



Department of
Biomedical Engineering
UNIVERSITY OF WISCONSIN-MADISON

Smart Walker

10/6/2023

Advisor: Dr. Christa Wille

Client: Mr. Danile Kutschera, PT

Background

- Mr. Kutschera is a physical therapist for rehab patients - many relearning how to walk
- Insurance companies like to see quantitative progress
- Progress tests include gait and distance measurements
 - Currently measured manually
- Pressure is also of interest



Image 1: Physical therapy patient with walker [1]

Problem Statement

Design a Smart Walker with the ability to measure distance traveled, gait speed, and pressure applied on the walker, in order to provide quantitative data to insurance companies, demonstrate progress to motivate the patient, and increase time used for patient improvement.

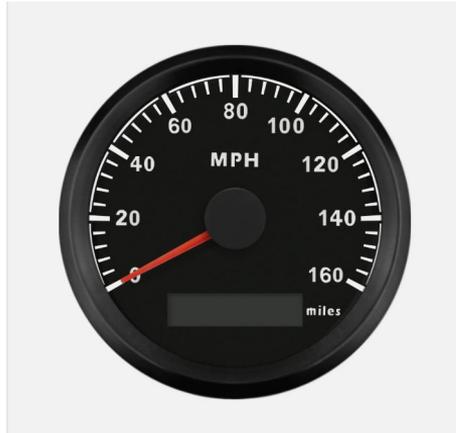


Image 2: Speedometer [2]



Image 3: Pressure gauge [3]

Summary of PDS

- Walker should be able to last for a minimum of 5 years [1]
- Needs to be kept in room temperature
 - Operated in room temperature (15-20 °C) [2]
- Needs to support a variety of different weights
 - Will support up to 136 kg [3]
- Max width = 63.5 cm
- Max height between 81.2 cm to 101.6 cm
- Weight should ideally be between 4.54kg and 9.07kg
- Walker should have a very simplistic design for easy use



Image 4: Walker

Client Requirements:

- Useable in clinical settings
- Created within \$400
- Contains a display for speed, distance, and pressure in (Meters/second, meters, N/meters² respectively)
- Start/Stop button
- Data needs to be uploaded to a server or cloud



Competing Designs

- Camino Smart Walker [4]
 - AI technology tracks metrics and maintains user safety
 - Not adaptable to client's clinical setting
 - Data cannot seamlessly be transferred
- Ambutrak Distance Walker [5]
 - Attachment to walker wheel recording distance and speed
 - Cannot measure pressure



Image 6: Camino Electronic Walker [4]



Image 7: Ambutrak Distance Tracker [5]

Pressure Design Options

- Compression force sensors?
- Hydraulics?
- Pneumatics?
- Force Sensing Resistor

Easy to integrate into the walker, occupies minimal space, inexpensive, accurate enough for the scope of the project



Pressure Sensor Placement Options

#1) Handles

- Easy integration
- Durable, easily serviced
- Higher cost due to the need for multiple sensors & a handle cover to prevent wear

$$(4 \times \$8.20) + (\$11.99) = \$44.79$$

- Measurement accuracy may decrease due to patient's grip force



Image 10: Walker

~ 12.5 cm

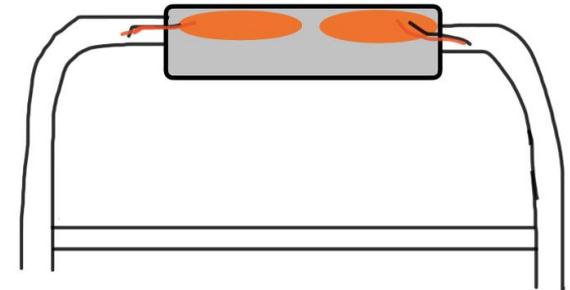


Image 11: Sideview of Sensor Placement on Handle

Pressure Sensor Placement Options

#2) Foot

- Fairly easily integration
 - Only two sensors needed
- $(2 \times \$8.20) = \16.40
- Durability is the main concern due to constant compression from patients and weight of the walker



Image 12: Walker

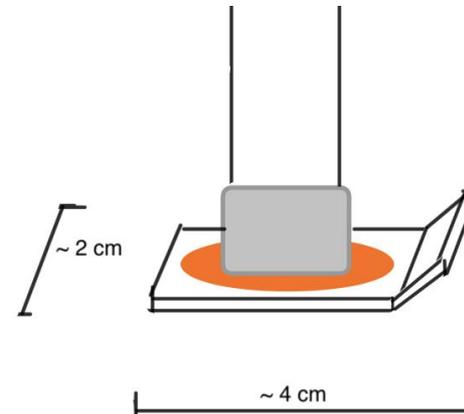


Image 13: Sensor Placement on Foot

Pressure Sensor Placement Options

#3) Wheel

- Difficult integration & wire management due to constant rotation of the wheels
- Only two sensors needed

$$(2 \times \$8.20) = \$16.40$$

- Durability is a concern due to constant contact with the ground
- Pressure measurement cannot be measured continuously



Image 14: Walker

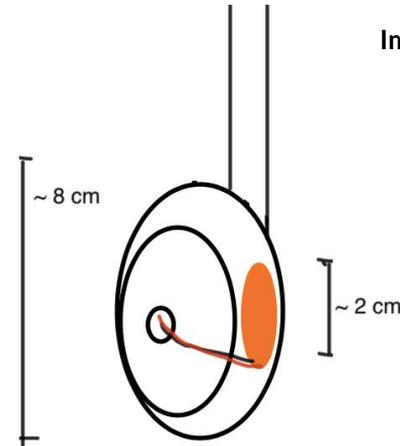


Image 15: Sensor Placement on Wheel

Pressure Design Matrix

Criteria	Weight	Handles		Foot		Wheel	
Accuracy/Precision	25	3/5	15	4/5	20	4/5	20
Ease of Use	20	5/5	20	5/5	20	5/5	20
Safety	20	5/5	20	5/5	20	3/5	12
Durability	15	4/5	12	1/5	3	3/5	9
Ease of Fabrication/Integration	10	5/5	10	3/5	6	2/5	4
Cost	10	3/5	6	5/5	10	5/5	10
Total:	100	Sum	83	Sum	79	Sum	65

Table 1: Pressure Design Matrix

Software App and Server



- Server receives, stores real time data
- Access server to analyze progress overtime

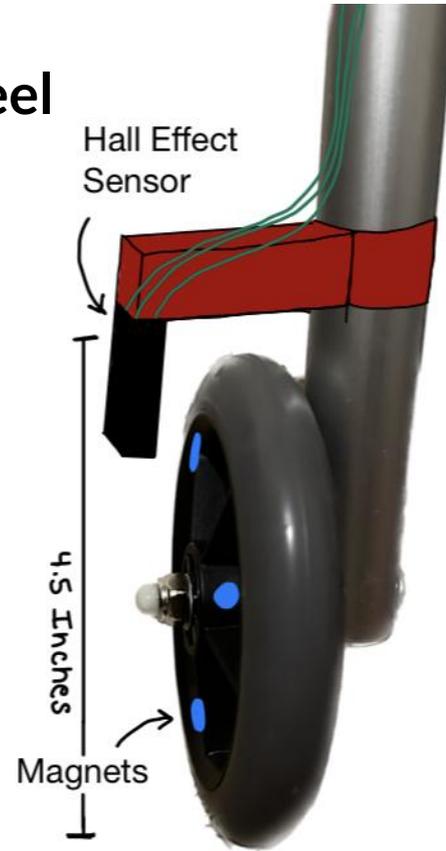


- App will retrieve and display data

Speed Design Ideas: Magnetic Sensor

Magnetic sensor measures rotation of wheel

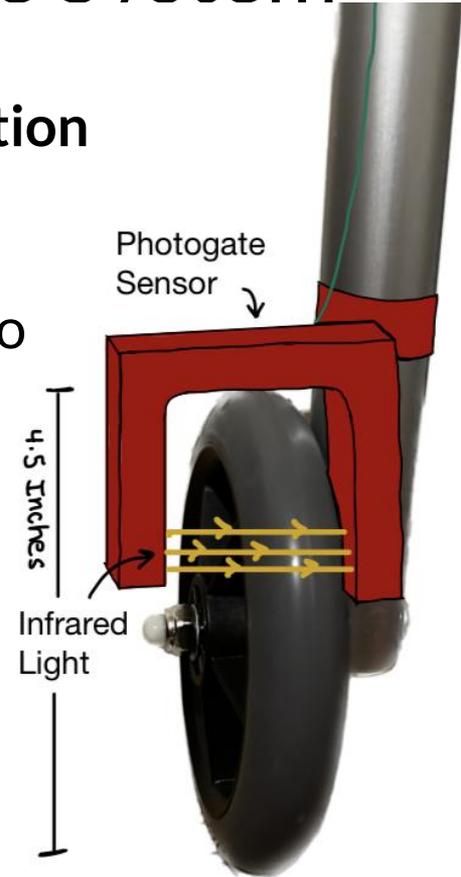
- Magnet on outer wheel
- Magnetic Sensor on frame
- Circumference and arduino timer for distance, speed



Speed Design Ideas: Photogate System

Photogate senses spokes of wheel during rotation

- Laser passes through holes of wheel
- Senses laser interference by spoke
- Arc length between spokes, arduino timer to measure speed



Speed Design Ideas: Distance Sensor

Ultrasonic Distance sensor

- Send out ultrasonic waves → bounce off surface → return to sensor
- Easy to integrate and accessible
- Does not account for turns
- Needs a wall or other flat surface



Image 20: Ultrasonic distance sensor

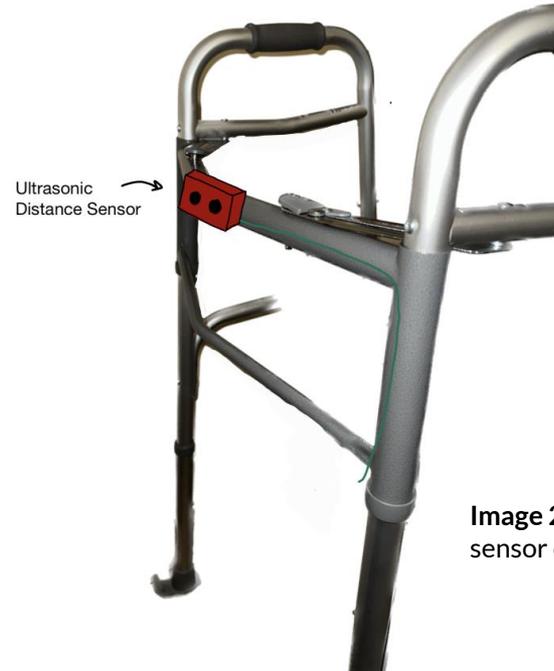


Image 21: Distance sensor design

Speed Design Matrix

Criteria	Weight	Magnetic Sensor		Photo Gate Sensor		Distance Sensor	
Accuracy/precision	25	4/5	20	4/5	20	3/5	15
Ease of Use	20	5/5	20	5/5	20	5/5	20
Safety	20	5/5	20	3/5	12	5/5	20
Durability	15	4/5	12	3/5	9	5/5	15
Ease of Fabrication/Integration	10	4/5	8	4/5	8	2/5	4
Cost	10	5/5	10	2/5	4	3/5	6
Total:	100	Sum	90	Sum	73	Sum	80

Table 2: Speed Design Matrix

Future Work

- Calibrate the magnetic sensor and pressure sensor
- Install the pressure sensors in the handle
- Connect server to the app
- Build a durable holder for the arduino and sensors on the walker frame



Image 22: Walker used in Smartwalker design

References/Acknowledgements

References

Photos

- [1] B. Spears, *A Walkthrough of Cardiac Rehab Phases 1-4*. 2022. Accessed: Oct. 05, 2023. [Online]. Available: <https://www.verywellhealth.com/four-phases-of-cardiac-rehabilitation-2696089>
- [2] Eling, *Universal MPH GPS Speedometer Odometer Kit 160MPH Speed Gauge for Car Motorcycle Tractor Truck with Backlight 85mm 12V 24V Replacement Speedo*. Accessed: Oct. 05, 2023. [Online]. Available: <https://www.amazon.com/ELING-Universal-Speedometer-Motorcycle-Backlight/dp/B074J8SG86>
- [3] Lanso, *Stainless Steel Pressure Gauge*. Accessed: Oct. 05, 2023. [Online]. Available: <https://www.lansoinstruments.com/products/b32sa-stainless-steel-pressure-gauge-safety-design.html>
- [4] Camino, *Camino First Mover*. Accessed: Oct. 05, 2023. [Online]. Available: <https://caminomobility.com/products/preorder>
- [5] AmbuTrak, *Distance Tracking Device for Rolling Walkers & Rollators w/Digital Display*. Accessed: Oct. 05, 2023. [Online]. Available: <https://us.amazon.com/AmbuTrak-Distance-Tracking-Rolling-Rollators/dp/B08B43T4R9>
- [6] C. Commons, *Force Sensitive Resistor 0.5"*. Accessed: Oct. 05, 2023. [Online]. Available: <https://www.sparkfun.com/products/9375/>
- [7] ICStation, *100kg Thin Film Pressure Sensor Force Sensor Diameter 16mm for Arduino Robot*. Available: <https://www.tindie.com/products/icstation/100kg-thin-film-pressure-sensor-for-arduino11690/>
- ### Research
- [1] Marquis, Jeremiah. "How Long Do Mobility Scooters Last with Proper Care?" *Mobility Plus Colorado*, Mobility Plus Colorado, 20 Sept. 2023, www.mobilitypluscolorado.com/blog/how-long-do-mobility-scooters-last.
- [2] gwn3000. "Arduino Circuit Lifespan?" *Arduino Forum*, 24 Jan. 2016, forum.arduino.cc/t/arduino-circuit-lifespan/360703/2.
- [3] "Walkers: Adult Walkers: Aluminum Walkers: Walkers Used after Surgery." *American Medical & Equipment Supply - Lift Chairs Recliners, Home Medical Supplies, Supports Canes and Crutches, Wound Care Supplies, Incontinence Supplies*, www.americanmedicalinc.com/store/p87/walkers.html. Accessed 22 Sept. 2023.
- [4] "Camino : The World's First Smart Walker." *Camino Mobility*, caminomobility.com/. Accessed 22 Sept. 2023.
- [5] E. H. and D. F., "AmbuTrak digital/electronic distance tracker for Walkers & Rollators," *Rehabmart.com*, <https://www.rehabmart.com/product/ambutrak-movement-tracker-for-rolling-walkers-47972.html> (accessed Sep. 22, 2023).



Questions?