Smart Walker

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Problem Statement

Walking speed and reliance on assistive devices are indicators that can be used to assess the functional mobility of patients in rehabilitation. Walking speed is 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 to assess patient reliance. This data must be displayed on the walker after collection in clinically relevant measurement units. This data 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].
- A smart walker would provide a quick method of measuring clinically relevant data which could inform patient care.
- Current walkers utilize hand based measuring systems in conjunction with motion capture.

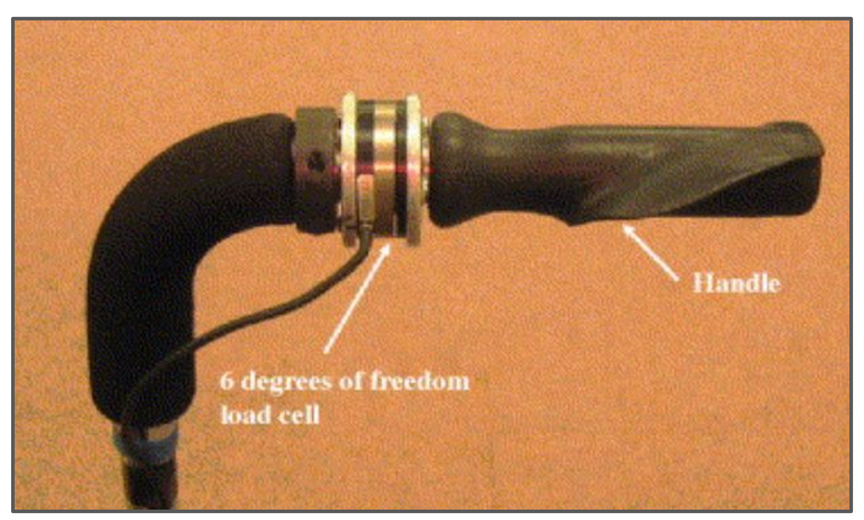


Figure 1: Handle based measurement from UVA [3].

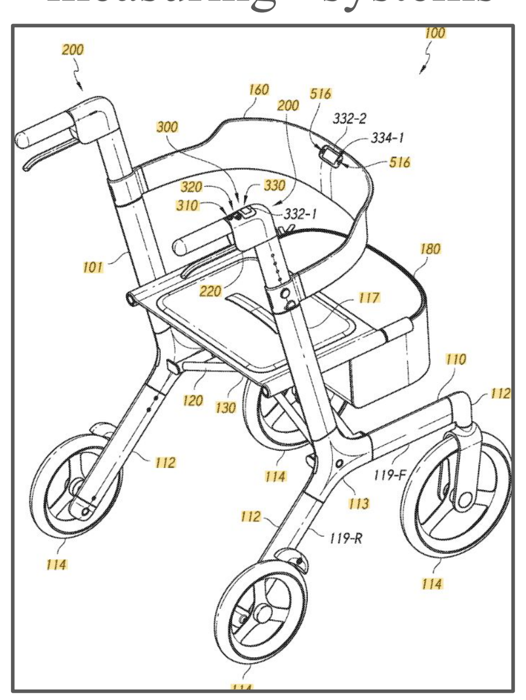


Figure 2: A patent outlying a Smart Walker [4].

Design Specifications

- Device must be able to be used for 10 patients a day, 5 trials each, with a maximum walking distance of 30m.
- Speed, distance, and weight biometric data must be displayed in real-time on the walker.
- Must support the weight of the user, maximum of 140kg (310lbs).
- Displayed measurements must be within 5% of real values and repeatable between trials.

Prototype Fabrication

Design Components:

- OLED Displays
- Trial and Power Switches
- Electrical Housing
- Raspberry Pi Pico Microcontroller
- Load Cell Holders
- Four Strain Gauge Sensors
- IR Sensor Holder
- IR Sensor
- High Contrast Markings

Figure 3: Final design and assembly.

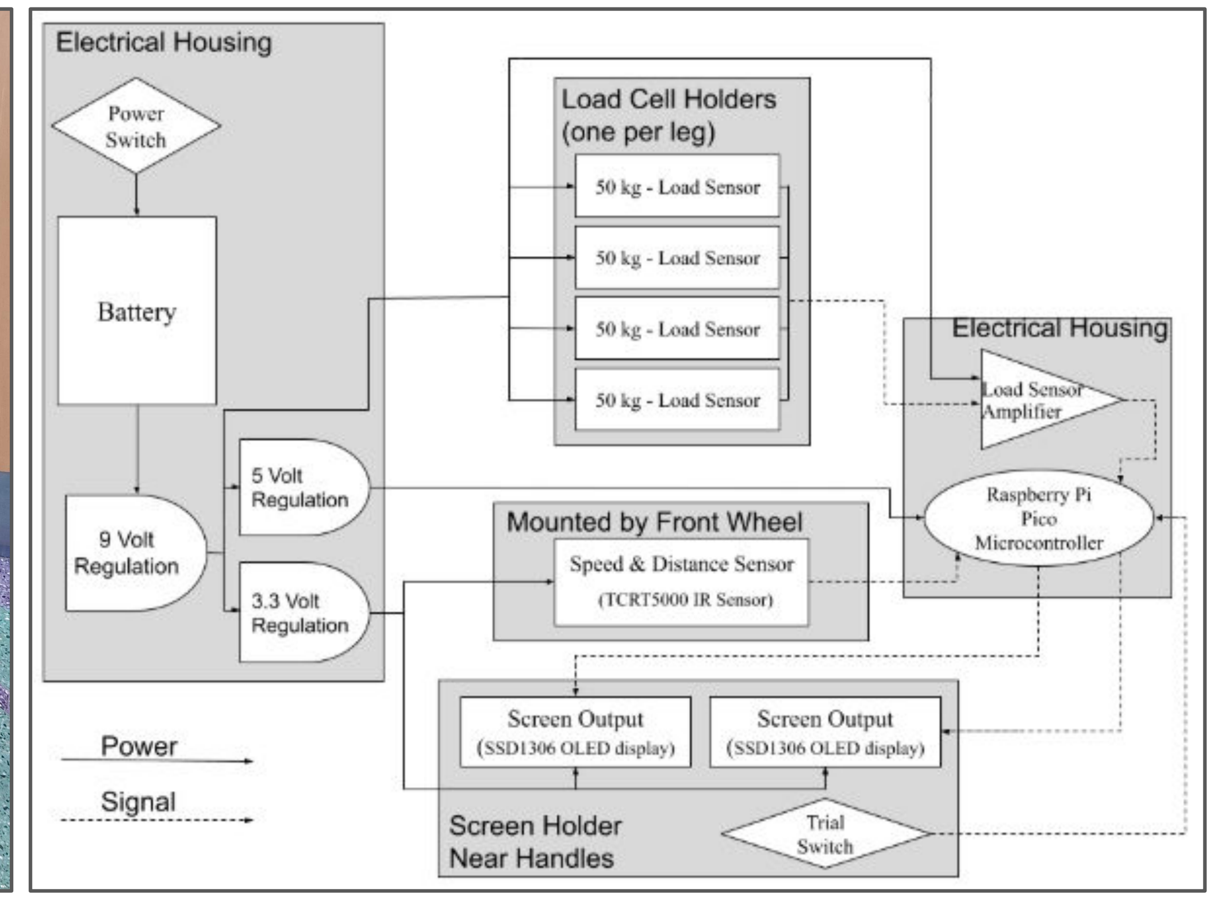


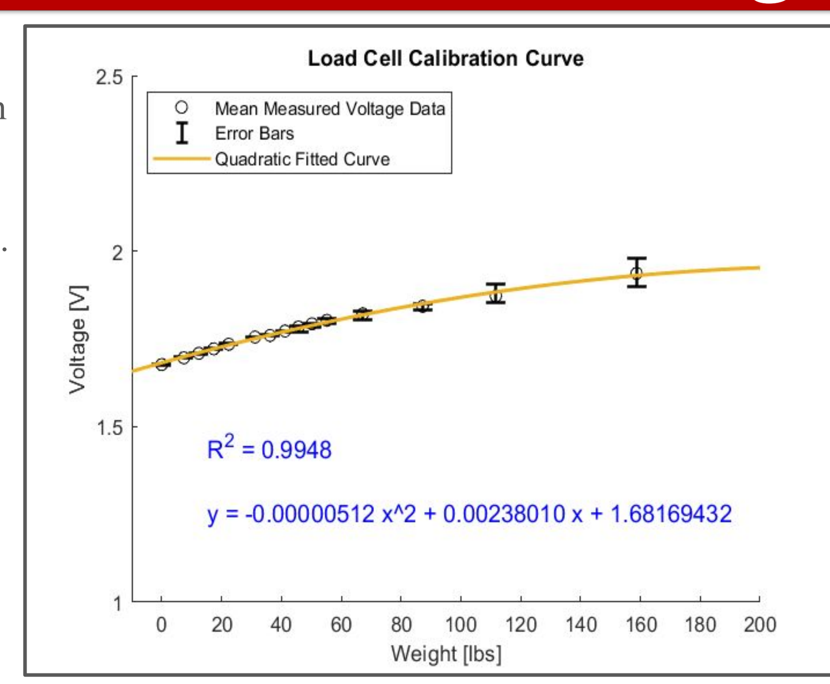
Figure 4: Block diagram of the smart walker's components.

Load Measurement:
Each leg has been modified to contain a strain gauge sensor within a load cell holder.

Speed and Distance Measurement:
A TCRT5000 Infrared Sensor along with high contrast markers were used to track wheel revolutions.

Testing and Calibration

Figure 5: Calibration curve for load calculation.



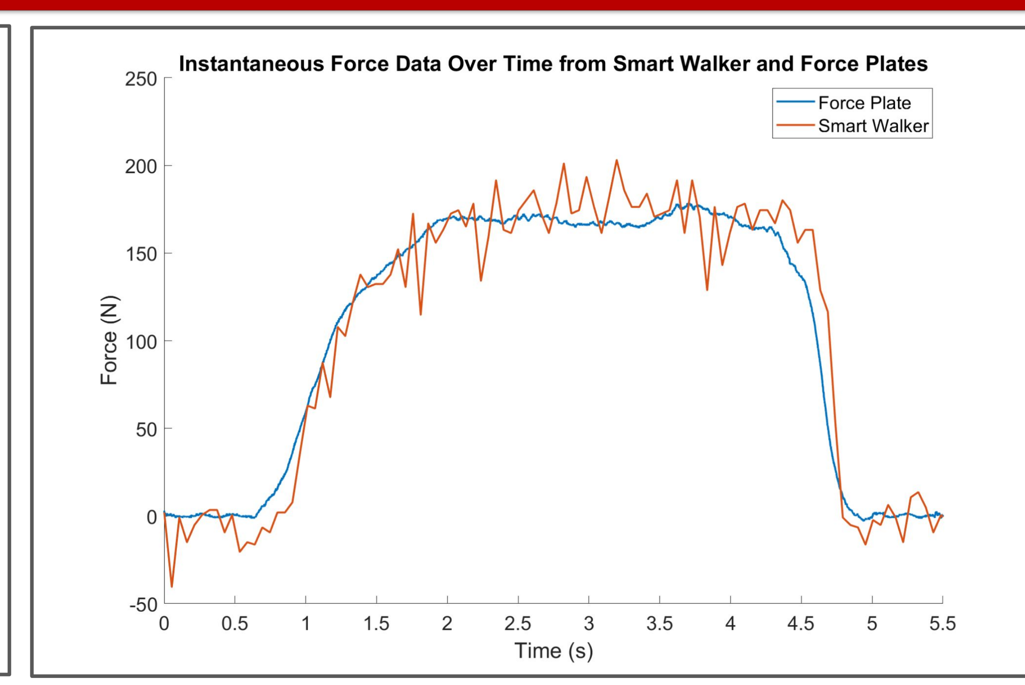
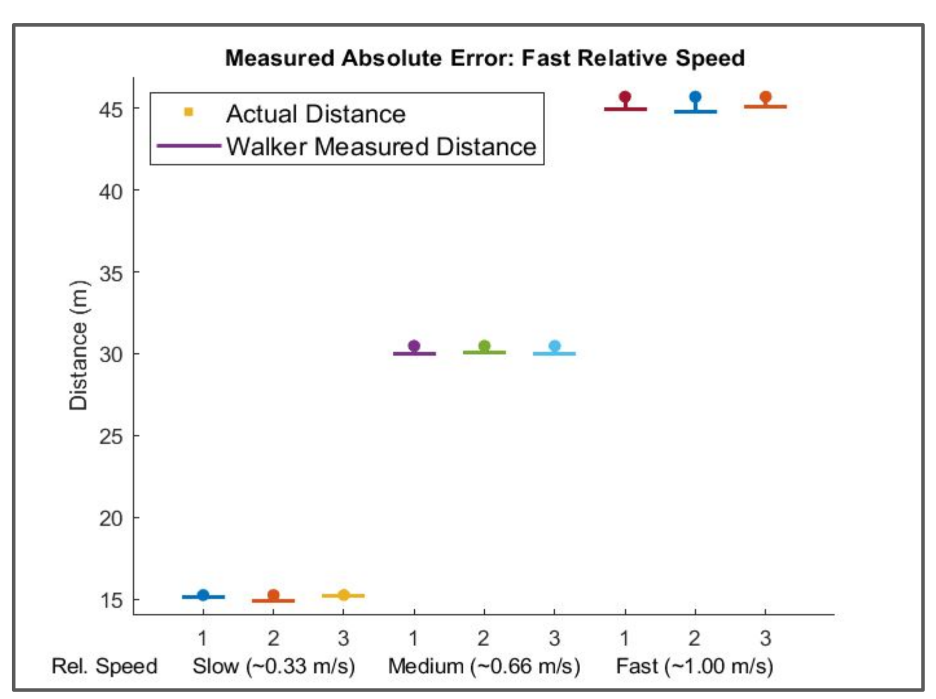


Figure 6: Visualization of one trial comparing instantaneous force between force plates and walker measurements.

Figure 7: Absolute error between distance and walker measured distance at fast relative speeds.



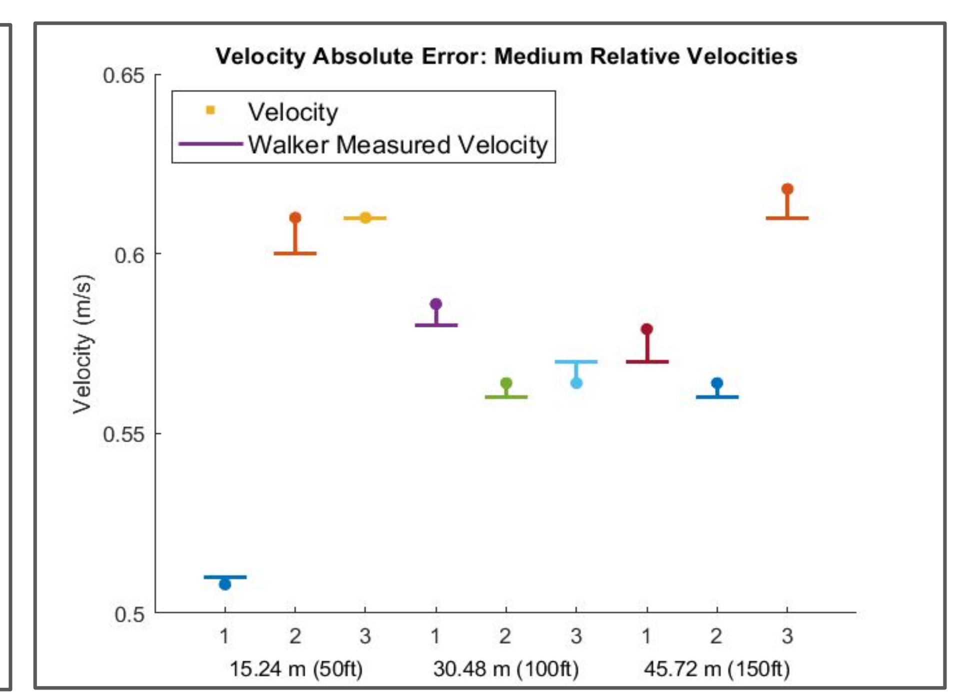


Figure 8: Absolute error between velocity and walker measured velocity at medium relative speeds speeds.

Discussion and Results

Load measurement:

- Calibration curve quadratic R^2 value of **0.995.**
- Average error of force measurement of **2.43%.**
- Due to averaging, changes in force are displayed over a short amount of time rather than instantaneously.
- Measurement inconsistencies from instrumentation or movement.

Movement measurements:

- Average speed and distance traveled measurements are very accurate, with relative errors of **1.20%** and **1.25%** respectively.
- Slow, medium, and fast instantaneous velocity had relative errors of **18.17%**, **17.69%**, and **26.06%** retrospectively. However, this is likely due to testing limitations.

Other:

- More than sufficient battery life, with a fast recharge time.
- Tested up to 90kg (200lbs).

Future Work

- Decrease signal noise and improve instrumentation components.
- Fix inconsistencies in load measurement.
- Test battery, improve testing of instantaneous data.
- Reduce horizontal translation of walker.
- Integrate a fall detection system with a gyroscope and other customer requested measurement systems.
- Implement a method to upload trial data to an external device.
- Further pursue patent application.
- Commercialize to clinics across the country.

Acknowledgements

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References

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[4] A. AlGhazi and A. Hejazi, "Mobility Assistance Apparatus," Jul. 7, 2022