Development of Haptic Prosthetic Hand for Realization of Intuitive Operation

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Abstract— Prosthesis is an artificial approach, which is used to replace a disabled body part. Prostheses are typically used to replace and provide supplement to disabled/defective body parts. Disabled body parts can be of any reason like lost accidently, birth physical disability etc. In addition to the standard artificial limb for every-day use, many disable have special limbs and devices to aid in the participation of sports and recreational activities. The main requirement is that its function should be as natural as real arm. There are various designs of artificial arm that are available in the market, categorized as electrical, mechanical and Myo-electric arm. Mechanical prostheses use some motion of the body to provide the power necessary to control the prosthetic component. Electrical arms activate the hand by a motor which is driven by micro switches and relays.

Key words: Haptic Prosthetic Hand, Disabled Body Parts

I. Introduction

A prosthetic hand is an artificial hand or a replacement of missing hand. A prosthetic hand is a fake hand for those who amputated their hand. Earlier armories used prostheses mainly in battle to hold sword and shield. Modern prosthetic principles evolved after II world war. In 1949 first myoelectric switch was developed. Earlier body powered prosthesis components have not much changed because most of the research has focused on externally powered prosthesis and high cost of manufacturing also a prime issue.

The first microprocessor-controlled prosthetic knees became available in the early 1990s. The Intelligent Prosthesis was first commercially available microprocessor controlled prosthetic knee. Blatchford & Sons, Ltd., of Great Britain, in 1993 made walking with the prosthesis feel and looks more natural. An improved version was released in 1995 by the name Intelligent Prosthesis Plus. Blatchford released prosthesis, the Adaptive Prosthesis, in 1998 [1]. The Adaptive Prosthesis utilized hydraulic controls, pneumatic controls and a microprocessor to provide control action

II. Related work

L. McLean, et al[1]discovered the designing of myo-electric control of prosthetic arms from its conception in post-war Germany thro ugh its popular acclaim in "bionic arms" toward its undertaking as a procedure and correct option for many arm Z. Escudero, et al[2] demonstrated handicapped people that amputees are one Of the most necessary groups in the nature. The aspiration of developing prostheses is mainly to improve their circumstances of life and to help them recover freedom and dignity's. H. Asyali, et al[3]says that electromyography (EMG) signal and existing assessment have validate that multichannel EMG signal controls are not appropriate due to early fatigue problems and high effort essential to perform even simple movements. Therefore, new voice-controlled active hand prosthesis to execute several basic functions was presented A. Vijayaraj et al[4]demonstrated mobile robot is controlled by using speech signal. The input speech signal is given through micro phone. Speech extractor is used to convert the given speech signal to word signal. The word signal produces the command. According to the given commands the various operations were demonstrated in the mobile robot like move forward, backward, left and right, clockwise rotate, anticlockwise rotate, and open, close.

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III. Block diagram

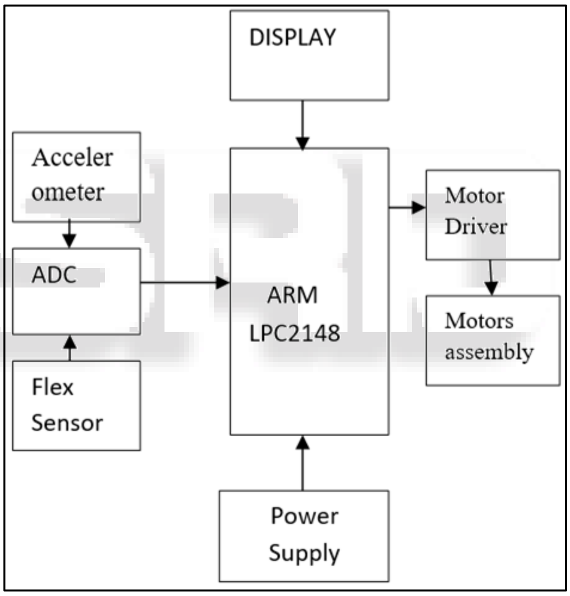

Fig. 1: Block Diagram

IV. Hardware requirements

A. ARM (LPC 2148)

The LPC2148 microcontrollers are based on a 32 bit ARM7TDMI-S CPU with real-time emulation and embedded trace support, that combines the microcontroller with embedded high speed flash memory ranging from 32 kB to 512 kB. A 128-bit wide memory interface and unique accelerator architecture enable 32-bit code execution at the maximum clock rate. For critical code size applications, the alternative 16-bit Thumb mode reduces code by more than 30 % with minimal performance penalty.

Due to the tiny size and low power consumption, LPC2148 is ideal for applications where miniaturization is a key requirement, such as access control and point-of-sale. A blend of serial communications interfaces ranging from a USB 2.0 Full Speed device, multiple UARTs, SPI, SSP to

I2Cs, and on-chip SRAM of 8 kB up to 40 kB, make these devices very well suited for communication gateways and protocol converters, soft modems, voice recognition and low end imaging, providing both large buffer size and high processing power. Various 32-bit timers, single or dual 10-bit ADC(s), 10-bit DAC, PWM channels and 45 fast GPIO lines with up to nine edge or level sensitive external interrupt pins make these microcontrollers particularly suitable for industrial control and medical systems.

1) Features

1) 16/32-bit ARM7TDMI-S microcontroller in a tiny LQFP64 package.
2) 8 to 40 KB of on-chip static RAM and 32 to 512 KB of on-chip flash program Memory.
3) 128 bit wide interface/accelerator enables high speed 60 MHz operation.
4) In-System/In-Application Programming (ISP/IAP) via on-chip boot-loader software.
5) Single flash sector or full chip erase in 400 ms and programming of 256 bytes in 1 ms.
6) USB 2.0 Full Speed compliant Device Controller with 2 KB of endpoint RAM.
7) In addition, LPC2148 provides 8 KB of on-chip RAM accessible to USB by DMA.
8) Two 10-bit A/D converters provide a total of 6/14 analog inputs, with conversion times as low as 2.44 micros per channel.
9) Single 10-bit D/A converter provides variable analog output.
10) Two 32-bit timers/external event counters (with four captures and four compare channels each), PWM unit (six outputs) and watchdog.
11) Low power real-time clock with independent power and dedicated 32 kHz clock input.
12) Multiple serial interfaces including two UARTs (16C550), two Fast I2C-buses
13) (400 Kbit/s), SPI and SSP with buffering and variable data length capabilities.
14) Vectored interrupt controller with configurable priorities and vector addresses.
15) Up to 45 of 5 V tolerant fast general purpose I/O pins in a tiny LQFP64 package.
16) Up to nine edge or level sensitive external interrupt pins available.

B. Motor Driver IC (L293D):

The L293 and L293D are quadruple high-current half-H drivers. The L293 is designed to provide bidirectional drive currents of up to 1 A at voltages from 4.5 V to 36 V. The L293D is designed to provide bidirectional drive currents of up to 600-mA at voltages from 4.5 V to 36 V. Both devices are designed to drive inductive loads such as relays, solenoids, dc and bipolar stepping motors, as well as other high-current/high-voltage loads in positive-supply applications. All inputs are TTL compatible. Each output is a complete totem-pole drive circuit, with a Darlington transistor sink and a pseudo Darlington source. Drivers are enabled in pairs, with drivers 1 and 2 enabled by 1,2EN and drivers 3 and 4 enabled by 3,4EN. When an enable input is high, the associated drivers are enabled, and their outputs are active and in phase with their inputs. When the enable input is low, those drivers are disabled, and their outputs are off and in the high-impedance state. With the proper data inputs, each pair of drivers forms a full-H (or bridge) reversible drive suitable for solenoid or motor applications.

C. DC Motor

The vary basic construction of DC motor contains the current carrying armature, which is connected to supply end through commutated segments, brushs and placed between south and north poles of a permanent or an electromagnet. Operating principal of DC motor is to determine the direction of force acting on armature conducts of DC motor.

Electrical motors are everywhere around us. Electro-mechanical movements present in our surrounding are caused either by a DC or an AC motor. Above block diagram shows electrical energy to mechanical energy. Speed control means purposefully changing the speed of the speed to a required value for performing the particular work process. Speed regulation is the concept of speed control variation. The operator manually control the speed or it is done by means of some automatic control device. The most important feature of the DC motor is that it is relatively easy to control the speed. For constant torque this method is economically beneficial.

A DC motor means a direct current (DC) motor of used in models, robot, toys and cordless tools. These motor are versatile in nature because of their direction and speed can be readily controlled speed by duty cycle or voltage and direction by its polarity. DC motor provides different amount of torque depending on their speed which is measured in revolution per minute. Motor power are measured in torque as higher the torque of motor the more weight it can move. At low RPM DC motor provides poor torque. However, in high torque the speed may be too high for an application.

D. Accelerometer

Here we use an accelerometer designed by Free scale Semiconductors. The MMA7361L is a low power, low profile capacitive micro-machined accelerometer featuring signal conditioning, a 1-pole low pass filter, temperature compensation, self-test, 0g-Detect which detects linear free fall, and g-Select which allows for the selection between 2 sensitivities.

1) Features

1) 3mm x 5mm x 1.0mm LGA-14 Package
2) Low Current Consumption: 400µA
3) Sleep Mode: 3µA
4) Low Voltage Operation: 2.2 V – 3.6 V
5) High Sensitivity (800 mV/g @ 1.5g)
6) Selectable Sensitivity (±1.5g, ±6g)
7) Fast Turn On Time (0.5ms Enable Response Time)
8) Self-Test for Free-fall Detect Diagnosis
9) 0g-Detect for free fall Protection
10) Signal Conditioning with Low Pass Filter
11) Robust Design, High Shocks Survivability
12) RoHS Compliant
13) Environmentally Preferred Product
14) Low Cost

E. Flex Sensors

Flex sensors are also called bend sensors. They measure the amount of deflection caused by bending the sensor. There are various ways of sensing deflection, from strain-gauges to hall-effect sensors. Each finger on the haptic glove is fitted with a flex sensor. Each flex sensor is 4.5" in length (except for little finger, 2.2" in length).As the sensor bends, the resistance across the sensor changes. The resistance increases with increase in angular bend. The resistance of the flex sensor varies only when the metal pads are on the outside of the bend. Unbent it measures about 10KΩ, to 20KΩ when bend 180º.

V. IMPLEMENTATION

The movement of the human hand is tracked by accelerometer and bending of fingers is tracked by flex sensors those sensor outputs are analog in nature and are converted to digital values by analog to digital converter as shown in fig5.

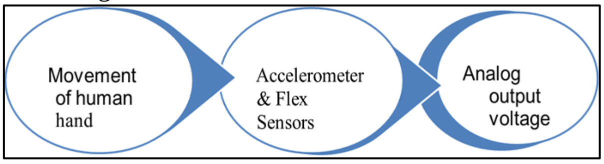

Fig. 5: Traking of Hand Gestures

These digitalized sensor outputs are analyzed by microcontroller lpc2148 which is coded to perform specific function based on sensor inputs the microcontroller drives the motor driver which in turn drives the motors as shown in the fig6.

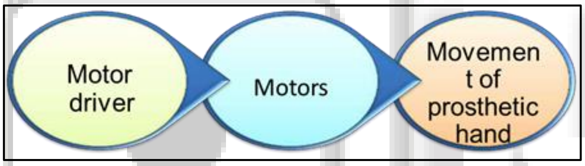

Fig. 6: Movement of Prosthetic Hand

VI. CONCLUSION

By developing the haptic prosthetic hand we had overcome the disadvantages of voice controlled hand where the accuracy was very low and which was even complicated to operate. By implementing hand gesture principle with the help of flex and accelerometer we could achieve high accuracy in motion and it was easy to operate and it has countless applications and can be used in different scenarios. For instance, at one place it can be used by physically disabled people, in military, in chemical laboratory and in Industries.

VII. FUTURE SCOPE

The project is built on a wired model and it is a prototype. It could further be developed to work on wireless communication, thus allowing the user to move in an even easier unrestricted manner and a 3D printed human hand will add more functionality.

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