Development of Hand Torque Assessment Device with Adjustable Angle of Attack, Knob Size, and Resistance

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ABSTRACT

Individuals who are suffering from hand impairment have weakened muscle function, making common daily activities, such as turning a doorknob, difficult to accomplish. Our study aims to assess the differences in hand function between healthy and hand-impaired groups, such as individuals with Multiple Sclerosis, and provide rehabilitation training using the developed hand function assessment system. This work focuses on the development of the hand torque evaluation device. The device consists of a DC motor, a torque sensor, and interchangeable knobs to measure hand torque and the angle of twist at different resistance level. The device's design allows for adjustment of the angle of attack. A preliminary user study will be conducted to test the functionality of the device that will follow by baseline data collection with healthy young adults and individuals with hand impairment.

INTRODUCTION

- Reduced hand function is a common occurrence in elderly adults after the age of 60 due to sarcopenia, or loss in skeletal muscle mass[1] and neuromuscular disorders.
- Previous research focused on hand torque[2,3,5,6] and cylindrical gripping[4] independently; however, no study have been conducted that analyzes the relationship of both.
- Robotic applications have been shown effective in hand torque rehabilitation with long-term retention[3,5,6]. Though these systems require specialized and costly hardware.
- In our previous work, a device for evaluating hand grip force vs load force in static and dynamic tasks was developed[7].
- Addition of turning function is being developed to create a comprehensive system for hand function evaluation.

Figure 1: Grip/Load Force evaluation device for unimanual gripping[5]

SYSTEM DESIGN

The system consists of the following main components:

Hardware/Software:

- Acrylic structure with interchangeable knobs at 2, 3, and 4-in diameters and variable angle of attack at 0.0°, 22.5°, 45.0°, 67.5°, and 90.0°.
- DC Motor with encoder to provide adjustable resistance and turn angle measurement
- Torque sensor
- Arduino Mega 2560 microcontroller for integration of sensor and actuator control and LabVIEW

Graphic User Interface (GUI)**:** Developed in LabVIEW to display parameters such as torque, angle of attack, and turn angle as well as providing ease of control for the operator.

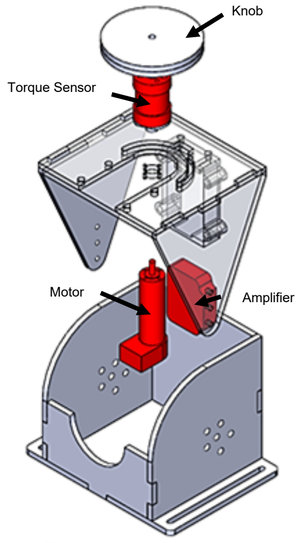

Figure 2:
SolidWorks assembly of the device sans Arduino Mega and motor shield

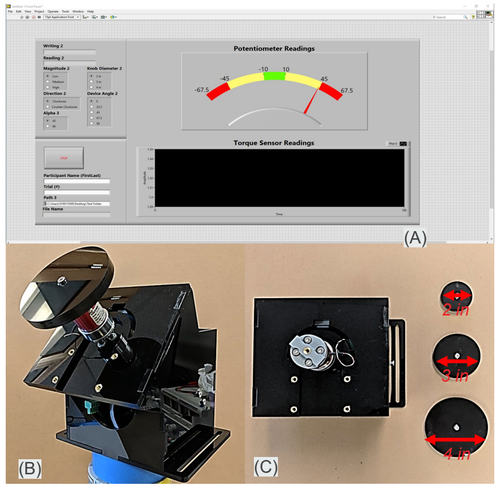

Figure 3:
(A) GUI developed in LabVIEW
(B) Device rotated at 45° angle of attack
(C) Device with available knob sizes

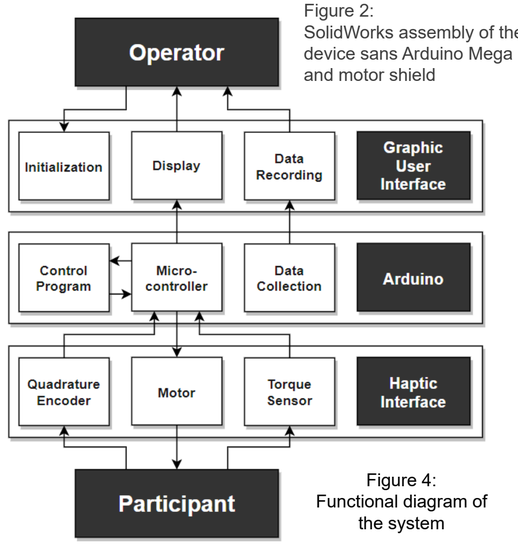

Figure 4:
Functional diagram of the system

PLANNED USER STUDY

	Static Test	Dynamic Test
Focus	Evaluation of the maximum torque	Evaluation of the hand torque control
Task	Participants to turn the device in pronation and supination for both dominant and non-dominant hands.	Participants to turn the knob to target angles for both dominant and non-dominant hands at different resistance levels.

EXPERIMENT VARIABLES

- Hand torque at varying grip diameters and angle of attack
- Grip force with respect to applied hand torque and different turn resistance
- Target over- and undershoot of angle of twist at different resistance

FUTURE WORK

- Addition of a force-sensing capability for grip force
- The functionality of the device will be tested using subjects without any known hand impairments.
- Collection of baseline data for comparison between groups with and without known hand impairments.
- Integration with the grip force/load force device for more detailed hand evaluation

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