Smart Walker

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Problem Statement

Walking speed and reliance on assistive devices are indicators frequently used to assess the functional mobility of patients in rehabilitation. These characteristics are currently measured most often through observation as opposed to objective data. For this reason Dan Kutschera, a physical therapist at the UW Rehabilitation Hospital, requires a clinical walker which measures gait speed and applied force to the walker. This data must be displayed on the walker after collection using clinically relevant measurement units. This data can then be used to inform plans of care and as a motivational tool for patients.

Motivation & Background

- People enter neurorehabilitation due to a variety of neurological disorders and injuries, the most common being strokes [1].
- The most common symptom of those requiring neurorehabilitation is gait impairment, a condition which reduces quality of life and increases the risk of future falls [2].
- There are currently walkers on the market which measure speed and pressure distribution, but these devices are frequently over engineered, time consuming to use, and expensive [3].
- A smart walker would provide a quick method of measuring clinically relevant data which could inform patient care.

Figure 1: Camino Smart Walker [3]

Design Specifications

- Device must be able to be used for 10 patients a day, 5 times each, with a maximum walking distance of 100 feet.
- Measurements of speed, distance, and weight must be displayed in real-time on the walker.
- Must support the weight of the user, maximum of 140kg (310lbs).
- All displayed measurements must be within 5% of actual measurements.

Prototype Fabrication

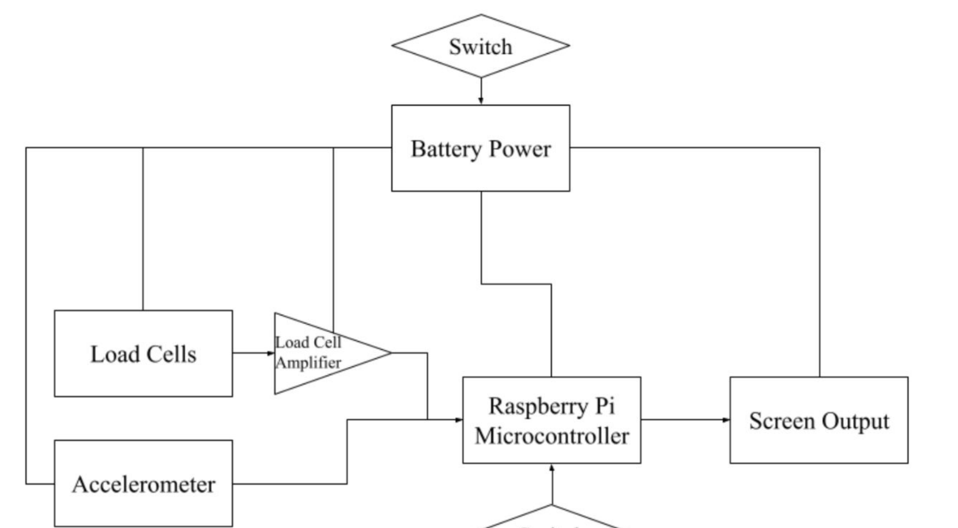

Figure 2

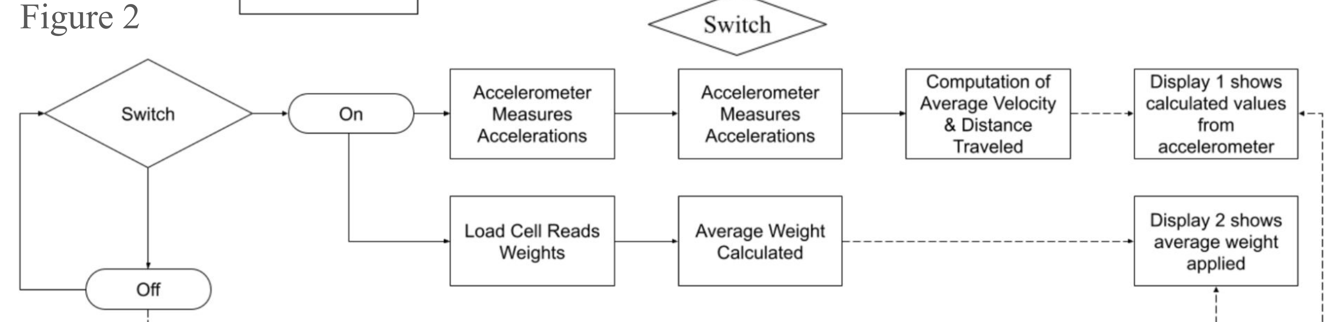

Figure 4

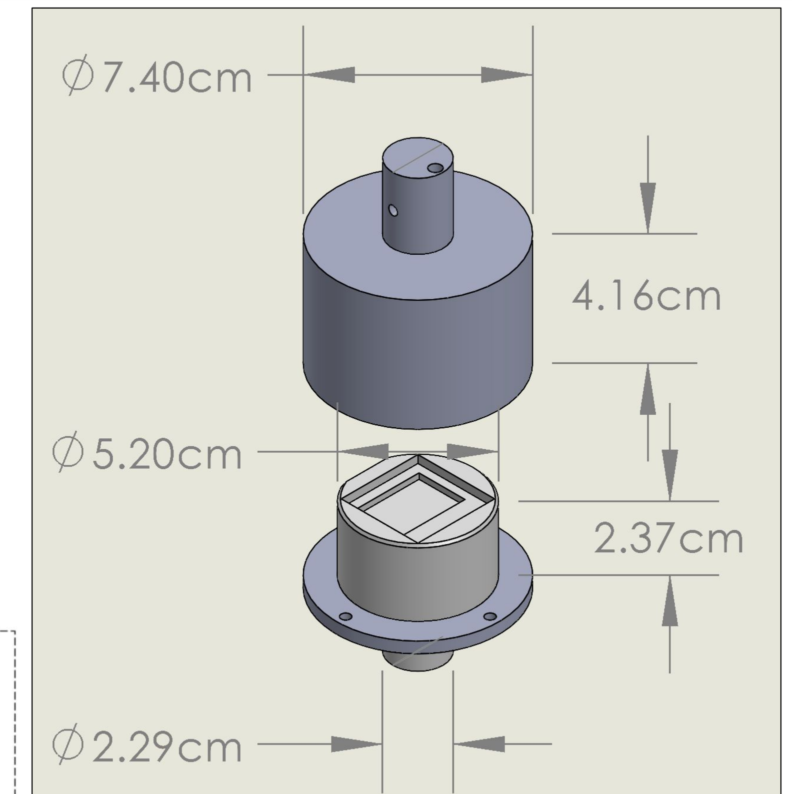

Figure 3

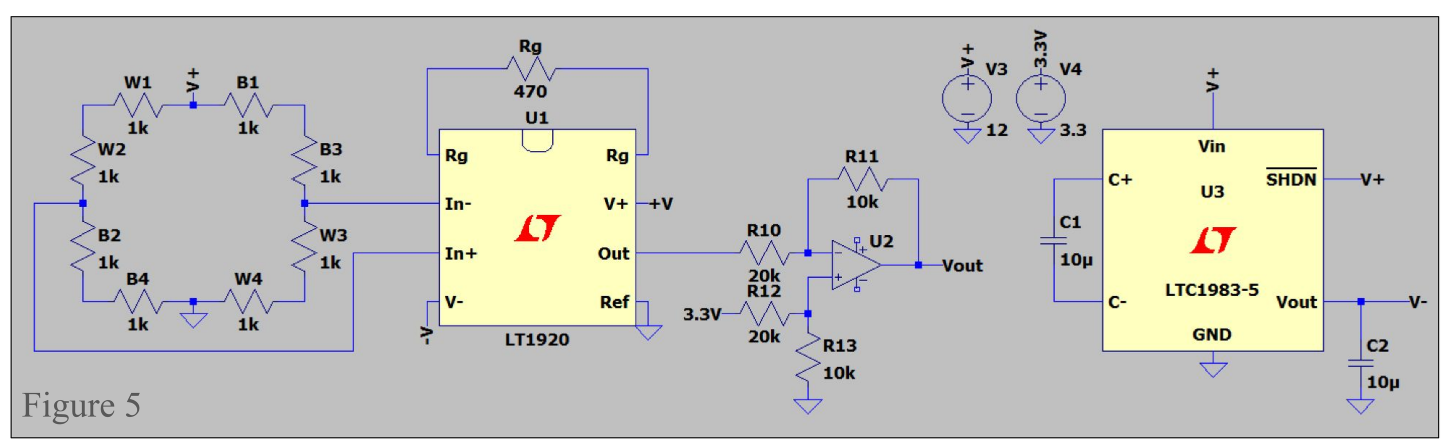

Figure 5

Figures 2,3,4,5: Figure 2 represents the hardware block diagram of the complete device. Figure 3 shows the dimensioned assembly of the load cell housing units. Figure 4 shows the software block diagram with the dotted lines representing the actions after the switch has been turned off. Figure 5 is the schematic of the load cells and the amplifying circuit.

Testing and Results

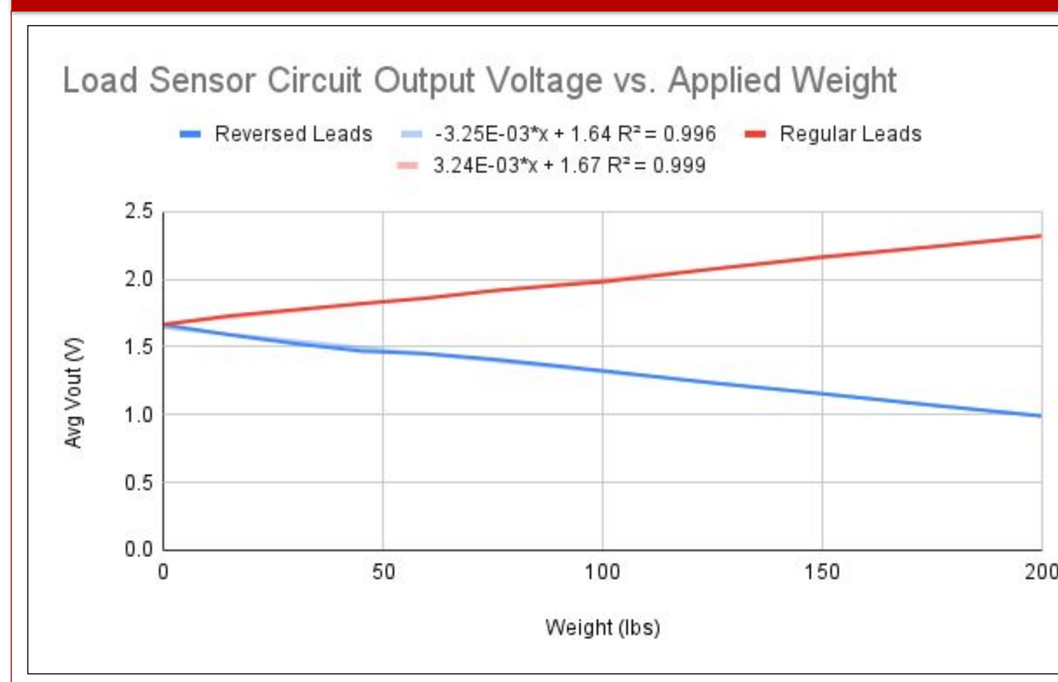

Figure 6: The load sensor calibration plot of output voltage vs applied weight

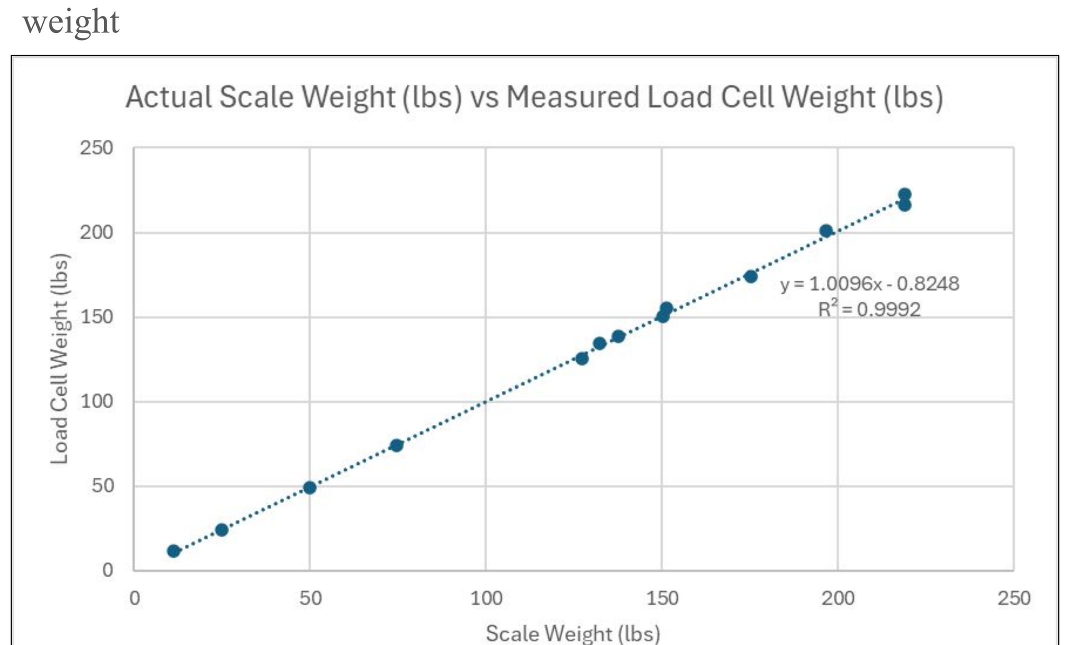

Figure 7: Testing of the load cells in comparison to a bathroom scale at varying weights

Sensitivity	Average Velocity (m/s)	Standard Deviation (m/s)
+/- 2 g	0.097	0.11
+/- 4 g	0.037	0.006
+/- 8 g	0.053	0.046
+/- 16 g	0	0

Table 1: Results of accelerometer debugging testing where the accelerometer was placed on a table to evaluate how well it measures no movement

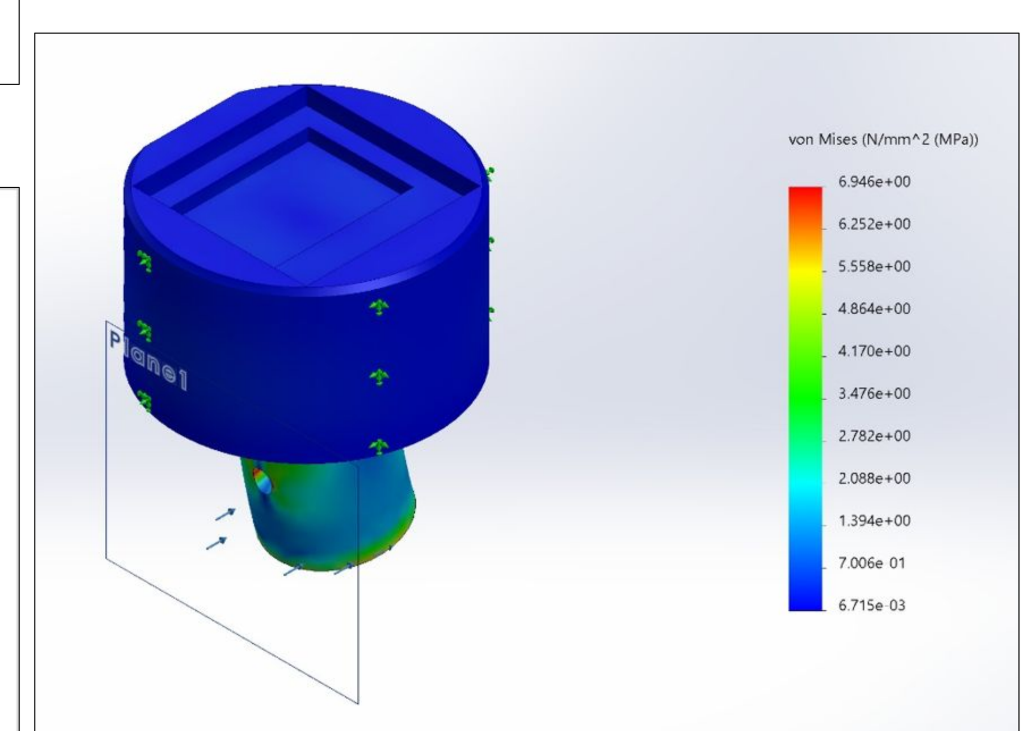

Figure 8: Solidworks simulation messing von Mises Stress of lower housing component during movement

Discussion

Load Sensors

- Calibration curve R^2 values of 0.99
- Average error when compared to an actual scale of 1.39%

Accelerometer

- Sensitivity issues: Higher sensitivity ranges don't pick up on smaller movements and vise versa
- Drift issues: Observed velocities when no movement is occuring

Screens

- Each screen will occupy both I2C buses

CAD Model

- ABS minimum flexural yield strength of 60.6 MPa means the factor of safety is 8 [4].
- The reduction of strength through 3D printing can be offset by using a high infill (80%).

Future Work

- In order for the Smart Walker to become a standalone device a portable, rechargeable power supply attached to the walker is needed
- Voltage regulation at 12V, 5V, and 3.3V would be useful for specific components to help decrease noise
- Fix accelerometer issues
- Finish solidworks designs
- Once all components are integrated together on the walker, the team will have to do another round of in-depth testing to ensure design specifications have been met.

Acknowledgements

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References

[1] "Brain rehabilitation," Mayo Clinic, https://www.mayoclinic.org/tests-procedures/brain-rehabilitation/about/pac-20393150 (accessed Dec. 4, 2024).

[2] M. Bonanno et al., "Gait analysis in neurorehabilitation: From Research to Clinical Practice," Bioengineering, vol. 10, no. 7, p. 785, Jun. 2023. doi:10.3390/bioengineering10070785

[3] Camino Mobility, https://caminomobility.com/ (accessed Oct. 3, 2024).

[4]ABS material data sheet, http://teststandard.com/data_sheets/ABS_Data_sheet.pdf (accessed Dec. 5, 2024).