

## Background

- White canes require special training and struggle with high obstacles / open spaces
- Guide dogs are expensive, availability is limited, and may not be suitable for everyone (e.g. allergic)
- Advancements in simultaneous localization and mapping (SLAM) and processing power increases enable real-time visualization on cellphones
- SLAM involves mapping an environment and locating the system within that environment

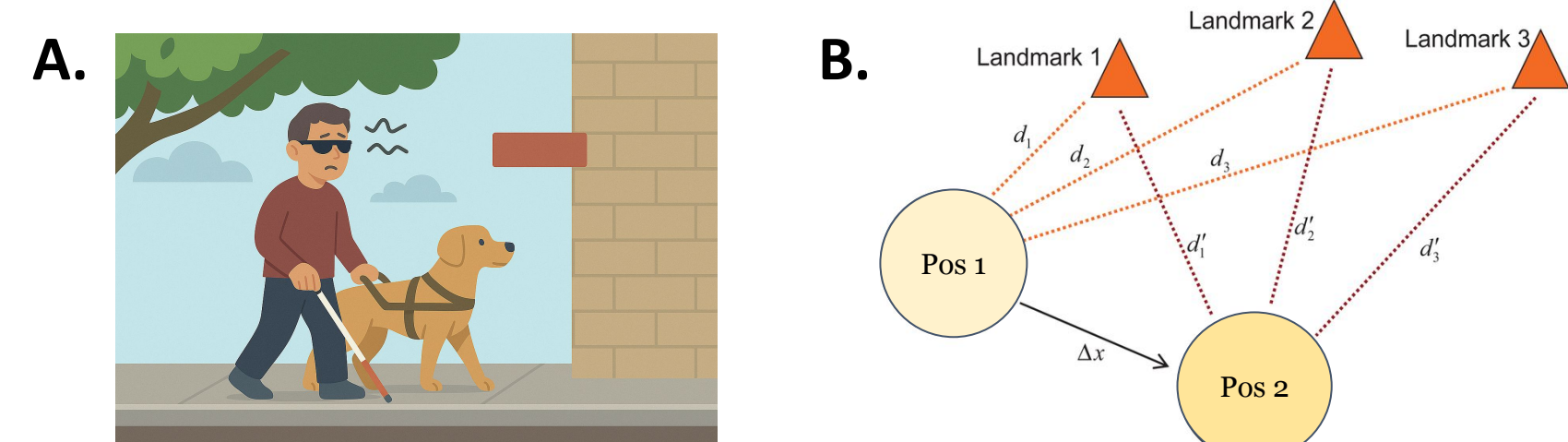


Fig 1). A. An individual with cane and guide dog. B. Distances from three landmarks across two positions to illustrate the geometric basis of SLAM

## Methods

- Design Goals**
- As close to **flawless reliability** as possible
  - **Robust** to many different environments and light levels
  - **Sufficient power** to run all components for >4 hours
  - **Low latency** and **high operational speed**
  - **Reduce costs** as much as possible
  - **Lightweight, comfortable** and easy to wear
  - Work seamlessly alongside existing aids
- HAVEN Modules**
- Autonomous vehicle and VR SLAM algorithms for environmental data capture (C++)
  - Stochastic pathing algorithm to direct the user with built-in safety mechanisms to ensure full transparency
  - Haptic subsystem to translate software output into tactor activation.
  - Head-mount for increased haptic sensitivity (3D printed)

## HAVEN Pipeline Overview

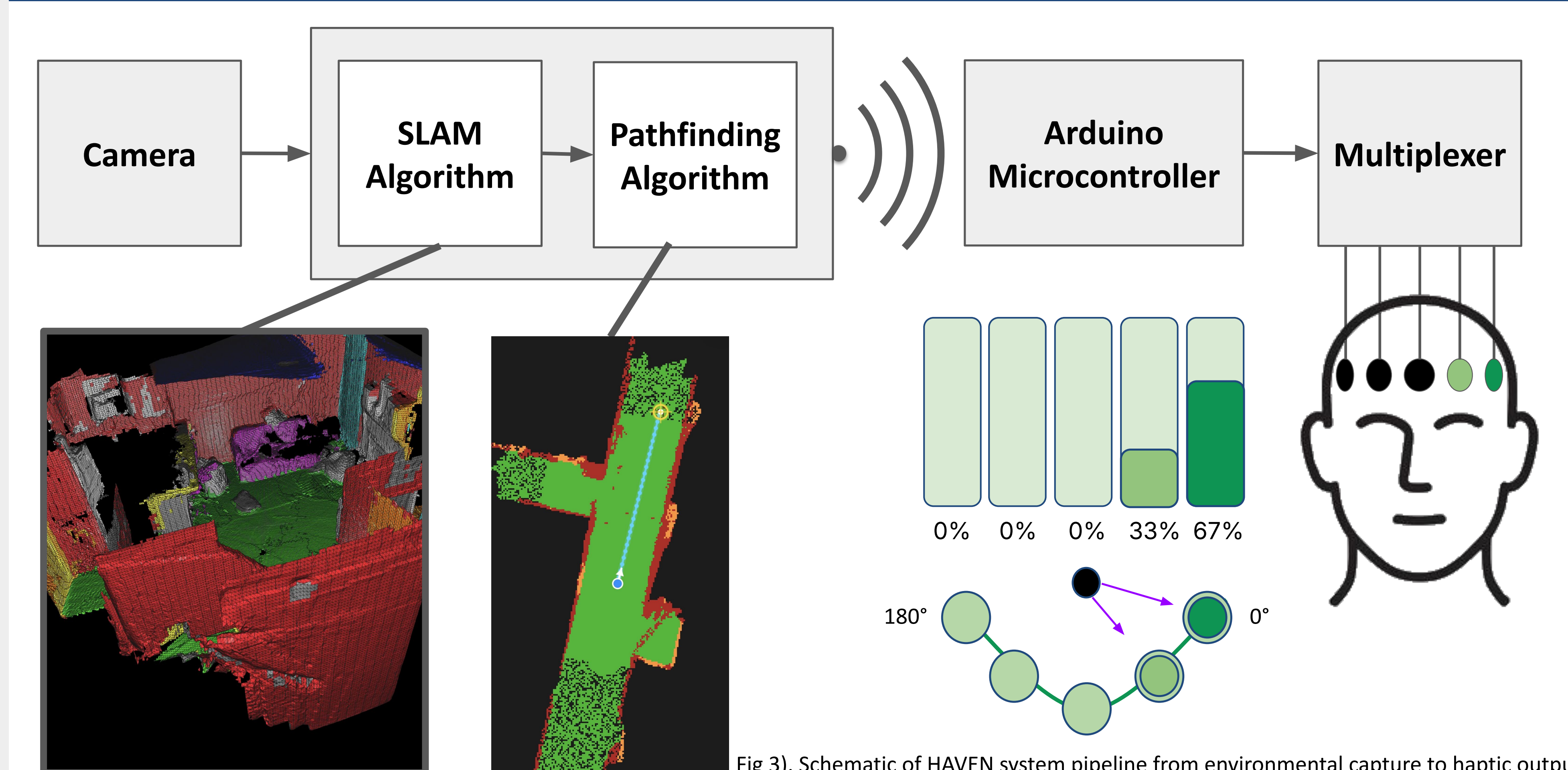


Fig 3). Schematic of HAVEN system pipeline from environmental capture to haptic output

## Hardware

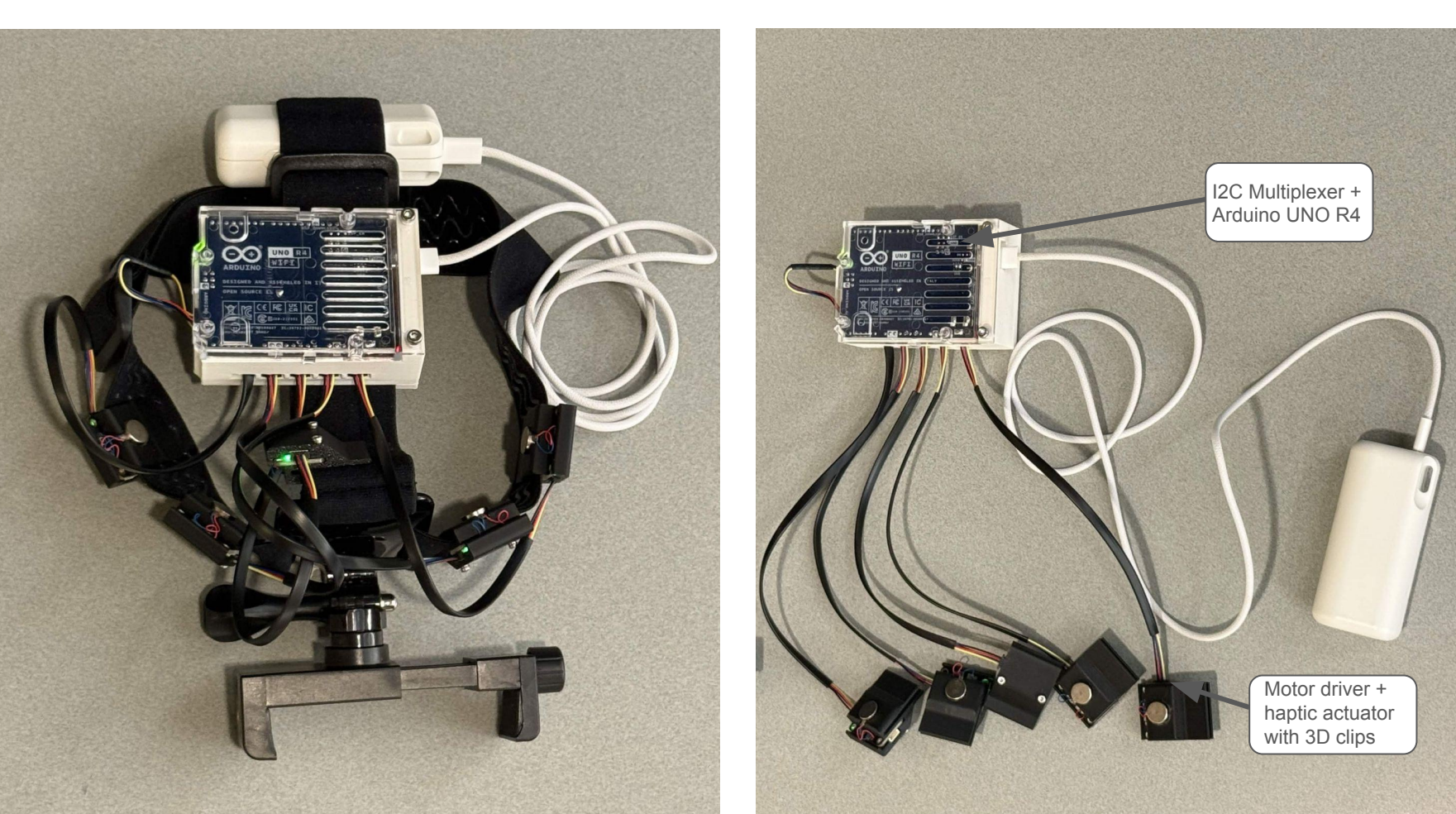
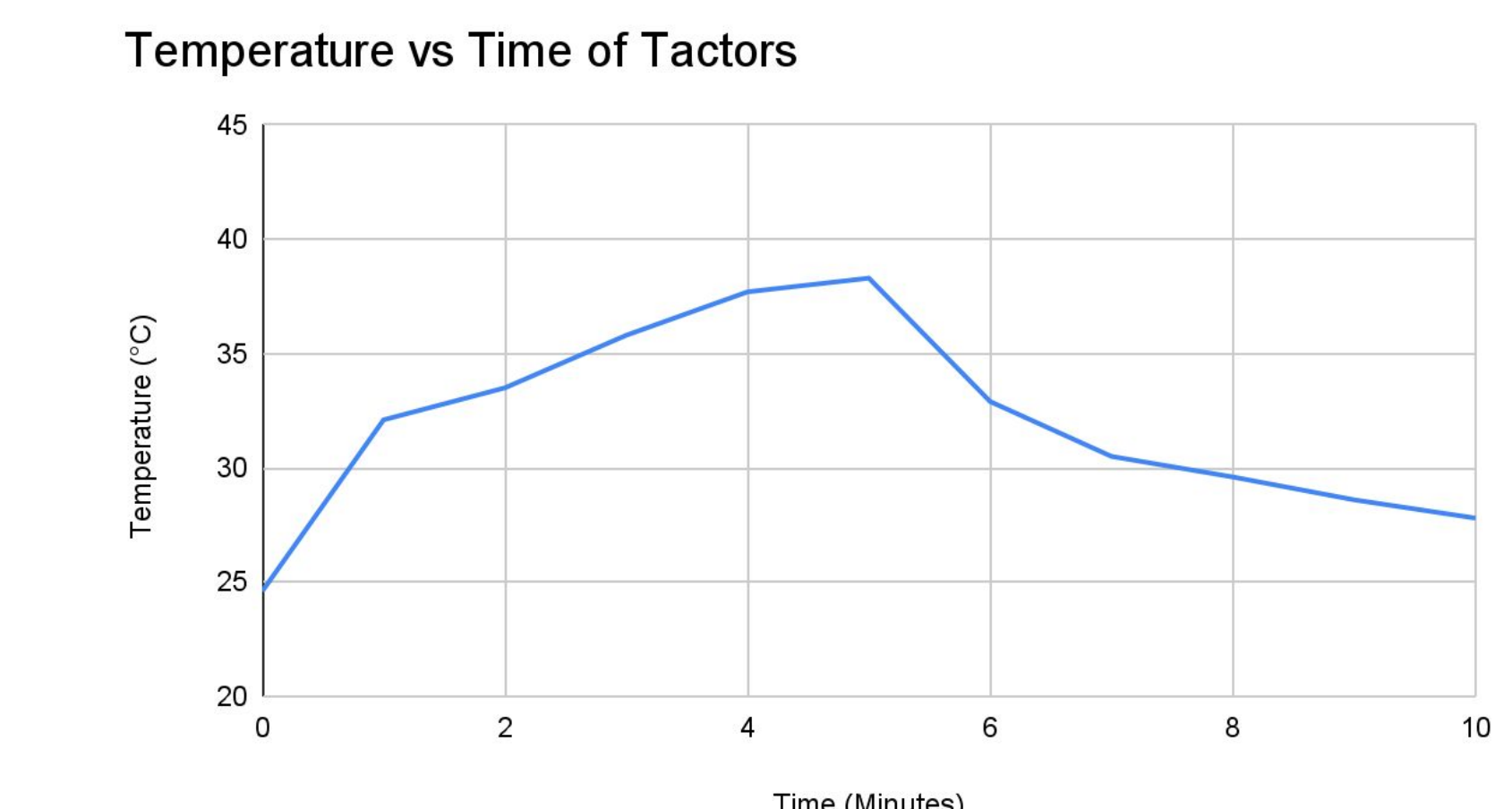


Fig 2). Wearable Hardware prototype (left); Electronics assembly (right)



Specifications	
Overall framerate	1.75 Hz
Battery life	6 hours
Device weight, head mount (Excluding phone)	250g ± 25g
Device temperature	< 104°F Plateau

## Future Directions & Limitations

- Future directions:**
- **Refine Head-Mount:** move away from friction fit clips, improve weight distribution
  - **Integrating Object Recognition with Haptic Feedback:** Employ classifier models to detect and alert users to unique features (e.g. doors, stairs, etc.)
  - **Integration with Global Navigation Systems:** Implement a hybrid system for seamless global-local navigation transition
  - **Improve Compatibility:** Utilize alternative vision algorithms for non LiDAR enabled iPhones, and add android support
- Limitations:**
- No user testing with visually impaired individuals
  - System requires a LiDAR-equipped iPhone

## Acknowledgement

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## Conclusions

- Total cost at an affordable level, with a price of \$124 & compatible phone (~\$200-250 used)
- Lightweight, wearable head-mounted navigation device enables extended usage without causing discomfort or physical strain
- Robust computer vision systems able to handle indoor and outdoor environments with various lighting
- Delivers real-time haptic cues to provide tactile guidance for visually impaired users

## Results

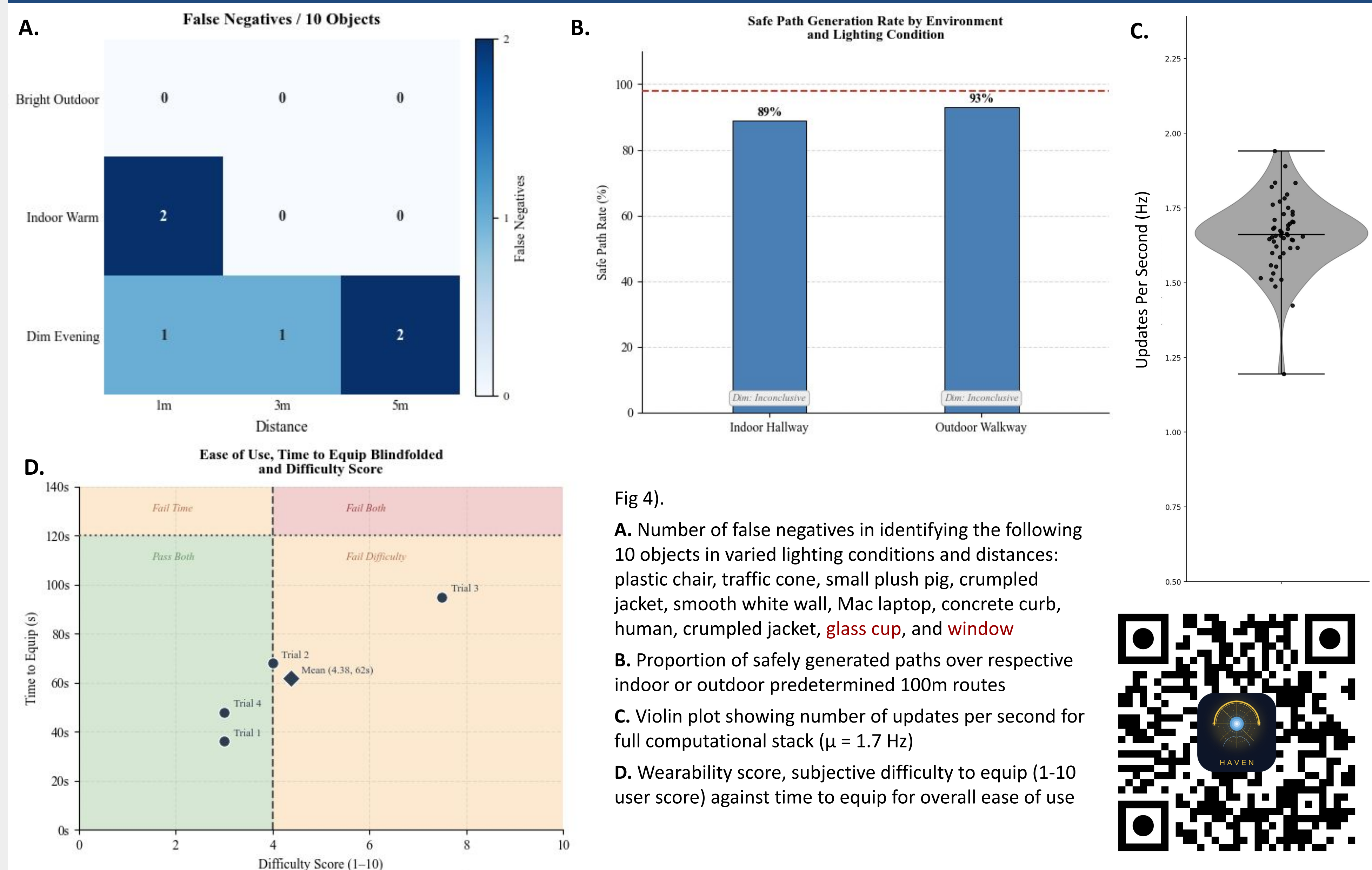


Fig 4).  
A. Number of false negatives in identifying the following 10 objects in varied lighting conditions and distances: plastic chair, traffic cone, small plush pig, crumpled jacket, smooth white wall, Mac laptop, concrete curb, human, crumpled jacket, glass cup, and window  
B. Proportion of safely generated paths over respective indoor or outdoor predetermined 100m routes  
C. Violin plot showing number of updates per second for full computational stack ( $\mu = 1.7$  Hz)  
D. Wearability score, subjective difficulty to equip (1-10 user score) against time to equip for overall ease of use

