DESIGN OF WEIGHT DISTRIBUTION MONITORING SYSTEM

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Abstract

Stroke victims commonly suffer permanent physical disabilities, such as hemiplegia. Hemiplegic individuals face many challenges in their recovery, including inability to balance, loss of ambulation, and muscular atrophy. Physical therapy remains one of the most effective methods of treatment for these conditions.

Our client liaison believes that a device allowing hemiplegic individuals to assess their standing weight distribution will be highly beneficial to their motor function. However, most weight distribution measurement devices are only available at the clinical research level and are not available for home use. Here we propose a design of a weight distribution sensor board that is portable and easy to use for those with limited motor function. This design will incorporate force sensors and audio biofeedback to assess and display weight distribution.

Background

- According to the National Stroke Association, a stroke occurs when a blood clot blocks an artery or when a blood vessel breaks, interrupting blood flow to an area of the brain
- In the United States, stroke is the fourth leading cause of death, killing over 133,000 people each year
- Estimated 7,000,000 stroke survivors in the U.S. over age 20
- Many stroke survivors experience brain damage resulting in impaired motor function, speech, or memory loss
- A victim's impaired motor function may include impaired balance, complete loss of ambulation, spasms, muscular atrophy, and osteoporosis
- Current need for improvement of treatment and rehabilitation methods, including effort training, gait training, and muscle training, for those who suffer from strokes to reduce the impact of strokes and improve patient quality of life
- Our client is a hemiplegic individual who suffered a stroke nine years ago
- Our client is ambulatory but standing and walking are both mentally and physically exhausting

Motivation

Current devices are too costly:
- Wii Fit Balance Board ($450)
- Balance Master ($25,000)

Problems with the previous design:
- Overall durability
- Damage to hardwood floors from metal hinges
- Biofeedback mechanism not hands-free

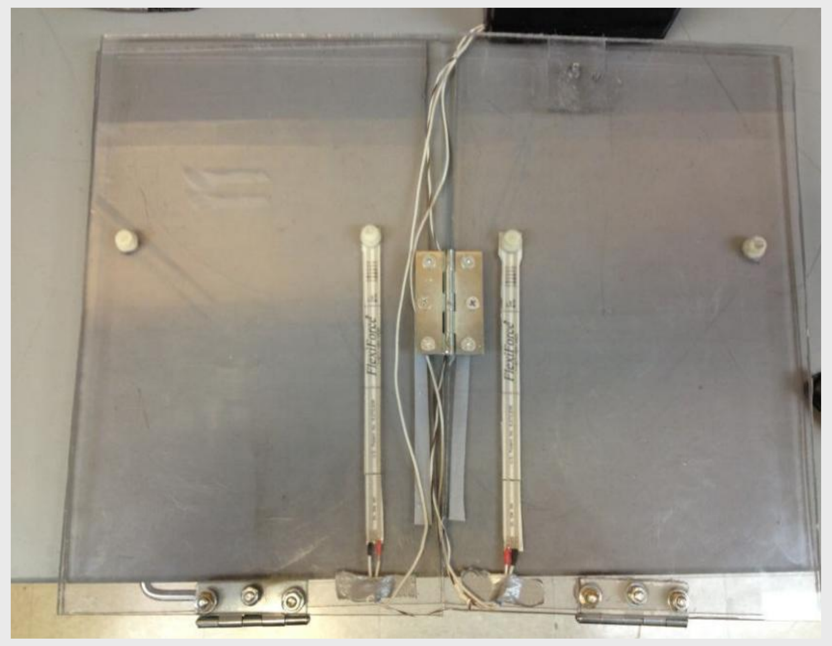
Figure 1: Previous year's design

Design Criteria

Client Requirements
- Biofeedback should be clear and easily interpreted
- Design cannot require client to look down or hold an object
- Free of metal hinges or parts that could damage flooring

Board Specifications
- Measure weight distribution accurately
- Portable, light, able to be carried in one hand
- Safe to balance without falling
- Thin as possible

Fabrication

- Bathroom scale was taken apart and manipulated in order to measure differences in weight distribution between the left and right feet
- Keeping circuitry and the existing microcontroller intact, various forces were tested and voltages were recorded from several points on the microcontroller
- Weight distribution mechanisms were not immediately evident - no change in voltage across load cells detected during loading

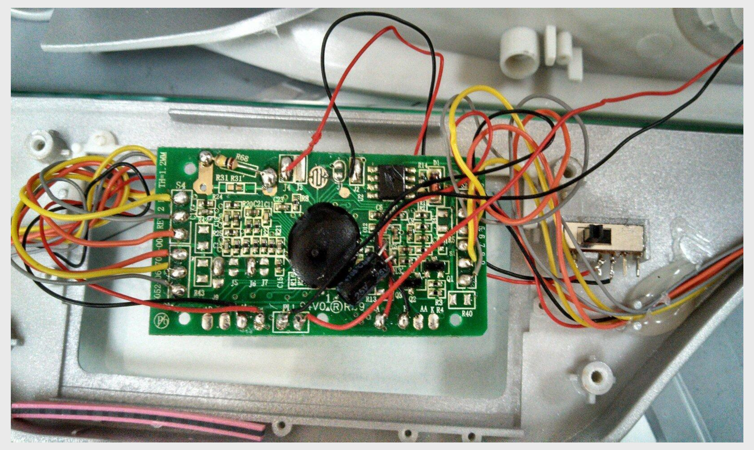
Figure 2: Bathroom scale's original circuit board

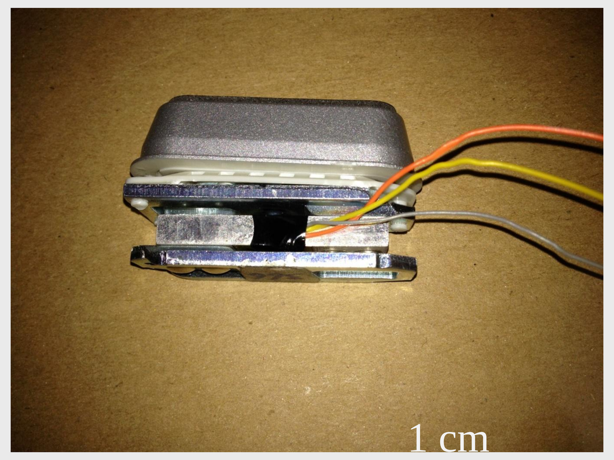

Figure 3: Bathroom scale's load cell

- Load cells were isolated from the scale, three wires from each
- Resistance measured across all wires, responded similarly to a potentiometer or half Wheatstone bridge

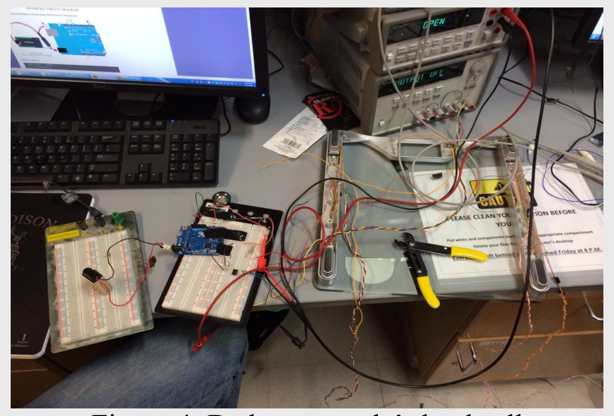
Figure 4: Bathroom scale's load cell

Experimental Testing

- 100 pounds of weights distributed on left and right side of the scale

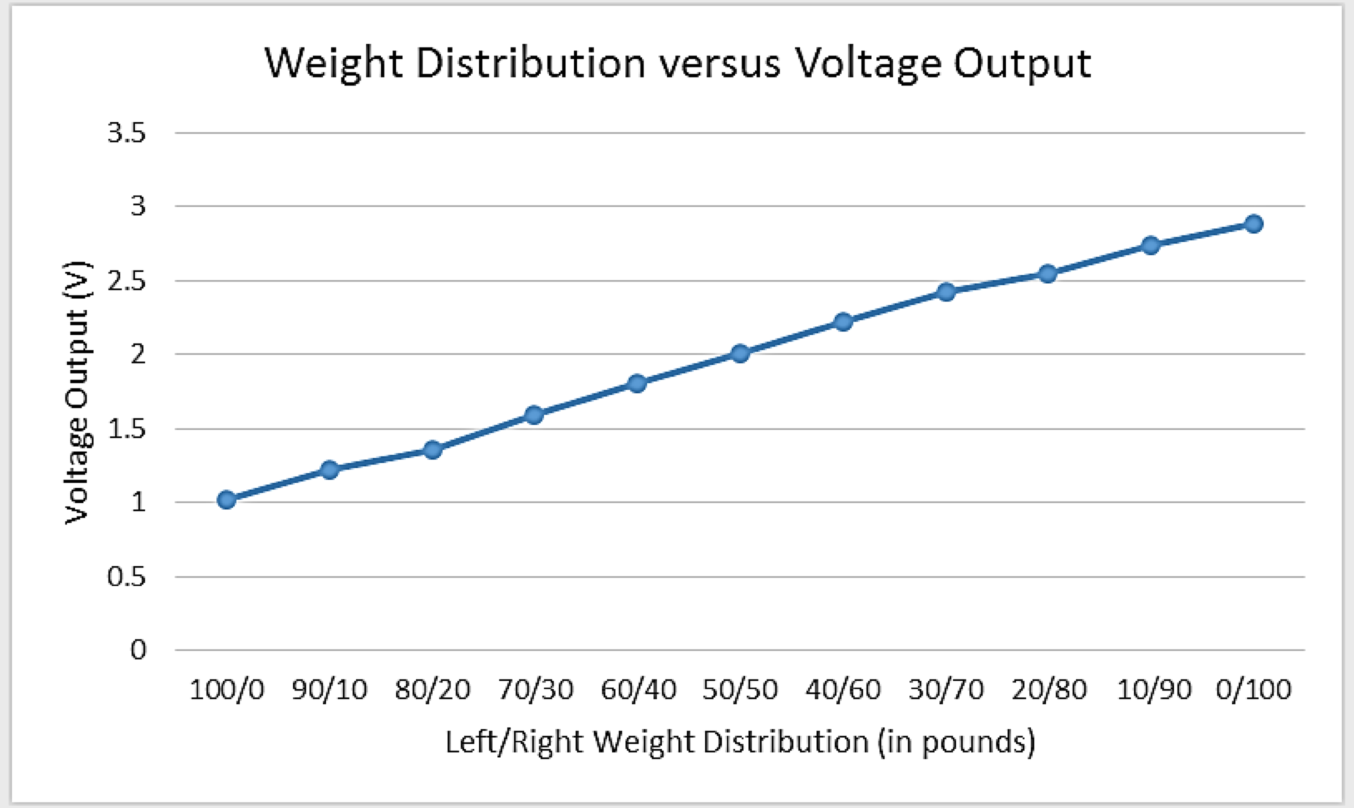

Figure 5: Voltage deflection due to weight distribution

Final Design

- Constant tone when balanced. Tone frequency increases as weight shifts to the right and decreases as weight shifts to the left
- Shifts in tone frequency correlated with notes in musical scale
- Load cells used in pairs to form Wheatstone bridge that varies based on the side that has more weight
- Only back two load cells used for weight distribution measurements
- Signal input into 1,000-gain amplifier to magnify signal for Arduino
- With readable signal, boundaries were adjusted so that there was an offset range, not requiring the patient to be perfect
- Pushbutton offers hands free operation

Specifications
- Health O Meter digital scale with 2 load cells
- Arduino Leonardo
- LM324 Op-Amp
- 8 ohm 0.1 W speakers
- 9-Volt battery

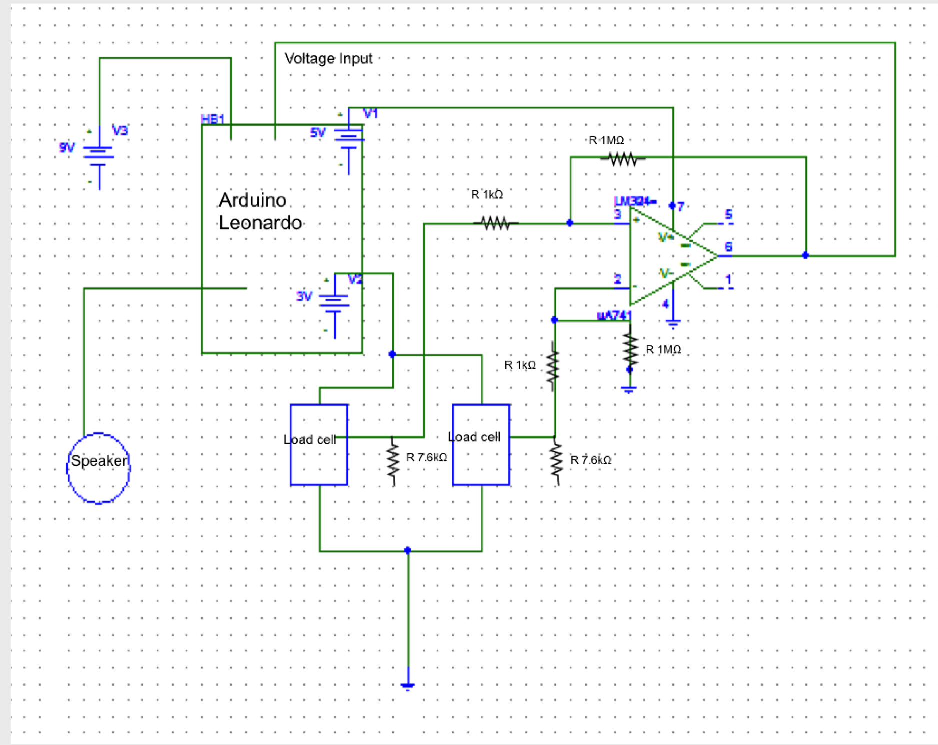

Figure 6: Circuit diagram of our design

Future Works

- Use a smaller Arduino or other microprocessor to decrease power consumption
- Use a more power efficient OP Amp
- Use low tolerance resistors to decrease noise in the circuit
- Increase volume of speaker
- Make Arduino auto-sleep when not in use
- Reduce the voltage noise to 0 V
- Use a printed circuit board to improve durability
- Make the board thinner, lighter and wider
- Build memory into the Arduino to track improvements and make device adaptable

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References

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