A Measurement Device for Quantifying Neuromuscular Impairment in Hands

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Neuromuscular impairments such as cerebral palsy, stroke, and spinal cord injuries limit the ability to perform activities of daily living, decreasing the quality of life of those affected. Soft exoskeletons have been proposed to address this need by assisting hand motor function for those with motor impairment to improve their overall quality of life. Before these devices can be commercialized and implemented in the home and clinic, their performance must be validated. To test the effectiveness of hand devices, there have been efforts to create models of the human hand. An instrumented hand developed recently has displayed near identical range of motion (ROM) and joint stiffness to a healthy hand [1]. However, impaired hands can be very different from healthy hands, with changes in stiffness and ROM (e.g., hypertonia). To test the effectiveness of soft devices on impaired hands, a model needs to be developed to simulate the range of joint stiffness and ROM seen in impaired hands. To build this model, designers first require accurate measures of impaired hand properties. The goal of this project is to develop a device that can accurately measure joint stiffness and ROM for testing on impaired subjects to make modifications to the instrumented hand and assist in the validation of soft exoskeletons. Validation of this device rests on producing the same double-exponential relationship between stiffness and ROM as seen in prior research [2]. The device, shown in Fig. 1, uses a motor-driven arm to rotate the subject's finger, which is attached to a load sensing component via a splint.

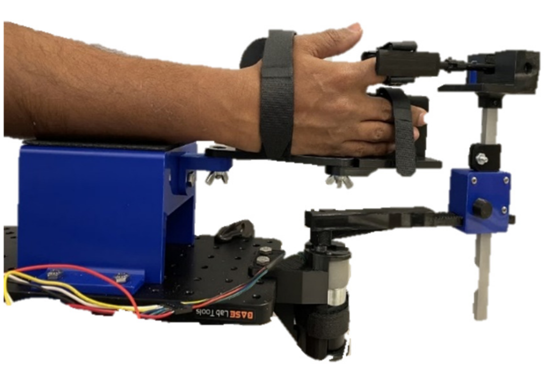

Figure 1. Joint stiffness measurement device

The subject's palm and idle fingers are held in place at a preset angle which can be adjusted. An encoder built into the motor tracks joint angle and interfaces with an Arduino microcontroller to increment finger angle by 10° in flexion and extension. A 50 lb. load cell connected to a National Instruments data acquisition device reads force measurements through a LabVIEW script. Each increment is held for 10 seconds, and the average force reading is recorded. Fig. 2 shows the joint torque results from initial measurement runs, accounting for finger and splint linkage lengths, along with a double-exponential trend line.

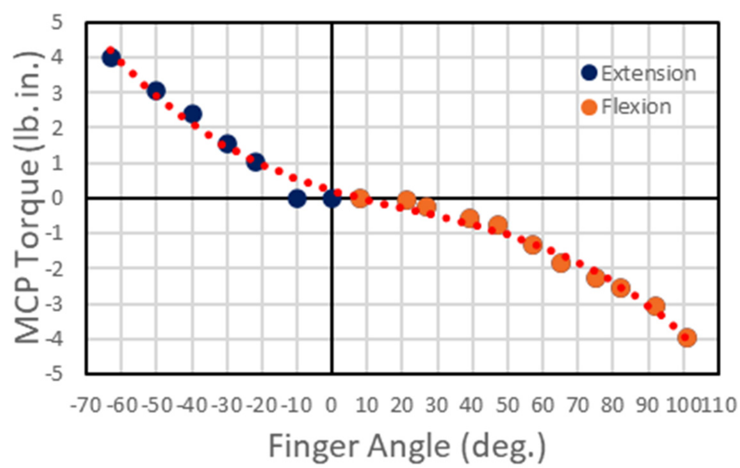

Figure 2. Joint torque results plotted against finger angle

The readings show a range of motion of -65° in extension to 100° in flexion, with a joint stiffness of 4 in-lb. to -4 in-lb., respectively. The results show double-exponential relationship between the two measured quantities, validating the device for further measurements. Modifying the device further will allow for more comprehensive measurements to be taken of hands of individuals with neuromuscular impairment. The gathered biomechanical data then be applied to the instrumented hand to validate soft exoskeletons.

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Statement of Research Advisor

Mark, through his independent research in my group has addressed a bottleneck in the measurement of biomechanical joint properties of individuals with neurological disorders or injuries, by developing a testbed which will serve a crucial role in future studies. Further, the adjustability of his testbed will enable investigations into the impacts of interjoint couplings between the wrist and fingers, further contributing to the field.
- *Chad G. Rose, Samuel Ginn College of Engineering*

References

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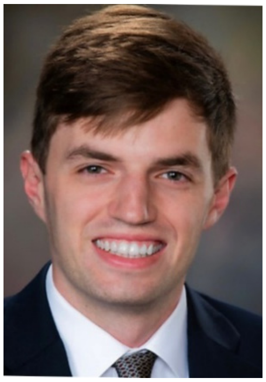
[2] Kuo, P., *et al.* "Design and Performance of a Motor-Driven Mechanism to Conduct Experiments With the Human Index Finger." ASME. *J. Mechanisms Robotics* 2015

Authors Biography



Mark Roces is a senior-year student pursuing a B.S. degree in Mechanical Engineering at Auburn University. Following graduation, he will be working as a Manufacturing Engineer for Eaton Corporation.

Chandler Stubbs is a Graduate Student pursuing an MS degree in Mechanical Engineering at Auburn University. He received a B.S. degree in mechanical engineering at Auburn University. He provided mentorship and guidance in the development of the device. His interests include robotics and human-robot interaction.

Chad G. Rose, PhD is an Assistant Professor in the Department of Mechanical Engineering. He holds a bachelor's degree in Mechanical Engineering from Auburn University and a master's degree and Ph.D. in Mechanical Engineering from Rice University. Dr. Rose's primary research focus is on the design and control of robots to rehabilitate, assist, or augment human motor and sensory function.