International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue V, May 2019- Available at www.ijraset.com

Exoskeleton Arm

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Abstract: Exoskeleton Arm is a supporting structure for body. The name stems from the words exterior and skeleton. The purpose of this project is to facilitate the movement of an arm by the use of an exoskeleton controlled by signals from sensor. The exoskeleton arm support system will help the user lift additional weight for day to day activities that the user is not normally able to lift. Information is sent about the user's muscle, which then gets processed through a series of filters. This signal goes to the microcontroller, performing algorithmic operations to move the cylinder depending on the flex sensor signals. The ultimate goal of this design is to produce a functional model that will help a wide variety of users.
Keywords: Exoskeleton arm, pneumatic cylinder, flex sensor, microcontroller.

I. INTRODUCTION

An exoskeleton is an external structural mechanism whose joints correspond to those of the human body. It is worn by the human and the physical contact between the operator and the exoskeleton allows direct transfer of mechanical power and information signals. Robotic exoskeletons provide the support a ravaged body that 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. For this reason, we are trying to build an efficient, lightweight, and surprisingly powerful robotic limb. To ensure a slimmer frame than other exoskeletons and make Exoskeleton Arm easier for patients to use, we have 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. Robot control varies greatly in the manner it is implemented and the type of material it uses to drive the structures. There are three drive methods or techniques to cause movements in the joints of robots. These are the hydraulic drive, pneumatic drive and the electric drive. Furthermore, exoskeletons are classified into three types:

1) *Passive Exoskeleton:* It does not require power supply, requires human efforts, helps in body posture.
2) *Powered Exoskeleton:* It requires power supply, does not require human efforts, helps to do jobs which are not humanly possible.
3) *Haptic Exoskeleton:* It is used in graphics, it used to capture motions accurately used in virtual reality.

Worn by the human, the exoskeleton transmits torques from proximally located actuators through rigid exoskeletal links to the human joints.

The same device with different control algorithms may be used in four fundamental modes of operation:

a) *Physiotherapy:* The patient wearing an exoskeleton perform a task-based occupation or physical therapy in an active or passive mode with the exoskeleton.
b) *Assistive Device (Human Amplifier):* The operator wearing an exoskeleton feels scaled-down loads while interacting with objects and the environment, most of the load being carried by the exoskeleton.
c) *Haptic Device:* The subject wearing an exoskeleton can physically interact with virtual reality objects while the forces generated through this interaction are fed back to the user through the exoskeleton conveying the shape stiffness texture or any other physical characteristics of the virtual objects.
d) *Master Device:* Replacing the virtual environment with a real robot the operator may use the exoskeleton to control a robotic system in a teleoperation (master / slave) mode, where the exoskeleton reflects back to the user the forces generated as the slave robot interacts with the environment.

Integrating humans and robotic machines into one system offers multiple opportunities for creating new assistive technologies that can be used in biomedical, industrial, and aerospace applications. One of the human limits in performing physical tasks is the muscles' strength. In addition, muscle strength may be decreased substantially as a result of verity of neuromuscular diseases, muscular atrophy, and dystrophy in disabled people. It seems therefore that combining these two entities, the human and the robot into one integrated system under the control of the human, may lead to a solution which will benefit from the advantages offered by each subsystem. The mechanical power of the machine integrated with the inherent human control system could perform tasks that need high forces in a very efficient manner. This is the underlying principle in the design of exoskeleton system.

II. RELATED WORKS

The earliest known exoskeleton-like device was a set of walking, jumping and running assisted apparatus developed in 1890 by a Russian named Nicholas Yagin. The apparatus used energy stored in compressed gas bags to assist with movements, although it was passive and required human power. In 1917, United States inventor Leslie C. Kelley developed what he called a pedomotor, which operated on steam power with artificial ligaments acting in parallel to the wearer's movements. With the pedomotor, energy could be generated apart from the user.The first true 'mobile machine' integrated with human movements was co-developed by General Electric and the United States Armed Forces in the 1960s. The suit was named Hardiman, and made lifting 110 kilograms (250 lb) feel like lifting 4.5 kilograms (10 lb). Powered by hydraulics and electricity, the suit allowed the wearer to amplify their strength by a factor of 25, so that lifting 25 kilograms was as easy as lifting one kilogram without the suit. A feature dubbed force feedback enabled the wearer to feel the forces and objects being manipulated. While the general idea sounded somewhat promising, the Hardiman had major limitations. It was impractical, due to its 680-kilogram (1,500 lb) weight. Another issue was that it is a master-slave system, where the operator is in a master suit, which, in turn, is inside the slave suit that responds to the master and handles the workload. This multiple physical layer type of operation may work fine but it responds slower than a single physical layer. When the goal is physical enhancement, response time matters. Its slow walking speed of 0.76 metres per second (2.5 ft/s) further limited practical uses. The project was not successful. Any attempt to use the full exoskeleton resulted in a violent uncontrolled motion, and as a result it was never tested with a human inside. Active exoskeletons were predecessors of the modern high-performance humanoid robots. The present-day active exoskeletons are developed as the systems for enhancing capabilities of the natural human skeletal system. The most successful version of an active exoskeleton for rehabilitation of paraplegics and similar disabled persons, pneumatically powered and electronically programmed.

III.PROBLEM STATEMENT

There are already many existing robot exoskeleton controllers. However, most of these are dependent on a computer terminal or mainframe to operate. Although the computer is a powerful computational device, physically, a personal computer still takes too much space and is heavy to move from one location another. This makes the robotic controllers attached to them inherit their properties of bulkiness and virtual immobility. Moreover, such designs also require the users to first understand their programs to properly operate the system. A user may need an additional background on how to operate a computer and interface the controller with it. As such, a non-technical person may find it hard to understand how such a device may work.

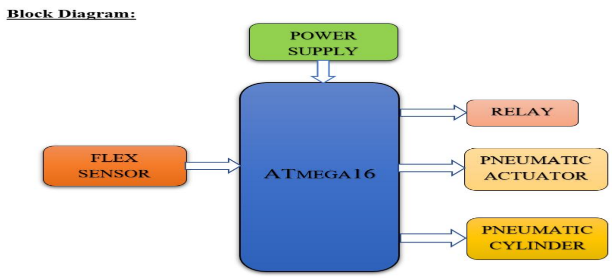
To answer these problems and at the same time provide an advanced feature, the project aims to develop an exoskeleton control for a prototype robotic arm that is:

1) Stand-alone, meaning it should be independent on any computer to perform its tasks;
2) Portable, meaning it should be small and light enough to be carried anywhere and plugged into any power source;
3) Programmable, meaning it should provide an option for the users to record a series of actions and be able to playback or perform the action repeatedly. This feature allows the transformation of the exoskeleton controller to a preprogrammed controller; and
4) User-friendly, meaning it should be comfortable enough to wear, easy to use, understand, and maintain.

IV.SYSTEM ARCHITECTURE

Our system is an Atmega16 based exoskeleton arm which uses codes as an encryption method for the proper lifting up an object. The user can pick up objects which are beyond his capability. The entire system is very easy to use. This exoskeleton arm is so user friendly that the user can easily operate it. The exoskeleton arm controlling motor and circuit is setup on backpack which allows the user to carry this entire system with him or her anywhere he wants.

The proposed model includes:



A. Flex Sensor.

Sensor plays an important role in robotics. Sensors are used to determine the current state of the system. Robotic applications demand sensors with high degrees of repeatability, precision, and reliability. Flex sensor is such a device, which accomplish the above task with great degree of accuracy. Flex sensors are analog resistors. These resistors work as variable analog voltage divider. Inside the flex sensor are carbon resistive elements with thin flexible substrate. More carbon means less resistance. When the substrate is bent the sensor produces resistance output relative to the bend radius. The flex sensor achieves great form-factor on a thin flexible substrate.

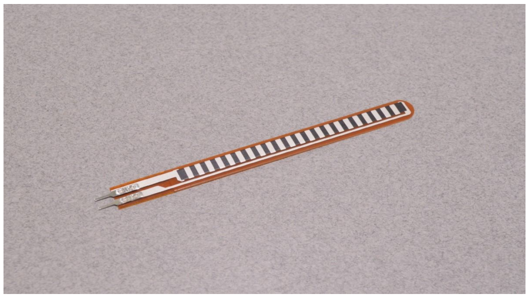


Fig-1: Flex Sensor

B. ATmega 16 Microcontroller.

Through the flex sensor signals, information is sent about the user's muscle, which then gets processed through a series of filters. This signal goes to the microcontroller, performing algorithmic operations. The relay become ON depending upon controller signal. The actuator actuates depending upon relay condition.

ATmega16 is a 8-bit Microcontroller with 16K Bytes In -System Programmable Flash. The microcontroller is based on the Atmel AVR enhanced RISC architecture. It executes instructions in a single cycle.

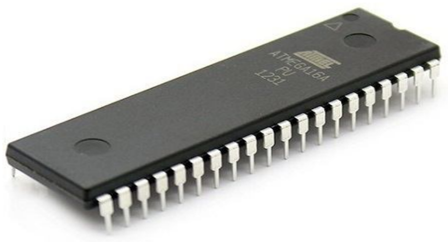


Fig-2: ATmega 16 Microcontroller

C. Pneumatic System.

The Pneumatic system consist of two parts that are pneumatic actuator and pneumatic cylinder.

1) *Pneumatic Actuator*: A pneumatic actuator is a device that is capable of converting energy from a pressurized gas into motion. Pneumatic actuators can be used to produce both rotary and linear motion and are usually powered by an electric compressor. In this actuator, the volume of the cylinder changes, aiding performance according to thermodynamic principles.
2) *Pneumatic Cylinder:* Pneumatic Cylinder are mechanical devices which use the power of compressed air to produce a force in reciprocating linear motion. the piston is a disc or cylinder and the piston rod transfers the force it develops to the object to be moved.

Fig-3: Pneumatic Cylinder

3) *Pneumatic Flow Control Valve: Flow Control Valves are used to reduce the rate of flow in a section of a pneumatic circuit, resulting in a slower actuator speed.*

Fig-4: Flow Control Valve

4) *Additional part:* The other important part of the exoskeleton arm is the skeleton. The aluminium alloys are used as they are lightweight. Initial exoskeleton experiments are commonly done using inexpensive and easy to mold materials, such as steel and However, steel is heavy and the powered exoskeleton must work harder to overcome its own weight in order to assist the wearer, reducing efficiency. As the design moves past the initial exploratory steps, the engineers move to progressively more expensive and strong, but lightweight materials, such as titanium, and use more complex component construction methods, such as molded carbon-fiber plates, and many more.

V. CONCLUSIONS

In this paper a prototype exoskeleton is proposed. This exoskeleton provides for the stroke patients, who have lost the movement ability of one arm or too weak to do some movements, to perform the rehabilitation exercise based on guidance from patient's own healthy arm. Above figure shows the generalized block diagram of the microprocessor-controlled exoskeleton arm. An initial prototype of the exoskeleton arm has been built and tested.

VI. APPLICATIONS

A. Primary use of Exoskeleton Arm is for heavy lifting as follows,
1) *Military:* It would enable soldier to carry heavy objects (80–300 kg) while running or climbing stairs.
2) *Civilian:* In day to day activities by housewives for heavy lifting.
3) *Rescues:* it can be used by fireman to go into risky and hazardous environment for rescue operations. It can be used to rescue people from the remains of destroyed buildings during natural disaster like earthquake.
4) *Labours:* Wearable exoskeleton allows the wearer to lift 10 times as much as they normally could.

B. Other use will be for people with arm injuries.

C. People in who suffer from muscle weakness or loss of movement in a group of muscles.

D. Provides an innovative approach to physical therapy in cases of injury and muscle disorders and diseases.

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