Pinch Meter For Stroke Patients

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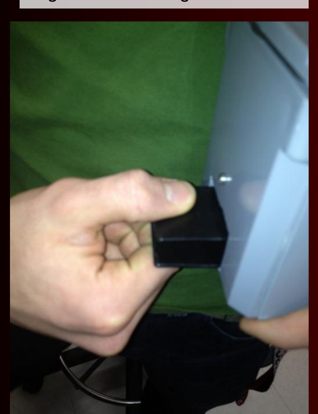
Client: Elizabeth Bourne

Problem Definition

Motivation: Every year approximately 800,000 people suffer from strokes in the United States (“Stroke” 2006). Three-quarters of these strokes occur in people over 65 years old. Strokes occur from blockages that prevent blood from reaching the brain. Following the stroke, mental and motor function may be impaired. The rehabilitation of stroke victims focuses on restoring fine motor control that may have been impaired (“Post-Stroke” 2008). Because of this, our mission is to design a device that measures the pinch force of stroke victims. This data can be used to measure the improvements in fine motor control.

Background: Pinch force dynamometers are used in hospitals to measure the force generated from the fingers. There are two different tests used to evaluate the strength: a two-finger test (Figure 1) is conducted between the thumb and index finger and a three-finger test (Figure 2) is conducted between the thumb, index, and middle fingers (Bourne 2011).

Figure 1: Two Finger Test



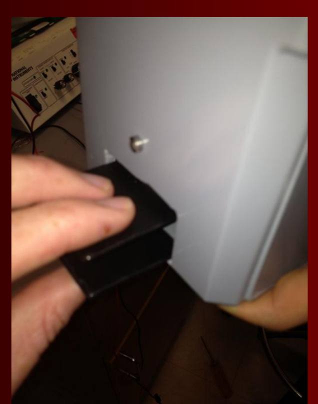


Figure 2: Three Finger Test

Digital and analog pinch force dynamometers are commonly used (Figure 3). These devices are held by a rehabilitation therapist while the device is in use (Bourne 2011). The head of the meter, which contains a spring sensor in analog and an electronic force sensor in digital devices, is extended toward the patient. When the patient presses on the head, the force is displayed on the dynamometer.

Most of the products available today provide a readout up to 22.6 kg, with accuracy within 0.5 kg (“Pinch Gauge” 2008). However, most recovering stroke victims can only provide a force of 2.26 kg; thus, a more precise device is needed (Bourne 2011).

Figure 3: A Digital Force Dynamometer[4].

Problem Statement

Our Client, Elizabeth Bourne of UW-Hospital's Department of Rehabilitation, would like us to design a dynamometer to measure the finger force generated by recovering stroke victims. Current hand dynamometers are not precise enough to measure the reduced force of stroke victims. The device needs to be accurate, precise, and easy to use.

Design Criteria

- Presentable and aesthetically pleasing
- Portable
  - Maximum Weight: 4.0 kg
- Affordable
  - Budget: $100
- Sturdy
- Ergonomical
- Accurate
  - Measures up to 2.3 kg (5lbs) in 0.09 kg (0.2 lbs) increments
- Safe
  - Nontoxic

Abstract

At the University of Wisconsin-Madison Hospital, Elizabeth Bourne, an occupational therapist, assists in the rehabilitation process of patients affected by the debilitating effects of strokes. Her objective is to use a measuring device to obtain a quantitative assessment on the progress of the patients’ force application abilities of a finger pinch. Currently, pinch meters that are available cost approximately $300 and do not sense forces small enough to interpret the extreme level of disability of the targeted stroke patients. Our goal is to design a device that is capable of sensing pinch force in 0.2 kg increments to further assist Elizabeth Bourne in bettering the stroke patient rehabilitation procedure. Through our research, we have designed a device that utilizes a load cell that can produce the proper efficiency and accuracy.

Final Design

1

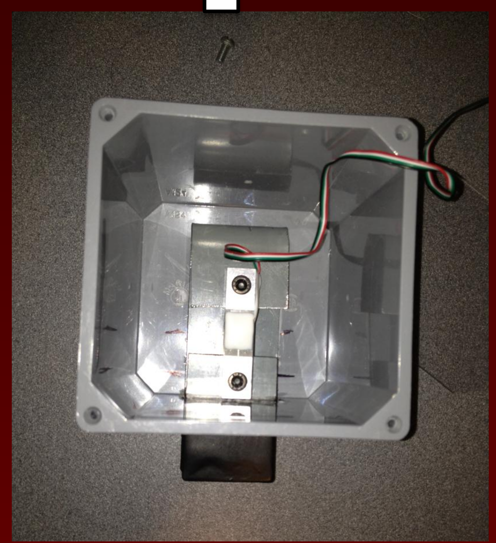


Figure 4: Top view of device with pinch meter and shelf

2

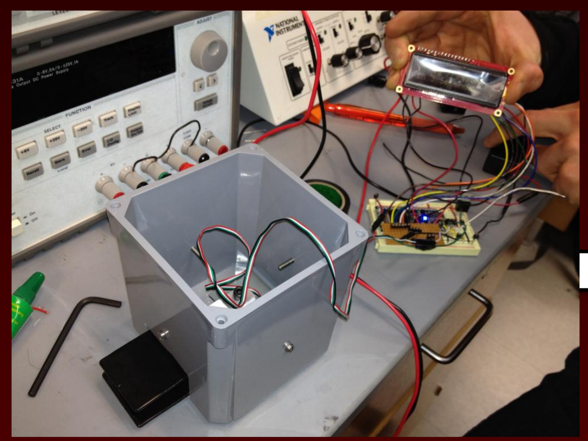


Figure 5: Device with unassembled circuit and LCD components

3

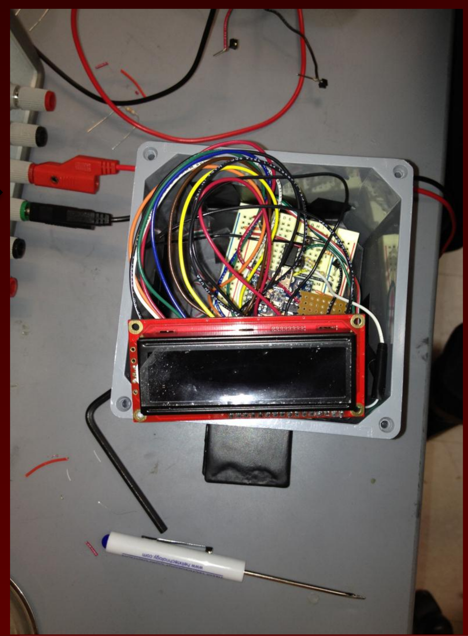


Figure 6: Top view of device with all components.

4

Figure 7: Top view of design with working LCD Screen

5

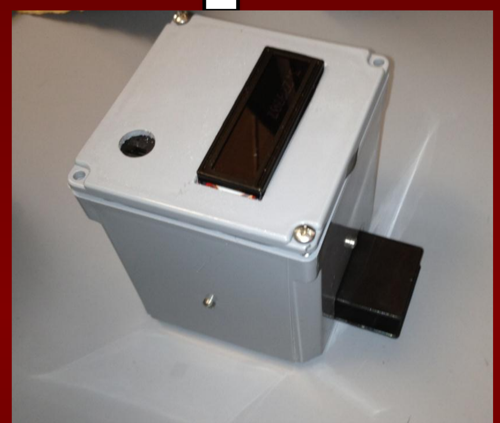


Figure 8: Final pinch meter design

6

Figure 9: Pinch meter design with demonstrative pinch.

- CZL635 Micro Load Cell: Decreases voltage when force is applied; strain gauges on the load cell bend and resistance of the strain gauge increases. Measures 0-5.0 kgs [0 -11.0 lbs];
- Differential Amplifier: Amplifies output from sensor; uses MCP6002 op amp; Amplifies to approximately 3.3 V
- mbed Microcontroller: Uses C++ Language; keeps track of minimum voltage; converts minimum voltage to the maximum force through calibration curve
- LCD Screen: Displays maximum force after a 5 second recording period.
- Power Source: Powered by 9 V battery
- Housing Unit: Modified PVC junction box with components secured with bolts and nuts.
- Price: $100.10

Alternative Designs

Sensors:
- Piezoresistive Sensor
- Force Sensitive Resistor
- Micro Load Cell

Figure 10. FX1901 piezoresistive sensor, which contains a pinch pad in the center of the device[2].

Housing:
- PVC Junction Box
- 3D Printer

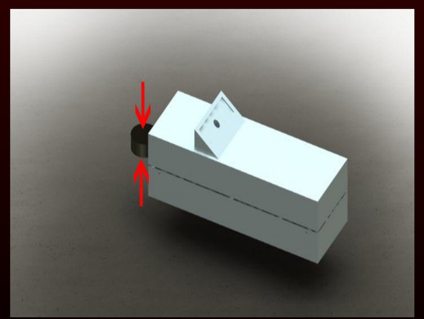


Figure 11: Solid Works Design of Possible Housing to be printed on 3D Printer.

Pinch Pad:
- Bending Methods
- Attachment to Sensor
- Coating

Testing

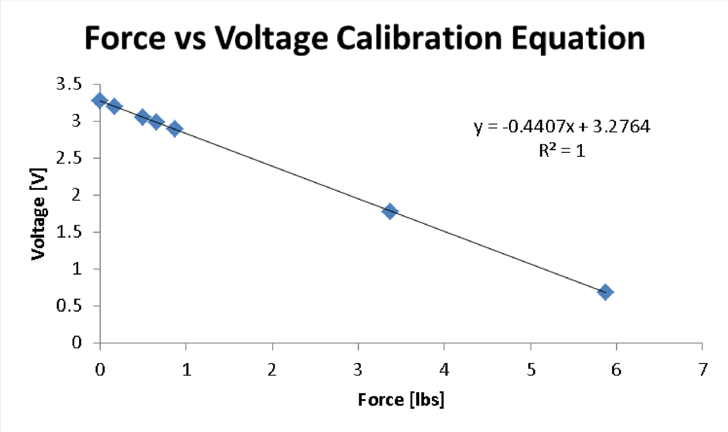


Figure 12: Calibration Curve Determined by Averaging 3 Trials at 7 different known weights.

- Calibration of the device was determined by hanging known weight off the force sensor.
- The device accuracy is ±0.02 lbs.
- The percent error at different points on sensor is 0.3%.

Future Work

1) Future Testing: Must test device on stroke rehabilitation patients in a clinical setting, which requires an IRB approval. Our device should then be compared to the Rehabilitation Center’s current pinch force dynamometer. This can be done with trials and surveys.

2) Improved Housing Design: A new housing design should be more aesthetically pleasing and more ergonomic. The cube design is difficult to hold. A suggested design is shown below and can be made using SolidWorks and a 3D printer

Figure 13: Ideal Housing Design using SolidWorks

3) Improved Programming: New calibration equation in program for each use to improve accuracy.

4) Increased Battery Life: Using a simpler microchip instead of a mbed microcontroller will decrease current allowing for a longer battery life.

5) Smaller Size to Improve Portability: Circuit can be reduced to microchip.

References

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Acknowledgements

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