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Smart Walker

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Overview

- Client Description
- Problem Statement
- Background Research
- Competing Designs
- Product Design Specifications
- Current Design
- Design Matrix: Distance Sensor & End-Cap Design
- Circuit Flow
- Future Work and Acknowledgements

Client

Mr. Daniel Kutschera

- Physical therapist in neurorehabilitation
- Acute Stroke Clinic - ThedaCare, Fitchburg , WI



Figure 1: Mr. Daniel Kutschera [1]

Background

Tracking Traumatic Brain Injury (TBI) Recovery Patient Walking Progress

- Current Methods
 - Timer and tape measure for speed and distance
 - No commercially available way to track weight put on walker
- Past BME Design Iterations
 - Compromised structural integrity of walker
 - Not easily replicable



Figure 2: 2024 Final Design

Problem Statement: The Project

Current TBI monitoring methods **only measure speed and distance** after trials, **ignoring weight data**.

Real-time metric collection could **reduce documentation time**, provide instant feedback on discharge readiness, streamline insurance processes, and **help patients track their progress**.

Competing Designs

- Bure Rise & Go Walker
 - Main function: standing assistance
 - Does not quantify gait or pressure metrics
- Camino Smart Walker
 - Enhances stability
 - Provides automated physical support
 - Expensive - \$2,999 [3]
 - Not designed for clinical settings



Figure 3: Bure Rise and Go Walker [2]



Figure 4: Camino Smart Walker [3]

Product Design Specifications

Client Requirements

- Easily installed and removed
- Will track
 - Walking speed
 - Distance traveled
 - Pressure applied to the walker
- Independent weight and speed measurements
- Display metrics from a mobile device

Accuracy

- Measure within $\pm 10\%$
 - Distances up to 10m
 - Speeds 0-9.65km/h
 - Weights of 0-100kg

Budget

- ~\$500

Current Design

- How it works
 - Load cells track weight
 - LiDAR tracks distance and speed
- Changes
 - Load Cells can not withstand load required
 - LiDAR laser can be interrupted
 - End caps are bulky, and unpolished

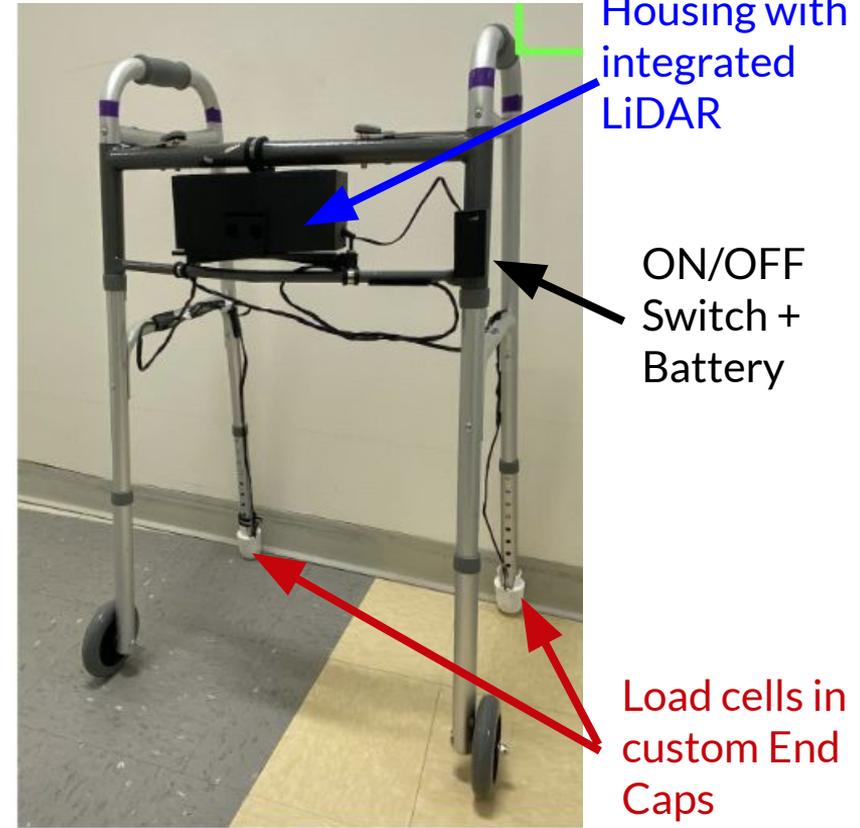


Figure 5: Fall 2025 Smart Walker

Ultra Wideband Sensors + Wi-GIM Network Design

- + Precise and accurate spatial tracking
- + Separates reflected signals
- + Measurement of gait stability
- Occlusion sensing
- Sensitivity of anchoring sensors

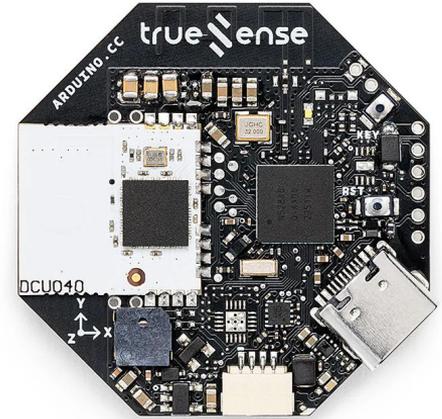


Figure 6: Arduino Stella DCU040 UWB module [4]

Accelerometer + Gyroscope

- + Sensitive to small changes
- + Cost effective, \$10-\$35 [5]
- + Size friendly, 20mm x 15mm [6]
- Distance mathematically calculated

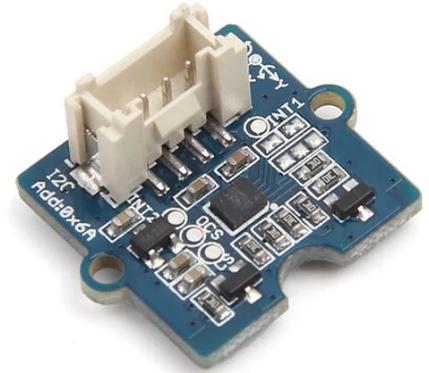


Figure 7: SEED Studio LSM6DS3 Accelerometer and Gyroscope [7]

mmWave Radar

- + High distance precision, 98%
- + Detects minute change
- + Occlusion sensing
- Large distances causes noise

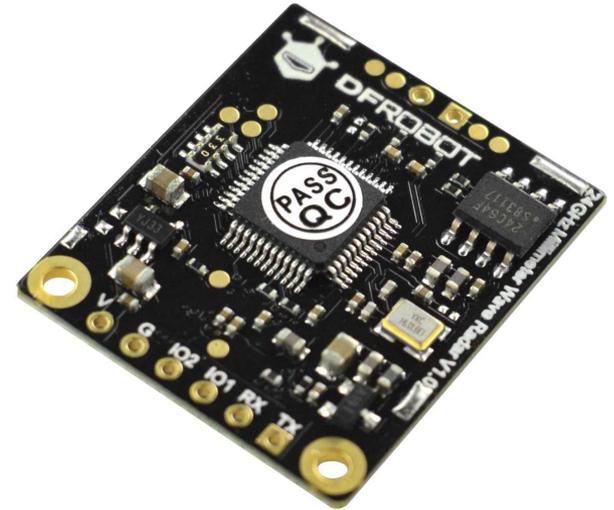


Figure 8: DFROBOT mmWave Radar [8]

Design Matrix: Distance Sensor

Criteria (weight)	Concept A: UWB + Wi-GIM Network 	Concept B: Accelerometer + Gyroscope 	Concept C: mmWave Radar 
Accuracy (30)	30	18	24
Consistency (25)	20	15	25
Occlusion Sensing (20)	16	12	20
Size (10)	6	10	8
Power Consumption (10)	4	10	4
Cost (5)	1	5	3
Total (100)	77	70	84

End Cap Design



Figure 9: Exploded design of Integrated End Cap

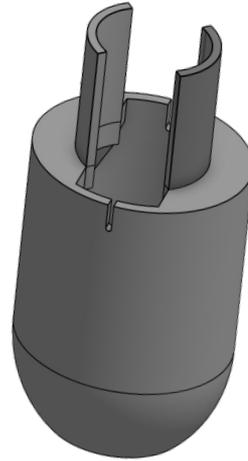


Figure 10: CAD of Custom End Cap

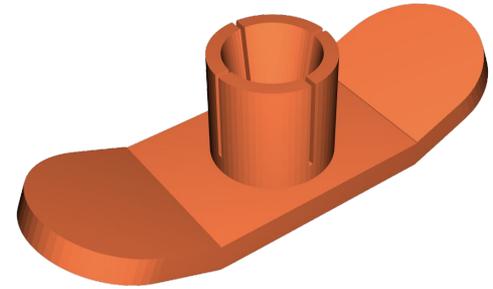
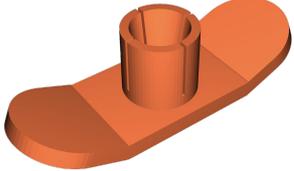


Figure 11: CAD of Sled End Cap

Design Matrix: End Cap Design

Criteria (weight)	Concept A: Integrated End Cap 	Concept B: Custom End Cap 	Concept C: Sled End Cap 
Durability (25)	25	20	15
Cost (25)	20	15	10
Reproducibility (25)	25	20	20
Ease-of-Use (15)	9	15	12
Safety (10)	8	10	8
Total (100)	87	80	65

Final Design Plan

- LiDAR -> mmWave Radar
 - Distance and gait stability tracking
 - Improved occlusion sensing capability
- Integrated end-cap design
 - Encapsulate load sensors for pressure measurement
 - Improved durability and reliability
- Arduino Uno WiFi Rev2
 - WiFi and bluetooth data transmission

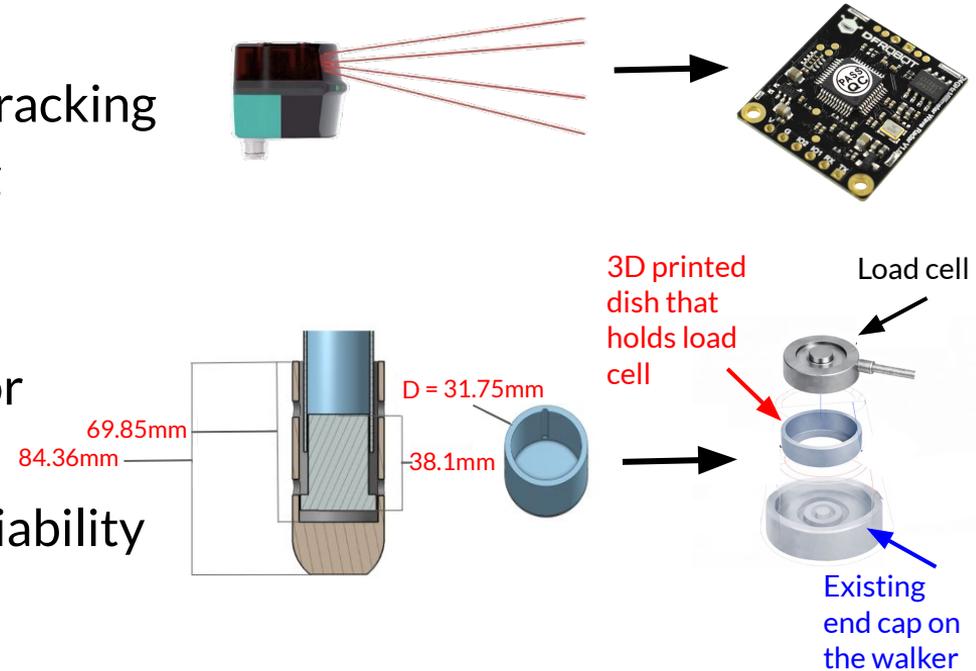


Figure 12: Illustration of changes in the design plan for both distance sensor and end cap design

Circuit Design Flow

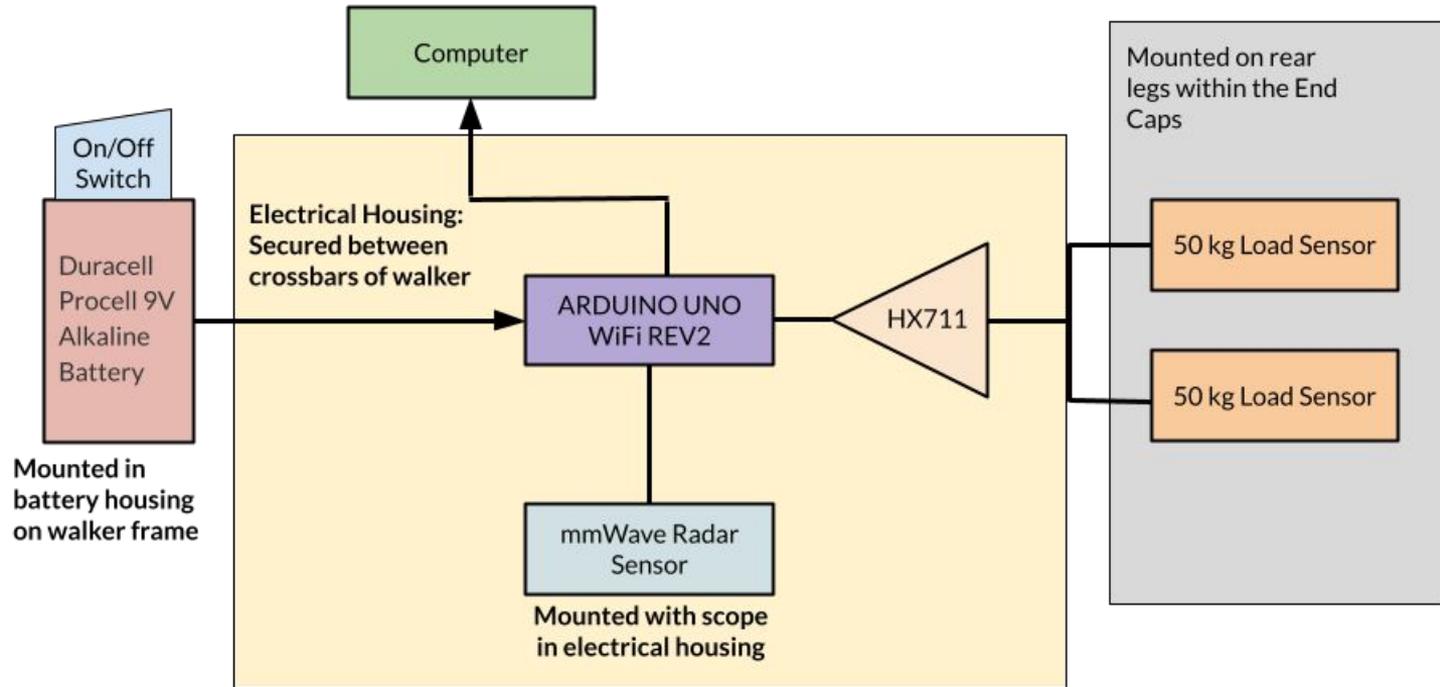
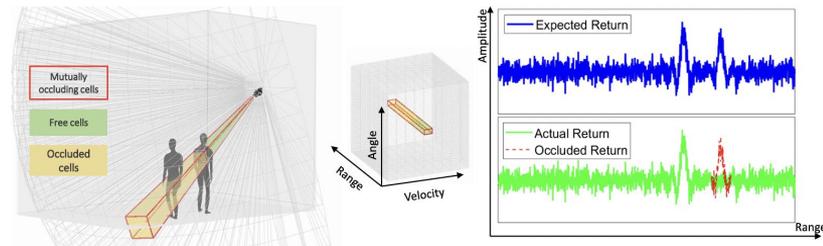


Figure 13: Circuit Design Flow for Smart Walker Attachments

Future Work

- Further improvements
 - Improve radar filtering and enclosure durability
 - Develop user-friendly mobile or clinician dashboard interface
- Testing
 - mmWave occlusion robustness testing (dB, %)
 - Load measurement testing (ms, RPS)
 - Wireless stability and range testing (m, dBs, % packet loss)

Figure 14: mmWave occlusion robustness testing from indoor sensing study [9]



Acknowledgements

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References

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Questions?