Walger LLC start up company – Team 21

Smart Walking Cane

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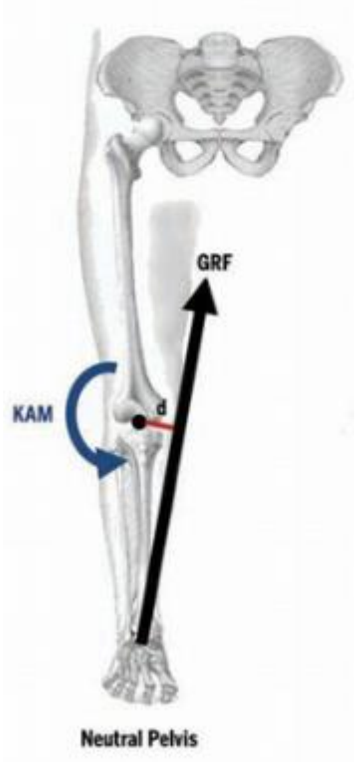
OBJECTIVE

Our objective is to design a smart walking cane capable of measuring forces applied by a user. The system design must accurately measure the applied loads while withstanding the dynamic conditions of daily use. The team was presented with a previous cane design to analyze failure modes and to inspire future concept designs. Through multiple prototype iterations of a custom strain gauge load cell on the handle of the cane, we confirmed the feasibility of this configuration to accurately measure force applied to the cane by acquiring multiple sets of consistently linear force reading data.

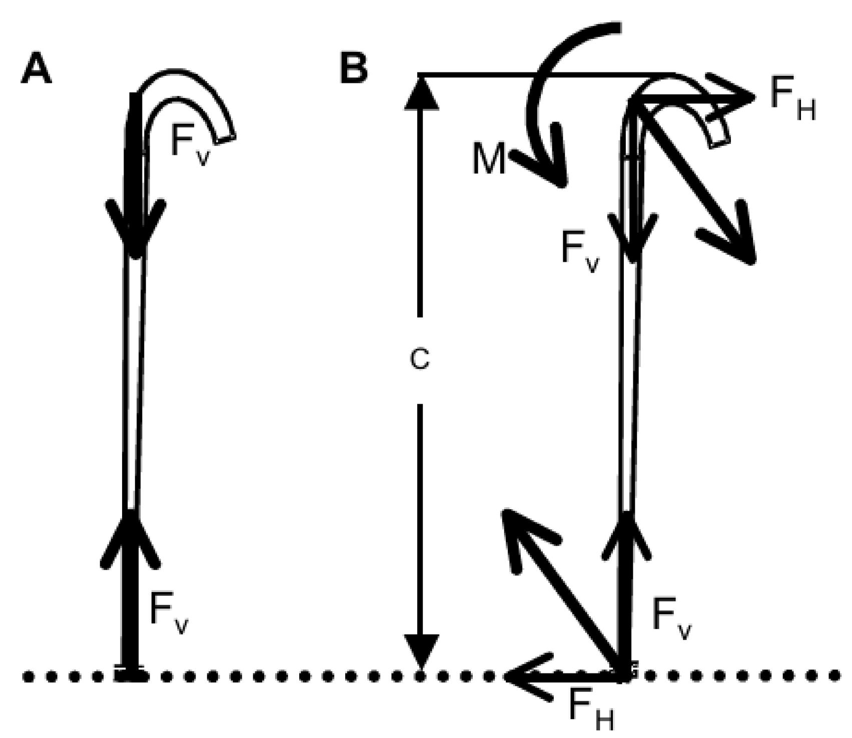
CUSTOMER PROBLEM AND BACKGROUND

Knee Osteoarthritis Biomechanics



[1]

Loading Conditions on Walking Cane



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Knee osteoarthritis impacts approximately 46% of people over their lifetime, especially among the elderly population. As cartilage deteriorates, individuals experience pain, swelling, and mobility issues, making assistive devices critical for maintaining independence.

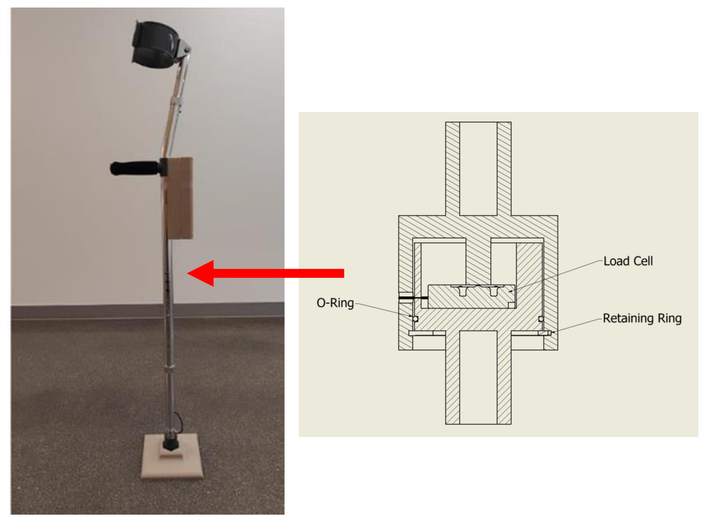
Traditional canes redistribute weight but fail to guide users in applying optimal force and angle, crucial factors in reducing knee adduction moment (KAM), a known contributor to disease progression. The previous CAPSTONE Team designed a haptic feedback cane, but the force readings were inaccurate and became worse over time.

This project aims to find a new method to accurately measure forces applied by a user to eventually be used in a haptic feedback cane. This will ultimately improve quality of life for users and enable healthcare providers to monitor and adjust rehabilitation strategies effectively.

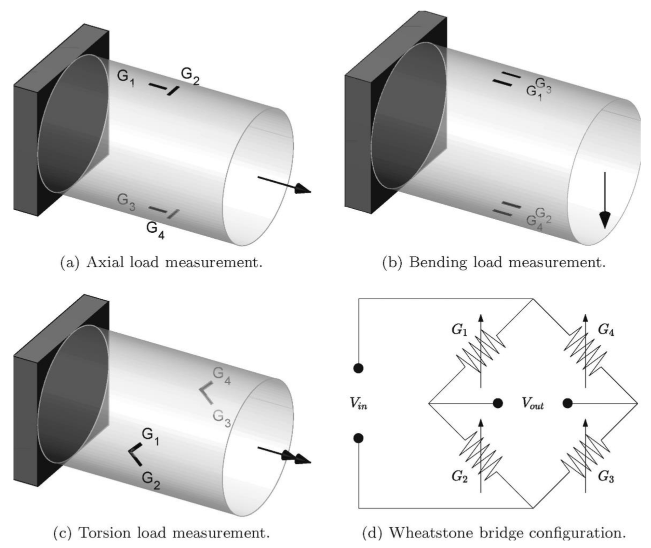
CONCEPTS AND EXPERIMENTATION

Our first design concept, shown to the right was Installing a commercial load cell within the shaft for direct force measurement but at the cost of added bulk and complexity. Our second design concept, shown to the right was using the bending forces applied to the handle to measure the force applied using strain gauges. We created four different prototypes for experimentation with two changing variables: strain gauge size (long and short) and strain gauge placement (close and apart), all fabricated with a consistent and well documented method.

Reinforced Load Cell Concept



Strain Gauges 1mm or 12mm apart on cane handle in bending load moment configuration (b)



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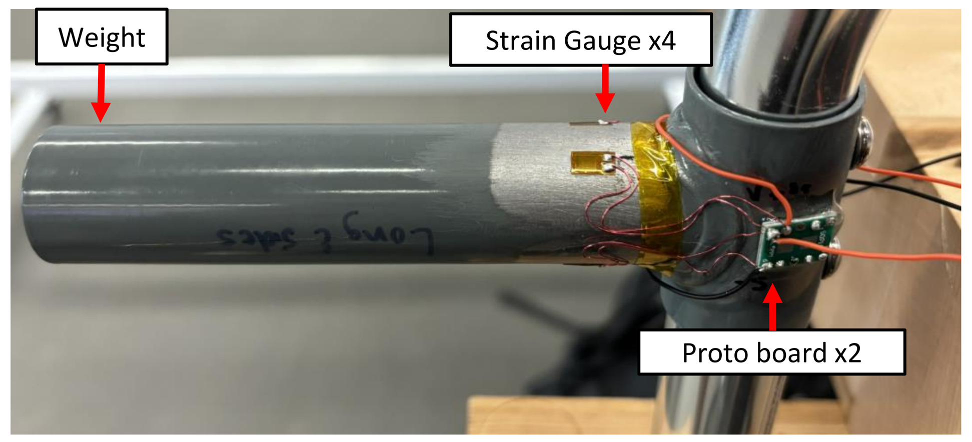
Experimental Variables	
Variable 1: Strain gauge type	Shorter 350 ohms
	Longer 120 ohms
Variable 2: Strain gauge placement	1mm apart
	12mm apart

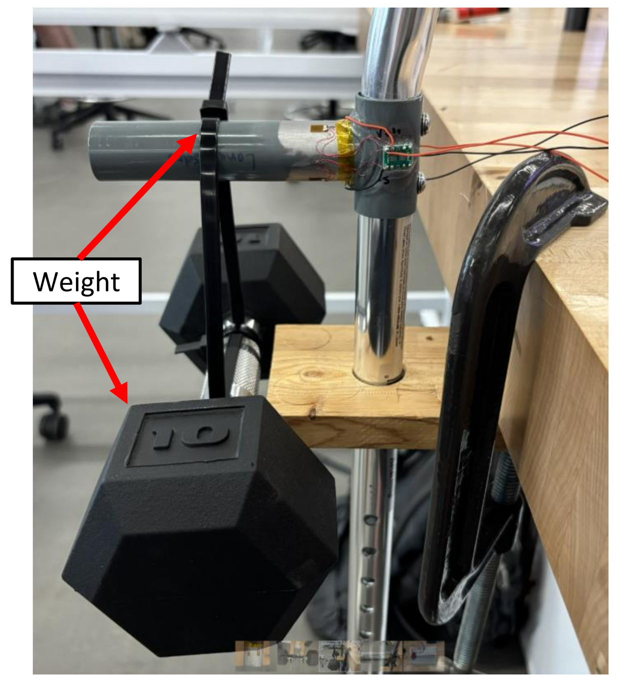
REQUIREMENTS AND FINAL DESIGN

1. Measures and displays 20–35 % body-weight support for optimal off-loading.
2. Handle-integrated strain gauges resist multi-axial forces and moisture for reliable readings.
3. Costs only $5–8 in 3D-printed parts by fitting into a standard cane handle.
4. Fully contained, sealed electronics keep the design sleek and splash-resistant.

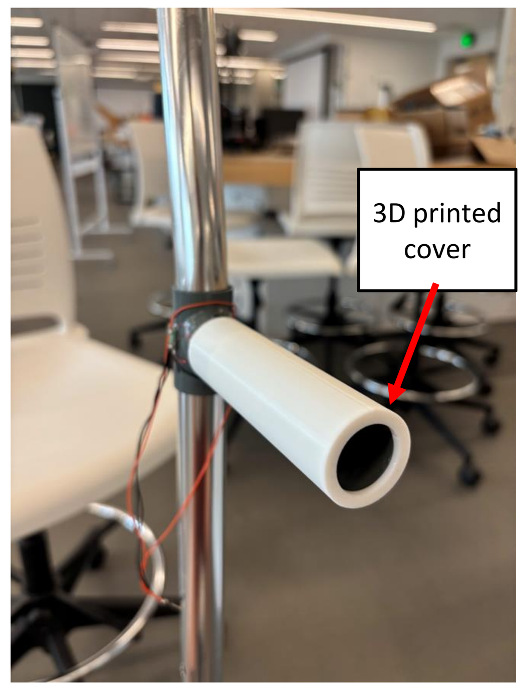
System Design



System Calibration

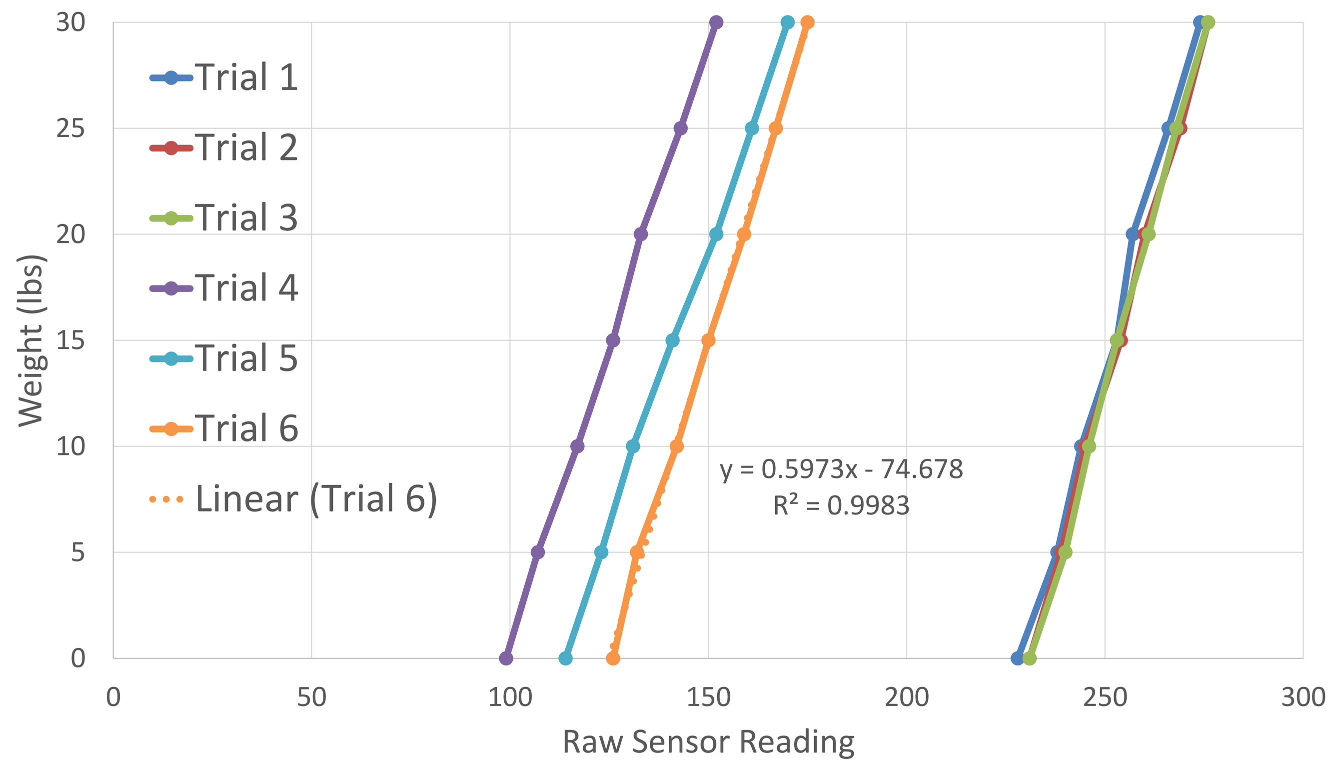


System Integration



Final prototype testing showed promising linearity between the force applied and signal output. While early prototypes exhibited signal drift in linearity, later refinements, including better surface preparation, stabilized wiring, and testing different strain gauge placements, reduced measurement variability. A drift in the unloaded value occurs due to environmental factors, but the code factors out the starting value and outputs the value in pounds using the slope of the line. Current prototypes demonstrate strong linearity between applied weight and sensor output, validating the feasibility of strain gauge sensing of the bending force in the handle.

TESTING RESULTS



CONCLUSION AND RECOMMENDATIONS

Testing and validation confirm that a handle-integrated strain gauge system is a viable and effective solution for accurately measuring user-applied forces.

The design meets core goals of accuracy, durability, and seamless user experience, while maintaining a lightweight and ergonomic structure.

Moving forward, we recommend further calibration refinement, long-term fatigue testing, and extensive user validation trials to simulate real-world daily use.

The next step would be to integrate this force sensing configuration with the haptic cane previously developed

CITATIONS

[1] Farrokhi, C. A. Voycheck, S. Tashman, and G. K. Fitzgerald, "A Biomechanical Perspective on Physical Therapy Management of Knee Osteoarthritis," *Journal of Orthopaedic & Sports Physical Therapy*, vol. 43, no. 9, pp. 600–619, Sep. 2013, doi: 10.2519/jospt.2013.4121.

[2] H. Bateni and B. E. Maki, "Assistive devices for balance and mobility: Benefits, demands, and adverse consequences," *Arch. Phys. Med. Rehabil.*, vol. 86, no. 1, pp. 134–145, Jan. 2005, doi: 10.1016/j.apmr.2004.04.023.

[3] X. Iriarte, J. Aginaga, G. Gainza, J. Ros, and J. Bacaicoa, "Optimal strain-gauge placement for mechanical load estimation in circular cross-section shafts," *Measurement*, vol. 174, p. 108938, Apr. 2021, doi: 10.1016/j.measurement.2020.108938.