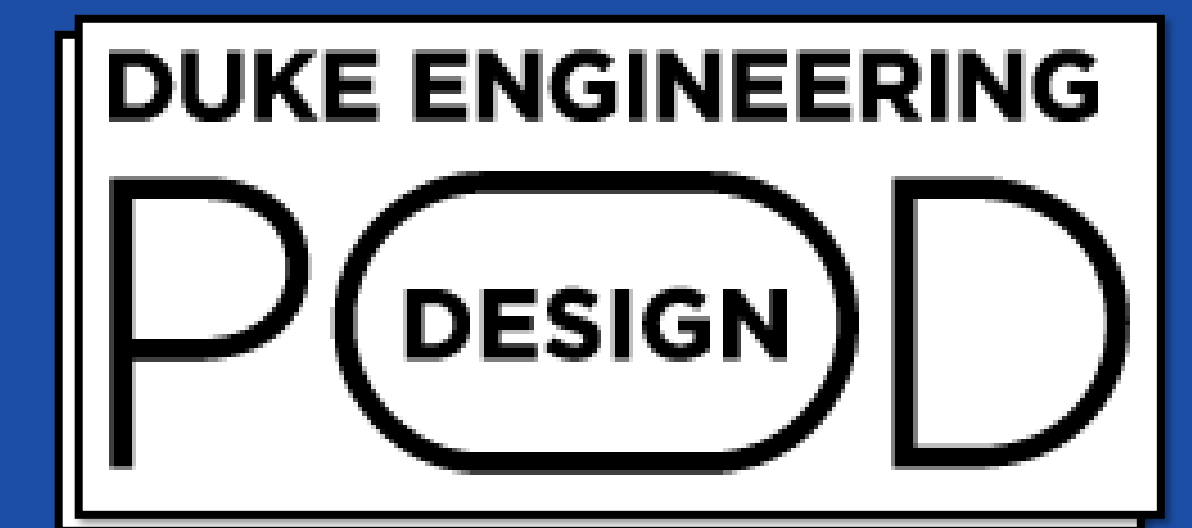


Hands-Free Wheelchair Distance Measuring

Wheelchair Warriors: Kevin Jin, Mitchell Ross, Abhishek Terala, Harshil Yerrabelli
Duke Pratt School of Engineering; Duke Access and Accommodation Services



Design Problem + Motivation

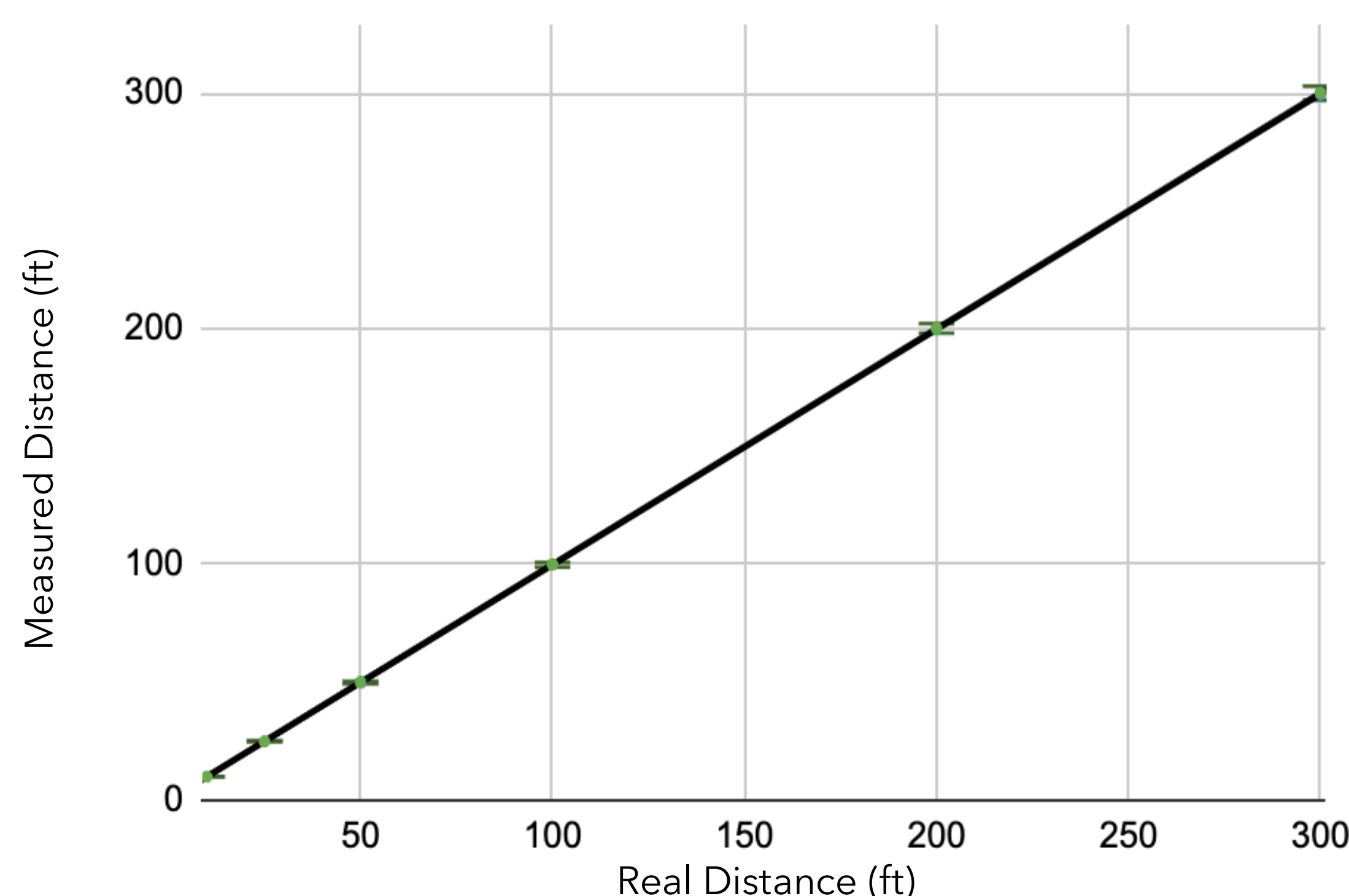
- It is impractical to measure long distances while maneuvering a wheelchair.
- Both wheels on the chair are controlled independently, so both hands are needed to move forward, preventing movement and measurement at the same time.
- Through a hands-free solution, users can move forward and measure simultaneously, speeding up the entire process and improving measurement precision.



Design Criteria and Testing

Design Criteria	Test Description	Target Value	Result
Distance Accuracy/Precision	Measure 5, 50, 100, 200, and 300 ft distances 5 times each.	Accuracy within 1in	PASS
Durability	Continually roll over bumps, sidewalk seams, and other obstructions. Then retest distance accuracy.	Less than 2% difference than pretest numbers.	PASS
Adaptability	Install device on at least 2 wheelchairs.	Accuracy within 1in on every wheelchair	PASS
Ease of Use	Measure the time it takes to attach system by 5 different people.	Likert scale where a 5 is below 40 seconds	PASS
Battery Life	Run app and device continuously under normal conditions and record time until battery pack is fully depleted.	Battery life \geq 5 hours of continuous operation.	PASS
Size, Weight, Price	Measure height, width, and length of system. Weigh system, sum costs.	Each dimension $<$ 4in $<$ 5lbs $<$ \$100	PASS
Waterproof	Spray casing with water from all angles	IP54	TBD

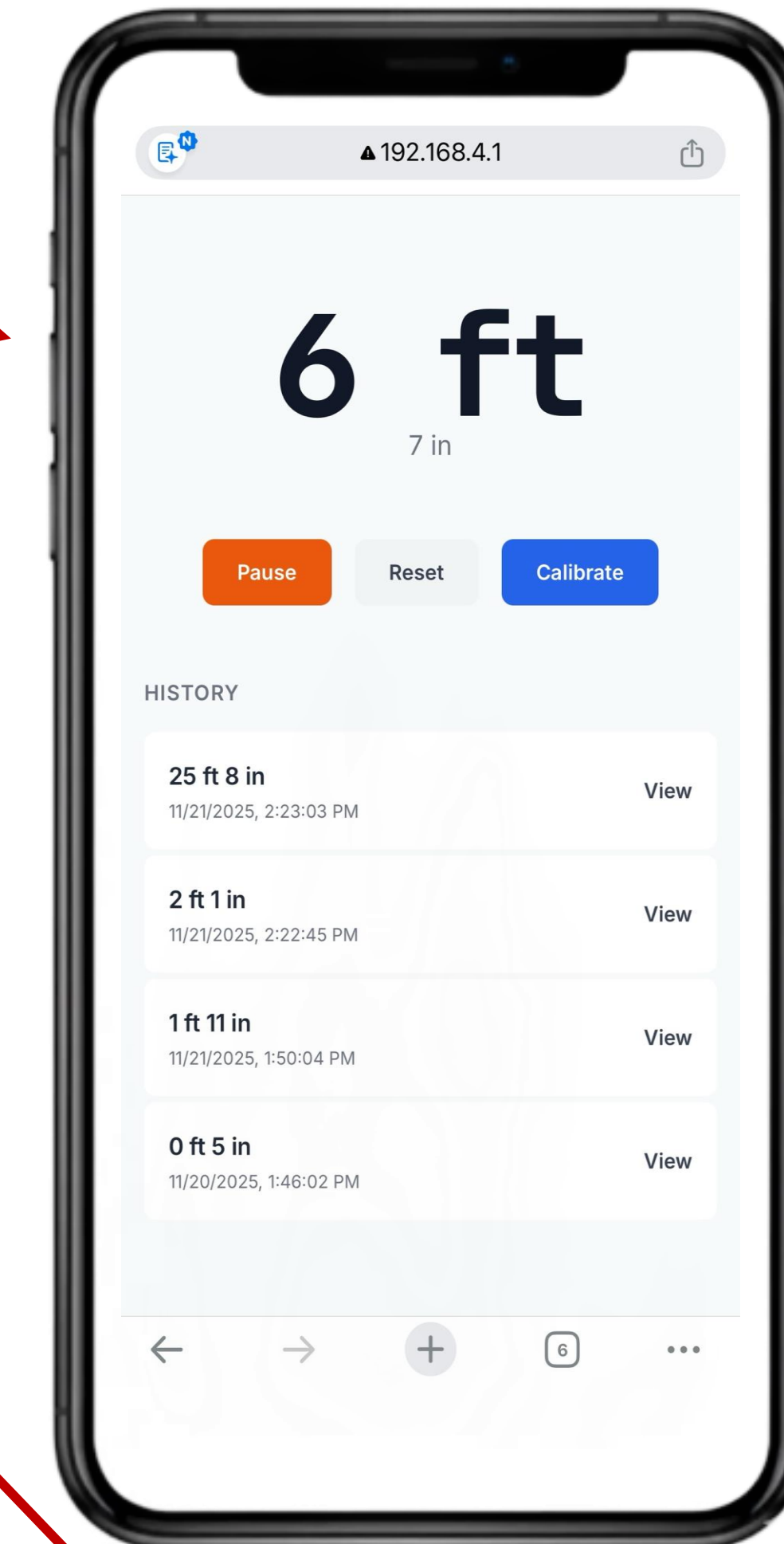
Results



Distance Accuracy Summary

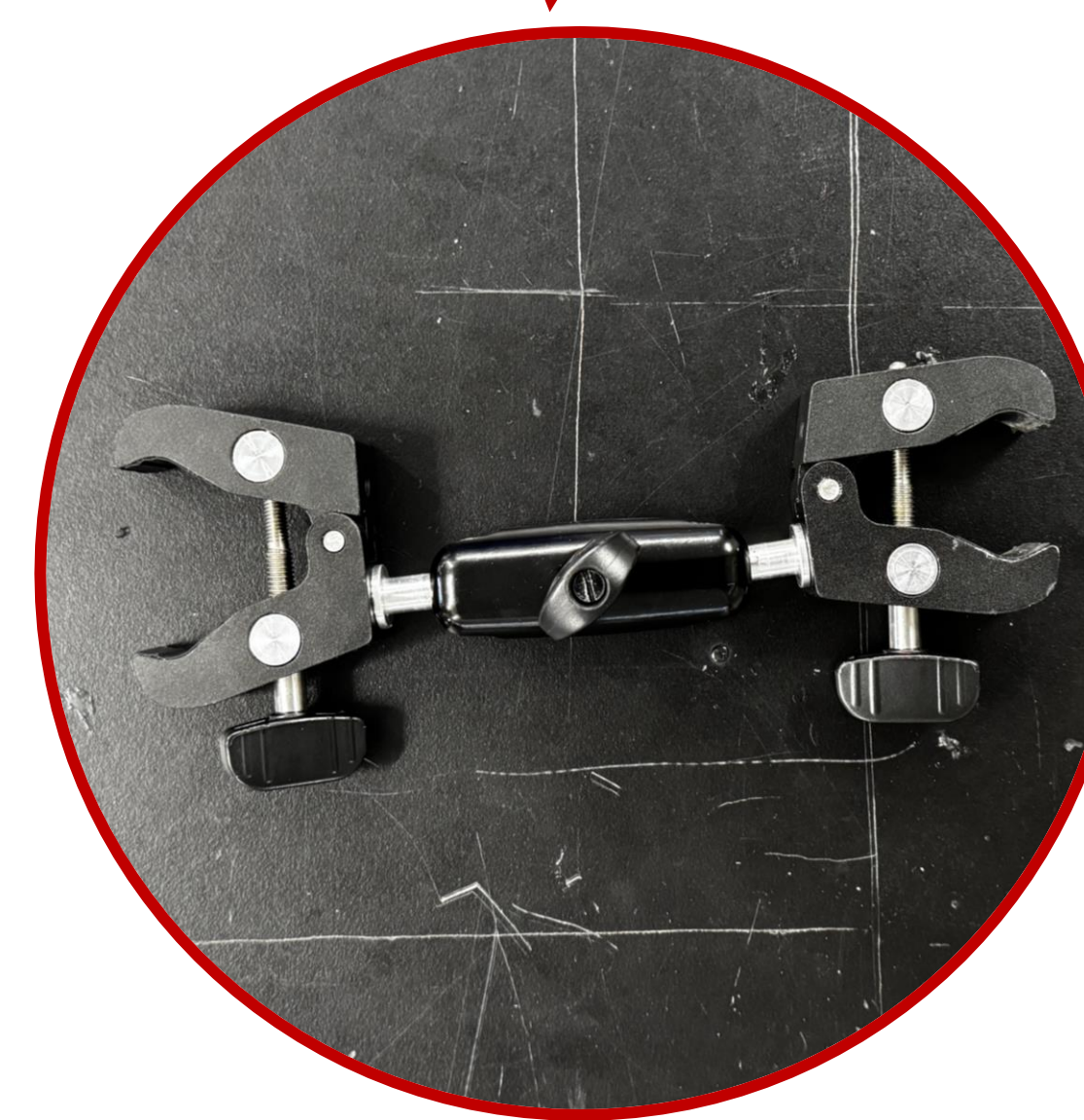
- Measured error across all tests: \leq 0.8 in
- Regression: **Slope = 1.00**, **$R^2 = 0.998$**
- Tested distances: **5 ft, 50 ft, 100 ft, 200 ft, 300 ft**
- Passes criteria of **Accuracy within 1 inch**
- Repeatability error: **$<$ 0.5% across trials**

Overall Design Solution



User Interface:

- Web server for easy access
- Pause and reset buttons
- History viewing
- Calibration so device can be used on any wheelchair



- Double jointed clamp for firm attachment
- Allows adaptability for device to fit on multiple wheelchairs



- Optical rotary encoder to measure wheel rotation
- Chosen wheel with increased friction to prevent slippage



- ESP-32 interprets data from rotary encoder, hosts server for mobile connections
- Battery pack supplies power, ensures long battery life, doubles as a phone charger when device is not in use

Conclusion + Future Work

Conclusion: Our team successfully developed a lightweight, wheelchair-mounted, hands-free device using an optical rotary encoder to record distances with inch-level precision and output results on a phone app, meeting all key design goals.

Future Work:

- **Speed Tracking:** Use encoder data to display real-time and average speed during wheelchair movement.
- **Distance Smoothing Algorithm:** Improve consistency by filtering out jitter or micro-vibrations in encoder readings.
- **Wheelchair Profiles:** Allow users to save presets for different wheel sizes or clamp positions.

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