Corridor-Walker: Mobile Indoor Walking Assistance for Blind People to Avoid Obstacles and Recognize Intersections

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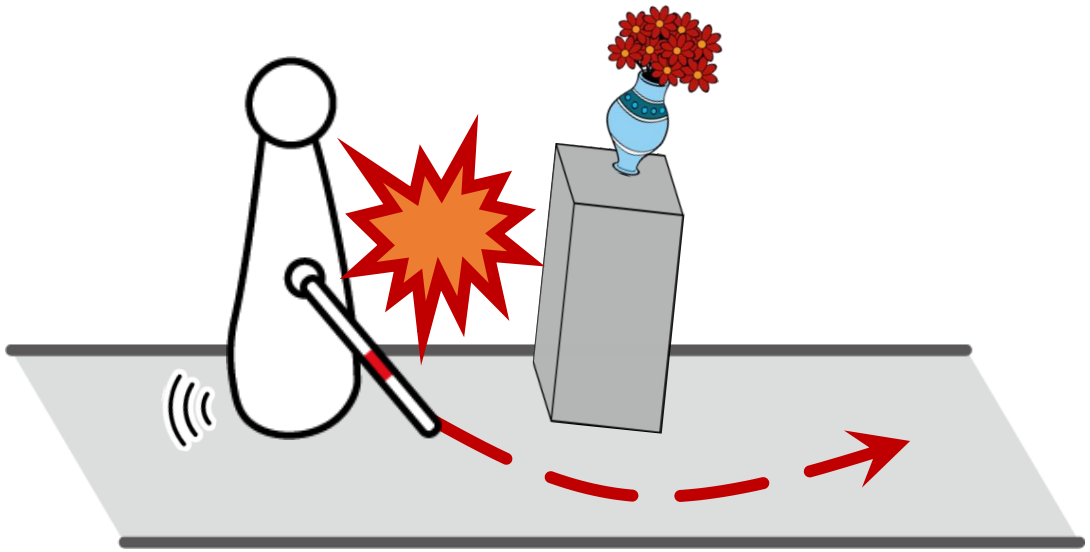
Overview

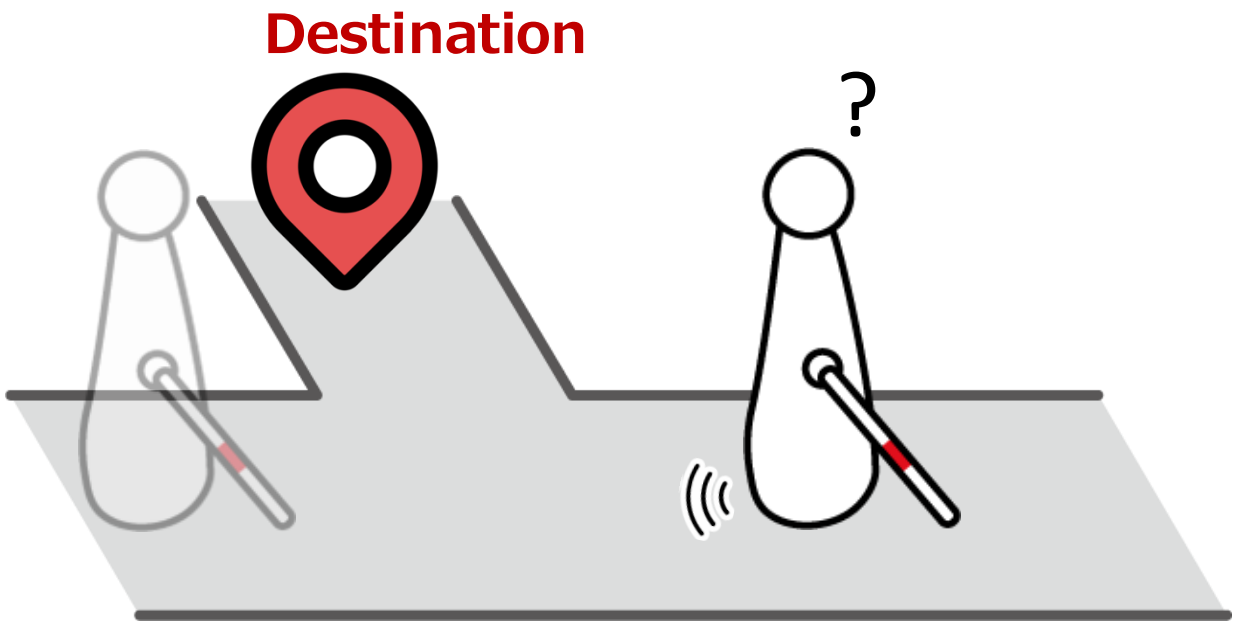
Difficulties Blind People Face when Navigating Indoor

Avoiding Obstacles



Don’t know path to avoid

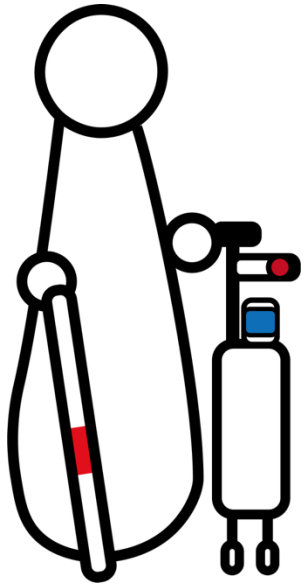
Finding Intersections

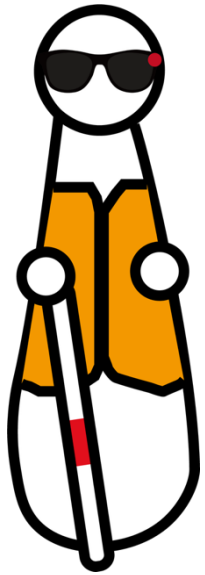


Don’t know location and shape of intersection

Existing Obstacle Avoidance System

Robots[1] and wearable devices[2] which provides obstacle-avoiding path





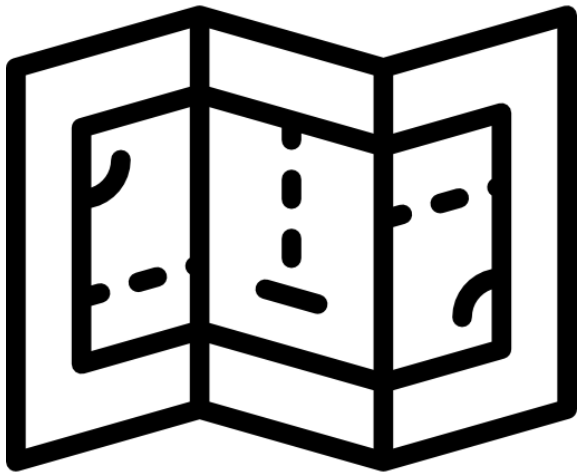
Use smartphone for better technology adoption[3]

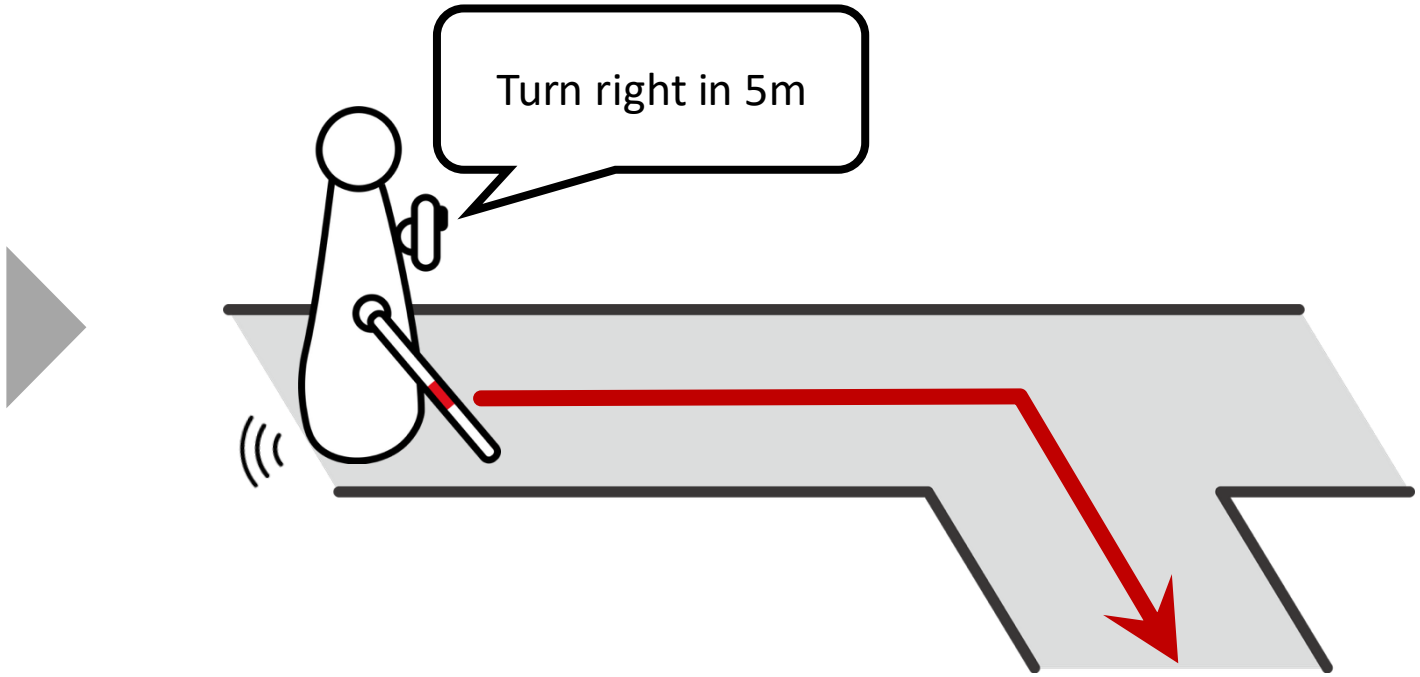
[1] Guerreiro et al. “CaBot: Designing and Evaluating an Autonomous Navigation Robot for Blind People” [2] Lee et al. “Wearable RGBD indoor navigation system for the blind” [3] Morris et al. “Blind and deaf consumer preferences for android and iOS smartphones”

Existing Navigation System That Navigates Blind People

Navcog [4] : An indoor navigation system that uses a prebuilt map

Map of building



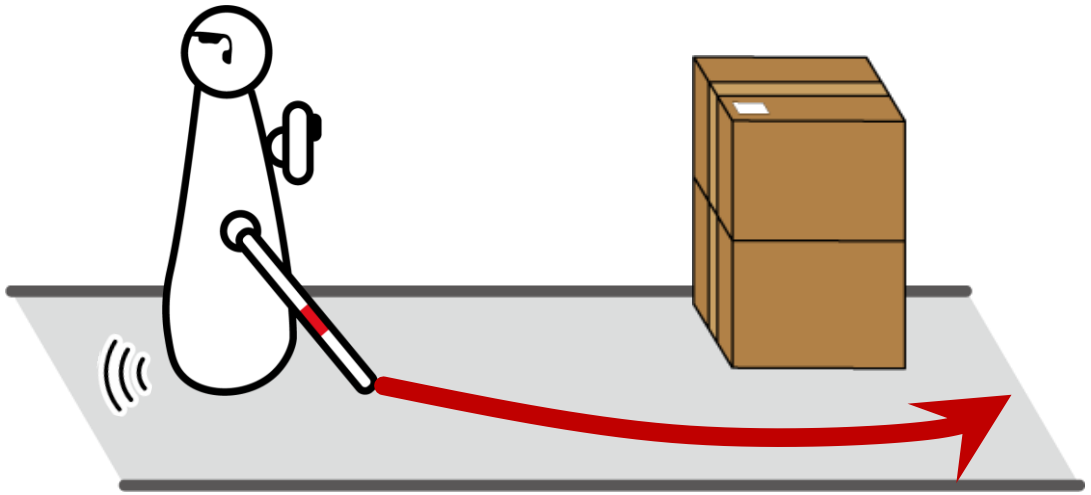


As maps for system may not be there[5], we detect intersections without a map

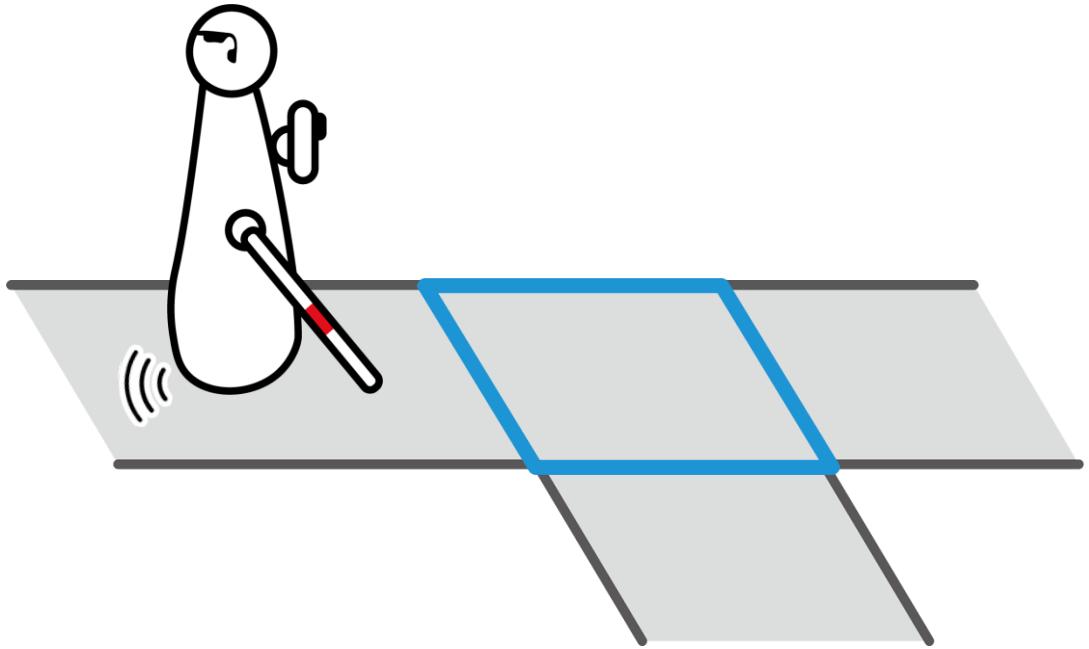
[4] Sato et al. “NavCog3 in the wild: Large-scale blind indoor navigation assistant with semantic features” [5] Striegl et al. “Analysis of Indoor Maps Accounting the Needs of People with Impairments”

System Overview：Two functions

Path planning based on
cost map from LiDAR sensor

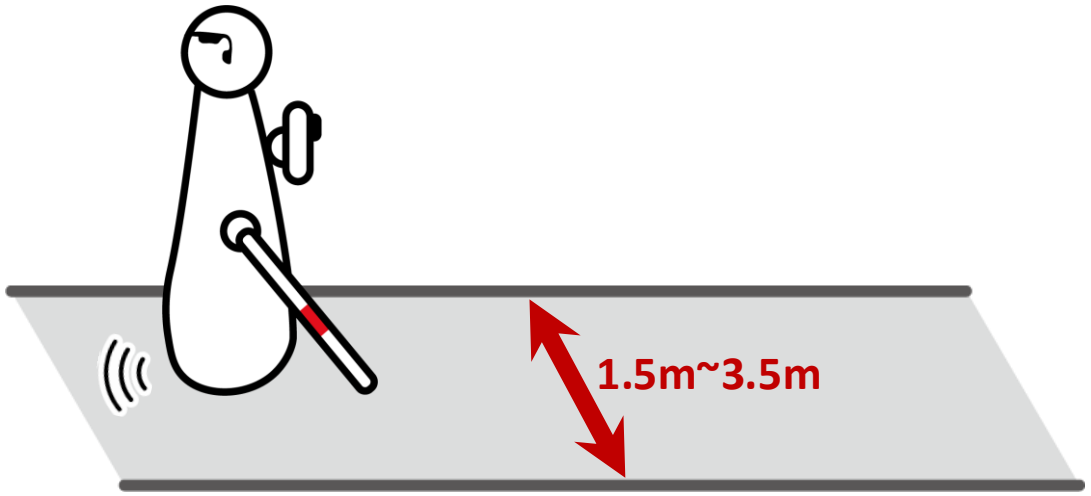


Intersection detection based on
cost map and object detection



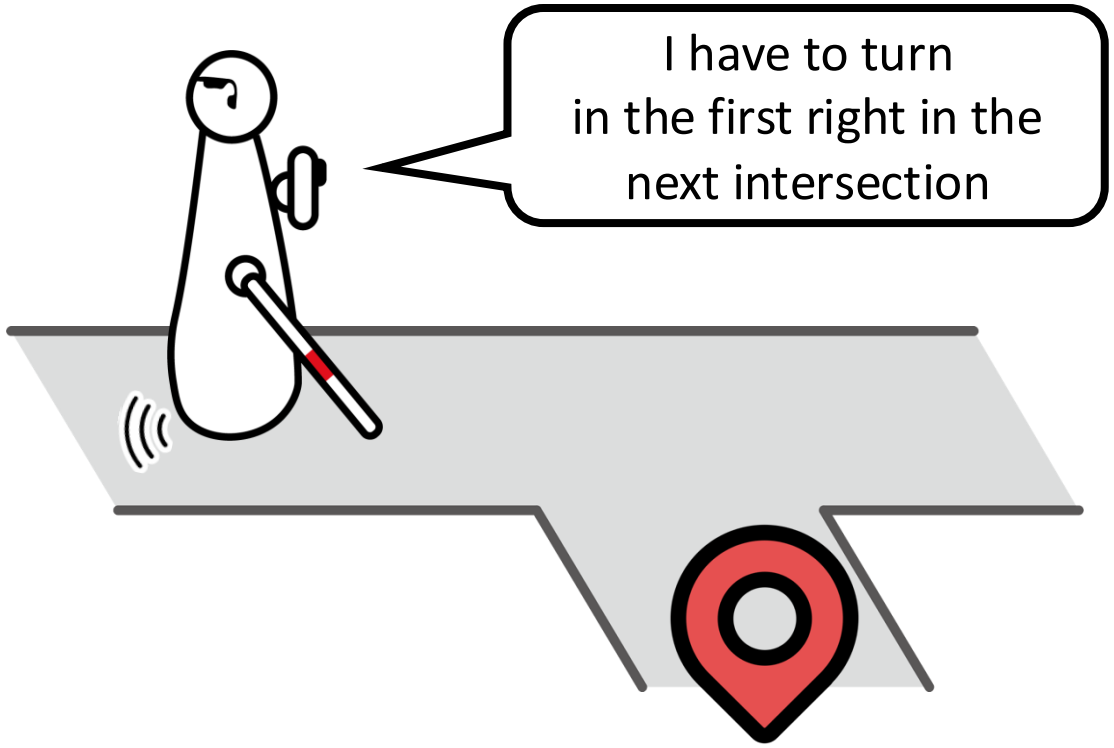
Situation to Use Corridor-Walker

1.5-3.5m wide corridor

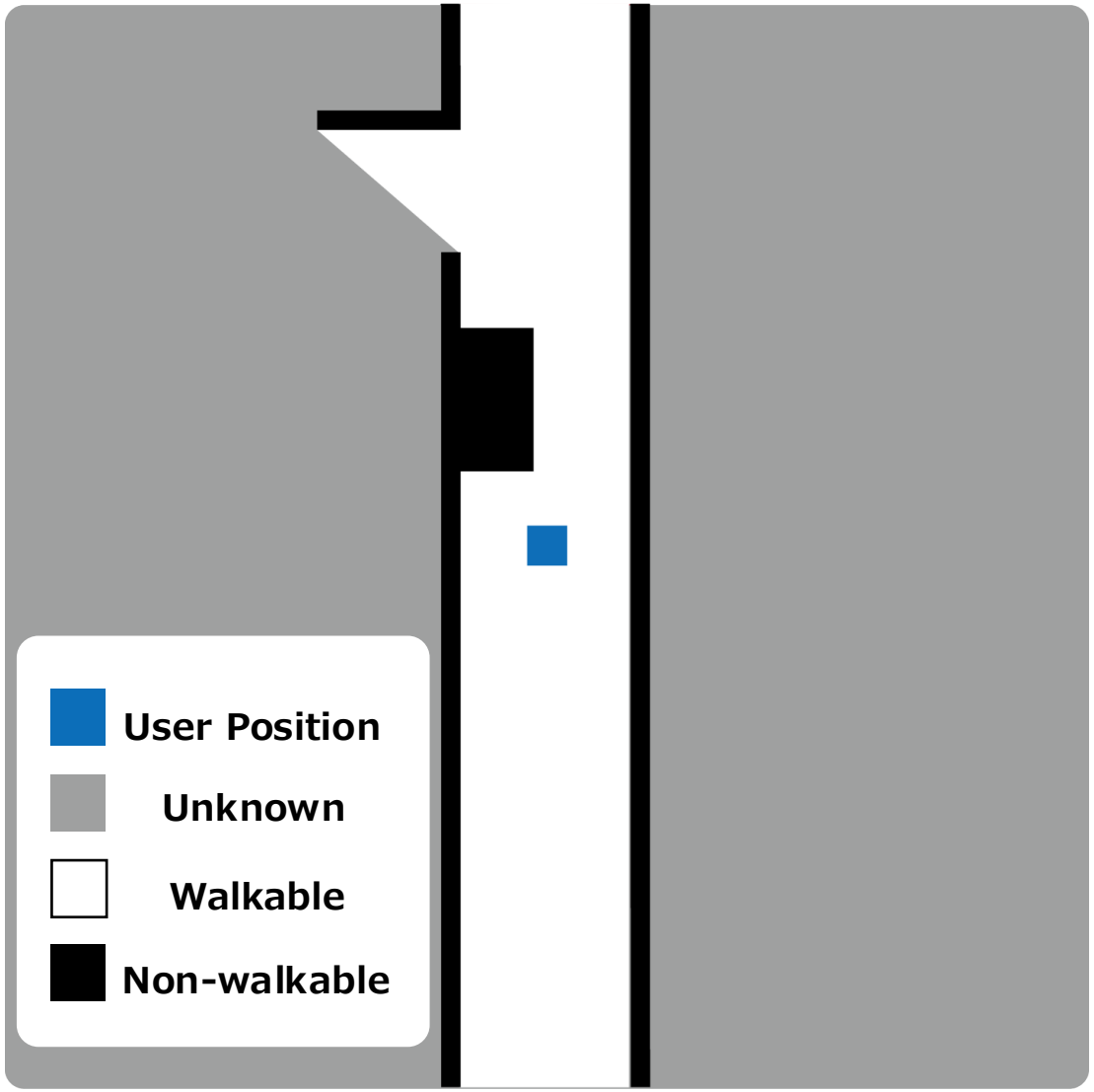


e.g., hotel and hospital

Where blind people knows
the route to destination

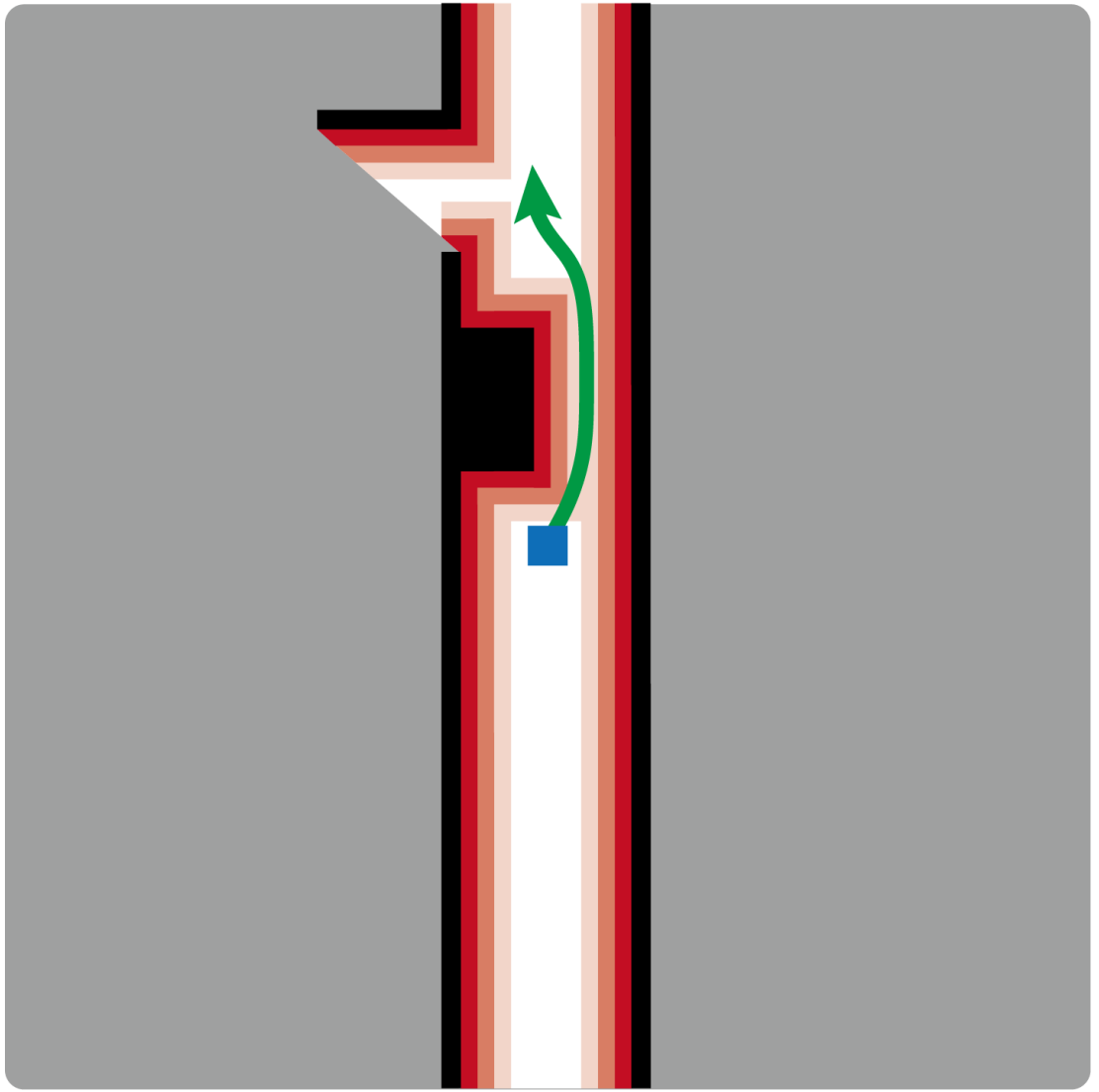


Real-time Construction of Cost Map Based on LiDAR Sensor



Assigning Cost and Planning Path

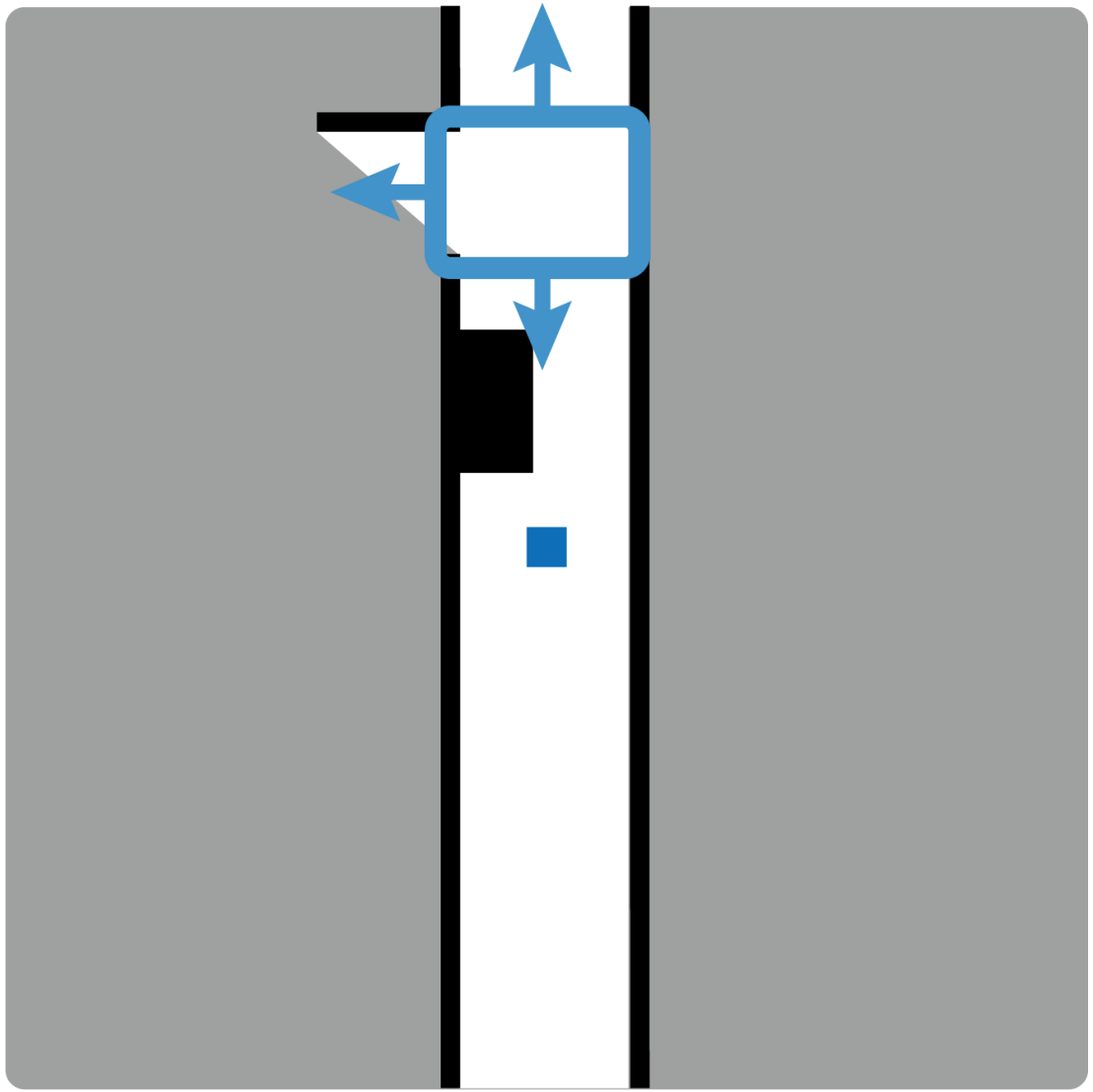
Assign cost to walkable cell depending on its distance with obstacle cell and plan an obstacle-avoiding path [6]



[6] Hart et al. “A formal basis for the heuristic determination of minimum cost paths”

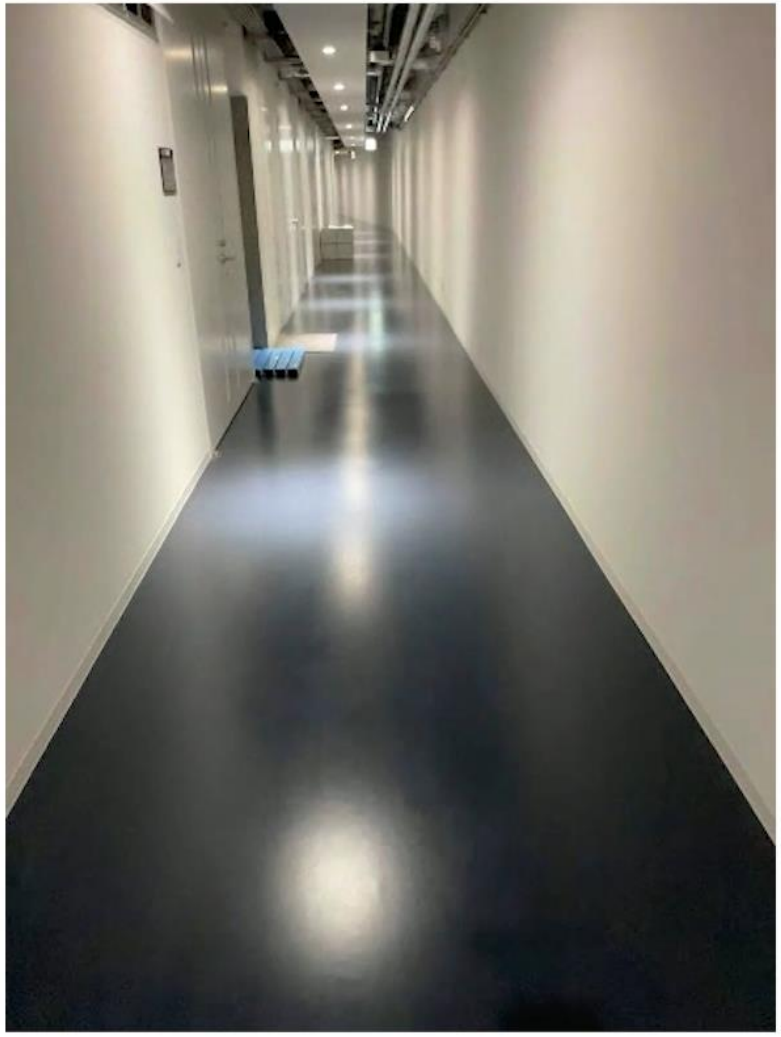
Intersection Detection

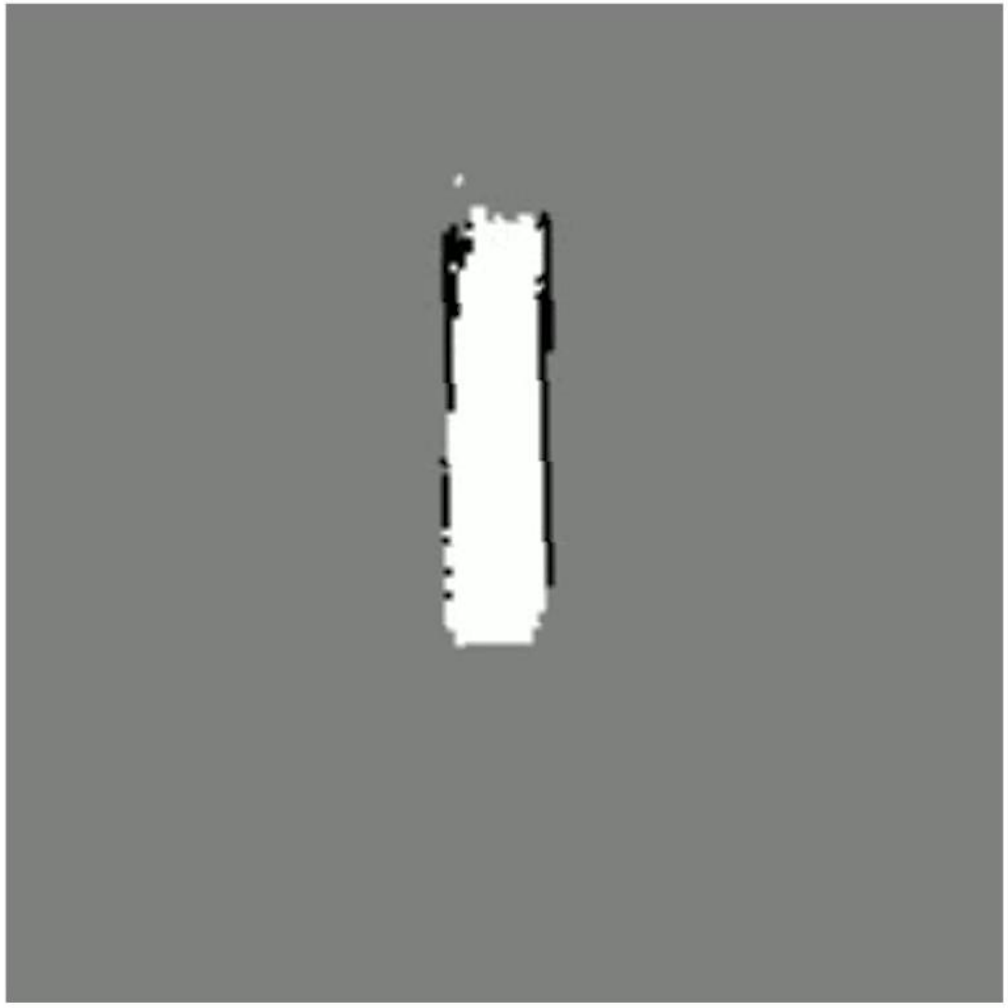
Detects location and shape of intersections using a cost map image and YOLOv3[7]



[7] Redmon et al. “YOLOv3: An Incremental Improvement”

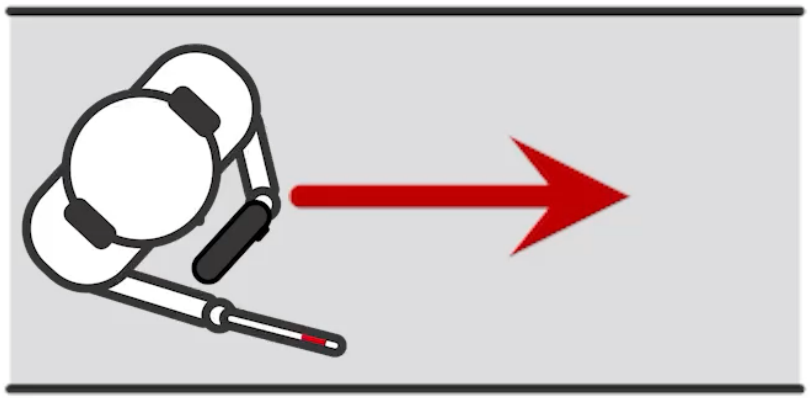
System video





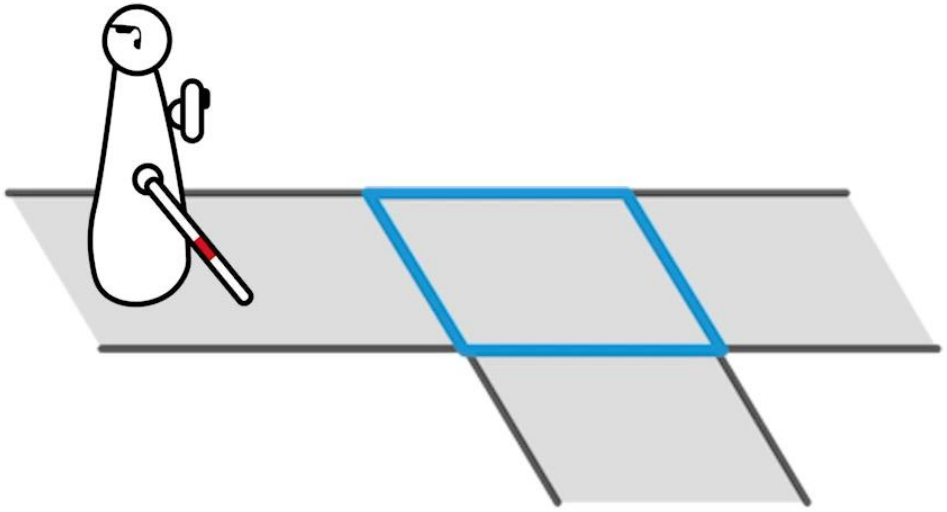
Interface of Corridor-Walker

Obstacle Avoidance



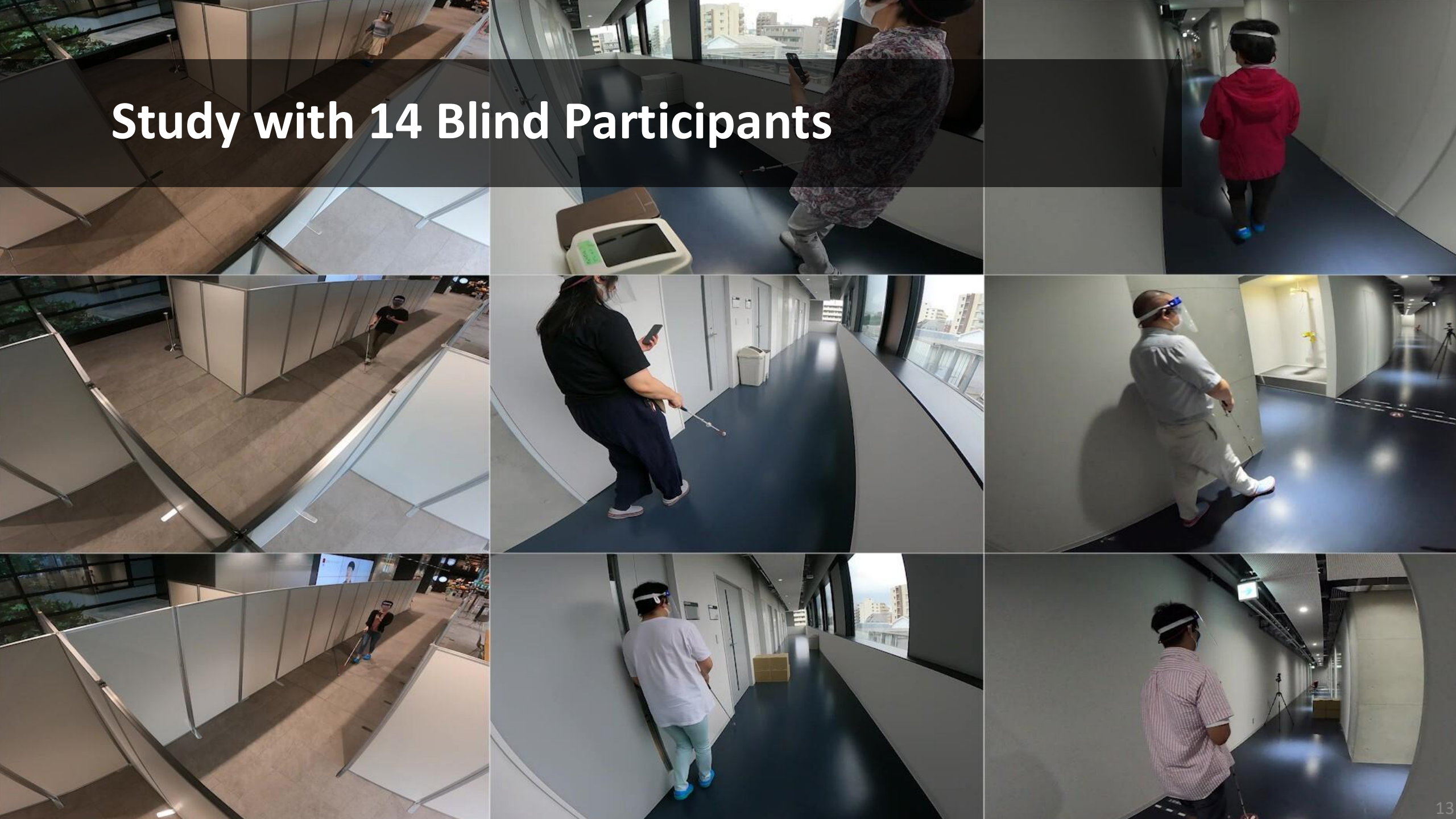
Emits a sound from the
correct direction using earphone

Intersection Detection



Vibrate to tell the existence,
tell the user to scan,
and then convey shape

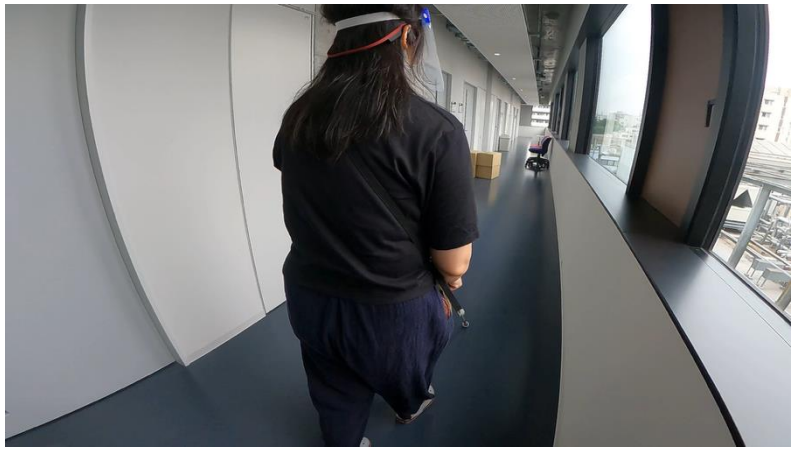
Study with 14 Blind Participants



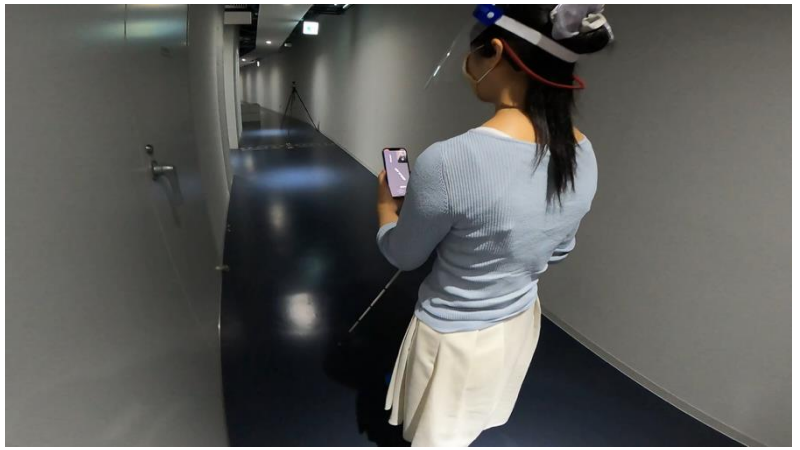
Three Tasks Conducted

1. Turn in a single intersection

2. Avoid obstacles in a straight corridor



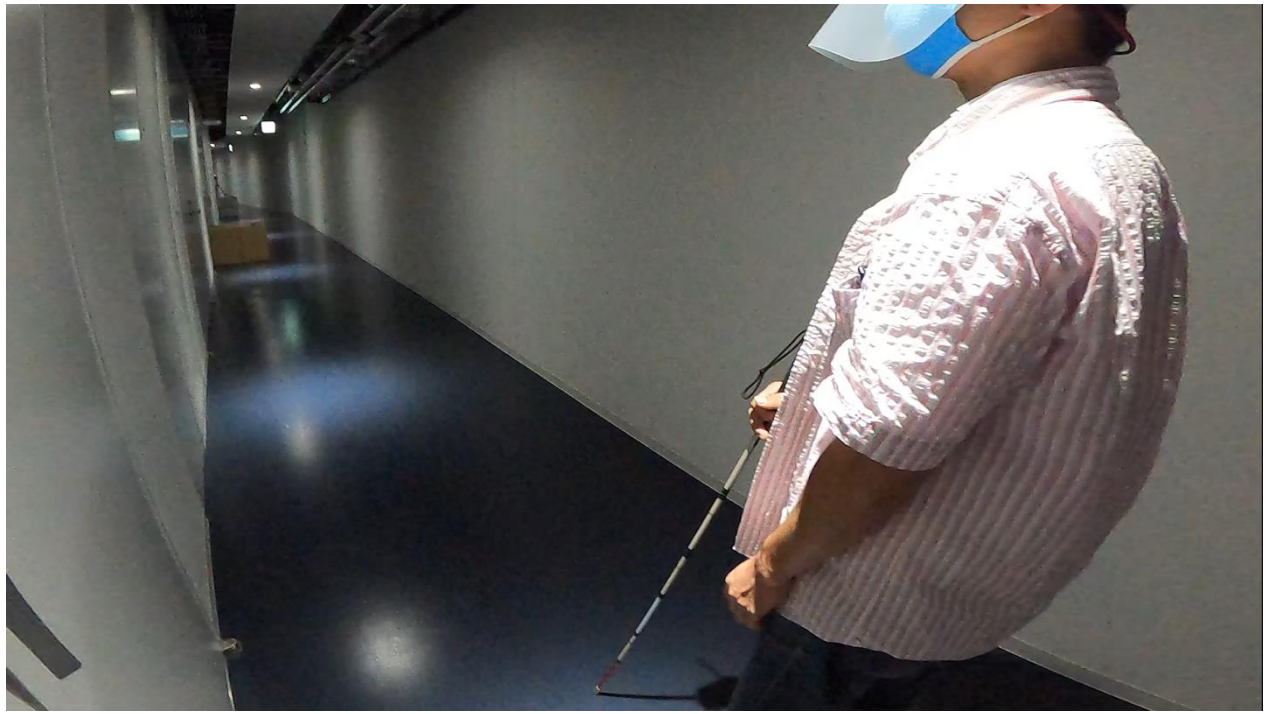
3. Avoid obstacles and turn in intersections



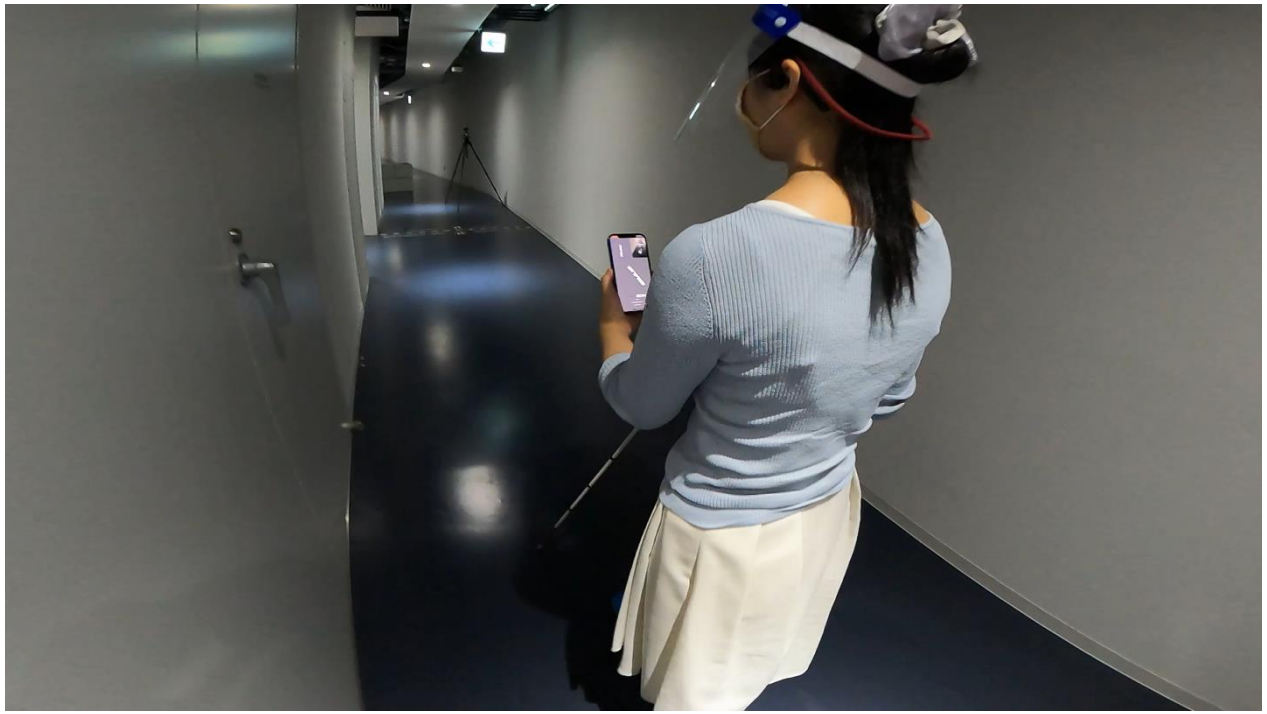
This presentation presents the result of 3rd task

Navigate in a Corridor With Several Obstacles and Intersections

Cane-Only



System-Aided

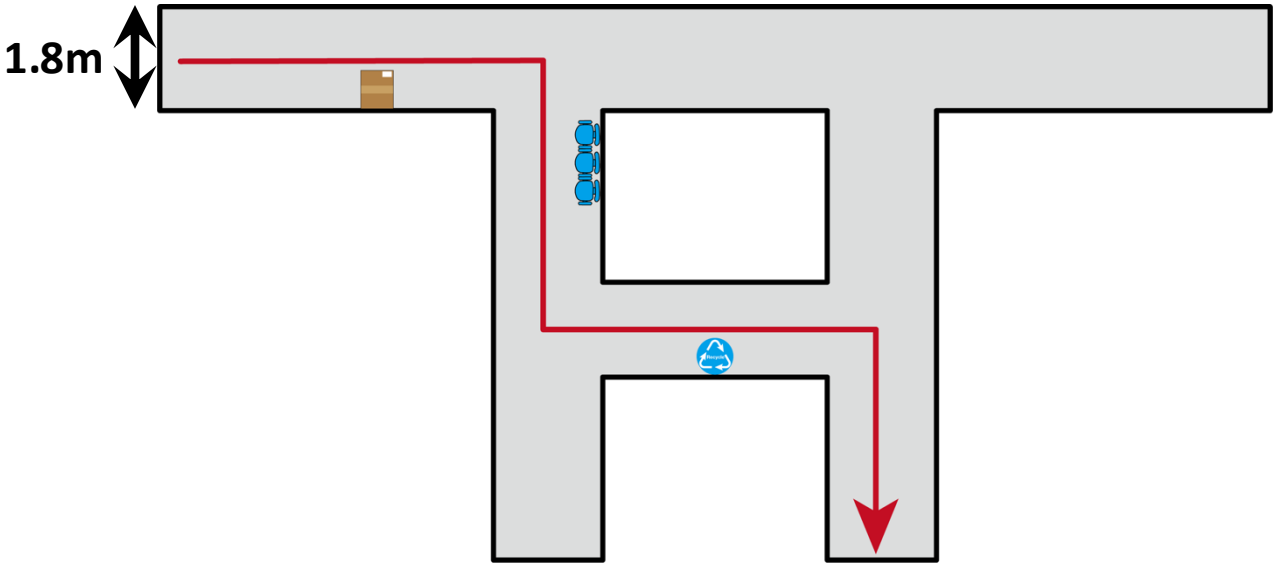


Compare cane-only and system-aided condition

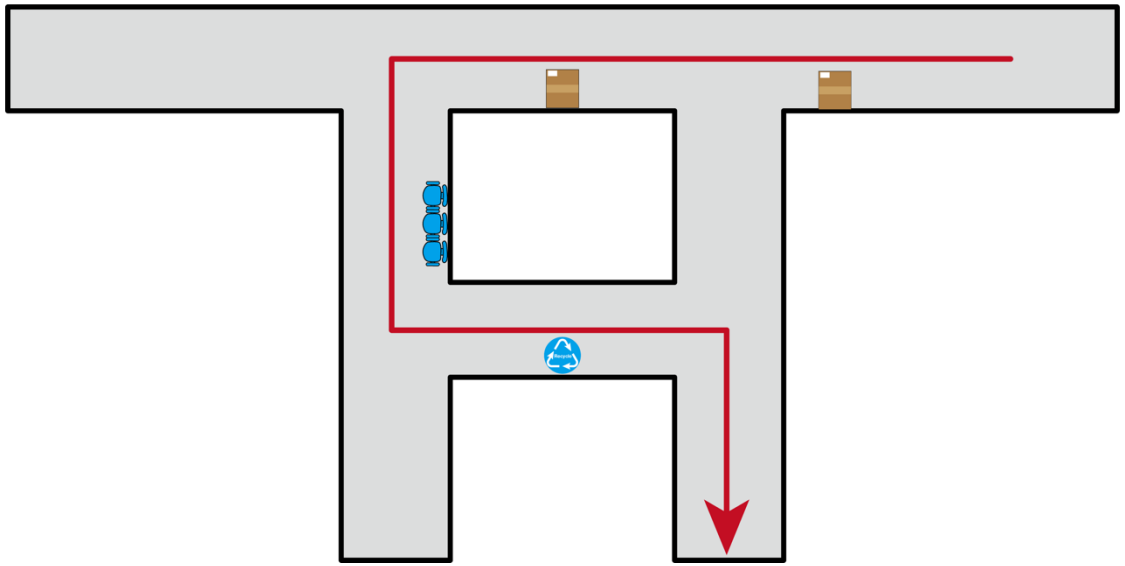
Navigate in a Corridor With Several Obstacles and Intersections

The routes were explained to participants before starting each tasks

Route 1: Route that turns in every intersection

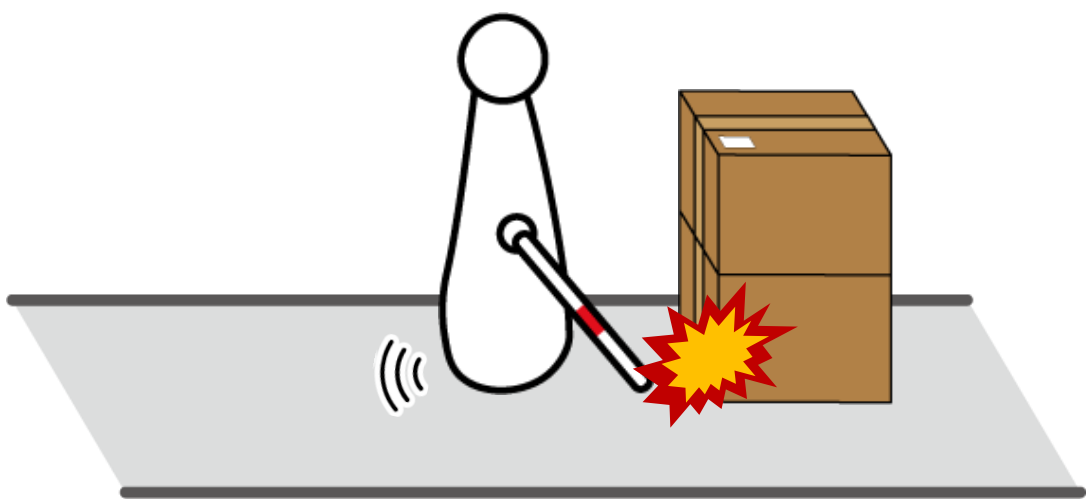


Route 2: Route that skips the first intersection

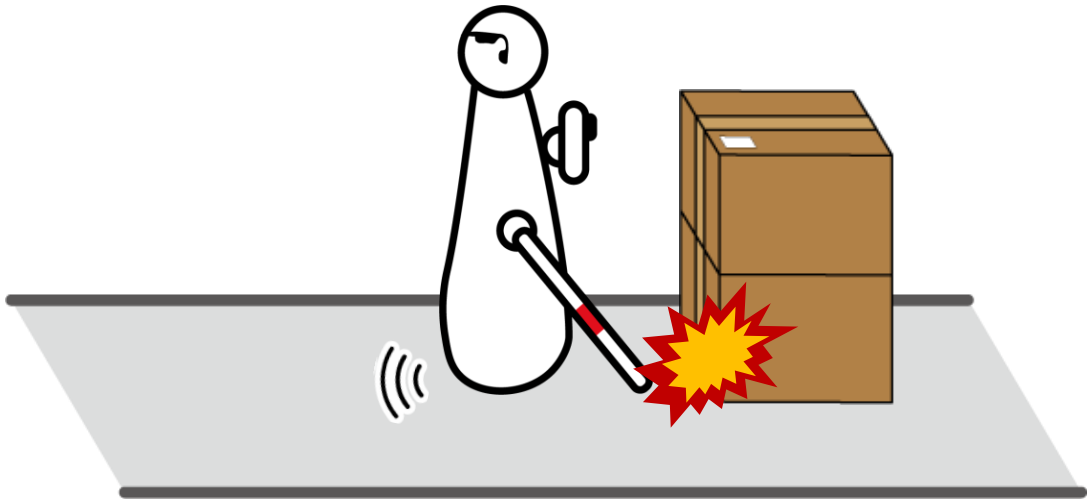


Metric: Contact with Cane and Obstacles

Cane-Only

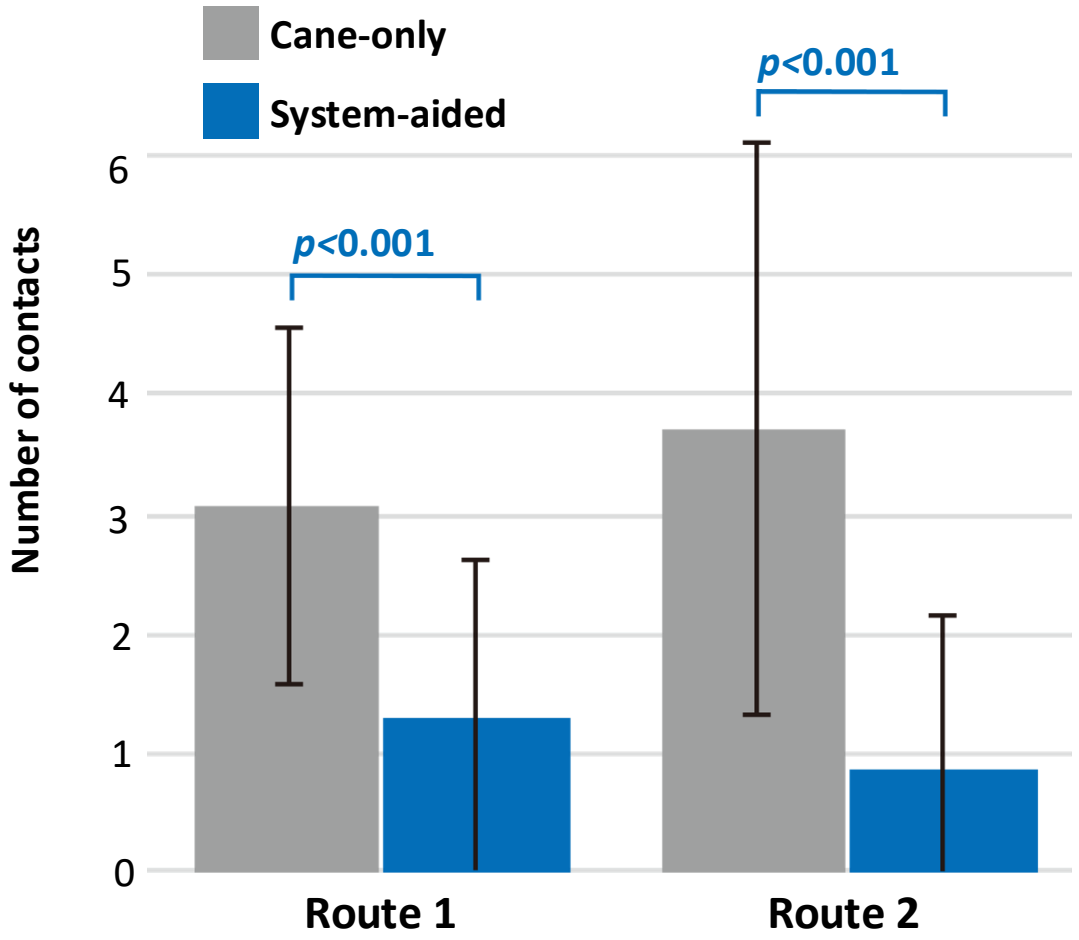


System-Aided



Measured how many times participants made contact with cane and obstacles

Result: Contact with Cane and Obstacles

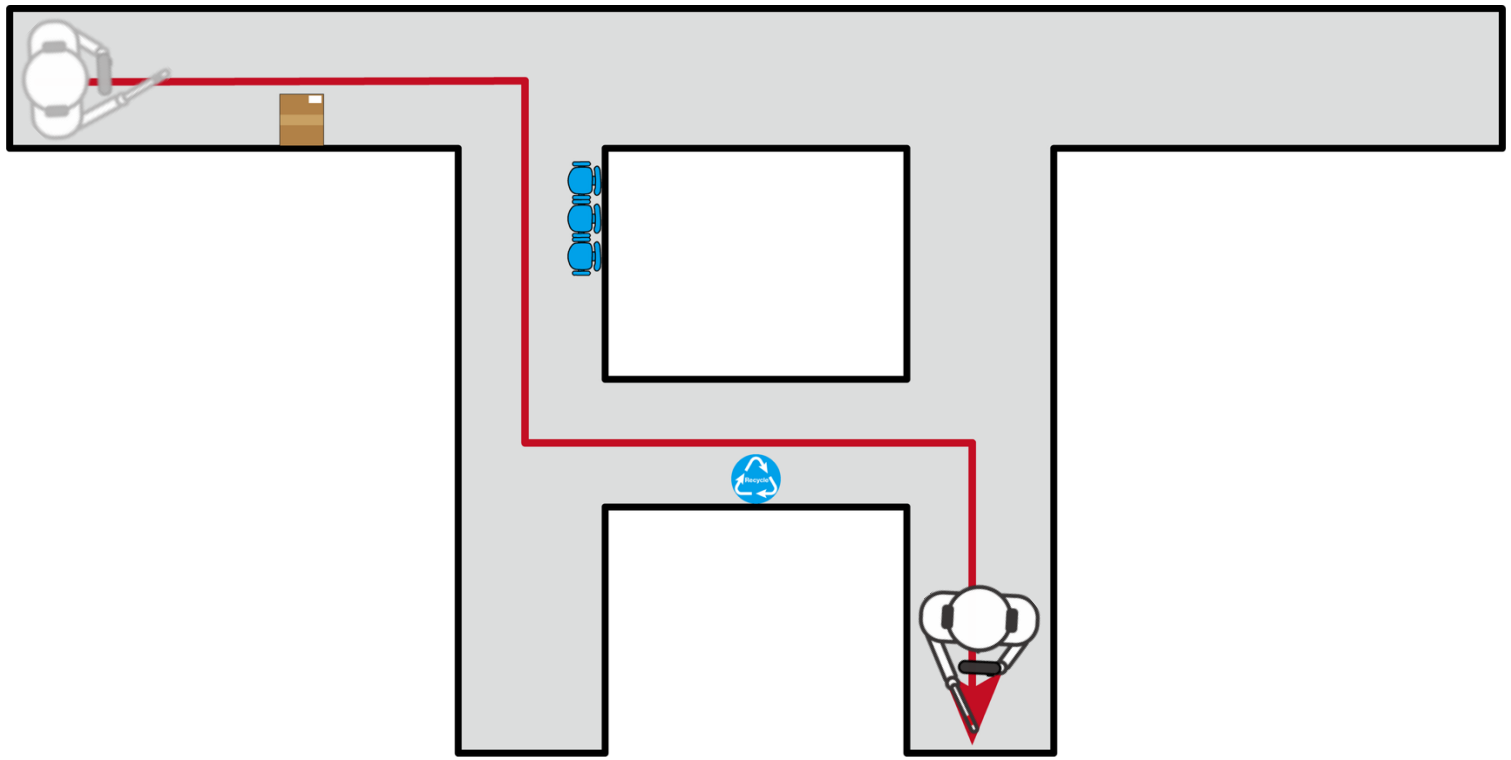


System significantly decreased

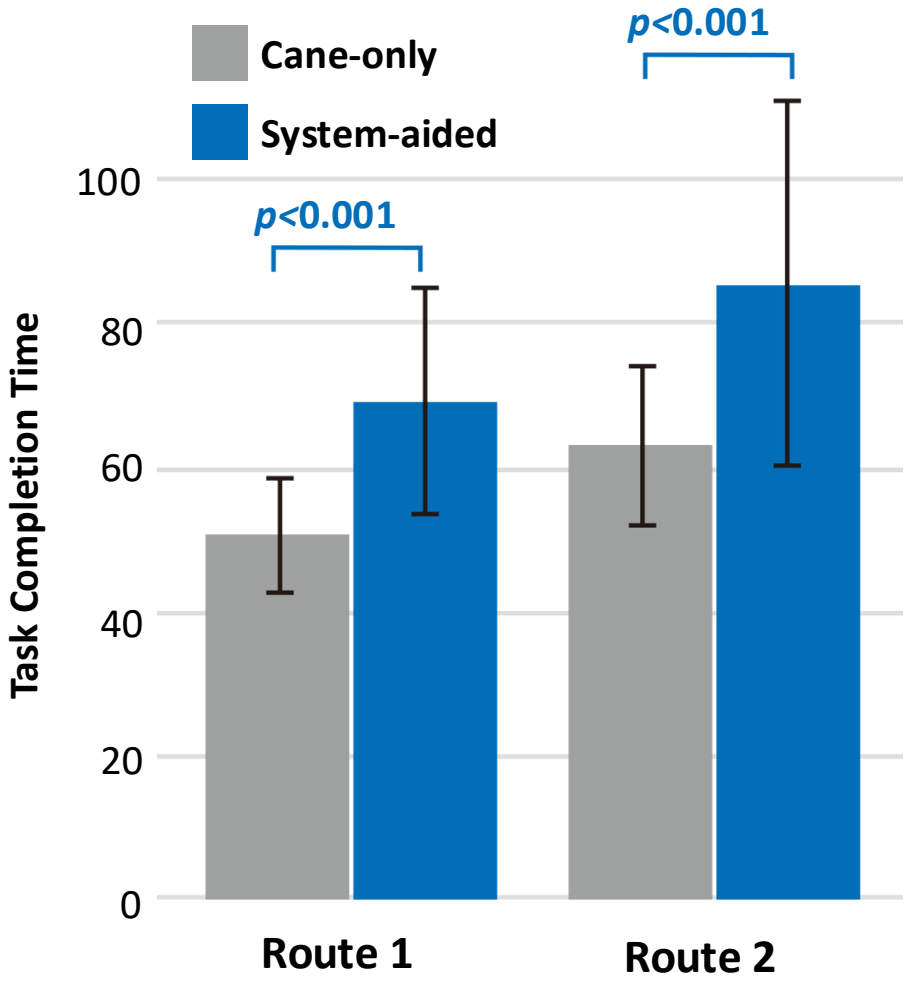
the number of contacts with cane

Metric: Task Completion Time

Measured time to walk from the start from the end of each route



Result: Task Completion Time



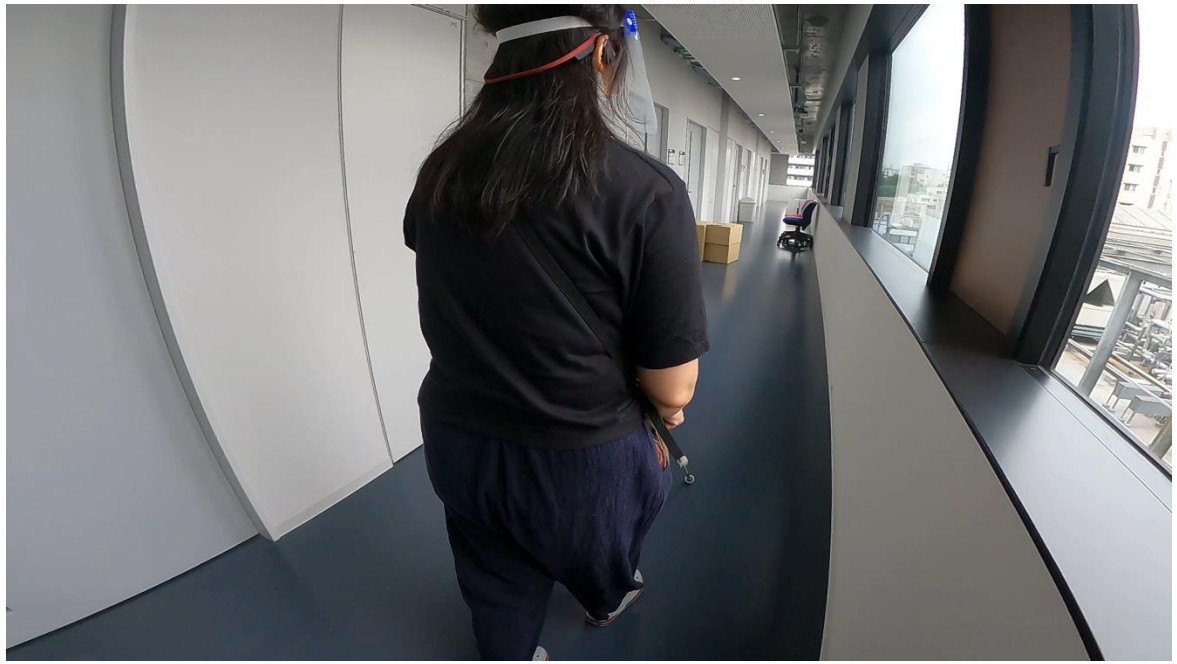
Task completion time increased

when using the system

Reason Why Task Completion Time Increased

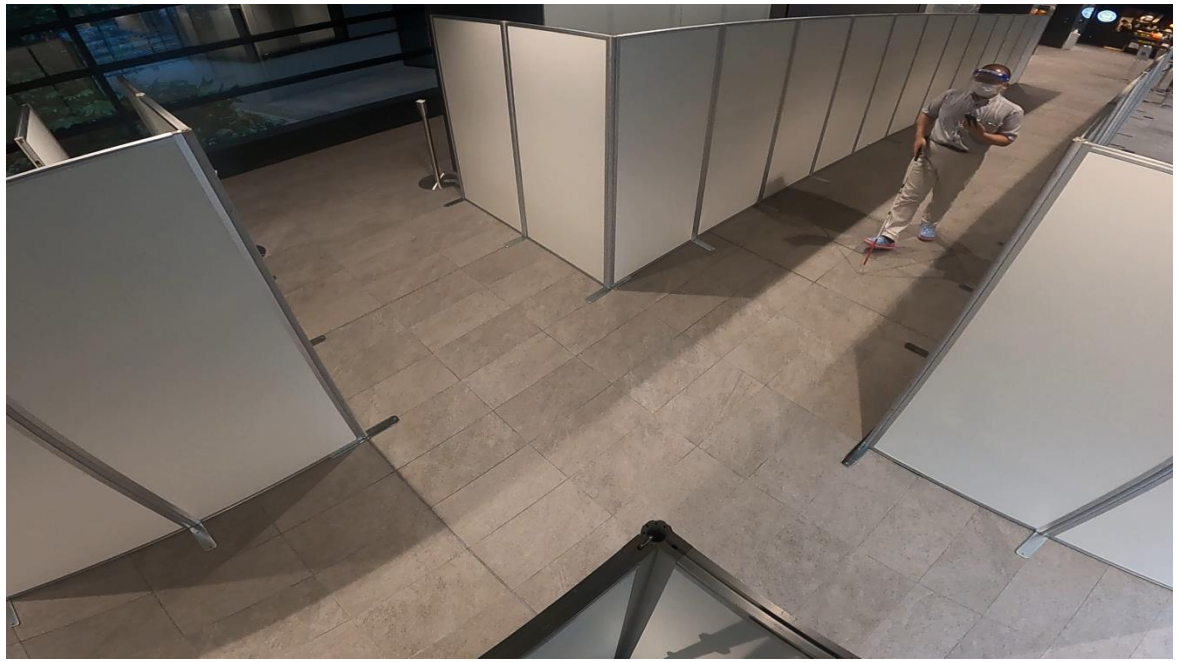
It took time for participants to

follow instructions of the system



It took extra time for participants

to scan in intersections



Extra time enabled them to avoid obstacles and recognize intersections

Advantage Participants Felt About Obstacle Avoidance

“Although I had to walk slower to listen to the feedback of the system,

I was glad that I did not bump into an obstacle”

P01

Advantage Participants Felt About Intersection Detection

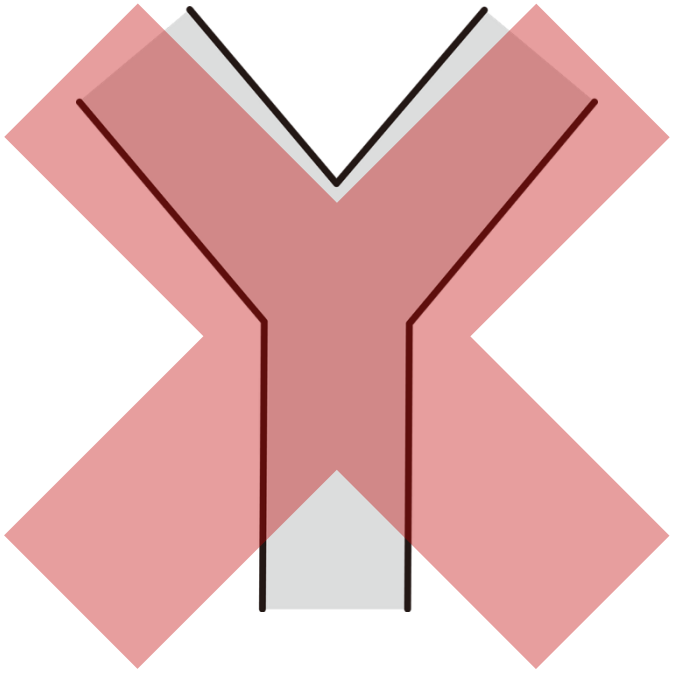
“Knowing that I am almost at an intersection means that I do not have to worry about running through it. By checking all the directions to which the intersection extends, I can discover that the path actually extends in another direction”

P11

Limitation of Corridor-Walker

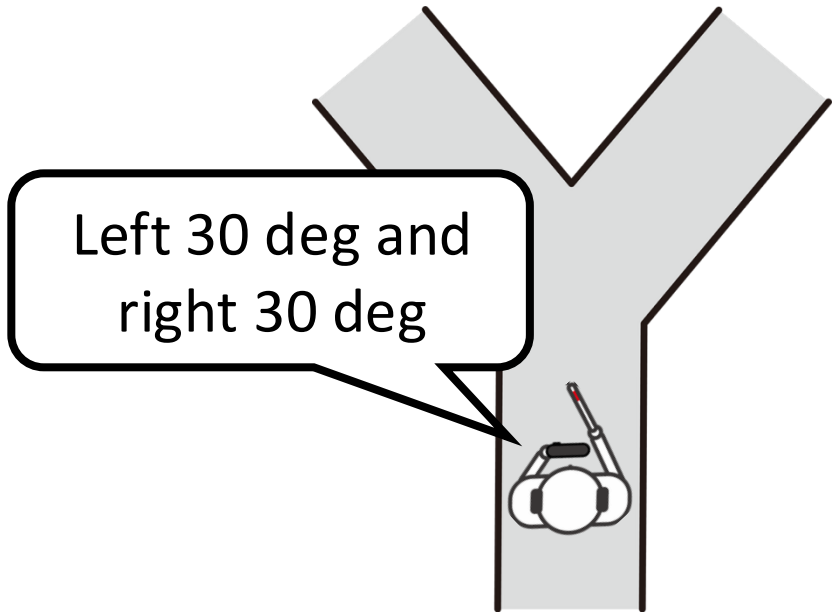
Limitation

It cannot detect intersections in any shape



Future work

Detect intersections by angle



Conclusion

- Corridor-Walker plans an obstacle-avoiding path and recognize intersections through a cost map constructed from smart phone LiDAR sensor
- Although it took more time for participants to complete tasks, they were able to avoid obstacles and recognize intersection using the system
- For future work, we aim to detect intersections in angles so that it cane be used in various places