Smart Walker

Advisor
Dr. Amit Nimunkar
Client
Dan Kutschera
The Team
Nolan BlomWillis (Leader & Communicator)
Eva Schiltz (BSAC)
Jacob Parsons (BPAG)
James Waldenberger (BWIG)

Client Description and Problem Statement

Dan Kutschera

- Physical Therapist
- Acute Stroke clinic in Madison, WI

Problem Statement

- Our team must design a device that works in conjunction with a standard walker that will measure the speed and distance the patient walks and the pressure applied to the walker.

Figure 1. Client Dan Kutschera [1]

Background

- Currently there is no way to have real-time analysis of a patient's progress with a walker.
- Rehabilitation is shifting more to a data driven approach to rehab.
- Current smart walkers are very expensive.

Figure 2. Rehab with a Walker [2]

Competing Solutions

Walking Distance Measuring Device

- No pressure readings
- Not a lot of patient information included
- Just a patent currently

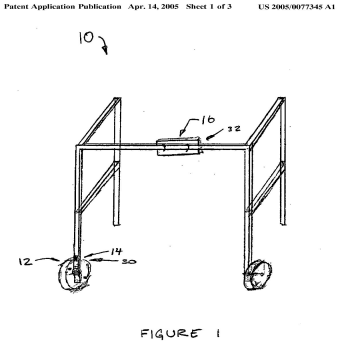

Figure 3. Walking Distance Measuring Device [3]

Camino Smart Walker

- Built in boost and brakes
- $2,500
- Not a clinical walker

Figure 4. Camino Smart Walker [4]

Design Specifications

- Device must last 10 years without maintenance needed
- Device will be used for a maximum of 10 patients a day and 5 trials per patient
- Must measure pressure in terms of pounds and speed in terms of miles per hour.
- Must be accurate within 5% of measured value.
- Must support the weight of the user (max of 140kg).

Pressure Sensor 1: Load Sensor

- Detects changes in resistance when stretched
- Used by previous team
- $4.50 per unit
- 50kg / 110 lbs
- Sensitivity of 1 +/- 0.1 mV/V

Figure 5. SparkFun Load Sensor [5]

Pressure Sensor 2: Piezoresistive Pad

- Similar function to load cell
- Integrated into walker handles
- $27.82 per unit
- 50 lbs
- 3% linearity error

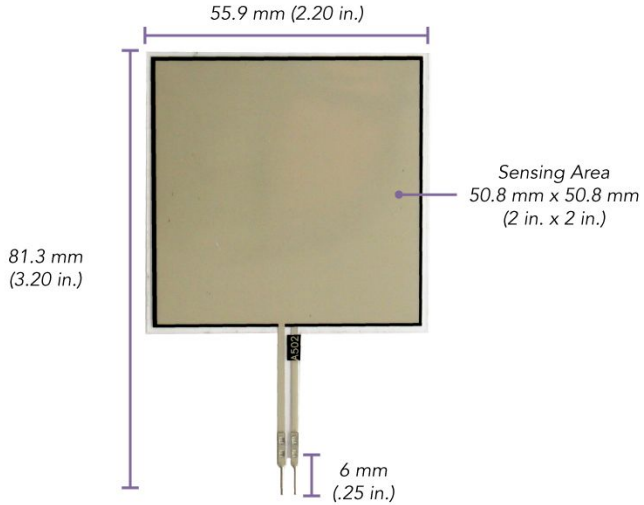

Figure 6. Flexiforce piezoresistive sensor [6]

Pressure Sensor 3: Capacitive Force Sensor

- Weight pushes plates closer together, changing capacitance
- $133 per unit
- 100 kg / 220 lbs
- Sensitivity 2.0 +/- 0.2 mV/V

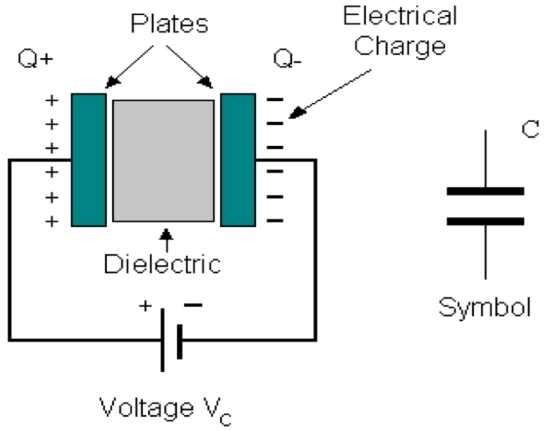

Figure 7. Capacitive load cell construction [7]

Figure 8. ATO Capacitive Force Sensor [8]

Pressure Sensor Design Matrix

Categories	Load Cell		Piezoresistive Pad		Capacitive Force Sensor	
Accuracy (30)	5/5	30	2/5	12	4/5	24
Ease-of-use (25)	3/5	15	4/5	20	3/5	15
Price (20)	4/5	16	3/5	12	2/5	8
Fabrication (10)	4/5	8	4/5	8	2/5	4
Reusability (10)	4/5	8	2/5	4	3/5	6
Total (100)	77		56		57	

Table 1. Pressure Sensor Design Matrix evaluation

Speed Sensor 1: Accelerometer

- Measures acceleration in x, y, and z
- 3.9 mg/LSB (least significant bit)
  - Less than 1 degree of sensitivity
- Low power
  - 23 uA currency supply
- $17.50 on Digikey

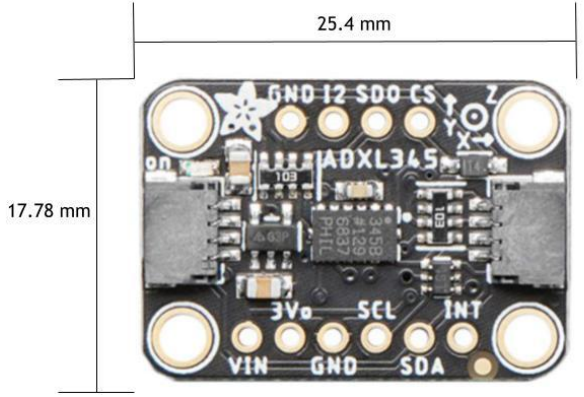

Figure 9. ADXL345 accelerometer board [9]

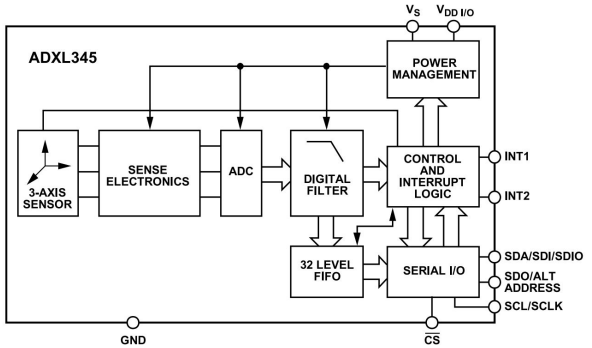

Figure 10. Accelerometer functional block diagram

Speed Sensor 2: Rotary Encoder

- Incremental Encoder
- Measures rotations of axle
  - Within 0.2 degree accuracy
- Located at wheel
- $53.17 on Digikey

Figure 11. AMT132S-V rotary encoder with modular axle diameters [10]

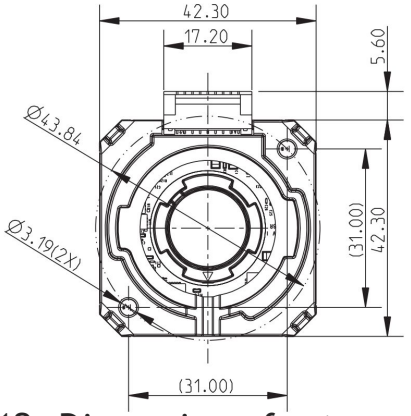

Figure 12. Dimension of rotary encoder

Speed Sensor 3: Hall Effect

- Detection of magnetic field
  - Hits “threshold” field and sends voltage
  - 2 mT sensitivity
- Located at wheel
- $0.44 per unit

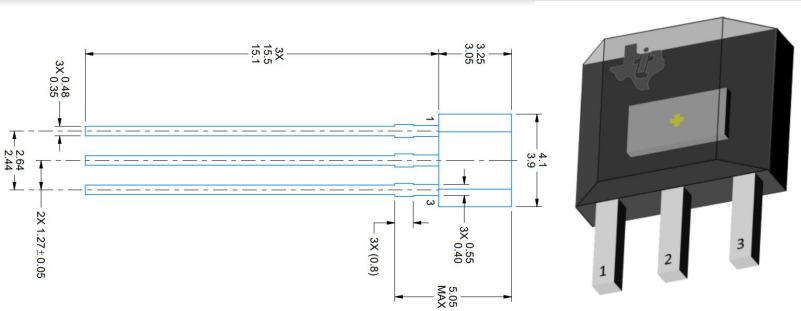

Figure 13. DRV5023 Hall effect sensor with dimensions in mm [11]

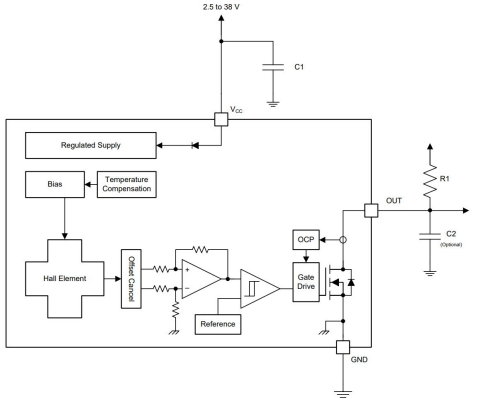

Figure 14. Functional block diagram of Hall effect

Speed Sensor Design Matrix

Categories	Accelerometer		Rotary Encoder		Hall Effect	
Accuracy (30)	5/5	30	5/5	24	3/5	18
Ease-of-use (25)	5/5	25	5/5	25	4/5	20
Price (20)	4/5	16	2/5	8	5/5	20
Fabrication (15)	4/5	12	3/5	9	3/5	9
Reusability (10)	4/5	8	3/5	6	3/5	6
Total (100)	91		72		73	

Table 2. Speed Sensor Design Matrix evaluation

Block Diagram

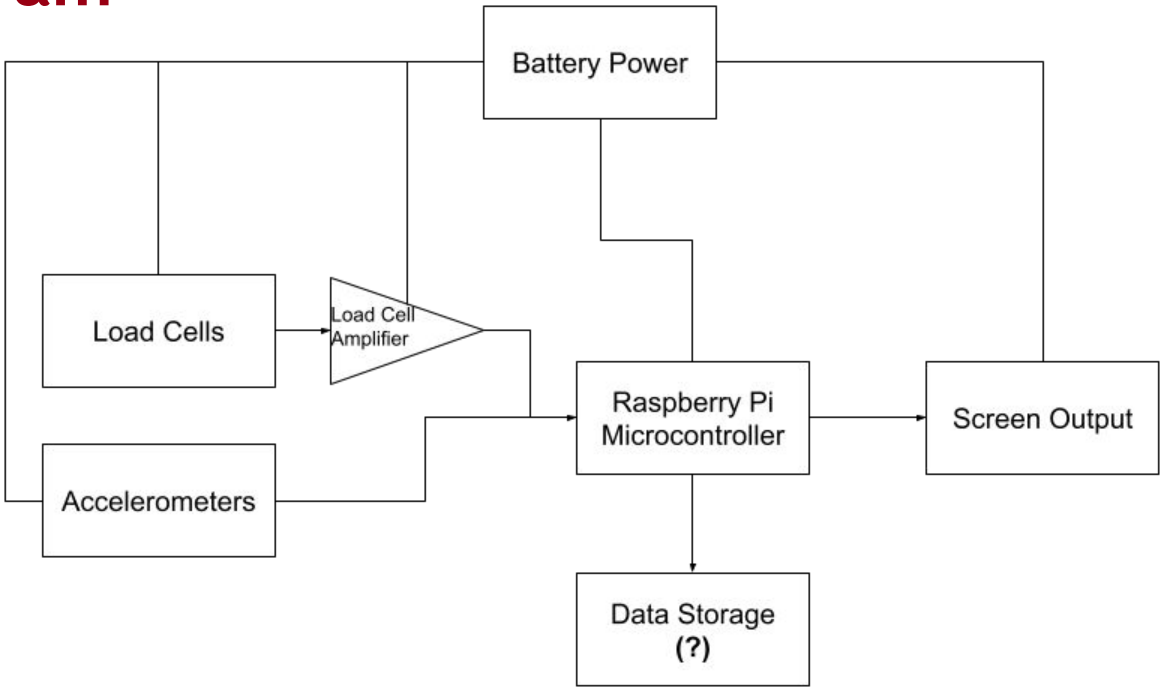

Figure 15. Block diagram of Smart Walker circuitry

Microcontroller & Display

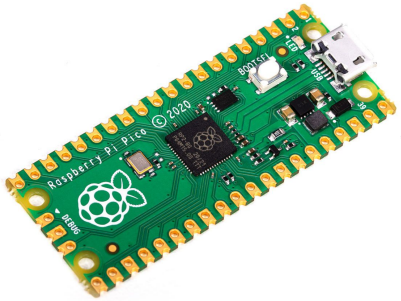

Figure 16. Raspberry Pi Pico [12]

- Raspberry Pi Pico
- 26 GPIO pins
- 133 MHz processing
- Handles input from sensors, calculations, and output to display

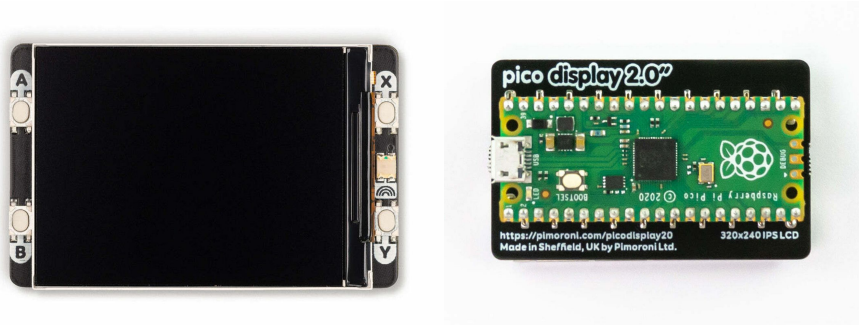

Figure 17. Pico Display 2” [13]

- Simple OLED/LCD screen
- 3.3 volts
- Limited to what the Pico can run
  - Low power consumption
  - Available drivers

Preliminary Design

- Sensor choice dictates sensor placement

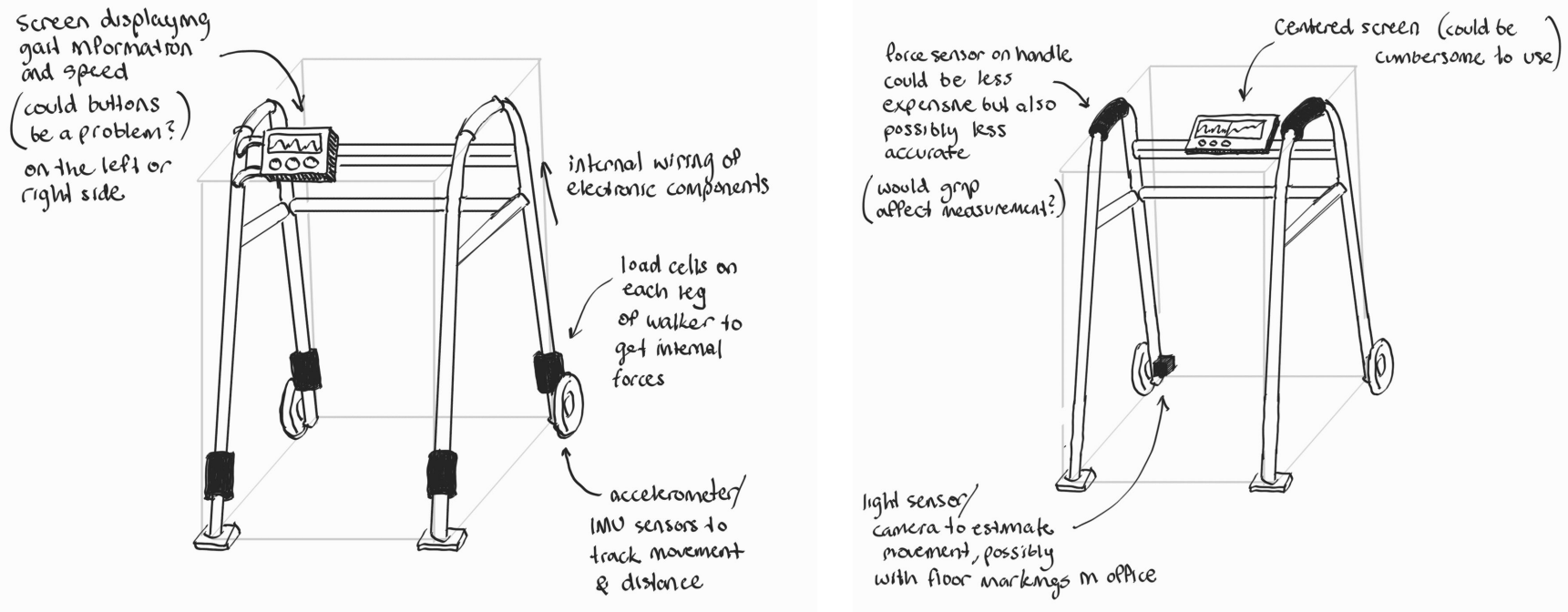

Figure 18. Two different design options for the Smart Walker

Future Plans

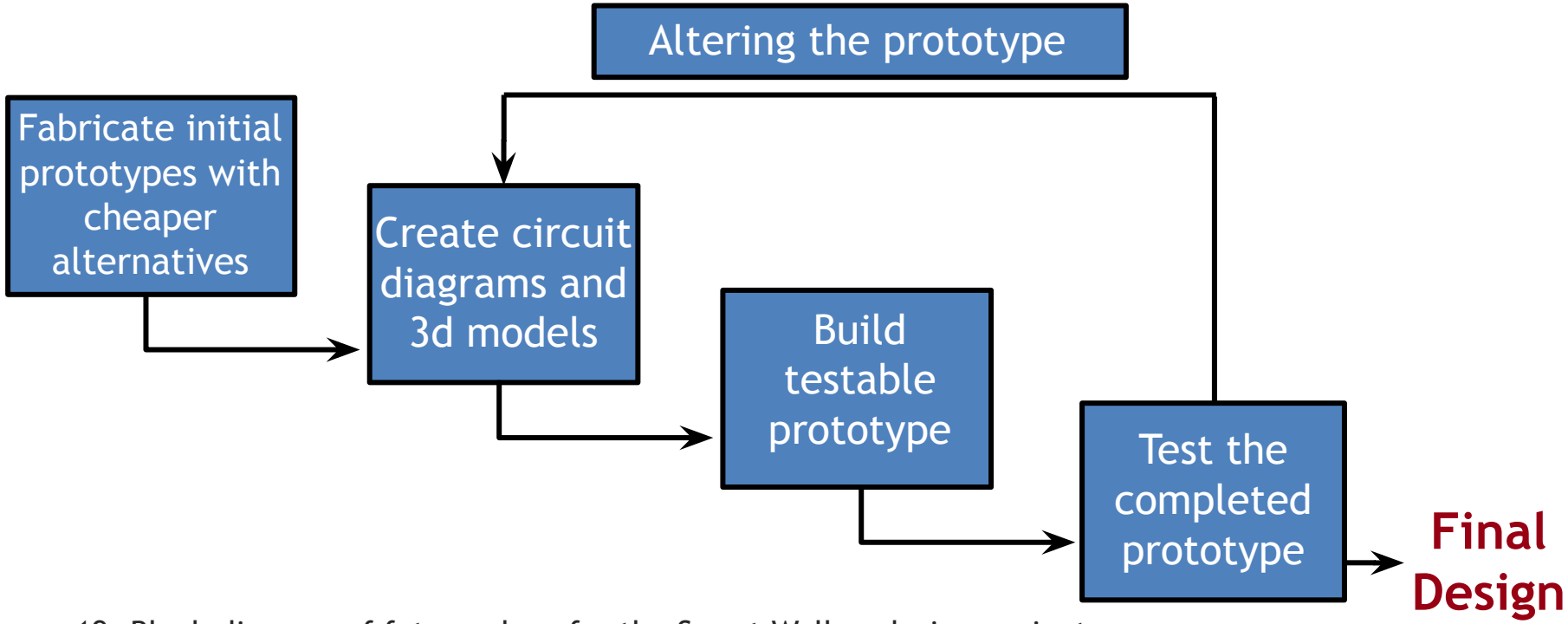

Figure 19. Block diagram of future plans for the Smart Walker design project

Acknowledgments

Thank you to our advisor Dr. Nimunkar
and our client Mr. Kutschera!

References

Figures

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Research

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Questions or Comments?