Snap&Nav:
Smartphone-based Indoor Navigation System For Blind People via Floor Map Analysis and Intersection Detection

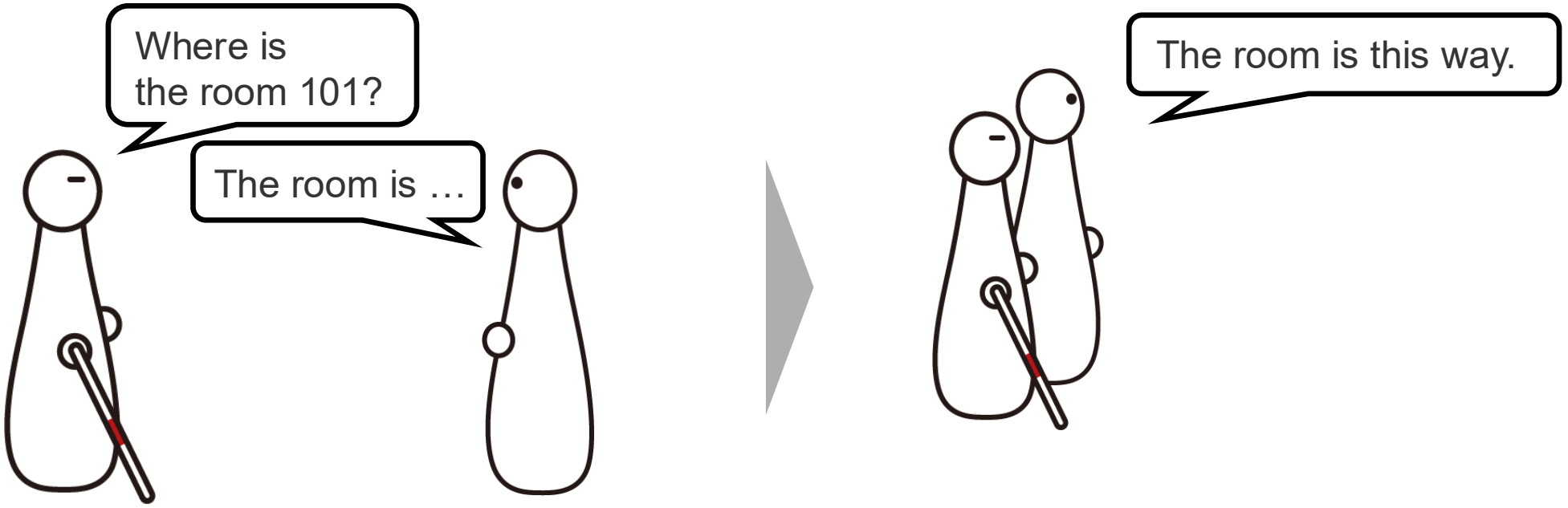
Masaya Kubota*,[1], Masaki Kuribayashi*,[2], Seita Kayukawa[2] Hironobu Takagi[2], Chieko Asakawa[3,4], Shigeo Morishima[5]

*Authors contributed equally, 1.Waseda University, 2.IBM Research-Tokyo, 3. Miraikan - The National Museum of Emerging Science and Innovation
4. IBM Research, 5. Waseda Research Institute for Science and Engineering

Blind People Need Help of Sighted People in Unfamiliar Buildings

Ask sighted people the route

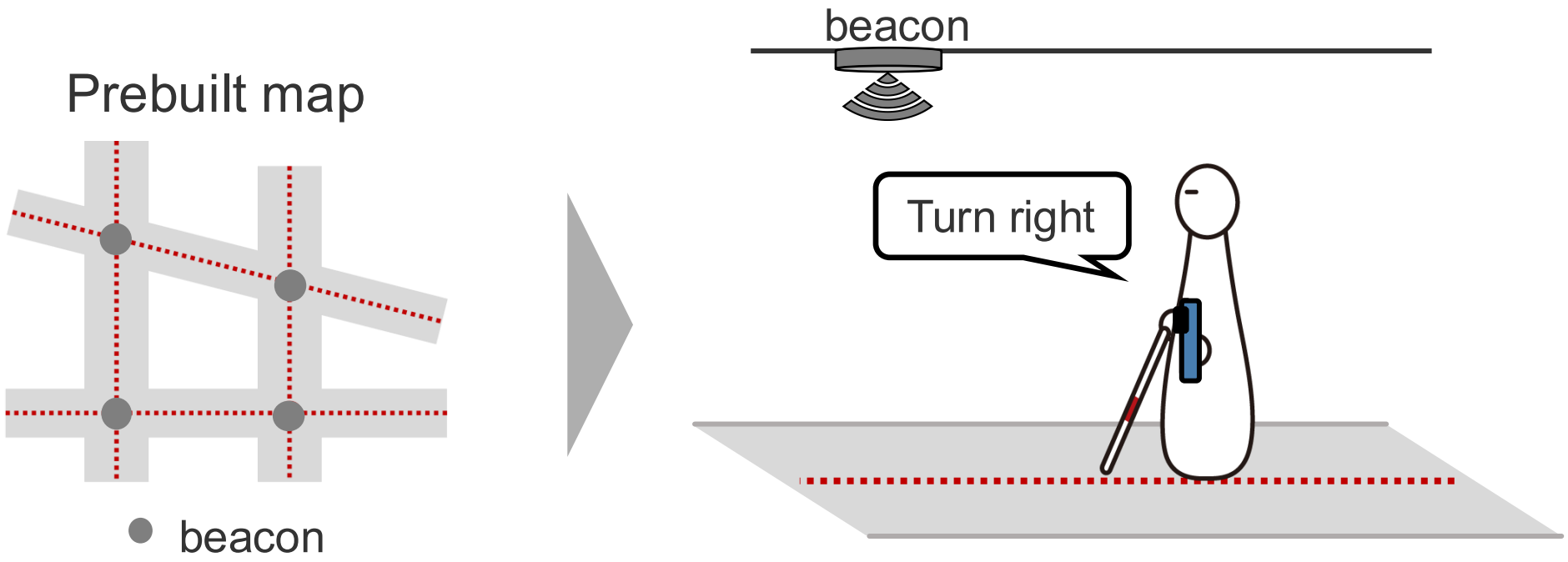
Navigate to a destination together



Assistant from sighted people aren't always available

Previous Navigation System With Prebuilt Maps

NavCog[1] Uses prebuilt maps and beacons to provide turn-by-turn instructions



This system can only be used in locations that have prebuilt maps

[1] Sato et al. “NavCog3 in the wild: Large-scale blind indoor navigation assistant with semantic features”

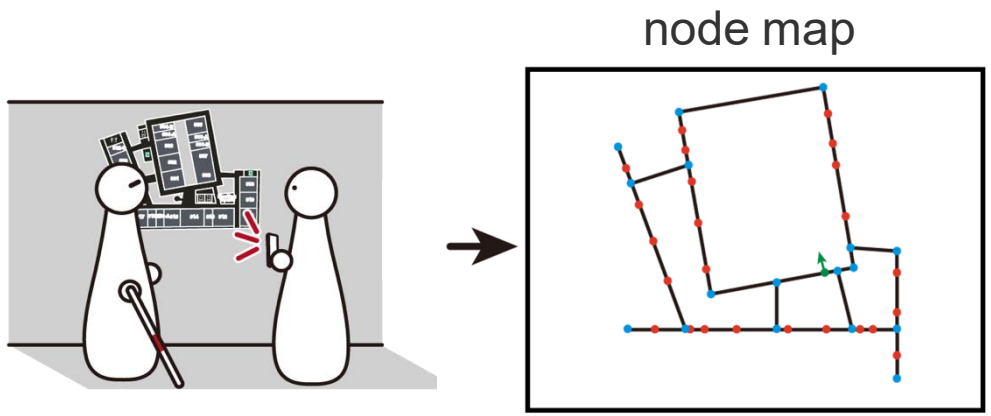
Snap&Nav

Navigation system using floor map image captured by sighted assistants as information source

System Overview

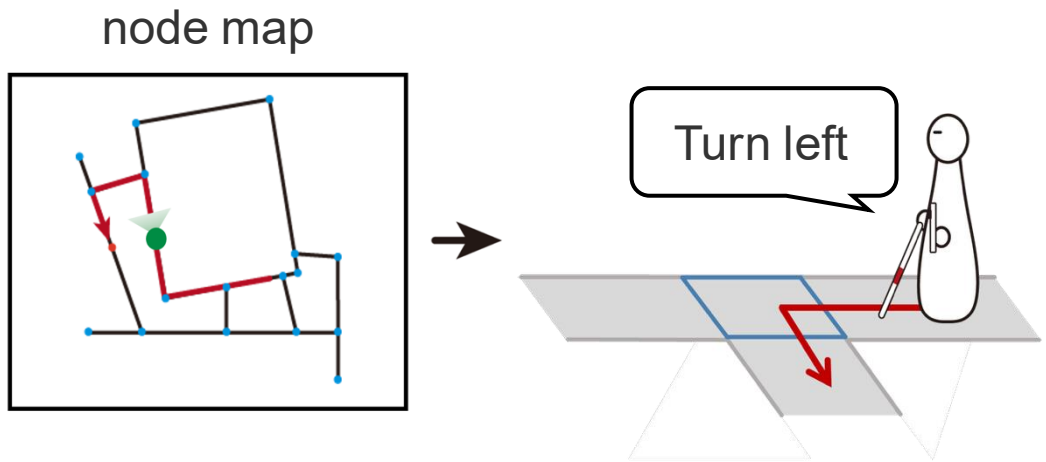
Map Analysis Module
For Sighted Assistants

Generate a node map by using a floor map



Navigation Module
For Blind Users

Navigate blind users by using the node map



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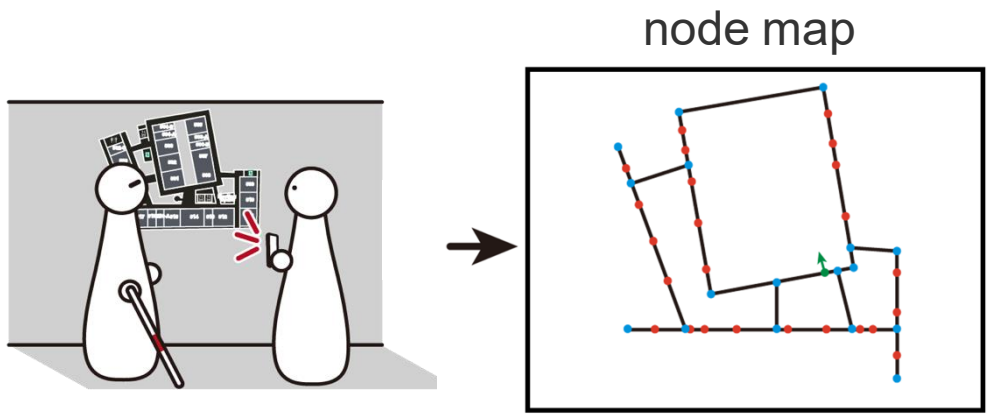

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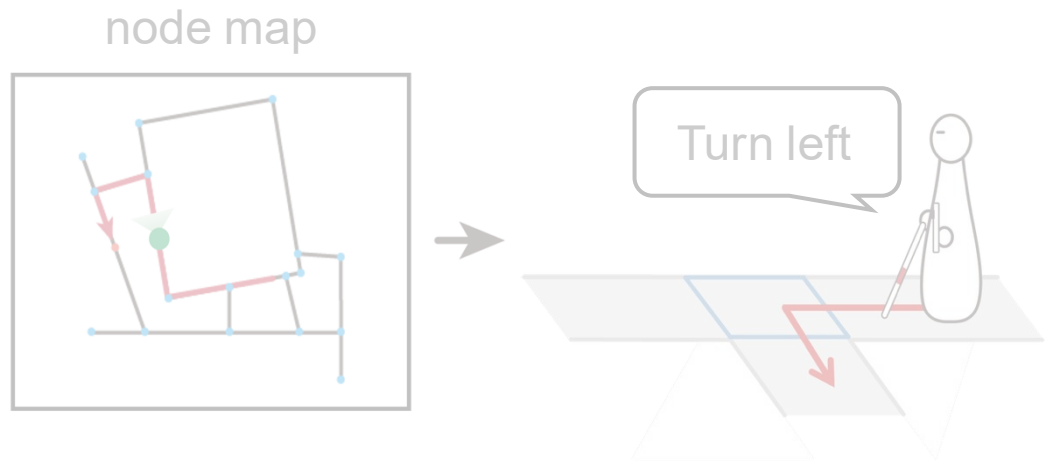
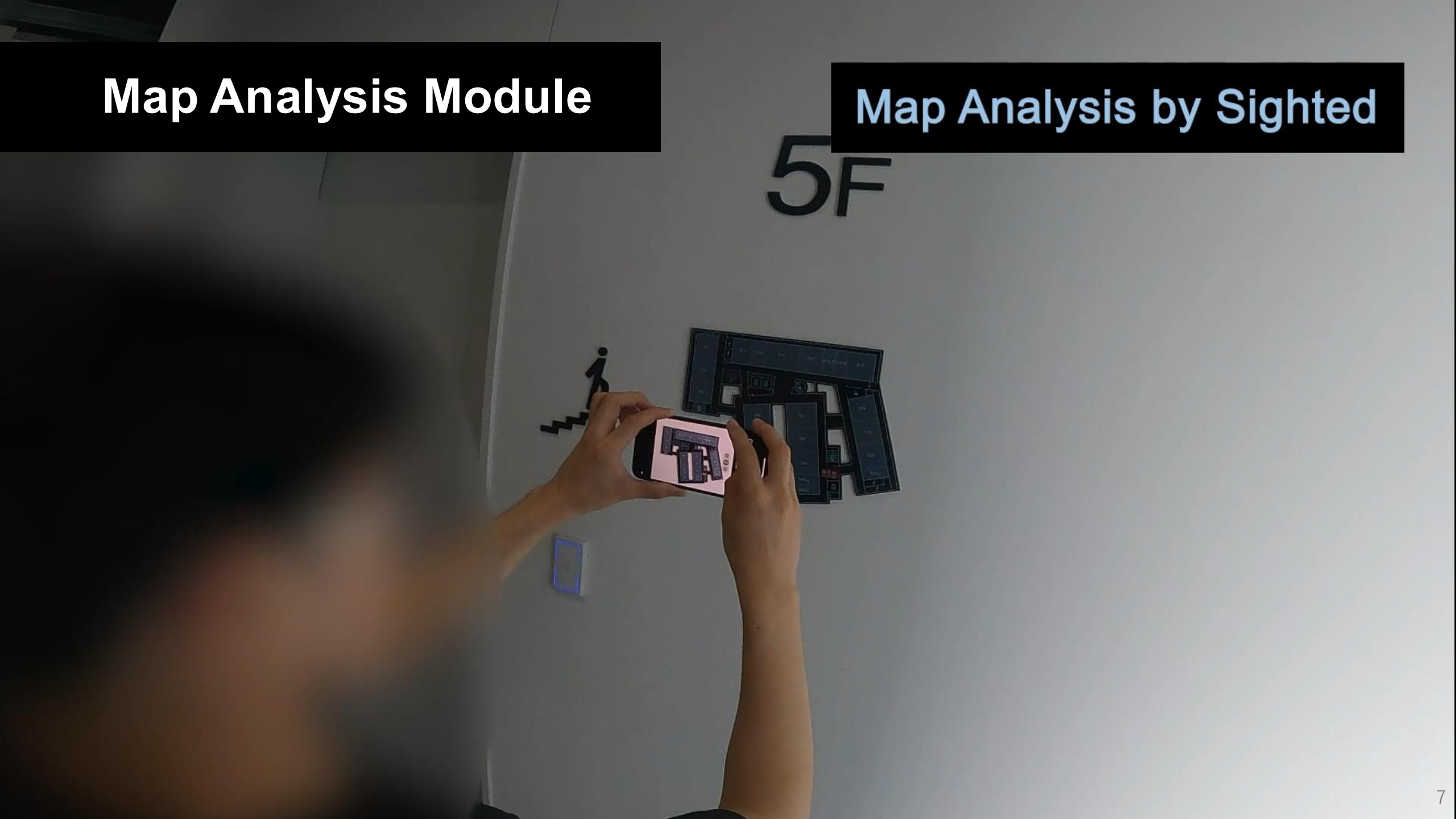
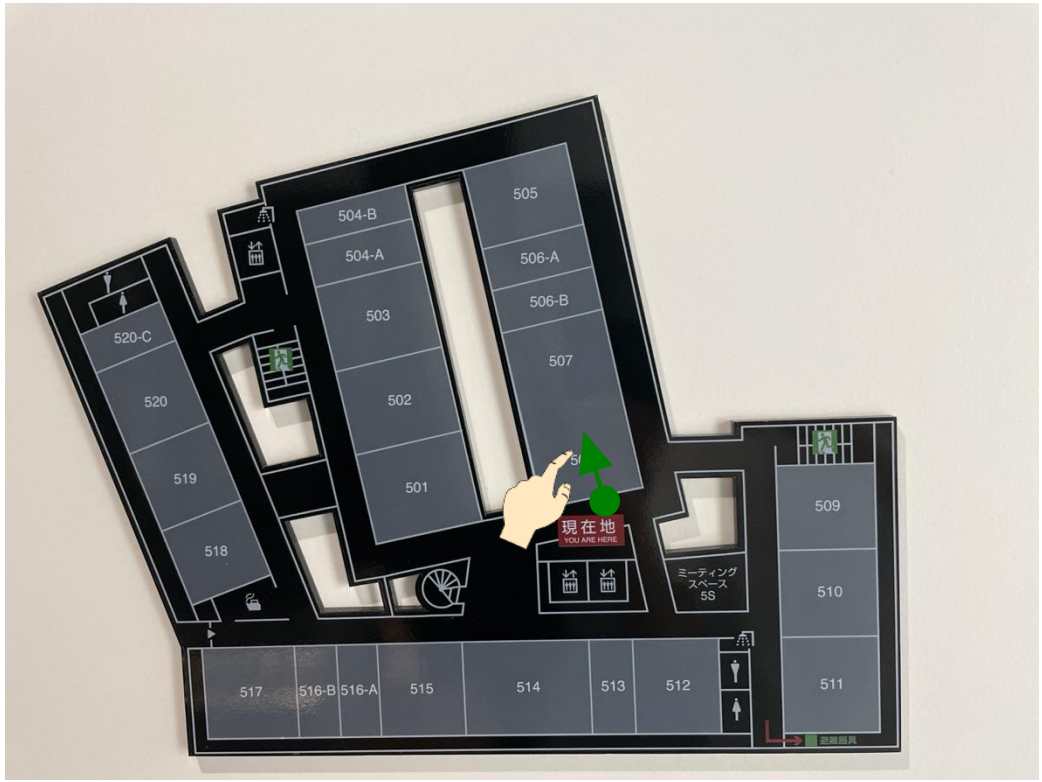


Map Analysis Module



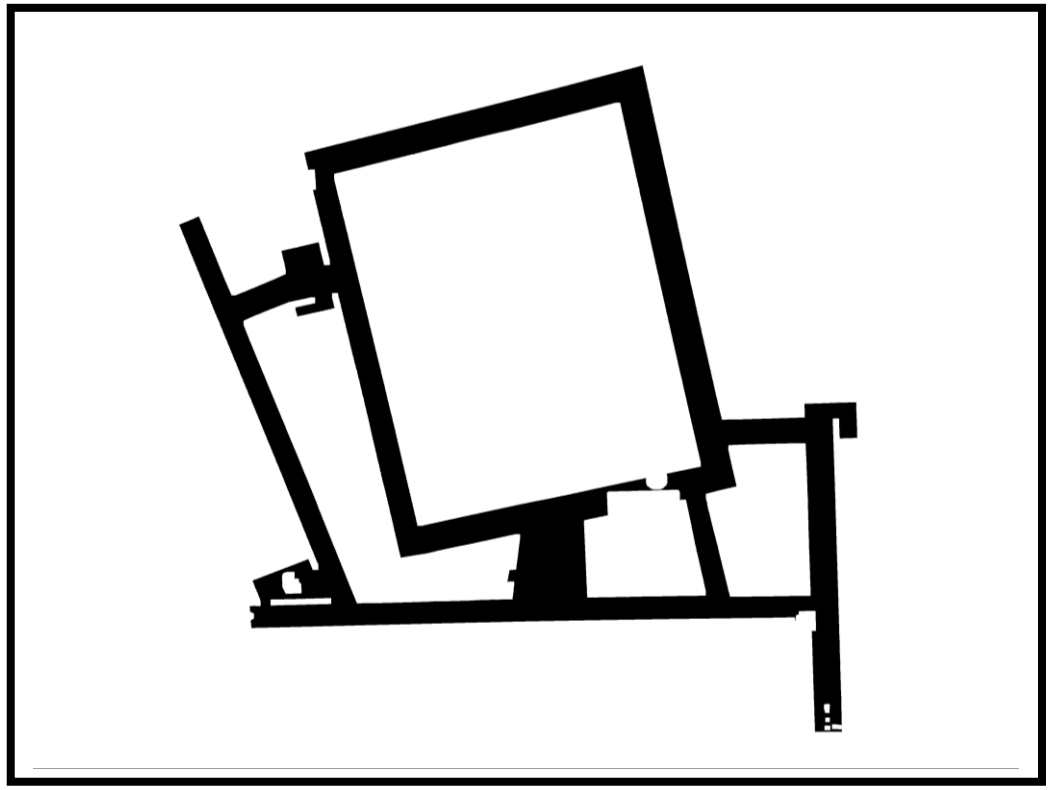
Floor Map Analysis Algorithm (1/7)

Sighted assistant **capture** a floor map image and **annotate** current location of the user



Floor Map Analysis Algorithm (2/7)

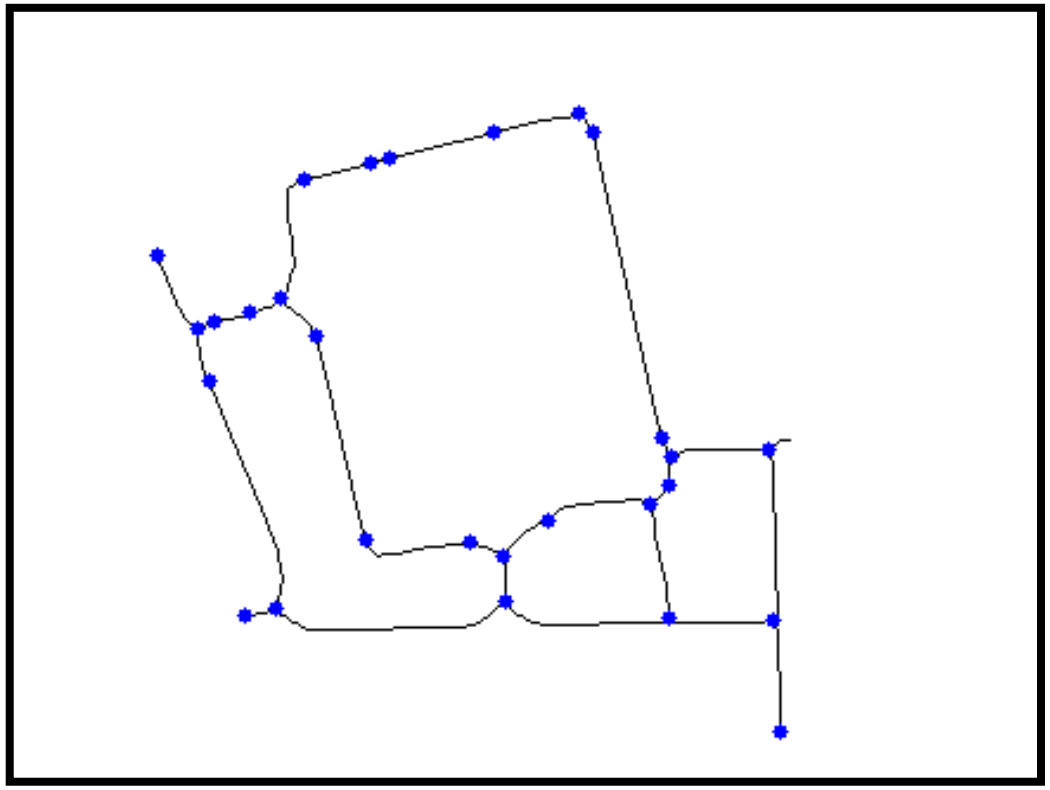
Extract the largest connected regions as **the path area**



Floor Map Analysis Algorithm (3/7)

Skeletonize the path area,

and **detect** the corner

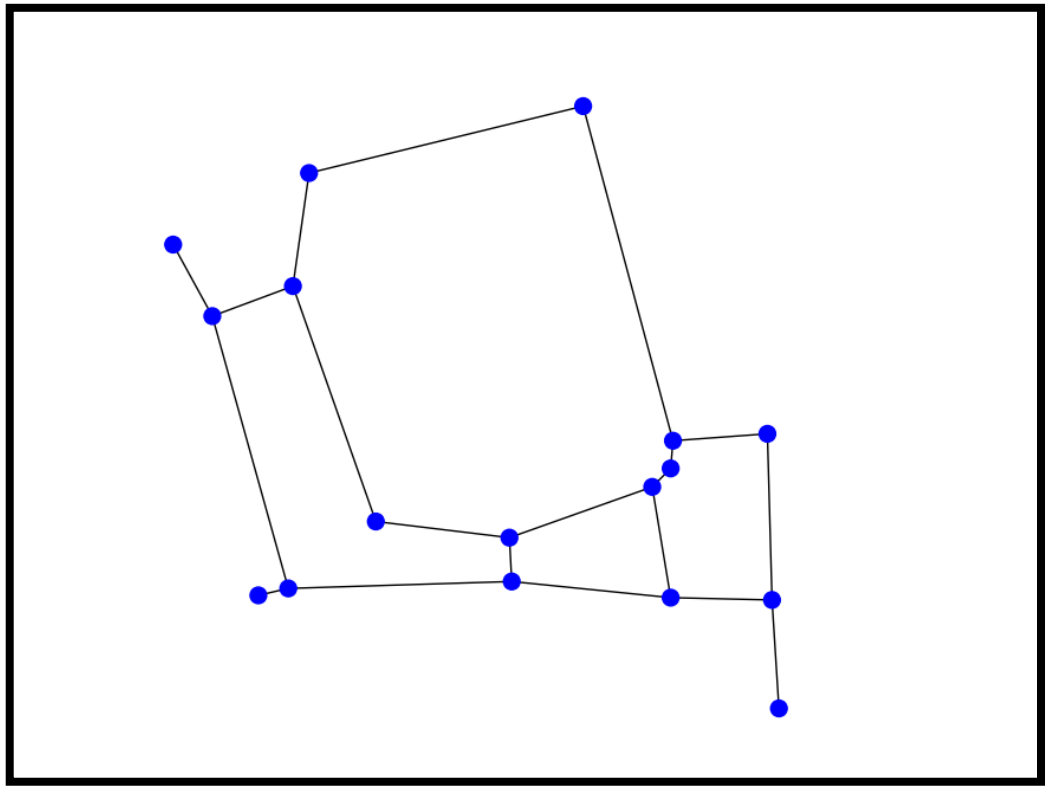


Floor Map Analysis Algorithm (4/7)

Filter out extra

intersection nodes

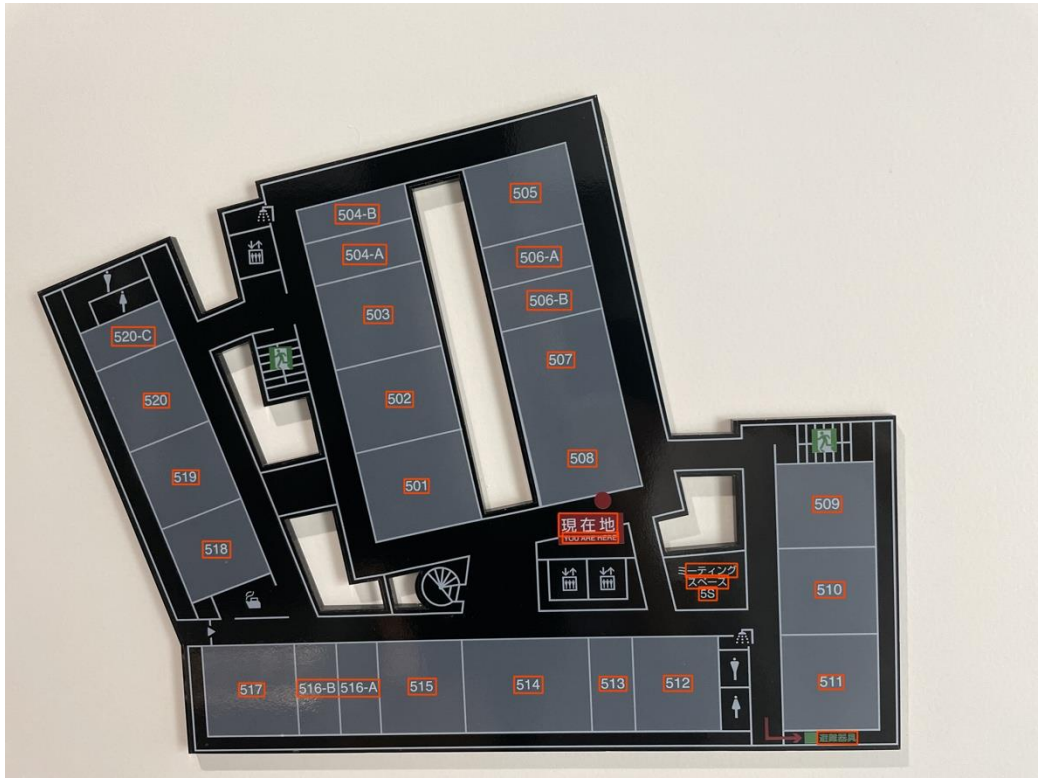
and generate the **node map**



Intersection node

Floor Map Analysis Algorithm (5/7)

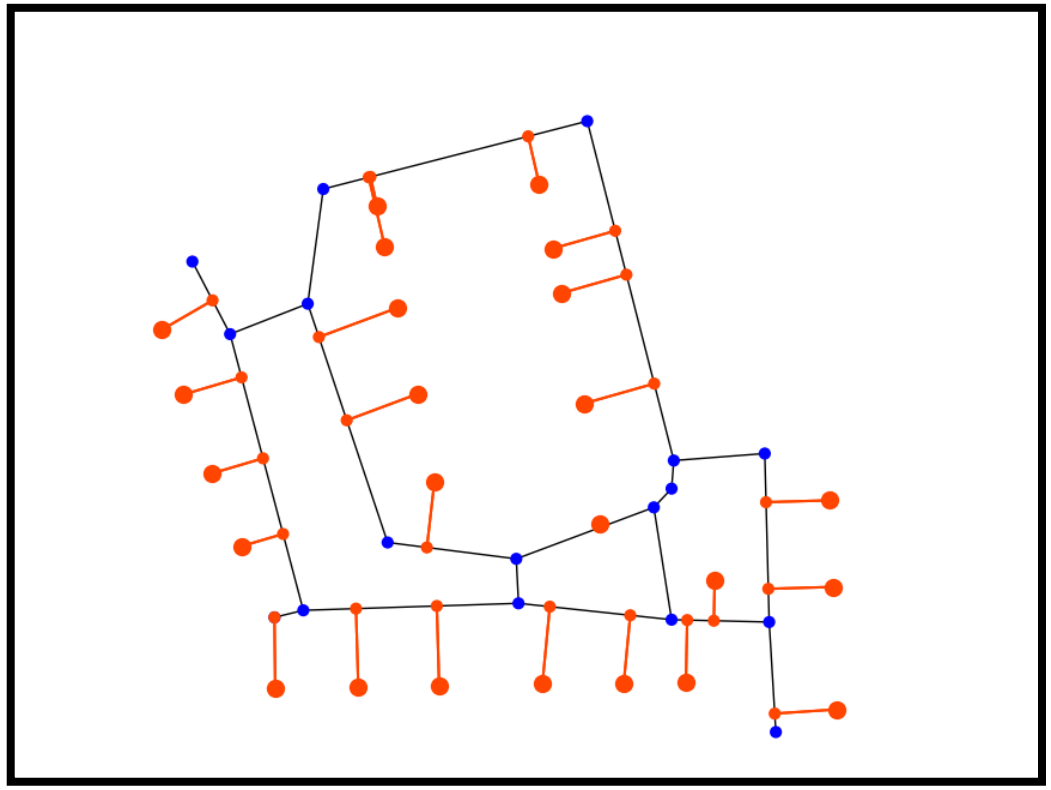
Apply OCR to the floor map image to obtain locations and names of **destinations**



Floor Map Analysis Algorithm (6/7)

Map **the destination nodes**

to the node map

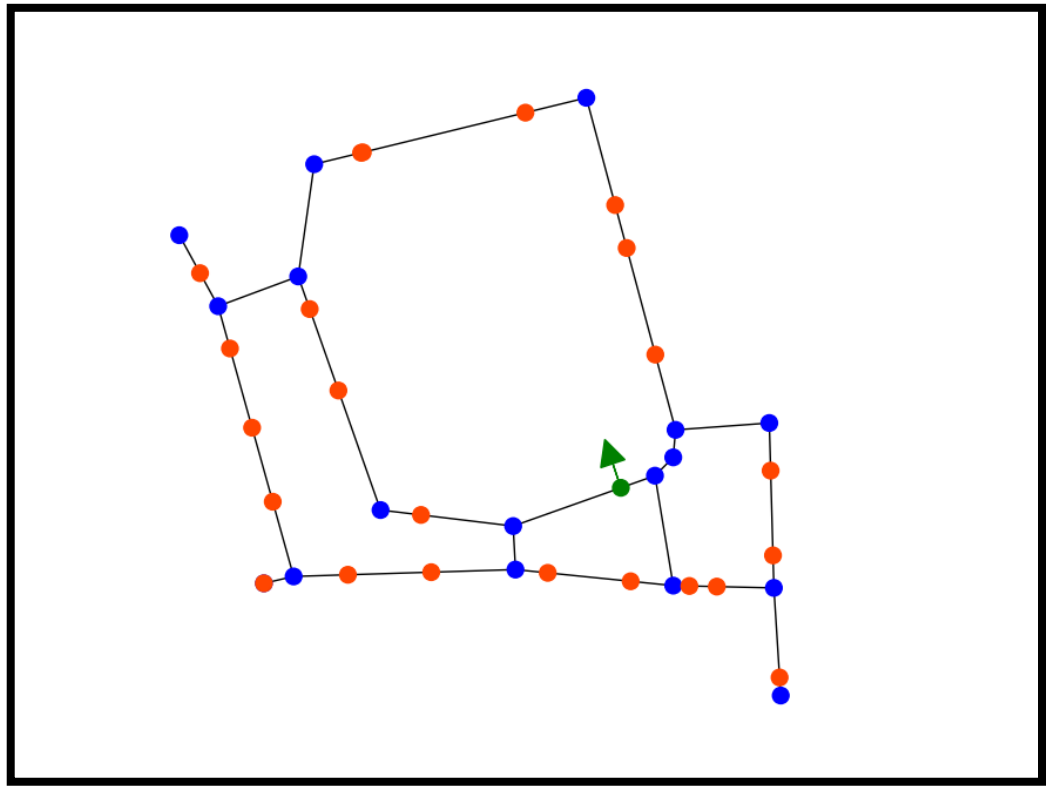


Destination node

Floor Map Analysis Algorithm (7/7)

Map **the user node** and

generate the final node map



User node

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For Sighted Assistants

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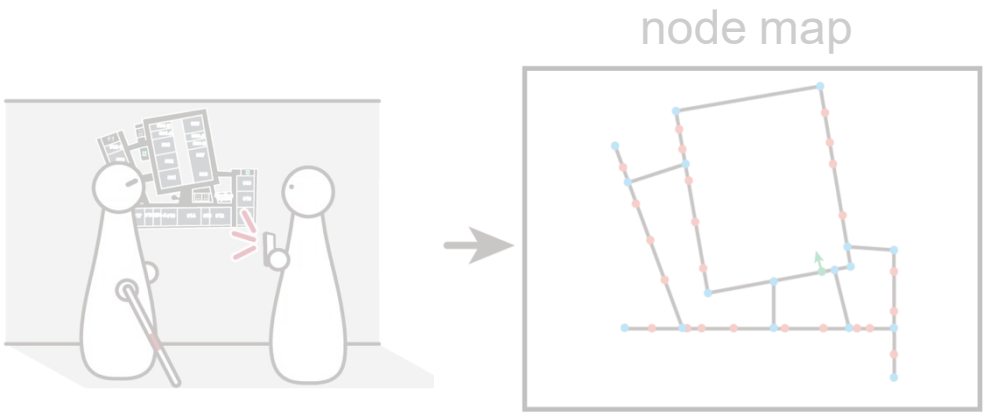
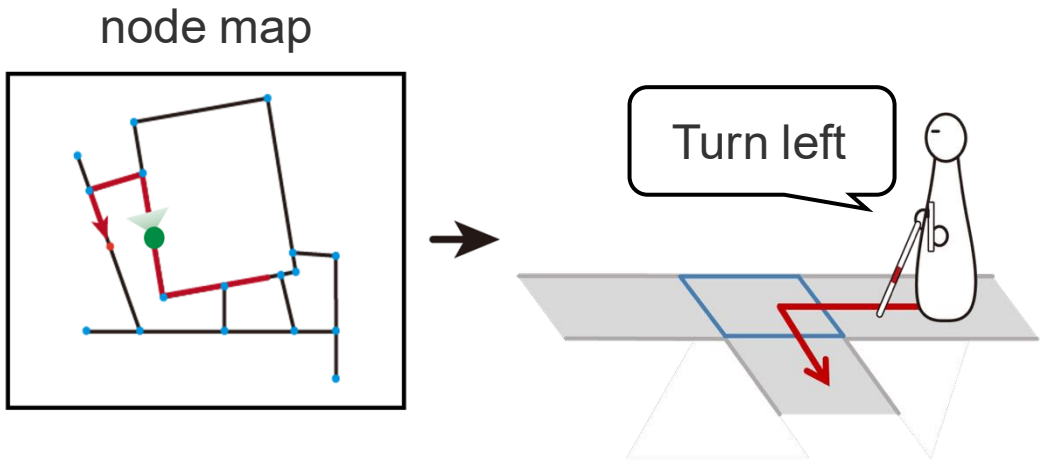
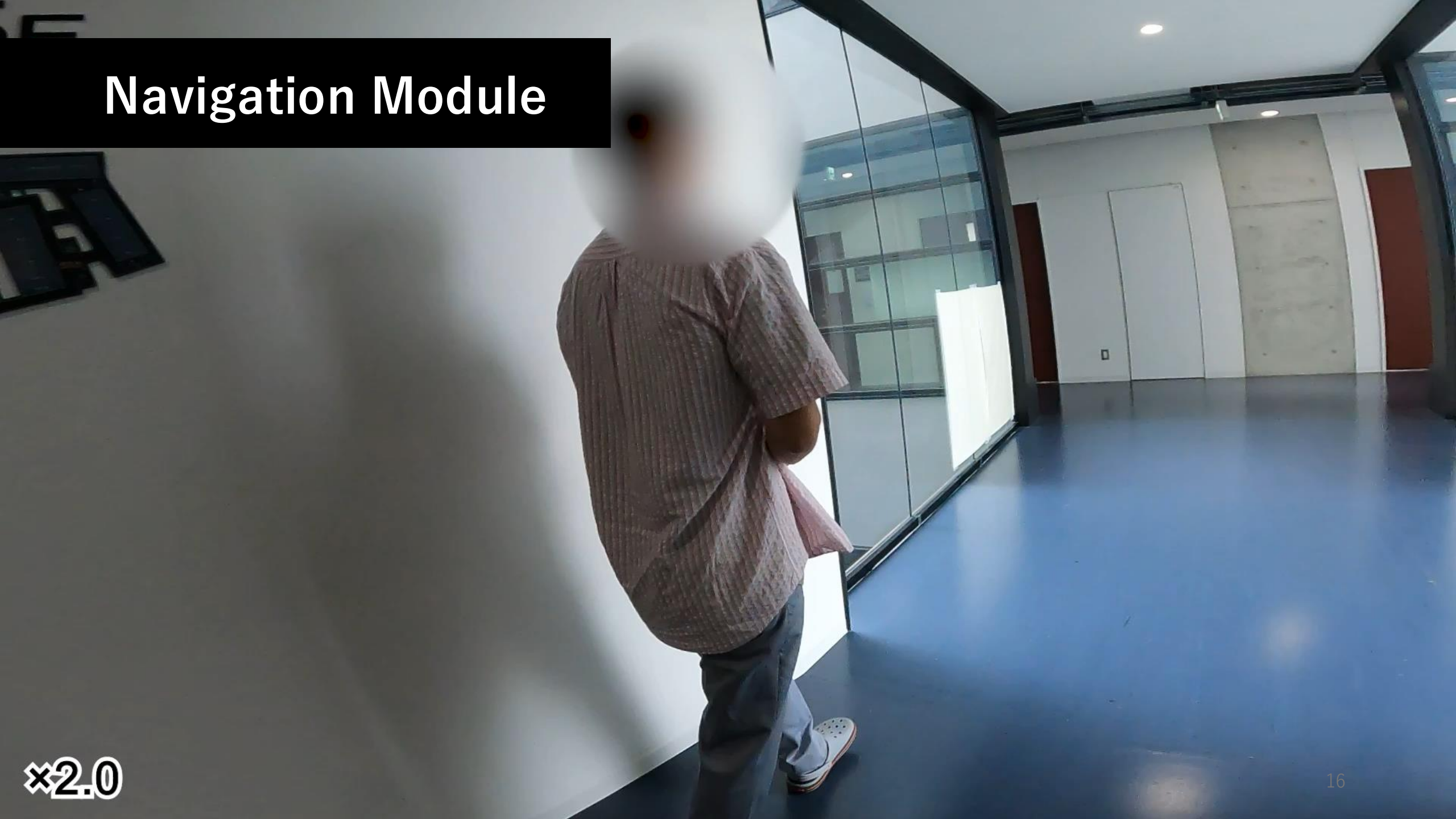


Navigation Module
For Blind Users

Navigate blind users by using the node map



Navigation Module

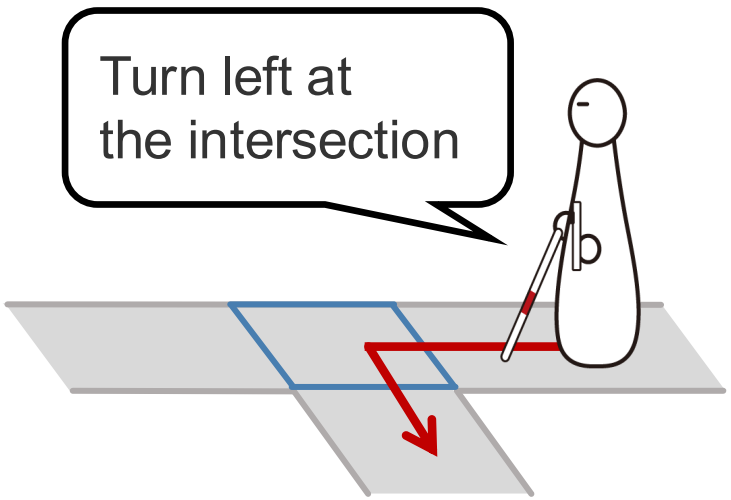


×2.0

Two Functionalities of Navigation Module

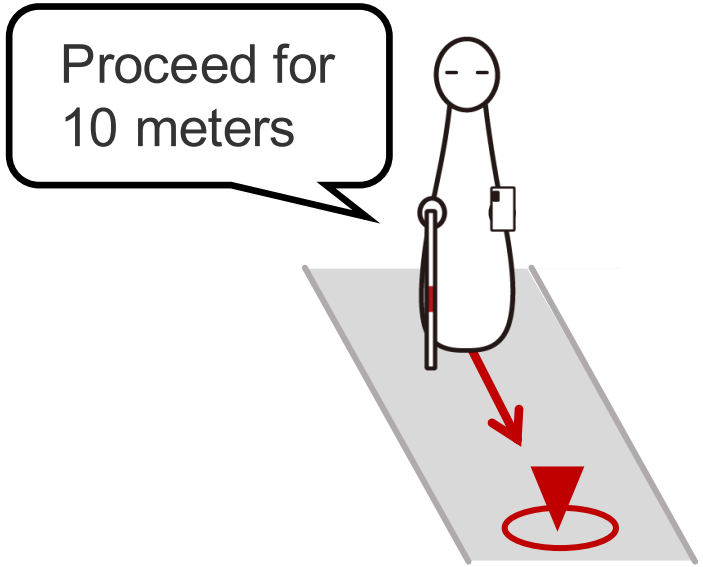
Intersection Detection

To provide turn-by-turn instructions



Scale Estimation

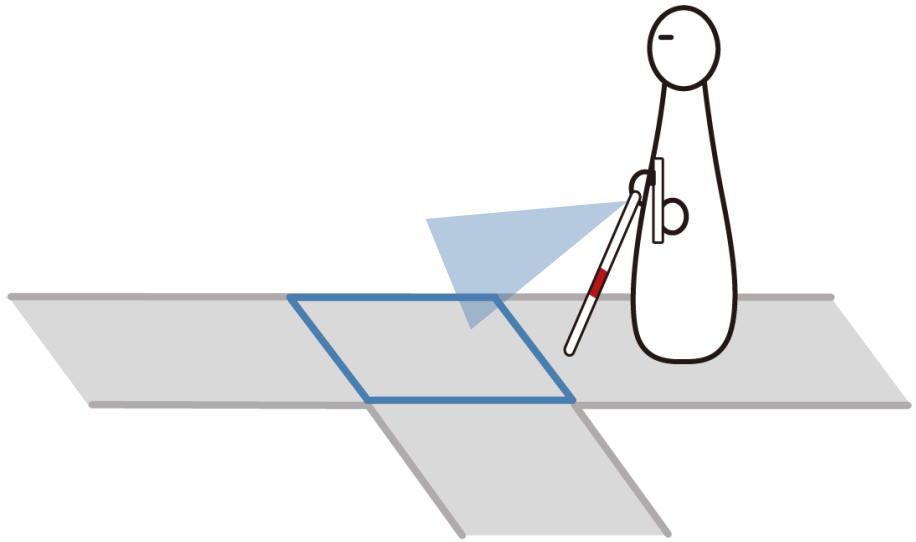
To provide distance information



Track User Position Using Intersection Detection (1/3)

Scan the intersection

by using LiDAR sensor

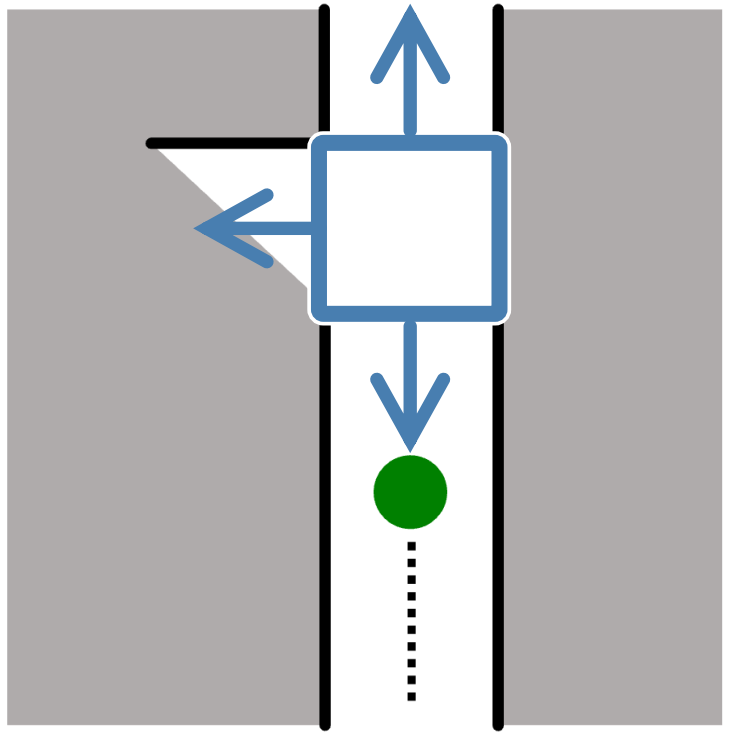


Track User Position Using Intersection Detection (2/3)

Construct a 2D grid map and

detect locations and shapes

of intersections[2]

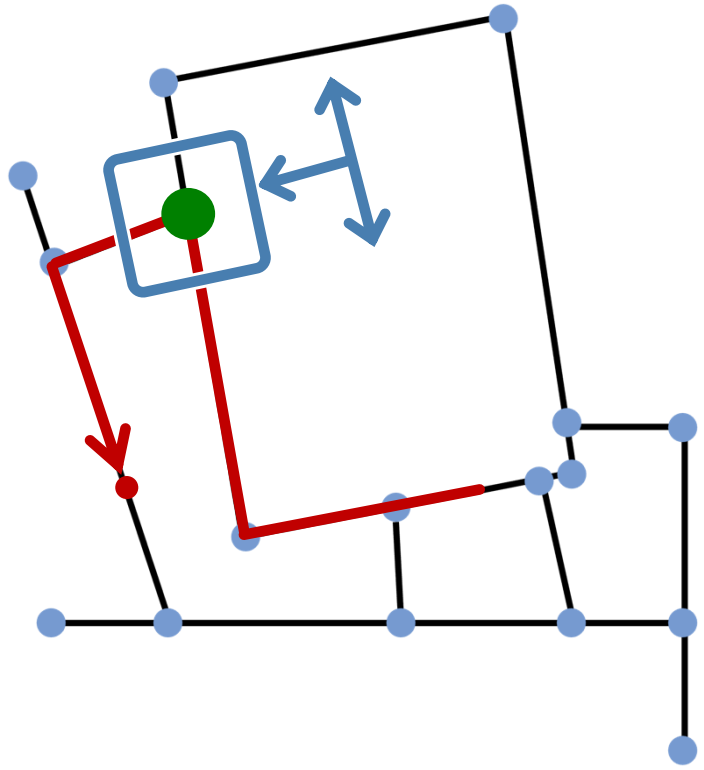


[2] Kuribayashi et al. “Corridor-Walker: Mobile Indoor Walking Assistance for Blind People to Avoid Obstacles and Recognize Intersections”

Track User Position Using Intersection Detection (3/3)

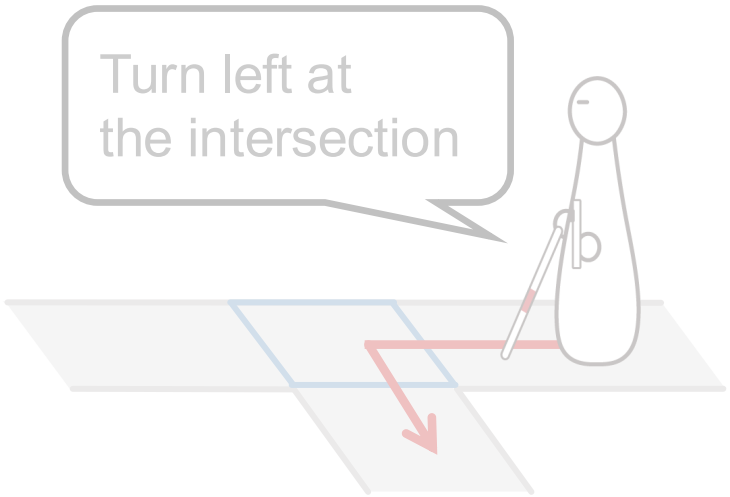
Match the intersection shapes

and localize the user location

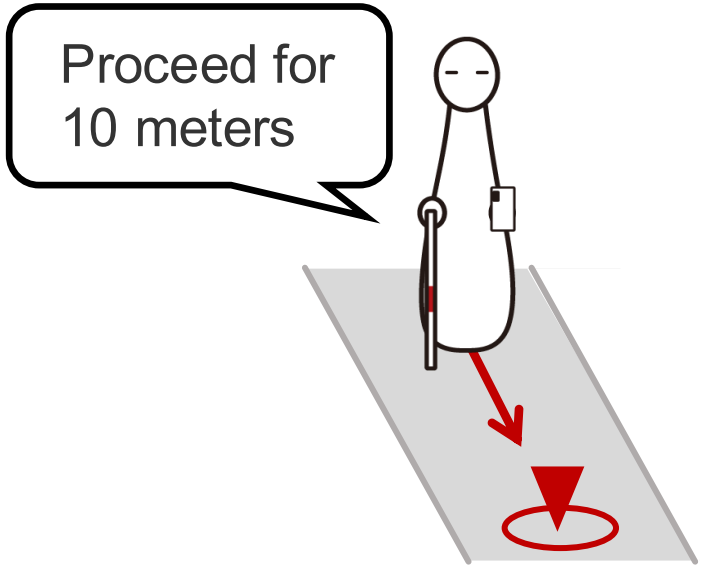


Two Functionalities of Navigation Module

Intersection Detection
to provide turn-by-turn instructions



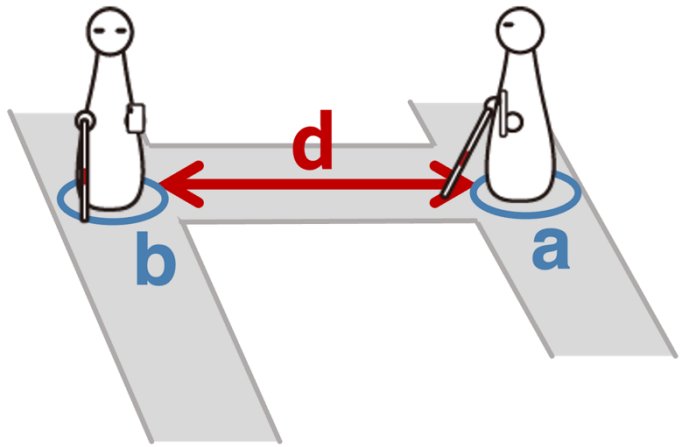
Scale Estimation
to provide distance information



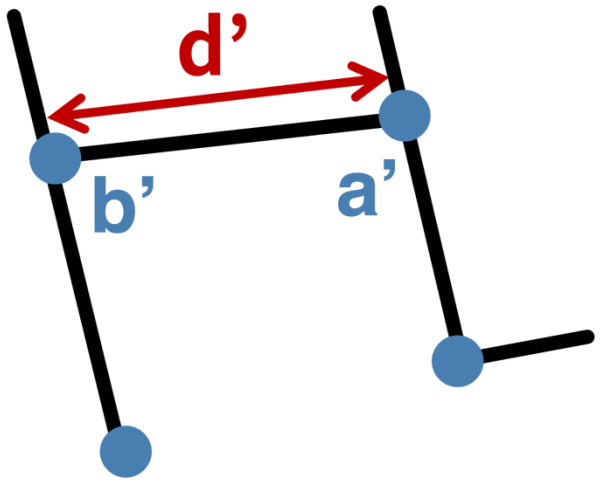
Estimate the Scale of Node Map

Calculate distance in the real world by using the scale **d / d'**

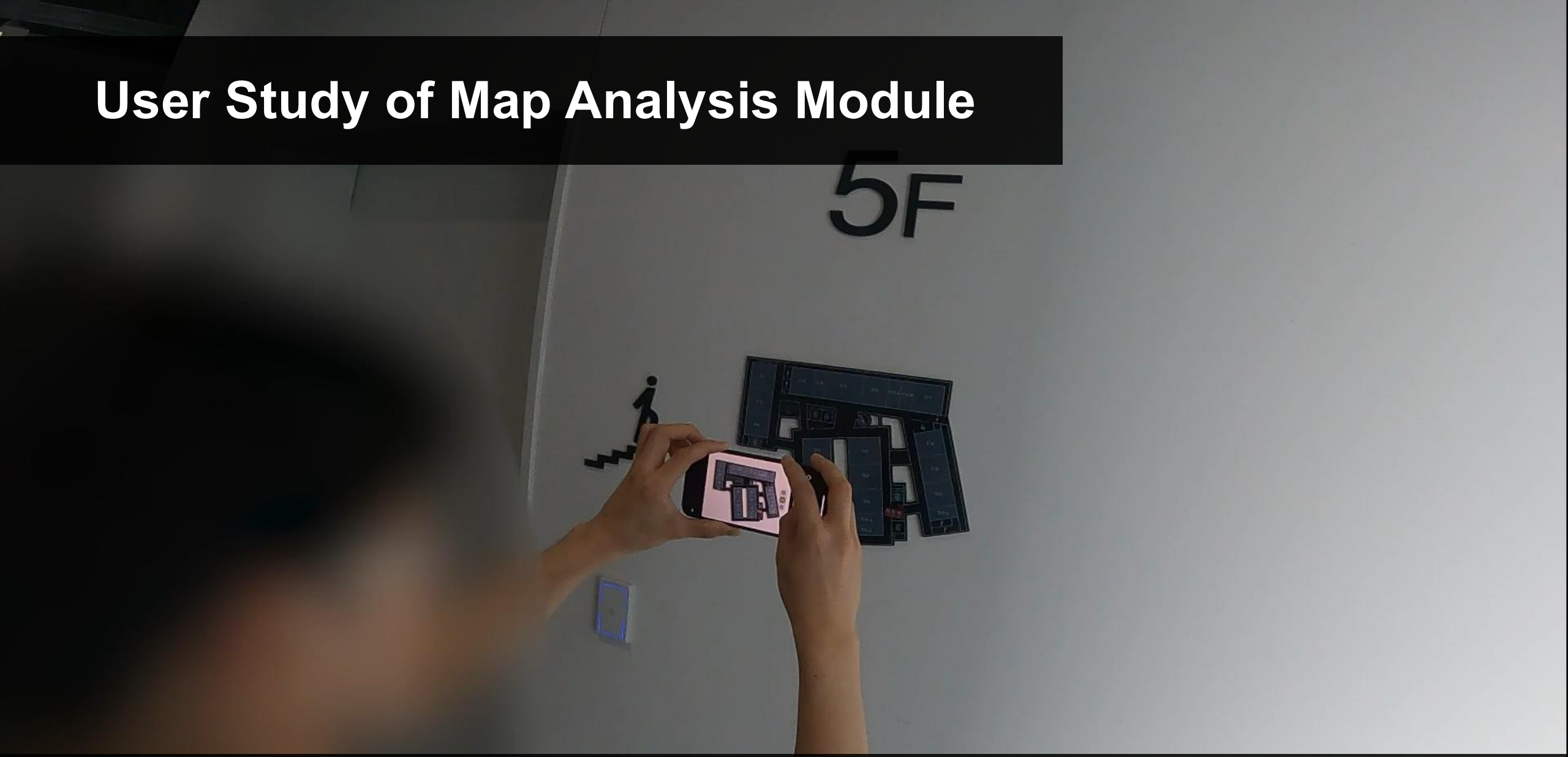
d is measured by LiDAR sensor



d' denotes pixels in the node map



User Study of Map Analysis Module



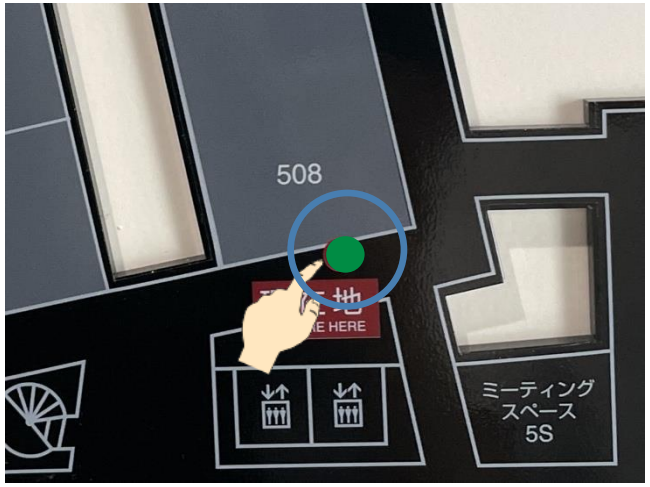
20 sighted participants use the map analysis module with **5 floor maps**

The Accuracy of User Node Input by Sighted Assistants

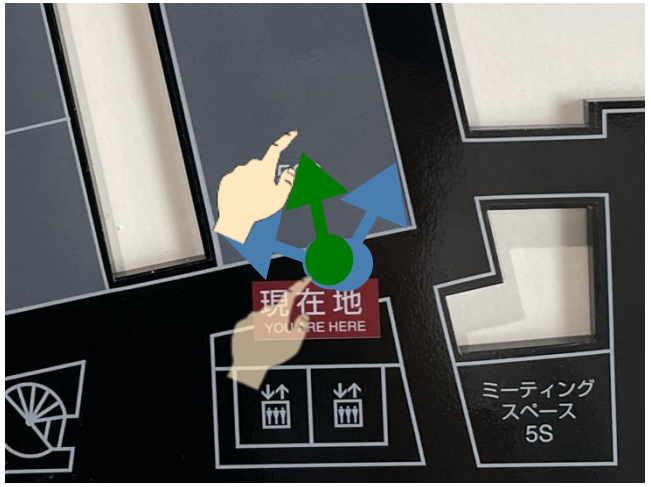
On their first use, 17 out of 20 participants were able to use the system correctly.

Correct if the **location** and **orientation** input are within the threshold.

Location: within 227 pixels

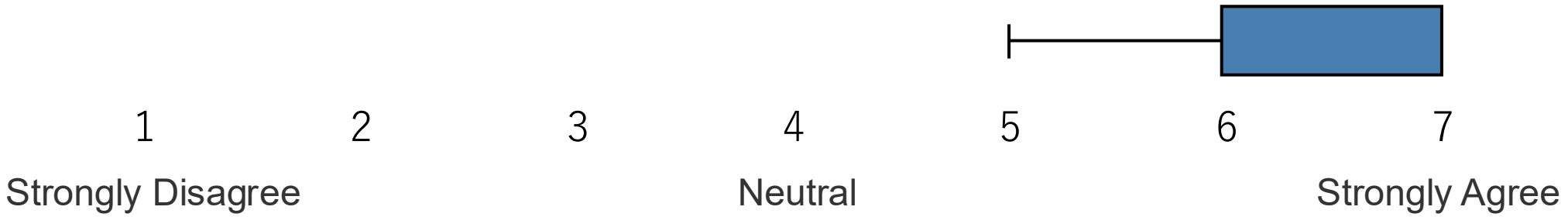


Orientation: within 45 degrees



Subjective Rating of The System

Q. I am willing to use this system for blind people when I am asked to do so.

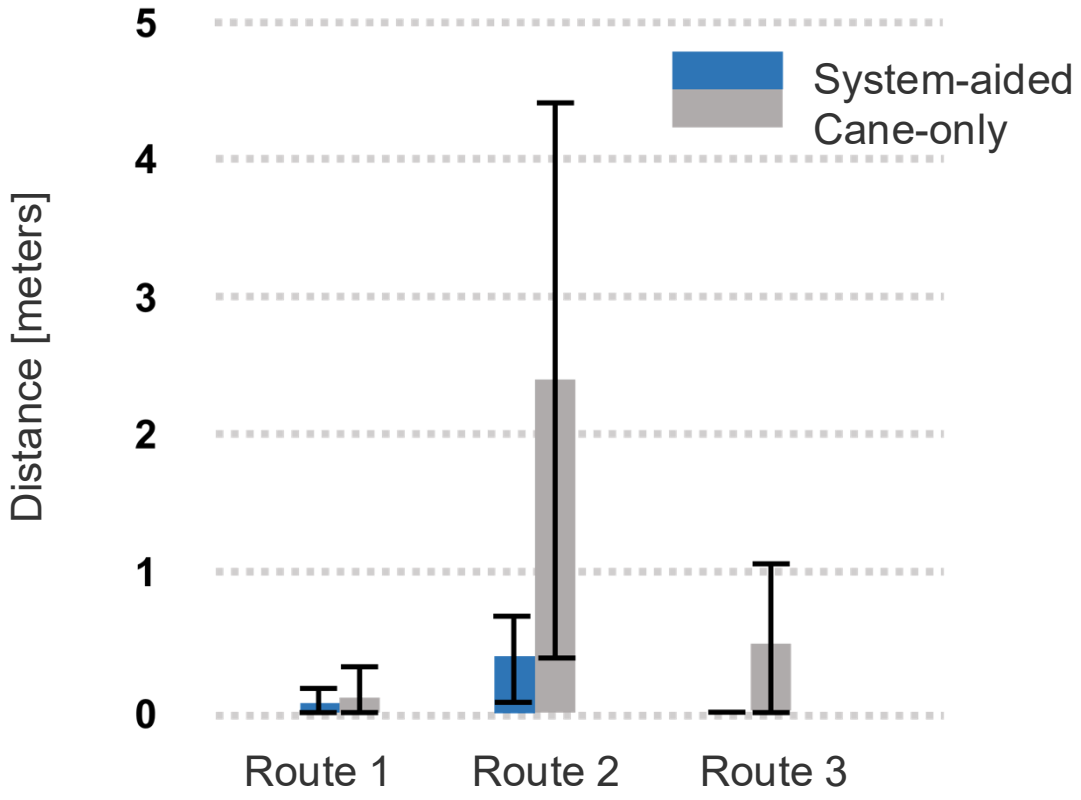


All participants are willing to use the system when asked to by blind people.

12 blind participants traveled to 3 destinations under 2 conditions

Distance to Destination Area

The deviation from the destination area upon arrival.

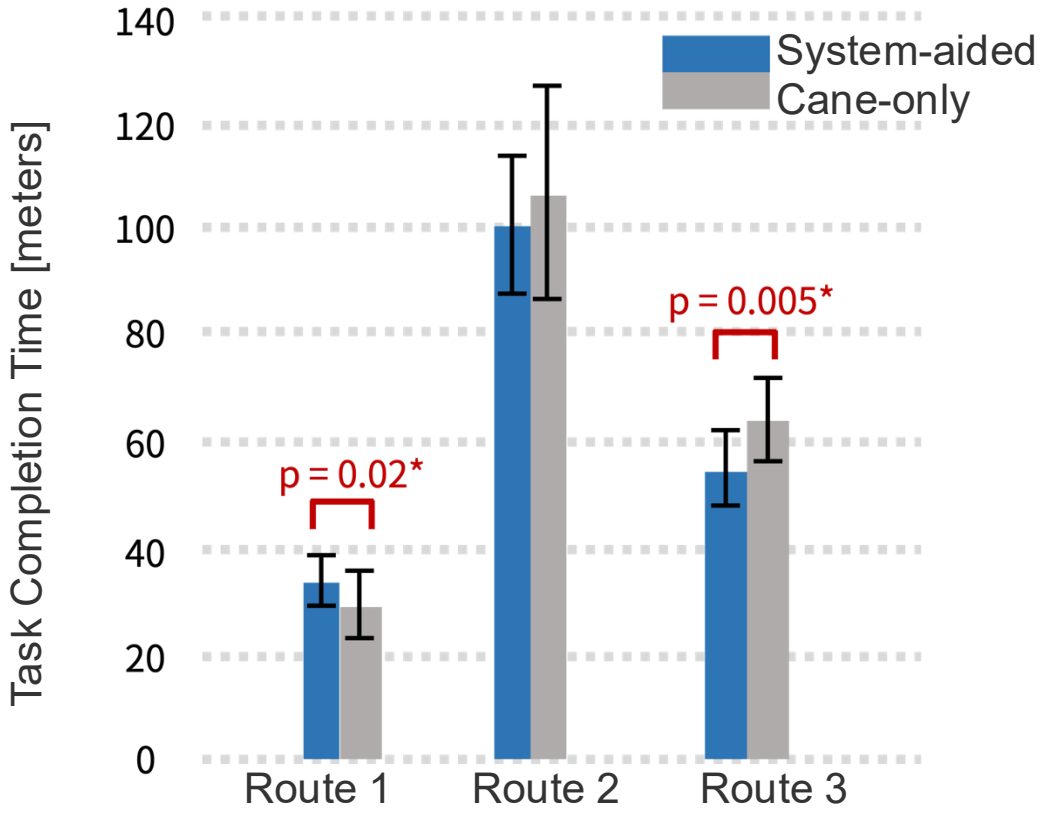


Using the system,

blind users were able to arrive near the destination.

Task Completion Time

Time to walk from the start to the end of the route.



Although system requires scanning, **there was no significant change** in task completion time.

Comment Appreciating the Design of the System

Not needing to memorize the route was appreciated.

*“ The system was very good because **I didn’t have to remember (the route), and I could leave it to the system to guide me.**”*

Comment Appreciating the Design of the System

10 participants expressed that the total benefits outweigh the need of asking for assistance.

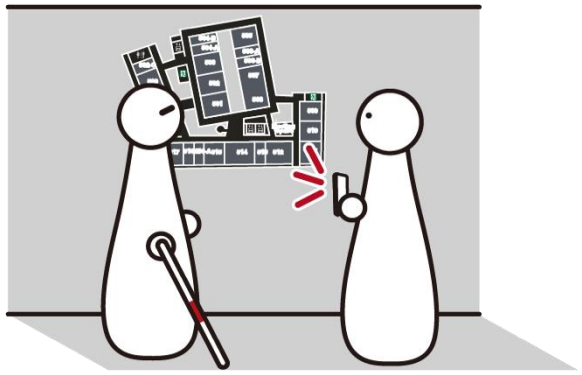
"If I have a picture of a floor map taken by a sighted assistant, I may be able to move around independently.

I think it is a good idea because we can reduce various costs just by having the photos taken."

Toward More Independent System of Sighted Assistants

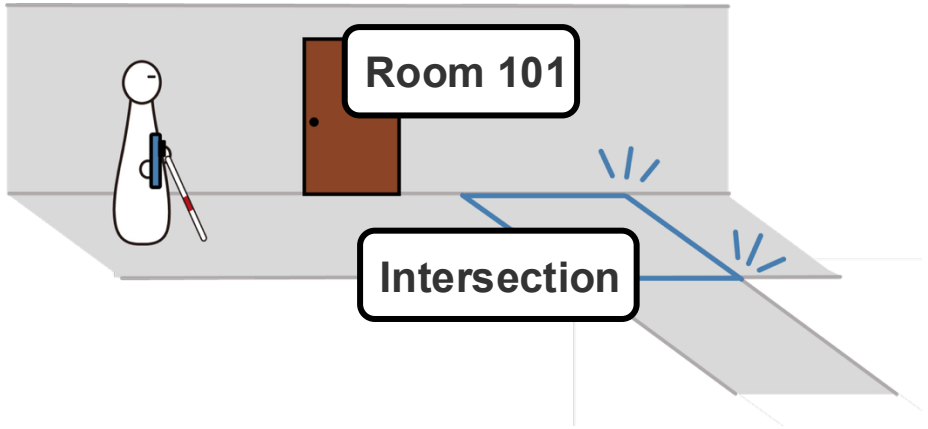
Proposed System

Sighted assistants took an average of 88 seconds to complete task.



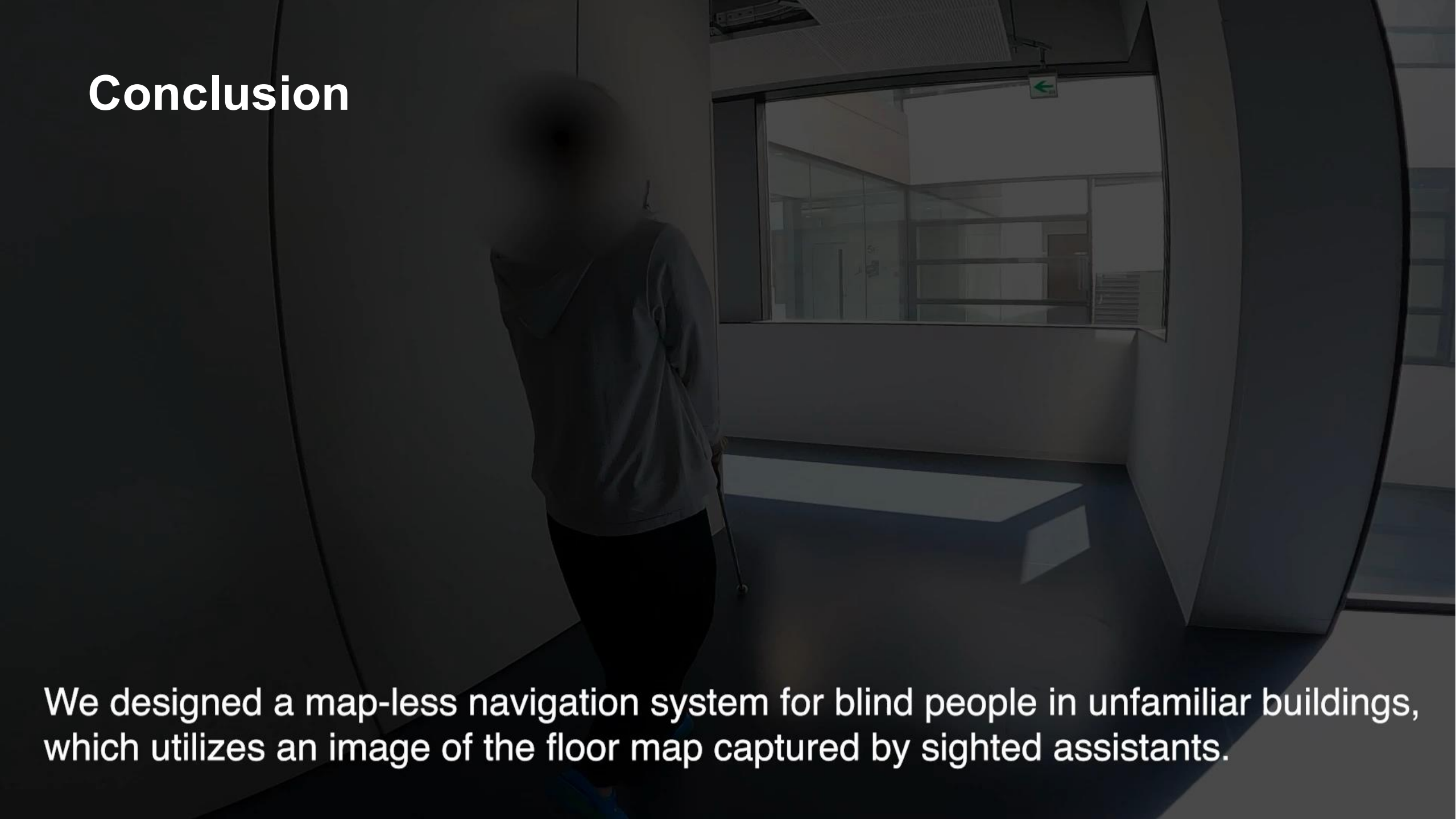
Future Work

Use landmarks such as intersections and signs for initial localization[3].



[3] Crabb et al. “A Lightweight Approach to Localization for Blind and Visually Impaired Travelers”

Conclusion



We designed a map-less navigation system for blind people in unfamiliar buildings, which utilizes an image of the floor map captured by sighted assistants.

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- We designed a map-less navigation system for blind people in unfamiliar buildings, which utilizes an image of the floor map captured by sighted assistants.

- In the user study, sighted assistants were willing to use it when asked, and blind users expressed that the total benefit outweighed the inconvenience.

- For future work, we aim to improve the system to be more independent of sighted assistants and develop a more generalized floor map analysis algorithm.

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