# Fabrication of Tilt Sensor Based Exoskeleton Arm

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*Abstract*— Exoskeleton robotics has grown enormously in this new era of modern neuromuscular rehabilitation engineering and assistive technology research. With creative imagination and more subtle approach towards engineering has led to the development of the exoskeleton. Exoskeletons are wearable electromechanical devices that have been developed as augmentative devices to enhance physical performance of the wearer or as orthotic devices to gait rehabilitation or locomotion assistance. We have outlined the process of developing an exoskeleton arm prototype which will help in rehabilitation of the post-stroke patients. Our prototype will be a low-cost, ergonomic device actuated through tilt sensor measuring the user's motion. Doctors can use this exoskeleton to use in physical therapy of their patients. With its low cost, hospitals could employ multiple devices and aid a larger audience of patients. Patients can use these in their homes for physical therapy and it will decrease the manpower and the necessity to travel to the hospital.

***Keywords:*** Tilt Sensor, Exoskeleton, Rehabilitation

## I. INTRODUCTION

Exoskeletons are wearable devices that work in tandem with the user. Exoskeletons are placed on the user's body and act as amplifiers that augment, reinforce or restore human performance. Exoskeletons are a type of skeletal architecture that surrounds the wearer instead of the traditional internal design. Exoskeleton wearable robots follow the same principle of having the pivotal structures outside its user allowing the mechanical system to be used as a suit.

These devices are usually anthropomorphic in nature, as they mechanically interact with the human upper-limb musculoskeletal structure. They share broad areas of application, e.g., power amplification in an industrial environment, neuromuscular impairment compensation or post-stroke rehabilitation, and support for disabled people in their activities of daily living.

An exoskeleton could reduce the number of therapists needed by allowing even the most impaired patient to be trained by one therapist, whereas several are currently needed. Also, training could be more uniform, easier to analyze retrospectively and can be specifically customized for each patient.

The exoskeleton is designed and built in such a way that it helps in the common movement of the arm. As a result, the arm diminishes the strain on the hand by producing mechanical work. This exoskeleton arm resembles a helping gadget which enables the human arm to move without hassle.

## II. LITERATURE SURVEY

[1]Guangye Liang, Wenjun Ye, Qing Xie. They developed a robotic exoskeleton used for rehabilitation of upper extremity. They designed a cascaded controller for each joint, which consists of speed loop and a position loop, based on the PID control method.

[2]Thunyanoot Prasertsakul, Teerapong Sookjit, Warakorn Charoensuk. The proposed exoskeleton arm has five degrees-of-freedom. Three degrees-of-freedom are at the shoulder joint, i. e. flexion/extension, abduction/adduction and internal/external rotation. The elbow joint has two degrees of freedom that are flexion/extension and supination/pronation. The exoskeleton arm can be controlled by the electromyography signals and a set of controllers which composes of the electromyography amplifier, analog to digital convertor, motor control and motor driver. Computer interface was utilized for design and development of the exoskeleton arm through simulation.

[3]Crocher et al. explored the programmable of upper extremity exoskeleton in impose certain joint coordination patterns during rehabilitation. Due to the conventional rehabilitation for upper limb involves the interaction with both upper arm and lower arm, it is expected that the robotic rehabilitation exoskeleton can cover both the endpoint control and inter-joint synchronization. An ABLE exoskeleton has been employed in their study.

[4] Mohammad H. Rahman, Maarouf Saad, Jean P. Kenné. They developed an exoskeleton robot(ExoRob) to rehabilitate upper limb motion. It comprised of seven degrees of freedom to enable naturalistic movements of the human upper-limb. A kinematical model of ExoRobi's developed here is based on Denavit- Hartenberg notations.

[5] Abhishek Gupta and Marcia K. O'Malley. In this paper, the authors present a detailed review of the requirements and constraints that are involved in the design of a high-quality haptic arm exoskeleton. Quality haptic interface is typically characterized by low apparent inertia and damping, high structural stiffness, minimal backlash, and absence of mechanical singularities in the workspace. In addition to these specifications, exoskeleton haptic interface design involves consideration of space and weight limitations, workspace requirements, and the kinematic constraints placed on the device by the human arm. These constraints impose conflicting design requirements on the engineer attempting to design an arm exoskeleton.

[6] Markus Puchinger, Nithin Babu Rajendra Kurup, Thomas Keck, Johannes Zajc, Michael Friedrich Russold and Margit Gföhler. They developed an exoskeleton for the disabled. The recovery of arm movements is one of the most important goals in the process of rehabilitation in order to avoid long term disability. In this study, the reduction of muscle activities and muscle forces with the gravity compensated RETRAINER upper limb exoskeleton were analyzed carrying out defined movements with healthy subjects.

[7] Urs Keller, Hubertus J. A. van Hedel, Verena Klamroth-Marganska and Robert Riener. ChARMin is the first actuated exoskeleton robot for pediatric arm

 

rehabilitation. The device was specifically designed to provide intensive rehabilitative training for children with affected arm motor function, e.g., due to cerebral palsty, therewith complementing conventional therapies.

[8] Yong-Kwun Lee, in this paper the author gives a detailed review of his design i.e., hand and arm movement disorders can be caused by stroke, fractures, ligament tear or loss of strength due to aging. Stroke is a disease accompanying partial paralysis in the muscle contraction and expansion, but stroke patients can be improved by rehabilitation training or physiotherapy. To increase the effectiveness of rehabilitation training, continuous and repeated movement training with a physiotherapist is needed and enhancement can be achieved in the process by using such designs.

## III. OBJECTIVES

The following objectives were made and are listed below:

1) To develop a prototype project of Tilt sensor-based exoskeleton arm.
2) To reduce human effort by lifting certain amount of weight.
3) To reduce the size and weight of the device to prevent the fatigue of the handicapped and disabled people.
4) To preserve the comfort of the user and to provide safety.

## IV. MATERIALS AND METHODOLOGY

### A. Materials Used

Our prototype is an Arduino based exoskeleton arm which uses a tilt sensor as a method for the movement of the arm. The exoskeleton is very convenient to use and hence can be easily operated. The materials used in the development of our project are as follows:

1) Aluminum flats
2) Tilt Sensor
3) DC Motor
4) Arduino UNO Microcontroller
5) 2 channel Relay
6) Li-ion Battery
7) 10mm nuts and bolts
8) Velcro straps

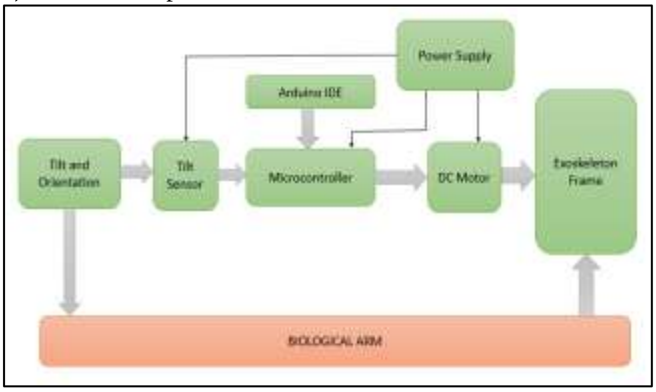


Fig. 4.1: Block diagram

1) *Tilt sensor:*

A tilt sensor is an instrument that is used for measuring the tilt in multiple axes of a reference plane. Tilt sensors measure the tilting position with reference to gravity and are used in numerous applications. They enable the easy detection of orientation or inclination.

2) *Arduino Uno:*

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller, simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

3) *DC Motor:*

Wiper motors rotate in a continuous motion and run on DC voltage. Since they run on DC, the motors can be sped up and slowed down based on the voltage level applied to them, and the direction can be reversed by reversing the power leads.

4) *Relay:*

A relay is an electrically operated switch. It consists of a set of input terminals for a single or multiple control signals, and a set of operating contact terminals. Relays are used where it is necessary to control a circuit by an independent low-power signal, or where several circuits must be controlled by one signal

### B. Methodology

The step by step method we took to complete our project is shown below:

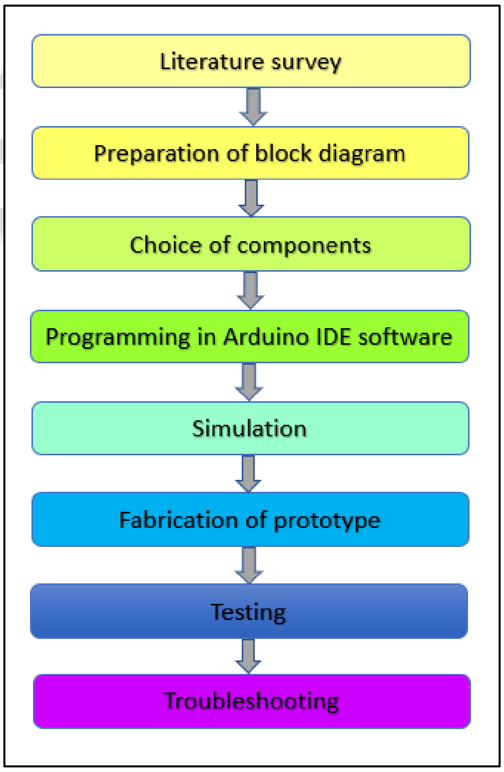


Fig. 4.2: Methodology

### C. Working Description

The exoskeleton arm consists of an embedded system consisting of Tilt Sensor, Arduino UNO Microcontroller, DC Motor, 2 Channel Relay and a Battery. In this work, Arduino board is used as user interface. The Microcontroller is programmed using Arduino IDE software which makes it operations in controlling the arm as per the commands coded in the program. This arm exoskeleton is driven and fully controlled using the tilt sensor and the DC motor. The tilt sensor passes the received electrical signals based on the commands from microcontroller for the prescribed movement of the hand when the power supply is given from the battery. In which the movement or the tilt of the arm is sensed by the sensor module. The input obtained from the sensor module is used to drive a microcontroller-based control circuit. The microcontroller is programmed in such a way that it produces the required output for the corresponding hand movements. The output of the microcontroller is given to the DC motor, which can control the direction of the motor. The DC motors actuate the motion by rotating in Clockwise or Counter clockwise directions making the exoskeleton to move upwards or downwards.

### *D. Flow chart*

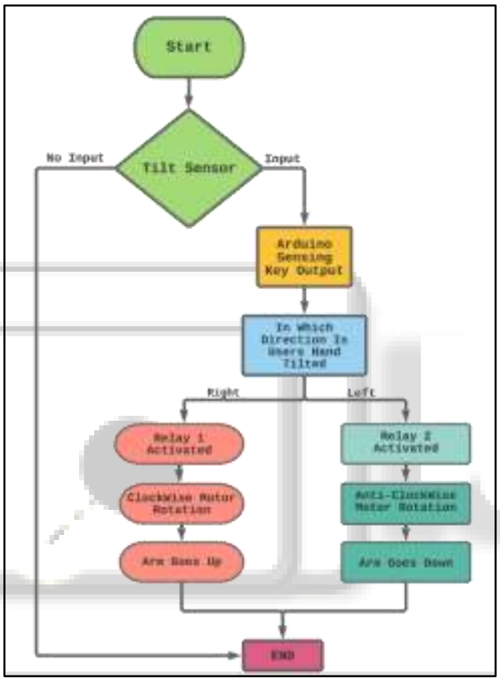


Fig. 4.3: Working of the exoskeleton arm

## V. RESULTS AND DISCUSSIONS

The frames were designed keeping in mind the average dimensions obtained from a survey of various human upper limb sizes. The Battery Powered Human Exoskeleton Arm was fabricated successfully as per the predefined metrics. The Prime material used for fabrication of the exoskeleton is Aluminium which reduced the overall weight of the assembly. With using tilt sensors, the microcontroller could process the signals and the embedded system could control the motor which is the power house of the exoskeleton, the muscle effort was considerably reduced. The fabricated tilt-sensor based Exoskeleton arm is economical, aesthetic, reliable, portable and ergonomic. The exoskeleton arm proves to be an excellent assist tool for the physically weak individuals. The exoskeleton arm is just the beginning of a potential power enhancing exoskeleton suit which is the technology of the future. The exoskeleton arm (by incorporating tilt sensor) can be an initiative to the advancement of mankind's perception of technology.

## VI. CONCLUSION

The proposed exoskeleton arm prototype has successfully replicated the elbow motion. The prototype exoskeleton arm is easy to use, safe, light-weight and portable making it more efficient. The batteries are rechargeable hence they are eco-friendly as well. Now the exoskeleton industry is gradually emerging and is making a huge impact in the market sector. Since the exoskeleton arm is user friendly and of low cost there is a great potential for the industry to be profitable in the near future.

### *A. Snapshots of our project*

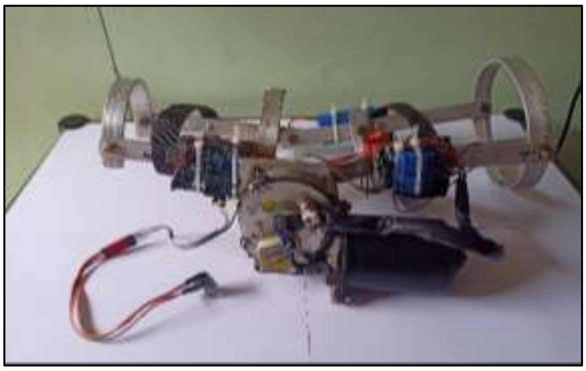

Fig. 6.1: Left-side view

Fig. 6.2: Right-side view

Fig. 6.3: Top view

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