KB (ATmega328)
Clock Speed 16 MHz

C. Servo Motor:

Motors are required to move the joints of arm so that it can do work. One of the factors that help robots achieve this is Servo motor. Servos are controlled by sending an electrical pulse of variable width, or pulse width modulation (PWM), through the control wire. There is a minimum pulse, a maximum pulse, and a repetition rate. A servo motor can usually only turn 90° in either direction for a total of 180° movements. The motor's neutral position is defined as the position where the servo has the same amount of potential rotation in the both the clockwise or counter-clockwise direction. The PWM sent to the motor determines position of the shaft, and based on the duration of the pulse sent via the control wire; the rotor will turn to the desired position. The servo motor expects to see a pulse every 20 milliseconds and the length of the pulse will determine how far the motor turns. For example, a 1.5ms pulse will make the motor turn to the 90° position. Shorter than 1.5ms moves it in the counter clockwise direction toward the 0° position, and any longer than 1.5ms will turn the servo in a clockwise direction toward the 180° position.

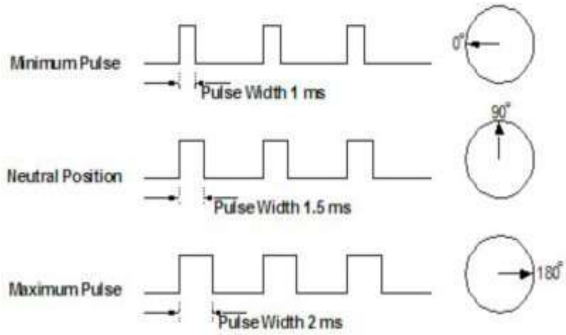

Figure 5. Servo motor movement

When these servos are commanded to move, they will move to the position and hold that position. If an external force pushes against the servo while the servo is holding a position, the servo will resist from moving out of that position. The maximum amount of force the servo can exert is called the torque rating of the servo. Servos will not hold their position forever though; the position pulse must be repeated to instruct the servo to stay in position.

Figure 6. Servo motor

Program:

```
#include <Servo.h>

Servo myservo;
Servo myservo1;
Servo myservo2;
Servo myservo3;
Servo myservo4;// create servo object to control a servo

int pos = 0;
void setup()
{
  myservo.attach(9);
  myservo1.attach(8);
  myservo2.attach(7);
  myservo3.attach(6);
  myservo4.attach(5);
  Serial.begin(9600);
// attach the signal pin of servo to pin9 of arduino

}


int dig1,dig10,dig100,dig1000;
void loop()
{
  if(Serial.available()>0)
  {
    int a=Serial.read();
    if(a=='T')
```

D. ZigBee:

ZigBee is a wireless networking standard that is aimed at remote control and sensor applications which is suitable for operation in harsh radio environments and in isolated locations. For up to 70m, wireless data transfer is possible using ZigBee. For stations situated at distance more than 70m, data is relayed from one node to the next in a network. ZigBee module is connected with USARTTX or RXpin, for sending and receiving data. ZigBee is a specification for a suite of high level communication protocols using small, low-power digital radios based on the IEEE 802.15.4-2003 standard for wireless personal area networks (WPANs)

ZigBee technology builds on IEEE standard 802.15.4 which defines the physical and MAC layers. Above this, ZigBee defines the application and security layer specifications enabling interoperability between products from different manufacturers. In this way ZigBee is a superset of the 802.15.4 specification.

The data is transferred in packets. These have a maximum size of 128 bytes, allowing for a maximum payload of 104 bytes. Although this may appear low when compared to other systems, the applications in which 802.15.4 and ZigBee are likely to be used should not require very high data rates.

The standard supports 64 bit IEEE addresses as well as 16 bit short addresses. The 64 bit addresses uniquely identify every device in the same way that devices have a unique IP address. Once a network is set up, the short addresses can be used and this enables over 65000 nodes to be supported.

It also has an optional super frame structure with a method for time synchronisation. In addition to this it is recognised that some messages need to be given a high priority. To achieve this, a guaranteed time slot mechanism has been incorporated into the specification. This enables these high priority messages to be sent across the network as swiftly as possible.

There are three different network topologies that are supported by ZigBee, namely the star, mesh and cluster tree or hybrid networks. Each has its own advantages and can be used to advantage in different situations.

The star network is commonly used, having the advantage of simplicity. As the name suggests it is formed in a star configuration with outlying nodes communicating with a central node.

Mesh or peer to peer networks enable high degrees of reliability to be obtained. They consist of a variety of nodes placed as needed, and nodes within range being able to communicate with each other to form a mesh. Messages may be routed across the network using the different stations as relays. There is usually a choice of routes that can be used and this makes the network very robust. If interference is present on one section of a network, then another can be used instead.

Finally, there is what is known as a cluster tree network. This is essentially a combination of star and mesh topologies.

Both 802.15.4 and ZigBee have been optimised to ensure that low power consumption is a key feature. Although nodes with sensors of control mechanisms towards the centre of a network are more likely to have mains power, many towards the extreme may not. The low power design has enabled battery life to be typically measured in years, enabling the network not to require constant maintenance.

Some of the applications are:

- 2400-2483.5 MHz ISM/SRD band systems
- Consumer electronics
- Wireless game controllers
- Wireless audio
- Wireless keyboard and mouse
- RF enabled remote controls

Figure 7. ZigBee Module

VIII. RESULT

The human personnel are required to undertake certain tasks in order to avoid the risk caused due to hazardous environment. Gesture controlled robots are designed to dispose nuclear wastes.

Hand gestures are used to control the robotic arm movement. Hand gestures are sensed using accelerometer sensors which are used to find out the position of each finger using 3 axes (X, Y and Z). Servomotors are used as actuators to move the robotic arm.

The communication between hand gesture and robotic arm is done using Wireless ZigBee Protocol. The arm movement will respond as quickly as the hand movement. The serial values of the output are generated in the system using Arduino in which the desired coding has been loaded. Thus the robotic arm will move and pick-up objects as done by the hand gesture, in order to replace the damaged parts in the nuclear reactor.

IX. APPLICATIONS

Apart from nuclear reactors, this method can be used in various hazardous environments. Some of the applications are:

a. Coal mines:

It is impossible for workers to dig holes underground during extreme hot temperatures. During this circumstance hand gesture control can be extremely beneficial.

b. Medical field:

Neuro-arm uses laser scalpels which can provide pin point accuracy.

c. Bomb defusing:

Bomb defusing is a challenging task. Special squad is required for performing this job. Since Bomb defusing will cause life risk to the members of the squad, the same work can be done using robotic arm which can be controlled by hand gestures.

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