IPIN 2025
FIFTEENTH INTERNATIONAL CONFERENCE ON
INDOOR POSITIONING
AND INDOOR NAVIGATION
15th – 18th September 2025, Tampere, Finland

IPIN 2025 Indoor Localization Competition

Track 5 (xDR Challenge 2025)
~ Smartphone with Navigation Robot~
(offsite, online)

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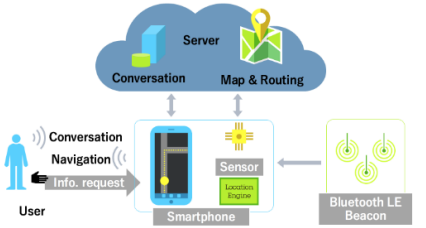
PDR Benchmark

IEEE DataPort™

Background

Understanding of spatial relationship **Ability to move from place to place**

- Support for **Orientation & Mobility (O&M)** of people with visual impairment
- Navigation assistants with smartphones
  - Do not limit user's **mobility** while inaccurate **orientation**
  - Requires investment in the environment (tags, feature point maps, etc.) & maintenance
  - Difficult to point at markers for people with VI
- Navigation robot
  - Reduces user’s cognitive load by precise **orientation**
  - Sometimes restricts user’s **mobility**
- Combination of these methods enables complementary navigation

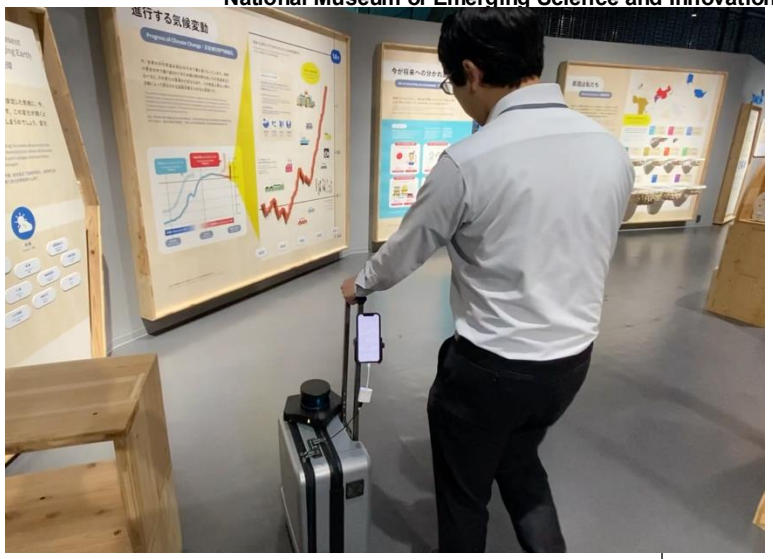


[D. Sato+, 2017]

[T. Takagi+, 2022]

https://www.linkx.dev/shikai

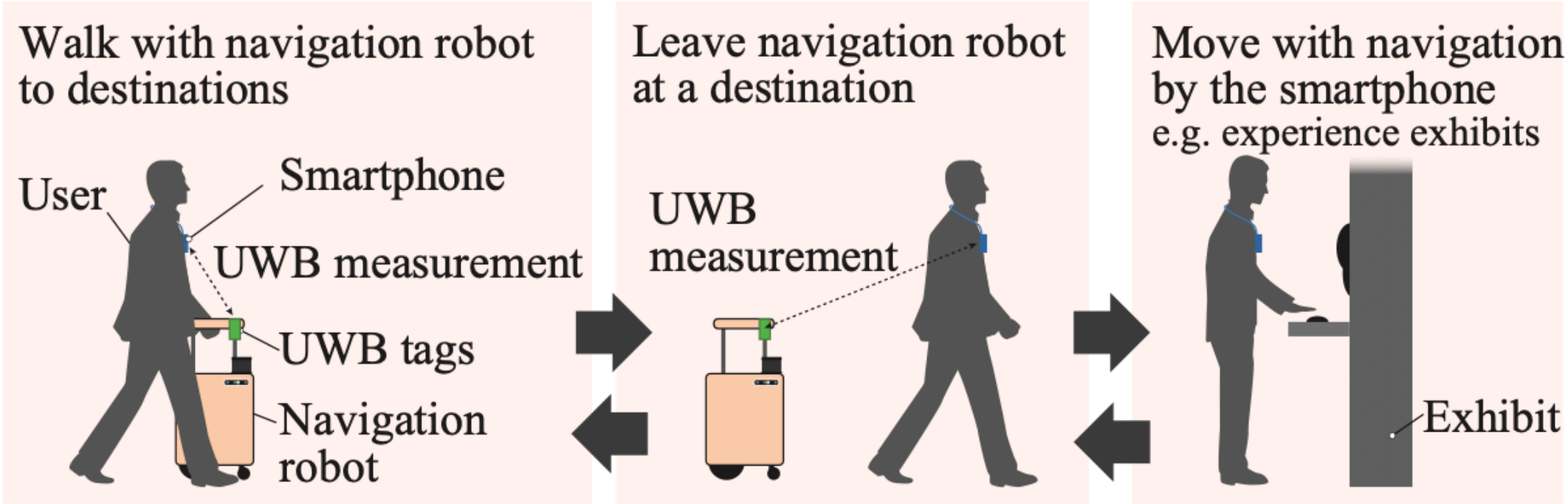
Permanent operation in EXPO 2025 & Miraikan - The National Museum of Emerging Science and Innovation



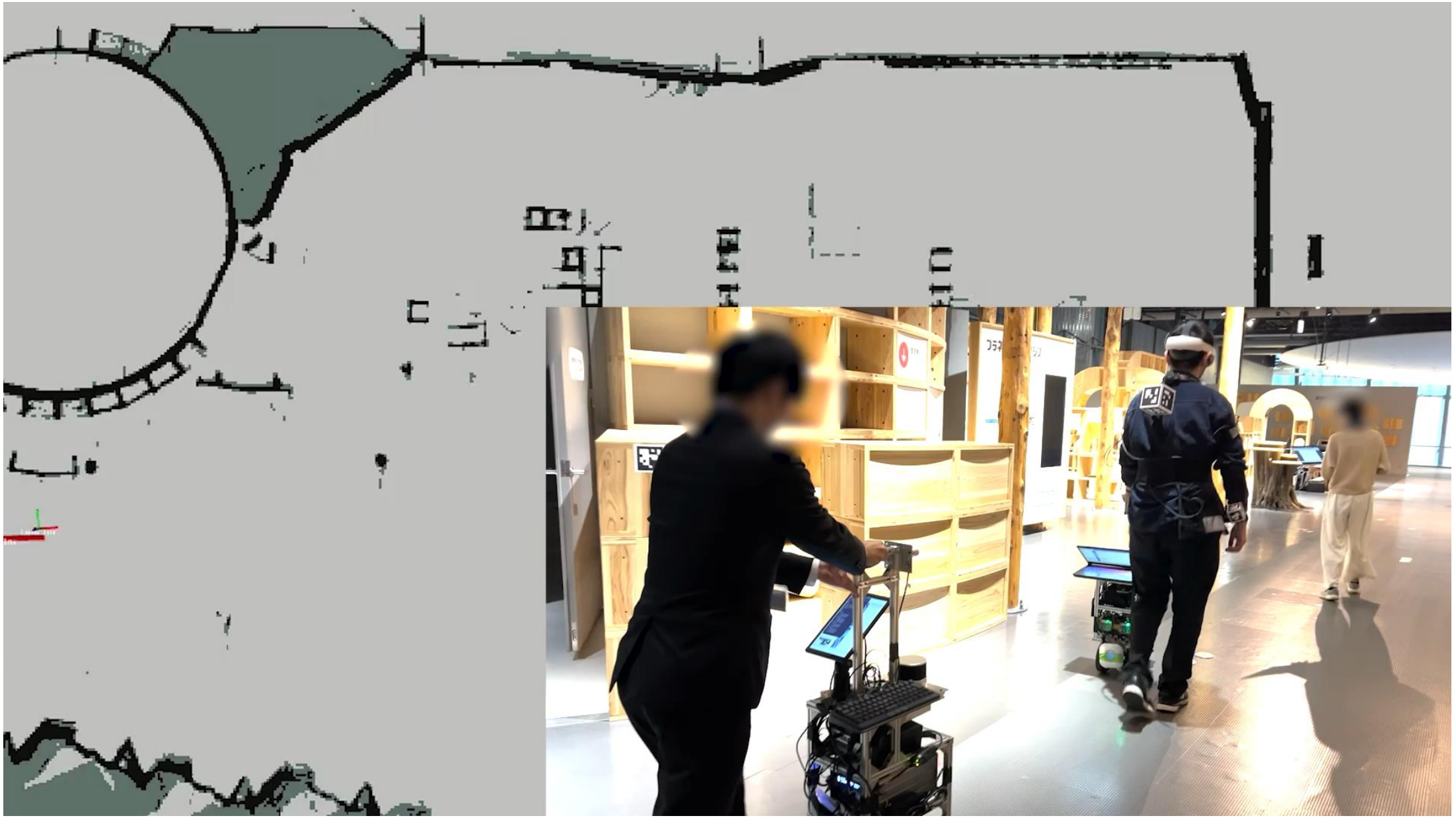
VI: Visual impairment

Scope of the competition

- **Assumption**: navigation robot is available in the target venue
- **Purpose**: estimate **smartphone's location and heading** without additional infrastructural investment & maintenance
- **Approach**: estimate the smartphone's location by utilizing a navigation robot as a reference point using relative position measurement by UWB



Example of localization



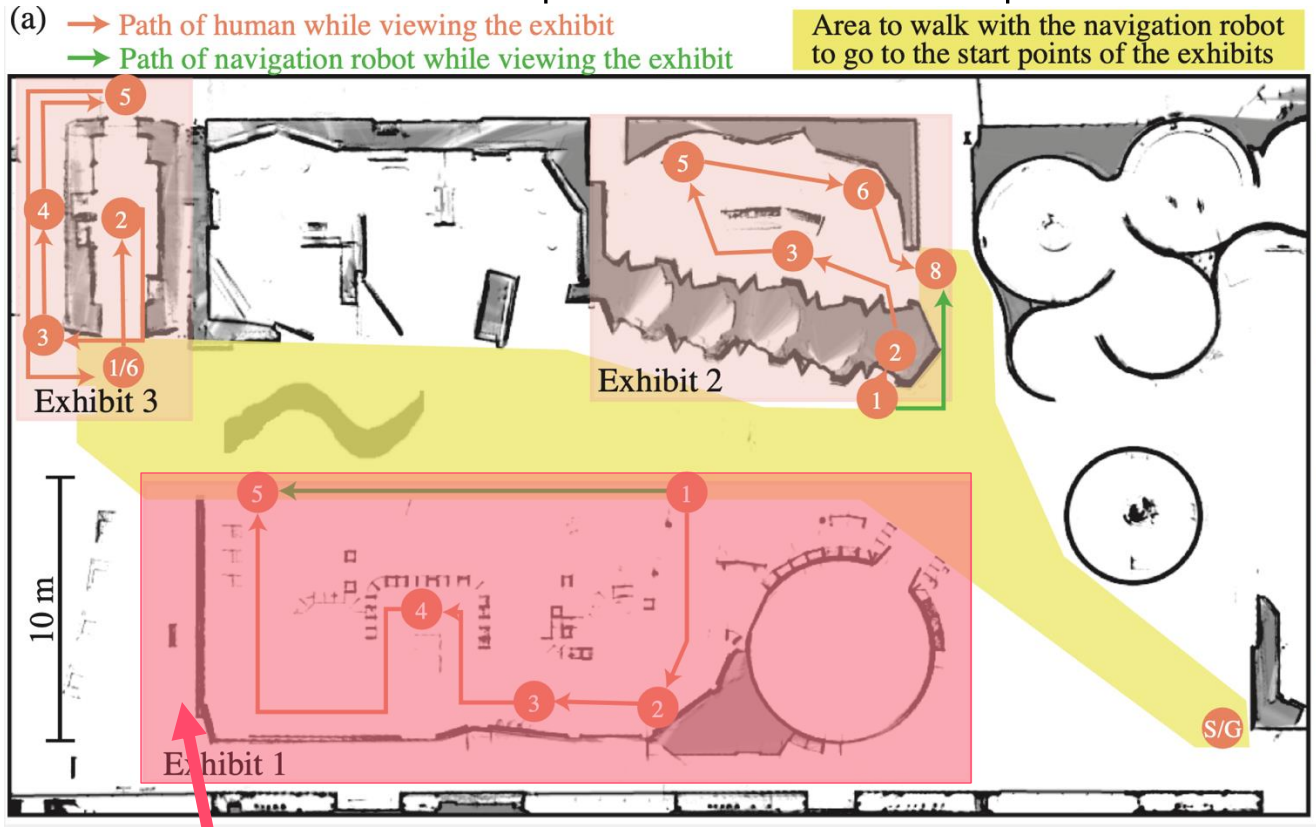
Experimental condition for dataset - Overview

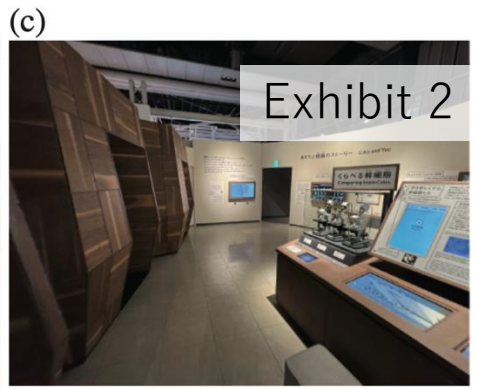
- Measure sensor data with mock tours in a museum
  - 15 to 30 minutes per tour
- Participants
  - 2 people with visual impairment (scoring trial)
  - 4 people without visual impairment
- Equipment & available data
  - Smartphone (iPhone 13 Pro, Apple)
    - VIO (ARKit, in its own frame)
    - IMU
    - UWB(range, AoA)
  - Navigation robot (AI Suitcase)
    - Location+pose of the robot and UWB tags in 6DoF
      - Calculated from LiDAR & IMU
    - UWB(range and AoA)

IRB number: HF2024-1438

Experimental condition - Venue and paths

- Miraikan - The National Museum of Emerging Science and Innovation
- 5th floor, following 3 exhibits
  - Exhibit 1: Relatively open space (some data contains tours with AI suitcase inside exhibit)
  - Exhibit 2: Small room with curtains at the start
  - Exhibit 3: Mockup of international space station module, made of metal





VIO was intentionally eliminated in the exhibit 1 to enforce PDR development for competitors

Evaluation metrics

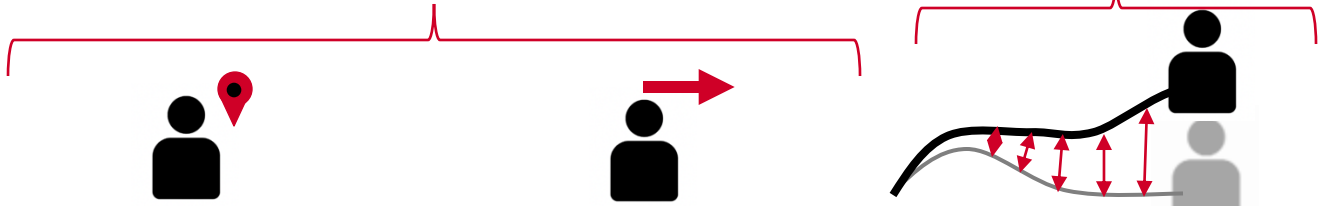
Multi-faced evaluation

Metrics are based on ISO/IEC 21134

Different units: normalized to 100-max (100=no error, 0=not usable at all) to mix for total score

Basic requirements for navigation

How much the PDR works well?



$$\text{Total score} = \text{CE95 score} + \text{HE50 score} + \text{EAG50 score}$$

$$+\text{RDA}_{\text{robot}}50 \text{ score} + \text{RPA}_{\text{robot}}50 \text{ score}$$

Can a user come back to the navigation robot correctly?
(the robot has UWB tags)

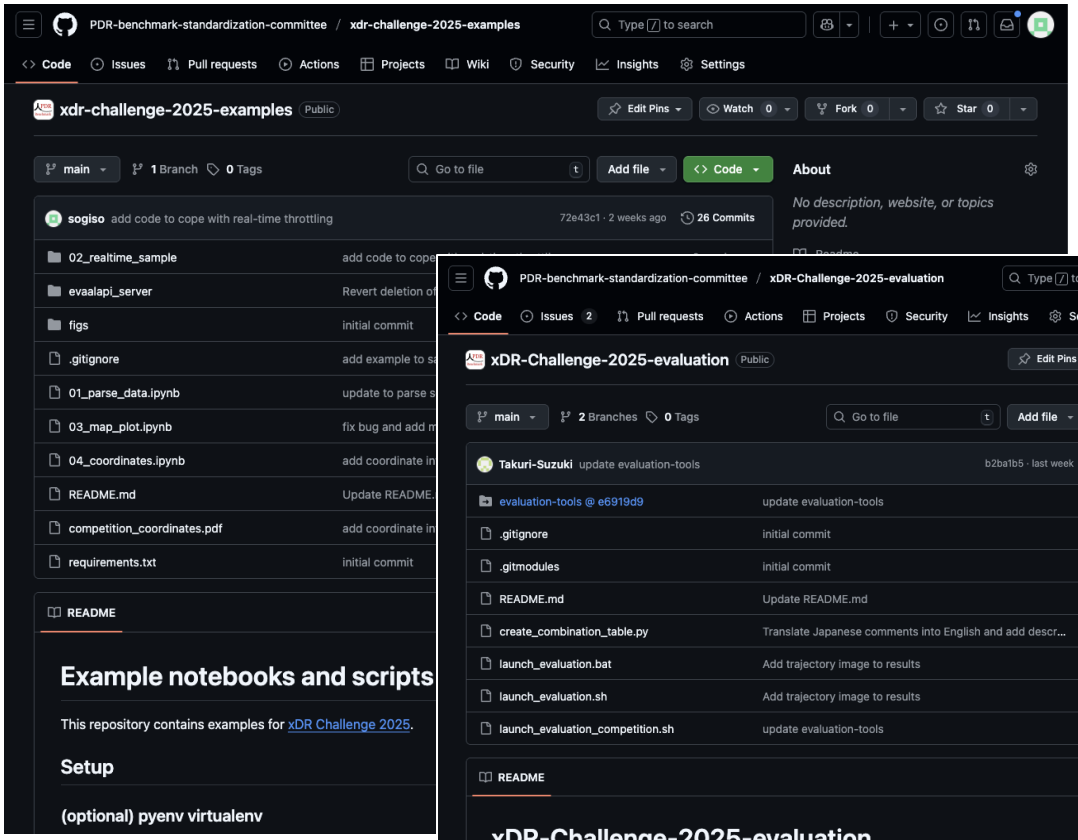
$$+ \text{RDA}_{\text{exhibit}}50 \text{ score} + \text{RPA}_{\text{exhibit}}50 \text{ score}$$

Can a user experience the exhibits correctly?
(the exhibits do not have UWB tags)

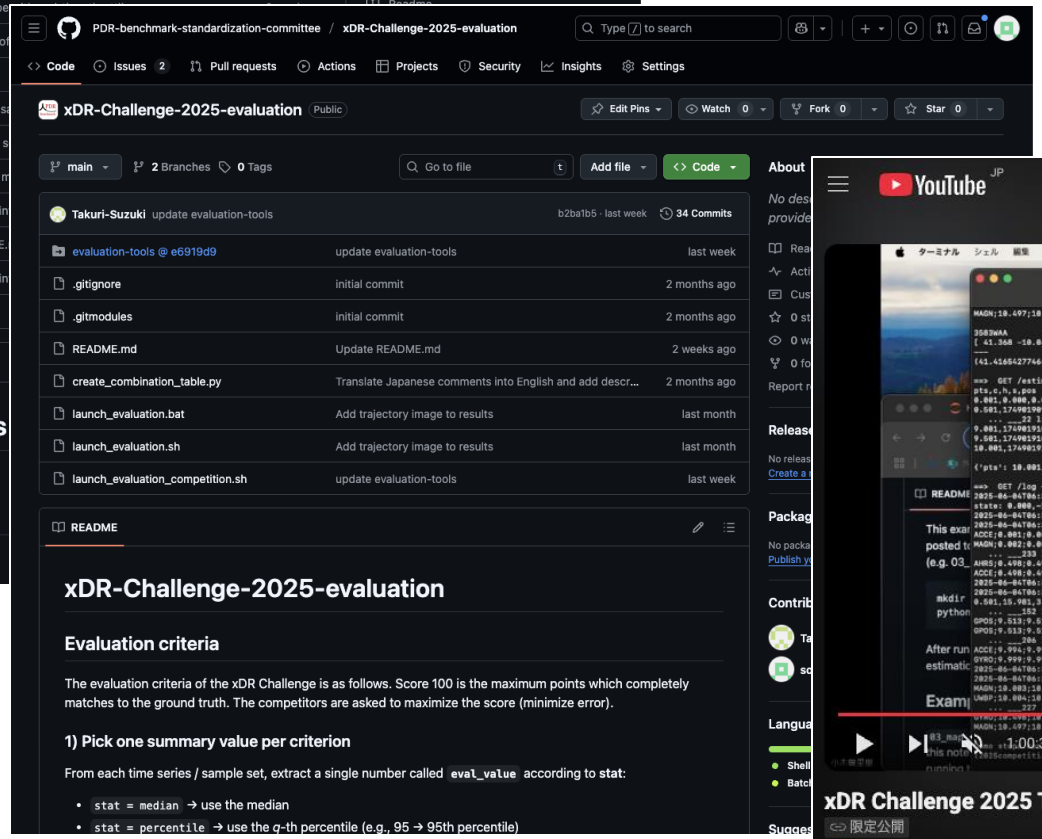
CE: Circular error
HE: Heading error
EAG: Error accumulation gradient
RDA: Relative distance accuracy
RPA: Relative pose accuracy

Resources for competitors

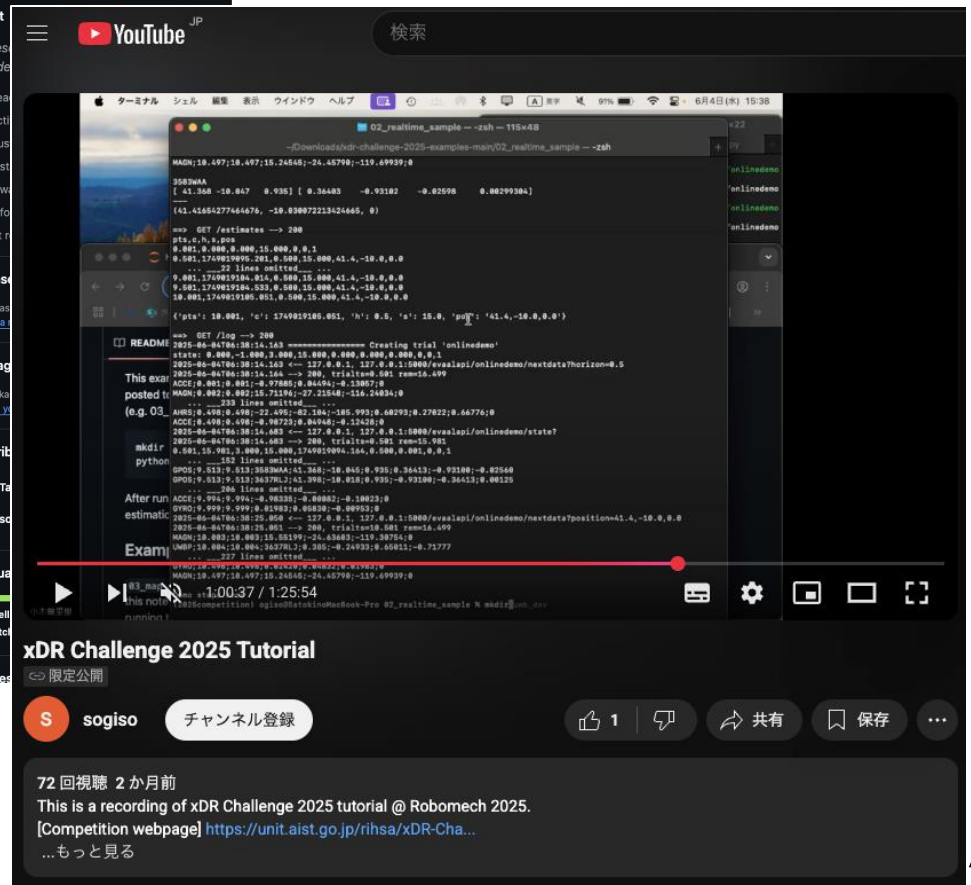
Complete baseline implementation of track 5 using EvAAL API



Evaluation tools



Video tutorial



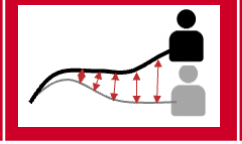
Competitors

Team name	Country	Affiliation
906 team	China	Beijing University of Posts and Telecommunications
Revenge of Dream Hunters	Japan	University of Tsukuba
KajiLab	Japan	Aichi Institute of Technology
CARELab	Japan	NARA Institute of Science and Technology

All teams chose Japan server for scoring

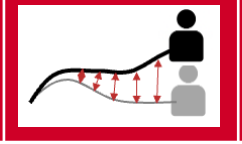
Results

score ↑
(error value ↓)

No.	Team	CE95 (m) *Exclude exhibit 1 	HE50 (rad) 	EAG50 (m/s) *Only in exhibit 1 	$RDA_{robot}50$ (m) *Only when the user approach to the robot 	$RPA_{robot}50$ (rad) *Only when the user approach to the robot 	$RDA_{exhibit}50$ (m) *Only when the user approach/experience the exhibit 	$RPA_{exhibit}50$ (rad) *Only when the user approach/experience the exhibit 	Total score ↑ (max:100)	CE75 (m) (not used, reference only)
2	Revenge of Dream hunters	-208.6 (30.9 m)	60.7 (0.62 rad)	2.7 (0.24 m/s)	54.0 (0.46 m)	59.6 (1.27 rad)	-351.7 (4.52 m)	78.3 (0.68 rad)	-43.6	20.15 m >15m
3	KajiLab	-803.9 (90.4 m)	**87.5 (0.20 rad)**	14.2 (0.21 m/s)	55.5 (0.44 m)	34.6 (2.05 rad)	-9.9 (1.10 m)	81.2 (0.59 rad)	-77.3	6.76 m
4	906 team	-2149.5 (225.0 m)	34.2 (1.03 rad)	-480 (1.45 m/s)	-4521.3 (46.2 m)	61.6 (1.2 rad)	-6359.0 (64.6 m)	46.2 (1.69 rad)	-1909.7	>45 m (3 times threshold)

Results

score ↑
(error value ↓)

No.	Team	CE95 (m) *Exclude exhibit 1 	HE50 (rad) 	EAG50 (m/s) *Only in exhibit 1 	$RDA_{robot}50$ (m) *Only when the user approach to the robot 	$RPA_{robot}50$ (rad) *Only when the user approach to the robot 	$RDA_{exhibit}50$ (m) *Only when the user approach/experience the exhibit 	$RPA_{exhibit}50$ (rad) *Only when the user approach/experience the exhibit 	Total score ↑ (max:100)	CE75 (m) (not used, reference only)
1	CARELab	**87.3 (1.27 m)**	75.4 (0.39 rad)	**63.4 (0.09 m/s)**	**85.2 (0.15 m)**	**82.6 (0.55 rad)**	**78.0 (0.22 m)**	**88.9 (0.35 rad)**	**80.1**	0.59 m
2	Revenge of Dream hunters	-208.6 (30.9 m)	60.7 (0.62 rad)	2.7 (0.24 m/s)	54.0 (0.46 m)	59.6 (1.27 rad)	-351.7 (4.52 m)	78.3 (0.68 rad)	-43.6	20.15 m >15m
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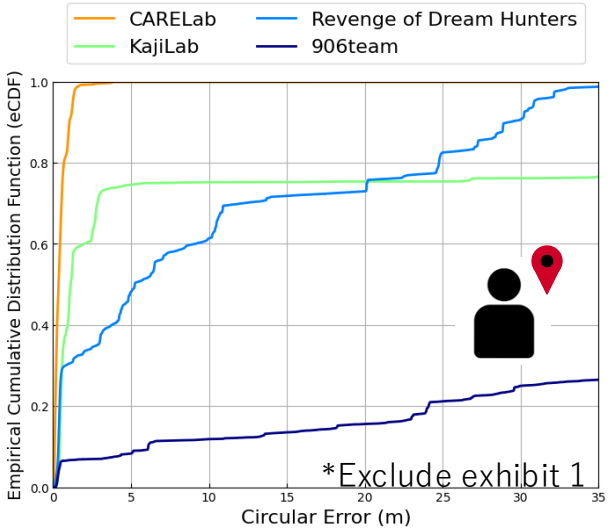
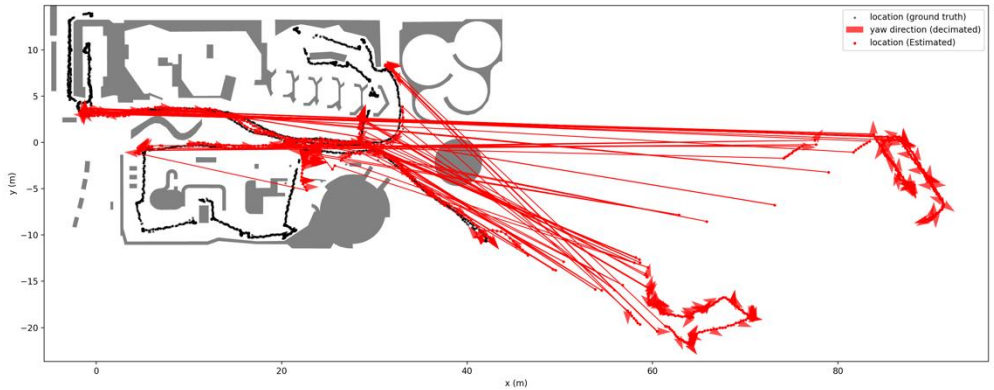
4	906 team	-2149.5 (225.0 m)	34.2 (1.03 rad)	-480 (1.45 m/s)	-4521.3 (46.2 m)	61.6 (1.2 rad)	-6359.0 (64.6 m)	46.2 (1.69 rad)	-1909.7	>45 m (3 times threshold)

Examples of results (scoring trial 1)



CARELab

KajiLab

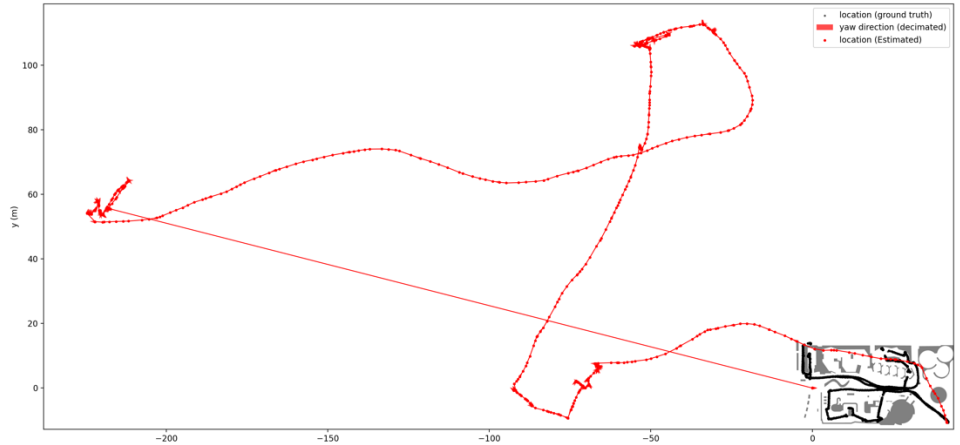


Revenge of Dream Hunters

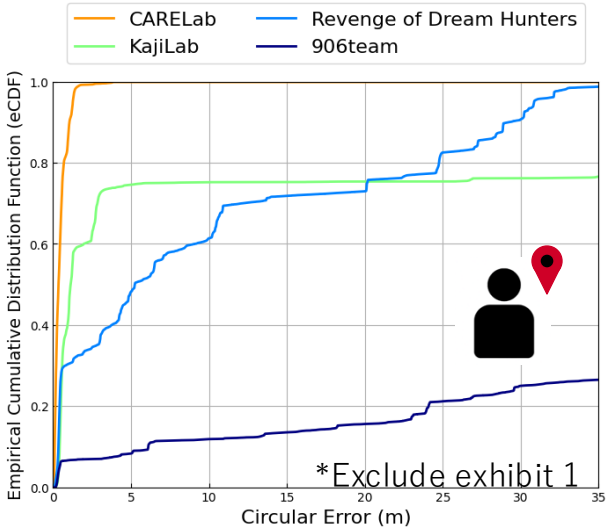
(failed to submit trajectory for scoring trial 1.

This result is a trial after the competition and shown for reference only)

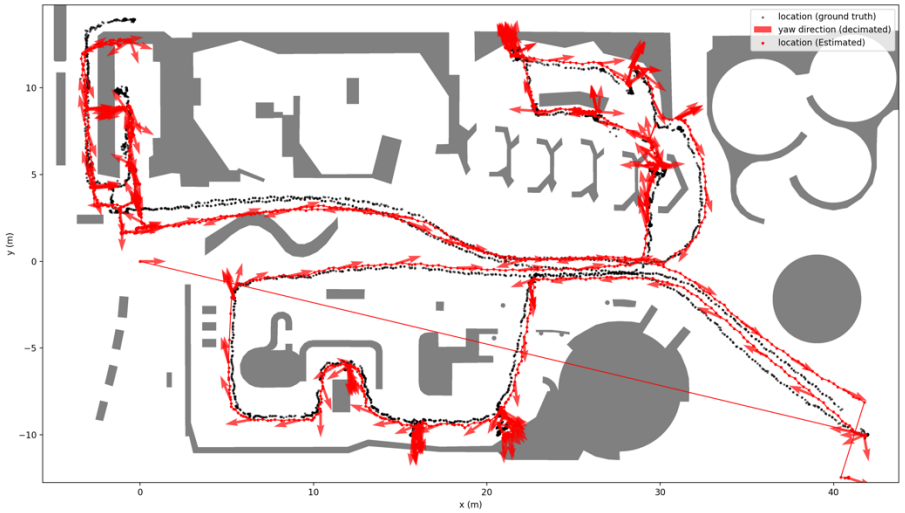
906 team



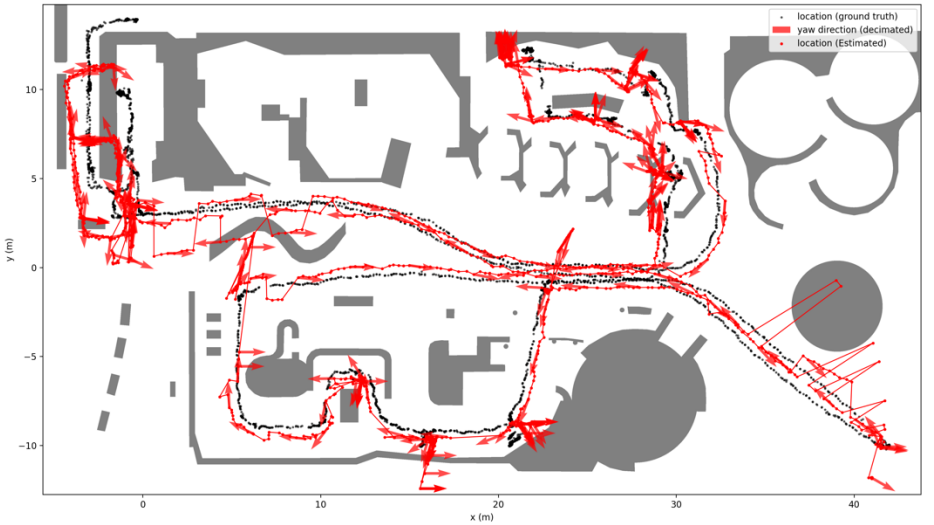
Examples of results (scoring trial 2)



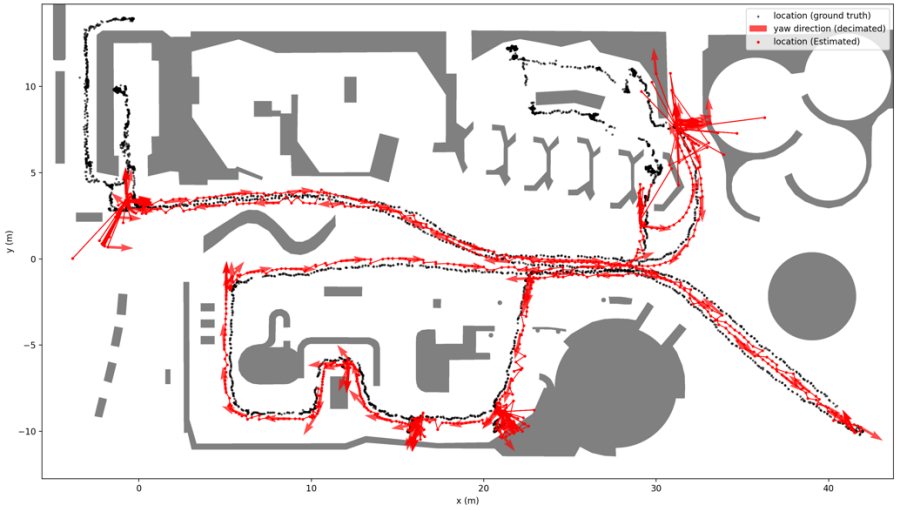
CARELab



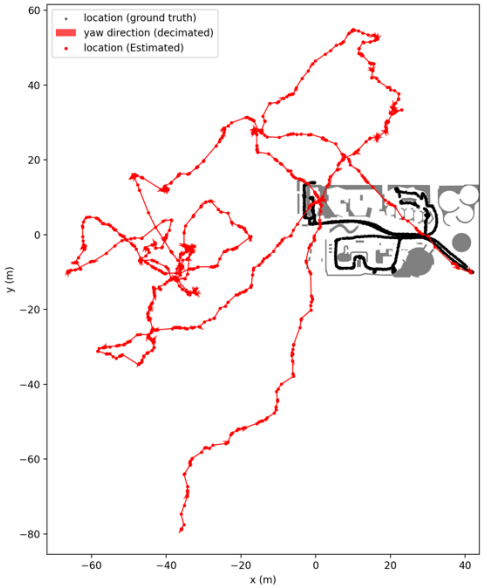
KajiLab



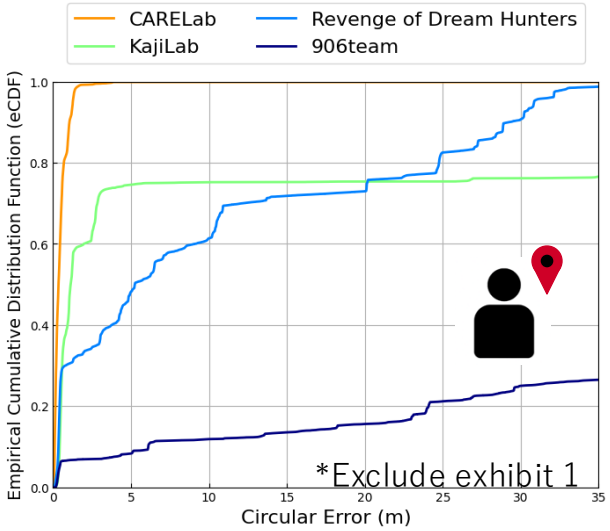
Revenge of Dream Hunters



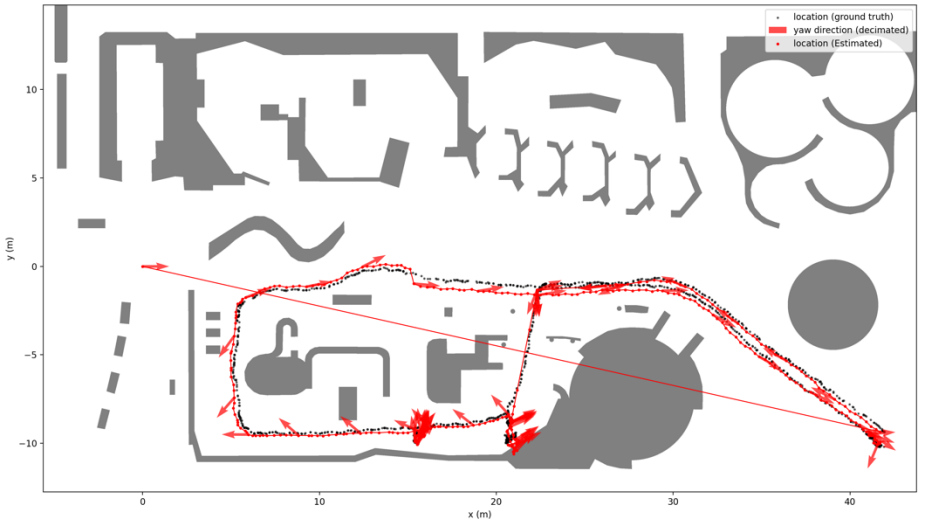
906 team



Examples of results (scoring trial 3)



CARELab



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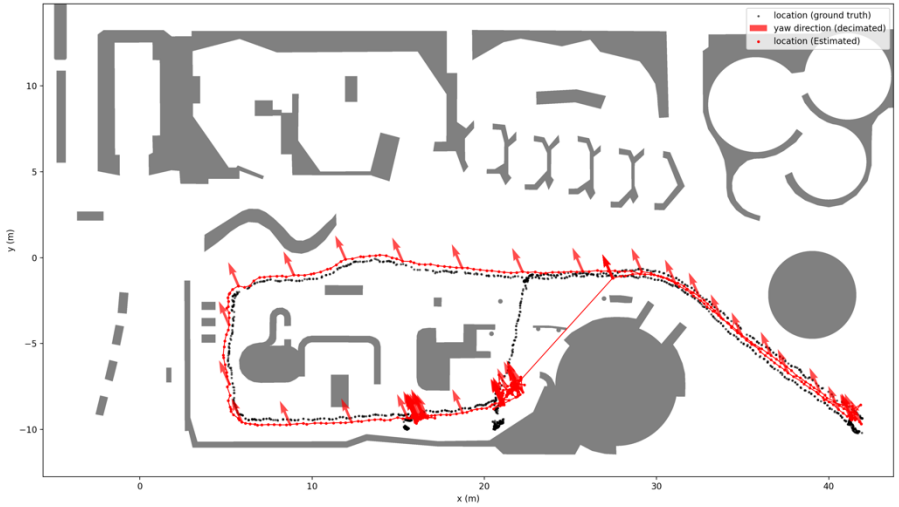
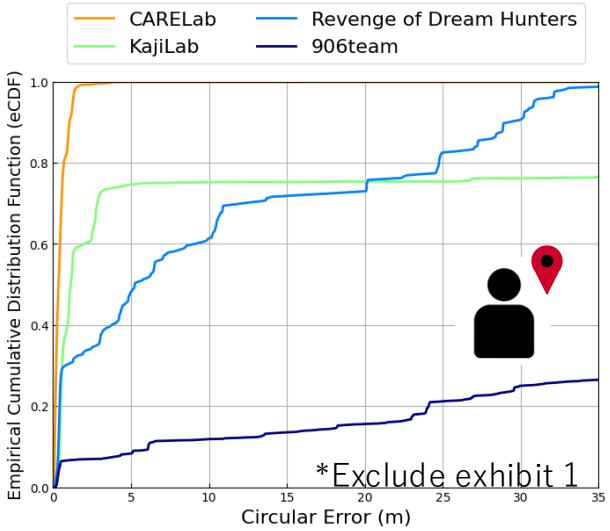
Revenge of Dream Hunters

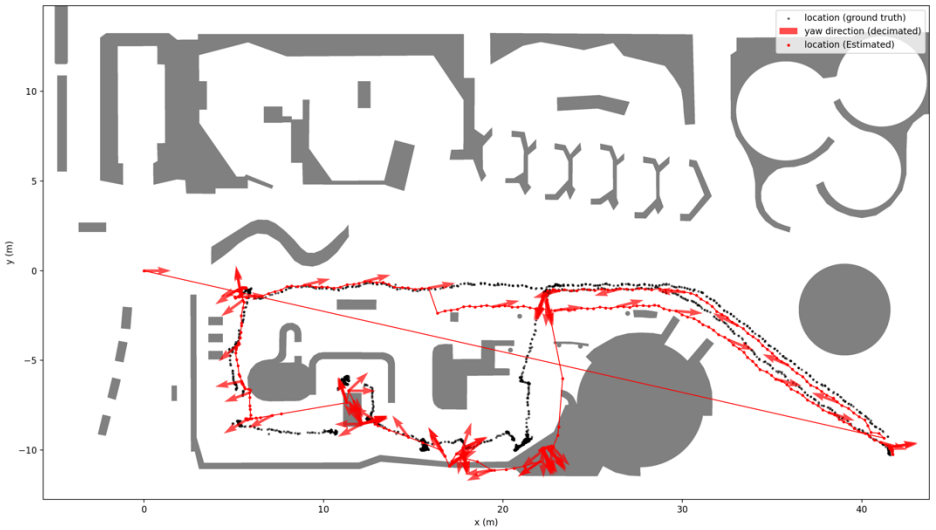
906 team



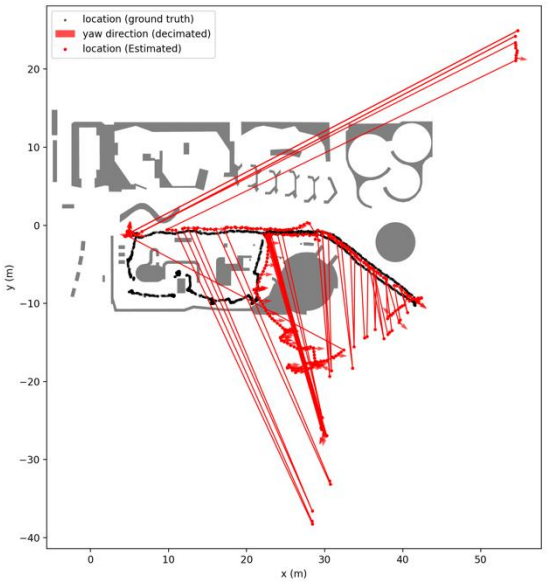
Examples of results (scoring trial 4)



CARELab

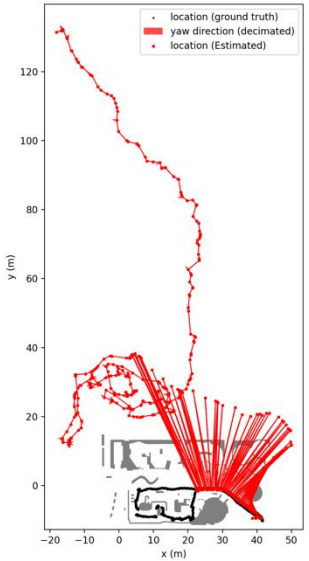


KajiLab



Revenge of Dream Hunters

906 team



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Congratulations

Track 5 winner

CARELab

Hideaki Uchiyama, Huakun Liu, Yutaro Hirao,
Monica Perusquía-Hernández, Kiyoshi Kiyokawa
NARA Institute of Science and Technology