LineChaser:

A Smartphone-Based Navigation System for Blind People to Stand in Lines

Masaki Kuribayashi[*1] Seita Kayukawa[*1] Hironobu Takagi [2] Chieko Asakawa [2] Shigeo Morishima [3]

1. Waseda University 2. IBM Research 3. Waseda Research Institute for Science and Engineering

*: authors contributed equally

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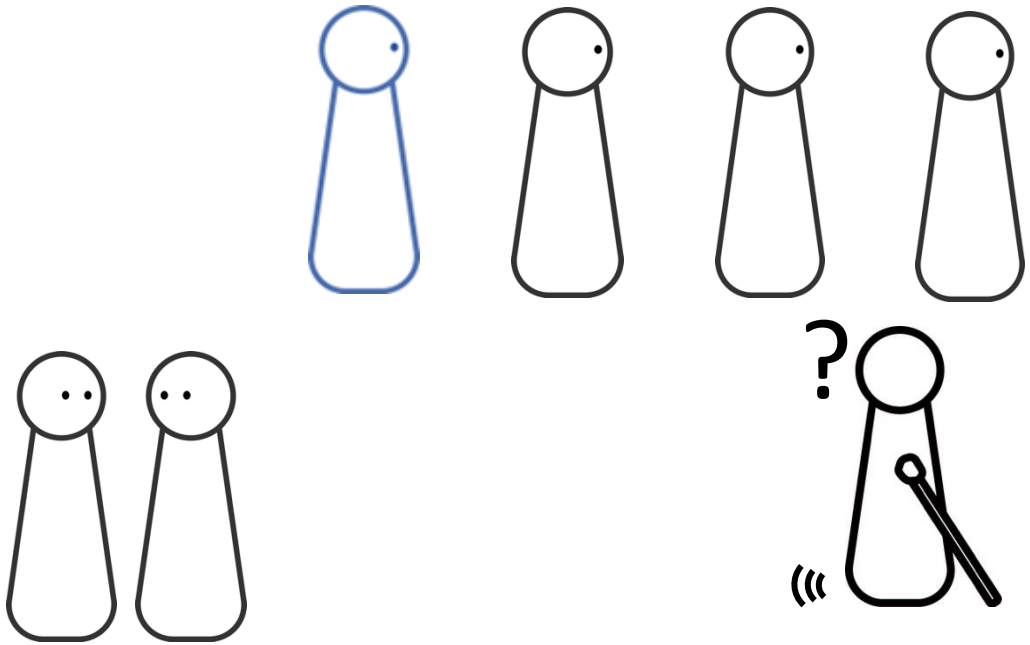
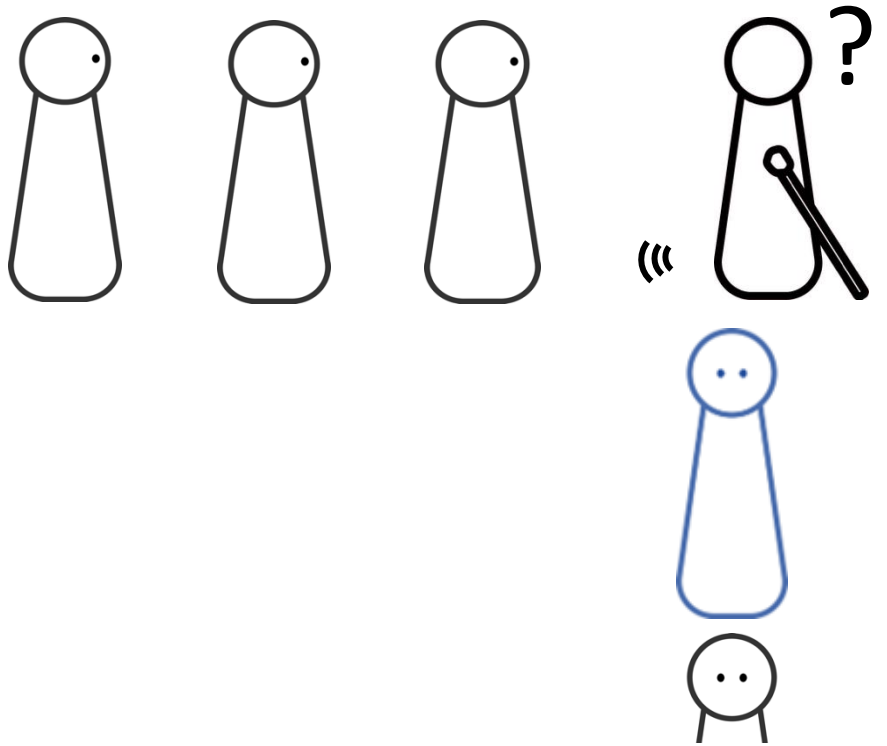
Difficulties Blind People Face when Standing in Lines

Finding the End of Line



Don’t know where the end is without visual sense

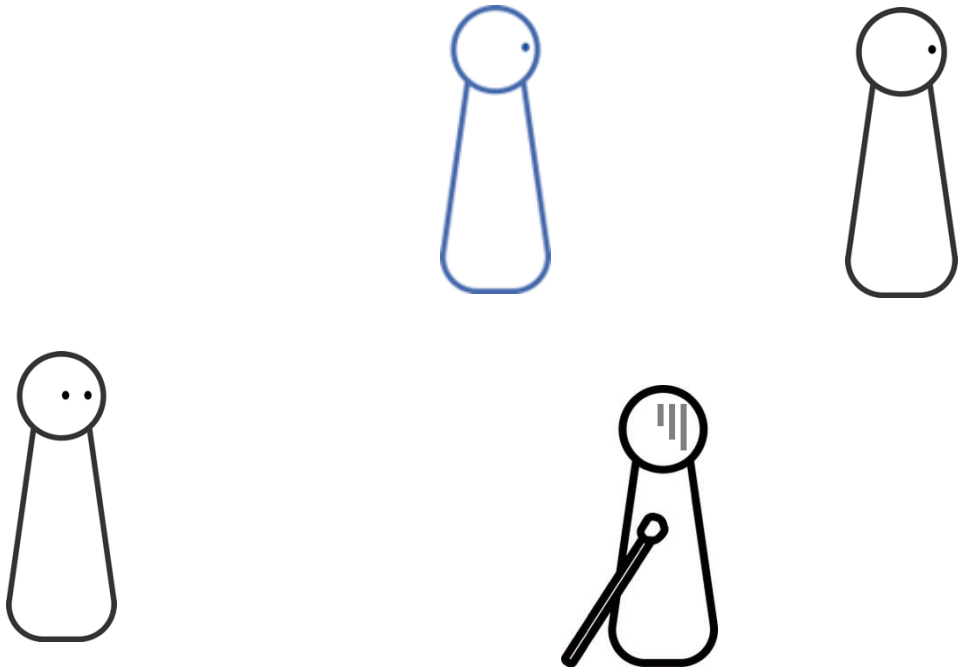
Following the Line



Don’t know which way and how long to walk

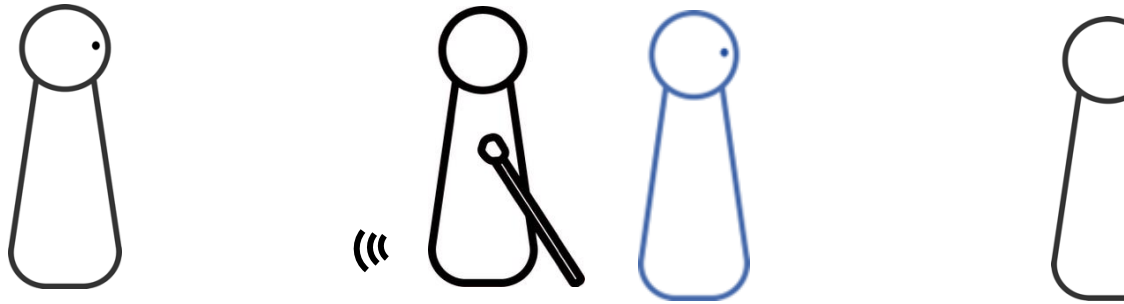
Difficulties Under COVID-19 Pandemic

Finding the End of Line



Hard to ask others for help

Following the Line



Cannot keep social distancing

Smartphone-Based Assistance System

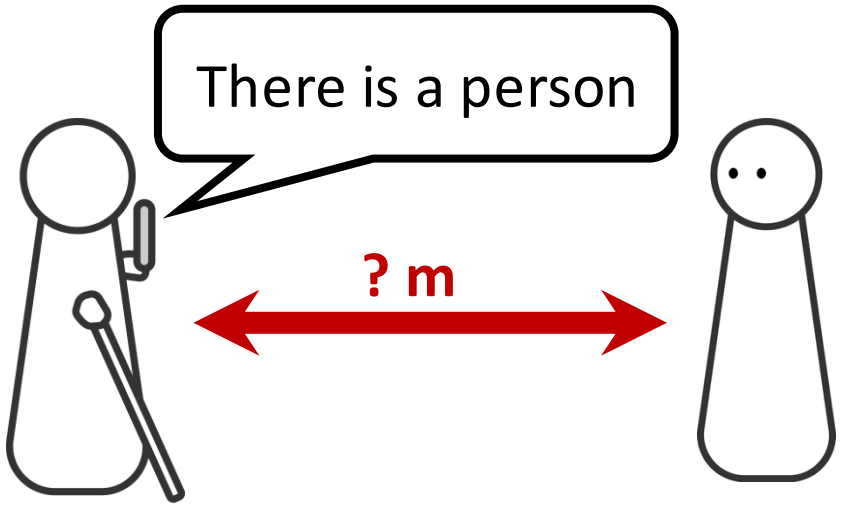
NavCog [1]

Navigation system

Does not navigate to the end of line

Seeing-AI [2]

Captioning system



Does not measure distance

[1] https://www.cs.cmu.edu/~NavCog/navcog.html

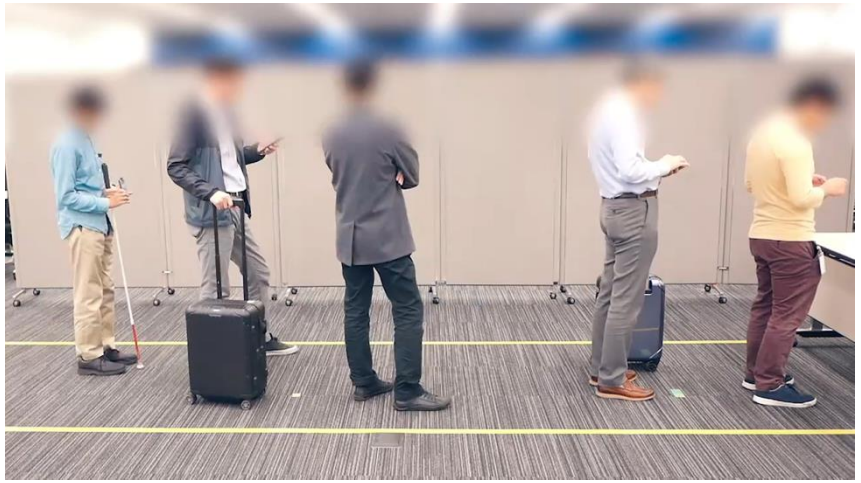
[2] https://www.microsoft.com/en-us/ai/seeing-ai

Research Procedure

Step1: Experiment with Prototype System

Assist blind people to follow a line

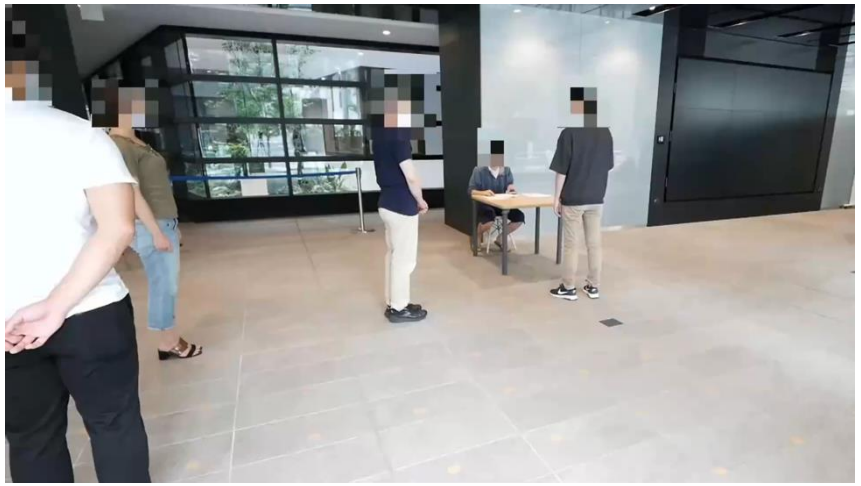
Preliminary study with 6 blind participants



Step2: Experiment Using LineChaser

Assist blind person to find and follow a line

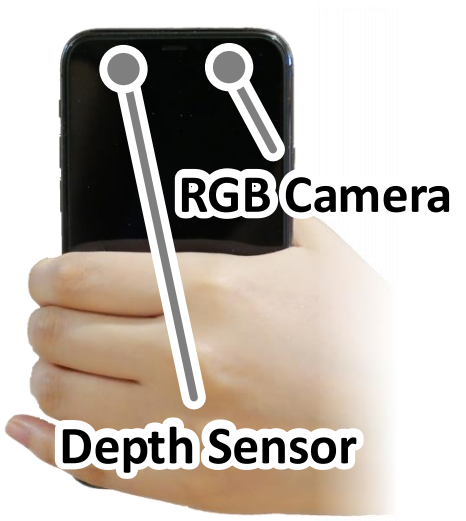
User study with 12 blind participants



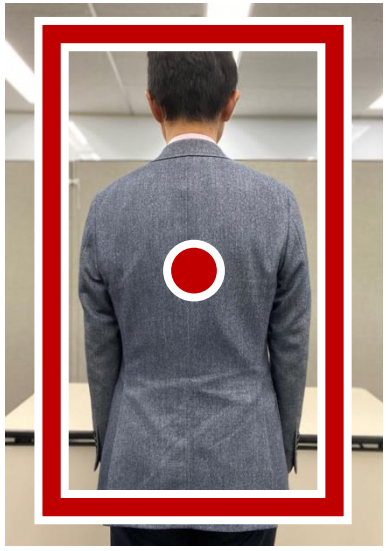
Prototype System

Instructs user to move forward based on the distance with the person in front

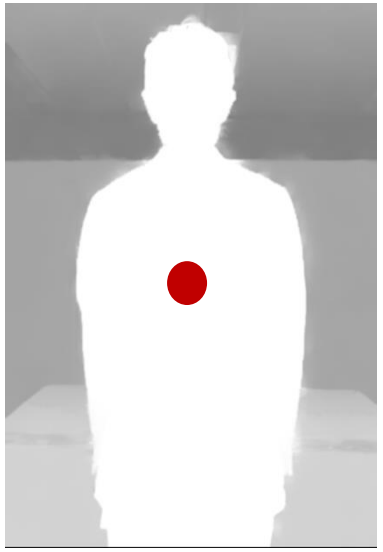
iPhone11Pro



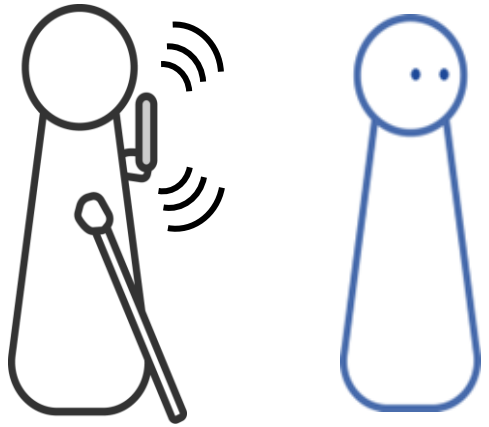
Person Detection[3]



Distance Estimation



Instruction to user



[3] Joseph Redmon, el al. “YOLOv3: An Incremental Improvement” arXiv 2018

User Study with 6 Blind Participants

Task : Follow the end of line using prototype system

Result

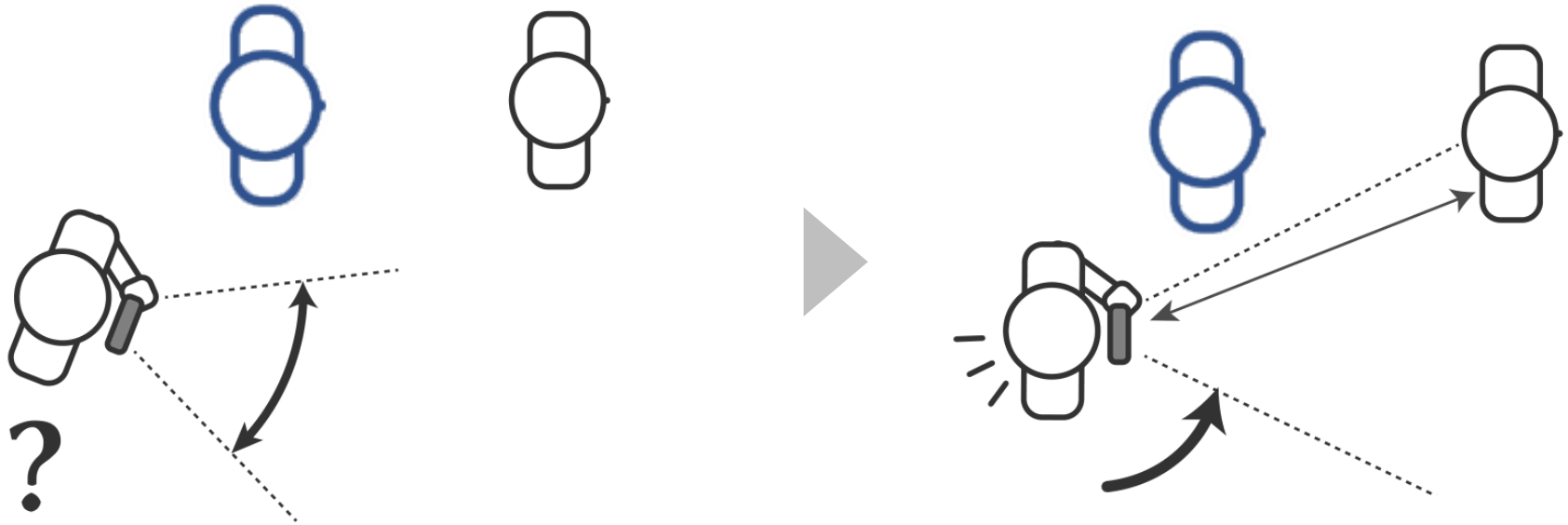
Blind participants were able to stand in line with 75% success rate

Failure Case

A blind participant followed the wrong person

Reason to Failure Case

The system detected the wrong person and instructed user to move forward



Improvement : Implement a function to track the person to follow

LineChaser:

Assist blind people to both

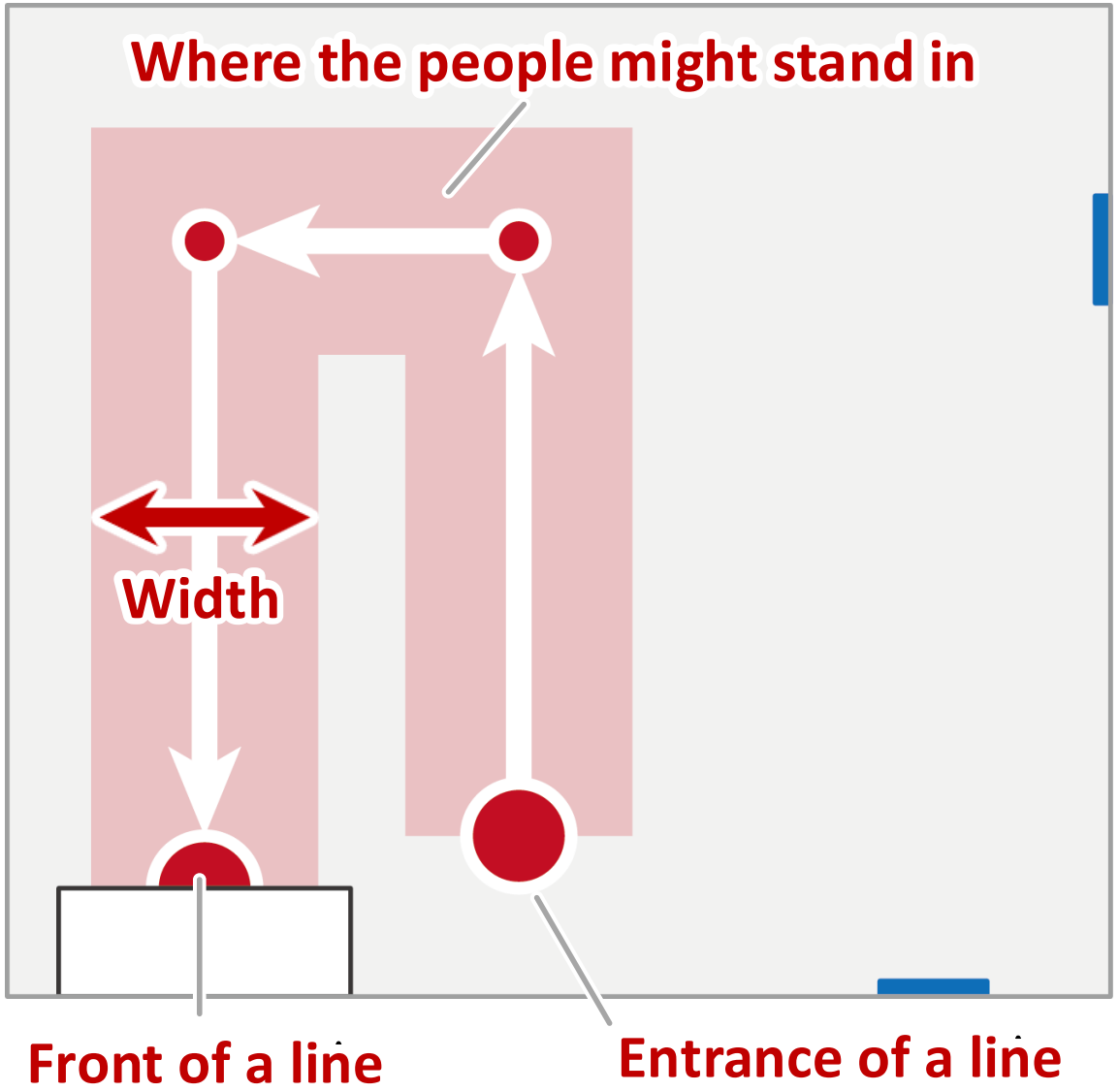
find and follow the end of line

using only one smartphone

Predetermined Map

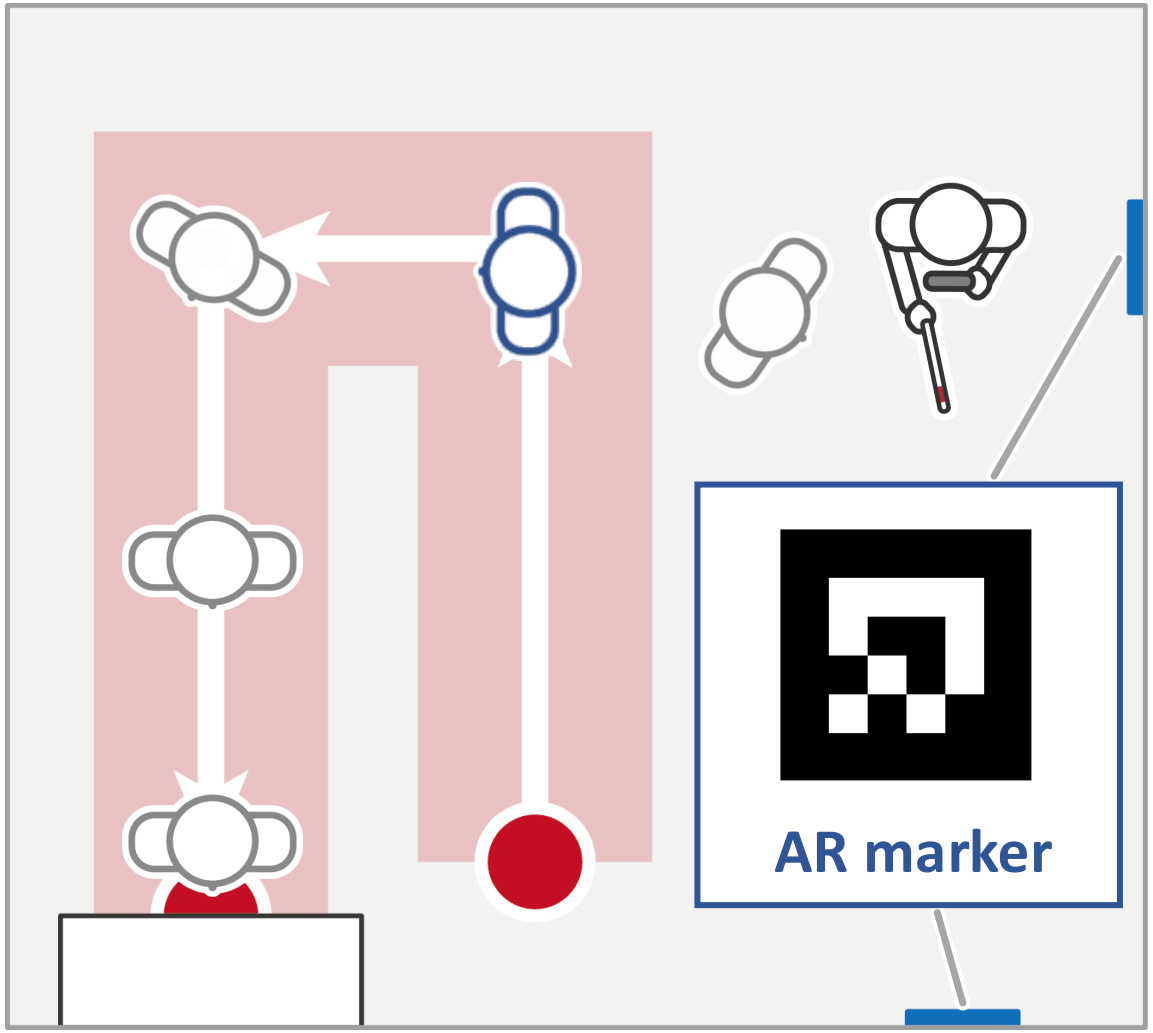
Uses a predetermined map

consists of information of a line



Step1：Navigate to the Entrance of Line

Navigates a blind user to the entrance of the line based on the localization result using AR marker

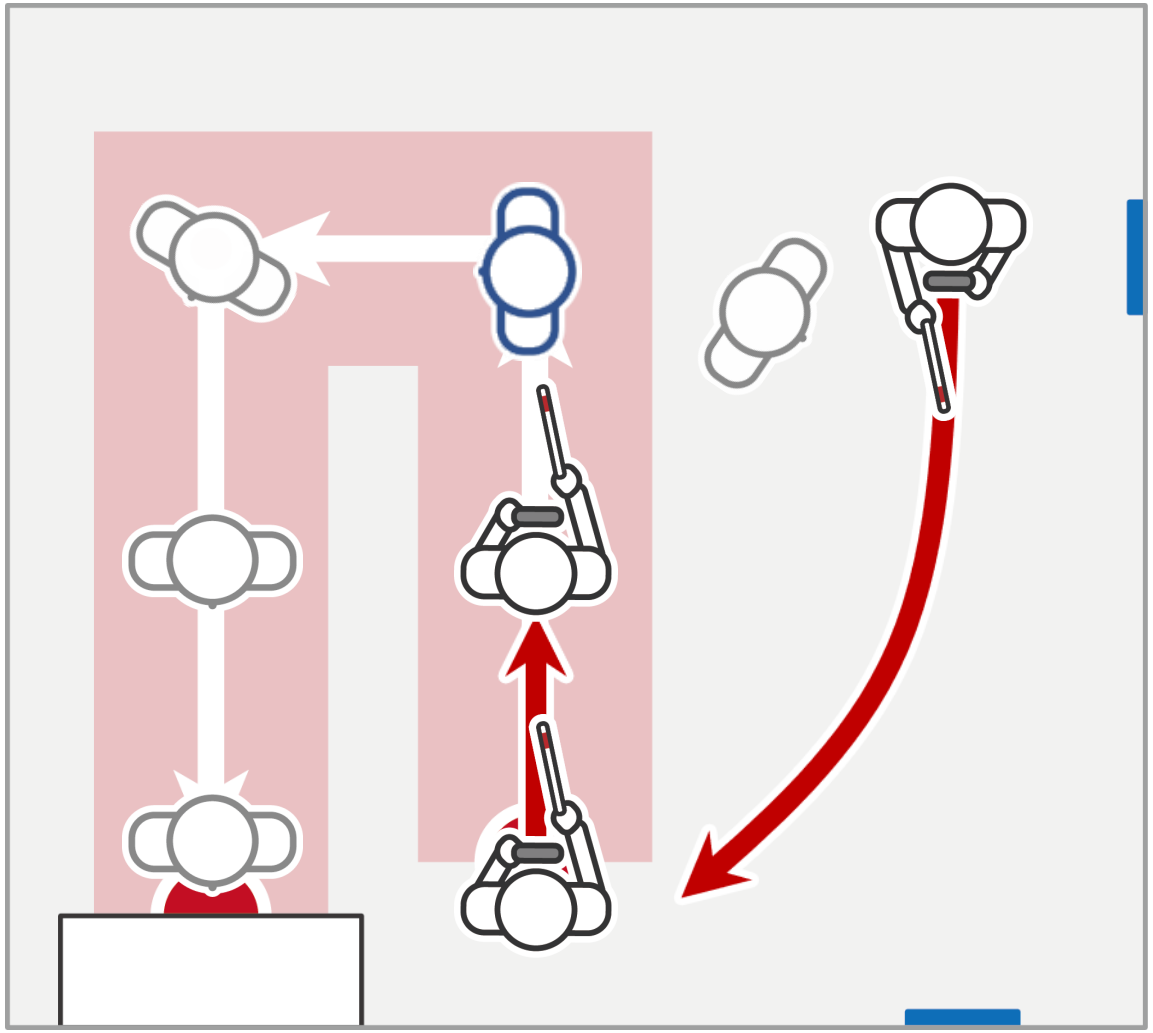


Navigate to the Entrance of Line

Navigates a blind user to

the end of the line

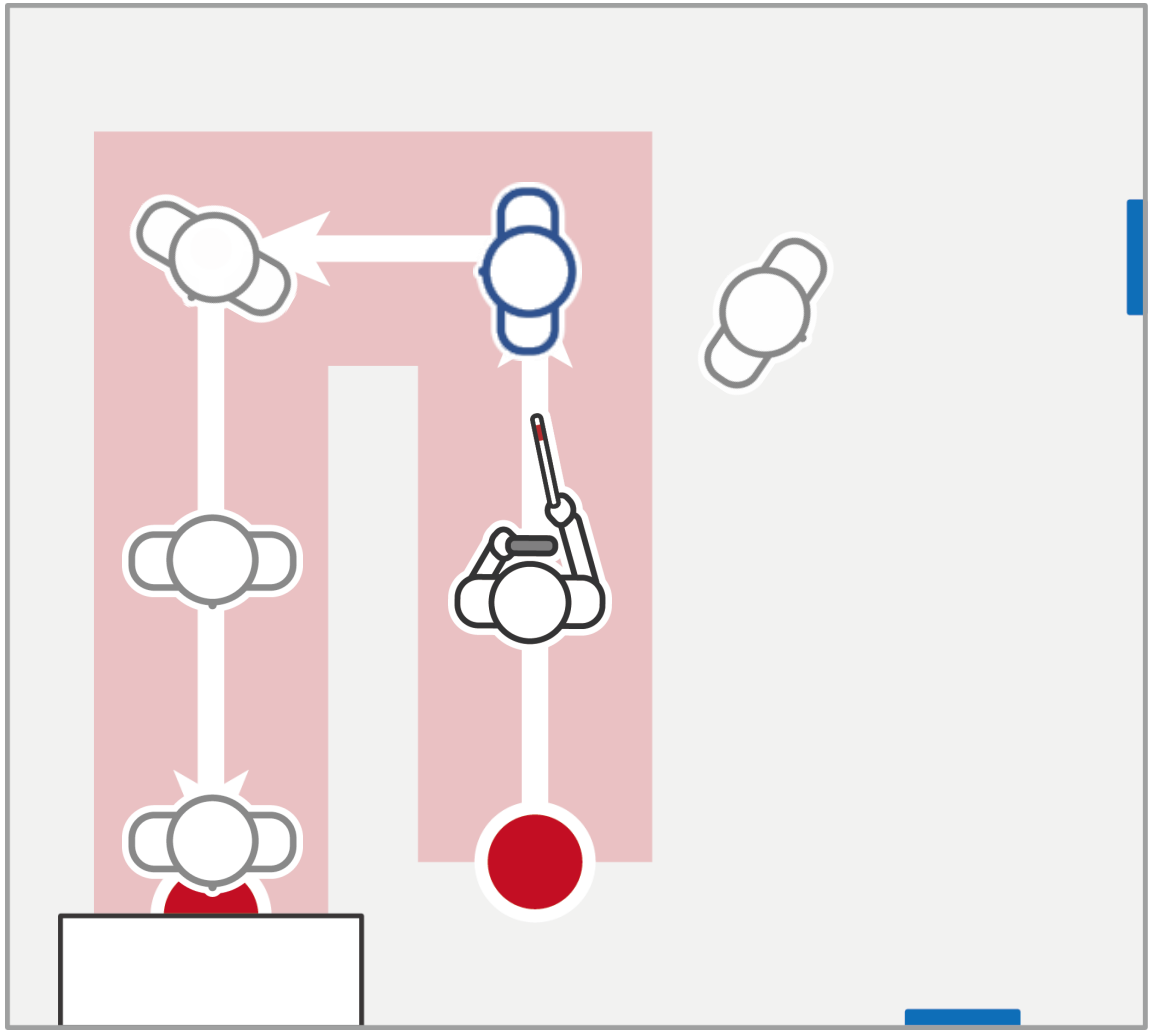
using predetermined map



Step2：Navigate Along the Line

Eventually the

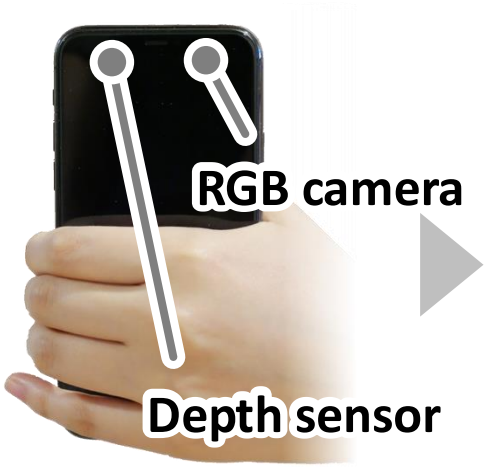
last person of the line will appear



Identify Line-Standing People

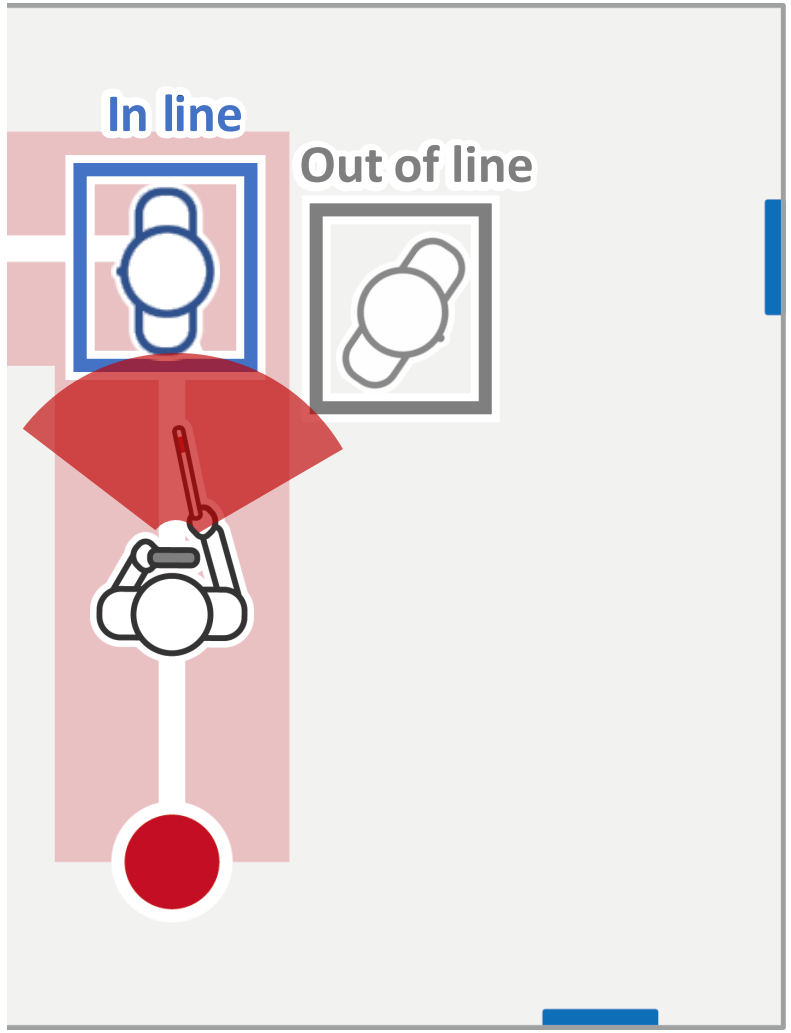
Identify line-standing people using predetermined map and results of **position estimation**

iPhone11Pro



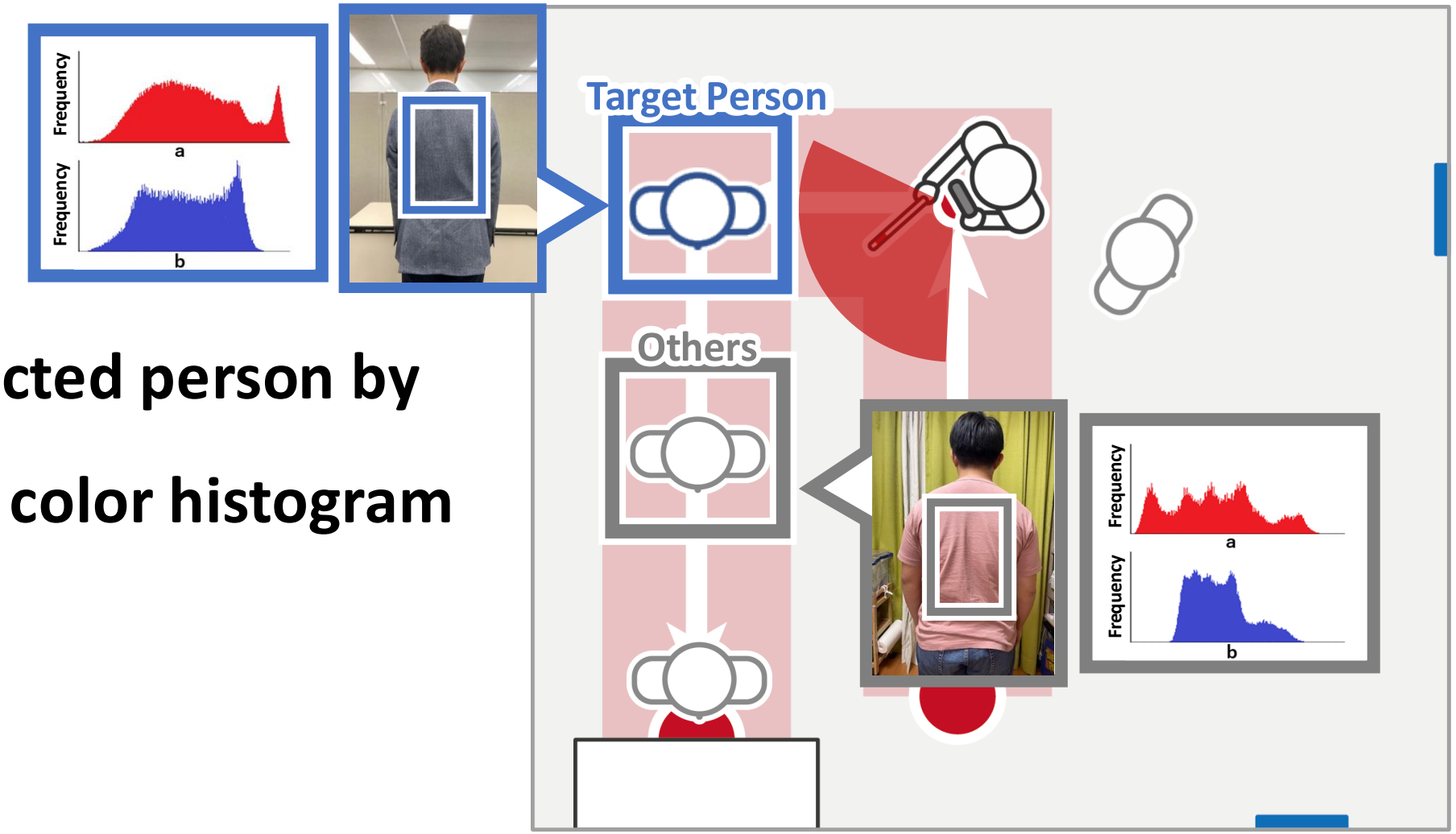
Person detection[3]

Position estimation



[3] Joseph Redmon, el al. “YOLOv3: An Incremental Improvement” arXiv 2018

Tracking the Target Person

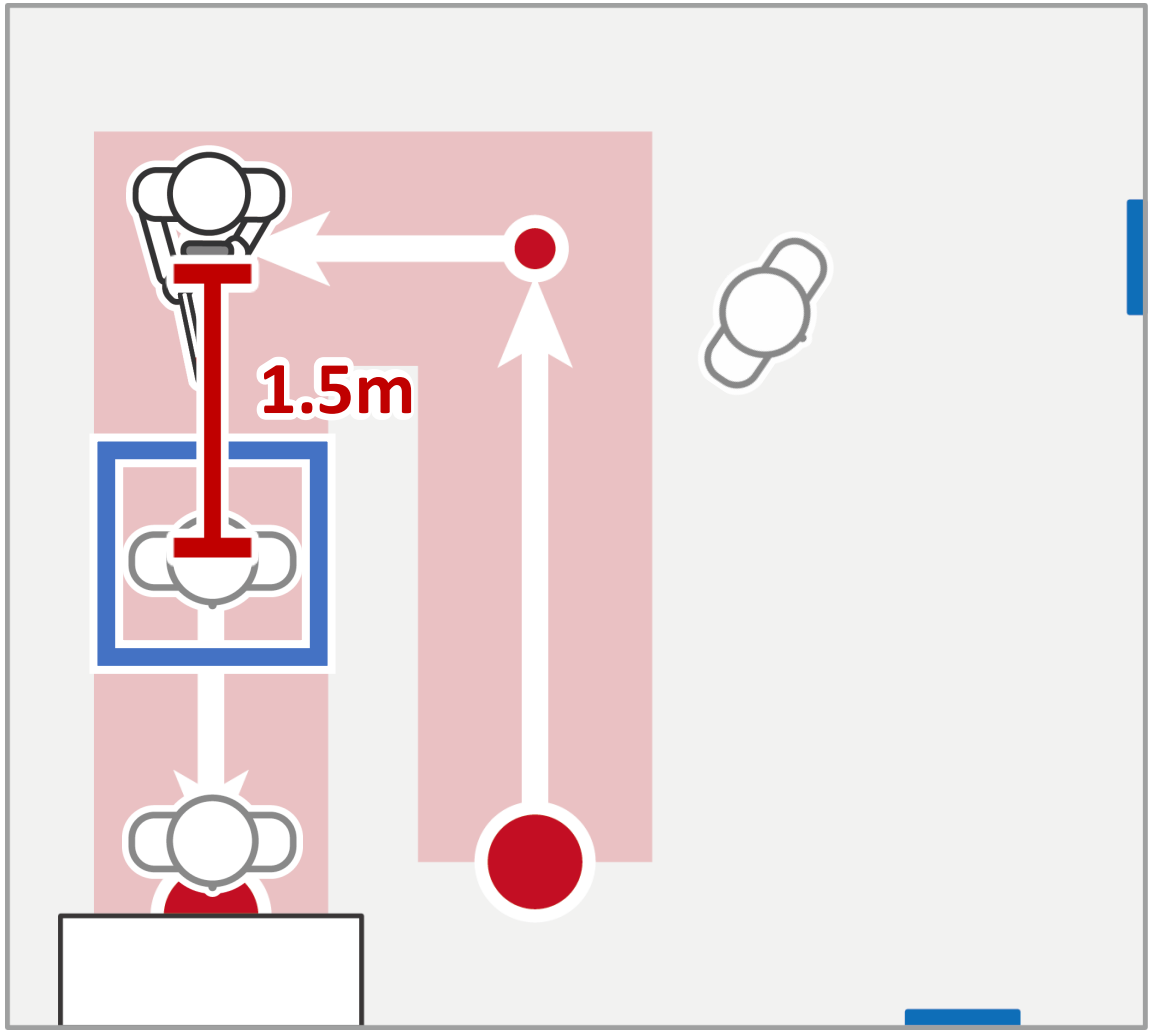


Distinguish detected person by comparing each color histogram

Follow the Line

Instruct the user to keep

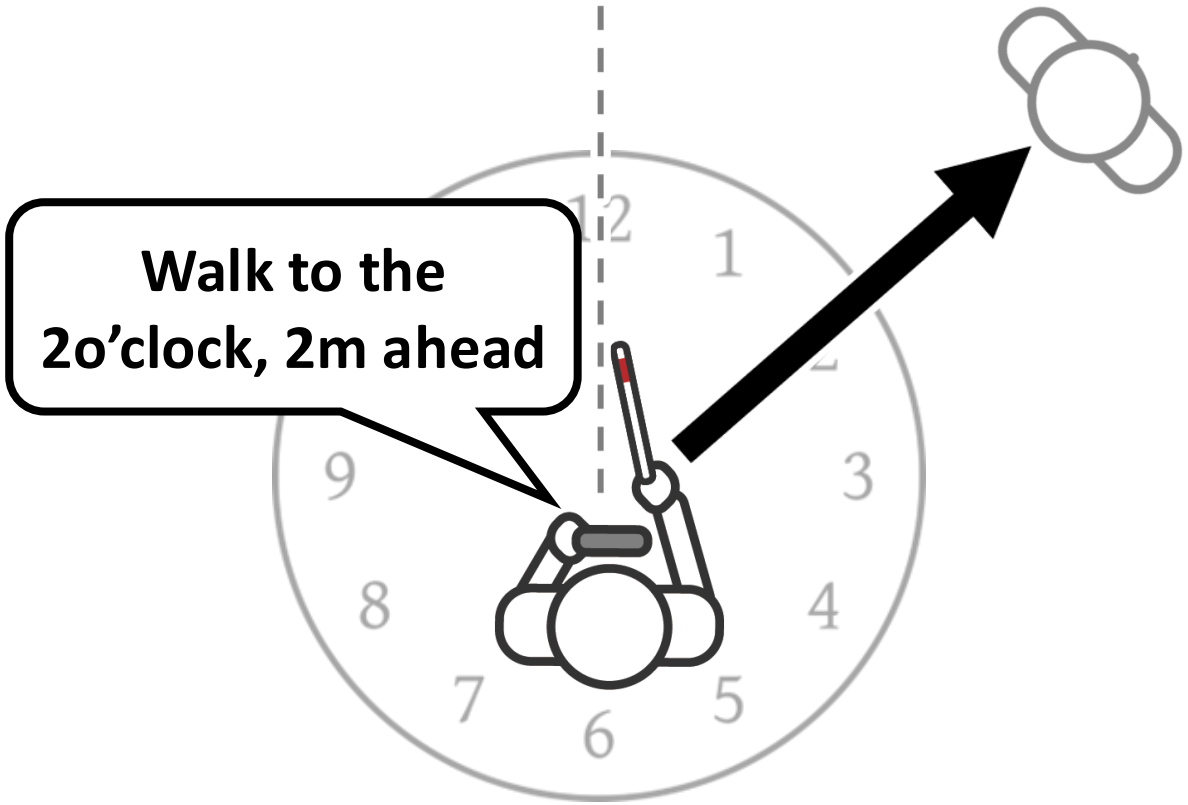
1.5m with the target person



Audio and Vibration Interface

Audio

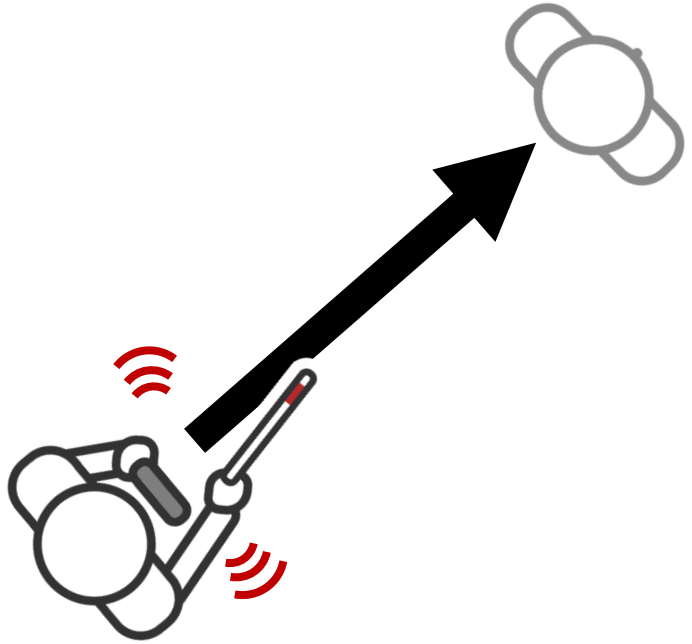
Conveys direction and distance



Notify user general position

Vibration

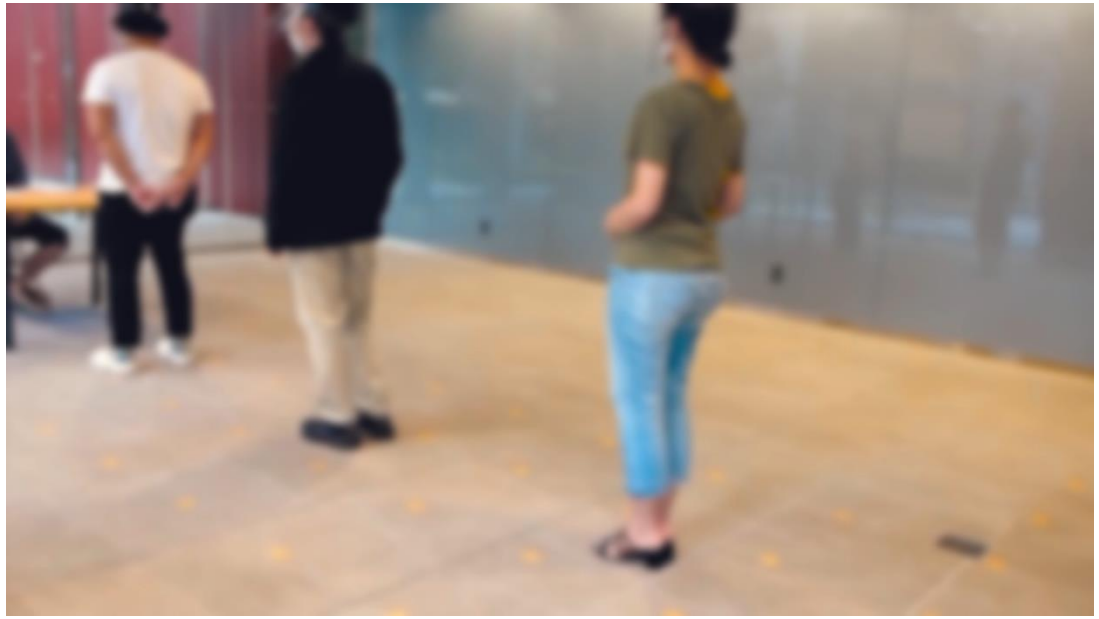
Vibrates when the user is facing the correct direction and should move



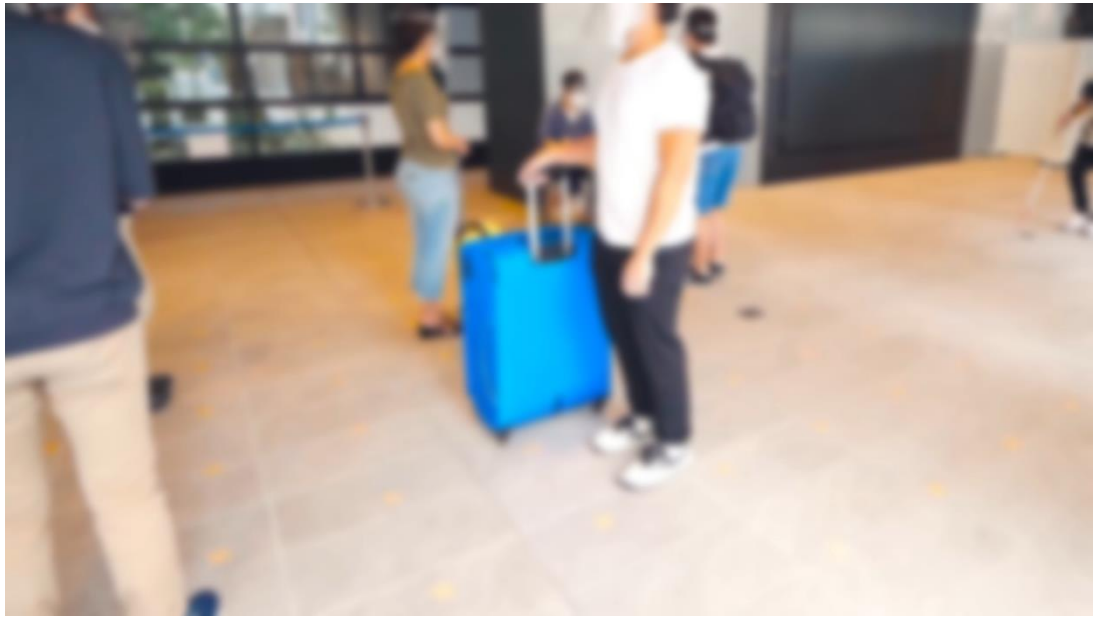
Notify user exact orientation

User Study with 12 Blind Participants

Straight Line



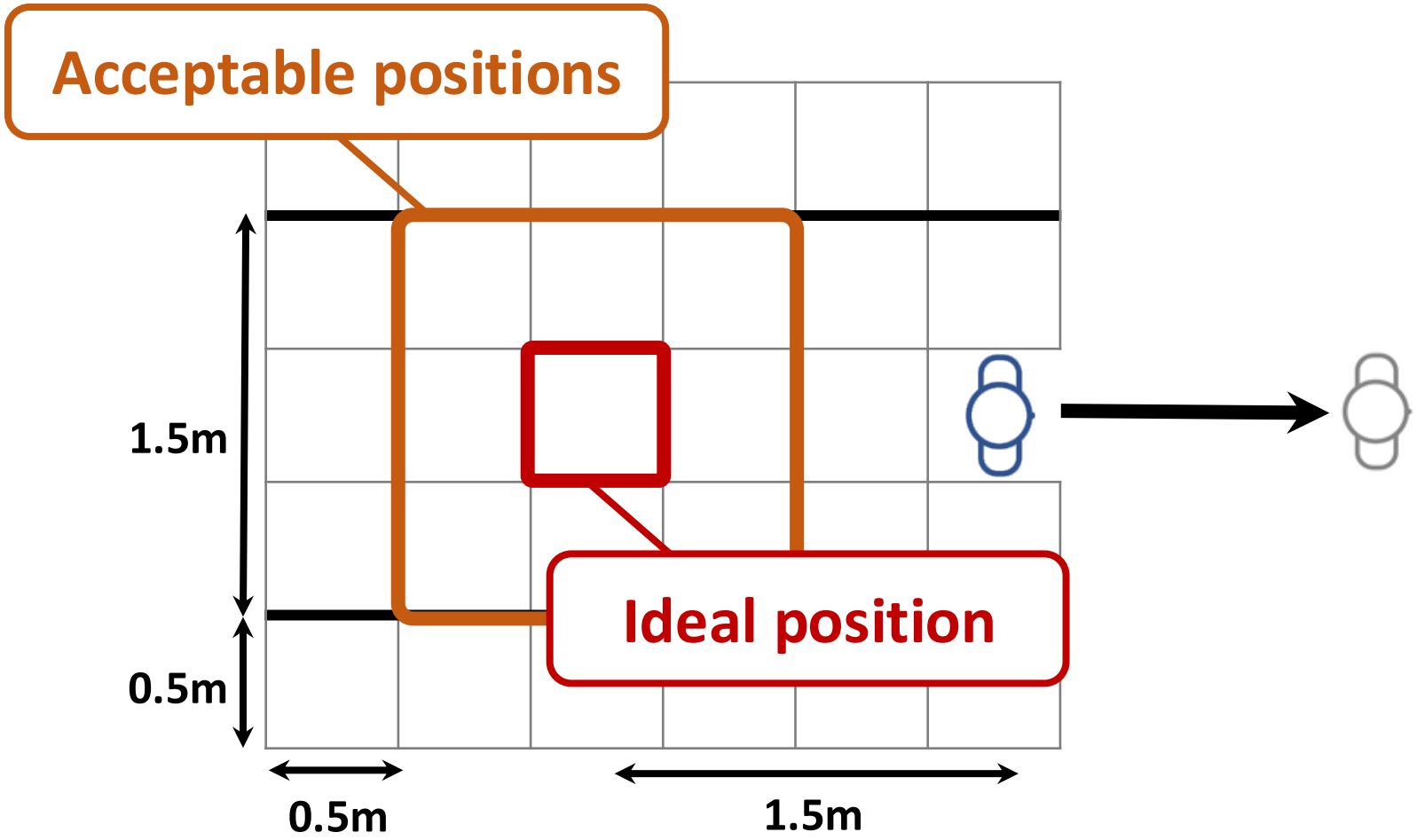
Serpentine Line



Task : Find the end of line and follow the line with LineChaser

Evaluation Measurements

Measure where and how many times the participants stopped in the line



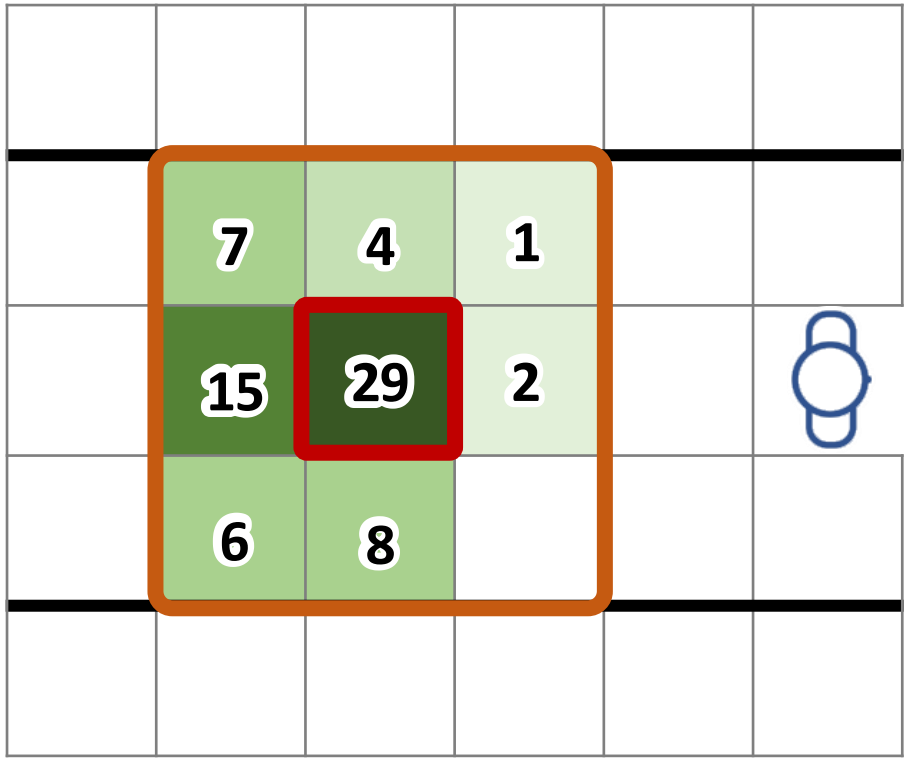
Distribution of Stop Position when Finding the Line

With the probability of 100%

stopped at Acceptable Positions

With the probability of 40.2%

stopped at Ideal Position



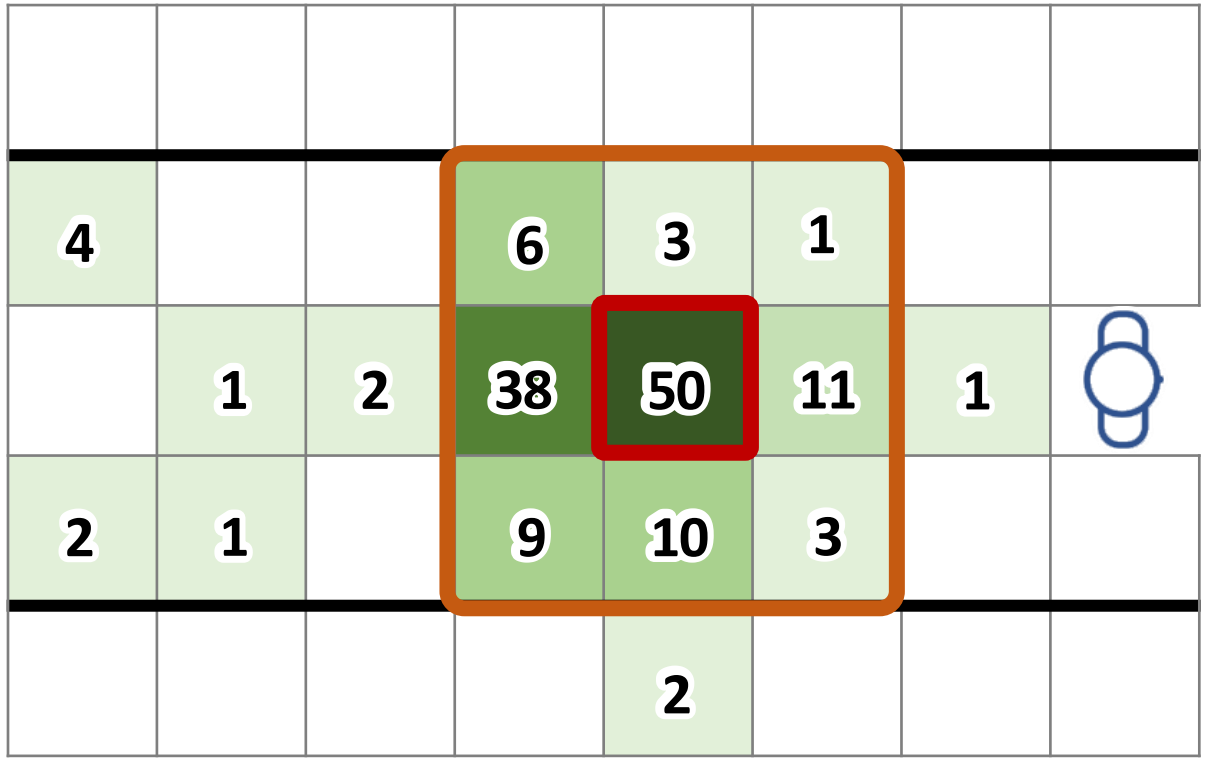
Distribution of Stop Position when Following the Line

With the probability of 90.9%

stopped at Acceptable Positions

With the probability of 34.7%

stopped at Ideal Position

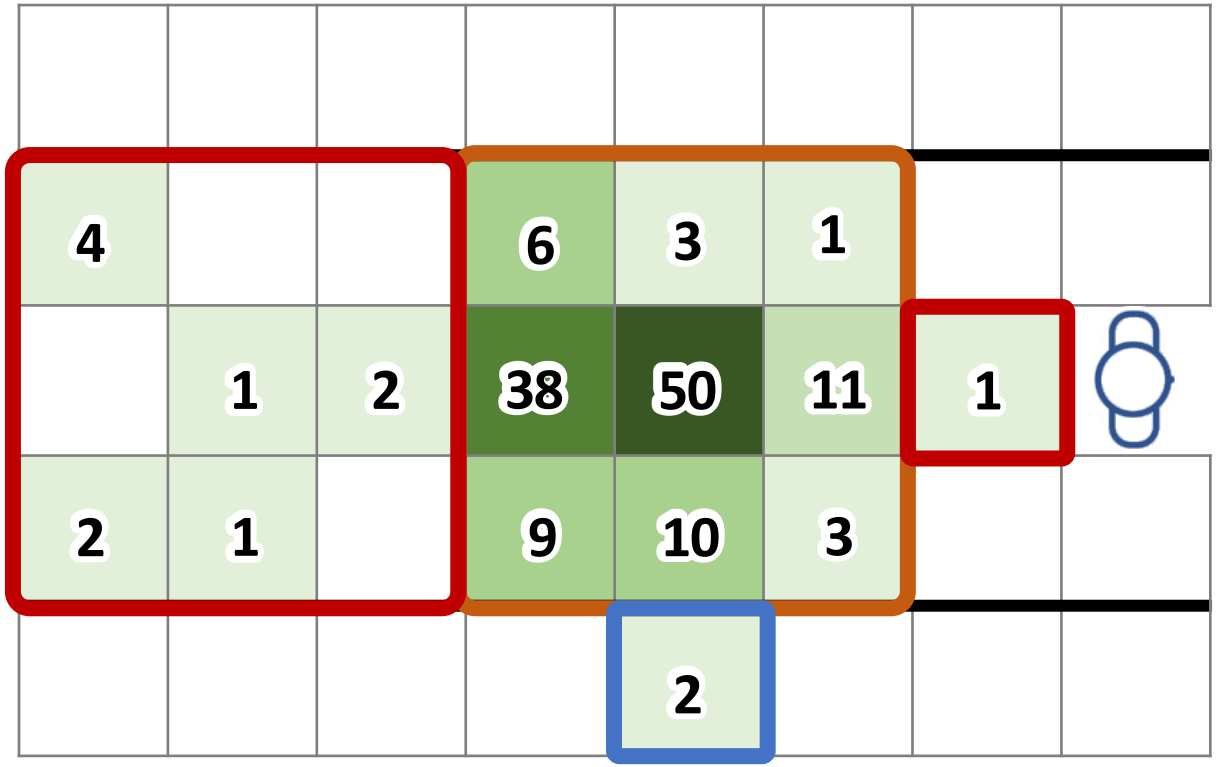


Reasons of Failure to Stop in Acceptable positions

Participants were unable to correct their orientation

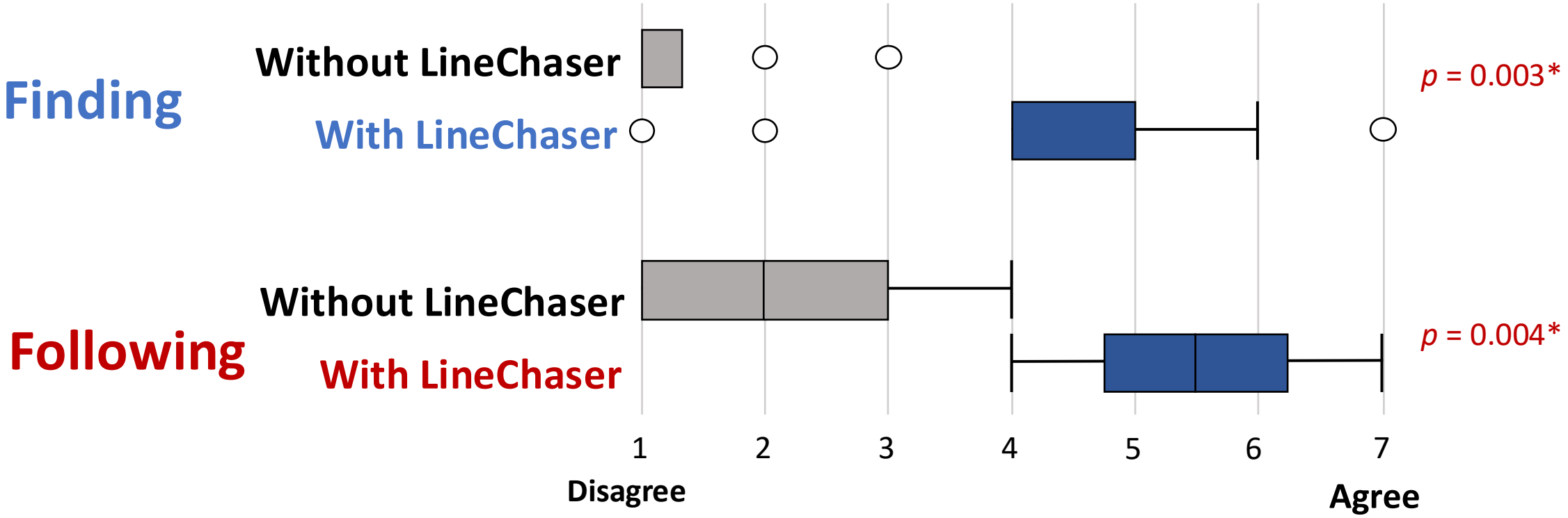
Participants did not understand how to use the interface of LineChaser

Localization error of LineChaser accumulated



Confidence when Standing in Lines

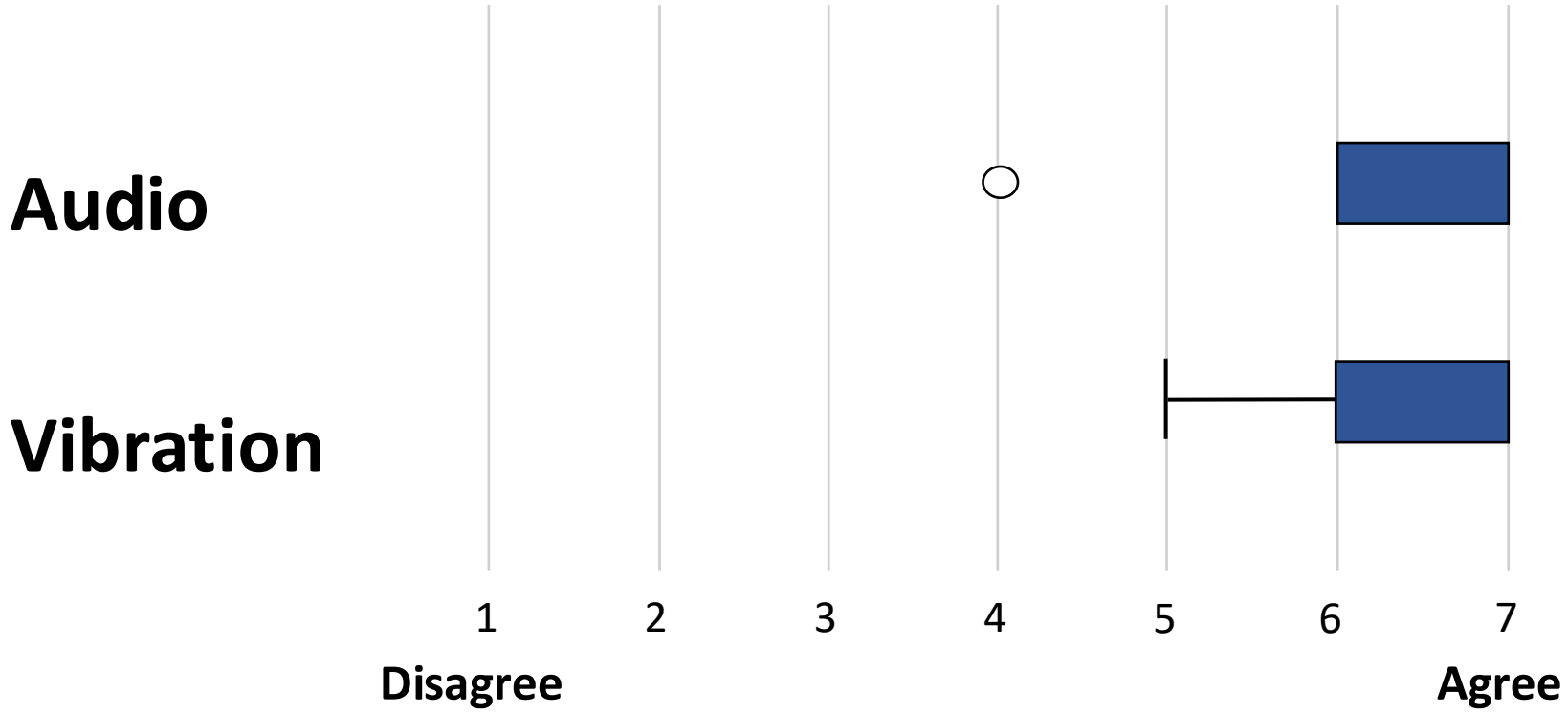
Q. In an unfamiliar place, I can find/follow a line by myself with confidence



Participants were significantly confident when using LineChaser

Evaluation of Interface of LineChaser

Q. Instructions of LineChaser were easy to understand



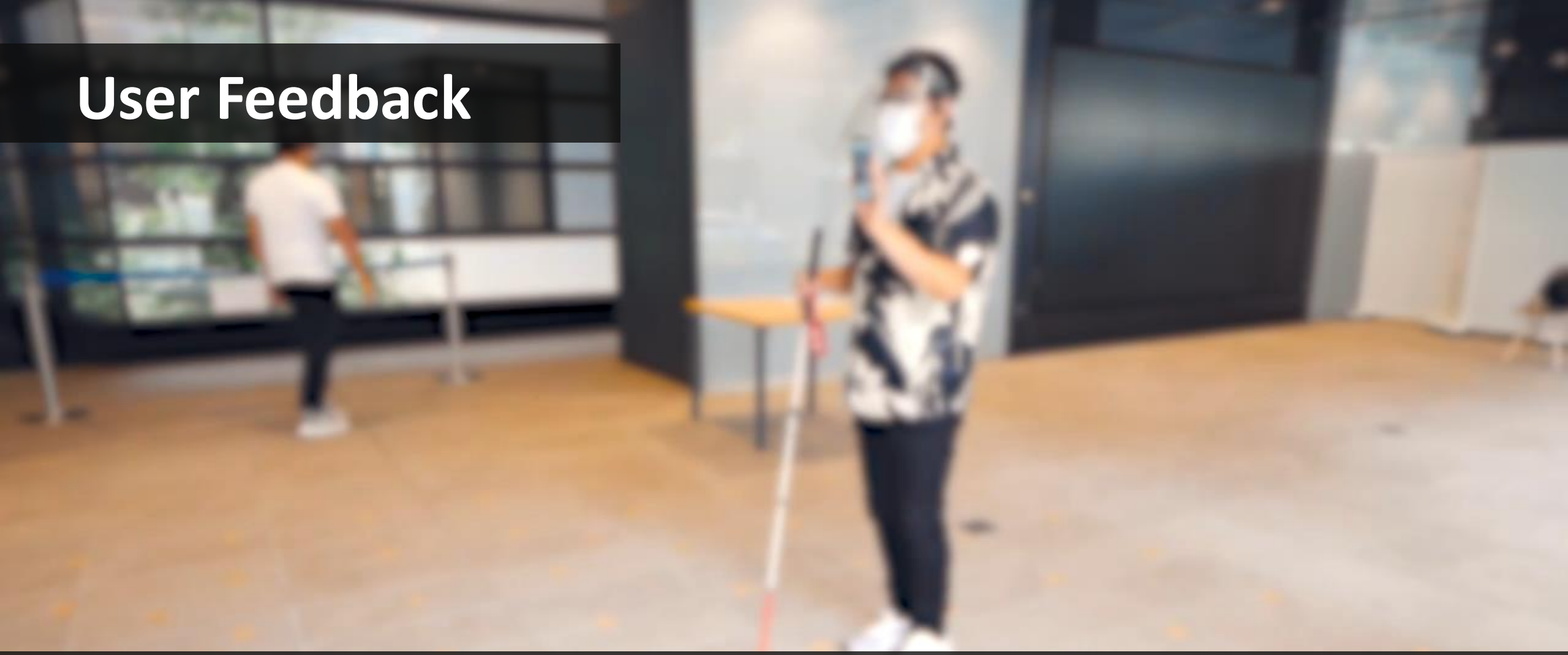
Participants found interface of LineChaser easy to understand

User Feedback

"I am very happy to be able to find a line without needing to touch anything.

Also, I was confident that I would not bump into the target." (P03)

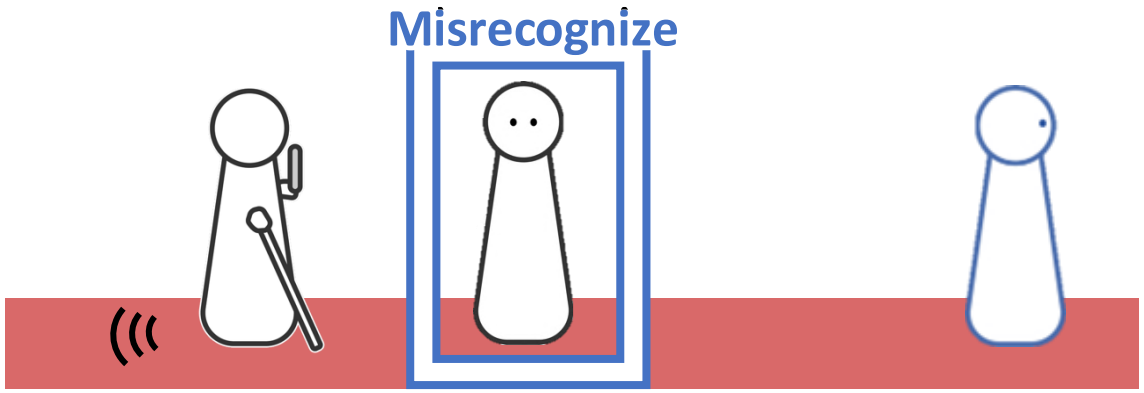
User Feedback



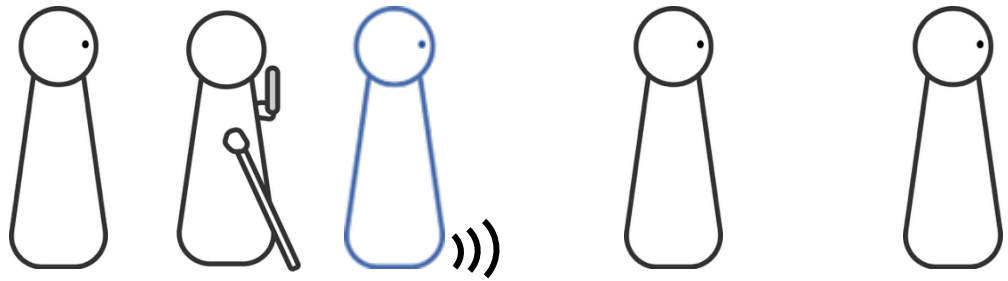
"The audio feedback gives me an approximate sense of the direction I should be facing. Then, I can find the exact direction with vibration feedback." (P09)

Situation which might happen in real-world

An irrelevant person might be standing in between the entrance and the end of line



The person in front might step backward to adjust distance in the line



Future work：Integrate with existing navigation system[1] and conduct a real-world user study

[1] https://www.cs.cmu.edu/~NavCog/navcog.html

LineChaser

The system that assists blind people to both find and follow the end of line

- **Determines line-standing people and tracks the target person**
- **Participants were able to stand in lines by themselves using LineChaser**
- **Participants found interface of LineChaser easy to understand**
- **Future work is to conduct a real-world user study**