THE EXO-ARM

THE FIRST STEP TO REAL LIFE IRON SUIT

[1]Tahir Showkat Bazaz, [2]Safura Hameed, [3]Munazah Shahdad, [4]Mohsina Manzoor, [5] Mehnaz Sibtain

[1]Junior Engineer, [2]B. E ECE, [3,4,5]B. E Electrical
[1]BSNL India, Srinagar, J&K
[2,3,4,5]Kashmir University, Srinagar, J&K.

Abstract

The aim is to design and fabricate a wearable robotic device that can be used for upper limb rehabilitation by stroke survivors who are struggling with paralysis in their arm and have lost the arm motor function due to sport injury, trauma, industrial injury or weakness in elderly people. Even nowadays in youth, the problem of cervical spondylosis has been increased tremendously. The Exo-Arm may be thought of as a part of superhero's costume but this idea is totally for an ordinary person, for his convenience. It is a rigid robotic design that would be worn by the user. It is a battery operated frame that will work on a windshield motor and will function as an assistive device to move the user's arm. Our prototype consists of a strong, reliable and rigid outer structure or frame made of iron and wood to provide proper support to arm. It consists of Arduino microcontroller, a motor driving IC and a motor. The lifting and releasing of the arm is controlled by a switch. After fully assembling the design, the hardware part and the frame part of our prototype was not more than 1kg and could easily lift up to 9kg of distributed weight. Though many Exoskeltons have been made, they are either expensive to buy or too bulky to carry. This prototype meets all the weight/volume/price requirements, and has a quick operation time.

IndexTerms– Arduino Nano, Windshield Motor, L298N IC.

MOTIVATION

The use of robotic devices in upper limb rehabilitation is seen to have started in the early 1990s. From then, many research groups have developed robotic devices for rehabilitation of stroke patients who lost their arm motor function. Authors have made an extensive review on the devices that have been used till date. Moreover, robotic devices have the potentiality ofbeing used in providing therapy for a long period of time irrespective of skills and fatigue compared to manual therapy. These emphasize the incorporation of robotic devices in rehabilitation therapy of post-stroke patients. Also, robotic devices can work in multi degrees of freedom with virtual reality interface and provide therapy ranging from passive to active rehabilitation. Thus integration of robotic therapy into current practice could increase the efficiency and effectiveness of therapists by alleviating the labour-intensive aspects of physical rehabilitation. Furthermore previous literature advocates that robot-assisted rehabilitation in post-stroke individuals have advantages in terms of clinical and biomechanical measures to regain arm motor function in comparison to conventional treatment. Indeed performing repetitive movements with the affected limb of the post-stroke patient obtain functional gain thereby an increase of motivation which helps to use arm further. The robotic devices have been incorporated in physical therapy and rehabilitation program for stroke patients from two decades ago. From then, researchers have developed devices both end effector type and exoskeleton type to use in rehabilitation of affected upper limb.

PROBLEM DESCRIPTION

1. Approximately 800,000 people suffer from stroke each year, and more than 140,000 people die as a result . The most common type of stroke is an ischemic stroke, which accounts for 80 percent of occurrences and it commonly leads to a disability of a part of the body, called paralysis, due to unstable connection between the brain and muscular system. Statistically, 9 out of 10 patients who survive from strokes experience paralysis. If the patient experiences paralysis, physical therapy is needed for recovery and these rehabilitative measures can require long and intensive effort to relearn and regain their ability of physical movement and coordination. Studies confirm that robotic assistive trainings can be more effective than conventional therapy. One study showed that after 6 months, patients with the robotic devices had an increase in kinematic movement of 5% over the conventional therapeutic group and a 30% bigger gain of strength. Another benefit is the larger motivation with the robotic devices that the patients using robotic devices had higher attention and motivation levels, expediting motor control recovery within the same amount. Conclusively, compared with conventional therapy techniques, robot assisted rehabilitation processes have advantages of not only in biomechanical measures but also in terms of clinical measures. Exoskeleton technology has become an emerging field of engineering not only in augment human capabilities, but in rehabilitative settings as well.
2. According to American heart association reports, approximately 785,000 persons experienced a new or recurrent cerebral vascular accident (CVA) or stroke annually in the United States among which number of deaths estimated at 58000.Stroke is a leading cause of serious long-term disability in the United States. The number of

people living with stroke is projected to increase by 4 million by 2030 in the USA. A large number of survivors following a stroke experience a disability like impaired upper limb resulted by loss of partial or full mobility. Physical disability due to sickness is quite common, this is a start of a long battle. 50-80% people are left unaffected due to the physical therapy, as physical therapy is not budget friendly. Most of the people cannot afford it. Even physical therapy doesn't guarantee full recovery. Moreover, physical disabilities such as full or partial loss of function in the shoulder, elbow or wrist are a common impairment in the elderly people. This impairment yields several impacts on domestic life, social life as well as economy of the country. The individuals those got a stroke, require incessant medical care and intensive rehabilitation often requiring one-on-one manual interaction with the physical therapist However, present demands and budget restrictions makes the duration of rehabilitation program shorter.

3. Industrial injury or physical disability due to sickness is very common. The accident rate is increasing rapidly day by day. In various industries labour and manual transporting are the main cause of injury, 4 out of 5 people suffer from injuries.
4. Considering the problem from our home only. A common problem in grandparents and elderly people is weak bones or problem in nerves due to which they need the support from other person to do their basic day today work. The shoulder being complex to be handled loses its arm motor function easily even if you perform basic necessities in a normal day routine say(carrying heavy backpack, writing more than 2 pages, accessing mobile) for a long time. Cervical spondylosis and disk rate was usually observed in people aged above 35 but nowadays these problems are encountered in youth as well. Physical therapy and even surgeries is an option but not a cure.

OUR SOLUTION

The Exo-Arm that we have designed is a device that can be used as a rehabilitative device used to relearn motor function and to rebuild muscles for those who have lost arm motor function. It's used to augment the strength in people in need of it. Compared to manual arm training, robot supported training can be more intense. As physical treatment and taking medicine can't guarantee full recovery. Other features of our solution include:

- It helps to lift objects as a part of daily life.
- It helps a wearer to lift 8-12kg of weight.
- It increases human strength and augments arm strength.
- It is affordable.
- As this device may be used by elderly people, it is light in weight and portable.
- The entire system is automatic and the motor part is placed in the backpack to provide support to the back. It makesthis device more powerful and strong.
- In a layman language it is a battery operated frame with a backpack.
- We can have various types of exoskeletons for legs and back part.
- For children we can model pieces of the frame using 3D printer eventually making most of the components light in weight.
- Sensors can be used to measure the range of motion to track rehabilitation programme.
- Safety: Wehave kept all the electronics housed. No wires is left open. Ease of device is considered.Noise level is managed. As the arm joint is weak and the device may be used by elderly people, the device should be properly tightened so that no slipping of the device occurs and for that purpose, belts are used to fasten the device.
- Material used: One of the user requirement is being comfortable. Human comfort is directly related to temperature and humidity of skin.Generally, the optimum condition is the combination that allows moisture to evaporate from the body at a rate at which body temperature is maintained. According to the article "Materials matter in wearable medical devices" by Norbert Sparrow, fiber - reinforced liquid silicone rubber (LSR) is the prime candidate for wearable devices.
- Battery: LiPo battery is used, these batteries are rechargeable and can last upto 12 hours, sufficient for our device.

HARDWARE COMPOSITION

The system uses Motor (windshield Motor), Arduino Nano, Voltage regulators (7805), Motor driver IC (L298N), Connecting wires, Buttons (2), Resistors (2), External frame for arm (aluminium / iron / wood), Belts to fasten the arm, Screws and nuts, PCB board, Battery(12V), Header pins and Jumper wires.

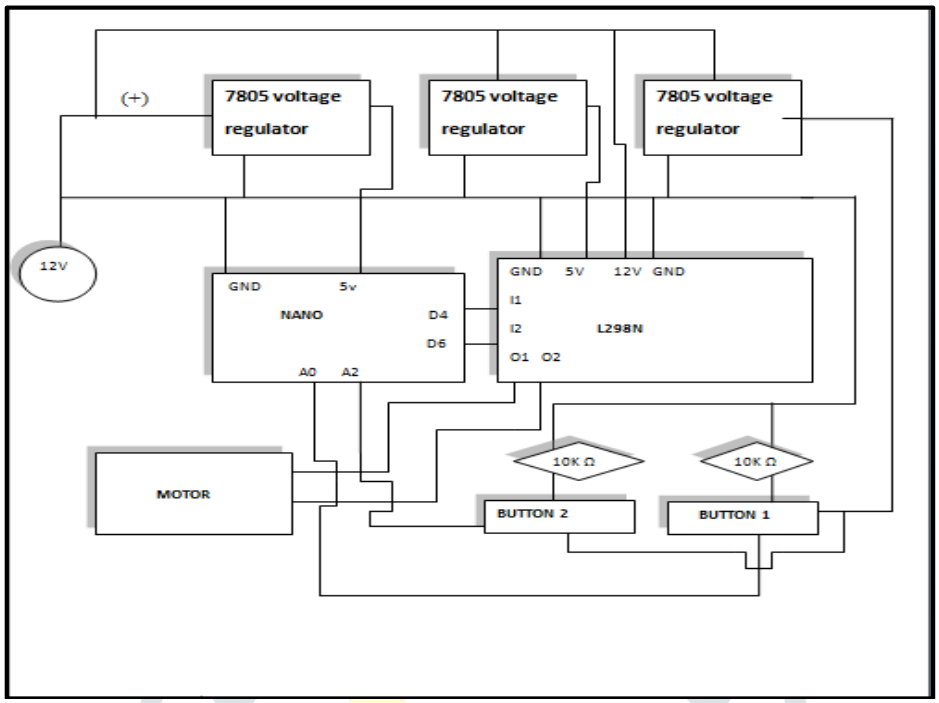
SOFTWARE AND PROGRAMMING USED

Arduino IDE
Embedded C/C++

Methodology

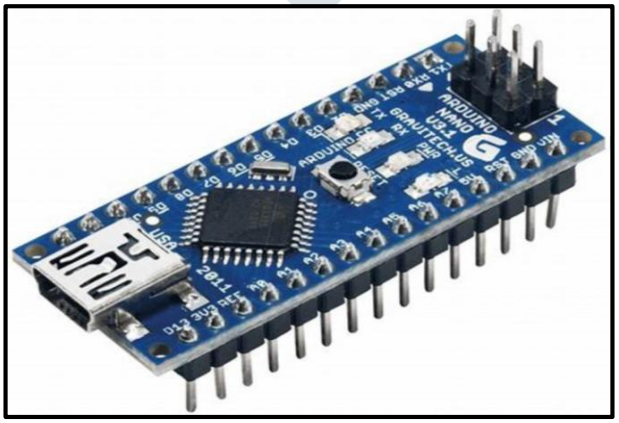
The Exo-Arm consists of a frame that is worn by the user. It is an eco-friendly structure with soft foam for extra safety. The belts are fastened by proper screws and bolts. The circuitry is based on a 5V powered micro-controller (Arduino), 12V powered Hyundai Glass motor and 12V external power source. There are 2 buttons, one gives the arm clockwise motion and the other gives it the counter clockwise motion. When a button is pressed, it sends a HIGH

signal to Arduino which in turn sends the specific signal to the motor driving IC L298N, that moves the motor clockwise or counter clockwise depending on the code uploaded in Arduino. To ensure safety, no motion is activated if both the buttons are pressed simultaneously. Arm rotation is not bounded by the micro-controller but it is limited by the hardware modelling. A 12V DC source is required for providing voltages to all the components. The L298N IC has 2 input pins and 2 output pins. The two input pins are connected to the digital pins of Arduino and the two output pins of L298N IC areconnected to the motor so that the DC motor operates in the desired direction. One terminal of the button is fed with 5V and the other terminal of button is connected to a resistor which in turn is connected to common ground. The terminal of the button that is diagonal with the 5V terminal is connected to the analog pin of the Arduino. The two input pins of the IC are attached to Arduino Nano that helps us in mentioning whether the motor moves in clockwise or counter clockwise direction. The resistor that is connected in series with the button acts as pull down resistor.



FIGUREI: Circuit Diagram

I. Arduino Nano



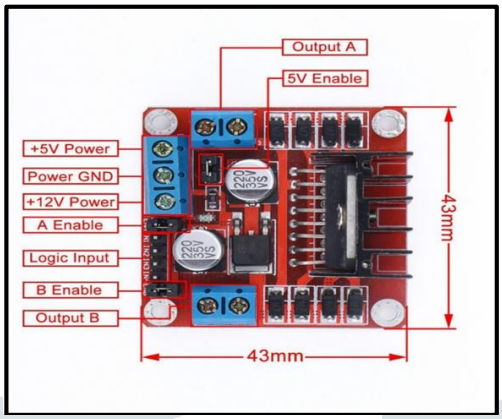
FIGUREII: Arduino Nano

Arduino is an open-source platform used for building electronic projects. Arduino consists of physical programmable circuit board (often referred to as a microcontroller) and a piece of software, or IDE (Integrated Development Environment) that runs on our computer and is used to write and upload computer code to the physical board. Ithas aATmega328 microcontroller, an eight (8) bit microcontroller

that can handle the data sized upto eight (8) bits at a time. It has abuilt-in internal memory of around 32KB.

L298N IC and buttons are connected to Arduino Nano. Arduino Nano keeps on checking the status of the buttons. When any button is pressed, a particular pin of Nano goes HIGH and a specific signal is sent to L298N IC to move the motor in the desired direction.

II. L298N MOTOR DRIVER IC



FIGUREIII: L298N IC

It's a typical motor driver IC which allows dc motor to drive in either direction. It's a 16 pin IC which can control a set of 2 dc motors simultaneously in any direction. It works on 12V as well as 5V supply. It gets activated due to 5v supply after being regulated by voltage regulator and further it provides 12V to the motor and drives the motor.L2N8N is a dual H-bridge motor driver IC. Motor driver acts as a current amplifier since it takes a low current control signal and provides a higher current signal. This higher current signal is used to drive a motor. It uses 5V for its own power and external power source is needed to drive the motors, which can be up to 36V.

III. BUTTON

FIGUREIV: Button

A push button is a simple type of switch that controls an action in a machine or some type of process. Most of the time, the buttons are plastic or metal. The push button can be normally open or normally close.Push button switches are popular in a variety of different applications, including calculators, push button phones and many home appliances. In our device, push buttons act as inputs to Arduino for moving the motor. Motor remains in motion until the button is pressed and stops the movement as soon as the button is released. This helps in providing the desired movement to the arm.

CONCLUSION

Rehabilitation robots have become important tool in stroke rehabilitation. Compared to manual arm training, robot-supported training can be more intensive, of longer duration and more repetitive. Therefore, robots have the potential to improve the rehabilitation process in stroke patients. Whereas the majority of previous work in upper limb

rehabilitation robotics has focused on end-effectors-based robots, a shift towards exoskeleton robots is taking place because they offer a better guidance of the human arm, especially for movements with a large range of motion. However, the implementation of an exoskeleton device introduces the challenge of reproducing the motion of the human shoulder, which is one of the most complex joints of the body. Thus, this paper presents a simplified model of the human shoulder and upon completion of manufacturing and assembly, our team was left with a device that could be independently worn on the arm and actuate motion along a desired range of motion

STRUCTURE OF EXO-ARM AT 180^0

FLEXED POSITION OF EXO-ARM

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