Team EE # 10 / ME # 29 Strength Assisting Orthotic

FAMU-FSU College of Engineering

Team Members: Ryan Whitney, Derek Pridemore, Robert Slapikas, Jared Andersen, Donglin Cai

Team Faculty Advisor: Dr. Patrick Hollis

Introduction

A strength assisting orthotic has a large market of use, and similar projects are being researched and developed around the world. A device like this has civilian, military and rehabilitation applications in its ability to assist lifting strength and stability. To make an orthotic that is useful, it is important that it will be lightweight and non-invasive to the natural movement of the user. Previous orthotics are bulky, heavy, and limit the user's movement.

Background

In order to develop the device, the load must be modeled. The greatest torque that will be applied to the arm will be when it is at 90 degrees, or perpendicular to the ground, where gravity will be the greatest. It is necessary for the motor to be able to handle the load at this point in order for the load to be lifted successfully by the device. We used the maximum length of the forearm to find the greatest torque applied at the point of actuation the elbow. Since the length of the arm has a adjusting forearm length and upper arm length 95% of earth's population will be able to use the strength assisting orthotic.

$$\tau_{load} = (mass)*(gravity)*\sin(\theta)*(Length_{Forearm})$$

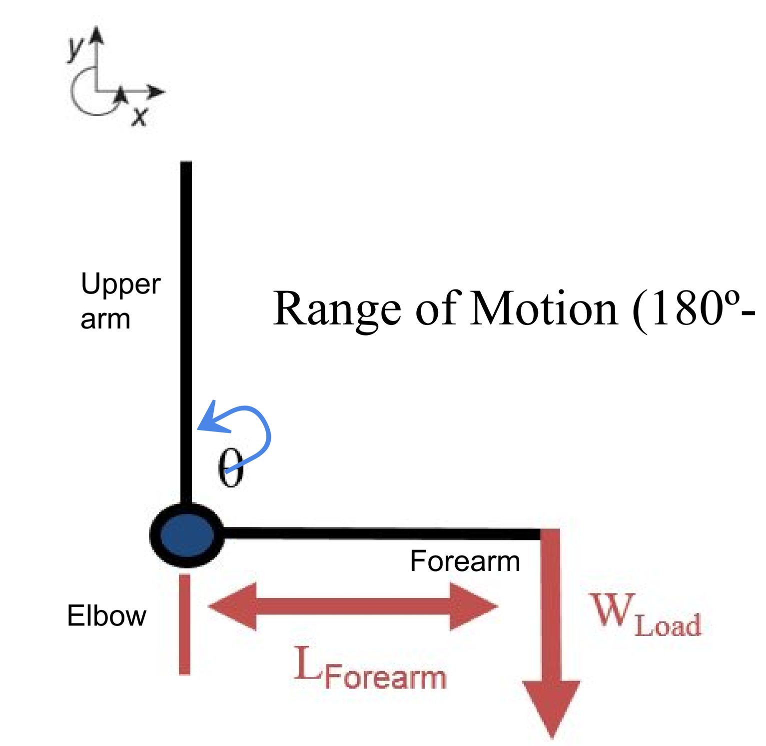

Figure 1. Modeling of the Load

This project is sponsored by the FAMU-FSU College of Engineering and by Dr. Devine, head of the business program at the FAMU-FSU College of Engineering.

Objectives and Constraints

- The goal of this project is to create a strength-assisting orthotic that increases the curl strength of the user by 20 pounds.
- Minimal objective is to lift a paper cup, for the arm to basically lift its own weight.
- Primary objectives for this project are safety, low cost, and limited loss in mobility.
- Constraints are safety, weight, strength, lifespan, and versatility.

System Overview

- Safety is a key priority in this system.
- System has multiple redundant safety features, both mechanical and electrical.
- Electrical energy is being converted to mechanical energy to provide the necessary torque.
- The worm gear serves to reduce RPM to a safe speed and increase torque to lift the goal of 20 pounds.
- The 24V battery will be used for both the motor and the microcontroller with a voltage regulator to decrease voltage for the Arduino.

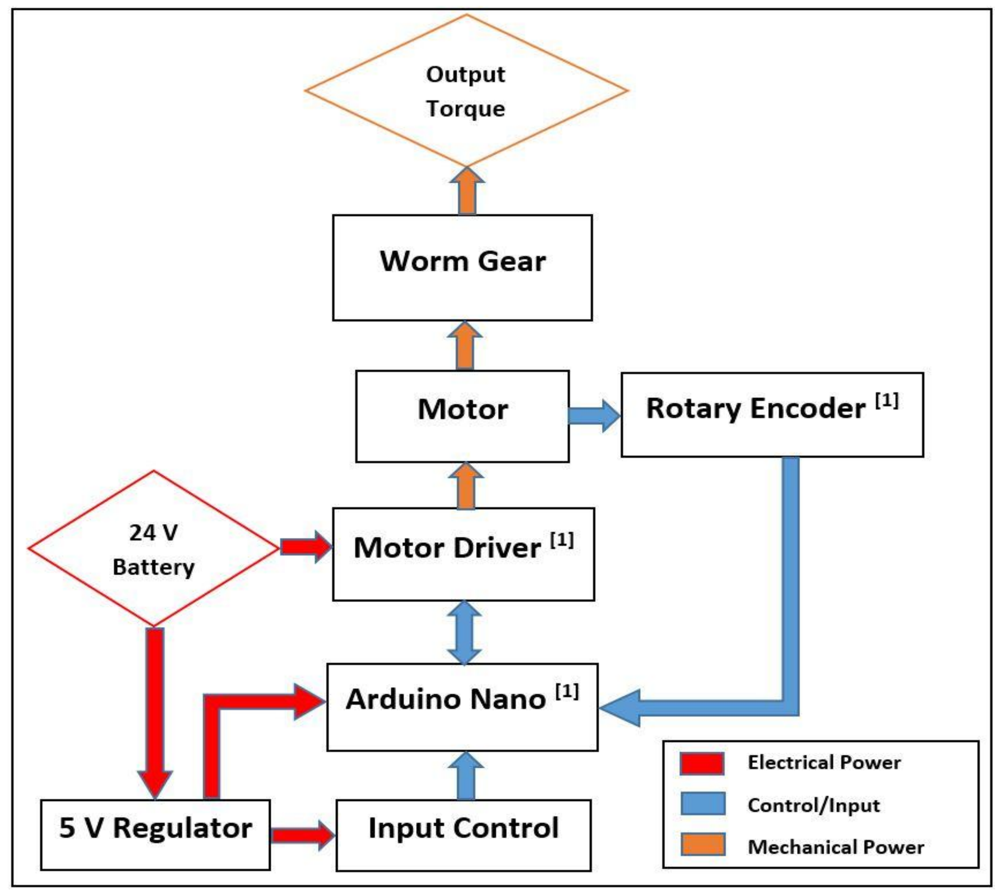

Figure 2: System Block Diagram

Frame

- The frame of the frame of the arm will consist of aluminum and steel.
- Length of the forearm: max of 53 cm and a min of 38 cm.
- Length of upper arm: max of 58 cm and a min of 40 cm.
- There is a 35 degree cut in the frame to stop the contracted arm and a 180 degree cut inside of the elbow to stop the arm at complete extension.
- Actuation will occur at the elbow with the use of a worm gear.
- A double u joint will be used to simulate a shoulder joint.

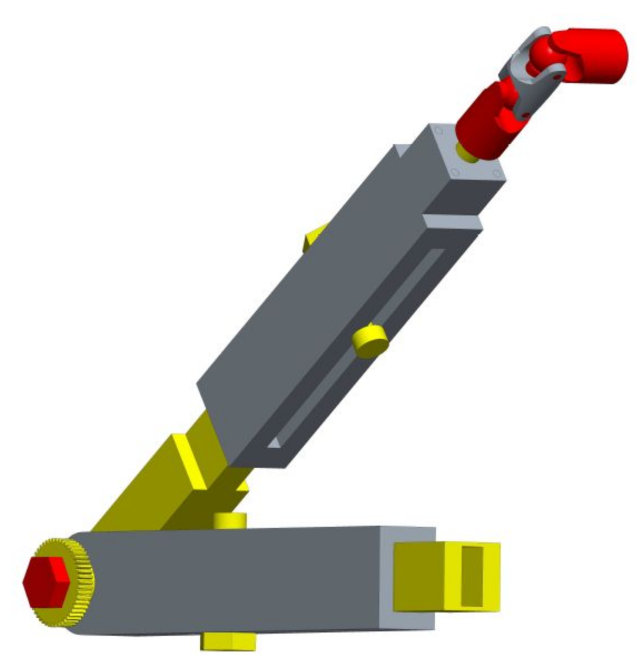

Figure 3: Frame at Minimum Angle

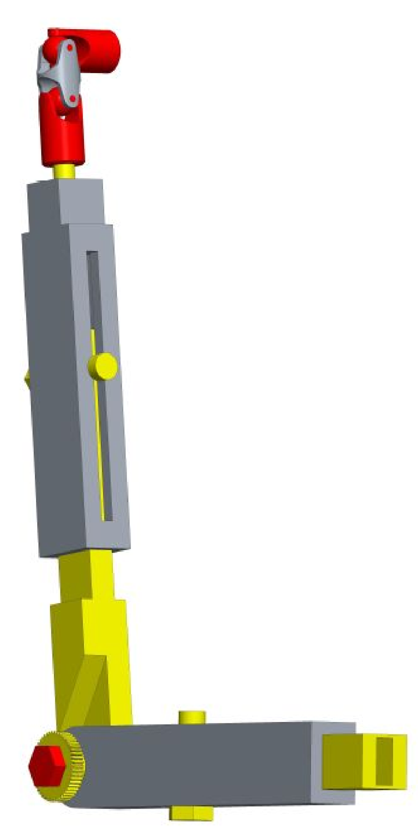

Figure 4. Frame at Maximum Torque

Electronics

- The Arduino controller is chosen for its ease of use and expansive code libraries.
- The driver will be bought pre-made, and implement some convenient safety features out of the box
- It will be controlled by an Arduino Nano.
- The motor chosen will provide the necessary torque and RPM as calculated.
- The rotary encoder will be used for an extra safety precaution only.
- Initial prototype will use two push buttons as input controls, one for up and one for down.

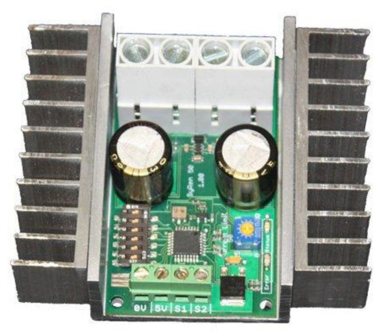

Figure 5: SyRen 50A Regenerative Motor Driver

Figure 6: Arduino Nano

Safety Features

- In order to provide a reasonable amount of safety while performing R&D on this project, a number of safety features will need to be implemented.
- The arm hinge will be designed in such a way as to be physically unable to extend past the limits of the human arm.
- The motor driver will have hardware limits built in to eliminate the possibility of power surges.
- The motor driver will also have thermal protection for itself and undervoltage protection for the battery.
- The Arduino will control the motor driver and receive feedback from the encoder to shut off the motor at unsafe angles.
- A hardware kill switch will be incorporated at multiple points in the arm to trigger in the event of abnormal operating conditions.
- If anyone of these safeties trip, the arm will immediately cease movement and hold in place.

Prototype

- The prototype budget is $1,400.
- The team will be building a full size prototype that fits within the budget and satisfy all constraints.
- The team plans to build a prototype that will have two telescoping parts one for the forearm and one for the upper arm.
- The aluminum pieces for the arm will be 3D printed.

Conclusions and Future Work

Over the span of this semester, the team has designed various arm frames, actuation methods and were then analyzed. The team has decided on a motor based actuation system that will be using a worm gear and will be attached at the elbow of the arm. The arm frame will be built from two sets of rectangular aluminum telescoping tubes that will be 3D printed. The design will also use a double u joint made of steel to allow full range of motion. The code will be finished after the circuit is assembled. The team is selecting and pricing the final materials that will be utilized for construction of the prototype in spring. During the next semester, the team plans to receive safety clearance from FSU and to start testing the design that was decided upon.

Contact Information

Team 29: Strength Assisting Orthotic
FAMU-FSU College of Engineering
Email: dbp12@my.fsu.edu
Website: www.eng.fsu.edu/me/senior_design/2016/team33