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DESIGN AND MANUFACTURING OF PROSTHETIC ARM

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ABSTRACT

A robotic arm is a type of mechanical arm, usually programmable, with similar function to a human arm.

A set of design requirements was formulated and adhered to for the remainder of the project. The design process began withbrainstorming followed by rough pencil sketches and finally detailed computer aided design work using Solidworks CAD software. As the mechanical design progressed, both electrical and mechanical components were sourced and integrated into the design.The physical structure of hand has been modelled such that it can be easily assembled. It has been simplified such that it has six degrees of freedom while retaining some of the important motions of the human hand that a two finger model has been constructed this model exhibit the full range of motion required to grip an object with some degrees of force A robot mechanism is a multi-body system with the multiple bodies connected together. We begin by treating each body as rigid, ignoring elasticity and any deformations caused by large load conditions. Each rigid body involved in a robot mechanism is called a link, and a combination of links is referred to as a linkage. In describing a linkage it is fundamental to represent how a pair of links is connected to each other Joint primitives and serial linkages, Analogous to coordinate systems, Parallel linkages. If multifunctional control of prosthesis is to be achieved then physicians and surgeons need to perform innovative procedures that can be coupled with the novel components and controllers that engineers and prosthesis create

INTRODUCTION

Human gestures are undoubtedly natural. They may often prove more efficient and powerful as compared to various other modes of interaction. The gestures are communicative, meaningful body motions- i.e. physical movement of the fingers, hands, arms, head, face, or body with the objective to convey information or interact with the environment. In our work gesture recognition has been proposed to understand the action of a hand. To increase the use of robots where conditions are not certain such as fire Fighting or rescue operation we can make robots which follows the instruction of human operator and perform the task, in this way decisions are taken according to the working condition by the operator and task is performed by the robots. Thus we can use these robots to perform those tasks that may be harmful for human beings [1]

BASIC BLOCK DIAGRAM

The user wears a glove with flex sensor the gesture made by the user is sensed by flex sensor and is given at the microcontroller. This occurs at the transmitter end. The microcontroller processes these signals and encodes it. These signals are transmitted to the receiver end. At the receiver end,

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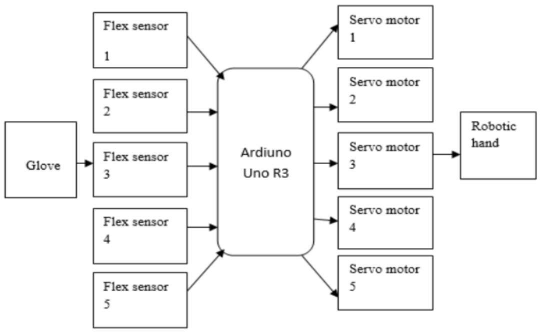
the received signal is decoded in the required form and makes the motor run. The basic block diagram of the project as shown in the Figure below

The block diagram in Figurebelow presents an overview of the entire project

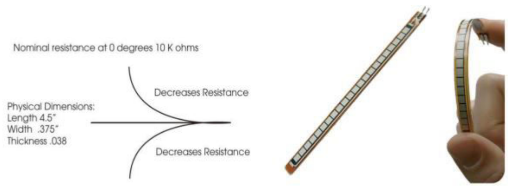


The project is divided into five major subprojects as follows:

- **Glove Design** device are connected through wired connection.
- **Sensor Feedback System** Flex sensors are used to provide feedback to the user on alignment, position and collision detection.
- **Microcontroller Programming** The microcontroller takes input from the sensor feedback system and generates an appropriate control signals for automated control of the robotic hand. The design and implementation of a sensor-based glove system that can be worn by the user and comfortably provide stable and accurate control of the robotic hand.
- **Servo Motor Data Signal Circuits** These circuits take input from the glove sensors and generate appropriate motor control signals based on those inputs.
- **Wired Communication** The robotic hand and gesture

MAIN PARTS OF PROSTHETIC ARM FLEX SENSOR

A simple flex sensor is 4.5" in length. As the sensor is bent, the resistance across the sensor increases. Flex sensors are sensors that change in resistance depending on the amount of the bend on the sensor. They are often used in gloves to sense finger movement. Flex sensors are simple in construction. As shown in Figure 3.1.1.1. they convert the change in bend to electrical resistance the more the bend, the more the resistance value. They are usually in the form of thin strip 1 -5 long that vary in resistance. They can be made unidirectional or bi-directional.



Flex sensors are passive resistive devices that can be used to detect bending or flexing. The flex sensor shown in this Figure 3.1.1.2. is a bi-directional flex sensor that decreases its resistance in proportion to the amount it is bent in either direction The sensor we are building is about 3/8" wide by 5" long. The ranges of the flexsensor are 10kΩ to 40kΩ. The Flex sensor offers variable resistance readings, resistance for the un-flexed is 10kΩ and for the flexed the resistance is 40kΩ. Flex sensors are analogue resistors. They work as variable analogue voltage dividers. The flex sensor

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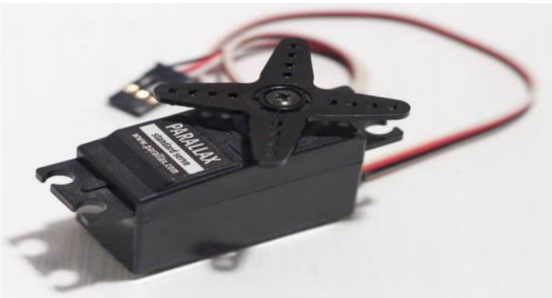
shown in Figure 3.1.1.2. is the unidirectional. Flex sensor is a unique component that changes resistance when flexed. Flex sensor is bent in one direction the resistance gradually increases.

ARDUINO

The only Uno is the latest version after the duemilanove, with an improved USB interface chip. Like the Duemilanove , it not only has an expended shield header with a 3.3V reference and a RESET pin(which solves the problem of how to get to the RESET pin in shield) and a 500□fuse to protect your computer's USB port, but also an automatic circuit to select USB or DC power without a jumper. The Uno is pin and code compatible with the duemilanove, diecimilla and older Arduino's your entire shield, libraries, code will still work. The new R3 (3rd revision) of the UNO has a few minor updates, with an upgrade to the USB interface chip and additional breakouts for the i2c pins and an I/O Ref pin [2].

SERVO MOTOR

Servo refers to an error sensing feedback control which is used to correct the performance of a system. A servo motor consists of three major parts: a motor, control board, and potentiometer (variable resistor) connected to output shaft. The motor utilizes a set of gears to rotate the potentiometer and the output shaft at the same time. The potentiometer, which controls the angle of the servo motor, allows the control circuitry to monitor the current angle of the servo motor. The motor, through a series of gears, turns the output shaft and the potentiometer simultaneously. The potentiometer is fed into the servo control circuit and when the control circuit detects that the position is correct, it stops the servo motor. If the control circuit detects that the angle is not correct, it will turn the servo motor in the right direction until the angle is correct. 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 90° to 180°. But servos do not rotate continually. Their rotation is restricted in between the fixed angles. Servo motors are shown in Figure 3.3.1.1 and Figure 3.3.1.2.



Servo motors have been around for a long time and are utilized in many applications. They are small in size but pack a big punch and are very energyefficient. Because of These features, they can be used to operate remote-controlled or radio-controlled toy cars, robots and airplanes as shown Figure 3.3.1.2. Servo motors are used in industrial applications. Servos are extremely useful in robotics and automation. Servo motors are used across various automation fields specifically where the motor must be able to operate at a range of speeds without overheating, operate at zero speed while being able to retain its load in a set position, as well as operate at low speeds. Robots utilize servo motors because of their smooth commutation and accurate positioning. The aerospace industry makes use of servo motors in their hydraulic

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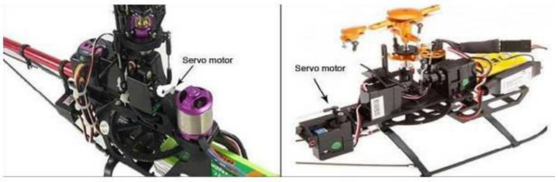
systems to contain system hydraulic fluid. The servo motor is relatively small in size, yet very powerful. The Servos are used for precision positioning. They are used in robotic arms and legs, sensor scanners and in RC toys like RC helicopter shown in Figure 3.3.1.2. airplanes and cars as shown in Figure 3.3.1.2.



THE GLOVE

First glove like device (cloth) onto which numerous touches bend and inertial sensors were sewn. Measured flexure, hand orientation and wrist-position, and hand tactile sensors are at fingertips. Orientation of hand tracked by video camera required clear line of sight observation for the glove to function. Finger flex sensors, tactile sensor at the fingertips, orientation sensing and wrist positioning sensors, position of sensors were changeable.

WHY USE A GLOVE DEVICE

Traditional data input device has a limited range of the amount of data they can input at a given time because they are limited to one, two or three degrees of freedom. Degrees of freedom are measure of the number of position of which the device can be read as inputting a different data values. Gloves offer for superior data input potential since they provide multiple degrees of freedom for each finger and the hand as a whole. By taking orientation of fingers and relative position of hand, glove devices can track an enormous variety of gestures each of which corresponds to a different type of data entry. This gives the glove remarkably rich expressive power, which can be used in the inputting of extremely complicated data as shown in the Figure 2.4.2.1 .

PROSTHETIC ARM=

The first robotic hand was developed in the 1950s by a scientist named George Devil, Jr., before which robotics were largely the product of science fiction and the imagination. The development of robotics was slow for a while, with many of the most useful applications being involved with space exploration. The use of robots toaid in industrialization weren’t fully realized until the 1980s, when robotic hand began to be integrated in automobile and other manufacturing assembly lines.

ROBOTIC HAND

A robotic hand can be any of a number of mechanical, programmable devices that are designed to manipulate objects in a way that is similar to the human hand. The robotic hand is one of the most useful pieces of technology to be introduced in the 20th century, and quickly became a cornerstone in many areas of manufacturing. It can be used for many different jobs and functions that may be too tedious, difficult or dangerous for a human to do. You might first think of the automobile industry when thinking about robotic hand, but they can be used for many other useful tasks besides welding and painting auto parts.

Robot hand can still have a much wider range of motion since their design can be purely up to the imagination of their creator. The joint that connects the segments of a robotic hand, for example, can rotate as well as moving like a hinge. The end of the robotic hand designed to actually do the work that it was designed for is known as the end effector, and can be designed for practically any task, for example gripping like a hand, painting, tightening screws and more. These robots can be fixed in one place, for example along an assembly line, or they can be mobile so they can be transported to do a variety of tasks in different places.

Autonomous robotic hand is designed to be programmed and then left alone to repeat their tasks independent of human control. Conversely, a robotic hand can also be designed to be operated and controlled by a human being. A situation where human-controlled robotic hand are essential is in space exploration, where robotic hand can be used to manipulate a heavy payload or do other work in space that would be difficult or even impossible for an astronaut to do.

The hand itself is only responsible for positioning. An end effecter is necessary for actual environmental interaction. Some common choices are grippers, sprayers, grinders, welders, and vacuums, though many other options are available. There is a large variance in complexity, ranging from flush mounted, non-moving parts (magnets or sticky pads) to multi-jointed, multi-sensor parts with various inputs and outputs. End effectors are typically chosen based upon the application, and many hands will fit multiple end effectors.

DESIGN DETAIL

DESIGN METHOD

The basic components of the glove are the hand itself, the servos, the Arduino, the glove and the flex sensors. The glove is mounted with flex sensors variable resistors that change their value when bent they're attached to one side of voltage divider with resistor of a constant value on the other side. The Arduino reads the voltage change when the sensors are bent, and triggers the servos to move a proportional amount.

MECHANICAL DESIGN AIM

The aim is to design a Five-fingered Humanoid hand using Solid works software Specification is taken from actual human hand because this is a Biology inspired technology- project and innovative in nature. The design specification must be practical considering the shape and the assembly properties of the hand

TASK SPECIFICATION

• The hand shall be able to grasp objects of smaller diameter, irrespective of height. That means the hand has to perform grasp.

• The hand shall be able to template the Gestures of Human hand operating the sensor Glove.

• The hand shall also be able to operate with Servo motor placed at distance of100mm-300mm from the Figure tip.

• The hand shall be able to press a button.

DESIGN SPECIFICATIONS

• The Hand shall house all actuators, control board and cab.

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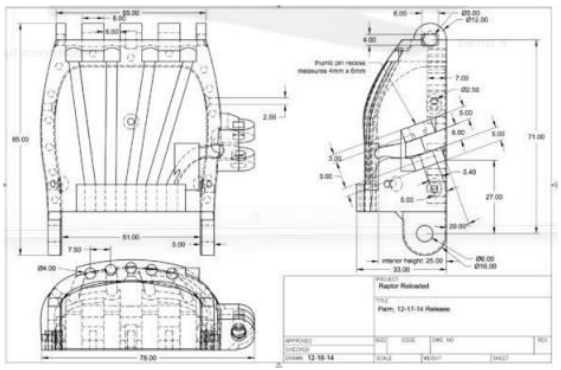
• The dimensions and the shape of the palm (hand) shall be close to a human hand.

• The hand shall also be able to operate with Servo motor placed at distance of 100mm-300mm from the Figure tip.

• The hand shall be easier to assemble.

• The Hand must be attractive in looks to the customers with good aesthetic features.

PERFORMANCE SPECIFICATIONS



2D DESIGN OF PROSTHETIC HAND

SOLIDWORKS

Solid Works is a 3D mechanical CAD (computer-aided design) program that runs on Microsoft Windows and is being developed by Dassault Systems Solid Works Corporation

MODELING METHODOLOGY

Solid Works is a Para solid-based solid modeler, and utilizes a parametric feature-based approach to create models and assemblies.

Parameters refer to constraints whose values determine the shape or geometry of the model or assert.] y. Parameters can be either numeric parameters, such as line lengths or circle diameters, or geometric parameters, such as tangent, parallel, concentric, horizontal or vertical., etc. Numeric parameters can be associated with each other through the use of relations, which allow them to capture design intent.

In an assembly, the analog to sketch relations are mates. just as sketch relations define conditions such as tangency, parallelism, and concentricity with respect to sketch geometry, assembly mates define equivalent relations with respect to the individual parts or components, allowing the easy construction of assemblies. Solid Works also includes addition. advanced mating features such as gear and cam follower mates, which allowed modeled gear assemblies to accurately reproduce the rotational movement of an actual. gear train.

The drawings can be created either from pans or assemblies. Views are automatically generated from the solid model, and notes, dimensions and tolerances can then be easily added to the drawing as needed. The drawing module includes most paper sizes and standards (ANSI, ISO, DIN, GOST, .11S, BSI and SAC).

PART MODELING

This module produces parts easily and rapidly by creating features such as extrudes, revolves, thin features, lofts, sweeps, advanced shelling, feature patterns and holes. The 3D part is basic building block of the SOLIDWOR KS mechanical designing software. In solid works the part can be designed by sketching its component shapes and defining their size, shape and inter relationships. By successfully creating their shapes, ca. features, the pan can be constructed.

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STEPS INVOLVED IN MODELLING PROCESS:

- Plan the part
- Create the base feature
- Create the remaining feature
- Analyse the part
- Modify the features as necessary

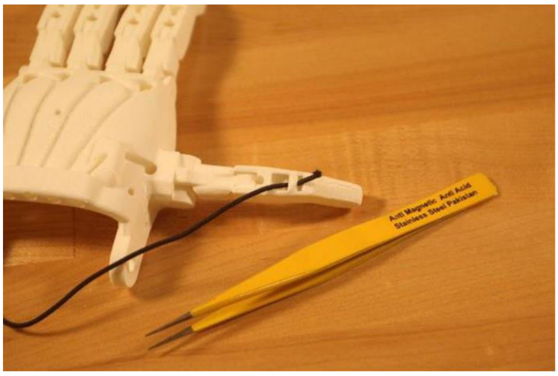
FINGER AND END CAP

Fingers are designed to act like spring once released from bend position they must return to their original extended shape. The lines from the Servo motor horn is directly tied through the centre hole in the End cap.

ASSEMBLY MODELING:

Assembly design gives a user the ability to design with user controlled associability. Solid Works builds these individual parts and the sub-assemblies into assembly in a hierarchical manner. This is based on the relationships defined by the constraints.

Solid Works assembly design reference parts din:01y and maintains relationships when creating new parts. In the assembly module, physical simulation and mechanical interaction between the parts can be performed and potential design flaws can be avoided.



Circuit design

The flex sensors require a circuit in order for them to be compatible with Arduino. It's a voltage divider: the flex sensors are variable resistors, and when paired with resistors of a static value, change in resistance (in this case bending the sensor) can be sensed through the change in voltage between the resistors. This can be measured by the Arduino through its analog inputs. The schematic is attached (red is positive voltage, black is negative, and blue goes to the Arduino). The resistors in the photo are 22KΩ. I color-coded the wires I used in the same way as the schematic, so you can see more easilyThe main GND wire is connected to all the individual GND wires from the sensors gets plugged into the Arduino’s GND. The +5V from wire, and each blue wire gets plugged into a separate analog input pin.

SEW THE GLOVE

After making the flex sensor circuit the next part of the project is sew the glove, first of all take the needle and thread, and mount the sensor and circuit onto the glove itself, drill the tiny hole in the plastic of the sensor(at the top, once the resistive material has ended). Be sure does not hit the resistive material then put on the glove and pull it tightly in

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the hand, on each finger, with a pencil or pen, make small lines over the tops of each joint. This tells where to sew the sensors, sew each sensor tip to the area of each finger just above where is each fingernail.

CIRCUIT OF PROJECT

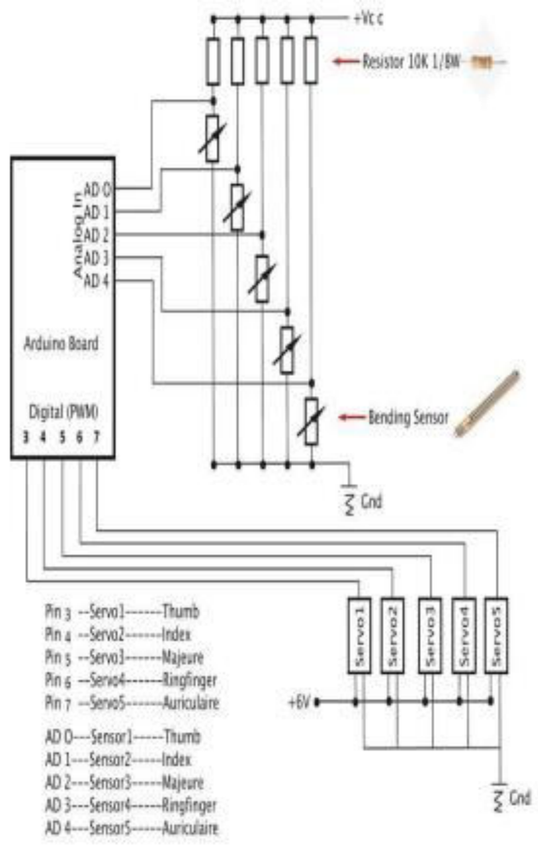
In our project we have used 5V for Arduino and same current used from Arduino to flex sensors. For Servo Motors we used extra Power from battery then we used circuit to connect Sensors and Motors to Arduino. Circuit is designed in a very compact manner, so that no or less wires are used and shown with 100% portability.

First of all we connected 5V and passed it through resistor of 22k and then attached analog Signal Sender wire on one side connected to flex sensor and on other side ground. In similar way, all 5 sensors are connected to Arduino. Analogue Reading is attached from pins A0 - A4 with each of 5 sensors.

Servo Motors are then attached to power and ground through battery and each of them are connected to digital pins from 3-7.

Flex Sensors send analog input to Arduino then Arduino converts them to digital reading and sends these readings to digital pins which make Servo Motors to move as Human Fingers move.

But this all hardware work does not make the system functional until it needs some sort of instructions to do so; we made a program and uploaded it. Program is shown below Figure 4.2.1.



PROGRAM

<--- Start of Program --->

#include<servo.h>//including library file for servo motors.

Servo myservo;//variables defined for servo motors 1 -5

Servo myservo1;

Servo myservo2;

Servo myservo3;

Servo myservo4;

/ /Setup of serial for sensors. Setup to attach digital pins to each servo motor.

Void setup(){

Serial.begin(600);

myservo.attach(7);

myservo1.attach(4);

myservo2.attach(5);

```
myservo3.attach(4);
myservo4.attach(3);}
//This area read again and by arduino unless detached from power. void loop(){
intflexsensorReading = analogRead(A4);// variables defined to take reading from sensors.
int flexsensorReading1=analogRead(A3);
int flexsensorReading2=analogRead(A2);
int flexsensorReading3=analogRead(A1);
int flexsensorReading4=analogRead(A0);
// Map readings first e.g. (sensor Reading, from low,from high, to low, to high);.
intval = map(flexsensorReading, 500, 1000, 0, 1000 );
intval = map(flexsensorReading1, 512, 1000, 0, 1023);
intval = map(flexsensorReading2, 512, 100, 0, 1023);
intval = map(flexsensorReading3, 512, 1000, 0, 1023);
intval = map(flexsensorReading4, 512, 1000, 0, 1023);
//Final step is to send readings to digital pins for servo motors to move.
myservo.write(val);
myservo1.write(val1);
myservo2.write(val2);
myservo3.write(val3);
myservo4.write(val4);}
```

<--- End of Program --->

3D PRINTING OF PROSTHETIC ARM

A method of manufacturing known as 'Additive manufacturing', due to the fact that instead of removing material to create a part, the process adds material in successive patterns to create the desired shape.

Main areas of use:

- Prototyping
- Specialized parts – aerospace, military, biomedical engineering, dental
- Hobbies and home use
- Future applications– medical (body parts), buildings and cars 3D Printing uses software that slices the 3D model into layers (0.01mm thick or less in most cases). Each layer is then traced onto the build plate by the printer, once the pattern is completed, the build plate is lowered and the next layer is added on top of theprevious one. Typical manufacturing techniques are known as 'SubtractiveManufacturing' because the process is one of removing material from a preformed block. Processes such as Milling and Cutting are subtractive manufacturing techniques. This type of process creates a lot of waste since; the material that is cut off generally cannot be used for anything else and is simply sent out as scrap. 3D Printing eliminates such waste since the material is placed in the location that it is needed only, the rest will be left out as empty space. Domain Group 3D Printing Workshop Notes 2 Proto+ Created by Lee Bullock Advantages and Limitations: Layer by layer production allows for much greater flexibility and creativity in the design process. No longer do designers have to design for manufacture, but instead they can create a part that is lighter and stronger by means of better design. Parts can be completely re-designed so that they are stronger in the areas that they need to be and lighter overall.

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CONCLUSION

The overall system performs reasonably well. The user is able to carry out comfortable and precise functions of the robotic Hand through the use of a sensor based control glove. Furthermore, the robotic Hand is capable to carry normal routine function as human hand does. The microcontroller accepts inputs from the sensor and generates the proper control signals based on those inputs. The lift-capacity of the servo motors on the robotic Hand is limited. Replacement of the current servos with a higher torque model would allow a complete range of motion when manipulating heavier objects. The usable lifetime of the flex sensors seems to be limited. The sensors themselves are very fragile and easily wear out from overuse. Careful maintenance and protection of the flex sensors is crucial to successful operation of the system.

REFRENCES

[1] www.sparkfun.com

[2] www.ciruictsathome.com

[3] www.instructable.com

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[5] www.servocity.com

[6] www.societyofrobot.com

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