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HUMAN ARM REHABILITATION USING ACCELEROMETER AND STRING MOTOR MECHANISM

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Abstract In the past few years, the authors have a proposed exoskeleton device which is in light weight for upper arm rehabilitation using multistage CAREX (Cable driven Arm Exoskeleton).Instead of using CAREX we can train the arm using accelerometer and string-motor mechanism which as the active-assistive mechanism. It is a portable and wearable upper limb exoskeleton devices attached to the patient's arm which assists the elbow flexion and extension motion for rehabilitation. This can be achieved by using the accelerometer sensor. Accelerometer place on the caliper senses the patient's angular bending and the string motor mechanism controls the motion of the device with speed. A control unit is given to the patient so that range of motion can be fixed by the individual for his convenience to perform the exercise.

Keywords-exoskeleton, accelerometer, string-motor, arm training, assist device, blood circulation

I. INTRODUCTION

Neuromuscular functions of the muscles can be affected due to the intensive and repetitive task oriented movement training. It becomes difficult in traditional rehabilitation due to intensive labour which is required from the physical therapist. It offers uniform performance over long durations as well as quantitative outcomes using the accelerometer sensor. It renders equal or better performance compared to the traditional therapy. Current robotic rehabilitation devices are usually anthropomorphic and are made out of rigid links attached to the human arm. The mechanical joints of these exoskeletons are driven by motor. It results in human arm dynamic changes. Human bones have several mechanical links and joints. So the mechanical axes should be aligned with the arm joint axes. Some designs have attempted to accommodate the GH-c movement by adding extra active or passive degrees-of-freedom.

Our circulatory and respiratory systems function to supply your body with blood and oxygen through all activity levels, from rest to physical exertion. The amount of blood circulated throughout the body is based on two measurable components – stroke volume and heart rate. The amount of each that your body is capable of producing is based on factors including fitness level, activity level, body size and medication.

II EXISTING SYSTEM

A human–exoskeleton interface was presented the CAREX on human subjects. CAREX is abbreviated form of Cable-driven Arm Exoskeleton. In this system, the cable attachment points were first optimized to achieve a large "tensioned" static workplace while avoiding potential collisions between the cables and the human arm. It has two scenarios, GH-c was assumed to be fixed and GH-c was assumed to be variable and estimated in real-time. CAREX can be evaluated on a stroke patient. It has three cuffs. The shoulder cuff is fixed on a chair. Crescent shaped foam piece is attached to this cuff for shoulder support. Upper arm cuff and forearm cuff are connected to the arm through an arm orthosis with a hinge. Cables are routed through these cuffs and controlled in tension. An orientation sensor and an encoder are attached to the orthosis for measurement of arm joint angles.

It provides functional training to subjects with arm weakness. The "tensioned" static workspace of CAREX is the set of arm configurations of a human subject in which the exoskeleton can hold against gravity, with cables in tension. The "tensioned" static workspace is reasonably large in the ipsi-lateral side of the saggital plane, while the static workspace in the contra-lateral side is limited. The positions of cable attachment points were constrained in a way that cables do not collide with the arm during motion. The desired workspace was discretized into configuration (30 configurations at each joint). A large "tensioned" static workspace increases the chance of keeping the cables in tension during dynamic motion.

In order to overcome the drawbacks given above, we propose a portable and wearable upper

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limb exoskeleton device attached to the patient's arm which assists the elbow flexion and extension motion for rehabilitation. Instead of using CAREX, this can be achieved by using an accelerometer and string motor mechanism.Accelerometer should be placed on the caliper which senses the angular bending of the patient and monitors patient's initial effort by measuring the partialangularbending. The string-motor mechanism controls the motion of the device with speed. A control unit should be given to the patient so that the range of motion can be fixed by the individual for his/her convenience to perform the exercise. [3] proposed a system about Efficient Sensor Network for Vehicle Security. Today vehicle theft rate is very high, greater challenges are coming from thieves thus tracking/ alarming systems are being deployed with an increasingly popularity .As per as security is concerned today most of the vehicles are running on the LPG so it is necessary to monitor any leakage or level of LPG in order to provide safety to passenger.

The device is attached with the patient's arm to assist the flexion-extension of the elbow point. When the patient effort stops, the band motor system assists to attain the given range of motion.The assist level of the device can be decided for each patient based on rehabilitation device.

III. MATERIALSANDMETHODOLOGY

A.ELBOW CALIPER

It is a device which is used to measure the two opposite sides of the elbow. Most commonly it has a inward and outward facing points. With the help of the ruler, the distance can be measured. The tip of the calliper can be adjusted to fit the points to be measured. Digital calliper is most commonly used in the arm rehabilitation device and is made of aluminium.

B.ACCELEROMETER

Accelerometers are devices that can measure acceleration, which is the rate of change of the velocity of an object. They measure in meters per second squared (m/s^2) or in G-forces (g). A single G-force for us here on planet Earth is equivalent to 9.8 m/s^2, but this does vary slightly with elevation (and will be a different value on different planets due to variations in gravitational pull). Accelerometers are useful for sensing vibrations in systems or for orientation applications. It is a electromechanical device that sense either static or dynamic forces of acceleration. Static forces include gravity, while dynamic forces can include vibrations and movement.Accelerometers can measure acceleration on one, two, or three axes. 3-axis units are becoming more common as the cost of development for them decreases. Generally, accelerometers contain capacitive plates internally. Some of these are fixed, while others are attached to miniscule springs that move internally as acceleration forcesact upon thesensor. As these plates move in relation to each other, the capacitance between them changes. From these changes in capacitance, the acceleration can be determined. Other accelerometers can be around piezoelectric materials. These tiny crystal structures output electrical charge when placed under mechanical stress.

Range

Most accelerometers will have a selectable range of forces they can measure. These ranges can vary from ±1g up to ±250g. Typically, the smaller the range, the more sensitive the readings will be from the accelerometer. For example, to measure small vibrations on a tabletop, using a small-range accelerometer will provide more detailed data than using a 250g range. The basic connections required for operation are power and the communication lines.

Communication Interface

Accelerometers will communicate over an analog, digital, or pulse-width modulated connection interface. Accelerometers with an analog interface show accelerations through varying voltage levels. These values generally fluctuate between ground and the supply voltage level. An ADC on a microcontroller can then be used to read this value. These are generally less expensive than digital accelerometers.ccelerometers with a digital interface can either communicate over SPI or I^2C communication protocols.These tend to have more functionality and be less susceptible to noise than analog accelerometers. Accelerometers that output data over pulse-width modulation (PWM) output square waves with a known period, but a duty cycle that varies with changes in acceleration.

Triple-Axis Accelerometer MMA7361L

This is a breakout board for Freescale's MMA7361L three-axis analog MEMS accelerometer. The sensor requires a very low amount of power and has a g-select input which switches the accelerometer between ±1.5g and ±6g measurement ranges. Other features include a sleep mode, signal conditioning, a 1-pole low pass filter, temperature compensation, selftest, and 0g-detect which detects linear freefall. Zero-g offset and sensitivity are factory set and require no external devices.

This breadboard friendly board breaks out every pin of the MMA7361L to a 9-pin, 0.1" pitch header. The sensor works on power between 2.2 and 3.6VDC (3.3V optimal), and typically consumes just

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400µA of current. All three axes have their own analog output.

C.MICROCONTROLLER (PIC16F877A)

It has 2 PWM 10-bit, 256 bytes EEPROM data memory, LCD, 25mA sink/source per I/O, self programming and a parallel slave port.

PARAMETER NAME	VALUE
Program memory type	Flash
Program Memory(KB)	14
CPU speed(MIPS)	5
RAM bytes	368
Data EEPROM (bytes)	256
Digital Communication Peripherals	1-UART, 1-SPI, 1-I2C1-MSSP(SPI/I2C)
Capture/Compare/PWM Peripherals	22 CCP
Timers	2 x 8-bit, 1 x 16-bit
ADC	8 channels , 10-bit
Comparators	2
Temperature Range	-40 to 125
Operator Voltage Range(V)	2 to 5.5
Pin Count	40

Table 1 Specifications regarding the microcontroller

D.DC MOTOR

A DC motor in simple words is a device that converts direct current (electrical energy) into mechanical energy. It's of vital importance for the industry today, and is equally important for engineers to look into the working principle of DC motor in details that has been discussed in this article. In order to understand the operating principle of DC motor we need to first look into its constructional feature.

A motor is an electrical machine which converts electrical energy into mechanical energy. The principle of working of a DC motor is that "whenever a current carrying conductor is placed in a magnetic field, it experiences a mechanical force".The very basic construction of a DC motor contains a current carrying armature which is connected to the supply end through commutator segments and brushes it is placed within the north south poles of a permanent or an electro-magnet. Now to go into the details of the operating principle of DC motor it is important that we have a clear understanding of Fleming's left hand rule to determine the direction of force acting on the armature conductors of DC motor

Fleming's left hand rule says that if we extend the index finger, middle finger and thumb of our lefthand in such a way that the current carrying conductor is placed in a magnetic field (represented by the index finger) is perpendicular to the direction of current (represented by the middle finger), then the conductor experiences a force in the direction (represented by the thumb) mutually perpendicular to both the direction of field and the current in the conductor.

The concept of back EMF force Unlike the other electrical machines D.C motors exhibit a unique characteristic; the production of back EMF . A rotating loop in magnetic field will produce an EMF according to the principle of electromagnetic induction

E.MOTOR DRIVER (L298)

It is ideal for robotic applications and well suited for connection to a microcontroller requiring just a couple of control lines per motor. It can also be interfaced with simple manual switches, TTL logic gates, relays, etc.

The L298 is an integrated monolithic circuit in a 15-lead Multiwatt and PowerSO20 packages. It is a high voltage, high current dual full-bridge driver designed to accept standard TTL logic levels and drive inductive loads such as relays, solenoids, DC and stepping motors. Two enable inputs are provided to enable or disable the device independently of the input signals. The emitters of the lower transistors of each bridge are connected together and the corresponding external terminal can be used for the connection of an external sensing resistor. An additional supply input is provided so that the logic works at a lower voltage.

This is a 5V, 10A 2-Channel Relay interface board. It can be used to control various appliances, and other equipment's with large current. It can be controlled directly with 3.3V or 5V logic signals from a microcontroller (Arduino, 8051, AVR, PIC, DSP, ARM, ARM, MSP430, TTL logic). It can be used to control various appliances and equipment with large current.

F.LCD (LIQUID CRYSTAL DISPLAY)

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters, animations and so on.A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data.The command register stores the command instructions given to the LCD. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD. Liquid crystal should able be to control both of the operation to transmit or can also able to change the polarized light.

*G.*HEARTBEAT SENSOR

We should detect the heart beat/pulse and count the pulses for one minute to get the beats per minute. So in order to detect the pulse we will pass light (using an LED) from one side of the finger and measure the intensity of light received on the other side (using an LDR). Whenever the heart pumps blood more light is absorbed by increased blood cells and we will observe a decrease in the intensity of light received on the LDR. As a result the resistance value of the LDR increases.

This variation in resistance is converted into voltage variation using a signal conditioning circuit usually an OP-AMP.The signal is amplified enough to be detectable by the microcontroller inputs. The signal given to the microcontroller input will look somewhat like shown in the image above in a oscilloscope. The microcontroller can be programmed to receive an interrupt for every pulse detected and count the number of interrupts or pulses in a minute. The count value of pulses per minute will give you the Heart rate in Beats per Minute. Alternatively to save time, only the number of pulses for ten seconds are counted and then multiplied by 6 to get pulse count for 60 seconds/1 minute.

The heartbeat sensor is based on the principle of photo phlethysmography. It measures the change in volume of blood through any organ of the body which causes a change in the light intensity through that organ (a vascular region). In case of applications where heart pulse rate is to be monitored, the timing of the pulses is more important. The flow of blood volume is decided by the rate of heart pulses and since light is absorbed by blood, the signal pulses are equivalent to the heart beat pulses.

IV.BLOCK DIAGRAM AND METHODOLOGY

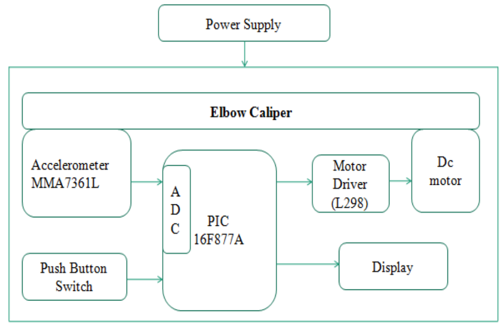

Fig.1. Block Diagram

When the power is switched on, the signal goes to microcontroller which is connected with the accelerometer, motor driver and the elbow caliper. The elbow caliper is interconnected with the accelerometer and dc motor. Elbow caliper is controlled by the accelerometer which initiates the movement of hand in the forward and the reverse direction. The dc motor requires 12V supply so the motor driver L298 is used to amplify the 5V signal from the microcontroller to 12V signal.

V. SIMULATION DESIGN

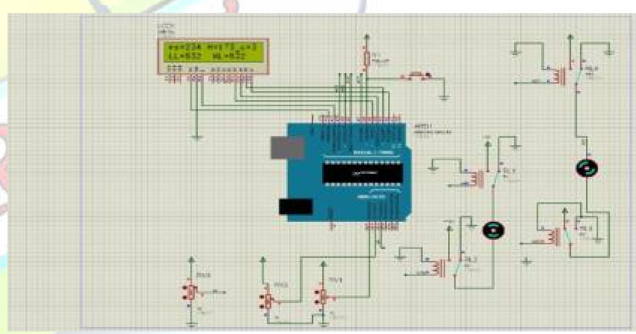

Fig.2. SIMULATION DESIGN

VI. CONCLUSION AND FUTURE SCOPES

Thus, in this design, by using the accelerometer and dc motor mechanism, we have many advantages like.It has Active-assistive motion.Continuous monitoring can be done with high precision and accuracy.It is user friendly.Patients feels easy to wear.It is portable from one place to another whenever necessary.Patient safety is considered.We can also check the pulse of the patient using the heartbeat sensor. Flex sensor can also be for the movement of the fingers. In future, robotic designed hand can be manufactured.

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