Design and Fabrication of Human Power Reduction Kit

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Abstract

Nowadays humans are facing many problems while lifting the heavy weight in upper body on exoskeleton for use in the fields of rehabilitation and therapeutic application, as well as occupations requiring augmented strength. Though systems exist, past exoskeleton endeavors have led to bulky, expensive, invasive, and tethered solutions. The challenge is to build an exoskeleton system that is inexpensive, streamlined, and wireless. In order to overcome the problem, it is challenge to develop a unique solution in the manner of low cost and ergonomic device. To achieve this, a kit is developed to lift the heavy weight application in various fields for user friendly interaction. With the help of arduino onboard sensing system, signal from the human body skeleton is acquired and the same is forwarded to the developed kit for actuating the cylinder. The retrieved data can be used by industrial workers to minimize the less time consumption of their work. Due to its low cost, hospitals can employ multiple devices and also the devices could even be used at home for physical appliances, which would dramatically increase quality of life for workers and patients. The developed device is highly augmented strength, so it is applicable to physically intensive occupations such as search and rescue operations. Hence, design and develop human power reduction kit device is required in the industry to achieve the human economic factors.

Keywords: Human Hand Assistance Device, Pneumatic Cylinder, Aluminium with Mild Steel, Exoskeleton Frame, Ergonomics Study

I. INTRODUCTION

Surviving a stroke or debilitating injury is often the start of a very long ordeal. Physical therapy can be slow and strenuous with no guarantee of recovery. Robotic exoskeletons can sometimes provide the support a ravaged body needs to heal and strength when it can't but they typically cost more than a car and must be anchored to a wall and plugged into a socket. Due to this reason it is tried to build an efficient, lightweight, and surprisingly powerful robotic limb. Its actuator, or electronic muscle, could provide resistance during therapeutic exercises and can augment strength, allowing its wearer to lift an additional 40 pounds or 20 kilograms with little effort. To ensure a slimmer frame than other exoskeletons and make Exoskeleton Arm easier for patients to use, the team situated its actuator in a backpack instead of in the limb itself. They also milled load-bearing parts out of aluminium to limit weight and power consumption. This would allow a patient to use an Exoskeleton Arm at home and a therapist to remotely monitor the exercises. Potential beneficiaries, including stroke victims and an injured snowboarder, have already reached out to the team with encouraging comments. The positive response to their $2,000 prototype has made Exoskeleton Arm's makers eager to push their invention toward a finished product and, to that end; they are now designing a more refined version figure-1.

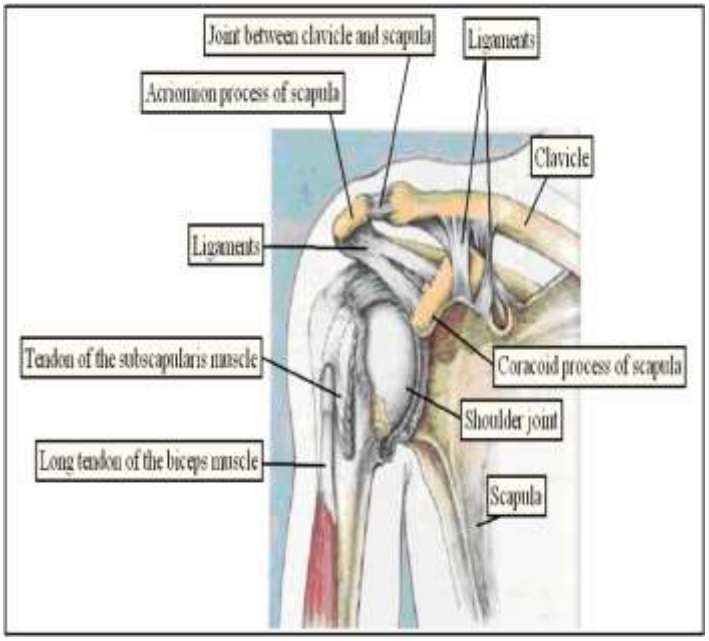

Fig. 1: Inner Part of Human Hand

The source of idea for design, concept, specification and other information that related to the project is explained as follows. It is found that necessary on the product that have been develop with user-friendly, simple to use and easy handling which reduces the effects of humans. Most of the researchers are doing research to design the human power reduction based kits which are assistance to humans. In order to develop the human assistance device it should be studied to ensure that device is developed to run efficiently while achieving the desired objective. All the theories of all devices and compatible software that are used in this research [1]. An exoskeleton robot is a wearable motion assist device consisted with actuators and sensors whose joints correspond to those of the human body .It is worn by the human and the physical contact between the user and the exoskeleton allows direct transfer of mechanical power and information signals. In utilizing the exoskeleton robot, the user provides the control signal for the exoskeleton, while the exoskeleton actuator provides most of the power necessary for performing the power assist [2].
Exoskeleton Arm, a battery powered upper-body robotic arm which instantly increases human strength. Exoskeleton Arm helps rehabilitate people with back injuries, allowing them to rebuild muscle and learn pneumatic control. The exoskeleton technology also aids for lifting the objects which are parts of our daily work, particularly in construction areas, delivery of large goods, etc.[3] Labour and manual transporting are the main cause of injuries in the work places, most of the injuries will affect the lower back region of workers. Exoskeleton Arm is obviously an ingenious design, which is modern, rapid – and relatively inexpensive – manufacturing techniques makes the project even more compelling. The materials used in exoskeleton arm is aluminium which is light in weight and high vibrational sustaining capability [4]. The fabrication process is conducted to achieve the following objectives: 1. Design and fabricates a low complexity and low engineering and low construction cost of a 1 DOF motion prototype upper arm (elbow joint) 2.To design a system for electro-mechanical structure of elbow joint 3.To provide a simple movement by actuation of pneumatic cylinder figure-2.

Fig. 2: Manual Lifting of Cylinders

II. COMPONENTS USED

A. Sensors Used

EMG is a medical technique for measuring muscle response to nervous stimulation. EMG is performed using an instrument called an electromyography, to produce a record called an electromyogram. An electromyography detects the electrical potential generated by muscle cells when these cells contract. EMG can be performed with needle electrodes, in order to study much localized potentials, or with surface electrodes to study larger muscle (group) contractions.

B. EMG Sensor

Electromyography (EMG) is an electro diagnostic medicine technique for evaluating and recording the electrical activity produced by skeletal muscles. EMG is performed using an instrument called an electromyography to produce a record called an electromyogram. An electromyography detects the electric potential generated by muscle cells. When these cells are electrically or neurologically activated. The signals can be analysed to detect medical abnormalities, activation level, or recruitment order, or to analyse the biomechanics of human or animal movement. The AD8232 is an integrated signal conditioning block for ECG and other bio potential measurement applications. It is designed to extract, amplify, and filter small bio potential signals in the presence of noisy conditions, such as those created by motion or remote electrode placement [5]. This design allows for an ultralow power analog-to-digital converter (ADC) or an embedded microcontroller to acquire the output signal easily. The AD8232 can implement a two-pole high-pass filter for eliminating motion artifacts and the electrode half-cell potential. This filter is tightly coupled with the instrumentation architecture of the amplifier to allow both large gain and high-pass filtering in a single stage, thereby saving space and cost figure-3.

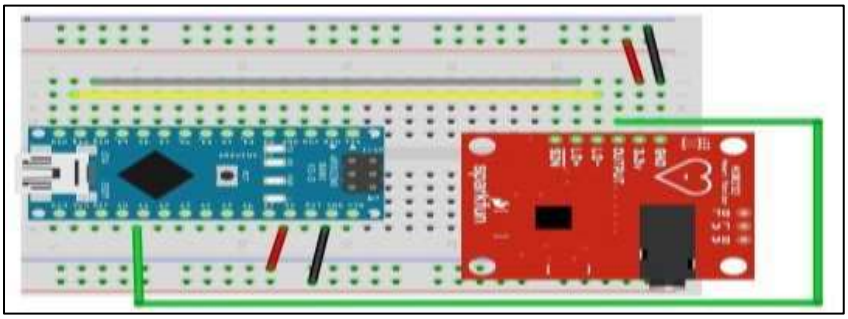

Fig. 3: AD8232

C. Controller

Arduino is a relatively easy to use microprocessor fitted to a development board. The Arduino micro can be coded in 'C' and has many easy to use libraries. Arduino is an open source computer hardware and software company project and user community that designs and manufactures microcontroller-based kits for building digital devices and interactive objects that can sense and control the physical world. An arduino board consists of an Atmel 8-, 16- or 32-bit AVR microcontroller with complementary components that facilitate programming and incorporation into other circuits. A handful of other processors have been used by arduino compatibles. Most boards include a 5 volt linear regulator and a 16 MHz crystal oscillator, although some designs such as the lily pad run at 8MHz and dispense with the onboard voltage regulator due to specific form-factor restrictions. An Arduino microcontroller is also pre-programmed with a boot loader that simplifies uploading of programs to the on-chip flash memory, compared with other devices that typically need an external programmer. At a conceptual level, when using the arduino software stack, all boards are programmed over an RS-232 serial connection, but the way this is implemented varies by hardware version. The arduino board exposes most of the microcontroller's I/O pins for use by other circuits. The arduino at mega provide 52 digital I/O pins, 3 of which can produce pulse-width modulation signals, and 16 analog inputs, which can also be used as 16 digital I/O pins. These pins are on the top of the board, via female 0.10-inch (2.5 mm) headers. The commercially available arduino at mega is shown in figure 4.2 and its pin diagram also shown. In this project, the arduino is used to fetch data from the arduino software to real time output using serial communication and the output is processed by the algorithm.

D. Pressure Control Valve

Air control valves are fundamental components of any pneumatic system. Selecting the right air control valves to regulate system pressure, direction of flow, and rate of flow is crucial when designing fluid power circuitry. If the pneumatic valve is too big for your application, you will be wasting air and money. If it's too small, the actuator will not function properly. Valves direct air flow to determine a sequence of operation in a pneumatic system. General purpose valves are typically used for controlling pneumatic cylinders. Air pilot valves are suitable for hazardous areas (or those without electrical power); choose manual valves for hand operation. Pipeline valves can control the flow of a wide range of process fluids figure-4.

Fig. 4: Pressure Control Valve

E. Pneumatic Solenoid Valve

This DCV solenoid valve has an overall length of 1.08" and height of .52" making it the ideal choice for applications where space is limited. Our 2 Way and 3 Way solenoid valves feature three connector options, leads, and plug-in connectors, to simplify installation. This versatile pneumatic solenoid valve offering includes 12 &24 Volt DC , 2-position, single pilot normally closed, spring return; 2-position, double pilot; 3position, double pilot centre closed, Single valve or multiple manifold mounted valve application figure-5.

Fig. 5: Pneumatic Solenoid Valve

F. Pneumatic Supply and Actuators

A pneumatic system would be a bit cheaper than a servo based system, but maintenance of pneumatic systems is a pain. Pneumatic Actuators as the name suggest use air as the working media. Now air is a compressible fluid which means some amount of energy is expended during the operation of the machine as waste heat due to undue expansion and compression of the working media itself. Air is more permeable in sealing materials than liquid, hence pneumatic seals are more expensive and fail more often. Air molecules being smaller pneumatic direction control valves need better sealing and closer machining (tighter tolerances) as compared to hydraulic systems. Electronic systems have it even simpler, they just need a switch, although in some cases it is programmable switch.

G. Pneumatic Cylinders

Pneumatic cylinders are known as air cylinder are mechanical devices which use the power of compressed gas to produce a force in a reciprocating linear motion. Like hydraulic cylinders, something forces a piston to move in the desired direction. The piston is a disc or cylinder, and the piston rod transfers the force it develops to the object to be moved. Engineers sometimes prefer to use pneumatics because they are quieter, cleaner, and do not require large amounts of space for fluid storage [6]. Because the operating fluid is a gas, leakage from a pneumatic cylinder will not drip out and contaminate the surroundings, making pneumatics more desirable where cleanliness is a requirement figure-6.

Fig. 6: Pneumatic Cylinders

H. Battery

An electric battery shown in figure 5.8 is a device consisting of one or more electrochemical cells that convert stored chemical energy into electrical energy. Each battery consists of a negative electrode (anode) that holds charged ions, a positive electrode (cathode) that holds discharged ions, an electrolyte that allows ions to move from anode to cathode during discharge (and return during recharge) and terminals that allow current to flow out of the battery to perform work.

I. 5V Relay

A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and they are double throw (changeover) switches. The relay's switch connections are usually labelled COM (POLE), NC and NO COM/POLE= Common, NC and NO always connect to this, it is the moving part of the switch. NC = Normally Closed, COM/POLE is connected to this when the relay coil is not magnetized. NO = Normally Open, COM/POLE is connected to this when the relay coil is MAGNETIZED and vice versa. A relay shown in the picture is an electromagnetic or mechanical relay. There are 5 Pins in a relay. Two pins A and B are two ends of a coil that are kept inside the relay. The coil is wound on a small rod that gets magnetized whenever current passes through it. COM/POLE is always connected to NC (Normally connected) pin. As current is passed through the coil A, B, the pole gets connected to NO(Normally Open) pin of the relay figure-7.

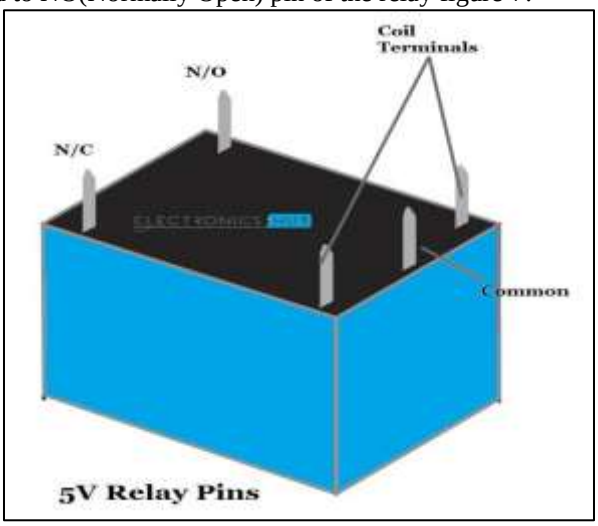

Fig. 7: 5V Relay

III. EXPERIMENTATION PROCEDURE

A. Design Calculation

1) Cylinder Diameter = 100mm
Length = 500mm
Area = (2*3.14*r*r)
= (3.14*2*50*50)
= 15700mm=15.7m
2) Volume = Area x length
= 15.7x 0.4
= $6.28m^2$
3) Force = Pressure Area
= 10 N/ 15.7
= 1 N/ 15.7
= 15.7 N
= 1.5kg

B. Material Utilizes

– For Linear Movement
- Aluminium
- Two Links

– For Upper Link

Volume = 175mm x 40mm x 6mm

– For Lower Link

Volume = 400mm x 40mm x 6mm

– For Round Shape Couple

Mild Steel

Volume = 180mm x 50mm x 2mm

IV. RESULT AND DISCUSSION

Mechanical structure of this proposed kit has been fabricated as shown in the Figure.8. It consist of three sections upper link, lower link and lifting section. Usually cylinders are used for extraction and retraction of the weight holding process. But this project cylinders are used to lift the object. Full mechanical setup has been constructed using Aluminium, because of its light weight and good tensile strength. Aluminium is superior malleability is suitable for extrusion. Weather this is metal either hot or cold, this property is also exploited in the rolling strips and foils, as well as bending and other forming operation. Mild Steel used to support the mechanical frame and holding purpose figure-8.

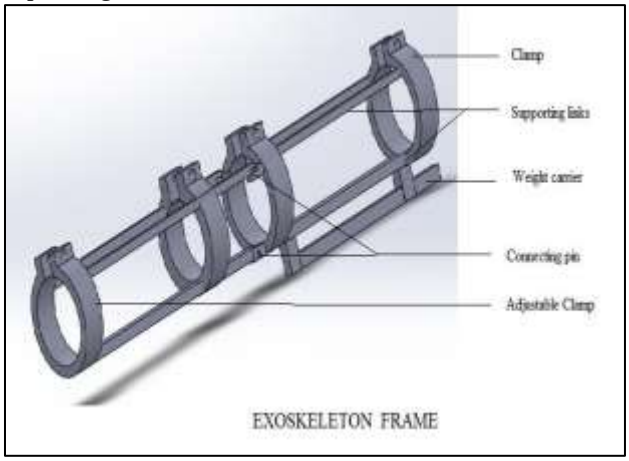

Fig. 8: 3D view of exoskeleton

In this fabricated Human Power Reduction kit, EMG electrodes are used to sense the deflection of muscles and transfer the analog signal to the IC. In that IC it has been programmed by the corresponding signals. The program has been coded on the basis of amount of deflecting signals which is transferring the signal to the board. Three electrodes has been used in the setup for acquiring the signals and the same has been wired to the IC (AD 8232) for the signals. In that kit, there are six pins are used for collecting the corresponding response and three more pins are used for collecting the muscle deflecting signals to actuate the cylinder. That six pins are connected to the arduino for achieving the cylinder actuation process. In the arduino board it has already preprogramed for the corresponding signals to actuate the cylinders. The output from the board is connected to the DCV solenoid valve for the actuation of the Pneumatic system. The solenoid used in the system is usually 3 way solenoid. The pressure from the solenoid is actually regulated by using pressure reducing valve. After the pressure has been reduced from the reducer and then passes through the T joint .Then it is separated to two cylinders. The output signals of arduino has been compared with the already programmed signal rate for extension of cylinders, if the signal is upto the desired level it will get elongation and vice versa. During the extension of the cylinder, the maximum amount of weight will be carried out by the piston itself, so the setup will provide a minimum weight to the users. Hence the kit has been used for domestic applications as well as industrial application. This kit also easy to wear and adjustable as per the required needs as shown in the figure-9.

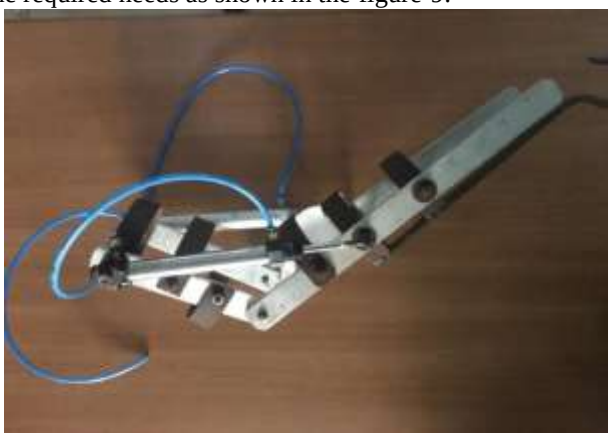

Fig. 9: Fabricated Kit

V. CONCLUSION

Hence this fabricated kit is used to lift the heavy things without manual effort and it will reduce the human efforts by 60% using the system. And some of the accidents like muscles braking, back bone disorder etc. can be avoided. Human fatigue can be minimized by using the fabricated kit. Mainly this kit is designed on the basis of ergonomics factor.With the help of this kit ergonomics factor can be fulfilled and great revolution can be brought. This will make the rise in demand for exoskeletons from the global medical and healthcare industry will become the key reason for its growth.

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