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Robotic Hand Control using Hand Gesture Recognition for its Operational Behavior

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ABSTRACT-*This paper presents a real time hand gesture recognition for controlling robotic hand by merely changing the hand gestures. With the help of this technique one can pose a hand gesture in the range of a robot and corresponding to this notation, desired action is performed by the robotic system. The development and operation of a robotic hand, has been explained and controlled wirelessly with the help of hand gesture. Navigating and controlling a robot in an indoor and outdoor environment by using the range of body-worn sensor has becoming an increasing research area in robotics. In such scenario, hand gesture offers unique human-robot interaction inherent to nonverbal communication. Therefore, we used a sensor based system, worn by the user, along with Arduino and wireless module (RF Module) for communication with robot at some specific distance.*

Keywords- Hand gesture recognition; sensors; Robotics; RF module; Arduino.

1. INTRODUCTION

Robotics is a current emerging technology in the field of science. As robots move away from industrial settings and closer into our lives, the question arises how to interact with these robots. A large part of interaction occur through hand gestures [1]. In fact Interpretation of human gestures by a computer is used for human-machine interaction [2]. The main purpose of gesture recognition research is to identify a particular human gesture and convey information to the user pertaining to individual gesture. Overall aim is to make the machine understand human body language [3], thereby bridging the gap between machine and human. Hand gesture recognition can be used to enhance human–computer interaction without depending on traditional input devices such as keyboard and mouse.

Robotic hand can be controlled remotely by hand gestures. Research is being carried out in this area for a long time. Hand gestures are extensively used for telerobotic control and application [4].Robotic systems can be controlled naturally and intuitively with telerobotic technologies [5]. It is used in agriculture industry as there is reduction in the traditional human harvesters who want to take up other jobs which pays good income. (As in one part of the world, the robot revolution in agriculture sector I already in progress, in India it is a difficult story). According to the report in huffintonpost.in [6], 55% of total population in India depends on farming whereas in US its only 2% because of heavy mechanization of agriculture. Several approaches have been developed for sensing hand movements and controlling robotic hand. The robotic hand, operated and controlled wirelessly with the help of hand gesture transmits signals to the robot through an auto device fixed on the gloves which is to be put on hands rather than controlling it manually through a conventional remote. The five finger hand combined with its integrated wrist and forearm has fourteen independent degree of freedom [7].With growing interest in using robots to perform above tasks, design of anthropomorphic robotic hands, the end effectors of robots, with desired dexterity and output power has become the focus of recent robotic research [8].Glove based technique is a well-known means of recognizing hand gestures. The Robot moves and acts in the manner depending on the gestures made by the fingers and hand from a distance. The robot moves in up, down, left or right directions and picks up objects from one place and keeps at another desired place as directed by the movements of fingers and hand. It is a Type –C Robot, programmable, Servo controlled with either point to point or continuous trajections.

2. OBJECTIVE

Our Objective in the proposed system is to make the system cheap and simple, so that it would be mass produced and can be used for various purposes. It will help to reduce human effort in controlling robotic systems using remotes and thereby providing a better and maximum efficiency at the output.

3. METHODOLOGY

Proposed methodology aims to build a robotic hand which efficiently translate the hand gestures into the movement of robotic hand (made of any material). Movement of hand in the specified direction will transmit a command to the robot which will then move in a specific direction. Proposed technique to control robotic hand using hand gesture is divided into 2 subparts:

- Transmitter section
- Receiving section

Figure 1 shows the flow diagram of the whole system, i.e. performing hand gesture identification and robot control. On the basis of the gesture identified, the robotic hand shows the same gestures as performed by the hand.

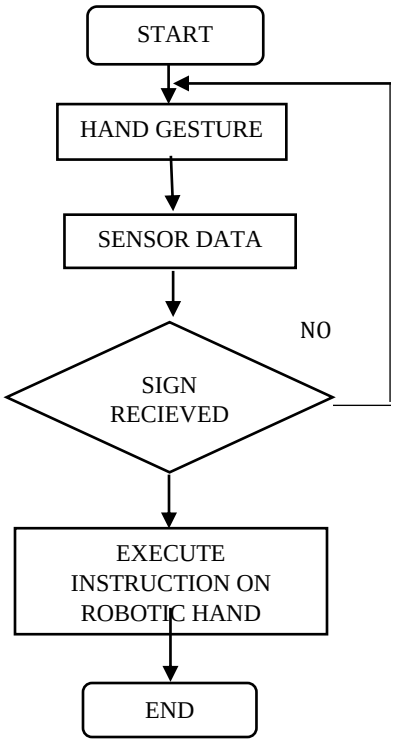

FIGURE 1. Flow diagram for robot system

The Transmitting section consists of one Arduino Nano, 7 flex sensors and one RF transmitter module. The Receiver section consists of Arduino Mega, 8 Servo Motors and one RF Receiving module. Here we will require two 5V power supplies which will be applied to both sections. The Arduino Nano will read the analog output values from the flex sensors and convert the analog values into digital values. The digital values will be processed by the Arduino Nano and will be sent to the RF transmitter which is received by the Receiver and will be processed at the receiver end which drives the motor to the particular direction. Figure 2 shows the whole system block diagram for controlling robotic hand wirelessly.

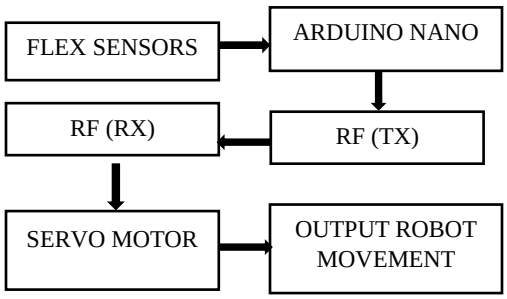

FIGURE 2. Block diagram for robot system

3.1 Robotic Glove

Robotic glove holds the circuitry which controls the robotic hand. It consists of Arduino Nano which is programmed in such a way that it transfers the required data with the help of a transmitter Module. At the same time the Flex sensor is doing its job by sending the degree of movement of the finger to the Arduino Nano. The processed values are then transmitted from the Module (NRF Transmitter) to the robotic hand. The module takes the feedback from the hand and sends the new processed signals to it.

3.2 Robotic Hand

It is the main part where implementation of the program from the robotic glove takes place. It consists of total of 8 Servos, connected in such a way that it provides **3 DOF's** (Degrees of Freedom) to the system. A microcontroller Arduino Mega inputs the values from the module and sends the data accordingly to the servos. Both the circuitry and base are clipped upon the common base, broad and thick enough to improve the stability. 5 servos are attached for controlling the movement of fingers. Two more servos are for wrist movements and therefore to control the overall movement of hand one servo is attached to the base. As mentioned above, the robotic hand mimics the movement of glove worn by the user, when the glove is tilted in the forward direction or any such direction, the arm spontaneously follows the suit.

4. HARDWARE REQUIREMENTS

Proposed project consists of following parts**:**

4.1 Transmitting End (Robotic Glove)

It contains the following modules:

- Arduino Nano
- NRF 24L01 Transmitter Module
- Flex Sensors

4.2 Receiving End (Robotic Arm)

- Arduino Mega
- NRF 24L01 Receiver Module
- Servo Motors

The construction is explained in various steps as follows:

STEP 1: Arduino

Arduino refers to an open source electronic platform or board which is designed to make electronics more easily accessible. It can be purchased, preassembled or because the hardware design is open source, built by hand. An Arduino board generally consists of an *Atmel* 8, 16 or 32-bit AVR microcontroller (although since 2015 other makers' microcontrollers have been used) with complementary components that facilitate programming and incorporation into other circuits.

Two microcontroller boards were taken as per requirement for the project:

Arduino Mega:

It consists Atmega AVR 2560 R3 micro controller. It has 54 digital Output/Input pins (of which 15 pins can be used as PWM signals), 16 analog inputs, 4 UART (hardware serial port), a 16 MHz oscillator. Opening voltage of the microcontroller is 5V.

Arduino Nano:

The Arduino Nano is a small, complete, and breadboard-friendly board based on the ATmega328 (Arduino Nano 3.x) or ATmega168 (Arduino Nano 2.x). It has more or less the same functionality of the Arduino Duemilanove, but in a different package. It lacks only a DC power jack, and works with a Mini-B USB cable instead of a standard one. It has 14 digital Output/Input pins (of which 6 pins can be used a PWM signals), 8 analog inputs.

STEP2: SENSORS

Sensor plays an important role in Robotics. Sensors are used to determine the current state of the system. Robotic applications demand sensors with high degrees of repeatability, precision and reliability. Flex sensor is such a device which accomplish the above task with great degree of accuracy. The pick and place operation of the robotic arm can be efficiently controlled using flex sensors via microcontroller programming.

Flex Sensor:

A simple flex sensor is 2.2" in length. As the sensor is flexed, the resistance across the sensor increases. The resistance of the flex sensor changes when the metal pads are on the outside of the bend (text on inside of bend). Connector is 0.1" spaced and bread board friendly. It should refrain from flexing or straining this sensor at the base. The usable range of the sensor can be flexed without a problem, but care should be taken to minimize flexing outside of the usable range. For best results, securely mount base and bottom portion and only allow the actual flex sensor to flex. The value of resistances on bending the flex sensors are tabulated as shown in Table 1. This resistance was further calibrated and converted into angles which was then used for the grabbing purpose in the Robotic Arm.

Table 1. Values of resistance as per degree bends**.**

BEND	RESISTANCE
0 Degree	9000 ohms
90 Degree	14000 ohms
180 Degree	22000 ohms

STEP3: SERVO MOTORS

A servo motor is a simple electrical motor, controlled with the help of servo mechanism. It is rotatory actuator or linear actuator, that allows for precise control of linear and angular position, velocity and acceleration. Thus, a servo is a mechanical motorized device that can be instructed to move the output shaft attached to a servo wheel or arm to a specified position. Inside the servo box is a DC motor mechanically linked to a position feedback potentiometer, gearbox, electronic feedback control loop circuitry and motor drive electronic circuit. If the motor as controlled device, associated with servo mechanism is DC motor, then it's commonly known DC Servo Motor. If the controlled motor is operated by AC, it is called AC Servo Motor. Thus, Servo Motor is a special type of motor which is automatically operated up to certain limit for a given command with the help of error-sensing feedback to correct the performance. The three electrical connection wires out of the side are V- (Ground), V+ (Plus voltage) and S Control (Signal). The control S (Signal) wire receives Pulse Width Modulation (PWM) signals sent from an external controller and is converted by the servo on board circuitry to operate the servo. A Servo motor can usually turn 90 degree in either directions, for a total of 180 degree. The figure 3. Shows standard servo motor with its x-ray view.

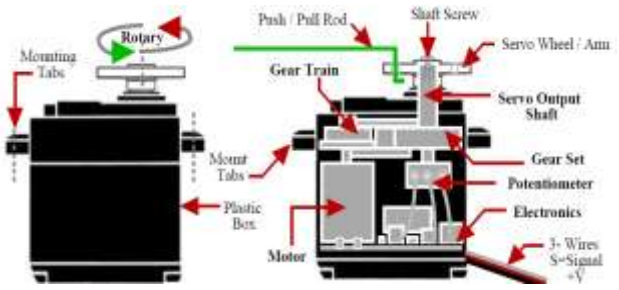

Figure 3. Standard servo motor with x-ray view

STEP4: RF MODULE

To get the most out of the system, it is better to transfer data wirelessly. This was done with the help of RF module communication between Robotic arm and glove. RF stands for Radio Frequency. This module further consists of two parts: Transmitter (TX) and Receiver (RX).The nRF24L01+ (nRF24L01p) is a single chip 2.4GHz transceiver with an embedded baseband protocol engine (Enhanced ShockBurst™), suitable for ultralow power wireless applications. The nRF24L01+ is designed for operation in the world wide ISM frequency band at 2.400- 2.4835GHz with an operating range of 400-500 meters. To design a radio system with the nRF24L01+, we simply need an MCU (microcontroller) and a few external passive components. The high air data rate combined with two power saving modes make the nRF24L01+ very suitable for ultralow power designs. NRF24L01+ is drop-in compatible with nRF24L01 and on-air compatible with nRF2401A, nRF2402, nRF24E1 and nRF24E2.It has high sensitivity and strong interference circumstances. Figure 4 shows the Pin configuration of nrf24L01

Figure 4. Pin configuration nrf24L01

The functions of various pins are given as:

VCC: 3.3V

GND: Ground

CE: Digital Input. Chip Enable Activates RX or TX mode. Need a resistor about 500Ω in series when connecting to Arduino board.

CSN: Digital Input. SPI Chip Select. Connecting with Digital pin 10 of Arduino board through a resistor about 500Ωin series.

SCK: Digital Input. SPI Clock. Connecting with Digital pin 13 of Arduino board through a resistor about 500Ωin series.

MOSI: Digital Input. SPI Slave Data Input. Connecting with Digital pin 11 of Arduino board through a resistor about 500Ω in series.

MISO: Digital Output. SPI Slave Data Output. Connecting with Digital pin 12 of Arduino board.

IRQ: Digital Output, Maskable interrupt pin, Active low.

STEP4: Robotic Hand Mechanism

It's a basic robotic hand mounted on the surface controlled with the help of Arduino development board .Each joint of the robotic hand is connected to the servo motors used to control the movement of joints. 5 servos for finger movement, 2 servos for wrist movement and 1 servo motor to control the rotation of the robotic hand.

5. SOFTWARE REQUIREMENT

Arduino programs may be written in any programming language with a compiler that produces binary machine code. Atmel provides a development environment for their microcontrollers, AVR Studio and the newer Atmel Studio.
The Arduino project provides the Arduino integrated development environment (IDE), which is a cross-platform application written in Java. It originated from the IDE for the Processing programming language project and the Wiring project. It is designed to introduce programming to artists and other newcomers unfamiliar with software development. It includes a code editor with features such as syntax highlighting, brace matching, and automatic indentation, and provides simple one-click mechanism for compiling and loading programs to an Arduino board. A program written with the IDE for Arduino is called a "sketch".

The Arduino IDE supports the C and C++ programming languages using special rules of code organization. The Arduino IDE supplies a software library called "Wiring" from the Wiring project, which provides many common input and output procedures. A typical Arduino C/C++ sketch consists of two functions that are compiled and linked with a program stub main () into an executable cyclic program:

- setup(): a function that runs once at the start of a program and that can initialize settings.
- loop(): a function called repeatedly until the board powers off.

After compilation and linking with the GNU tool chain, also included with the IDE distribution, the Arduino IDE employs the program avrdude to convert the executable code into a text file in hexadecimal coding that is loaded into the Arduino board by a loader program in the board's firmware.

6. APPLICATIONS

The Robotic Hand finds its wide applications in various fields such as:

- It can be used in Industrial jobs such as in Painting shops, shot blasting chambers, etc., where the atmosphere is dusty and harmful for humans. The operator controls the robotic functions from outside the hazardous chambers looking through a glass door.
- It helps in automatic picking of small objects moving on a conveyor belt and placing them at their desired locations in manufacturing industries like Cosmetics, Food Products, and Medicines etc.
- It can be used in automatic metal cutting machines, located in high temperature zones.
- Robots controlled cranes, lifting objects etc. operated from a distance with hands/finger controlled remote systems.
- It can be used in surveillance purpose, by attaching a camera on the robotic system.
- It can be used in agriculture industry to automate or semi-automate labour intensive work. They can help in weeding, harvesting, spraying fertilizers etc.

7. CONCLUSION

The aim of our proposed system is to construct a sensor based Hand Gesture Controlled Robot. It can be moved in any direction by making simple gestures. This becomes an example of companionship between man and machine further enhancing the technology to next level from wired connections and speech recognitions to wireless hand gesture control technology. After studied on this system we can conclude when user movements his hand in Left, Right, Down, Up then flex sensors will detect the variation and send the particular signal to Arduino board and that signal will be sent to the receiver part of the system with the help of RF module and then on the basis of transmitted signal robot will move. This system will not only provide convenience to the common man in handling things more easily but also will be a boom for physically handicapped and disabled peoples. Hence, we conclude that our system will be very cheap and simple with wide applications as mentioned before.

8. FUTURE WORK

Future work will build upon the improvement for correctly recognizing the more complex gestures and precise movement of robots. One approach might be implementation of gyroscope into the system, in order to separate the acceleration due to gravity from the inertial acceleration other approach might install a GPS in the

system in order to track the position of robot. The use of more servos is another possibility.

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