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Design And Development of Bionic Hand Using Voice Control

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Abstract:–In the continuous quest for improved performance and functions, the field of Bionics and Robotics has been evolving and establishing great technological innovation. The bionic hands are wonderful technology to make lives of hand amputees better. The user control interface for bionic hands has been evolving to a great extent over time. The control of bionic hand with EMG sensors and flex sensors has been an expensive and sophisticated. The sophistication of these control units lead to involvement of long training and user calibration sessions. Such tedious procedures make it hard for hand amputees to get adapted to the technology. The muscle tension sensor implants lead to adverse conditions of nerve failure and health hazards in some cases. Hence, an inexpensive, user-friendly and optimized control of bionic hand using voice control will be a beneficial scientific innovation for the hand amputees.

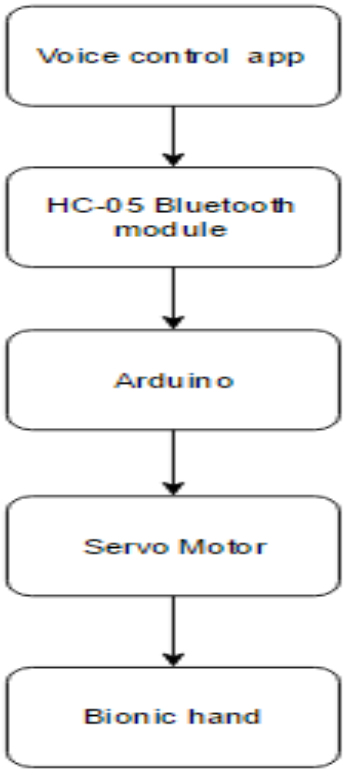
Keywords:– *Bionics, Robotics, Voice control, Microcontroller*.

I. INTRODUCTION

The Bionic hand is an extensive bio-mechatronic device involving a wide range of concepts involving biology and mechatronics. The bionic hand is designed based on the ergonomics and functions of a human hand. The bionic hand of today has progressed greatly since the hook prostheses that were introduced centuries ago. The device is designed with appropriate control to provide the hand amputee a comfortable and healthy user experience. The bionic hand are generally designed with multiple degrees of freedom. The involvement of these multiple degrees of freedom is based on the actual mechanism of a human hand. The sensors, control units and actuators are prime parts of an bionic hand. The control of bionic hand using voice control establishes user-robot interface without any complex training and health risks. The voice control concept can also be established in a inexpensive way to ensure greater reach of the device to the society.

II. PROPOSED IDEA

The Bionic hand is implemented using servo controlled finger mechanism. The voice control is established using an application (Android platform) and HC 05 – Bluetooth module. The Arduino Bluecontrol application in android platform is used for voice command recognition.. The commands are assigned to unique and individual characters in the application. The application transmits the character as ASCII value to the HC-05 bluetooth module. The ASCII value is passed to the serial communication modules of the Arduino Nano board. The microcontroller code is designed in the way to establish perfect interpretation of the data received from HC-05. The motor actuation is performed based on the unique characters interpreted. The human hand gestures are mimicked by the bionic hand based on the motor actuation.



III. ARDUINO NANO

The Arduino Nano is a powerful tool with ATMEGA328PU microcontroller to program and manipulate the electronic functions. The Arduino Nano is implementation of 32kBflash memory with read while write capabilities. It is designed with 32 registers for various purposes, serial communication with USART, two-wire serial interface, SPI

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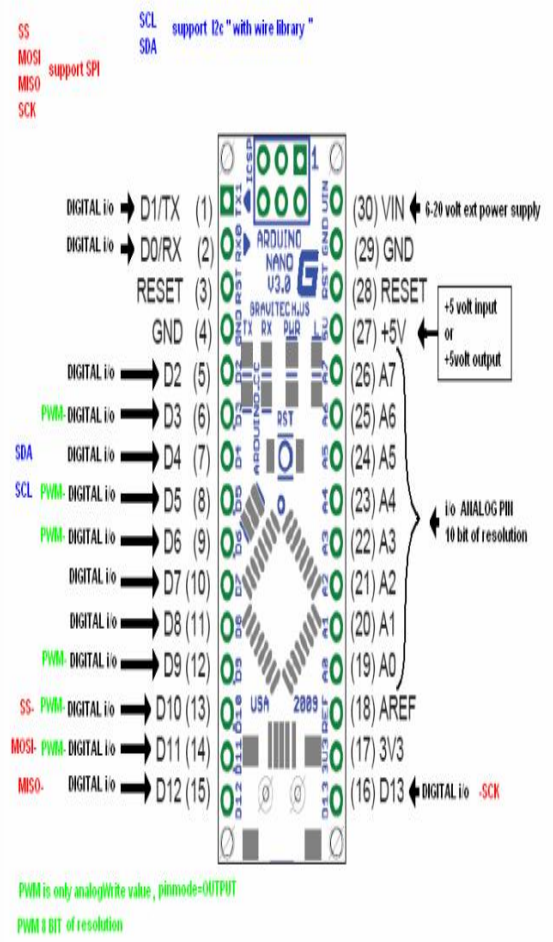
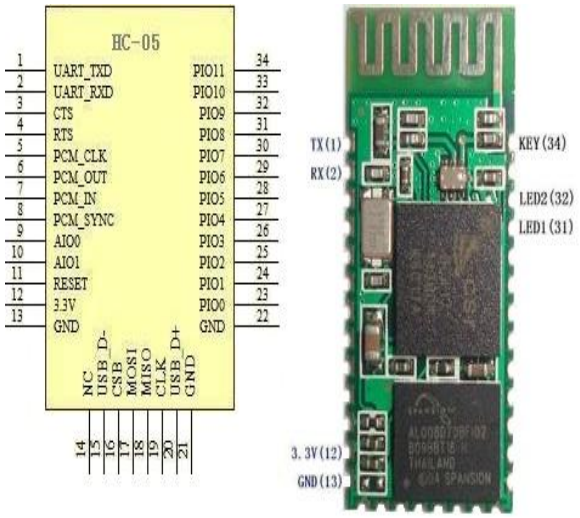
serial port, 6-channel 10-bit ADC, programmable timer with internal oscillator and power saving modes. The device operate in the input voltage range of 1.85V to 5V. The Arduino Nano can be programmed with Arduino IDE. The 32 registers are connected to the Arithmetic Logical Unit directly, allowing access to two independent registers in a single cycle.



IV. HC05 BLUETOOTH MODULE

The bluetooth module HC05 is an implementation of master/slave communication concept. The HC05 bluetooth module is designed with Slave mode of operation by default. The slave module can accept connections from other modules but cannot initiate connection with other modules. The Bluetooth module uses the updated technology of CSR Bluecore with Adaptive Frequency Hopping and CMOS technology. The Bluetooth module functions at an voltage level of 3.3 to 5V I/O. The module is enhanced with UART interface with programmable baud rate. The default baud rate of the system is 9600 and it consists of 8 data bits. The auto connect to the last device on power is default.



V. SERVO MOTORS

`A servo motor is a rotary actuary that allows accurate control of actuation in angular way. The motor is coupled for feedback with a sensor. The output of the servo motor is the control of the shaft position. The input is given in implementation of pulse code modulation to establish the angular position of the shaft. The modern servo motors are functioning using rotary encoders with either absolute or incremental methodology. The servo is interface using the three connecting pins of the motor, Vcc, Gnd and Signal pins . The servo motor used for the finger mechanism actuation is the SG90. The servo motor for the axial rotation of the hand is MG995.

Servo specifications SG90,

- Operating voltage - 5v
- Angular speed - 60 deg / 0.12 sec
- Torque - 1.8 kg/cm (~ 4.8v)

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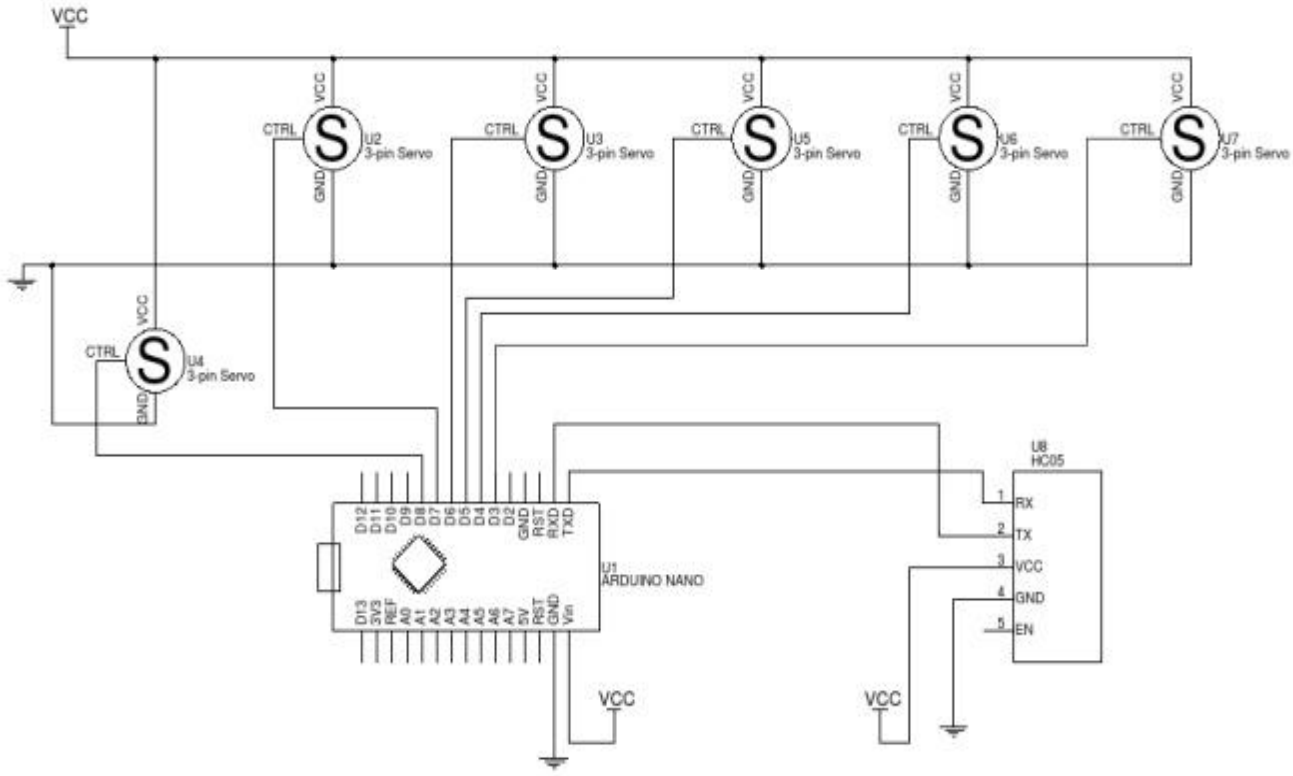
Servo specifications MG995,

- Operating voltage - 5v
- Angular speed - 60 deg / 0.12 sec
- Torque - 9.4 kg/cm (~ 4.8v)

VI. ELECTRONIC CIRCUIT DESIGN

The electronic circuit is designed with implementation of components HC05, Arduino Nano and Servo motors. The HC05 bluetooth module is used to establish connectivity to the mobile application in android platform. The Arduino Nano receives the data from the HC05 module using the serial communication protocol. The Rx and Tx pins of HC05 are connected to the Tx and Rx pin of Arduino Nano respectively. The Servo motors are interfaced with the Arduino Nano, to actuate the finger and other hand mechanisms based on the voice command. The servo motor signal pins are connected to digital pins D3, D4, D5, D6, D7 and D8.



VII. FORCE CALCULATION

The calculation of force required to actuate the finger mechanism is done using the values of torque of servo (at 4.8v) and length of the servo horn used in each servo motor. The force required to actuate the finger mechanism is an important parameter in the design of bionic hand. The pulling force for each hand is unique, and depends on parameters such length and position of servo horns. The angular rotation of the horn results in finger mechanism actuation. The relation between force, torque and distance from axis of rotation is given by,

Force = ((Torque/Distance) x (9.8068))

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Units :

- Force - Newton
- Torque - kg/cm
- Distance - cm

Data:

- Length of horn = 2.5 cm.
- Torque=1.8kg/cm

(The SG 90 servo used to actuate fingers has a torque of 1.8 kg/cm (at 4.8v).)

Force = ((1.8/2.5)*9.8068) N
Force = 7.0609 N.

Thus, the force required to actuate the finger mechanism is determined to be 7.0609N.This force is exerted at the servo horn end to actuate the individual finger mechanism from open to close position. Each servo motor exerts the individual force of 7.0609 N to actuate the finger mechanism with servo horn end being the string connection end.

VIII. VOICE COMMANDS

The voice controlled application in android platform is preset by users with 10 vocal commands. These commands are assigned to corresponding unique ASCII character. By calling these vocal commands, the recognition system triggers the corresponding character to be sent through the established Bluetooth serial communication. The commands are assigned to unique and individual characters in the application. The application transmits the character as ASCII value to the HC-05 bluetooth module.

COMMAND	CHARACTER	FUNCTION
Left	a	Turn left
Centre	b	Centre position
Right	c	Turn right
Open	d	Open Hand
Close	e	Close Hand
Little	f	Close little finger
Ring	g	Close ring finger
Middle	h	Close middle finger
Index	i	Close index finger
Big	j	Close thumb finger

IX. RESULTS AND DISCUSSION

The Bionic hand design and fabrication is implemented and verified for desirable functions and operations. The bionic hand has been designed with 5 servo motors for finger mechanism and actuation and one angular rotation of arm base. The servos are placed at desirable positions to exert required force through the string connecting the servo motor and the finger mechanism. The angular rotation of arm base has been implemented by fixing the arm base with servo hones axially. The rotation of the base joint has verified using serial communication commands using serial monitor control in arduino IDE. The rotation angles of the used servo was manually determined and implemented in the final program code. The individual finger mechanisms have been tested and actuated separately using serial communication commands using serial monitor in arduino IDE.

The angle of servo rotation for open and close for each finger was determined manually and the data was appropriately used for the manipulation of the corresponding servo rotation. The open and close angle being the important parameter in the work paradigm of the bionic hand was given higher importance in manual calibration process. The manual calibration was done for each servo rotation. The power supply for the microcontroller being 5v and 1 amp, a separate battery pack is used for the microcontroller power supply. The servos with great need for adequate power supply are supported by 8v and 1 amp battery pack and IC7805 voltage rectifier circuit. This ensures proper and adequate power supply to both the microcontroller and servo power supply circuits. The two power supply circuits are linked together using a common ground to prevent any short circuit situations. The voice recognition application used for the bionic hand is linked with Google assistant in the back end. This enables a huge voice analysis database for the bionic hand. The voice control application with required commands and corresponding characters to establish proper correlation between the two parameters. The voice control application is tested with optimum internet connectivity to ensure stable voice command recognition. The program for the bionic hand is uploaded with all required servo angular setting for each finger action and corresponding character verification from serial communication registers of the microcontroller. The voice command is set for ten numbers of commands. The ten commands are specified as per the voice command list. The voice control has proved to be successful to trigger all the desirable finger manipulation. The arduino nano being a open source development hardware, its easy for future concept and algorithm implementation to be easier in the bionic hand. The

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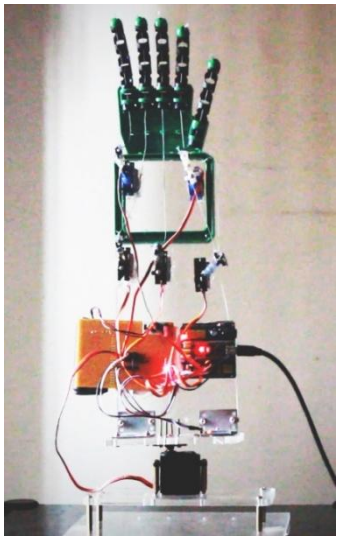
bionic hand can be tested and developed for different program paradigms and interfacing of the new features in the hand such as tactile sensors will be a easier task with this open source hardware. The rotation of the arm base joint is controlled using left, right and centre command. The SG90 servo actuates finger mechanism in the most desirable speed and to the accurate open and close level to mimic finger movements. The voice command for individual finger actuation and various other finger positioning has proved to be successful and spontaneous. The speed of motor actuation is varied with delay commands in arduino IDE. The usage of dual power supplies ensures stable power for microcontroller, thereby establishing a stable connectivity to voice control application through Bluetooth module. The design and fabrication of bionic hand using lightweight material such as acrylic sheet has been a great boon on servo torque requirement. The overall weight of the bionic hand reduced with usage of acrylic sheet and thereby the lower weight servos. The usage of flexible material for finger mechanism has made the actuation of finger mechanism easier. The response of the finger mechanism at various actuation levels is optimum and desirable. The low cost and reliability of the bionic hand enhances the user feasibility and product dynamics. The inexpensive design and fabrication of bionic hand makes the product available to more amputees, thereby increasing the reach of the product to the real world. The bionic hand is a successful implementation of desirable attributes and finger mechanisms. The bionic hand proved to be working with stable serial communication, process control and servo actuation.



X. CONCLUSION

Bionic arm is the most efficient upcoming technology which can put many differently able people at ease with it's simple design and working. The methodology of the bionic hand is really simple and easily adaptable unlike other devices. It works with the help of voice commands thereby making it easier for people with multiple amputations. The voice commands are simple mostly single words thereby making it easier for people to memorize and use it. It's a highly cost efficient and hence it's highly affordable for almost all hand amputees. The voice control option gives the user a set of commands using which he can control his prosthetic bionic arm and hand. A voice-user interface makes human interaction with bionic hand possible through a voice/speech platform in order to initiate an automated service or process.

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