

Course Summary:

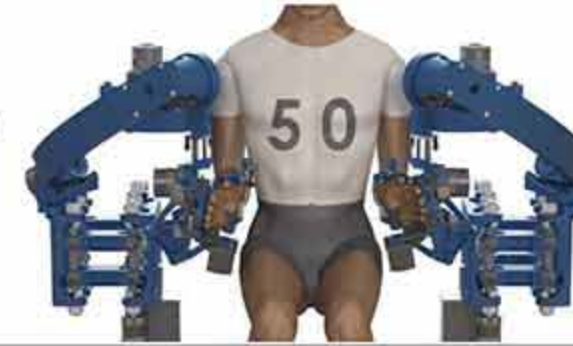
Assistive Technologies for Physical Impairment is an introductory course to the world of assistive and rehabilitative robotics.



In the course, we look into the basic design and purpose of the brain and body, and some common pathologies;



we discuss components used in the development of robotics for rehabilitation and assistance;



and we review literature on exoskeletons, brain-machine-interfaces, and other topics toward development of assistive technology (AT) design projects.



HIP ORTHOSIS FOR MULTIPLE SCLEROSIS

Stu Sater, Katie Farris, and Jorge Gonzalez

Introduction: Multiple Sclerosis (MS) is a progressive degenerative disease that attacks the central nervous system. Over time, MS leads to loss of coordination, muscle weakness, and gait impairment (Fig. 1). With weakened muscle control, the hip internally rotates, impairing normal range of motion. Our brace corrects for this, easing the burden on the user during normal movement in ADLs and exercise.



Figure 1. Knee valgus associated with MS.

Objective: Our brace (Fig. 2) is designed to (1) externally rotate the hip by a minimum of 15°; (2) provide adjustable torque via a Boa cable system; (3) be comfortable and easy to adjust; and (4) take <5 minutes to don/doff.

Methods: Calculations were performed to estimate the amount of force required to externally rotate the hip during walking and to direct material selection. Materials were then selected based off their mechanical properties and dimensions were specified to best match the required forces (Fig. 3).



Figure 2. Model of orthosis design. Red arrow shows where the force is applied to rotate the hip.

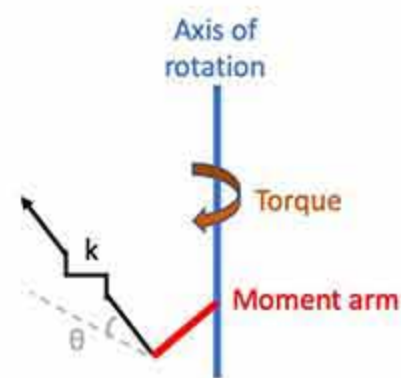


Figure 3. Schematic of geometries used in simulation.

Results and Future Work: The range of forces required to correct hip rotation in the inner quartile range of males, was estimated to be 20.4 to 28.1 lbs (Fig. 4). Given this force range and an adjustable range of 7.9 in, it was determined to use three 4.7-inch lengths of surgical tubing in parallel to apply the force.

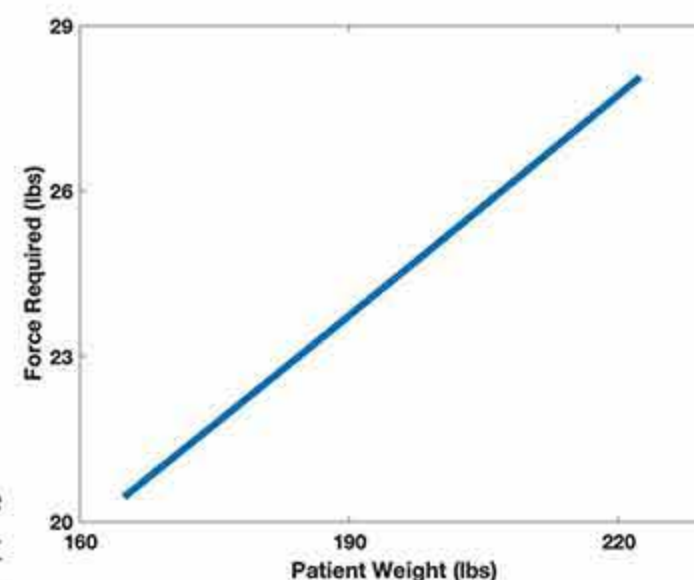


Figure 4. Plot of estimated force required vs patient weight.

WREX REDESIGN FOR 3D-PRINTING

Abhishek Rathod, Zhihui Wang, Lucas Sass

Introduction: Arm weakness leads to difficulties with routine tasks for people with neuromuscular diseases. The Wilmington robotic exoskeleton (WREX) assistive orthosis [1] compensates for the user's arm weight allowing better control, Fig 1 (left). Our goal is to redesign WREX for 3D-printing and reduce its weight for future application to a wearable form.

Methods: Analytic models of the upper and lower arm mechanisms (Fig. 1, right) were developed to optimize the tradeoff between support force and linearity, Fig 2. This was accomplished by adjusting the aspect ratio of the 4-bar and 2-bar systems. Continuous fiber reinforcement 3D-printing allows selective material placement in areas of high mechanical stress, Fig 3.

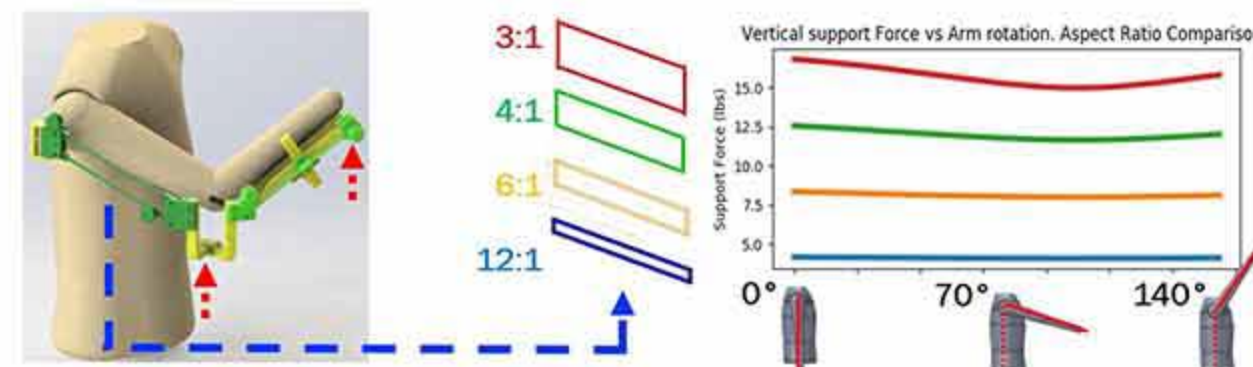


Figure 1. WREX gravity compensation of arm weight at elbow and wrist (left). Support force across shoulder rotation angles and 4-bar aspect-ratio (right).

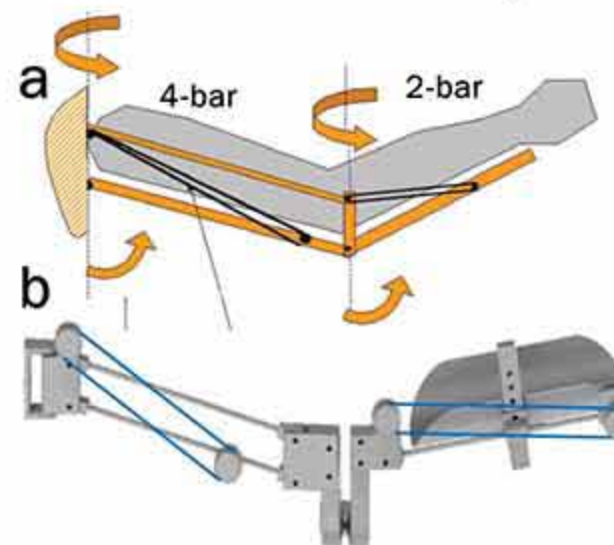


Figure 2. a) WREX mechanism, b) CAD model.

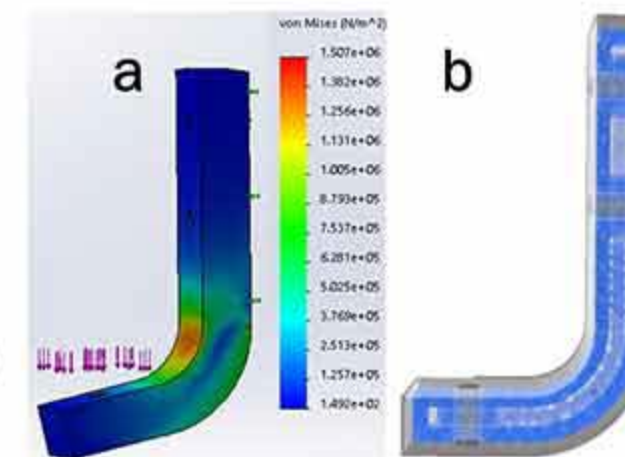


Figure 3. a) Detail of elbow joint stress simulation and b) reinforcement placement (blue).

Results and Future Work: Weight reduction of ~50% compared to the commercial offering is estimated from our initial results. Future efforts will focus on reducing printing cost and on construction of a prototype for testing.

[1] T. Rahman, et al., "body-powered upper limb orthosis," *J Rehabil Res Dev*, vol. 37, no. 6, pp. 675-680, Dec. 2000

3D SCANNING OF FOREARM FOR HUMAN MACHINE INTERFACE (HMI) APPLICATIONS

Jacob Brower, Robert Carne, Melissa Bogert

Introduction: The geometry and mechanics of the human forearm are incredibly complex (Fig. 1). Misalignment between a user and robot's rotational axes are potential comfort and safety issues that can cause further injury and performance issues with the user's therapy motivation, range of motion, and the robots tracking accuracy. Improving comfort and fit accuracy of forearm orthoses in robotics can increase usability and tracking accuracy.

Objective: Our goal is to create a closed-form model of the forearm for use in the design of orthoses.

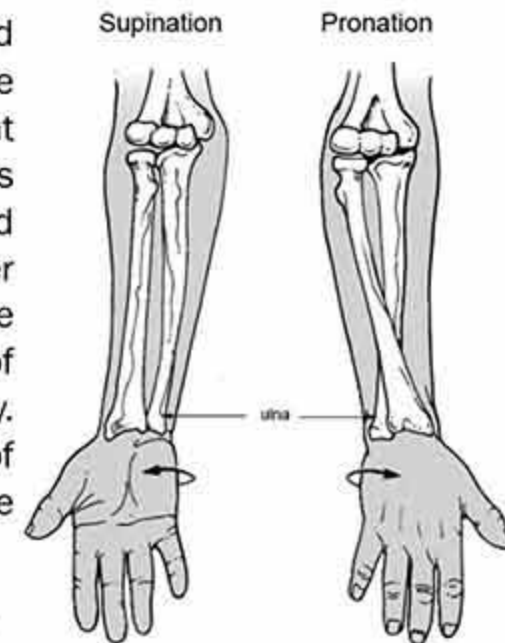


Figure 1. Human arm in pronation and supination poses (photo credit: wikifoundry.com)

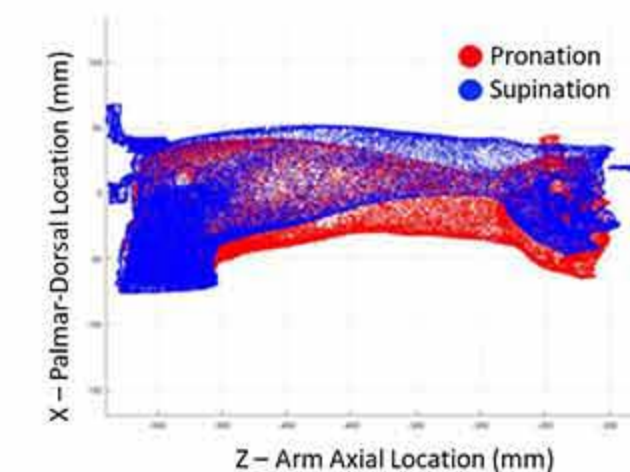


Figure 2. Two scans of the same subject's arm with one scan in each pose

Methods: By taking 3D scans of a human arm in pronation and supination poses (Fig. 2), then fitting ellipses to them, the error associated between them may be evaluated. These ellipses aid in the evaluation of the 3D data and provide an equation-driven description of an average arm shape that can be easily reproduced in CAD programs.

Results and Future Work: Fig 3

Forearm model successfully created based on two forearm poses: pronation and supination. The next step is to design, build, and model an orthosis that properly secures the user to the exoskeleton (Fig. 3).

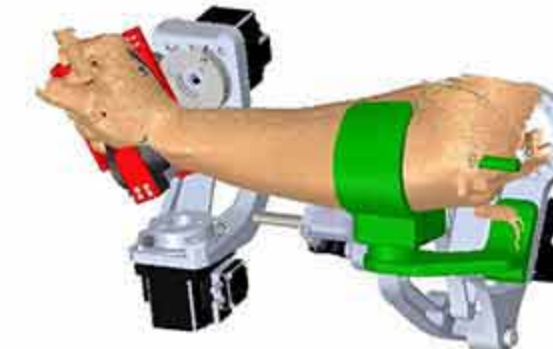


Figure 3. Computer-generated model of right forearm attached to exoskeleton with hand and forearm orthosis.