Development of a Hand Grasp Assessment Device with Variable Resistance

CALIFORNIA STATE UNIVERSITY **LONG BEACH**

BUILD CSULB

Samid Ceballos[1], Panadda Marayong, Ph.D.[1], and I-Hung Khoo, Ph.D.[2]

[1] Department of Mechanical and Aerospace Engineering, [2] Department of Electrical Engineering

INTRODUCTION:

- Hand impairment is common in elderly over the age of 65 due to neuromuscular disorders and loss of skeletal muscle mass[1]. Hand impairment makes activities of daily living, such as opening a jar difficult to accomplish.
- Existing research focuses on turning torque[2,4] and grasping independently[5].
- Previous robot-assistive devices can provide intensive hand rehabilitation which promotes neuroplasticity; however, these systems are costly[4,5].
- A device was developed to measure hand turning torque and grasping force for evaluation and rehabilitative training of individuals with hand impairment, such as individuals with Multiple Sclerosis.
- Previously, a device was developed to assess grip force vs load force and arm movement coordination in static and dynamic manipulation tasks[3].

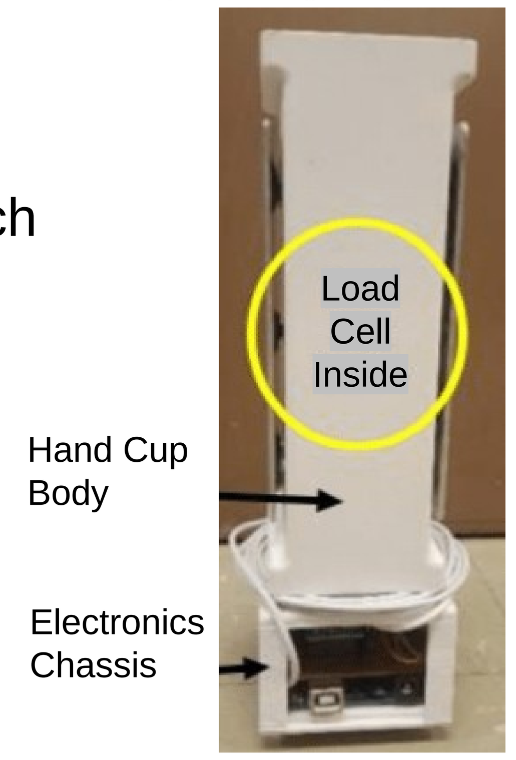

Figure 1: Grip-Load Device

OBJECTIVE:

Further develop the hand grasp device by integrating a force sensor to measure grasping force and analyze the relationship between grasping force and turning torque to fill in the existing literature gap.

EXISTING DEVICE:

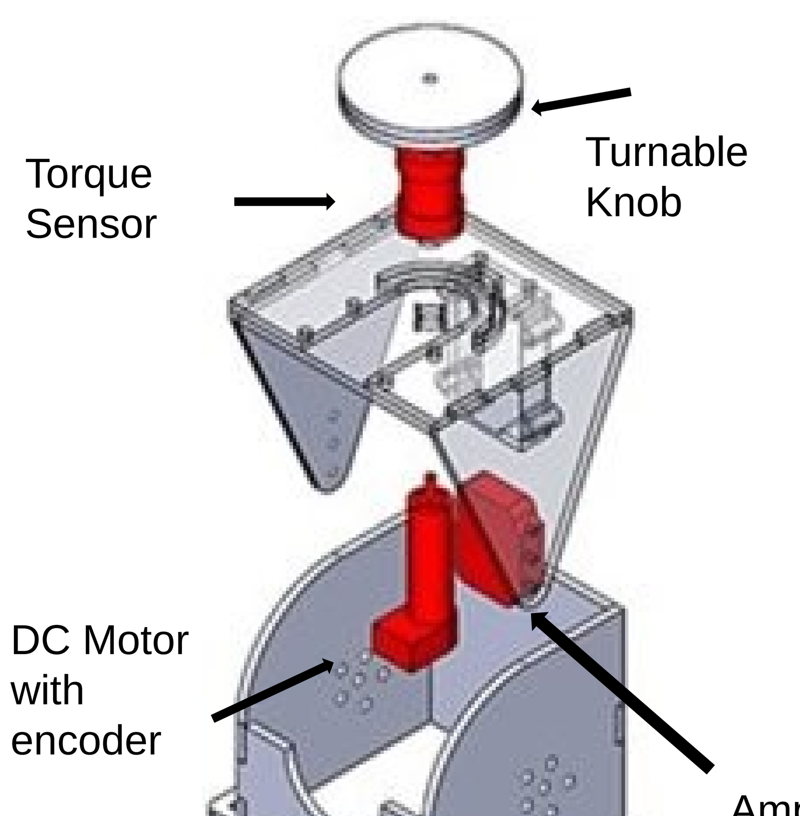

Figure 2: SolidWorks assembly without Arduino Mega and motor shield

Hardware/Software

- DC motor with encoder for variable turn resistance and turn angle measurement
- Torque sensor to acquire turning torque
- Arduino Mega 2560 microcontroller for sensor integration and actuation control and LabVIEW
- Acrylic structure with three available knob sizes and five planes from the horizontal.

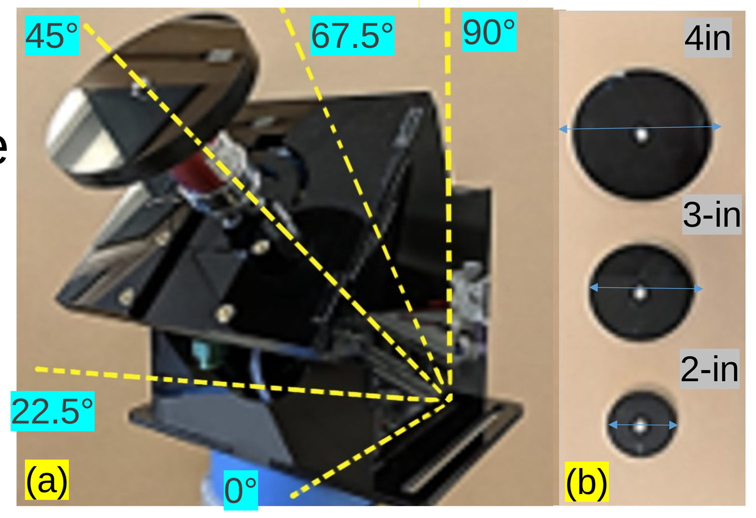

Figure 3: (a) Device at a 45° plane from the horizontal (b) Available knob sizes

FORCE SENSING RESISTOR INTEGRATION:

- Electrical resistance is inversely proportional to the applied force
- Thin and flexible characteristics allows integration of the FSR on the knob to measure applied grasping force
- Enables analyzing the relationship between grasping force and turning torque

Figure 4: SolidWorks model of FSR and Knob.

Graphical User Interface (GUI):

- Developed in LabVIEW to display experiment parameters
- Redesigning to provide visual feedback to the user and a grasping force parameter for the operator

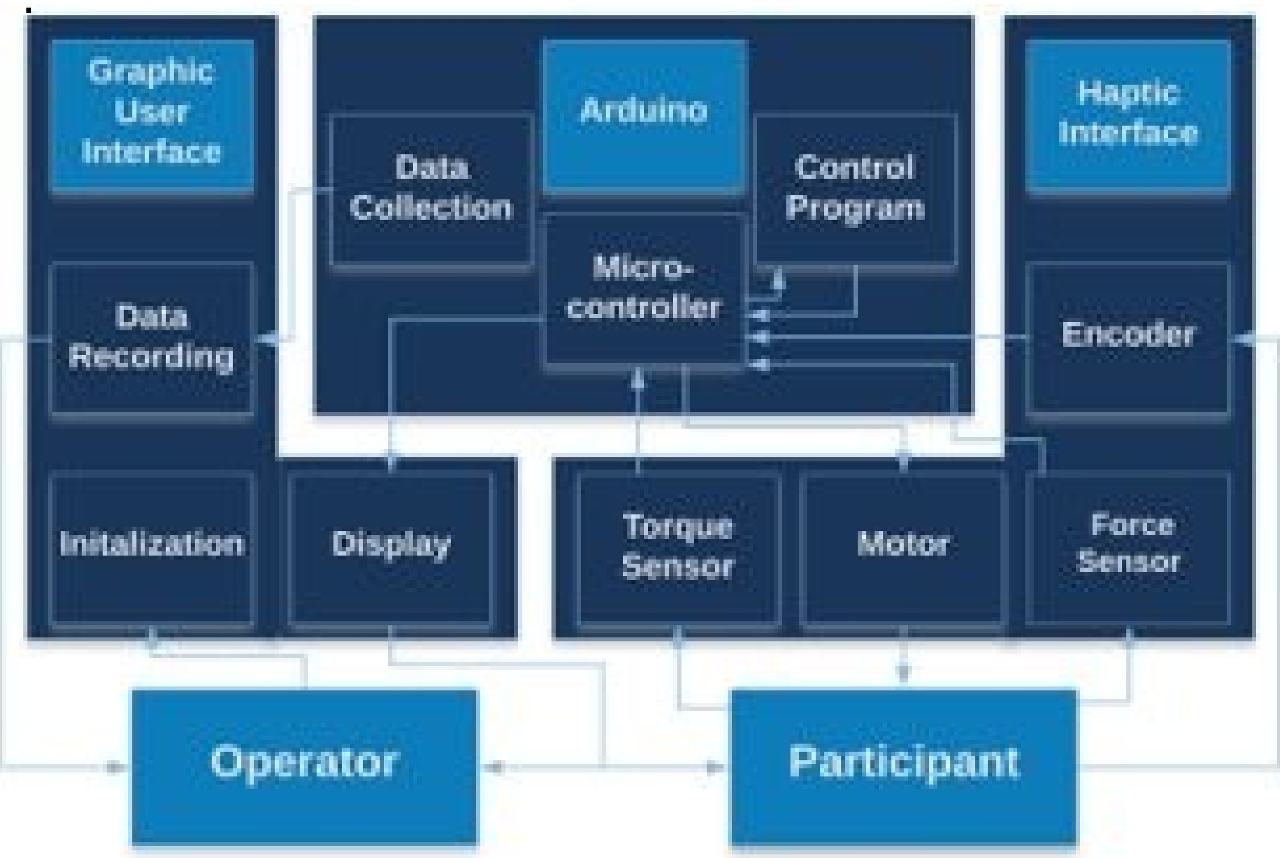

Figure 5: System design layout

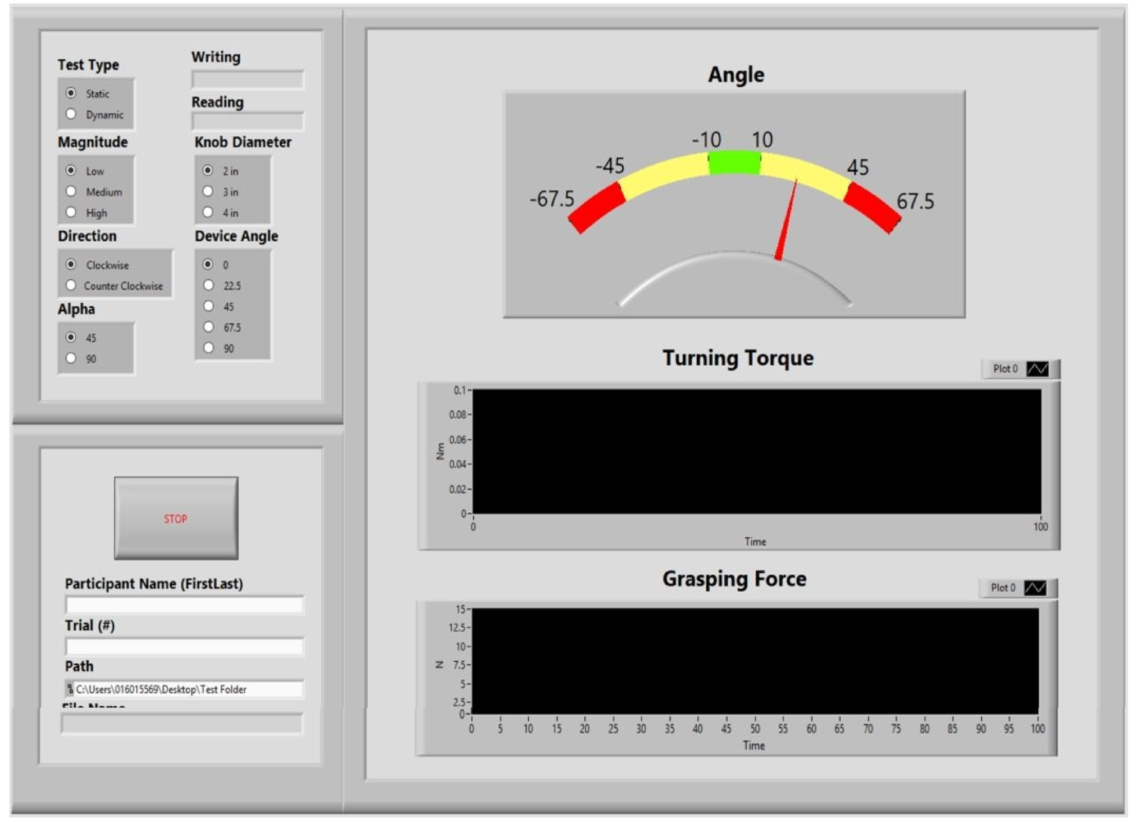

Figure 6: GUI designed in LabVIEW

TEST MEASUREMENTS:

For Both Dominant and Non-Dominant Hands:

- Grasping force against turning torque at various turn resistance
- Maximum turning torque at varying knob sizes, wrist extension, and in pronation and supination.
- Target over- and undershoot of turn angle at different resistance
- Turning torque during target angle test

FUTURE WORK:

- Test the functionality of the device with healthy subjects
- Pilot study with individuals with hand impairment
- Integration of Grip-Load Device for a complete hand function assessment

REFERENCES:

1. Carmeli, E., et al. "The Aging Hand." *The Journals of Gerontology: Series A*, vol. 58, no. 2, 1 Feb. 2003, doi:10.1093/gerona/58.2.m146.
2. Gurari, N., and A. M. Okamura. "Human Performance in a Knob-Turning Task." *Second Joint EuroHaptics Conference and Symposium on Haptic Interfaces for Virtual Environment and Teleoperator Systems (WHC'07)*, 2007, doi:10.1109/whc.2007.71
3. Herrera, D. "Hand Force and Arm Movement Coordination in Static and Dynamic Manipulation Tasks." California State University, Long Beach, 2018. [MS Thesis]
4. Kazemi, H., et al. "A Robotic Interface to Train Grip Strength, Grip Coordination and Finger Extension Following Stroke." *2012 Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, 28 Aug. 2012, doi:10.1109/embc.2012.6346820.
5. Metzger, J., et al. "Design and Characterization of the ReHapticKnob, a Robot for Assessment and Therapy of Hand Function." *2011 IEEE/RSJ International Conference on Intelligent Robots and Systems*, 25 Sept. 2011, doi:10.1109/iros.2011.6094882.
6. Romeo, R.A, et al. "Development and preliminary testing of an instrumented object for force analysis during grasping," *2015 37th Annual Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*, Milan, 2015, doi: 10.1109/EMBC.2015.7319935.

ACKNOWLEDGEMENTS:

This research was supported by the National Institute of General Medical Sciences of the National Institutes of Health under Award Numbers; UL1GM118979; TL4GM118980; RL5GM118978. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health. The authors would like to thank Don G. Napasindayao for initial development of the device and his support.