HAND GESTURE BASED WIRELESS ROBOTIC ARM
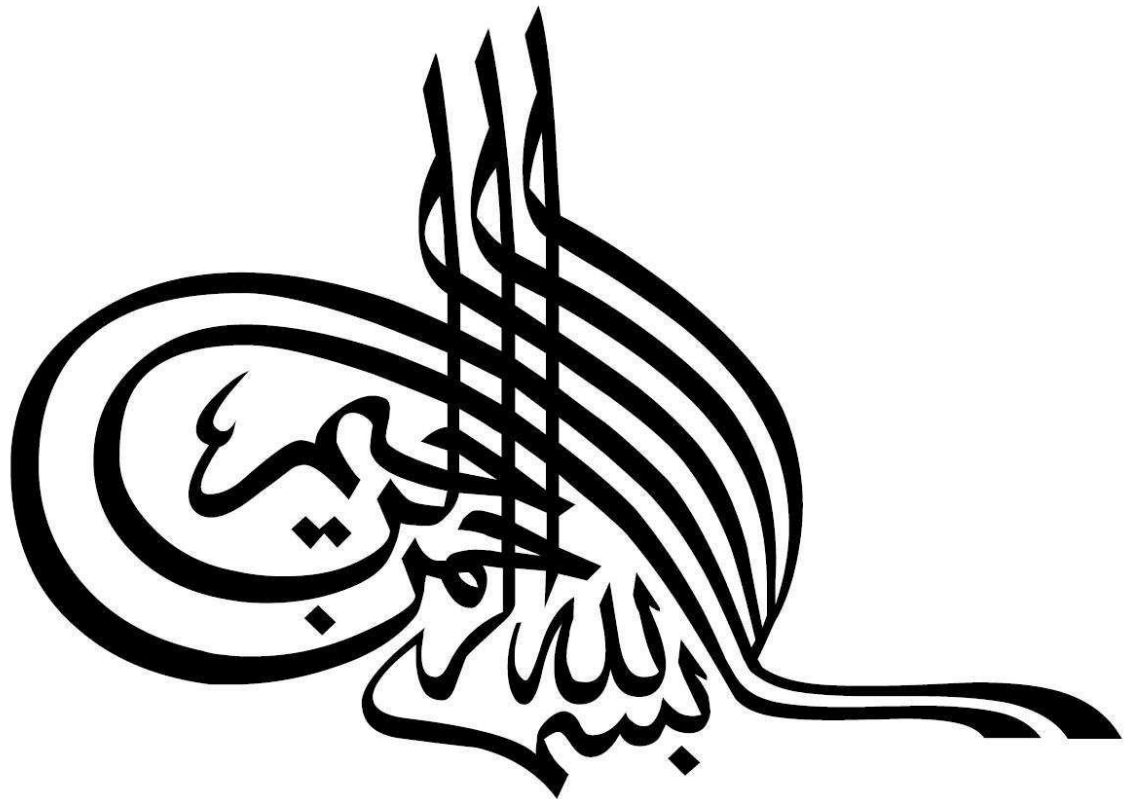## FINAL YEAR PROJECT REPORT

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SESSION (2012-2016)

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NATIONAL UNIVERSITY OF SCIENCES AND TECHNOLOGY, ISLAMABAD

(JUNE 2016)

In the name of Allah,
the Most Beneficent,
the Most Merciful

DEDICATION

We dedicate this project to our Supervisor and faculty members
Who always helped, encouraged and guided us
For attaining this level
And our families who for being our well wisher

CERTIFICATE

This is to certify that this project report entitled "**Hand Gesture Based Wireless Robotic Arm**" *by* **Capt Ahsan Ali, Capt Altaf Wasif and Capt Mirza Usman,** submitted with fulfillment of the requirements for the degree of BE (Electrical Telecom) in Military College of Signals (NUST) during the academic year 2015-16, is a bonafide series of job carried out under assistance and supervision.

Name (Supervisor): _____

Signature: _____

Date: _____

ABSTRACT

Prosthetic body parts have always intrigued us. The research we have witnessed and read about in the field have always motivated us to try and find solutions to assist people with disabilities, this project is innovative step in that direction. It is much more practical and potentially useful from a purposeful and economic standpoint. Artificial arm controlled by a glove with flex sensor is an engineering project with the goal of creating a system to provide hap tic feedback from a robotic arm. The robotic arm is controlled by hand gesture with a glove worn on someone's hand and IR proximity sensor detect the presence of nearby object, control signal is sent from human hand wearing glove using RF transmitter. At the receiver hand, proximity sensor detects the object. In case of presence of object moment is produced in robotic arm to move at particular location from one position to another. The item being sensed is often referred to as the sensor's target. The sensed object then grabbed by artificial hand. The hand and the glove both work with Arduino. This project is simply a system of servos controlled via flex sensors and IR proximity sensor meant to detect the object and grabbing the object by the hand signal of the person.

ACKNOWLEDGEMENT

Thanking ALLAH for His Blessings, Mercy & Favours'. We would like to acknowledge our Parents and all Teachers, who supported us both morally and technically, especially our supervisors Lieutenant Colonel Babar Aslam / Major Muhammad Faisal Amjad who helped us at every step in the making of our project, helped us in the clarification of our queries related to our project and technical problems. Also our special thanks to all class fellows and seniors, who helped us in clarification of any issue as well as implementation and in documentation.

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CHAPTER 1

INTRODUCTION

1.   Enhance in technology has given hope in every walk of life. Big size computers are now integrated in to smart phones, electronics and electrical items have gone cheap and man has touched Mars to discover new world.

2.   This project is a step in adding idea by implementing wireless artificial robot which would be of very vast span. Wireless artificial arm having IR proximity sensors, use to identify/detect the object nearby, is being controlled by a glove with flex sensors on human hand, this is an idea with the goal of creating a system to provide haptic feedback from a robotic arm. Our project consists of two parts, one is human hand wearing glove on which flex sensors are placed which controls the artificial robotic hand using arduino, second parts is the artificial robotic arm having proximity sensors for object detection. Robotic arm receive signal wirelessly through RF from human hand and IR proximity sensors then sense whether the object is placed nearby to be picked/grabbed or not. If object is present, it then tells the robotic arm to move at the particular location and pick/grab the object. The artificial robot then actuate through actuator by the signal of human hand, the robotic arm will grab the object accordingly. The robot and the glove both work with Arduino. The basic mechanism of the hand and glove will be the hand itself, the servos, the Arduino, glove, and the flex sensors. The glove is mounted with flex sensors: variable resistors that alter their value when bent. The Arduino reads the voltage modification when the sensors are bent, and triggers the actuators to move a proportional amount. The actuator then produces rotation allowing the artificial robot to move, this all is done wirelessly.

3.   **<u>PROBLEM STATEMENT</u>**

Unfortunately few people are born disabled such as without hand, leg dumb etc. Apart from them few lost their limbs while working in some factory or become part of accident, there are few others as Sappers who lost their hand etc while defusing the bombs/ Improvised Explosive devices. There is serious need of user friendly Prosthetic/ artificial product to compensate the loss to some extent.

4.   **<u>Scope:</u>** The scope of work of this project is:

The essential learning of the RF technology

Mandatory study about the Micro-Controller Programming

Designing of the circuit

To have systematic knowledge about the mechanism used in the project

5.   **APPROACH.**   The clarification to the above stated problem is acquired by the end product of this project i.e. the wireless robotic arm. The approach used to attain that is recapitulated in the following flow diagram

6. **<u>OBJECTIVES</u>**

    a.   **<u>Project objective.</u>**   The purpose of this project is to design a working model/ prototype for Gesture based wireless Artificial Robotic arm for military field environment, for disabled personal, medical and industries.

    b.   **<u>Academic objective.</u>** The academic objectives include:

    1) To design and comprehend Wireless Technologies.

    2) To replicate diverse circuit designs of the Sensors.

    3) To build up the hardware for various fields such as military, medical, industries etc.

    4) To assess the system on a model.

CHAPTER 2

7.   **BACKGROUND STUDY**.   Our assignment primarily deals with understanding and implementing the present technologies. In our literature review we considered the present technologies that are used for controlling the things at a far distance using artificial arm. We have carried out a in depth understanding of the proposed solution to the problem given in various research papers and come to an eventual design of our wireless artificial robot. In addition to this basic understanding, design of a system which uses flex sensors and IR proximity sensors and integrating it with different wireless technologies and choose RF technology, need to be dealt with in this portion along with few other academic concepts for better implementation of the system.

LITERATURE REVIEW

8.   **Design Requirements**.   Following are the requirements of our Project:

    a.   Microcontroller Arduino
    b.   IR Proximity Sensor
    c.   Flex Sensors
    d.   Servo Motors
    e.   RF Transmitter
    f.   RF Receiver
    g.   Voltage dividers
    h.   Operational amplifier
    i.   Glove
    j.   Fibre sheet
    k.   Hand structure

9.   **Design Specification**

    a.   **Microcontroller Arduino.** Arduino is illustrated as "an open-source electronics prototyping platform based on flexible, easy-to-use hardware and

software, " In short, it is a fashionable open-source electronic board that is capable of controlling just about any hardware project.

ATMEGA328P-PU Chip to Arduino Pin Mapping

Arduino function				Arduino function
reset	(PCINT14/RESET) PC6 ☐ 1		28 ☐ PC5 (ADC5/SCL/PCINT13)	analog input 5
digital pin 0 (RX)	(PCINT16/RXD) PD0 ☐ 2		27 ☐ PC4 (ADC4/SDA/PCINT12)	analog input 4
digital pin 1 (TX)	(PCINT17/TXD) PD1 ☐ 3		26 ☐ PC3 (ADC3/PCINT11)	analog input 3
digital pin 2	(PCINT18/INT0) PD2 ☐ 4		25 ☐ PC2 (ADC2/PCINT10)	analog input 2
digital pin 3 (PWM)	(PCINT19/OC2B/INT1) PD3 ☐ 5		24 ☐ PC1 (ADC1/PCINT9)	analog input 1
digital pin 4	(PCINT20/XCK/T0) PD4 ☐ 6		23 ☐ PC0 (ADC0/PCINT8)	analog input 0
VCC	VCC ☐ 7		22 ☐ GND	GND
GND	GND ☐ 8		21 ☐ AREF	analog reference
crystal	(PCINT6/XTAL1/TOSC1) PB6 ☐ 9		20 ☐ AVCC	VCC
crystal	(PCINT7/XTAL2/TOSC2) PB7 ☐ 10		19 ☐ PB5 (SCK/PCINT5)	digital pin 13
digital pin 5 (PWM)	(PCINT21/OC0B/T1) PD5 ☐ 11		18 ☐ PB4 (MISO/PCINT4)	digital pin 12
digital pin 6 (PWM)	(PCINT22/OC0A/AIN0) PD6 ☐ 12		17 ☐ PB3 (MOSI/OC2A/PCINT3)	digital pin 11(PWM)
digital pin 7	(PCINT23/AIN1) PD7 ☐ 13		16 ☐ PB2 (SS/OC1B/PCINT2)	digital pin 10 (PWM)
digital pin 8	(PCINT0/CLKO/ICP1) PB0 ☐ 14		15 ☐ PB1 (OC1A/PCINT1)	digital pin 9 (PWM)

Digital Pins 11,12 & 13 are used by the ICSP header for MISO, MOSI, SCK connections (Atmega168 pins 17,18 & 19). Avoid low-impedance loads on these pins when using the ICSP header.

b. **IR Proximity Sensors**. A proximity sensor is a sensor able to detect the presence of nearby objects without any physical contact. A proximity sensor often emits an electromagnetic field or a beam of electromagnetic radiation (infrared, for instance), and looks for changes in the field or return signal. The object being sensed is often referred to as the proximity sensor's target. Different proximity sensor targets demand different sensors.
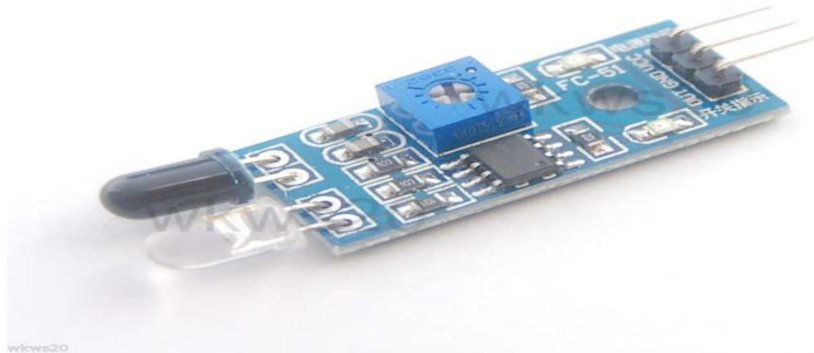
Type	Use
Inductive	Detection of metallic objects.
Capacitive	Detection of metallic and non-metallic objects.
Photoelectric	Use light sensitive elements to detect objects.
Magnetic	Detects the presence of permanent magnet.

c. **Flex Sensors**. At one end of the aquarium tubing, was an IR LED. And at the other, was the IR sensor. Basically, this was a ghetto fibre optic cable (dategloves back then had fibreoptic sensors that detected finger flex). However, this transmitted the IR too well and I was not incurring enough losses due to the assembly being flexed, so I threw in lengths of scrap wire to interfere with the the IR transmission. This worked surprisingly well. And the entire thing was sealed in heatshrink to cut out any external light.
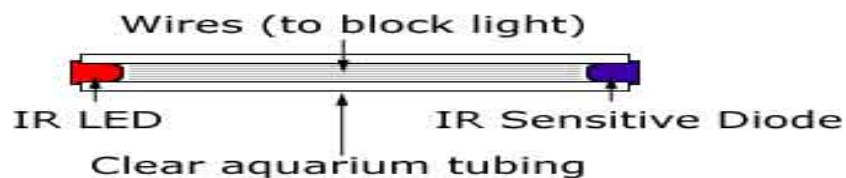
d. **Servo Motors**. Servo refers to an error sensing feedback control which is used to correct the performance of a system. Servo or RC **Servo Motors** are DC motors equipped with a servo mechanism for precise control of angular

position. The RC servo motors usually have a rotation limit from 0° to 180°. But servos do not rotate continually. Their rotation is restricted in between the fixed angles
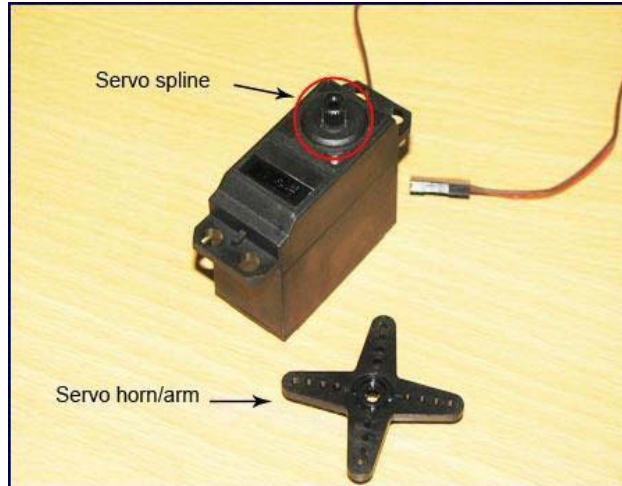
e. **<u>nRF Module</u>**.   An nRF Module is a small electronic circuit which is used to receive, transmit or transceiver radio waves on one of a number of carrier frequencies. RF Modules are often used in consumer applications including wireless alarm systems, garage door openers, industrial remote controls, wireless home automation systems and smart sensor applications. Due to RF modules not requiring line-of-sight operation, they are often used instead of infrared remote controls. A module is a self-contained component of a system, which has a well defined interface to the other components. An RF module is a functional integration of semiconductor devices. In this project 2.4 GHz RF module is used to communicate between actual and artificial hand.

The nRF24L0+1 is a unique wireless solution for compact, battery operated applications with stringent requirements on battery lifetime and cost. The transceiver operates in the license free worldwide 2.4GHz ISM band. It is specifically designed for two types of application: PC peripherals and ultra low power applications such as sports and wellness sensors. For PC peripherals such as wireless mice, keyboards and media center remotes it enables high performance and long battery life at a low solution cost. For sensor applications the ultra low power consumption and advanced power

management enables battery lifetimes up to several years on a coin cell battery.

1) **Features**

    a)   Low cost single-chip 2.4GHz GFSK RF transceiver IC

    b)   Worldwide license-free 2.4GHz ISM band operation

    c)   1Mbps and 2Mbps on-air data-rate

    d)   Enhanced Shock Burst hardware protocol accelerator

    e)   Ultra low power consumption – months to years of battery lifetime

    f)   On-air compatible with all Nordic nRF24L Series in 1 and 2Mbps mode

    g)   On-air compatible with Nordic nRF24E and nRF240 Series in 1Mbps mode

2) **RF Transmitter**

Working voltage: 1.9 to 3.6 V
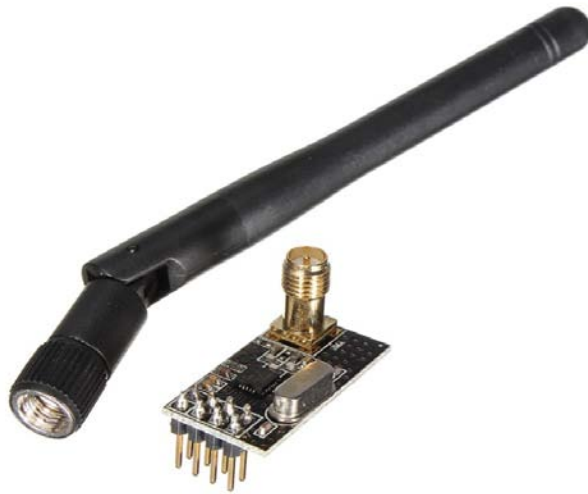
Working current: ≤ 14 mA

Working method: FSK

Working frequency: 2.4 GHz

Bandwidth: 1 - 2MHz

Operating temperature: -40 to +85 C

Range: 100 Ms

Pin Configuration

Vcc	-	1.9 – 3.6 V
GND	-	0 V
CE	-	Chip Enable
CSN	-	Chip select NOT
SCK	-	SPI
MOSI	-	Master Out slave In
MISO	-	Master Out slave out
IRQ	-	Interrupt request

3) **RF Receiver**

Working voltage: 5.0VDC

Working current:≤5.5mA max

Working method: OOK/ASK

Working frequency: 433.92MHz

Bandwidth: 2MHz

Sensitivity: excel –100dBm

Transmitting velocity: <9.6Kbps (egat 315MHz and -95dBm)

Pin Configuration

Vcc   -   1.9 – 3.6 V

GND -   0 V

CE   -   Chip Enable

CSN   -   Chip select NOT

SCK   -   SPI

MOSI -   Master Out slave In

MISO -   Master Out slave out

IRQ   -   Interrupt request

f. **Transistor**.   A transistor is a semi conductor device that is used to amplify or switch electronic signals and electrical power. It is composed of semiconductor material with at least three terminals for connection to an external circuit. A voltage or current applied to one pair of the transistor's terminals changes the current through another pair of terminals.
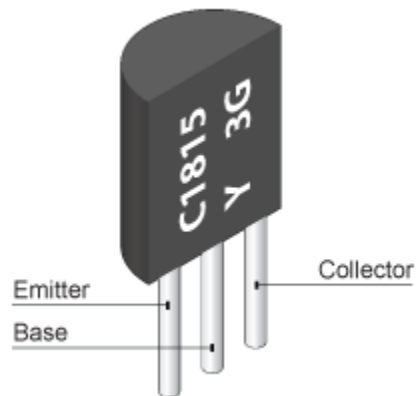
g. **Relay**. A relay is an electrically operated switch. Many relays use an electromagnet to mechanically operate a switch, but other operating principles are also used, such as solid-state relays. Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal.
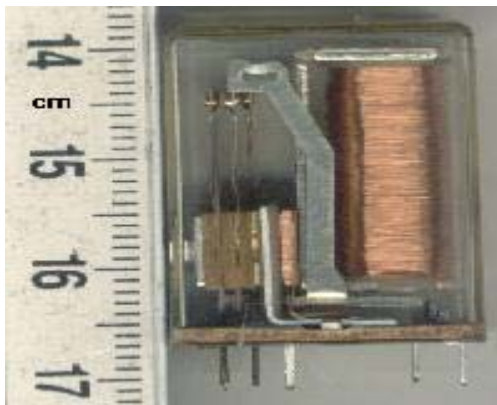
h. **Diode.** In electronics, a diode is a two-terminal electronic component that conducts primarily in one direction (asymmetric conductance); it has low (ideally zero) resistance to the flow of current in one direction, and high (ideally infinite) resistance in the other. A semiconductor diode, the most common type today, is

a crystalline piece of semiconductor material with a p–n junction connected to two electrical terminals.
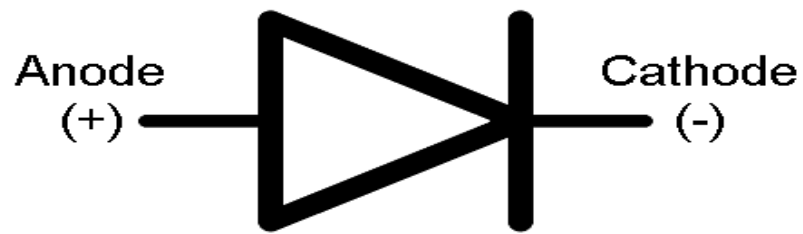
i. **Glove**.　　Normal glove for human hand and use for general purpose.

j. **Fibre sheet**.　　A flexible sheet which will connected with motor and will help in movement of the finger

k. **Robot structure**. Artificial structure of arm which will do the task by gesture of human hand.

CHAPTER 3

10.   **DESIGN AND DEVELOPMENT**

a.   **Human hand with Glove.**   This portion is designed with Glove on human hand which has flex resistors/ sensors on it. Here, when fingers are moved then flex sensors/ resistors convert the movement in voltage form which will be passed to controller (Arduino).

The Flex sensors/ resistor is analogue in nature and required to be converted in digital form before transmitting it from RF transmitter module, as RF module works on the principle of RS232. RF Tx module transmit it serially which is transmission bit by bit.
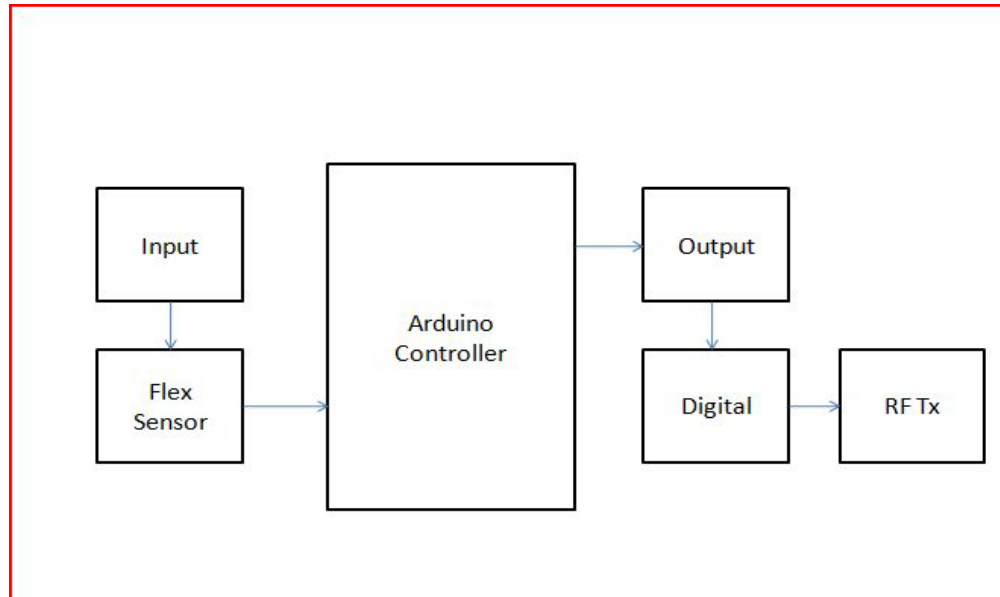
b.   **<u>Artificial Robotic Arm.</u>**   It main part of the project which receives indication from actual hand with glove and processes the signal first, after processing is done the processed signal control the motors to produce required movement as it was feed by actual hand for carrying necessary action from robot. The feed signal to robotic arm is mentioned in later part.

The Signal is received by RF Receiver, and the signal is digital in nature which then feed to Arduino controller for necessary processing, the processing in arduino will have mainly two reasons:

(1)   The mapping of signal at particular servomotor

(2)   The Segregation of signals
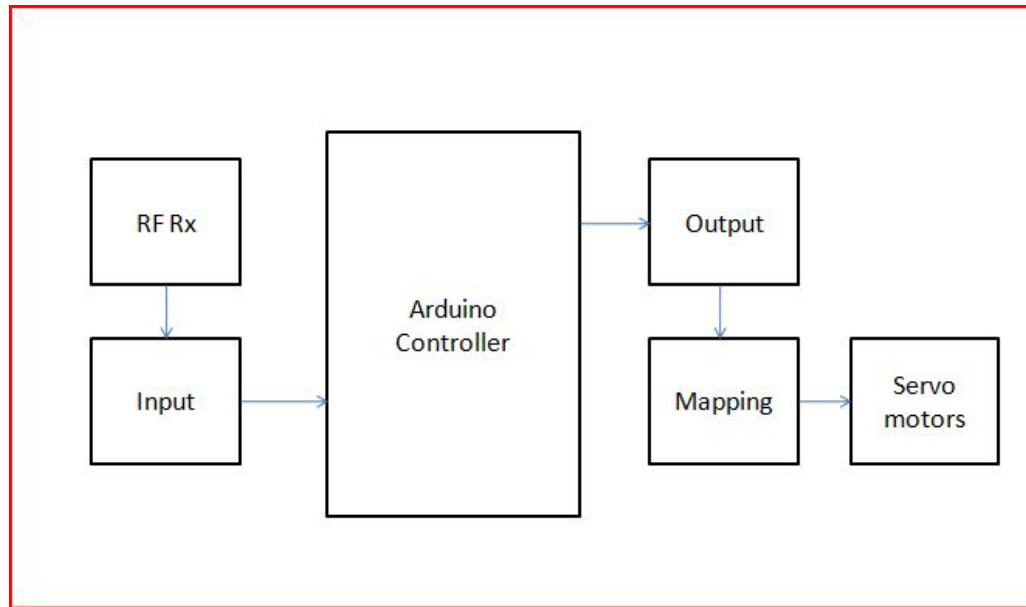
c.   **RF Module.** This is acting as a wireless medium for communicating with above mentioned human hand with glove and Artificial hand. By using RF module we can utilise the use of project in very efficient way as our robotic hand and glove can communicate at long distance upto 100 ms.
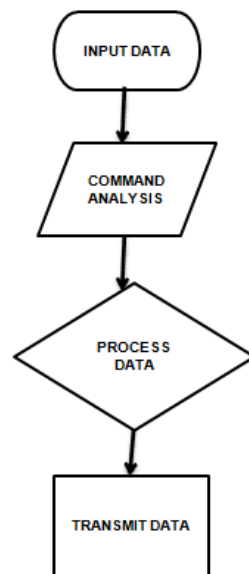

d.   **Algorithm and Code**. Final Algorithm of model is shown as below :

```
#include <SPI.h>
#include <nRF24L01.h>
#include <RF24.h>
#define CE_PIN  10
#define CSN_PIN 9
const uint64_t pipe = 0x1A2AALL;
RF24 radio(CE_PIN, CSN_PIN);
int Values[3];
int led=3;
const int rotory1 = A0;
const int rotory2 = A1;
const int flex   = A2;
void setup()
{
  Serial.begin(9600);
  radio.begin();
  radio.openWritingPipe(pipe);

  pinMode(rotory1, INPUT);
  pinMode(rotory2, INPUT);
  pinMode(flex ,  INPUT);
  pinMode(led ,  OUTPUT);
}
void loop()
{
  Values[0]= analogRead(rotory1);
  Values[1]= analogRead(rotory2);
  Values[2]= analogRead(flex);
  //digitalWrite(led,HIGH);
  //delay(2);
  //digitalWrite(led,LOW);
```

- //delay(2);
- radio.write(Values, sizeof(Values));
- }

ALGORITHM - TRANSMITTER

```
          ┌──────────────┐
          │  INPUT DATA   │
          └──────────────┘
                 │
                 ▼
          ╱──────────────╲
         │   COMMAND      │
         │   ANALYSIS     │
          ╲──────────────╱
                 │
                 ▼
            ╱─────────╲
           ╱  PROCESS  ╲
           ╲   DATA    ╱
            ╲─────────╱
                 │
                 ▼
          ┌──────────────┐
          │ TRANSMIT DATA │
          └──────────────┘
```

- #include <SPI.h>
- #include <nRF24L01.h>
- #include <RF24.h>
- #include <Servo.h>
- #define CE_PIN   8
- #define CSN_PIN   9
- const uint64_t pipe = 0x1A2AALL;
- Servo rotory;
- Servo flap;
- int count=0, led=6, IRsensor=0, Psensor=0, x=0;
- RF24 radio(CE_PIN, CSN_PIN);
- int Value[3];

```
int rotorypval=90;
int rotoryval=0;
int flappval=10;
int flapval=0;
void setup()
{
  Serial.begin(9600);
  radio.begin();
  radio.openReadingPipe(1,pipe);
  radio.startListening();
  rotory.attach(4);
  rotory.write(rotorypval);
  flap.attach(5);
  flap.write(flappval);
  pinMode(led, OUTPUT);
}
void loop()
{
  if(radio.available())
  {
    bool done = false;
    while (!done)
      {
       done = radio.read(Value, sizeof(Value));
      }
IRsensor=analogRead(A5);
    if (IRsensor<100)
      digitalWrite(led,HIGH);
    else
      digitalWrite(led,LOW);
    if (Value[1]!=rotorypval && Value[1]!=0)
```

- {
- rotoryval = map(Value[1], 0, 1011, 0, 180);
- rotory.write(rotoryval);
- rotorypval=Value[1];
- }
- Psensor = analogRead(A4);
- Serial.print(Value[0]/25);
- Serial.println();
- if (Value[2]!=flappval && Value[2]!=0)
- {
- x = 700-Value[2];
- flapval = map(x, 0, 1011, 0, 120);
- flap.write(flapval);
- flappval=Value[2];
- }
- }
- }

ALGORITHM - RECEIVER
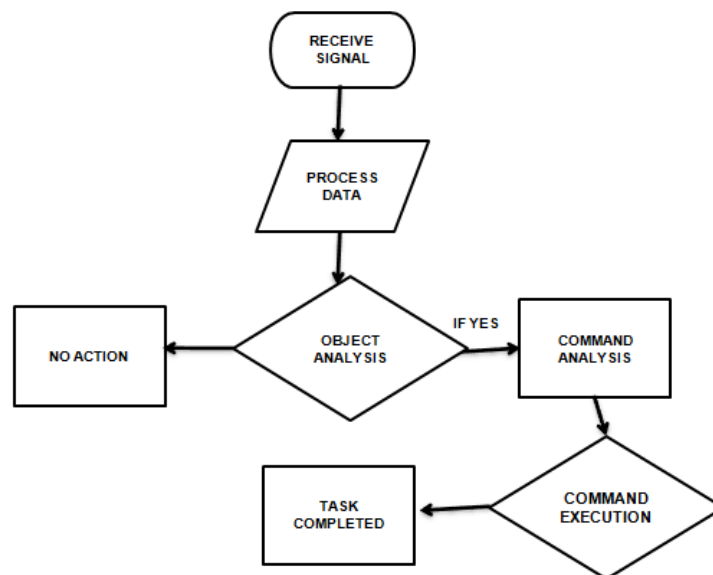
CHAPTER 4

11.   **FUTURE WORK.**   Following work is suggested for improvement in project/model:-

     a.   **Increasing Degree of freedom**.   Presently Arm has two degree of freedom which can be increased to three degree by incorporating a servo in robotic arm

     b.   **Multiple task Robot**.   Nature of task can be increased for getting maximum benefit out of product

     c.   **Multi Purpose Circuit**.   The circuit can also be used as multipurpose circuit, such as an emergency switch for shutdown of big power plant and Machines in natural/ artificial hazard by simply giving gesture wirelessly from large distance

CONCLUSION

12.   Controlling a robot arm, in real time, through the hand gestures is a novel approach. The technique using flex sensors proposed here has been tested and remarkable results were achieved. If this idea is implemented at higher level then can be of remarkable use for industry and disabled person with such a cheap solution.

13.   Researcher can work for wireless control of the robotic arm by employing some wireless application protocol. Then the robotic arm can be more efficiently employed

BIBLOGRAPHY

While carrying out our research, we came across few research papers that discussed implementation of Artificial hand . References are as under:
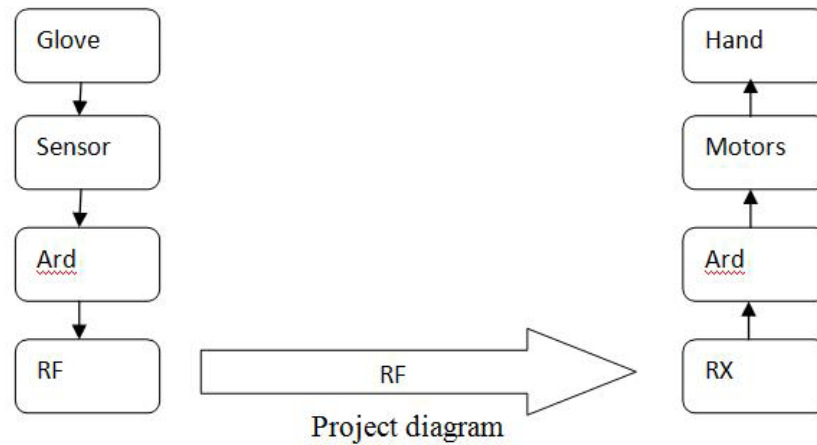
[1] Abidhusain Syed, ZamrrudTaj H. Agasbal, ThimmannagoudayMelligeri , BheemeshGudur,*Journal of Software Engineering and Applications*, 2012, 5, 364-366

[2] http://www.SciRP.org/journal/jsea

[3] R. Slyper and J. Hodgins, "Action Capture with Accel-erometers," Euro Graphics/A CMSIG GRAPHS Sympo- sium on Computer Animation, 2008.

[4] E. Foxl and L. Naimark, "Vis-Tracker: A Wearable Vi-sion-Inertial Self-Tracker," *IEEE Virtual Reality Confer-ence*, 22-26 March 2003, Los Angeles.

[5] M. Gross and D. James, "Eurographics/ACM SIGGRAPH Symposium on Computer Animation," *Smart Objects Con- ference SOC* '03, Grenoble, 2003.

[6] http://en.wikipedia.org/wiki/80c51

[7] http://en.wikipedia.org/wiki/Arduino

[8] Real-Time Robotic Hand Control Using Hand GesturesJagdishLalRaheja, RadheyShyam, G. ArunRajsekhar and P. Bhanu Prasad *Digital Systems Group, Central Electronics Engineering Research Institute (CEERI)/Council of Scientific & Industrial Research (CSIR), Pilani, Rajasthan India*

Hand Gesture Based Wireless Artificial Robotic Arm

Extended Title: Prototype for Gesture Based Wireless Artificial Robotic Arm

Brief Description of The Project / Thesis with Salient Specs: Our aim for this project is to design a Hand Gesture Based Robotic Hand for accomplishing multipurpose which can be very helpful for disabled people and Military use using it at distance.

There will be two parts of the project one will be the transmitter and other will be the artificial hand which will be controlled wirelessly using RF preferably.

```
Glove                                           Hand
  |                                               ^
  v                                               |
Sensor                                          Motors
  |                                               ^
  v                                               |
Ard                                             Ard
  |                                               ^
  v                                               |
RF          ========  RF  ======>               RX
                 Project diagram
```

Project diagram

Scope of Work : The scope of work of this project is :

(1) The basic study of the RF technology

(2) Requisite study about the Micro-Controller Programming

(3) Designing of circuitry

(4) To have thorough knowledge about the components used in the project

Academic Objectives :

The project will involve:

- Understanding of RF technology

- Comprehending and employing Microcontroller
- Exercising C++ programming

References.

[1] Becerra V.M., Cage, C.N.J., Harwin, W.S., Sharkey, P.M. Hardware retrofit and computed torque control of Puma 560 robot updating an industrial manipulator.IEEE Control Systems Magazine, 24(5): 78-82. 2004.

[2] Advance in Electronic and Electric Engineering, ISSN 2231-1297, Volume 3, Number 5 (2013), pp. 601-606, **Hand Gestures Remote Controlled Robotic Arm,** *M.S , Bharati Vidyapeeth College Of Engineering, New Delhi*

.

Application / End Goal Objectives : The Applications are as under:

Mine clearing in Field at distance

Usage for Disabled people

Industry

Previous Work Done on The Subject :

Following patent exist on the subject :

[1] R. Slyper and J. Hodgins, "Action Capture with Accel-erometers," Euro Graphics/A CMSIG GRAPHS Sympo- sium on Computer Animation, 2008.

[2] http://en.wikipedia.org/wiki/Arduino

Material Resources Required :

Controller (8051/Ardino)

RF

Flex sensors

Motors etc

Group Members:

Capt Ahsan Ali, Capt Altaf Wasif, Capt Mirza Usman

Special Skills Required :

Wireless Networks, Interfacing, C++ Programming, Handling of controller