Hand Grasp Assessment Device with Variable Haptic Feedback– Work In Progress

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
Robotics and Interactive Systems Engineering (RISE) Laboratory

BUILD
CSULB

Introduction

- Hand impairment is common in elderly over the age of 65 due to neuromuscular disorders and loss of skeletal muscle mass[1]

Figure 1. Jar[7].

- Previous robot-assistive devices can provide intensive hand rehabilitation which promotes neuroplasticity; however, these systems are costly[4,5]

- Previously, a low-cost device was developed to assess grip force vs load force and arm movement coordination[3]

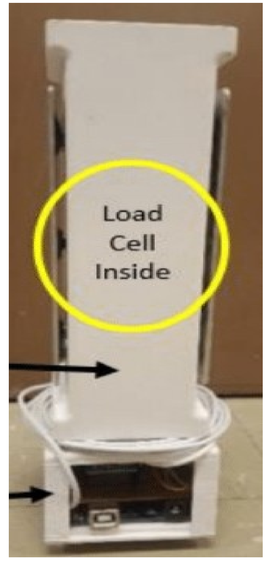


Figure 2. Grip/Load Device

- Existing robot-assistive devices for turning tasks focus on turning torque[2,4] and grasping independently[5,6]

BUILD
CSULB

Hand Device System Overview – Hardware Design

- Acrylic structure with three available knob sizes and five angles from the horizontal.
- DC motor with encoder for variable torque feedback and turn angle measurement
- Torque sensor to acquire turning torque
- Arduino Uno microcontroller with motor shield for sensor integration and actuation control

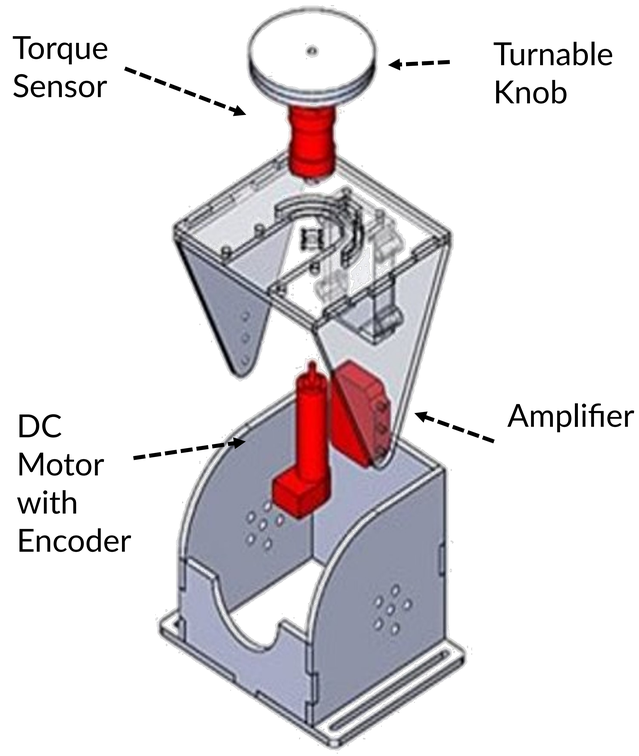


Figure 3. Exploded view

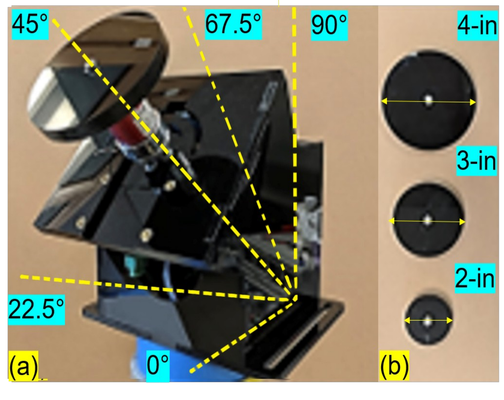


Figure 4. (a) Device at 45° plane from the horizontal (b) Available knob sizes

BUILD
CSULB

Hand Device System Overview - Sensor Integration

Force Sensing Resistor (FSR)

- Thin and flexible characteristics allows integration of the FSR on the knob for grasping force measurement

Figure 4. FSR[8]

- Electrical resistance is inversely proportional to the applied force and is proportional to voltage

- FSR calibration

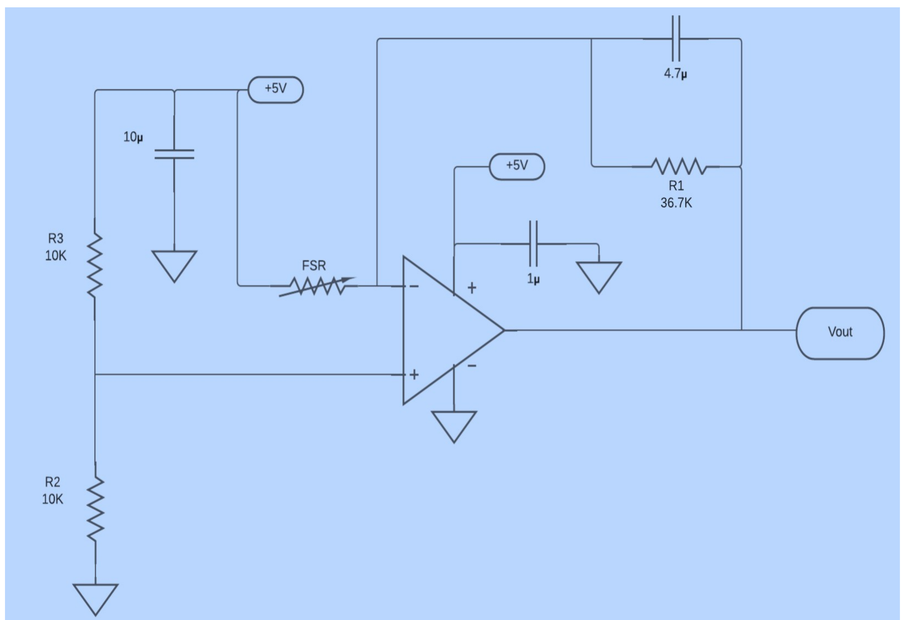
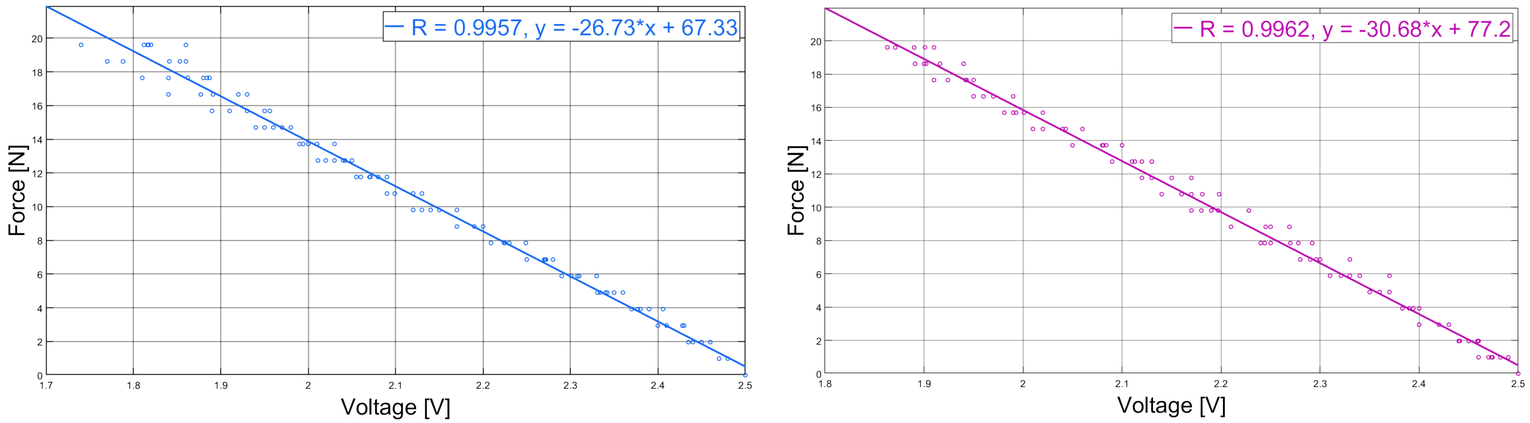


Figure 5. FSR circuit



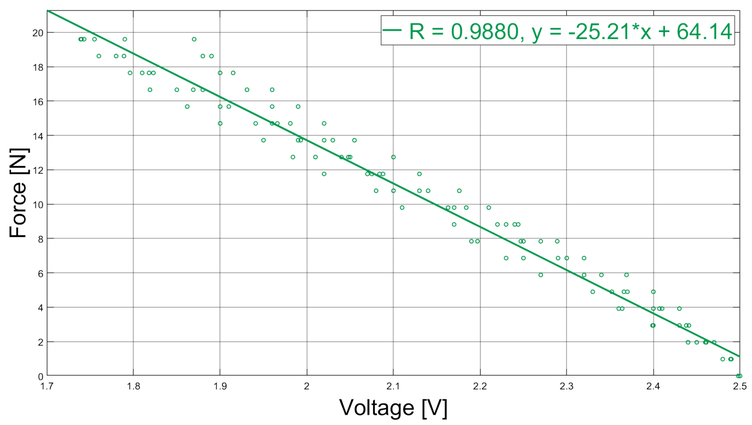


Figure 6. FSR calibration results

BUILD
CSULB

Hand Device System Overview - Sensor Integration

Torque Sensor

- Converts an applied torque into an electrical voltage output signal

- Torque sensor calibration

Figure 7. FUTEK torque sensor model TFF350

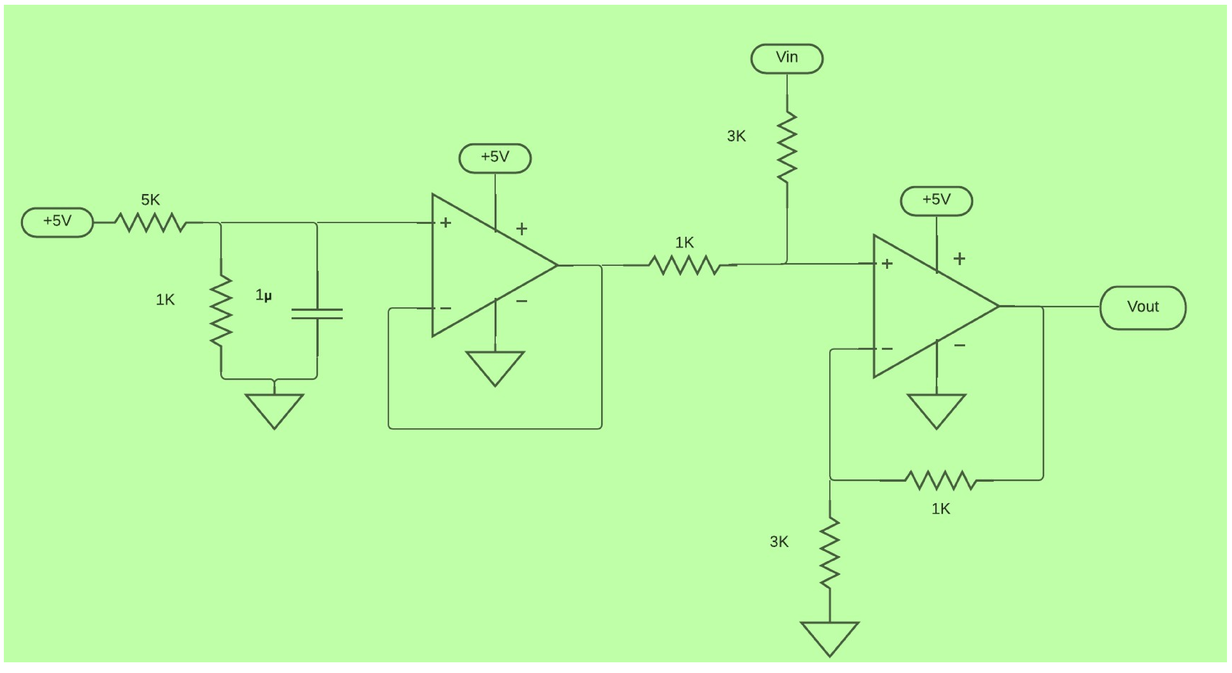


Figure 8. Shifter circuit

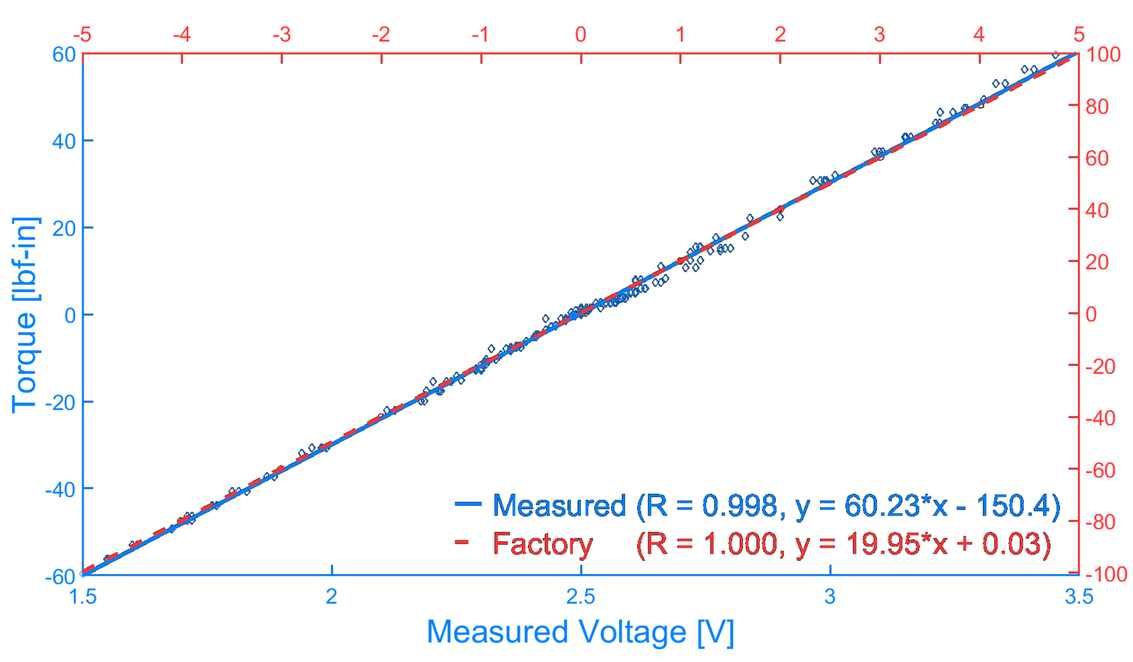


Figure 9. Calibration comparison

BUILD
CSULB

Hand Device System Overview –Graphical User Interface (GUI)

- Developed in LabVIEW to display experiment variables
- Redesigned to provide visual feedback to the user and data collection

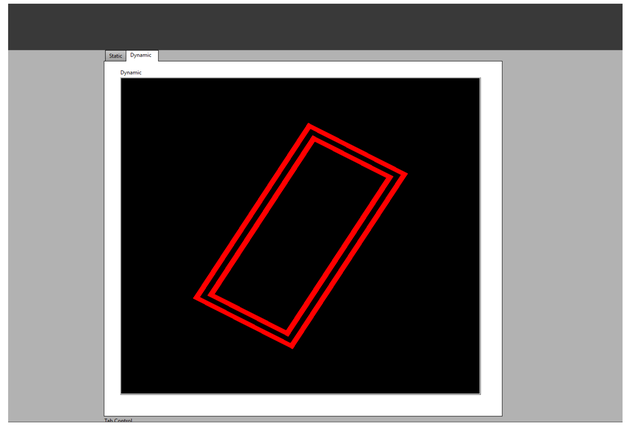


Figure 11. Visual feedback: user reaches the target

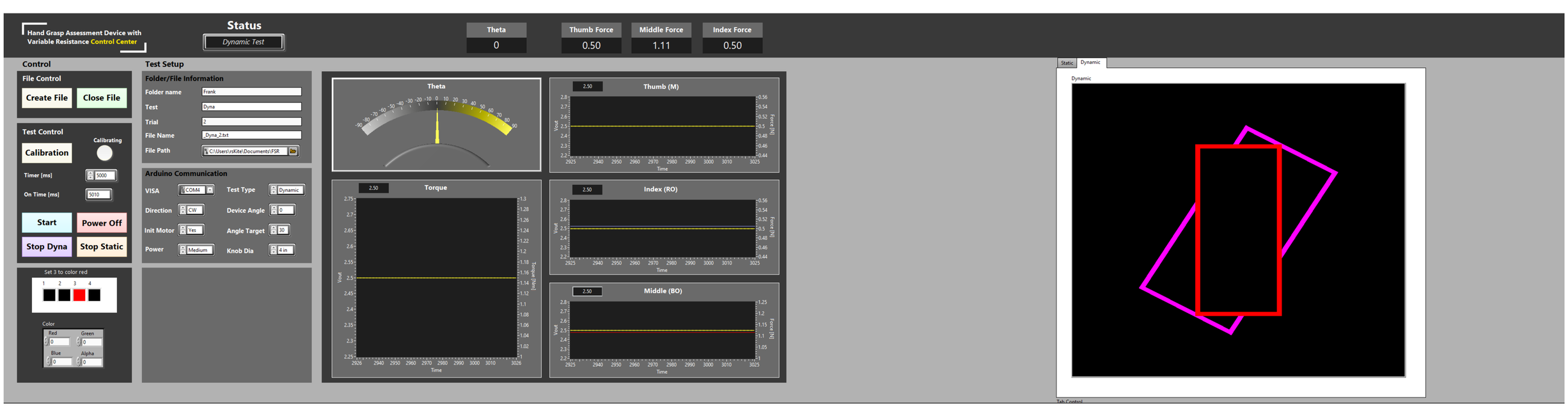


Figure 10. Full GUI View shown in a dynamic test

BUILD
CSULB

Hand Device System Overview

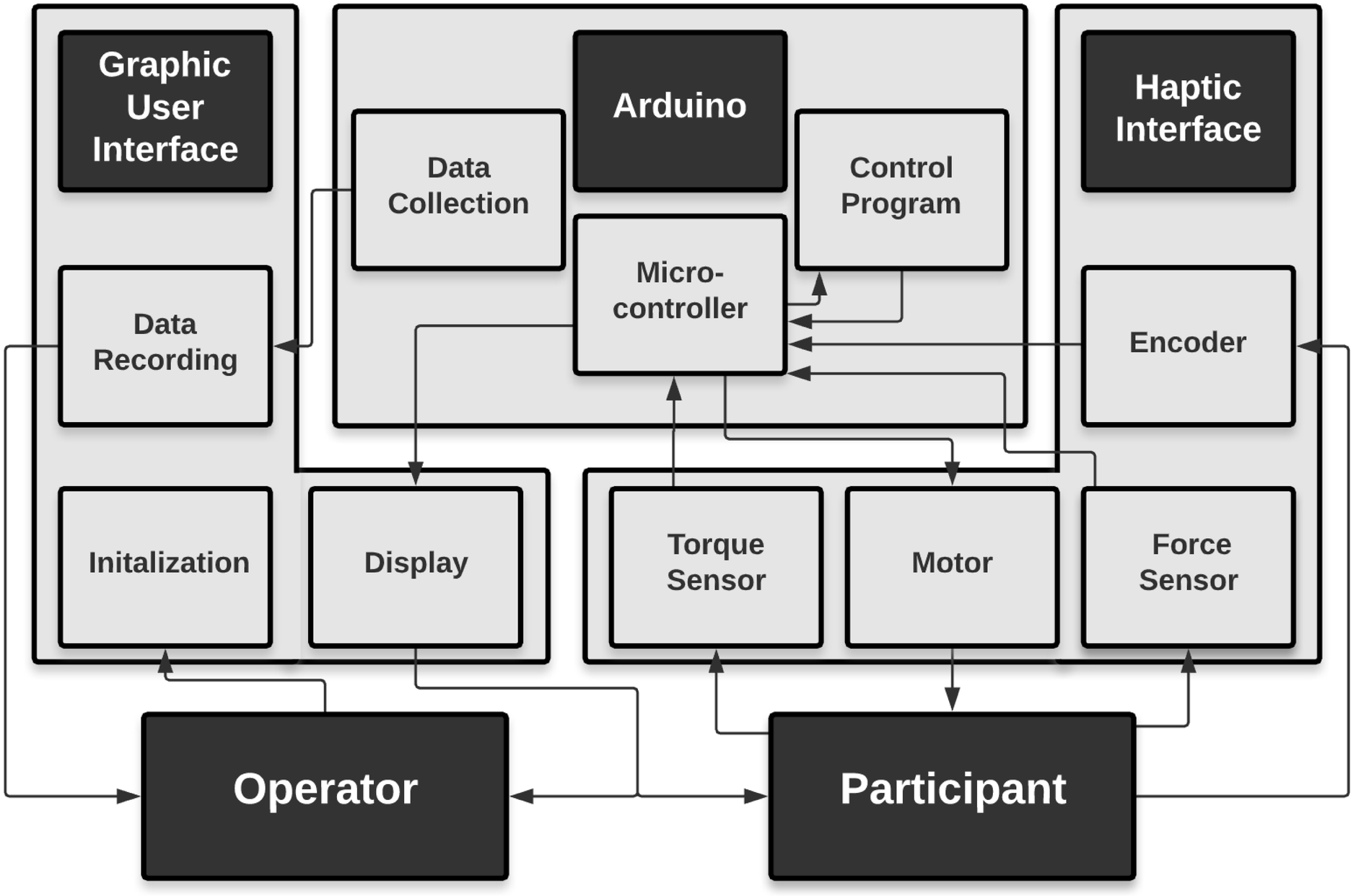


Figure 12. System design layout

BUILD
CSULB

Human Subject Experiment Protocol

Static Test (Power Focus)

- Max turning torque at varying knob sizes and wrist extension

Dynamic Test (Precision Focus)

- Grasping force against turning torque at different resistance levels
- Target over- and undershoot of turn angle at varying torque feedback
- Time to target during target angle test

Figure 13. Transition of a power grasp (top) into a precision grasp (bottom) while opening a jar[9]

Future Work

- Redesign knobs for FSR integration and design attachment for static testing

- Test the functionality of the device with healthy subjects

- Baseline data collection for assessing coordination between grasping force and turning torque with healthy and hand impaired subjects

- Integration of a grip force/load force device that was previously developed for a more detailed hand evaluation

BUILD
CSULB

References & Acknowledgements

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.

7.12 x Candle or Storage Jar. (n.d.). [Photograph]. Pastimes. https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.pastimesltd.co.uk%2F12-x-candle-or-storage-jar-2698-p.asp&psig=AOvVaw3DwXC7F2fkro_Gv1-1bnD1&ust=1615059864829000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCODT4_30me8CFQAAAAAdAAAAABBW

8.FLEXIFORCE A401 SENSOR 25LBS. (n.d.). [Photograph]. Antratek Electronics. https://cdn.antratek.nl/media/product/8c2/flexiforce-a401-sensor-25lbs-sen-11207-098.jpg

9.Napier, John R. "The prehensile movements of the human hand." *The Journal of bone and joint surgery. British volume* 38, no. 4 (1956): 902-913, doi: 10.1302/0301-620X.38B4.902.

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.