Enhancing Blind Visitor's Autonomy in a Science Museum Using an Autonomous Navigation Robot

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Museum Experience for Blind People

By **walking around a museum floor**, blind visitors can

- **Listen to the sound** at various locations
- **Sense the size** of the sub-exhibits
- **Feel the atmosphere** of the museum

[Asakawa et al., ‘19]

Museum Experience for Blind People

Museum Tour for Blind Visitors

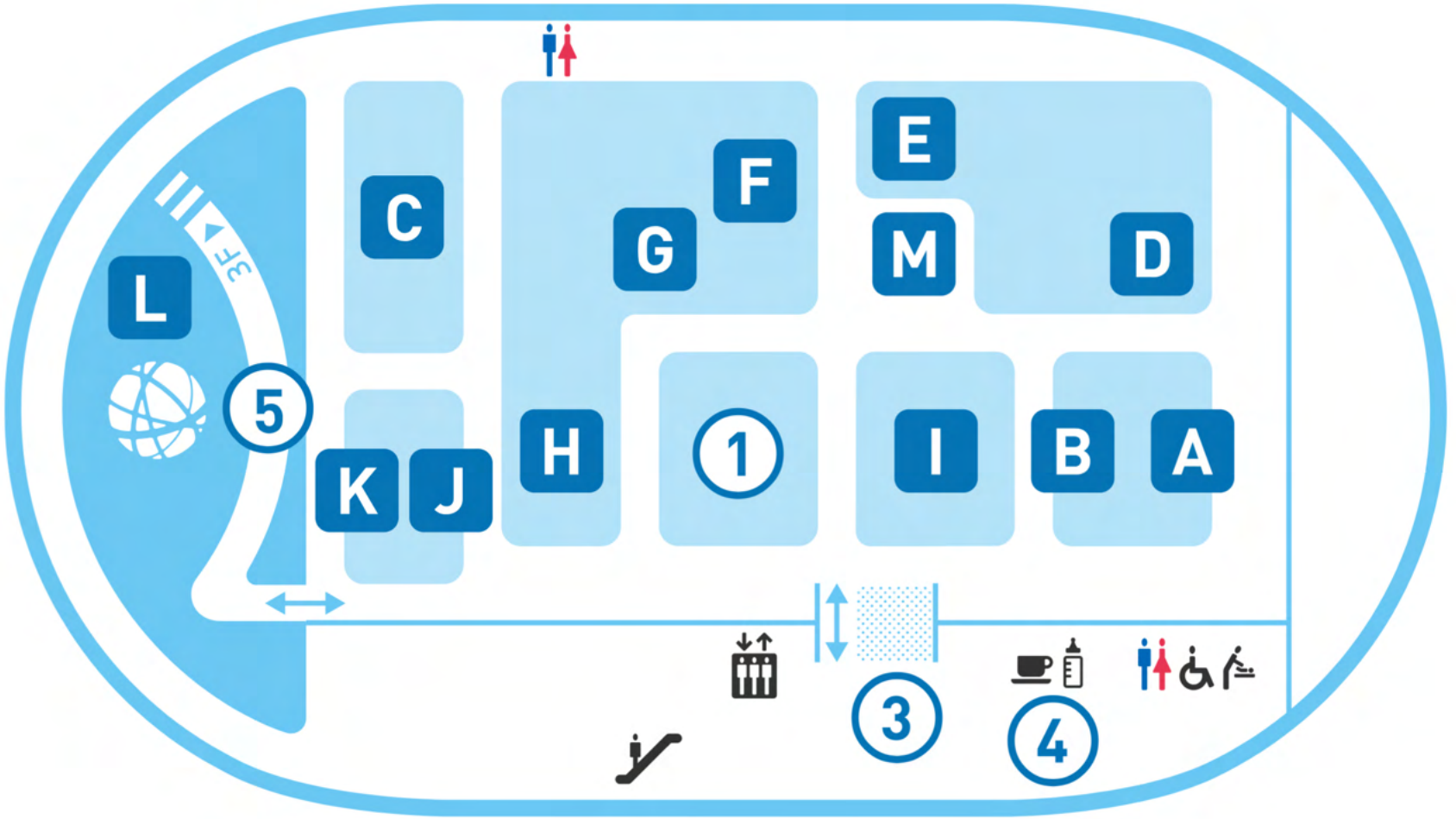
Help from their Families or Friends

It is challenging for blind visitors to enjoy a museum independently

https://www.anabaptistdisabilitiesnetwork.org/Newsletter/Pages/2016/Walking-by-Faith.aspx

https://www.gettyimages.co.jp/detail/ニュース写真/people-walk-past-blind-visitors-participating-in-the-first-ニュース写真/474598831?adppopup=true

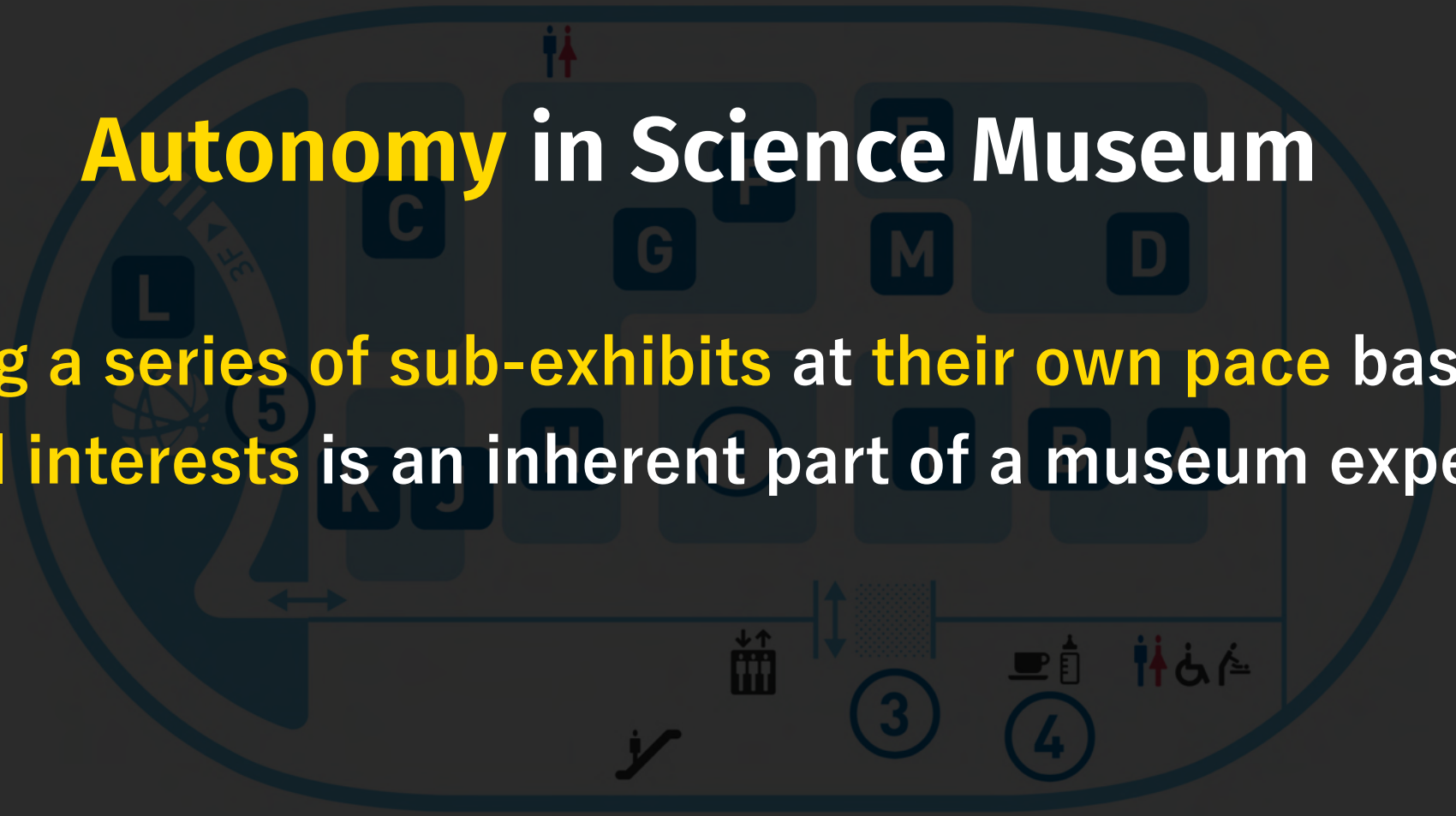
Exploration in Museums



Freely arranged exhibits and no clear route indication

https://www.miraikan.jst.go.jp/visit/floormap/

Exploration in Museums



Autonomy in Science Museum

Choosing a series of sub-exhibits at their own pace based on personal interests is an inherent part of a museum experience.

Freely arranged exhibits and no clear route indication

https://www.miraikan.jst.go.jp/visit/floormap/

Assistive Technologies for Museum Visitors

Exhibit Accessibility

Tactile Representation of Artworks

[Luis et al., ‘21]

Orientation & Mobility

Floor Navigation

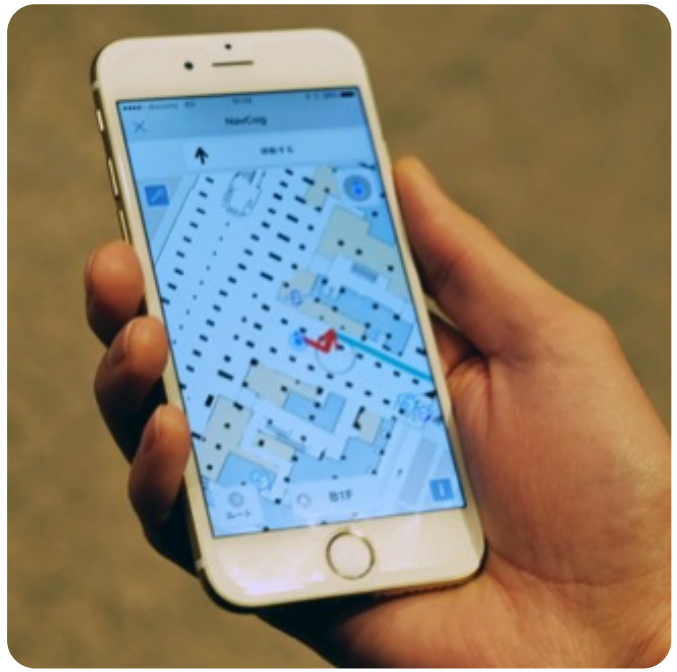
[Asakawa et al., ‘19]

Autonomy

Museum Exploration

Orientation & Mobility Assistance

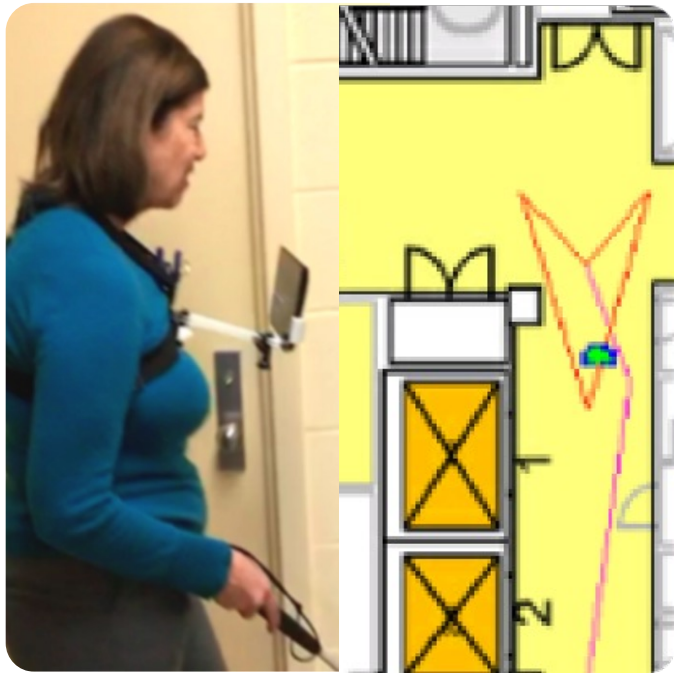
Smartphone



NavCog

[Ahmetovic et al., ‘16]

Wearable Device



ISANA

[Li et al., ‘15]

Autonomous Robot

CaBot

[Guerreiro et al., ‘19]


AI-Suitcase Project
Suitcase-shaped Navigation
Robot for Blind People

Automated Mobility Assistance

Robotic Navigation

Autonomous robot

[Guerreiro et al., ‘19]

?

Museum Navigation

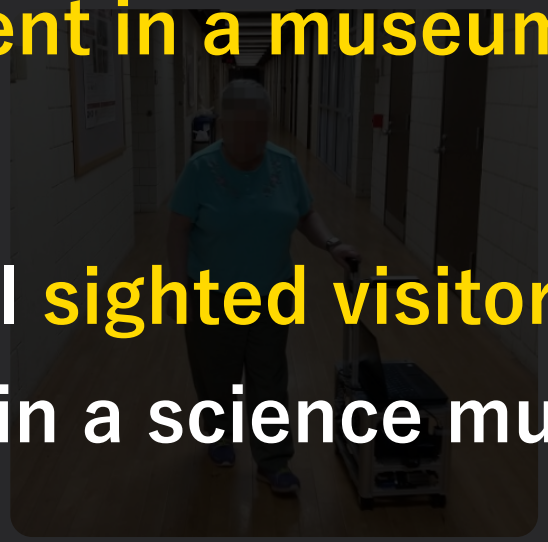
Smartphone

[Asakawa et al., ‘19]

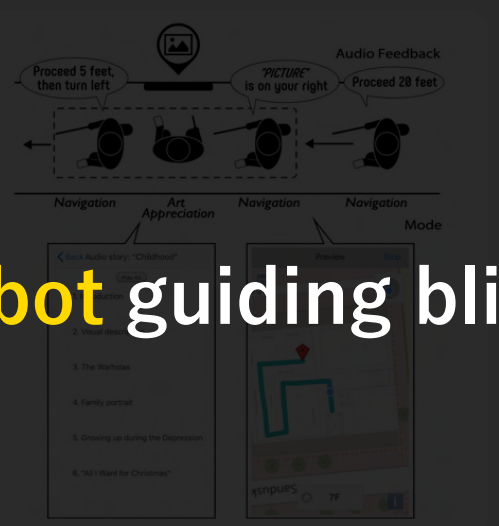
Research Questions

To what extent can an autonomous robot-based navigation system contribute to increasing blind visitors' autonomy and enjoyment in a museum?

How will sighted visitors perceive the robot guiding blind visitors in a science museum?



[Guerreiro et al., ‘19]



[Asakawa et al., ‘19]

Hardware

iPhone
Robot’s destinations control

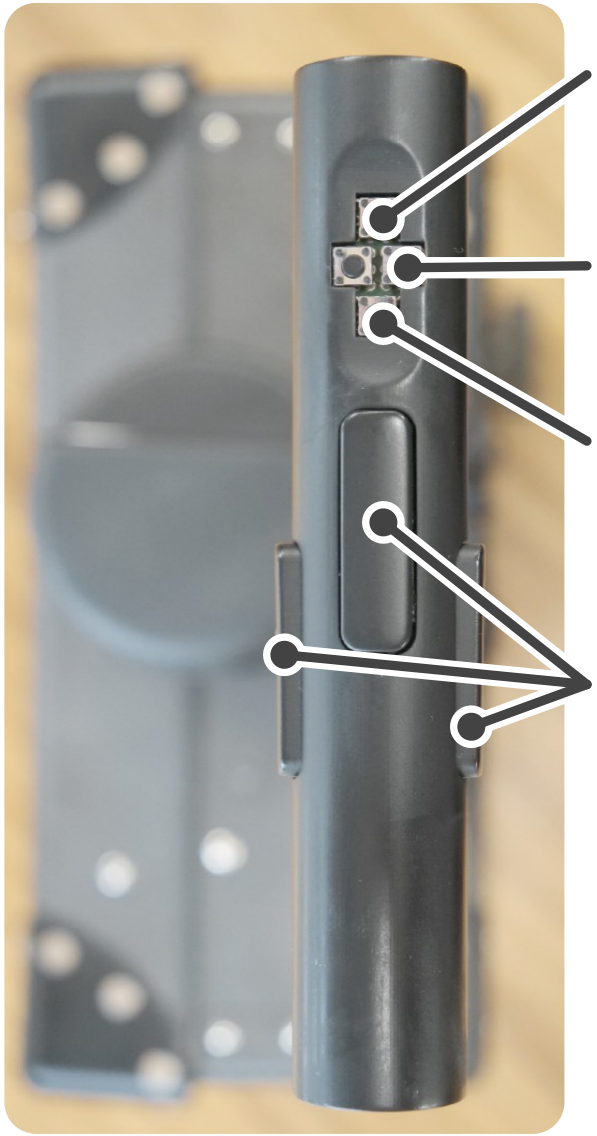
RGBD-Camera
Pedestrian detection

LiDAR
Localization & Obstacle Detection

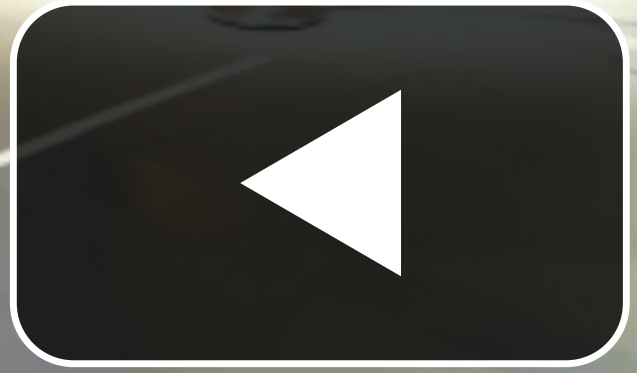
CPU, Battery
Robot control

Motor
Autonomous driving

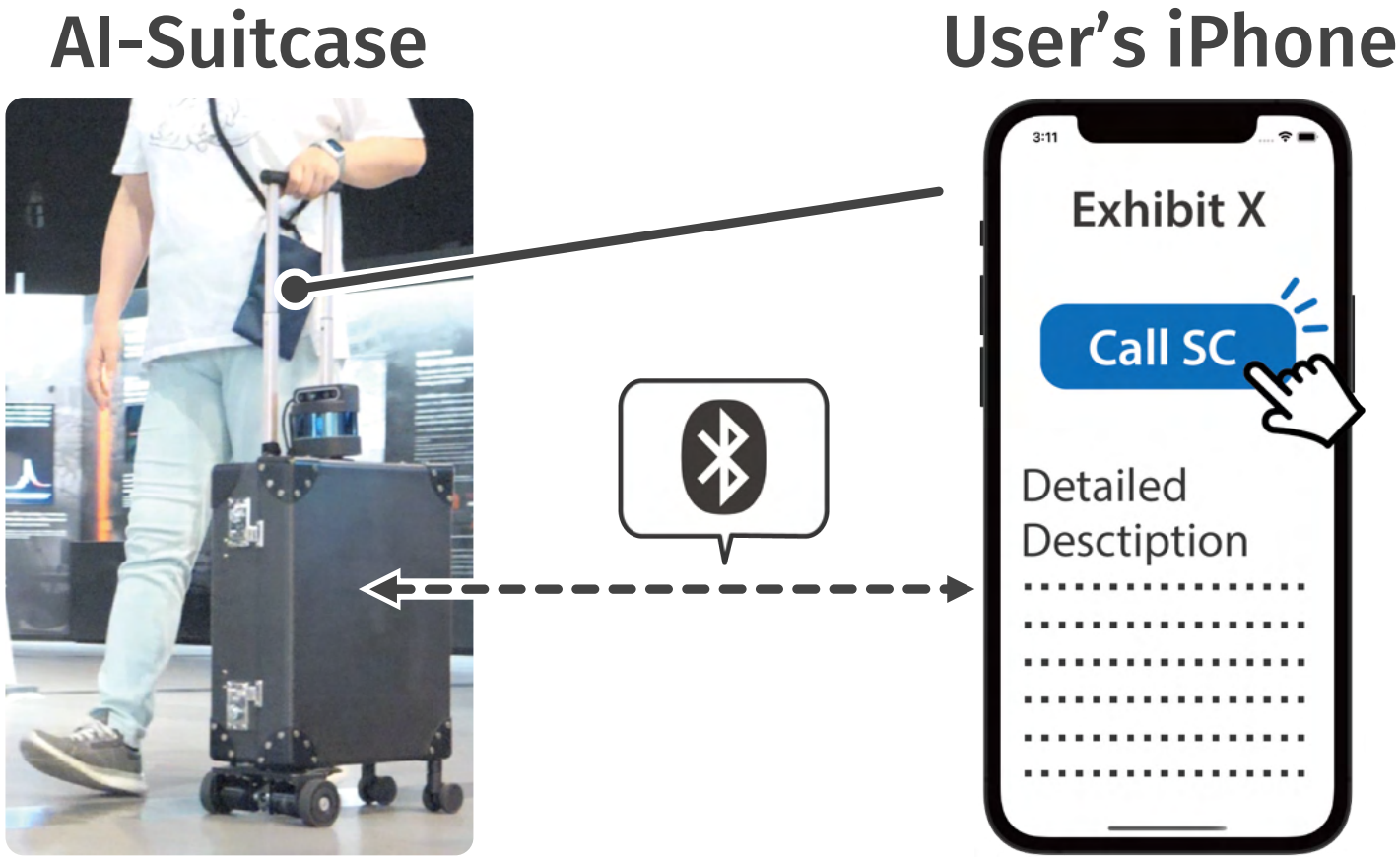
Hardware


Haptic Handle
Speed Up
Next Exhibit
Speed Down
Vibrotactile Device

System Overview



System Design

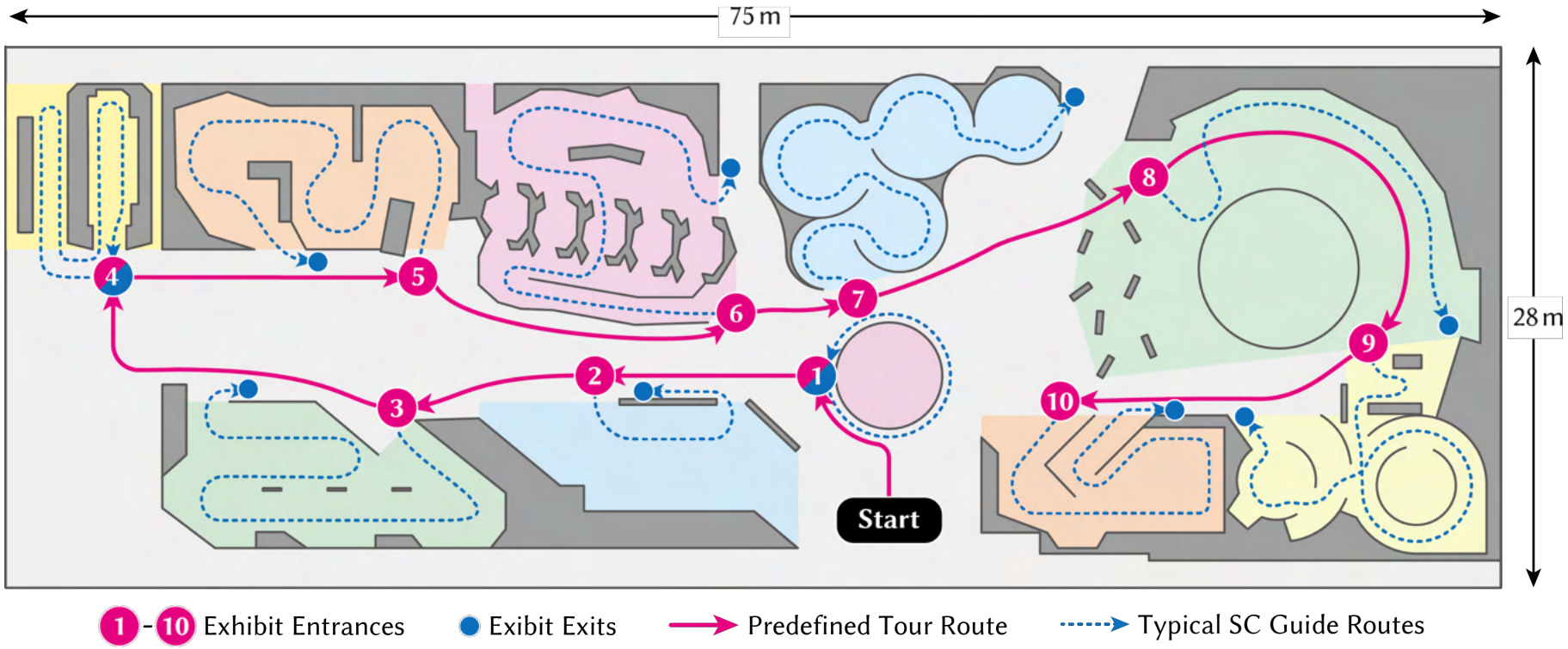


SC: Science Communicator

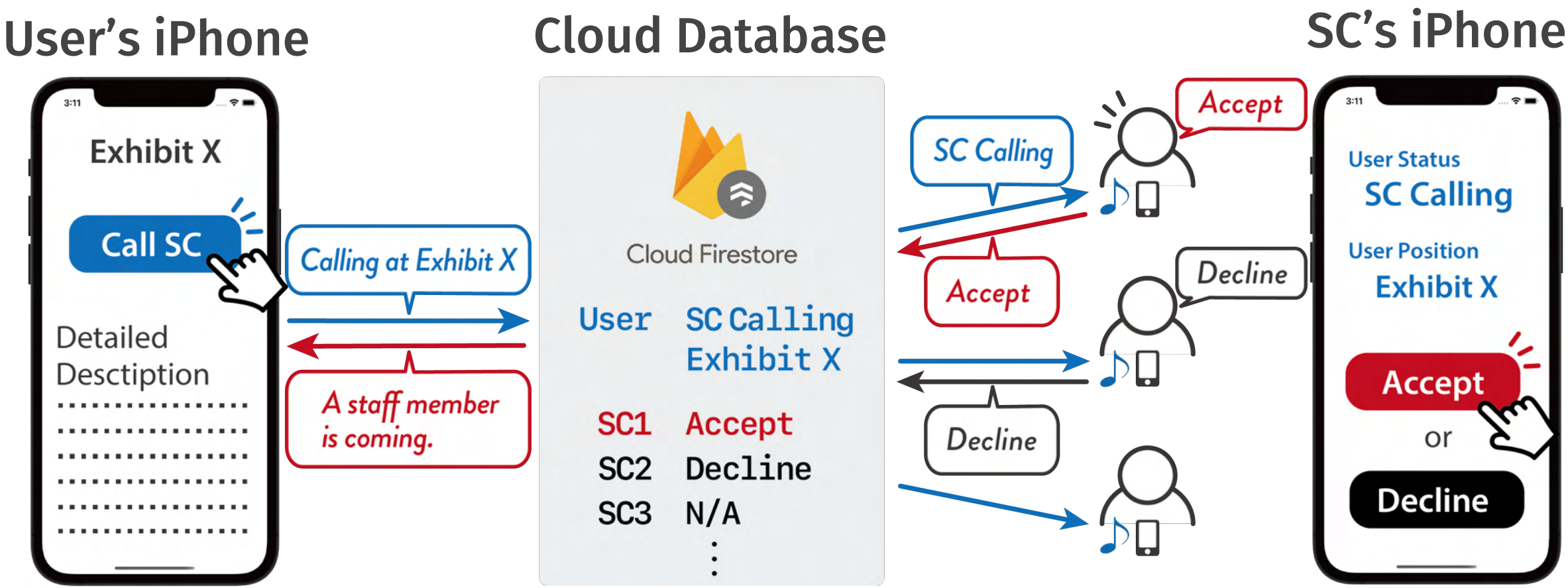
Set Robot's Destinations

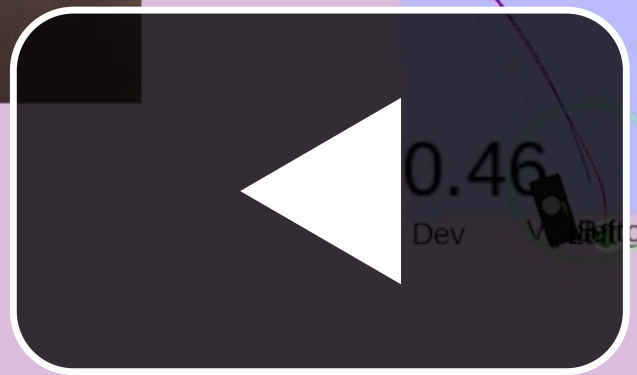
- Specific exhibits from the list of exhibits

- Predefined tour that navigates all the exhibits



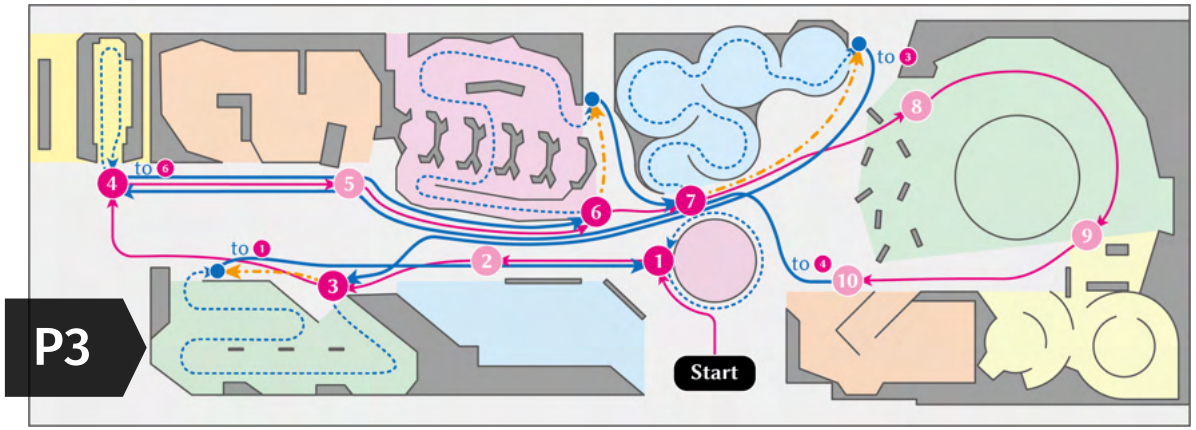
System Design

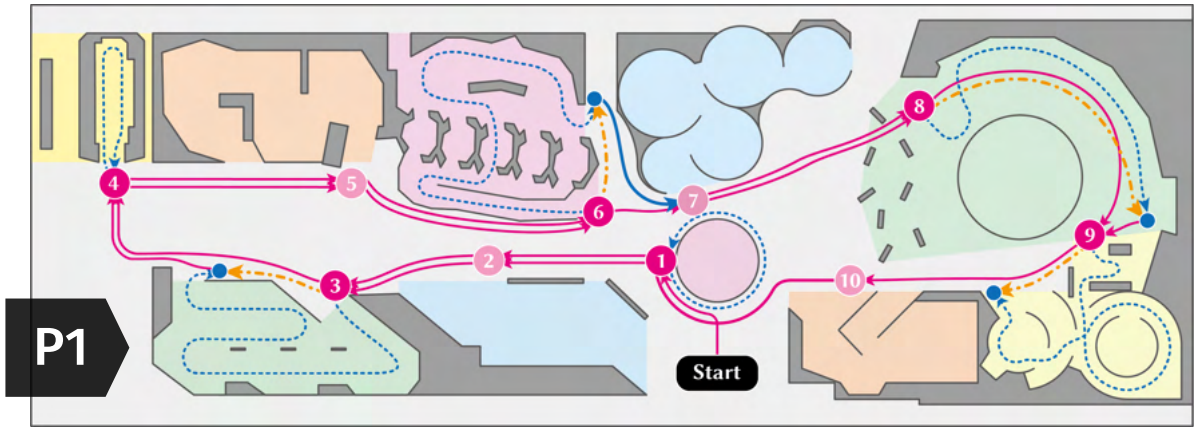


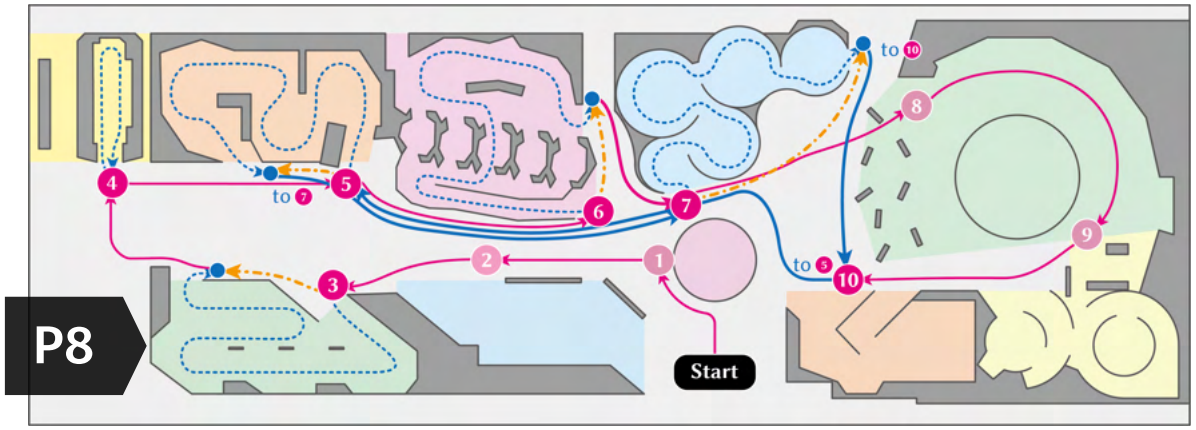


(-0.62)
0.46
m/s
Dev
(0.85)
x 10

Route Examples

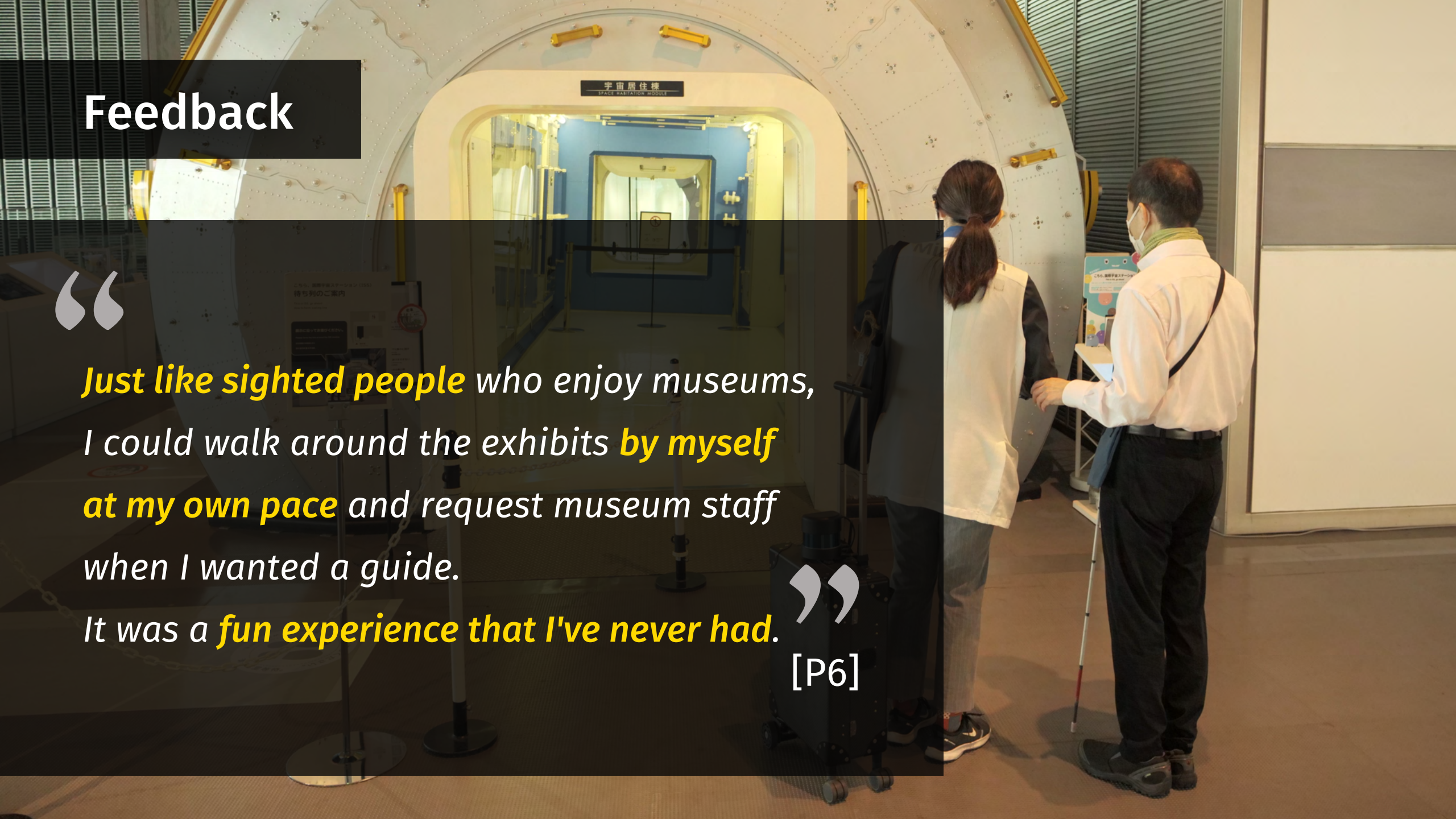






The participants **chose to visit a variety of exhibits** according to their **own interests and strategies**

Feedback



“*Just like sighted people who enjoy museums, I could walk around the exhibits by myself at my own pace and request museum staff when I wanted a guide. It was a fun experience that I've never had.*”

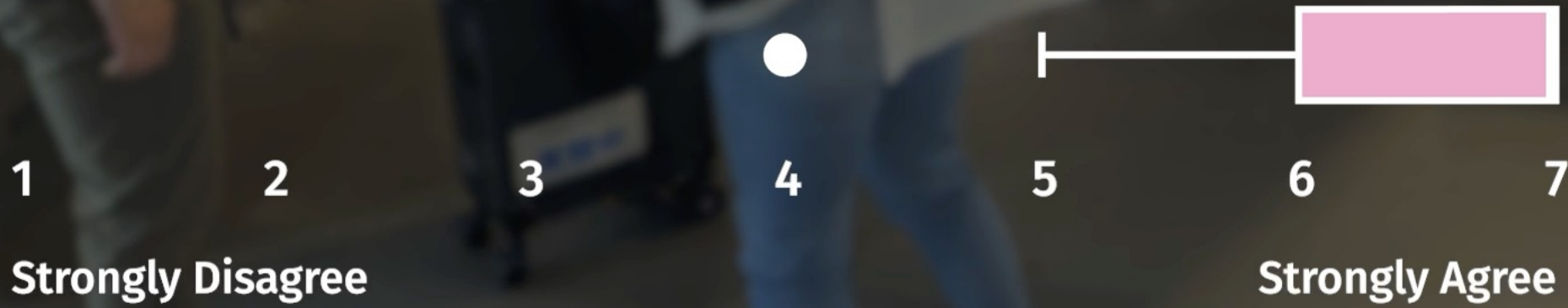
[P6]

Subjective Ratings (1: Strongly Disagree, 7: Strongly Agree)

	P1	P2	P3	P4	P5	P6	P7	P8	Median
I enjoyed exploring the museum with the robot.	7	7	7	7	6	7	7	7	**7**
I could explore the museum independently at my own pace.	7	7	7	7	6	7	7	7	**7**
The system was easy to use.	5	7	7	7	6	3	7	6	**7**

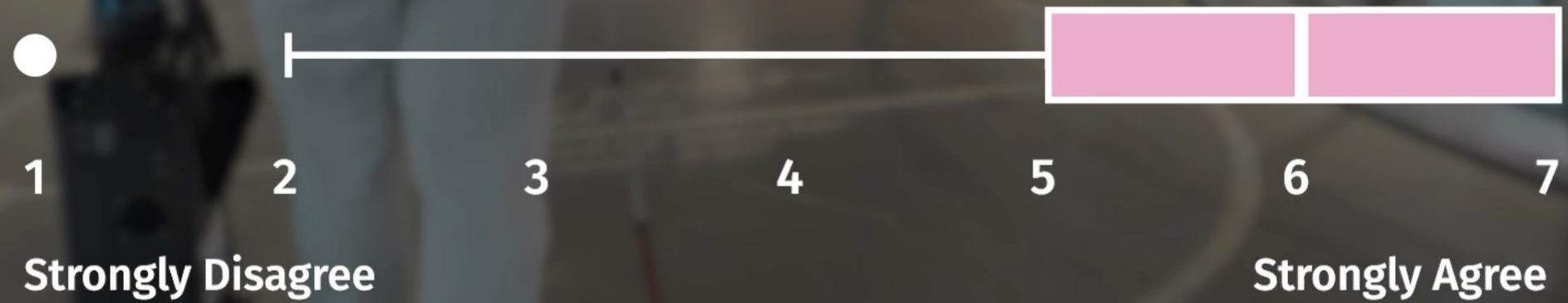
Social Acceptance of the Robot

I agree that such assistive robots for blind visitors should be introduced in museums.



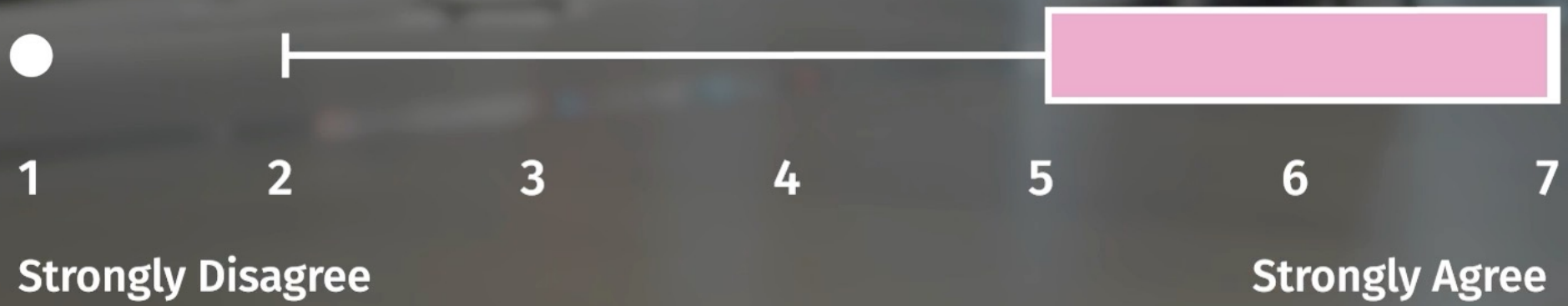
Social Acceptance of the Robot

The movements of the blind people and the robot looked natural.



Social Acceptance of the Robot

I am okay with the robot's camera capturing me if the captured data is not saved.



Toward a More Independent Museum Experience

Total elapsed time (around 90 minutes)

Interact with the system	Interact with the museum staff
around 30% (26 minutes)	around 70%

> *Rather than just listening to guidance in front of the entrance, it would be nice if I could **listen to the descriptions while walking inside with the robot** and experiencing the objects' sizes.*

[P2]

Toward a More Independent Museum Experience

Finer Navigation

AI-Suitcase

Navigate inside exhibit

+

Q&A System

- Remote Assistant System
- Chat System with Museum Staff
- AI-based Q&A System

Enhancing Blind Visitor's Autonomy in a Science Museum Using an Autonomous Navigation Robot

- We designed a **science museum exploration system** by combining a **navigation robot** and the **intelligence of human assistants**.

- Our study at a science museum revealed that blind participants **could explore the museum independently** and appreciated the ability to **choose exhibits according to their own interests** and **enjoy the museum at their own pace**.

- The study also showed that **the sighted visitors** who saw the participants walking with the robot **accepted the assistive robot well**.