SMART STEP

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Problem Statement

- More than 7 million Americans are visually impaired (CDC, 2024)
- Fewer than 10% of the visually impaired population use white canes (Perkins School for the Blind, n.d.)
- White canes are limited in practicality
- Canes also only provide feedback when physical contact is made

Design Requirements

1. The device must detect obstacles with at least 90% accuracy

2. The device must weigh less than one kilogram

3. The device must detect objects and obstacles up to one meter away

4. The device must be able to withstand 100 Newtons of force across its midsection and 250 Newtons of force exerted onto its tip

Methodology/Approach

1. Brainstorming forms of detection and feedback
2. Tested 3 Arduino positions, detection methods, and feedback types on existing white cane.
   a. LiDAR sensor with a beeper
   b. Object Detection Camera and audio speaker
   c. Sonar sensor with a vibration motor
3. Fusion360 used to design cane shaft for hardware housing and wiring
4. Tested with client to collect feedback
5. Improvements made to design and functionality from feedback
6. Final version produced

References

Centers for Disease Control and Prevention. (2024, May 15). *Fast facts: Vision loss*. https://www.cdc.gov/vision-health/data-research/vision-loss-facts/index.html
Perkins School for the Blind. (n.d.). *10 fascinating facts about the white cane*. https://www.perkins.org/10-fascinating-facts-about-the-white-cane/

Figure 1: Initial Brainstorming and Design Concepts

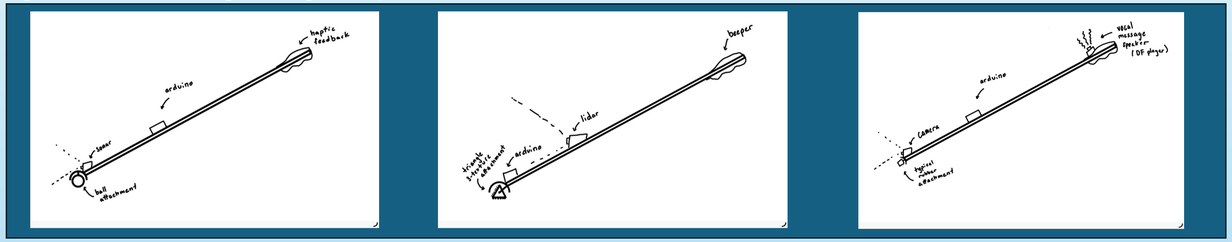
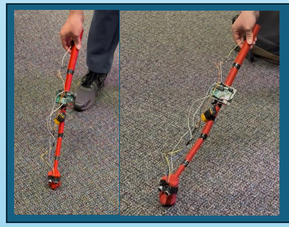
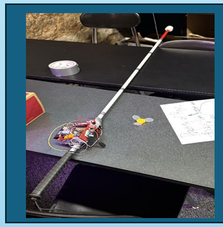


Figure 2: Prototype 1 – Version 1



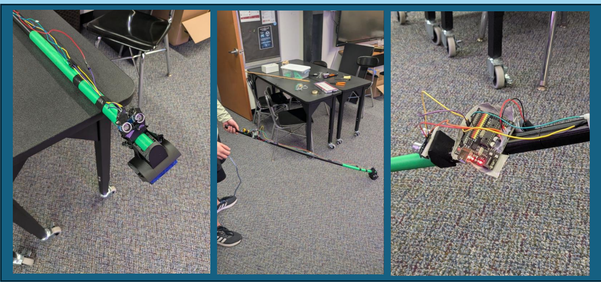
- Sonar + vibration motor
- Ball attachment
- Not a formal cane design
- Could not be used in practice but proved the efficiency of sonar

Figure 3: Prototype 1 – Version 2



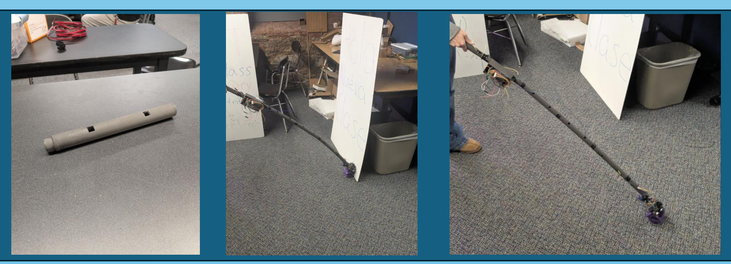
- Initially began with an Object Detection Camera, but did not provide adequate feedback time
- Moved to sonar and speaker testing
- Mounted on an approved white cane

Figure 4: Prototype 2 – created with PLA Plastic



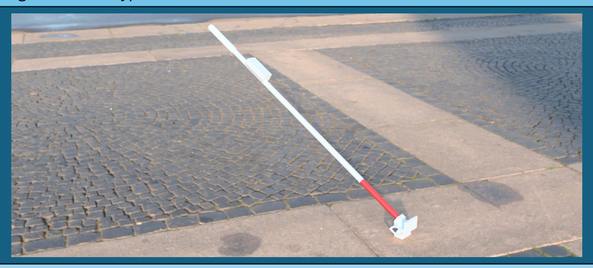
- Made of PLA Plastic
- Not very sturdy, cannot withstand much force
- Confirmed that the sonar + vibration motor was the best combination
- Foot-piece was tested with different material

Figure 5: Prototype 3 - created with Nylon Plastic



- Made of Nylon Plastic
- Durable but overall design was flawed
- Foot-piece was not allowing for easy sweep-ability

Figure 6: Prototype 4- created with ASA + ABS Plastic



- Made of ASA and ABS Plastic
- Lightweight and still durable
- Foot-piece now sweeps with ease and is weather resistant
- Hardware housing decreased in size

Design Studies

- **Design Study I: Weight**
  - Weighed individual components and summed
- **Design Study II: Durability**
  - Measured horizontal and head on forces applied to cane
- **Design Study III: Detection Range**
  - Compared cane's range according to design requirement
- **Design Study IV: Detection Accuracy**
  - Recorded each design's accuracy in varying environments (varying lighting, angles, sweeping speed, obstacles)

Results

1. Prototype 1:
   - 0.4kg weight
   - Withstands 100N of force
2. Prototype 2:
   - 90% accuracy up to 2m
   - Weight of 0.6kg
   - Collapses under 40N of force
3. Prototype 3:
   - 90% accuracy up to 2m
   - Weight of 1.10kg
   - Withstands 50N of force

Final Prototype:
- >95% accuracy with capabilities up to 3m of detection
- Weight of 0.45kg
- Withstands 70N of force

Analysis

- Greater detection range significantly improved potential user reaction time
- Curved edges of the foot-piece resulted in easier sweeping
- A lightweight cane added to the overall ease of use forthe user

Future Work

- Further strengthening structural integrity
- Adding an audio component to alert the user of an object ahead through an ear-piece
- Improving and fabricating a rotating foot design so attachments don't have to be changed between surfaces