Center for Service Research

National Institute of Advanced Industrial Science and Technology
AIST

MR Models for Practical Evidence-Based Services

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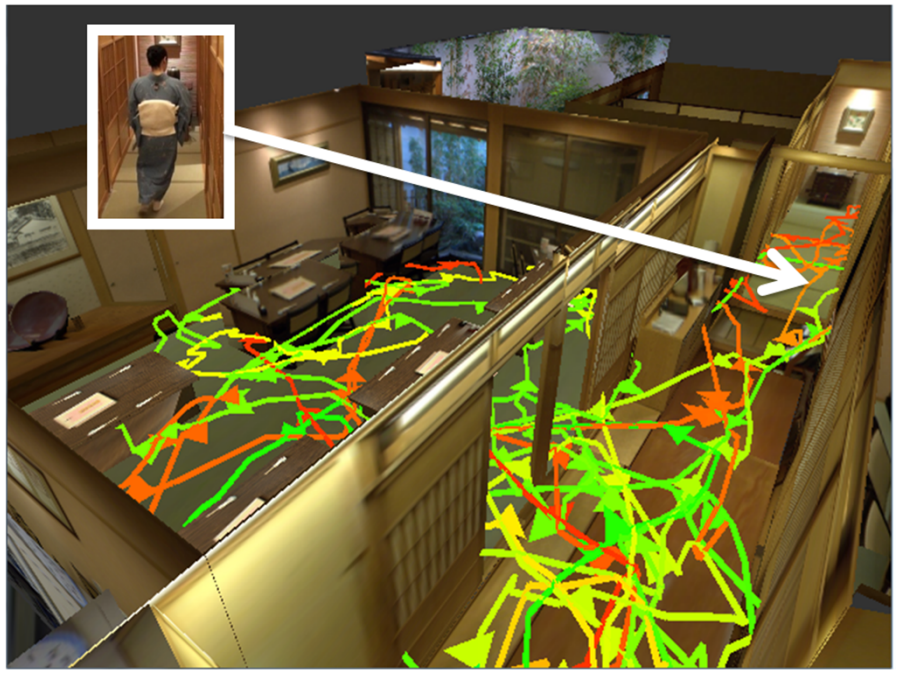
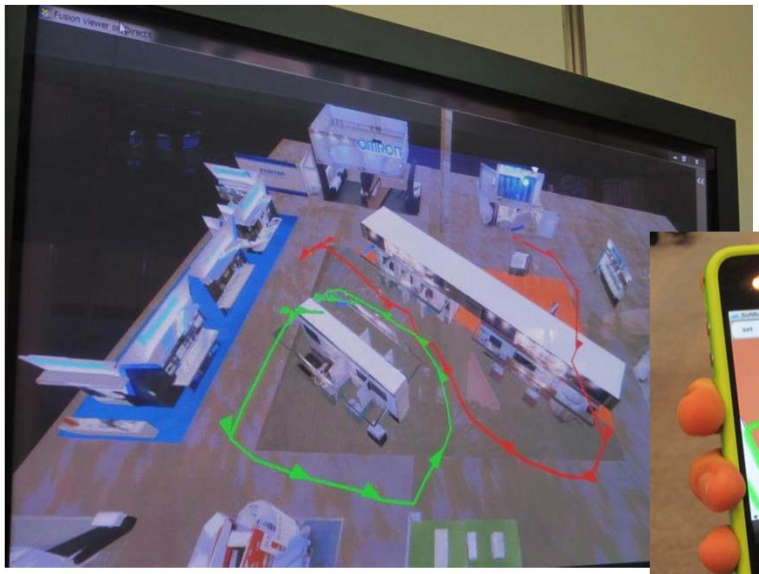
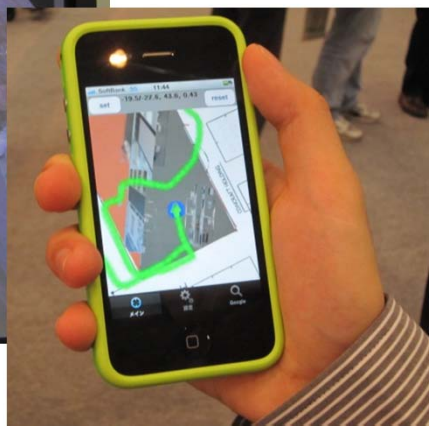






Indoor Pedesterian Navigation @ISMAR2009, Orlando FL

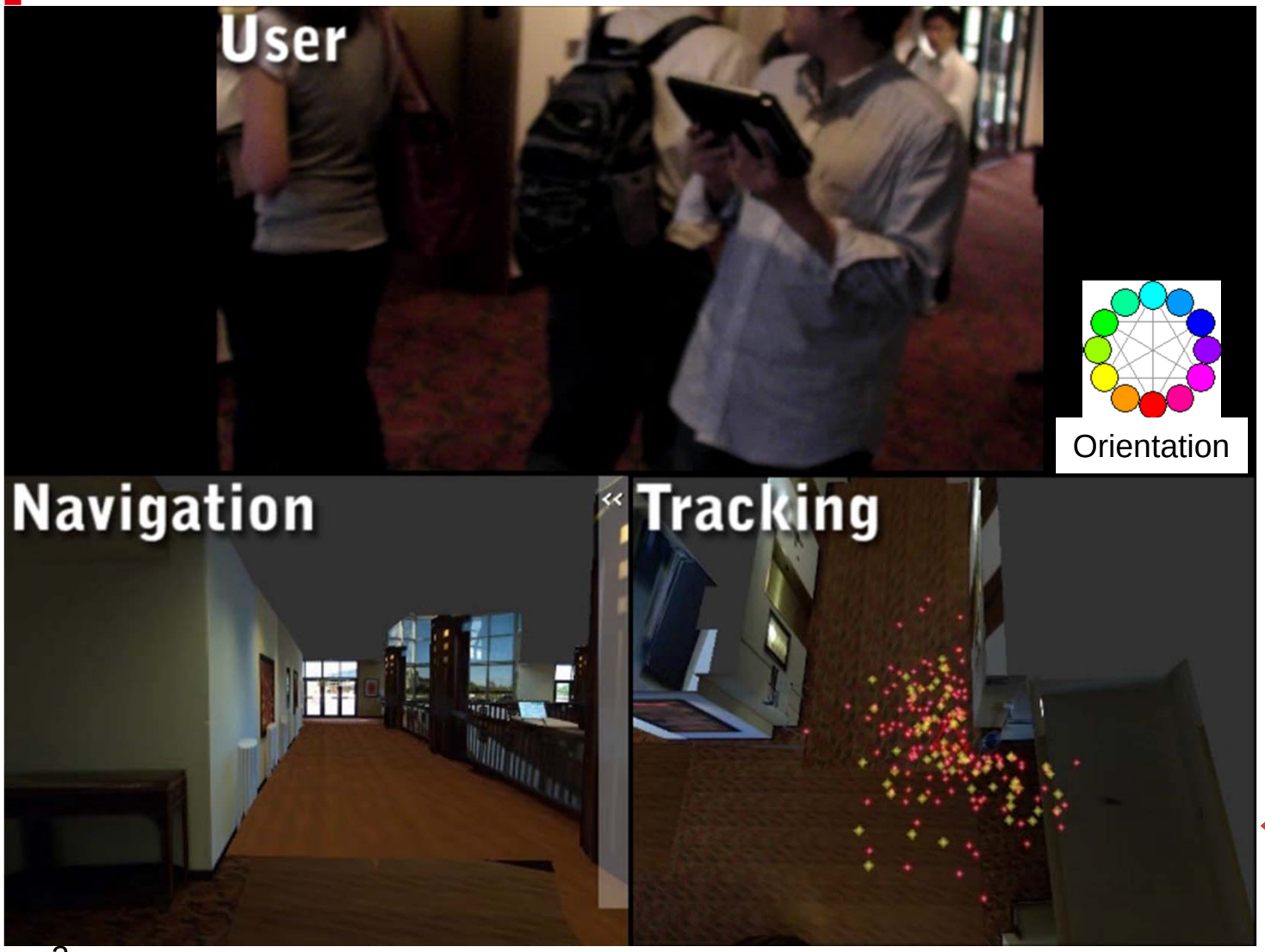
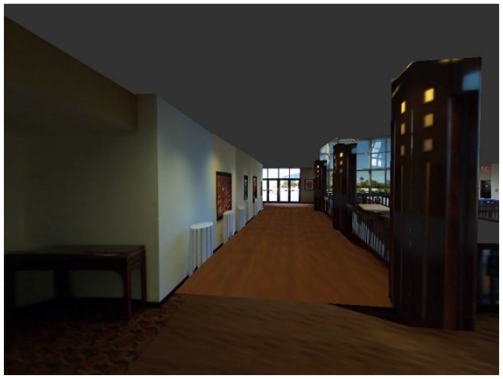


Photo taking the day before demo

Model authoring with interactive modeler



For navigation content and map matching

PDR（Pedestrian Dead-Reckoning）

Estimates velocity vector, relative altitude, and actions by measurements from waist-mounted sensor module.

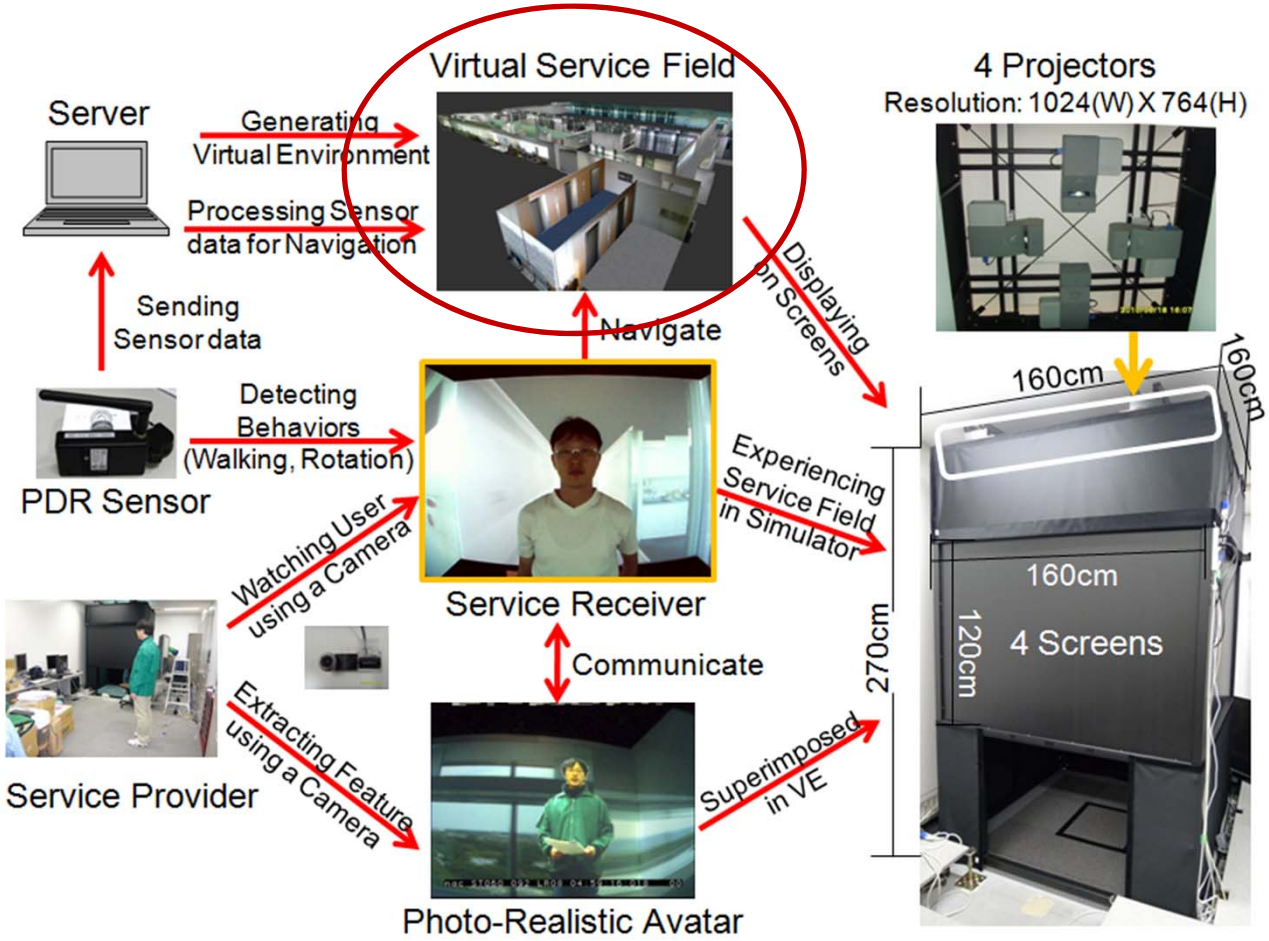
- Wearing sensor module on waist
  - ✓ Easy to wear and maintain
  - ✓ Easy to measure data for action recognition
  - ✓ Relatively easily to apply for handheld setting compared to she-mounted PDR based on Zero Velocity Updates (ZUPTs)
- Recognition of walking locomotion
  - ✓ Low-cost sensors

Sensor module
- Accelerometers
- Gyro-sensors
- Magnetometers
- Barometer

M. Kourogi and T. Kurata, “Personal Positioning Based on Waling Locomotion Analysis with Self-Contained Sensors and a Wearable Camera”, ISMAR2003, pp. 103-112, 2003.

Service-Field Simulator (SFS)

- Repetition of locomotion on foot and relatively simple work is one of the most frequently occurring situations in daily lives and services.
  - The subject moves to some destination while holding a map or a handheld device, and sometimes talks with employees, etc.,
- Omni-directional Service-Field Simulator (SFS): Reproduce such situations in the lab within reasonable costs.



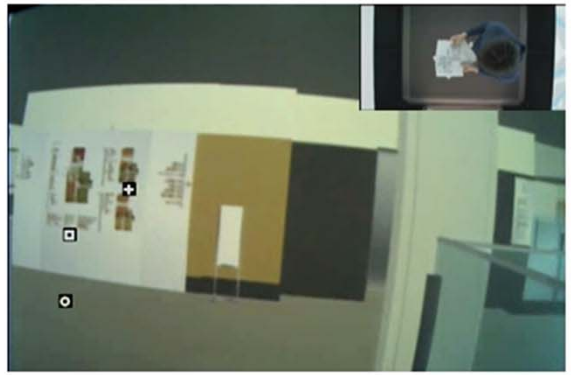
A. Park, et al.,ISVC2009 (Formerly WFS (Walk-Through Simulator)), J. Hyun, et al., ICAT2010

Features of SFS

- Preservation of sense of absolute orientation (prevention of VR sickness)
- Hands-free control by footfall, and body rotation
- Verbal/Non-verbal communication with others by photo-realistic avatars
- convenience of duplication by compact and ease mechanism

SFS with Eye tracker

Taking an escalator



Seeing a signboard

Confirming destination with a map

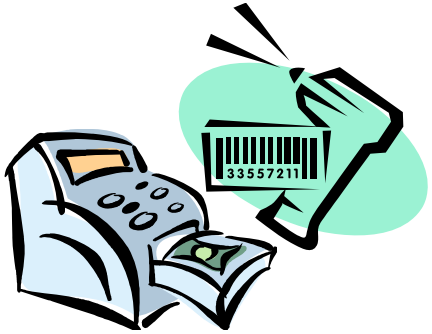
Talking with a photorealistic avatar

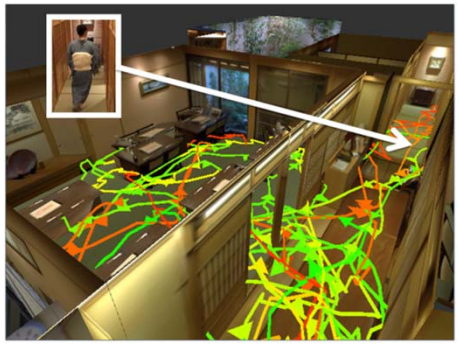
Towards Evidence-Based Service (EBS)

- EBM, EBH, EBP
  - Evidence-Based Medicine/Healthcare/Practice
  - Propounded in Canada and the US in 1991~92, and gradually became widespread.
  - UK National Health Service (NHS)
    - Administrative Decision Making: Which health-care service should be invested? (Related to governmental financial issue)
    - Individual Decision Making: Which medical care should be chosen for each patient? (From the limited knowledge to the current best knowledge)
    - The Cochran Collaboration was established in 1993 and became expanded all over the world.
- The Cochran Collaboration and Cochran Library
  - Updating Systematic reviews on randomized controlled trials (RCT).
  - Promoting the accessibility of the library.

Post POS?!

- Real-virtual correspondences of products with POS (Point-Of-Sales) systems
  - Facilitate modeling and designing the flow of the products by not strongly relying on tacit knowledge.
  - Brought about drastic changes in retail, chain restaurant, logistics, etc.
  - Realized EBS to some extend.



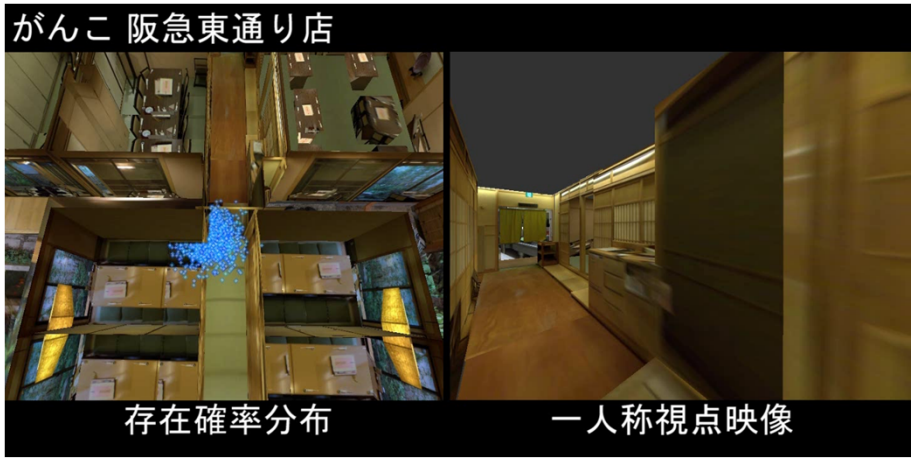


- On the analogy…
- One of the next key issues for service innovation

→ How to Make better correspondence between customers/employees/service processes/environment and the computerized ones.

MR for EBS

- MR technology has the potential to realize EBS (Evidence-Based Service) if we can make MR technologies more practical. =>> Post POS!
- One of the key components of success is whether MR models including 3D geometry and semantic models can be obtained, utilized, and circulated considering the balance of efficiency and effectiveness in terms of cost, accuracy, and the other benefits.



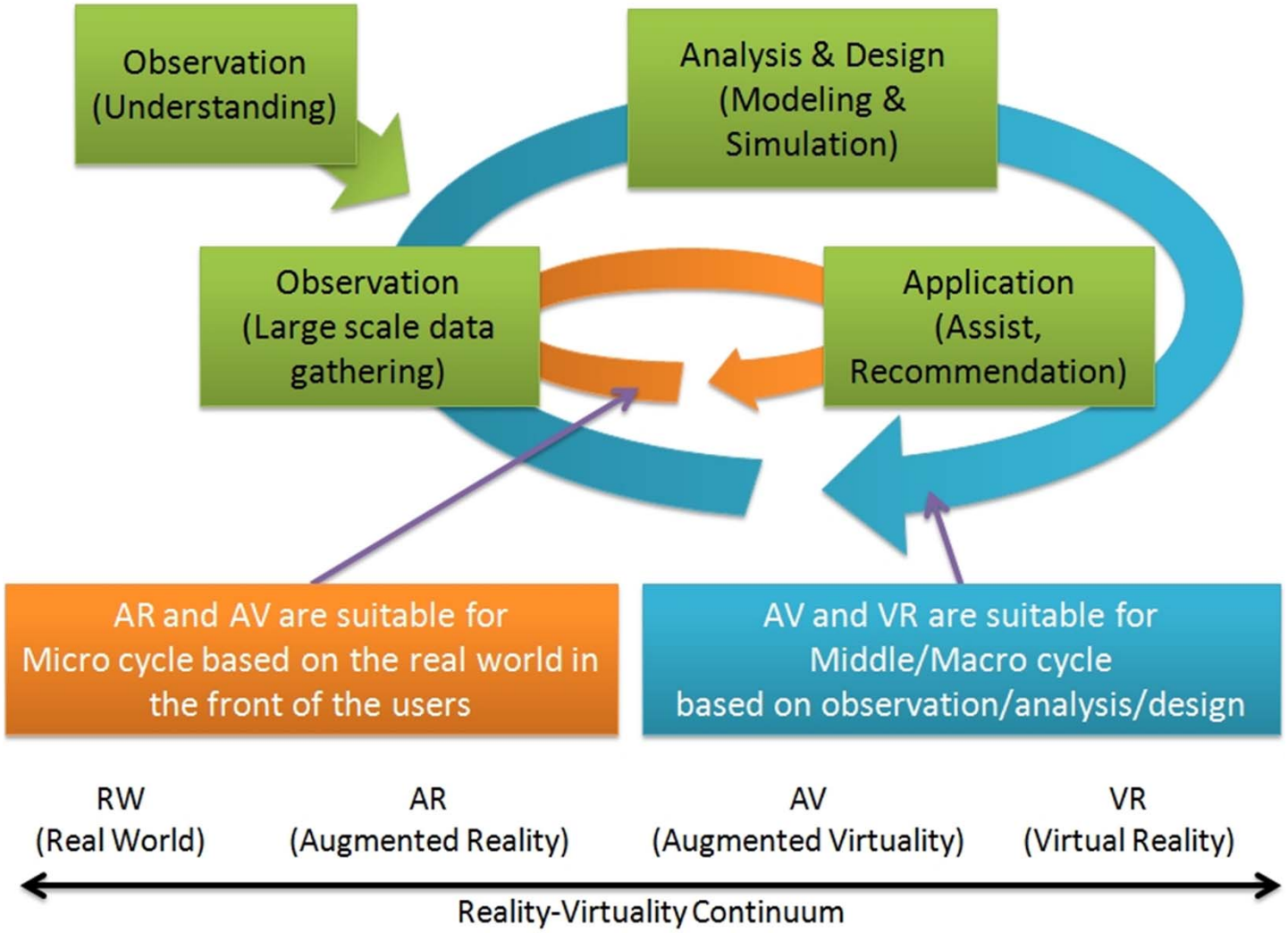
What is MR (Mixed Reality)?

- Comprehensive technical field that addresses not only virtualization of real-world entities such as human, object, and environment, but also information presentation by considering the following consistency according to its necessity;

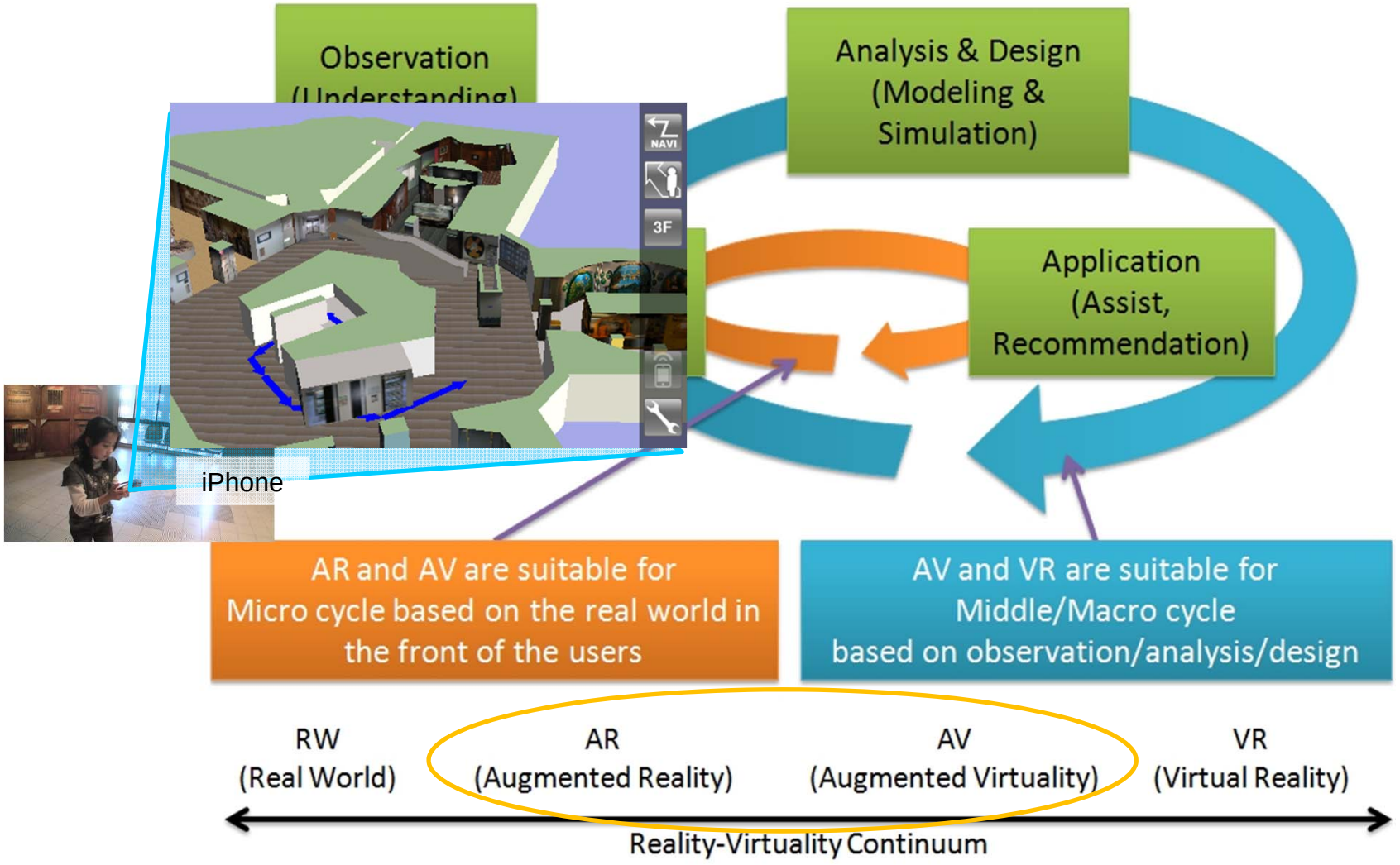
Consistency of real-world entities and virtual entities in terms of

- Geometrical aspect
- Optical aspect
- Temporal aspect
- **Semantic aspect**

Continuum of MR along with Service-Design Cycle



Continuum of MR along with Service-Design Cycle



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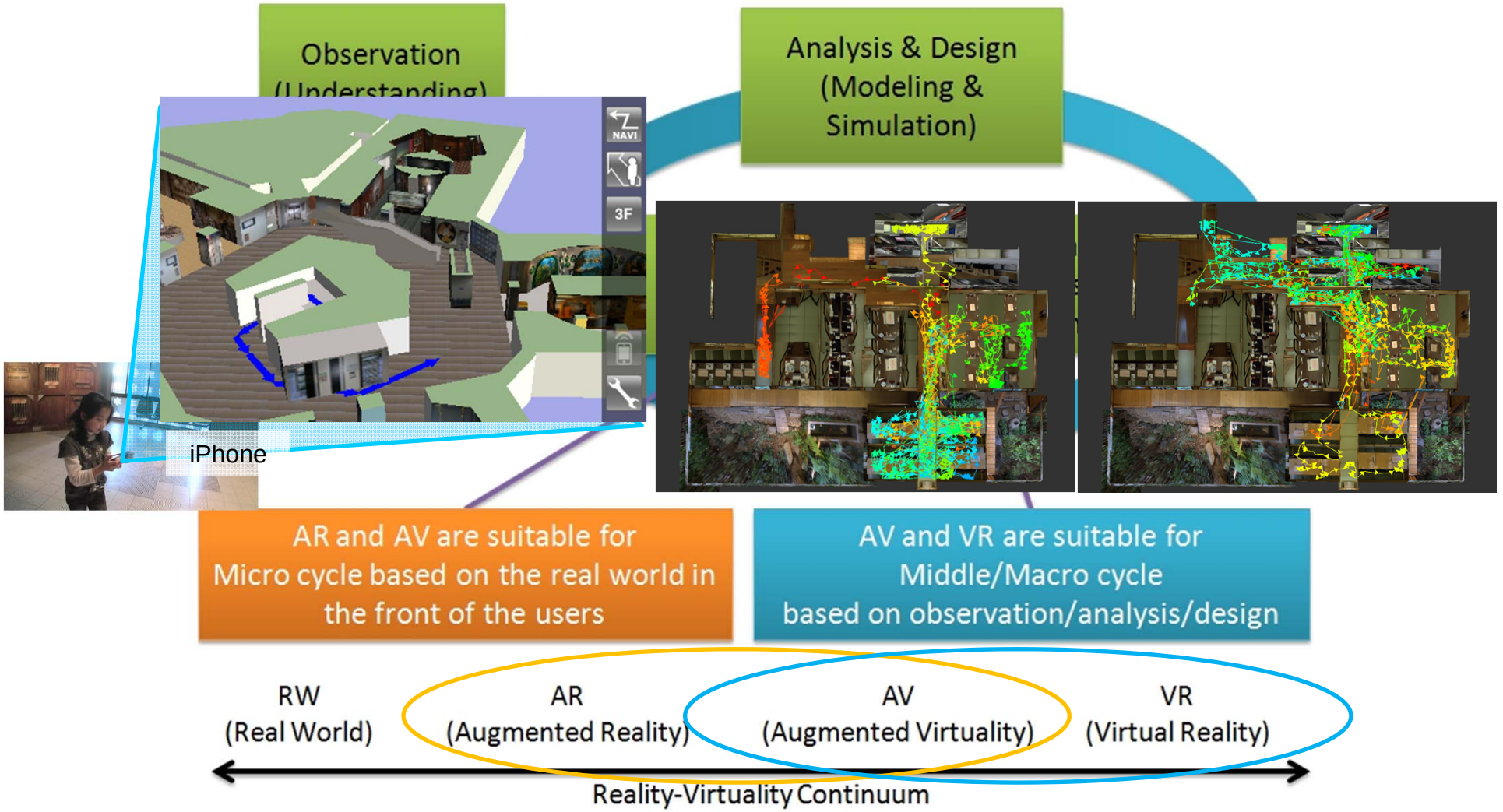
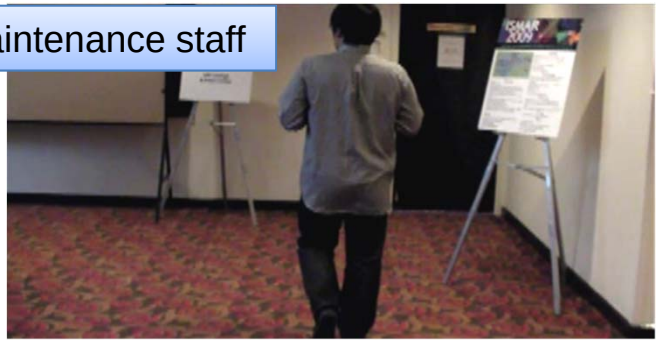
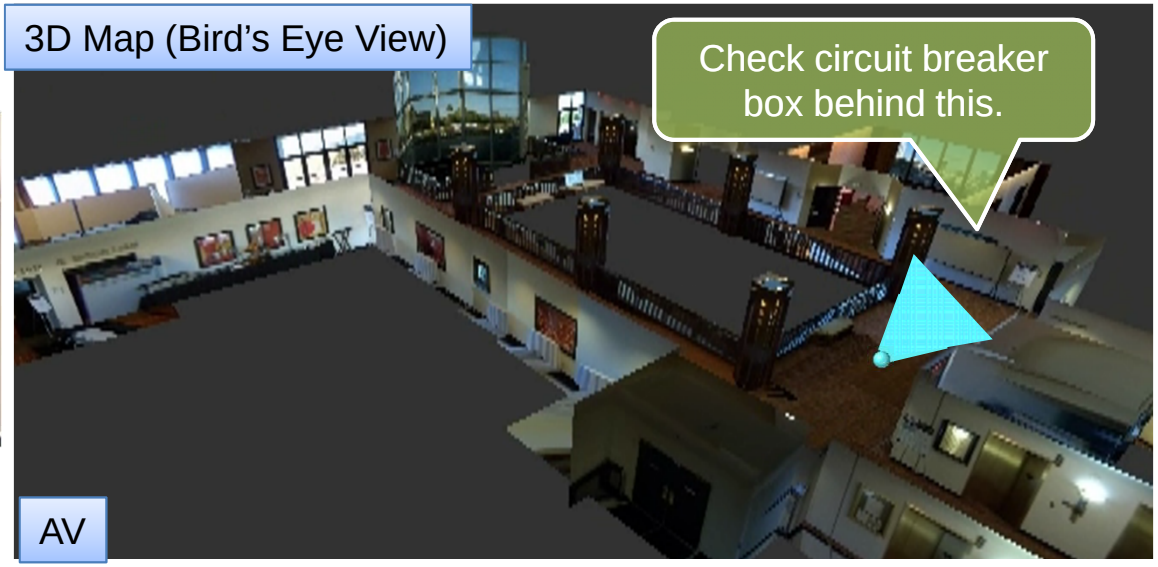


AR or AV?

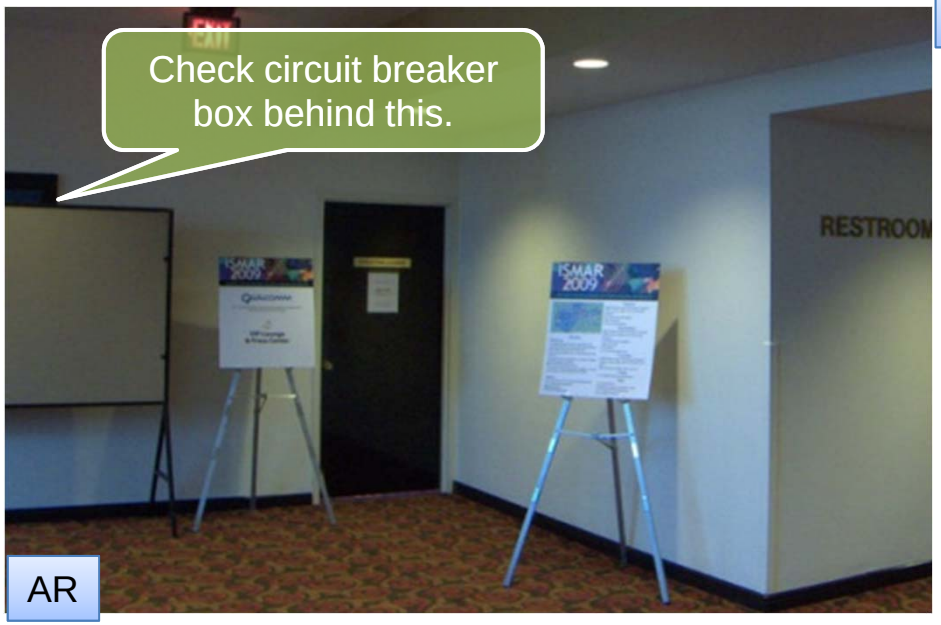
Maintenance staff



3D Map (Bird's Eye View)

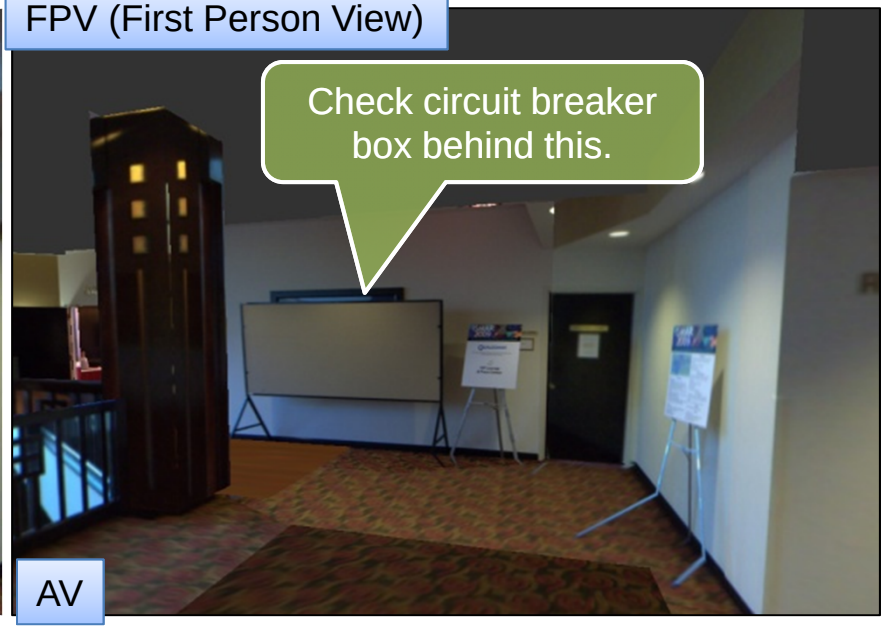


AV



AR

FPV (First Person View)



AV

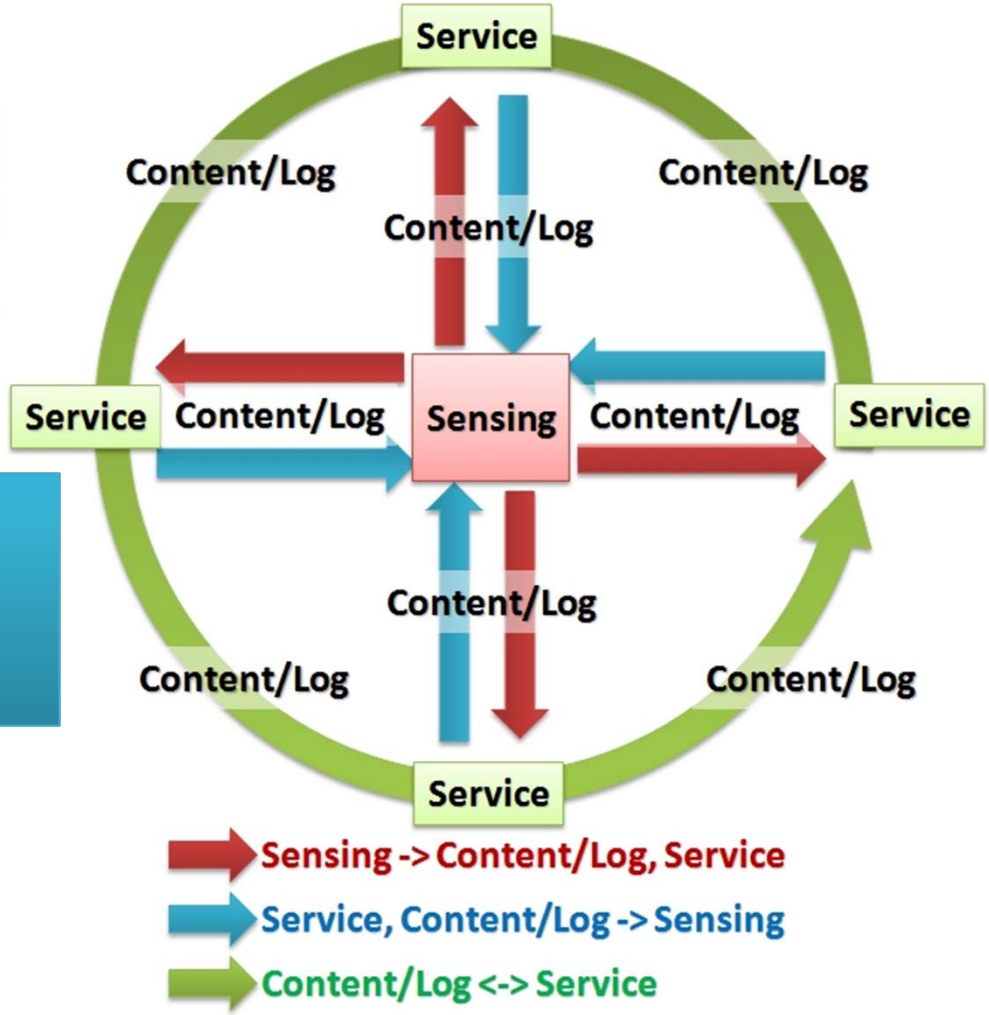
To make MR widespread

Establish an efficient framework on
MR model/Information sharing and service cooperation in which

Real-world sensing contributes the efficiency of service operation, content gathering and authoring.

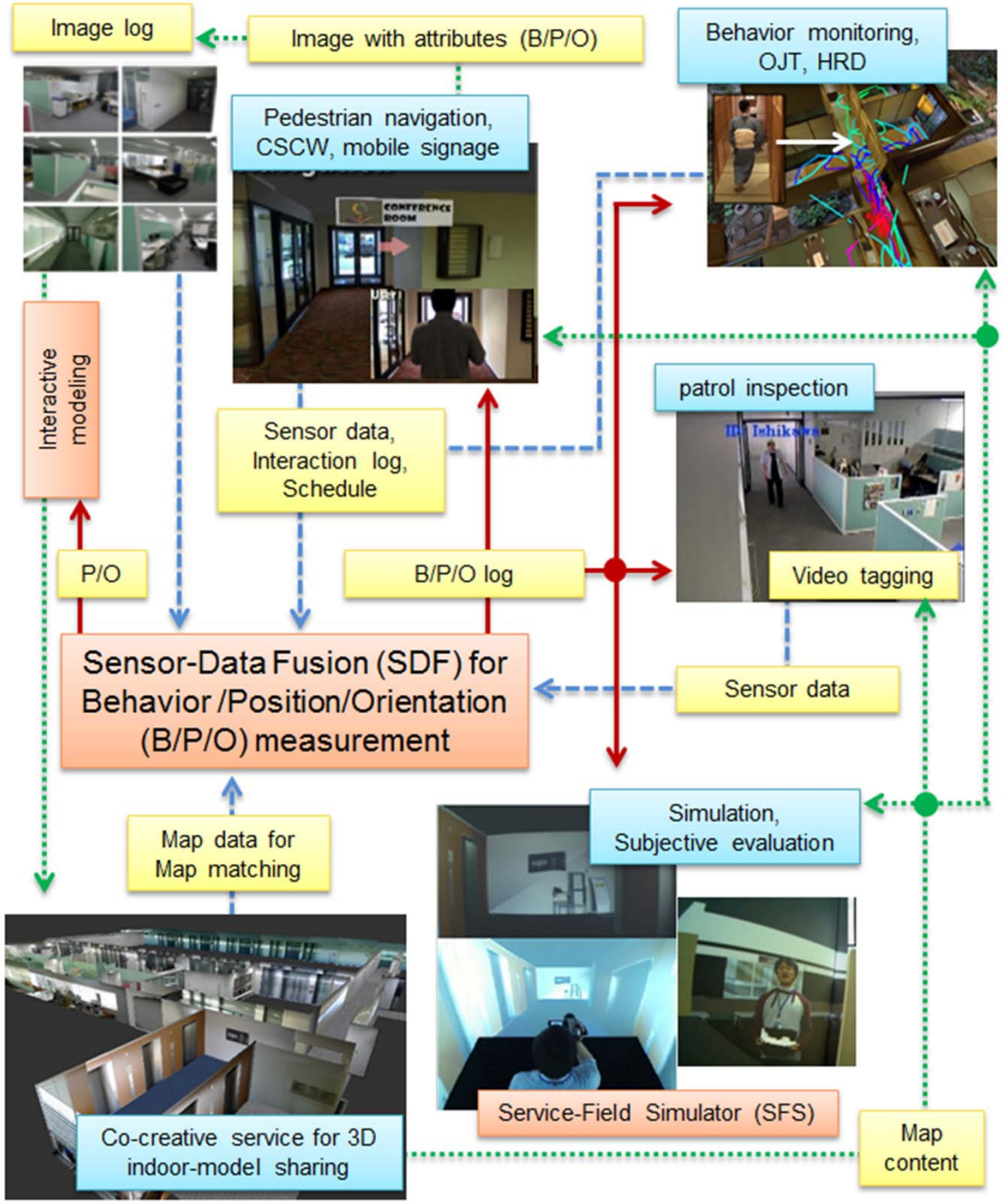
Digital content and service operation log improve the performance of real-world sensing.

MR Models
act as a medium.



Example of MR information-sharing framework

This talk: Introduce our own works relevant to MR for EBS such as interactive indoor modeling, pedestrian navigation, patrol inspection, behavior analysis and service redesign.

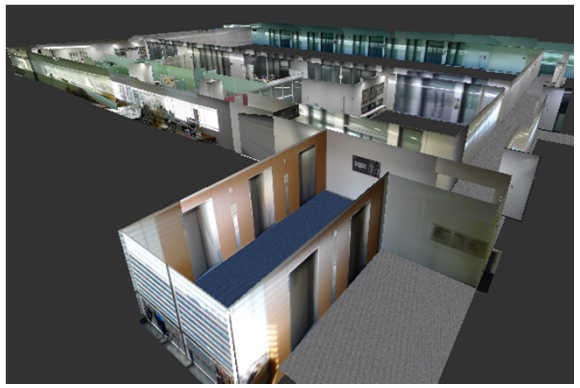


T. Kurata, M. Kourogi, T. Ishikawa, J. Hyun and A. Park: "Service Cooperation and Co-creative Intelligence Cycles Based on Mixed-Reality Technology", INDIN2010

In-situ interactive indoor modeling from multiple photos

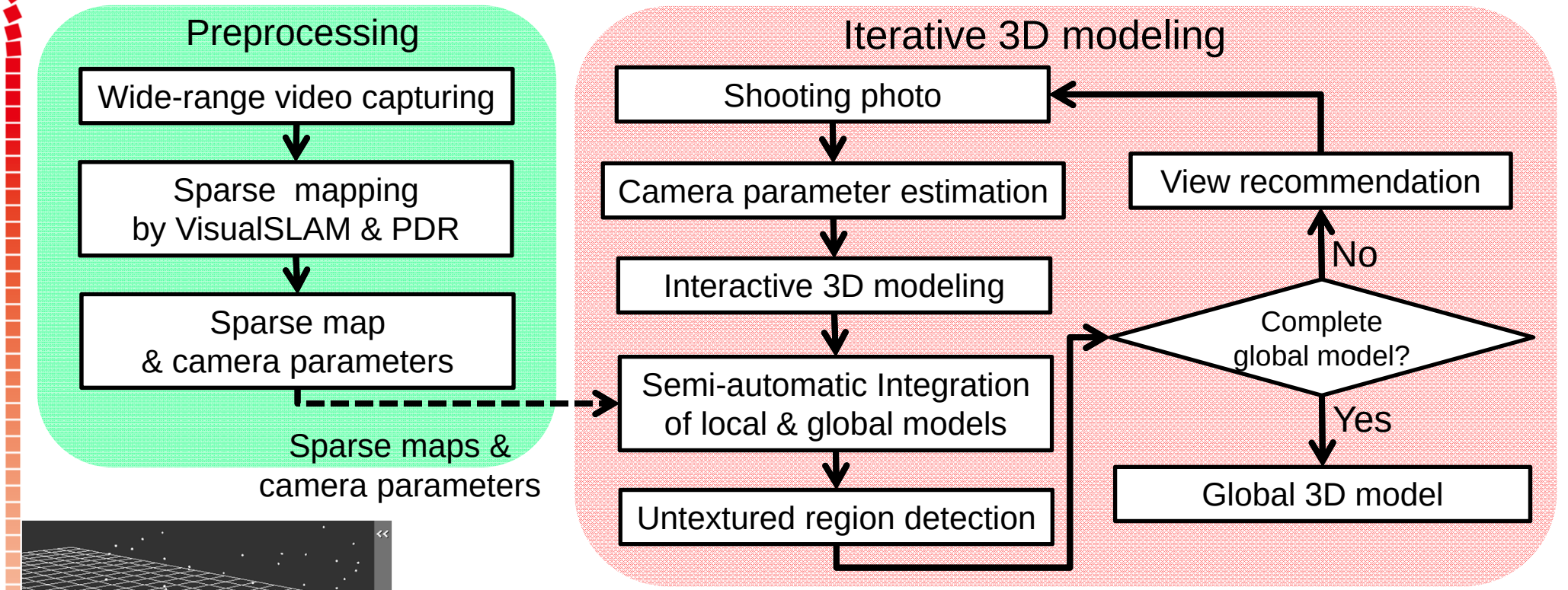
- ✓ Local modeling from single photo with geometric constraints
- ✓ Semi-automatic integration for creating large indoor models
  - Using location information from VisualSLAM and PDR
- ✓ View recommendation for capturing untextured regions
  - Untextured region detection by photos and created models
  - Intuitive presentation of untextured regions and user's location
- ✓ Inpainting for untextured regions

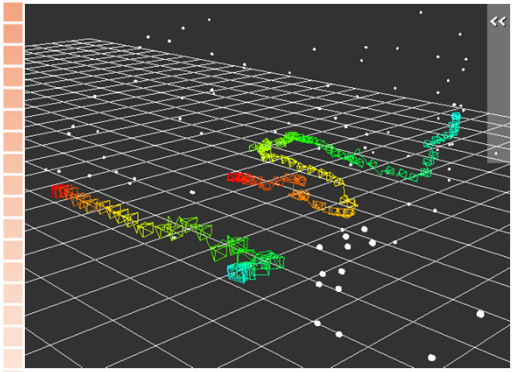
Interactive 3D modeling

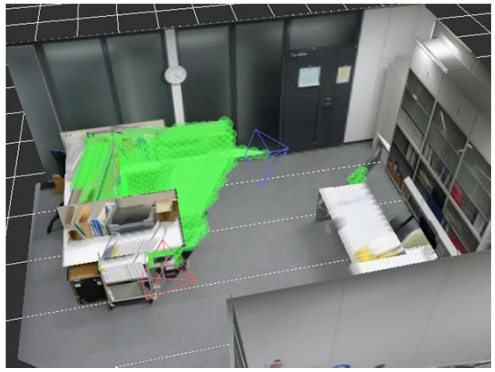


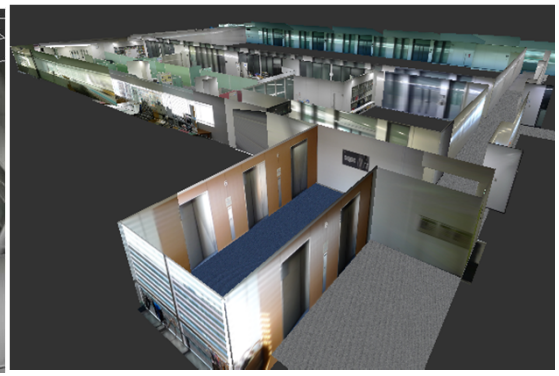
T. Ishikawa, K. Thangamani, M. Kourogi, A. P. Gee, W. Mayol, K. Jung, and T. Kurata, "In-Situ 3D Indoor Modeler with a Camera and Self-Contained Sensors", In Proc. HCII2009, LNCS 5622, pp. 454-464, 2009.

Overview of 3D Indoor Modeler









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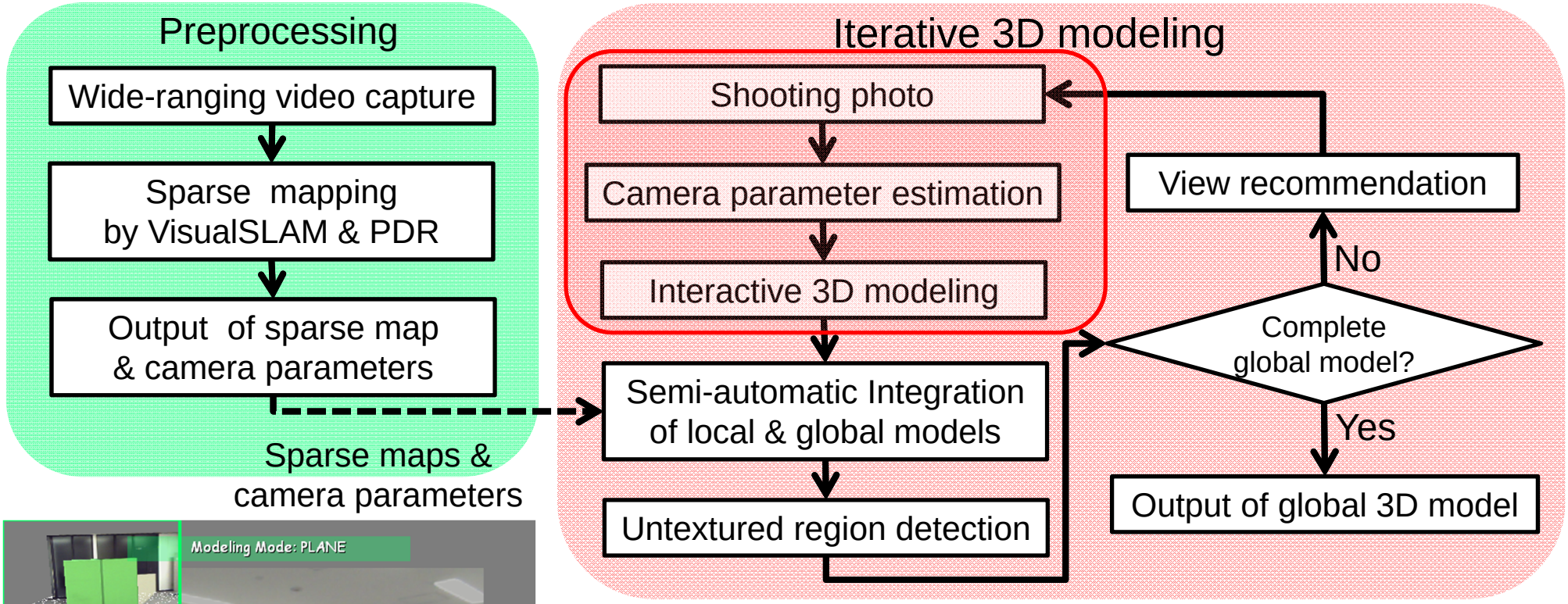

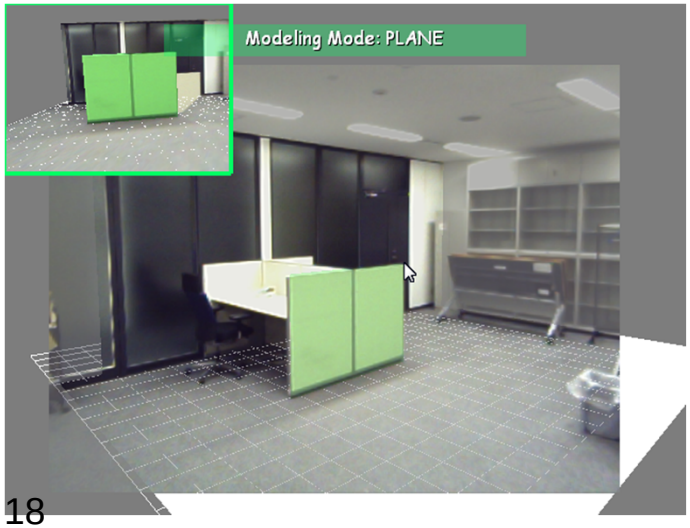

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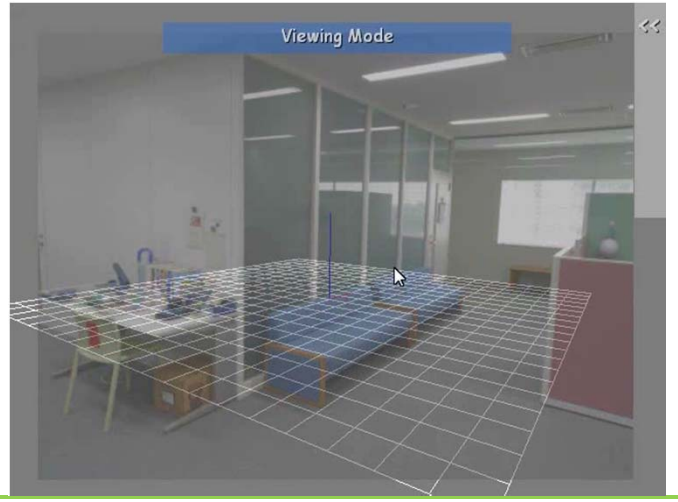
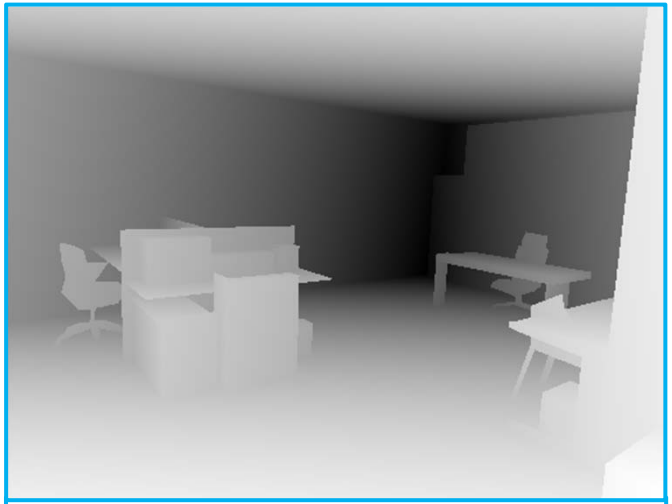
Local Modeling from Single Photo

Input : Indoor photo

Camera-parameter estimation



Interactive modeling & checking

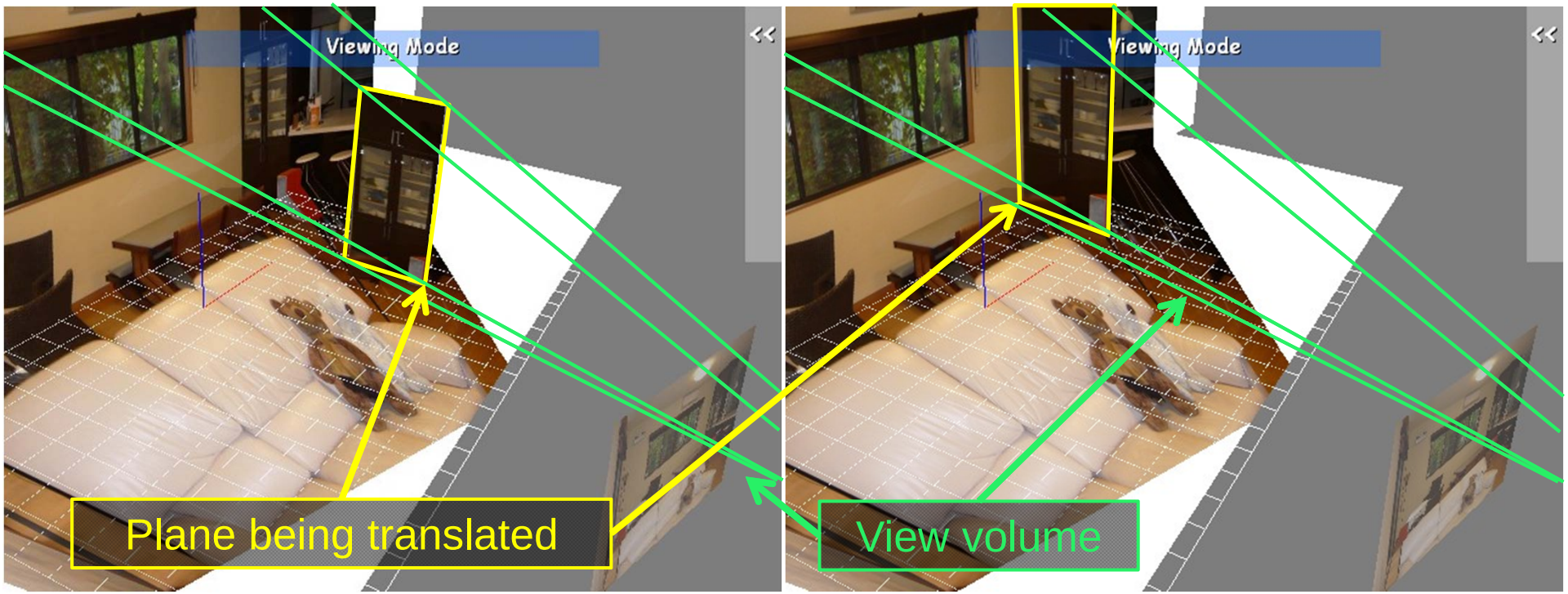


Output : 3D indoor model

Plane manipulation with geometric constraint

Manipulations to keep 2D shapes projected onto photo

- Depth adjustment
- Normal adjustment



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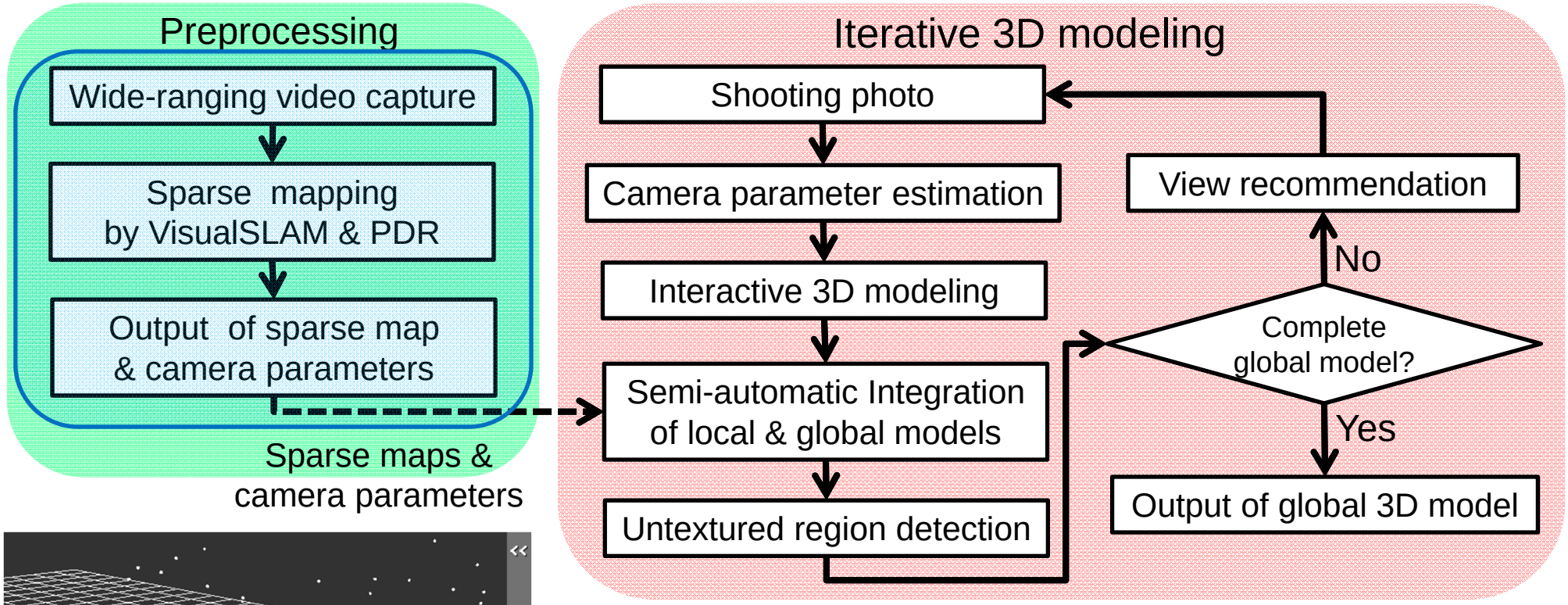
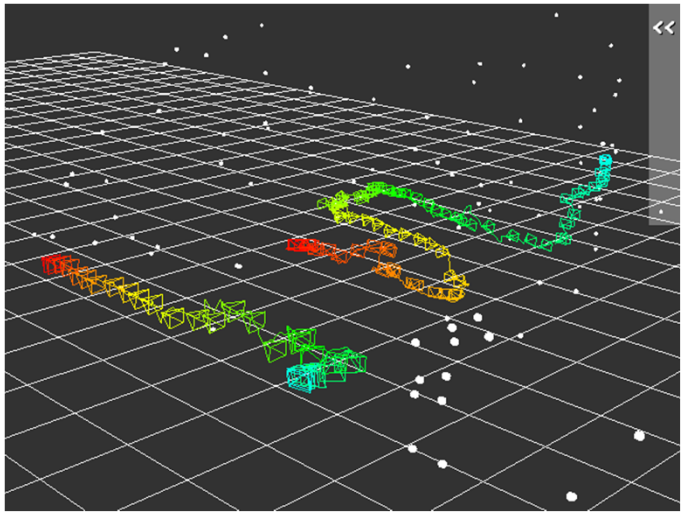
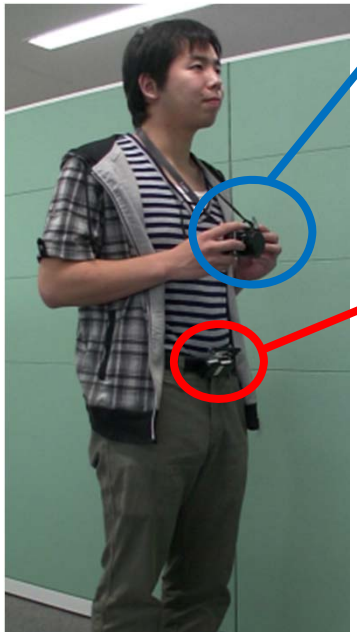




Sparse Mapping by VisualSLAM & PDR

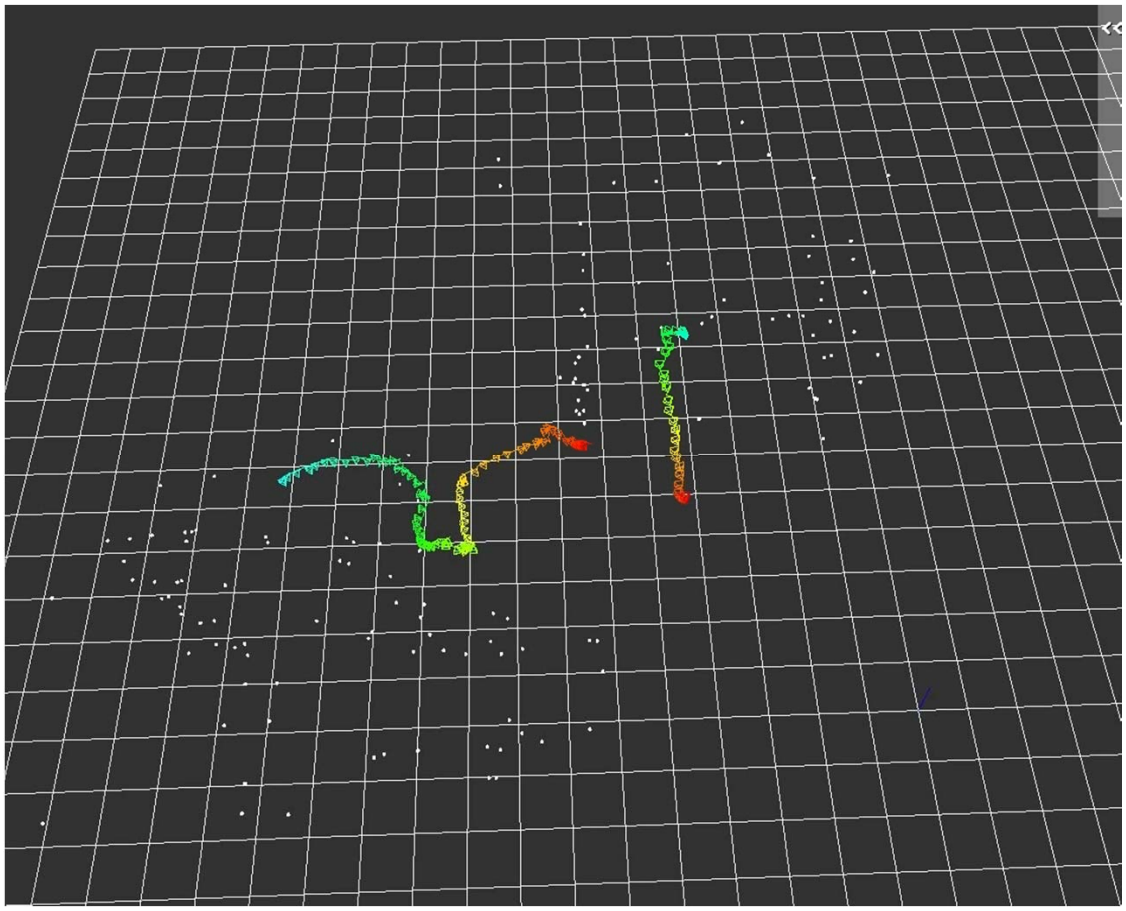


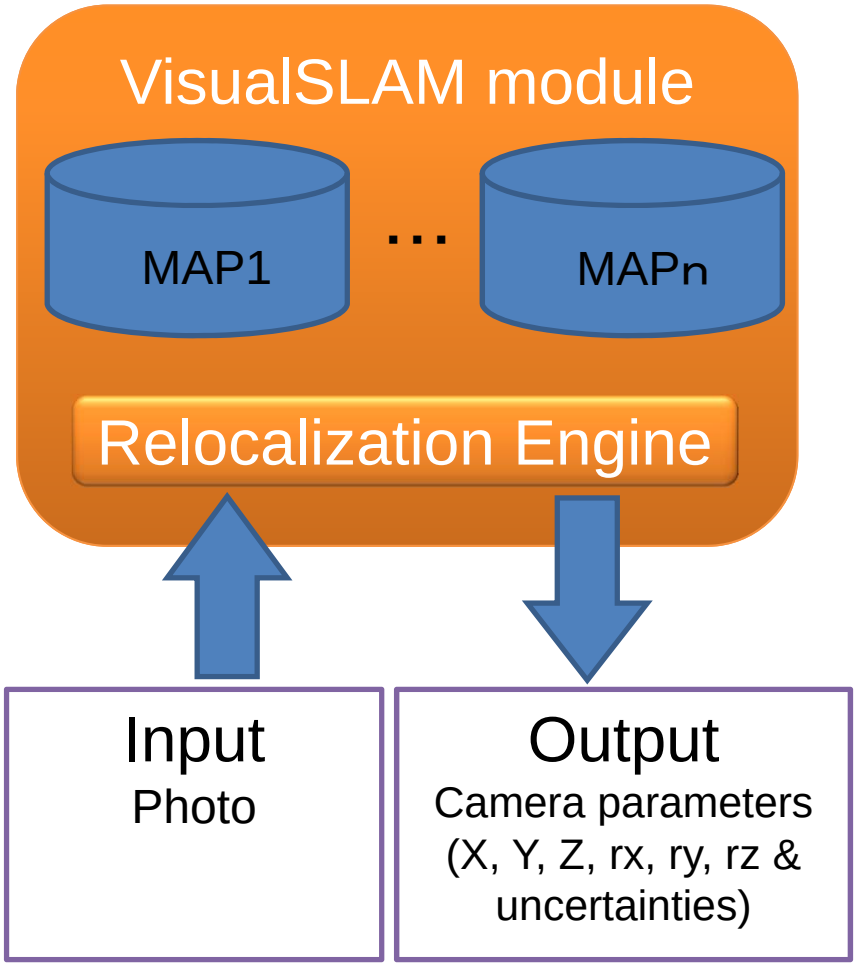
Camera
- Panasonic LUMIX DMC-LX3

Sensor module
- Gyro sensor
- Accelerometers
- Magnetometer

- VisualSLAM (simultaneous localisation and mapping)
  - Camera parameters (with uncertainties) and sparse point cloud
  - Suitable for smooth in-situ modeling by quick mapping
- PDR (pedestrian dead-reckoning) based Nabigation
  - Position and orientation in global coordinate system
  - Relatively stable and sustainable

Example of Estimated Sparse Maps





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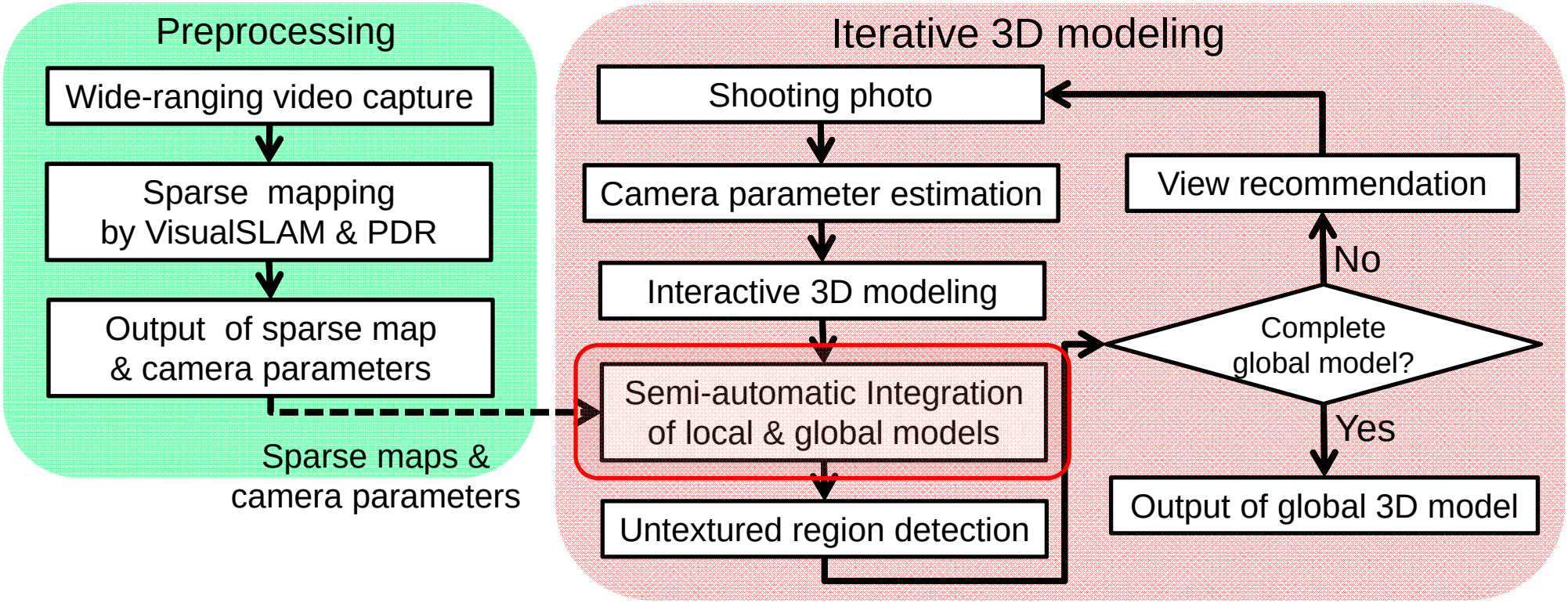
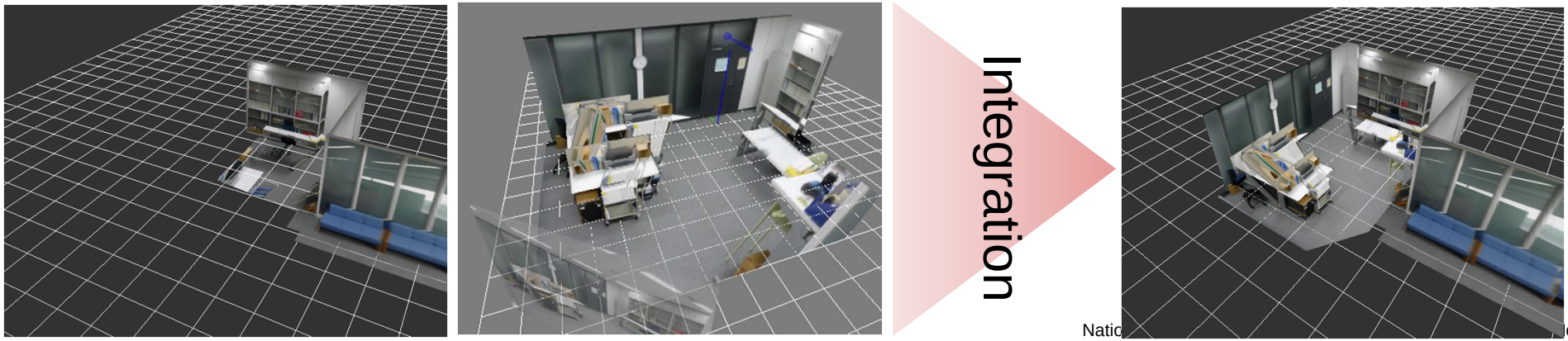
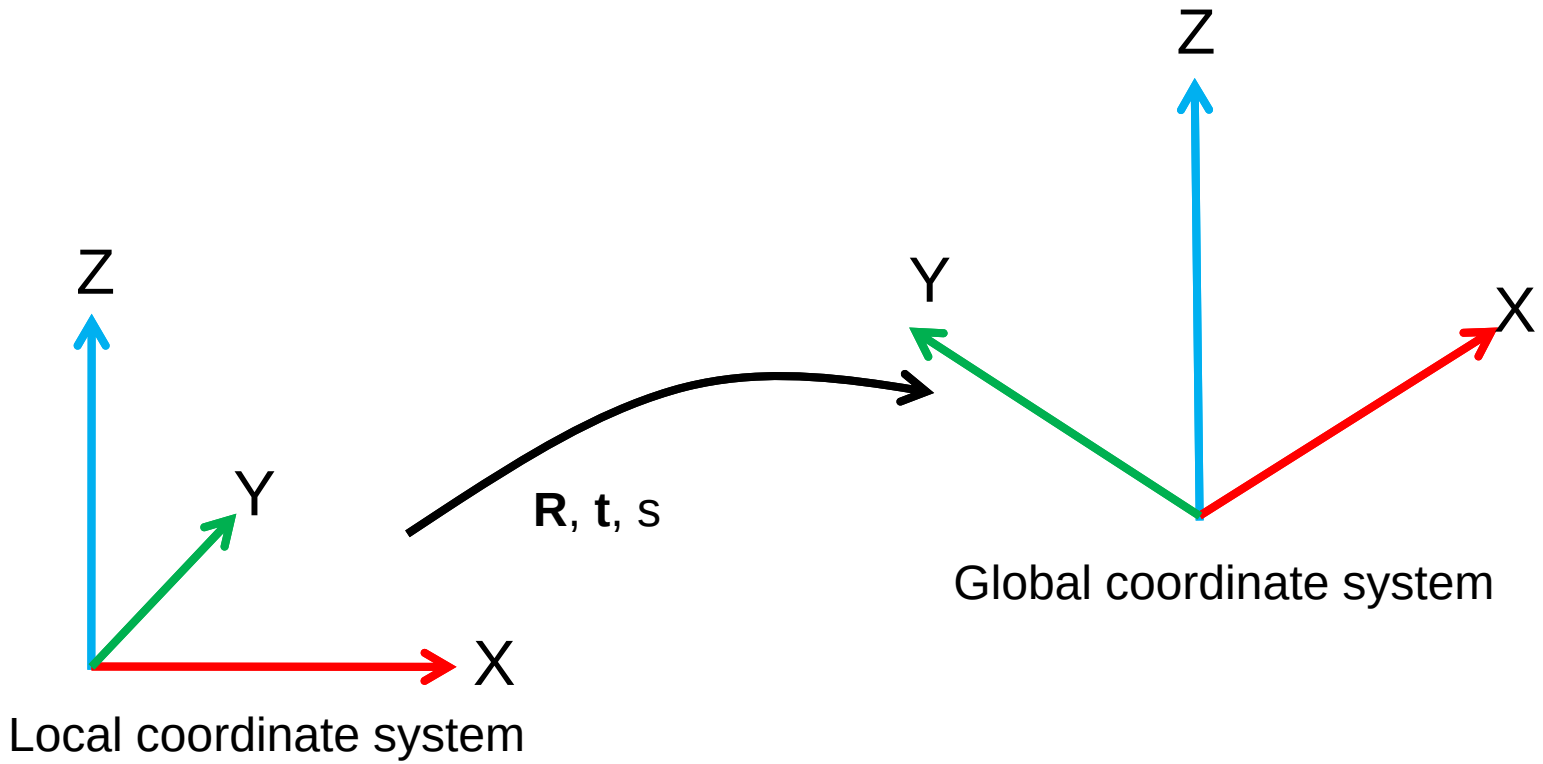




Semi-Automatic Integration

Integration process for estimating transform parameters

- **First stage:** Automatic function by relocalization and image feature matching
- **Second stage:** Manual function with geometric constraints



Semi-Automatic Integration -First Stage-

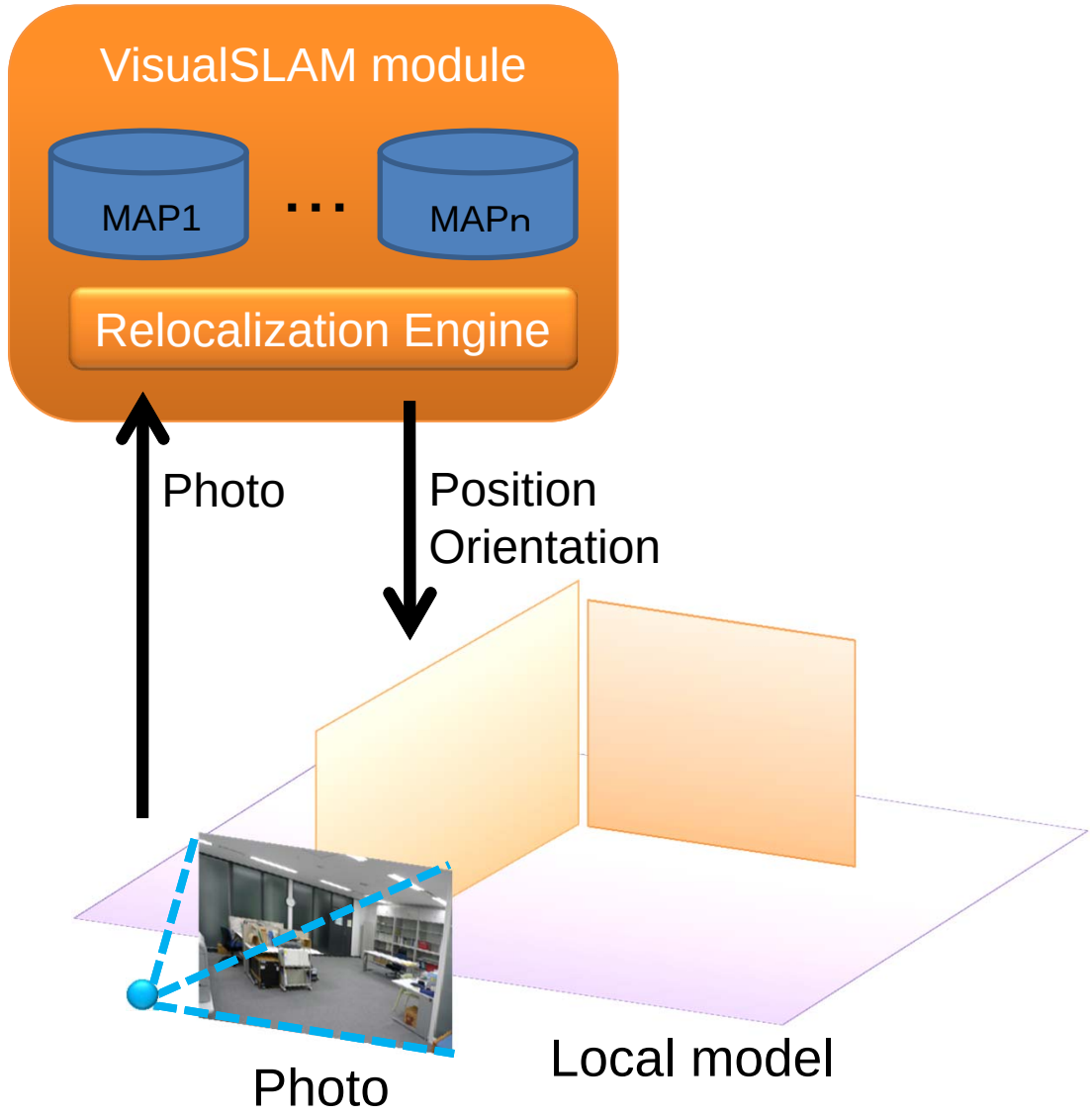
First stage

Position estimation of local model by relocalization and PDR

Image feature matching between local model and nearest model

Converting into 3D point correspondences

Estimation of transform parameters (**R**, **t**, s)



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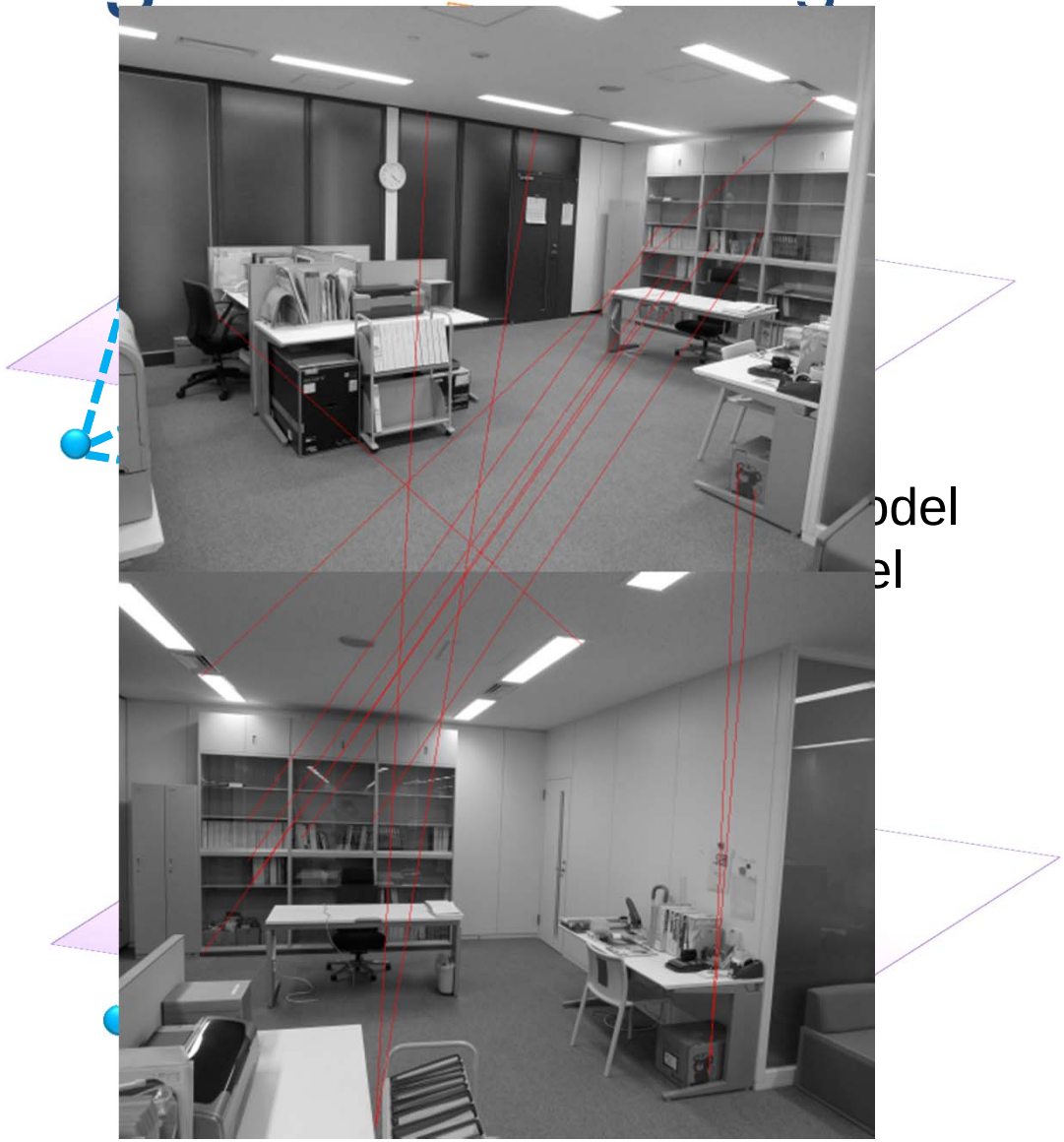

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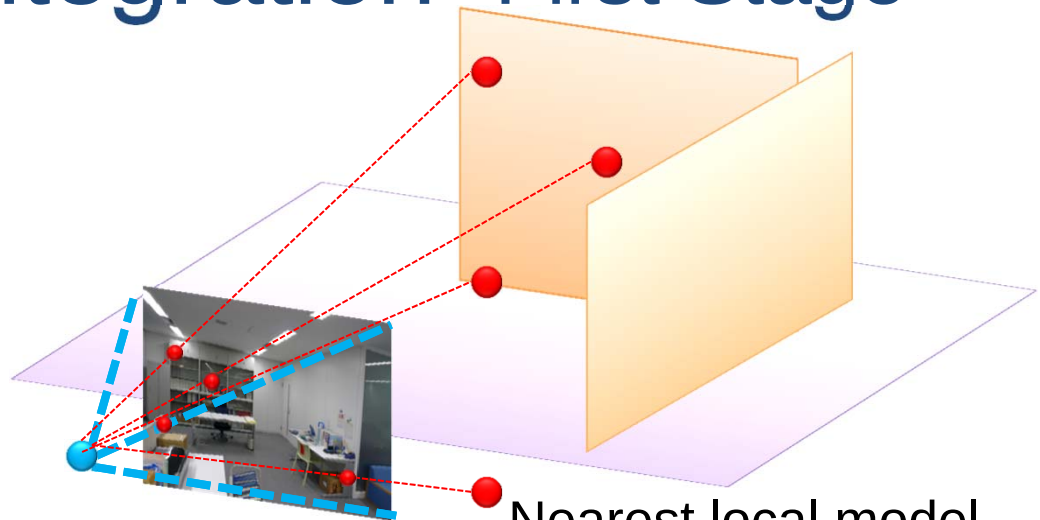
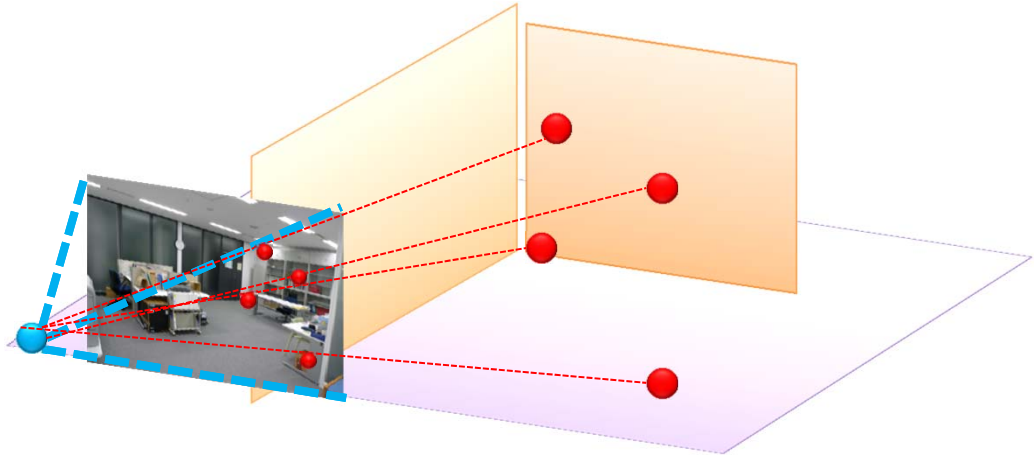


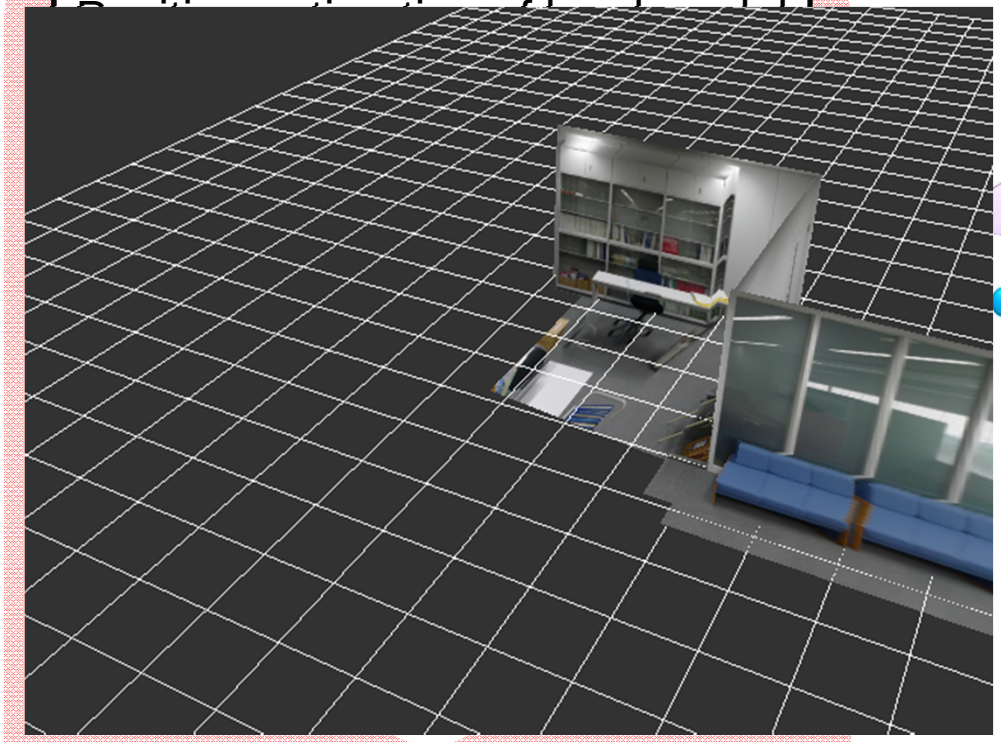
Nearest local model in global model



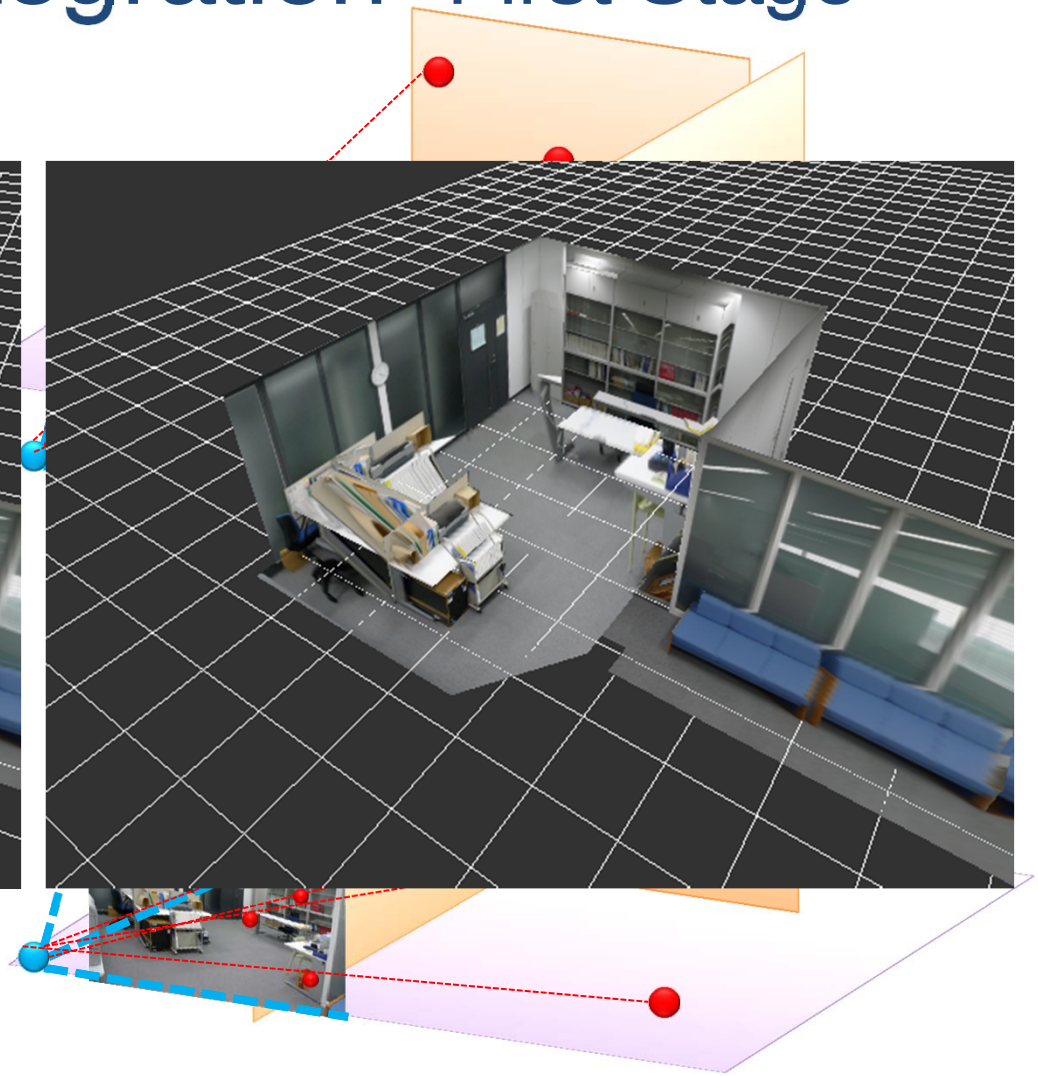
Local model

Semi-Automatic Integration -First Stage-

First stage

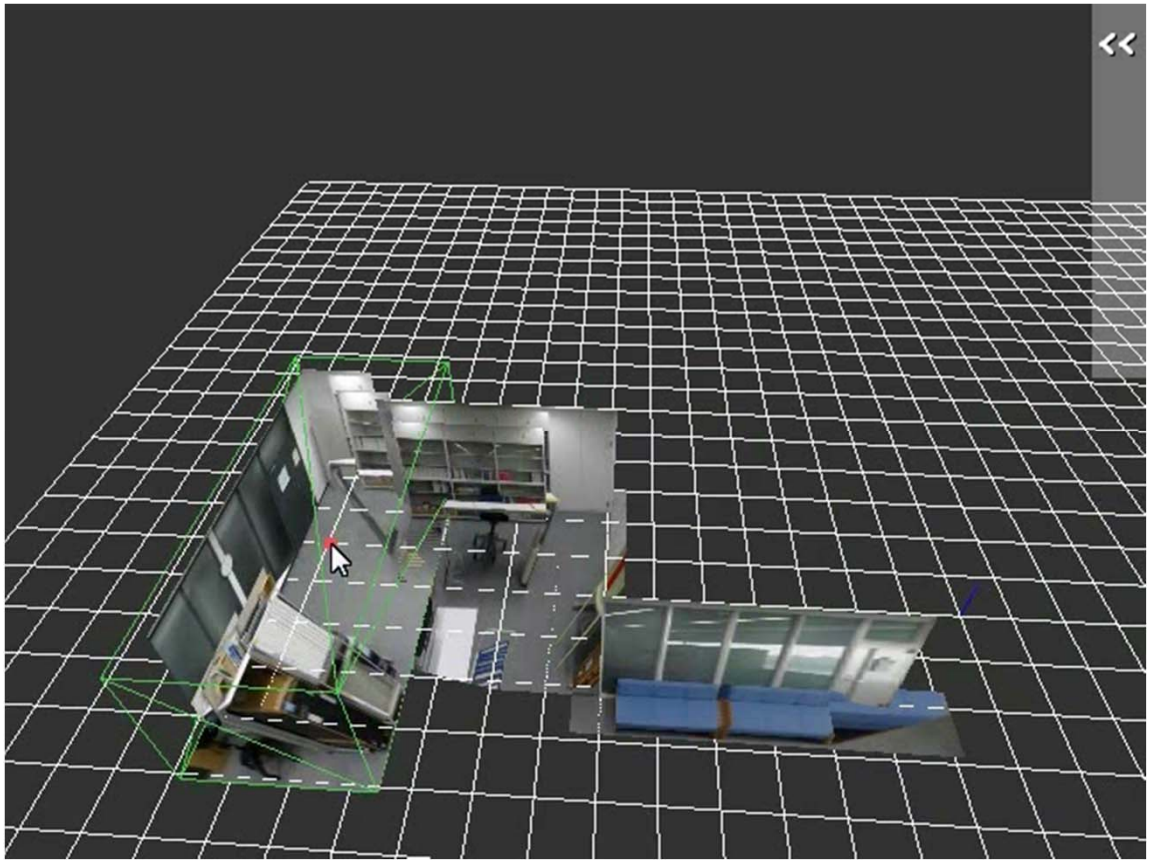


Estimation of transform parameters (**R**, **t**, s)



Local model

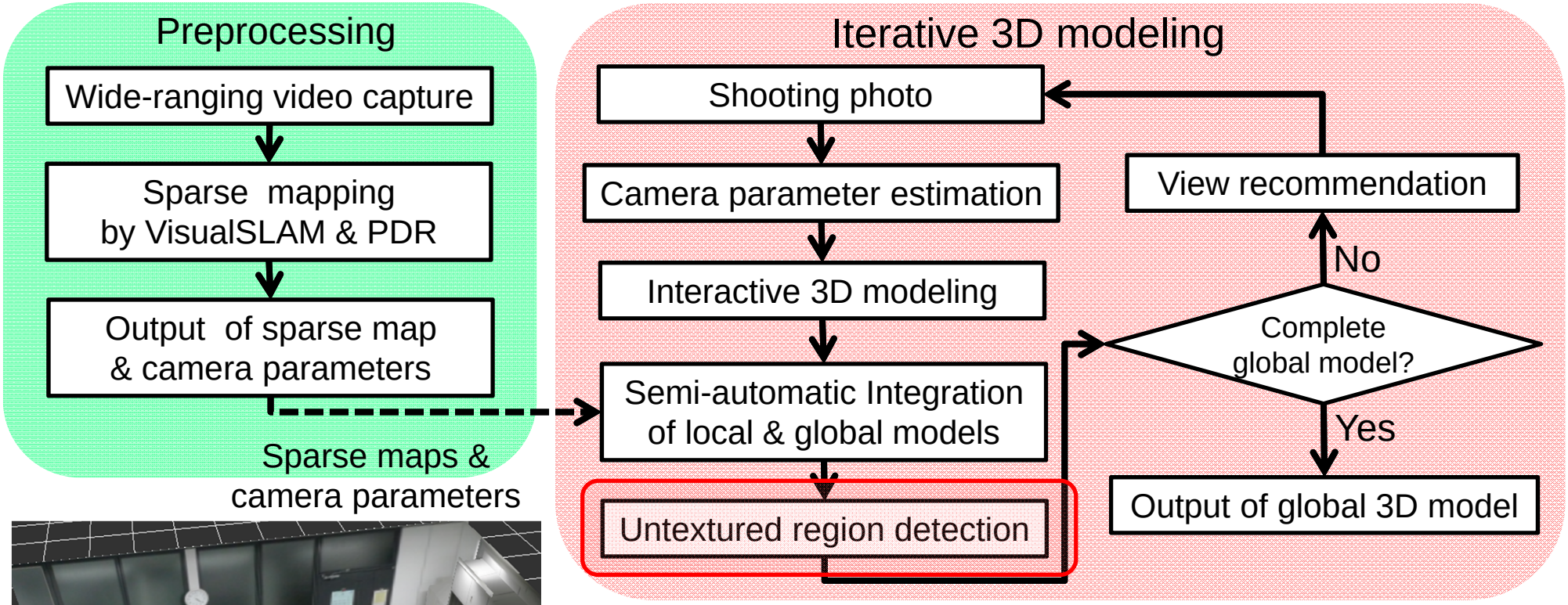
Semi-Automatic Integration -Second Stage-

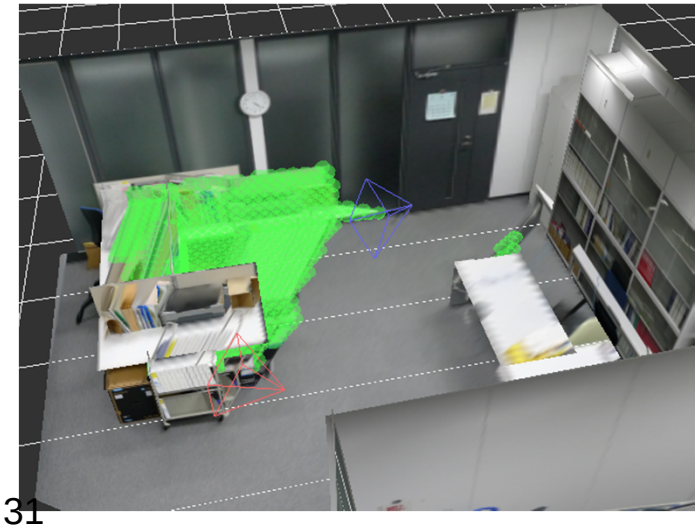


Geometric constraints

- ✓ Ground planes in both coordinate systems lay on same plane.
- ✓ Upward vectors of Z axis in both coordinate systems are same direction.

Overview of 3D Indoor Modeler





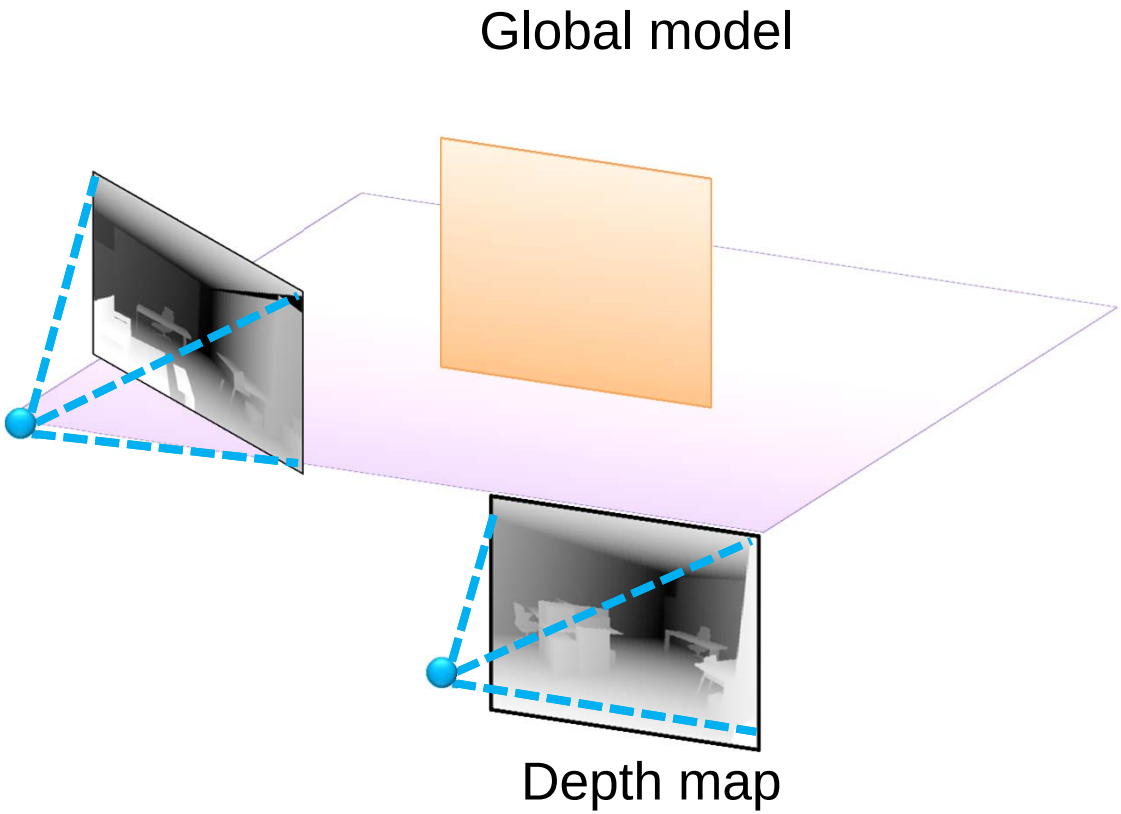
Untextured Region Detection

Computing depth maps
for each photo

Approximating models
by points on models

Carving visible points
by checking depth of points

Searching for
dominant point cluster



Untextured Region Detection

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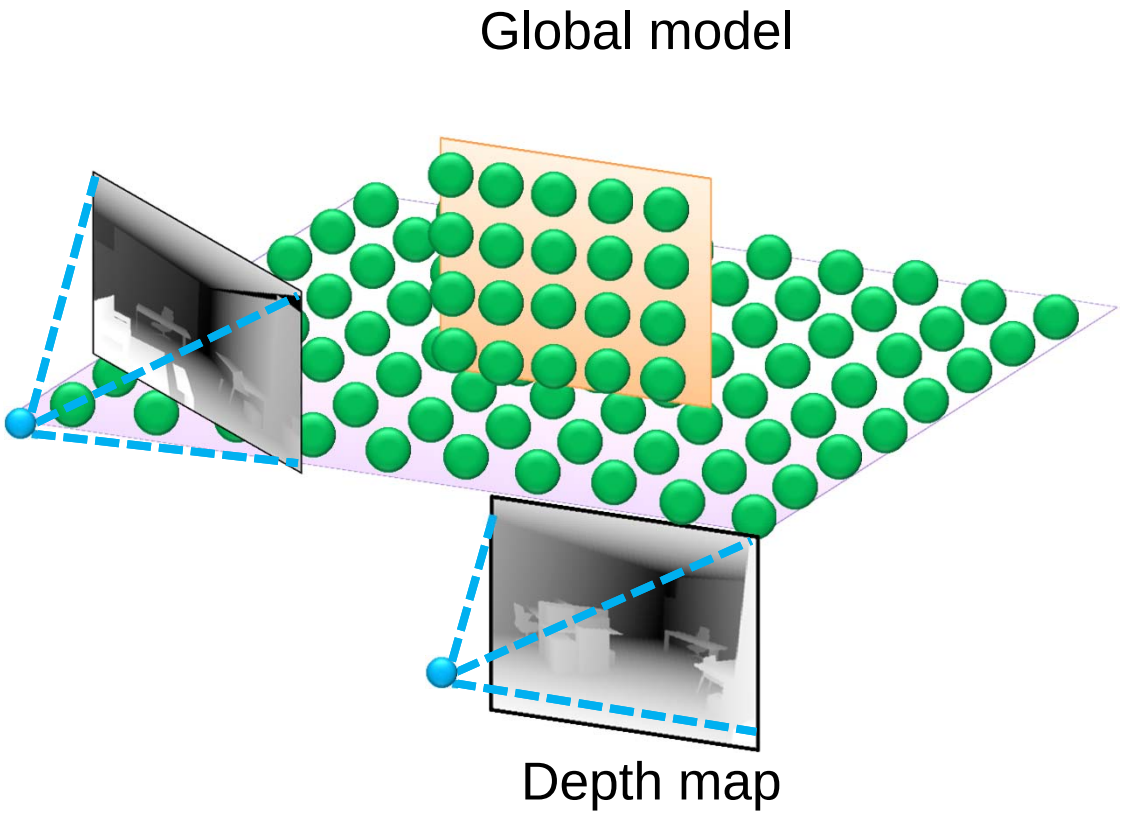
Approximating models
by points on models

Carving visible points
by checking depth of points

Searching for
dominant point cluster



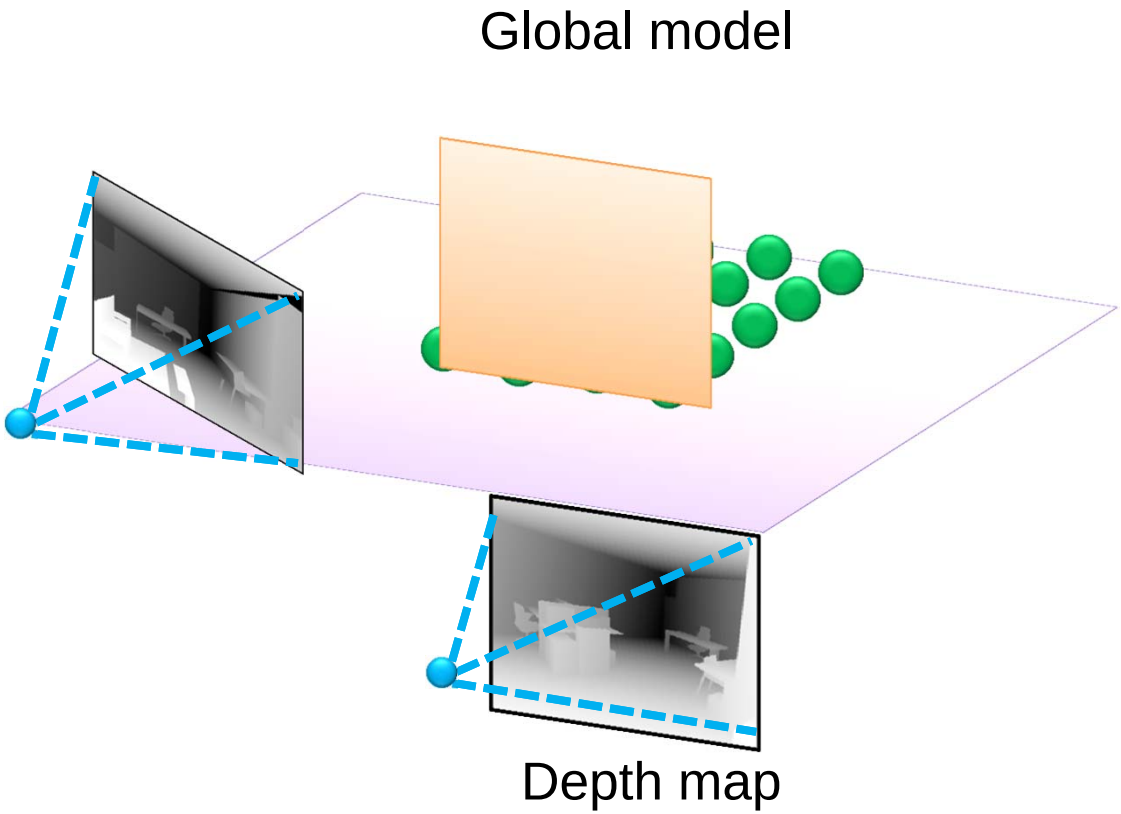
Untextured Region Detection

Computing depth maps
for each photo

Approximating models
by points on models

Carving visible points
by checking depth of points

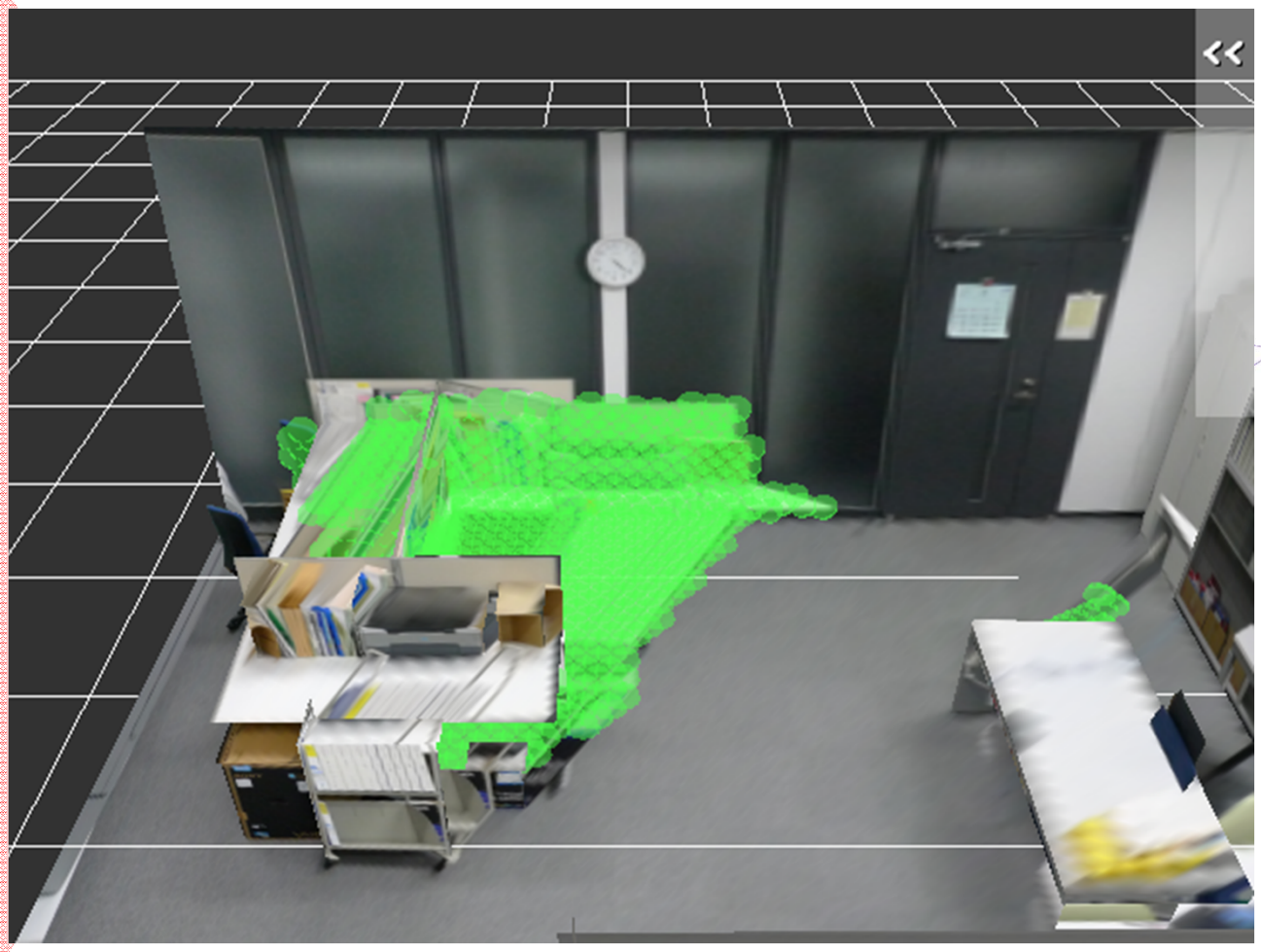
Searching for
dominant point cluster



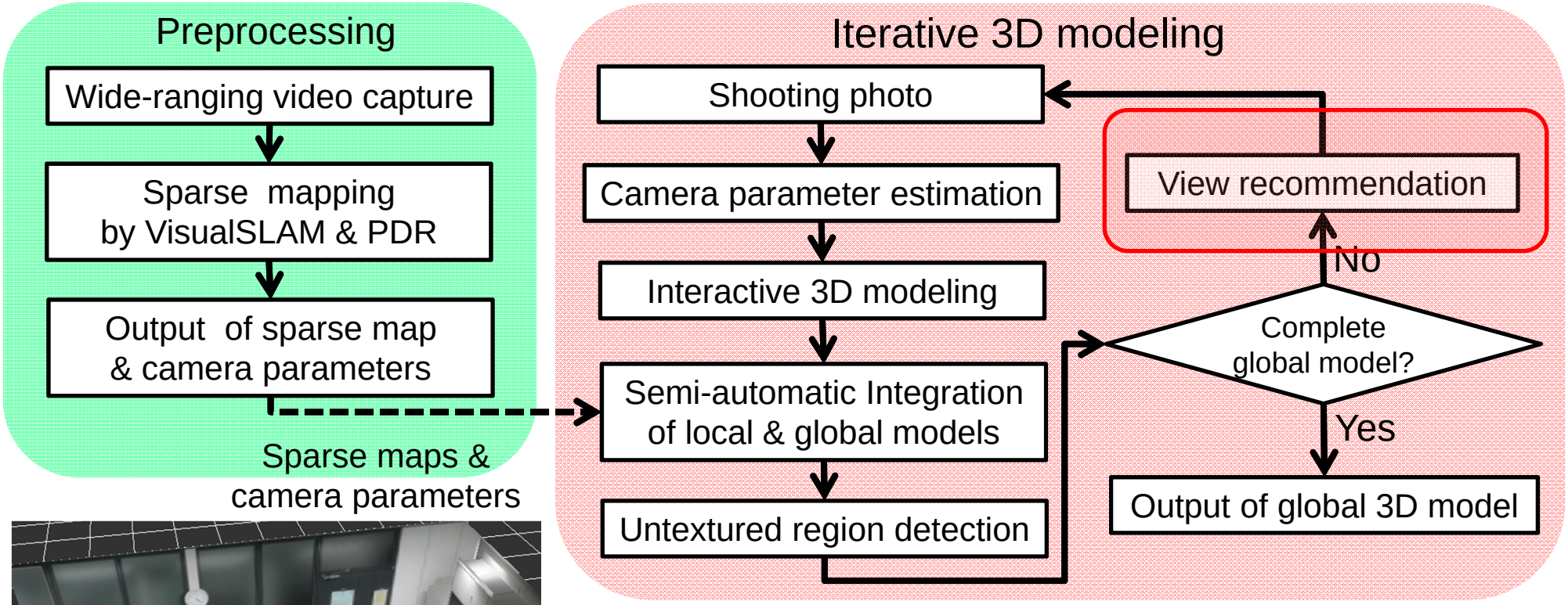
Center for Service Research

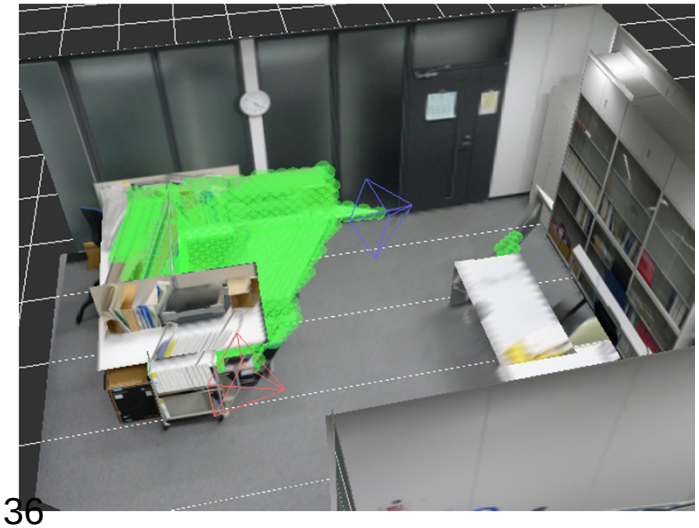
Untextured Region Detection

- Computing depth maps for each photo
- Approximating models by points on models
- Carving visible points by checking depth of points
- Searching for dominant point cluster

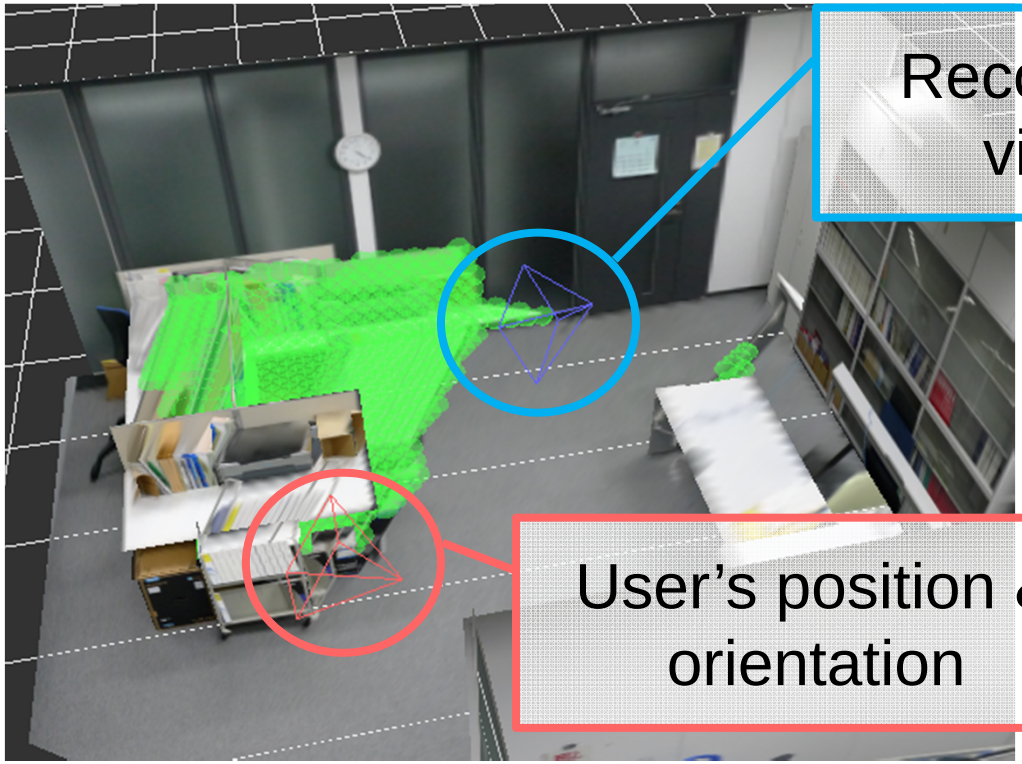


Overview of 3D Indoor Modeler





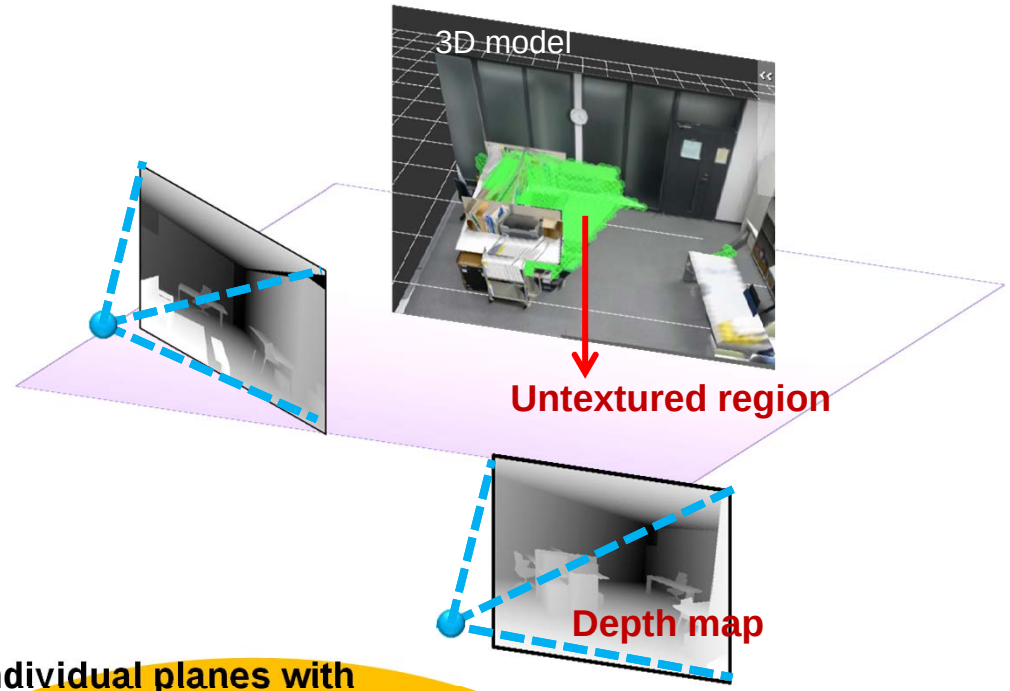
View Recommendation



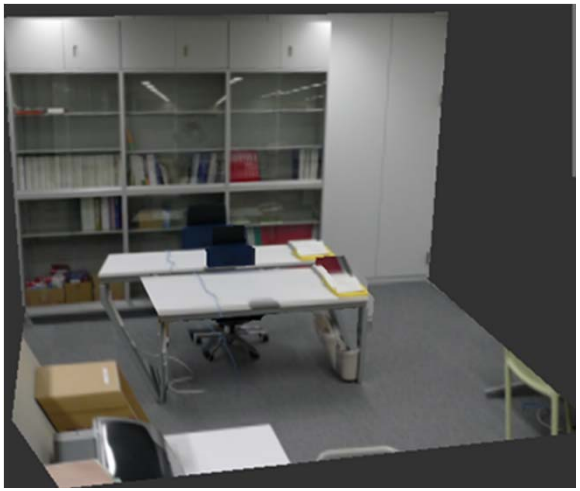
Criteria for view search

1. Observability : Viewpoint should capture untextured region as large as possible.
2. Easiness : Viewpoint should be below eye level.
3. Distance : Viewpoint should be close to untextured region.

Inpainting for Interactive 3D Indoor Modeling



Application of Exemplar-based inpainting



Before inpainting

After inpainting

K. Thangamani, et al., ISUVR2010

Pedestrian Tracking System

Sensor module

Barometer | Magnetometer | Accelerometers / gyro-sensors | RFID reader

Active RFID tag

Surveillance camera

ID

Atmospheric pressure

Magnetic vector

Acceleration / angular velocity

ID
RSSI

Video

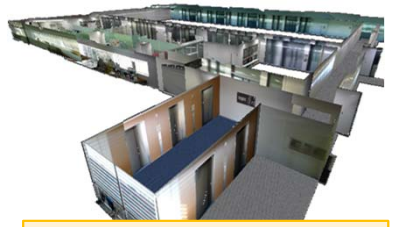
Walking velocity

Pedestrian dead-reckoning

Trajectory matching/ Velocity estimation

Velocity vector /
Relative altitude /
Action type

RF-based positioning



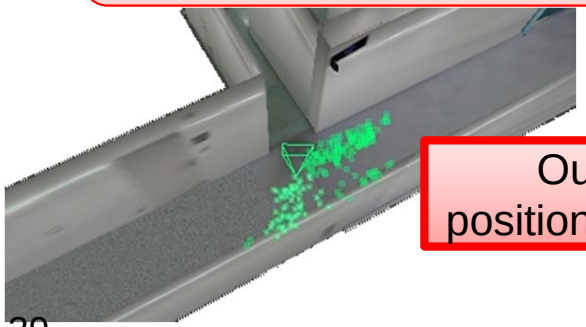
Absolute position

Sensor/Data fusion (Particle filter)

Trajectory

3D model

3D environment model

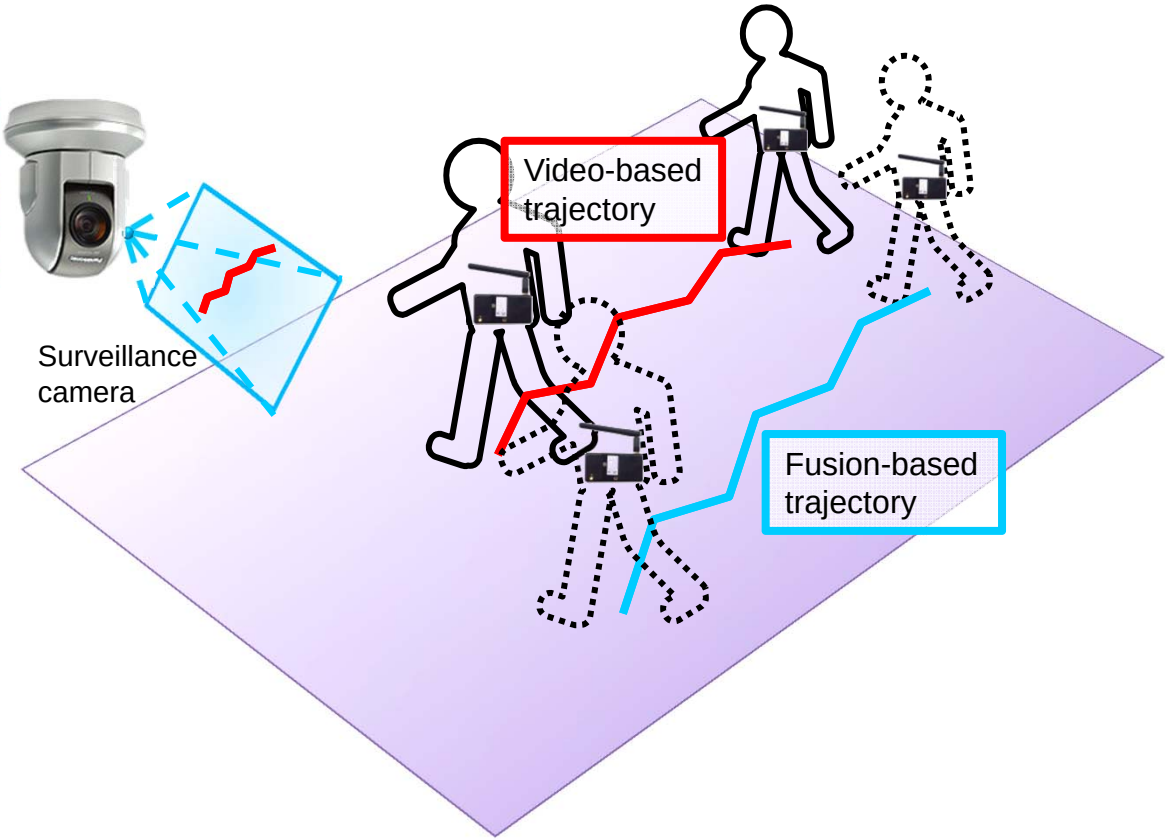


Position / Orientation

Output of position/orientation

T. Ishikawa, M. Kourogi, T. Okuma, and T. Kurata, “Economic and Synergistic Pedestrian Tracking System for Indoor Environments”, In Proc. SoCPaR2009, pp.522-527, 2009.

Trajectory matching for SDF, PDR parameter modification, and Video tagging



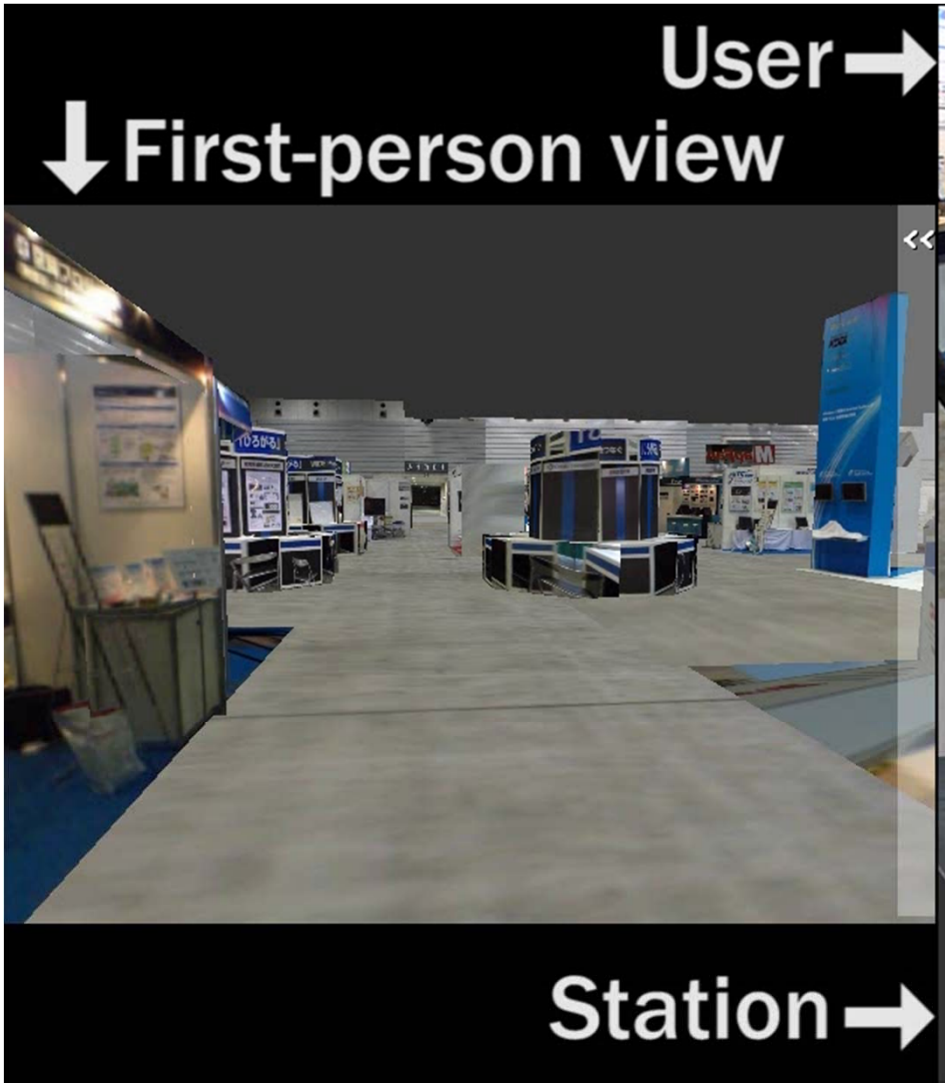
Patrol inspection service

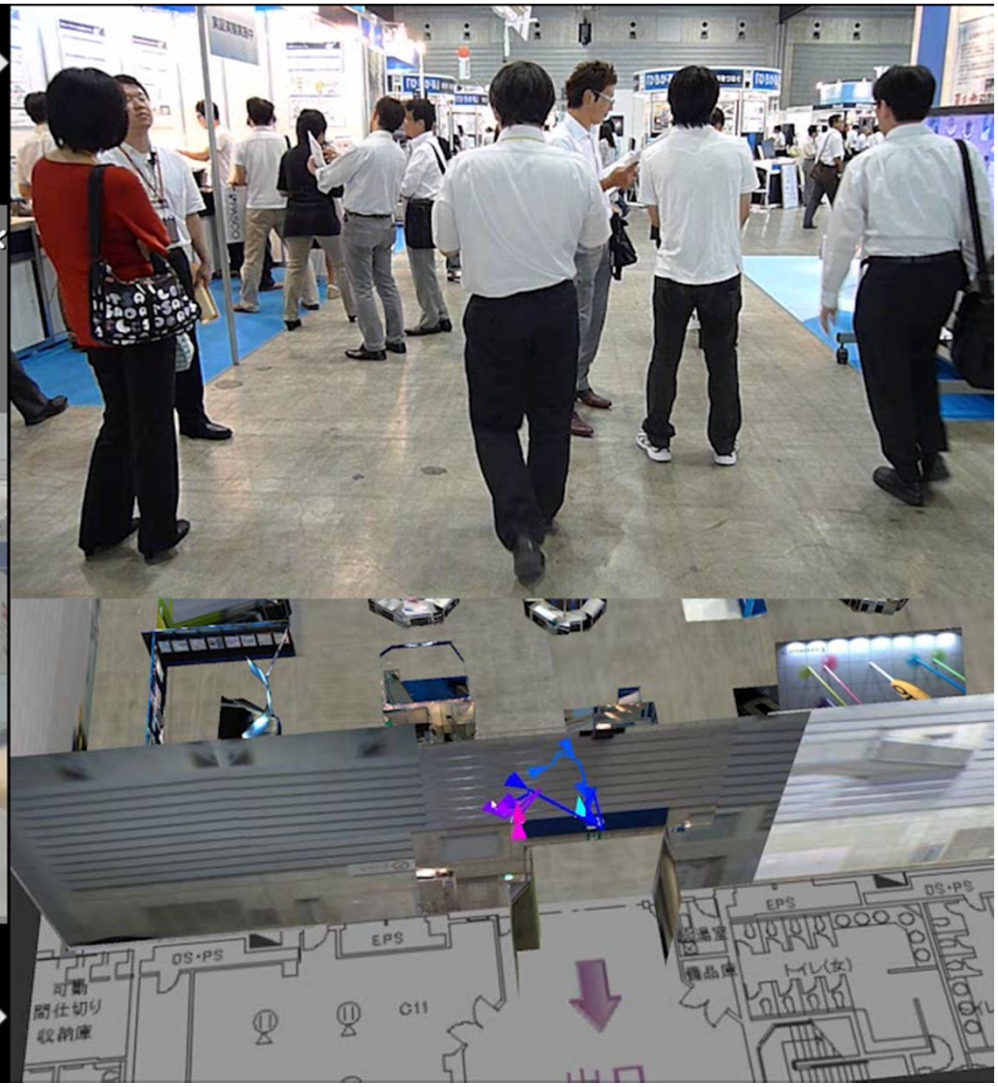
@G-spatial EXPO on Sep 19-21, 2010

1) Standalone iPhone4

@G-spatial EXPO on Sep 19-21, 2010

2) UMPC+PDR module





@CEATEC on Oct 5-9, 2010

1) Standalone iPhone4, 2) UMPC+PDR module

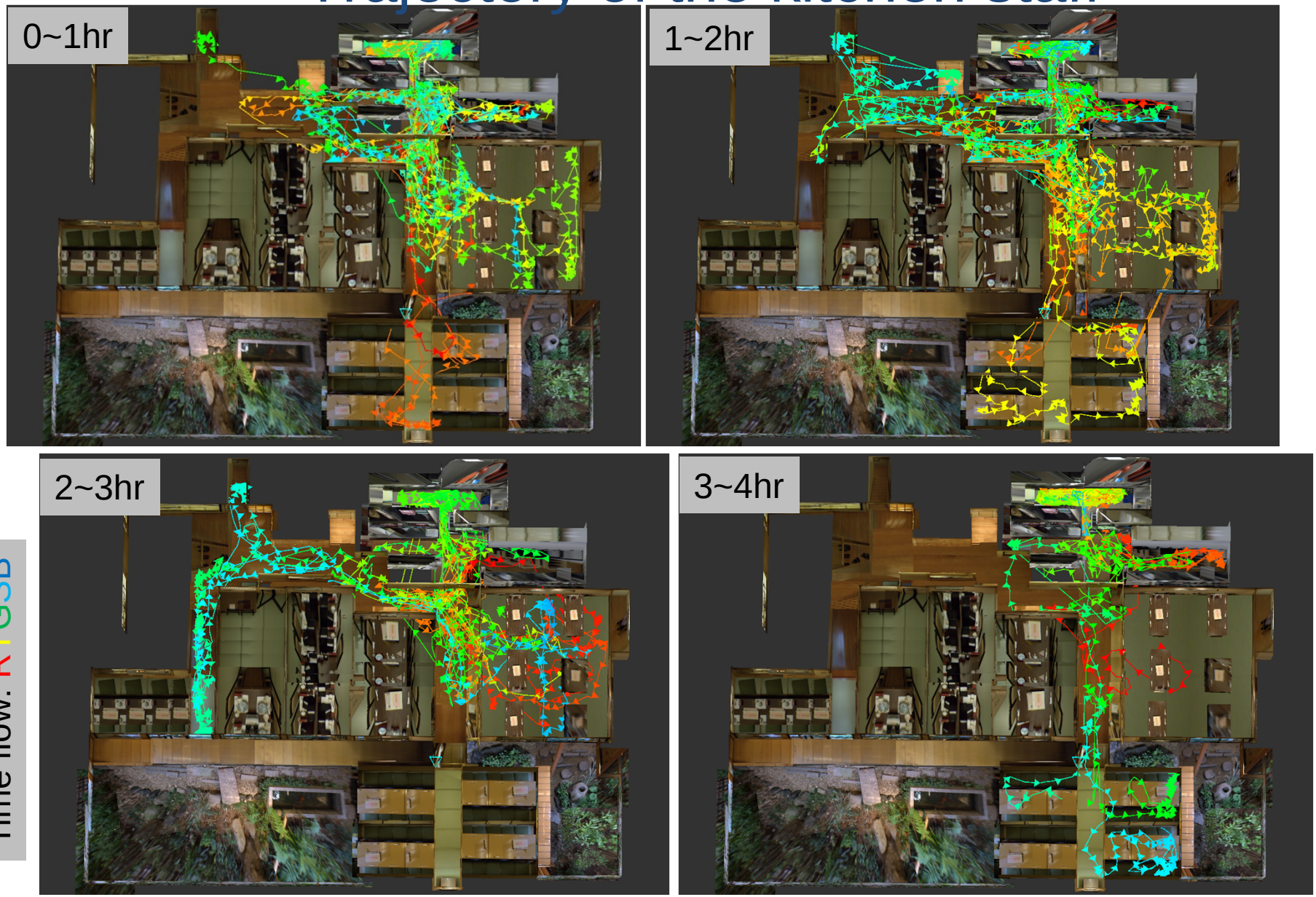
Behavior Measurement of workers at Japanese Restaurant (Ganko)

Chief hostess (Okami)

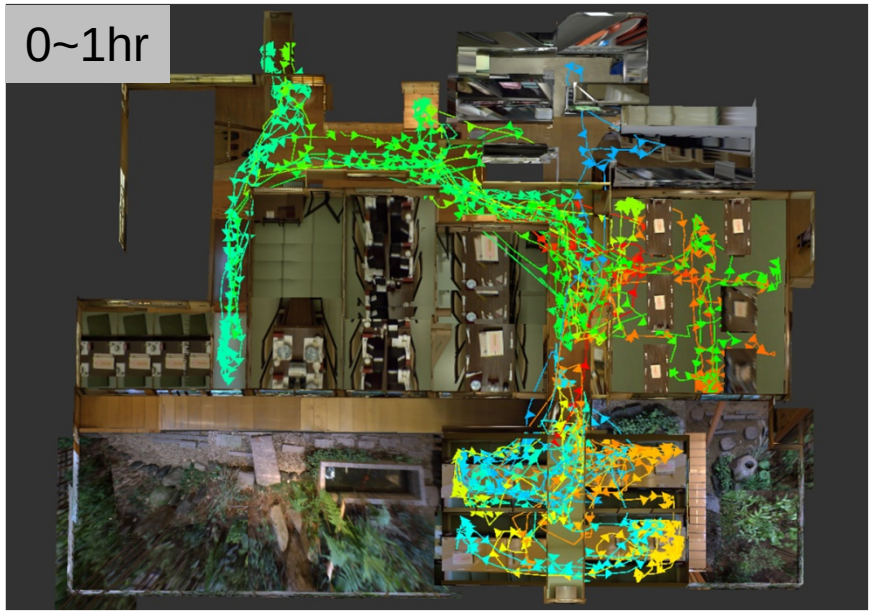
Kitchen staff (Ohakobi)

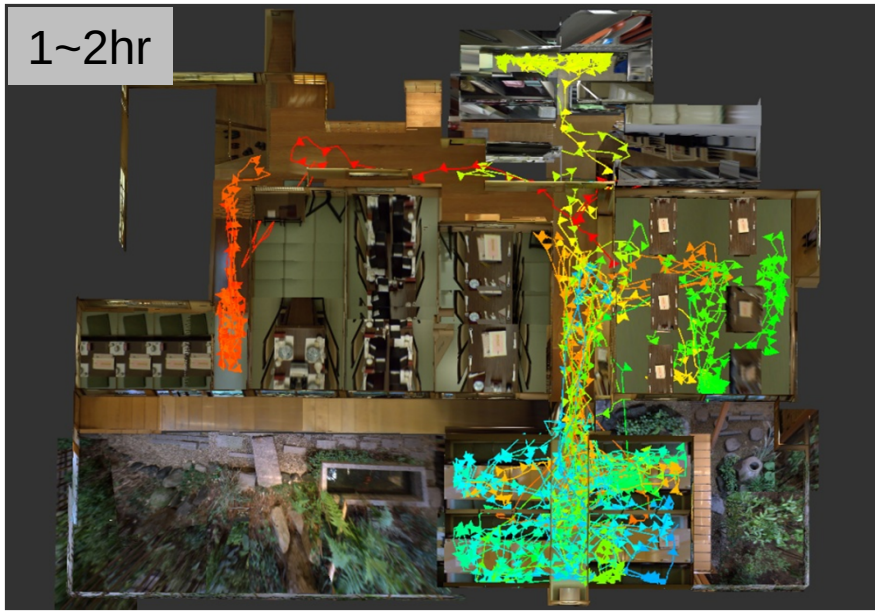
Surveillance camera
Active RFID tag
Eco sensor

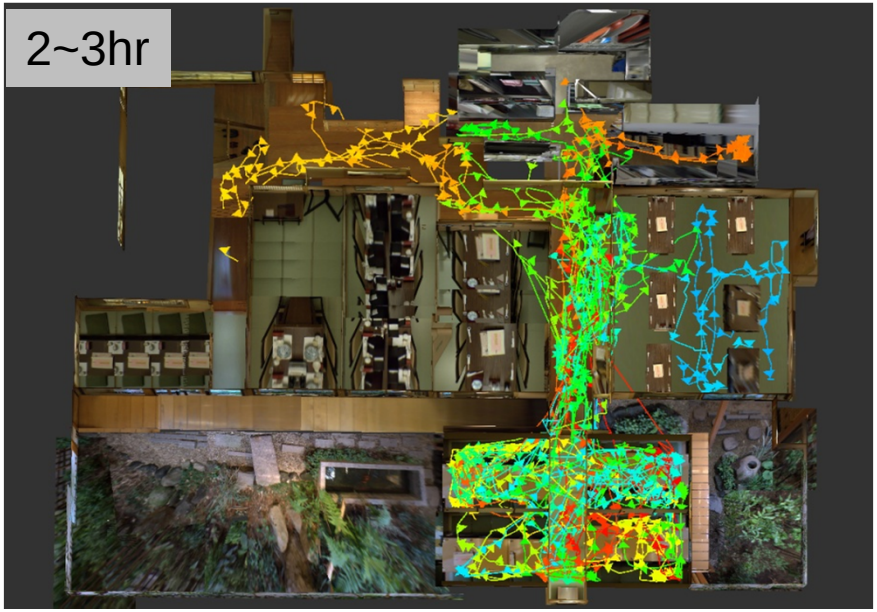
Mieruka (Visualization): Trajectory of the kitchen staff

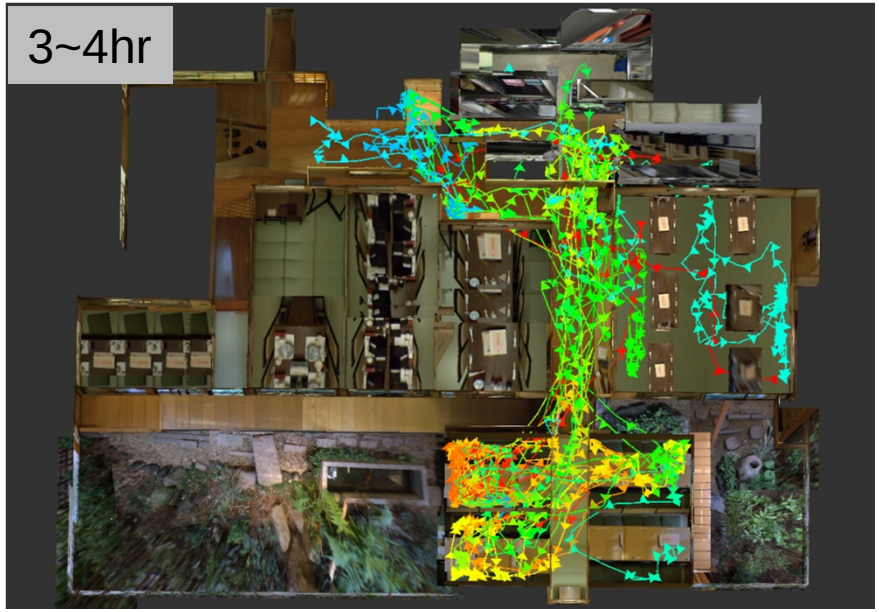


Trajectory of the chief hostess









Time flow: RYGSB

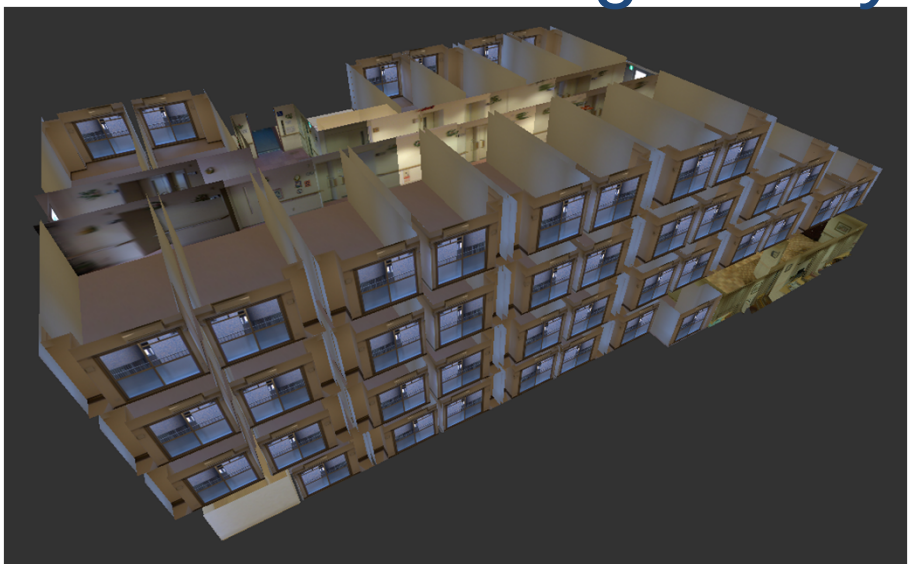
HRD (Human Resource Development) and Business Ethnography

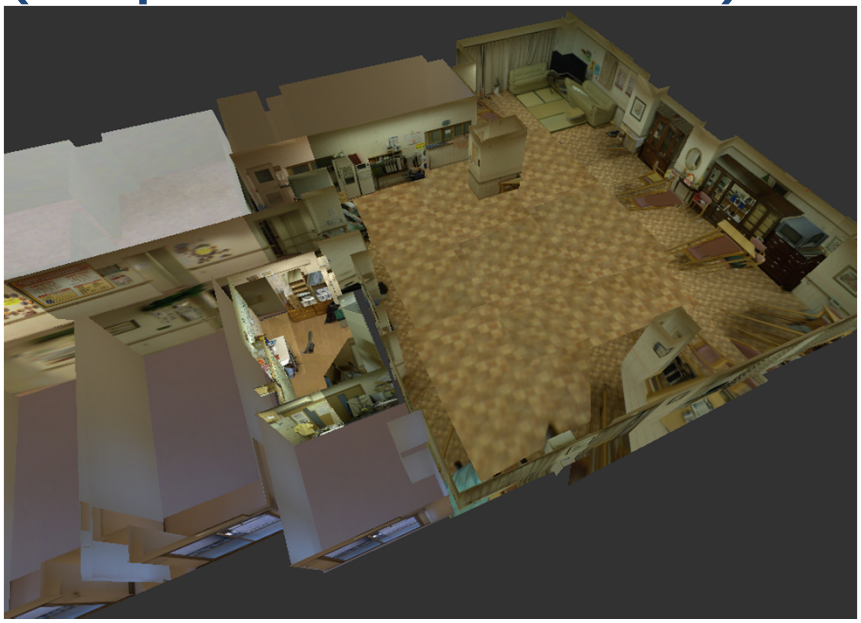
Bird's eye view to show
the probabilistic distribution of
the chief hostess

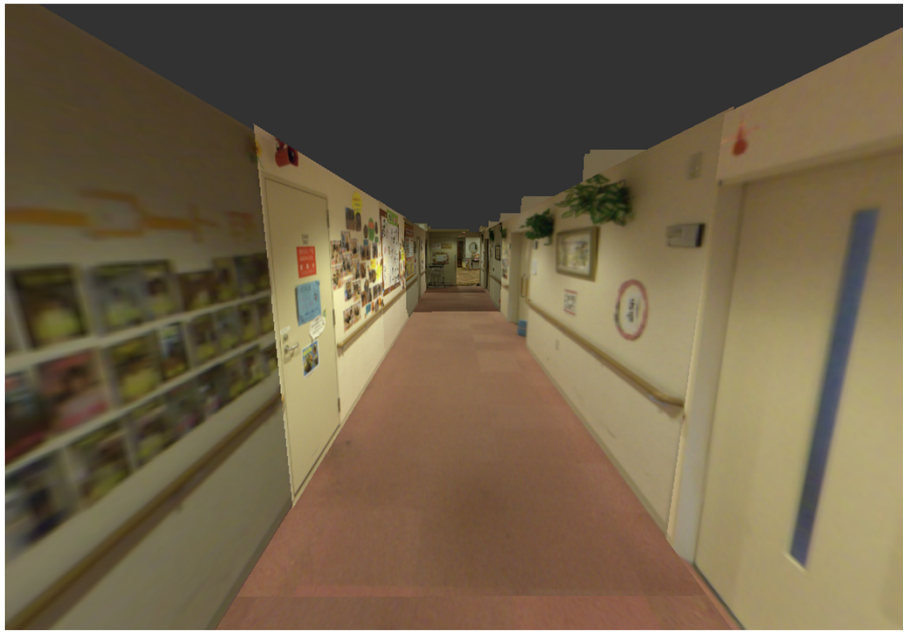
First person view
for virtually reliving her movement

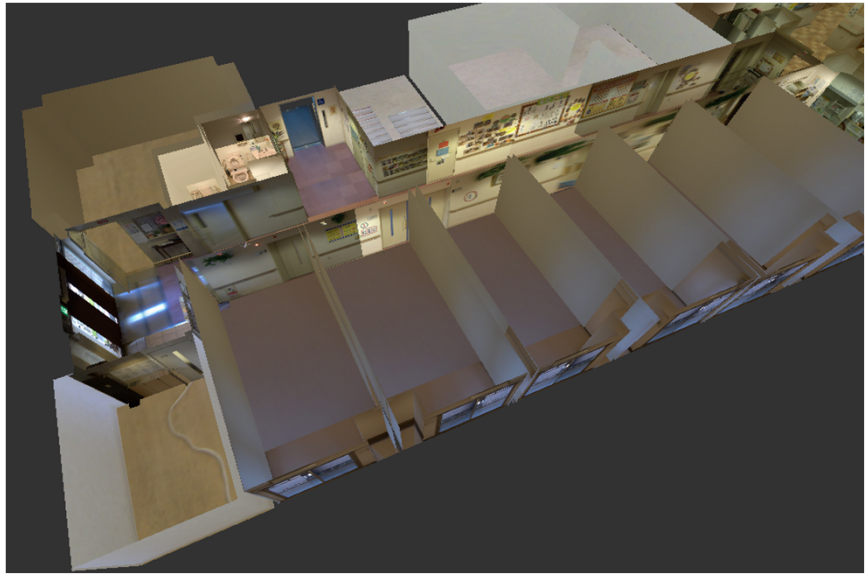
Center for Service Research

Behavior Measurement of workers at Nursing facility (Supercourt Hirano)

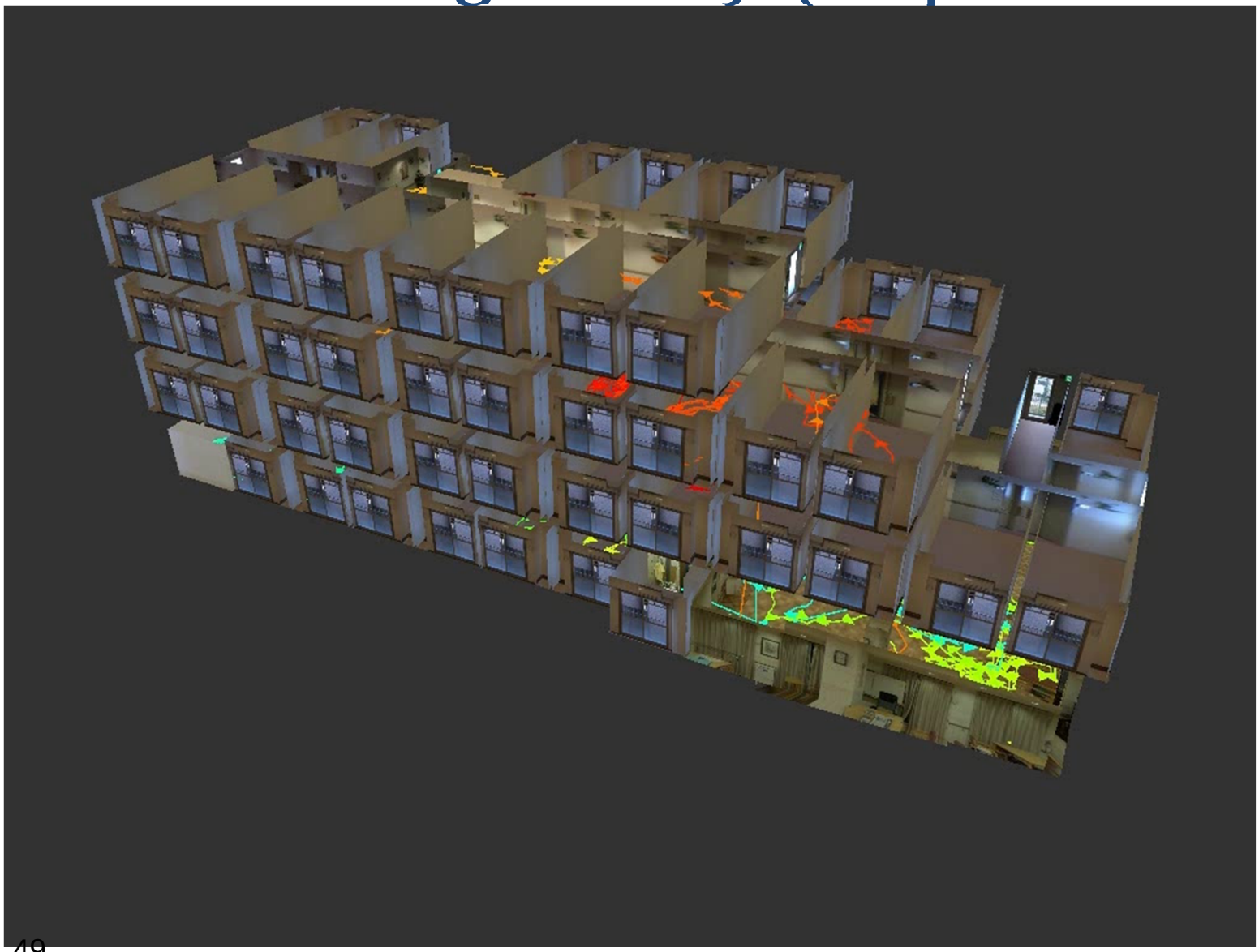


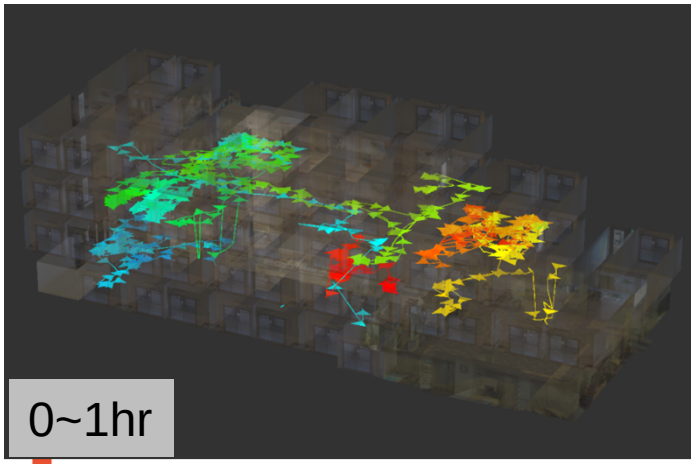


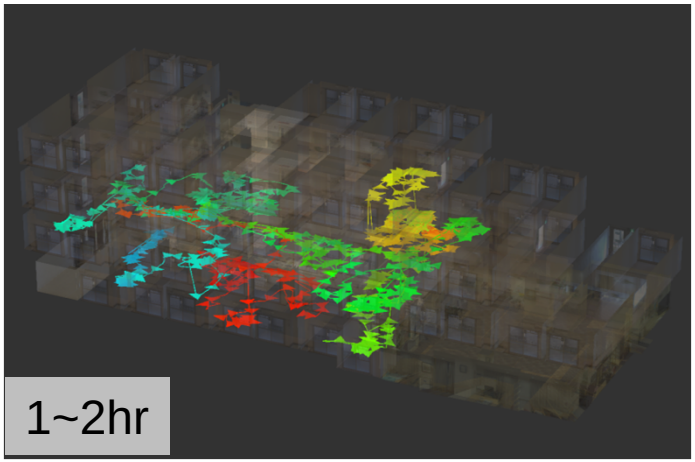


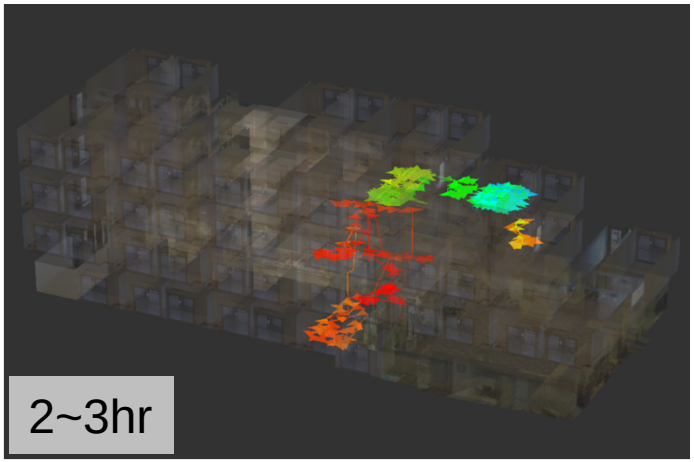


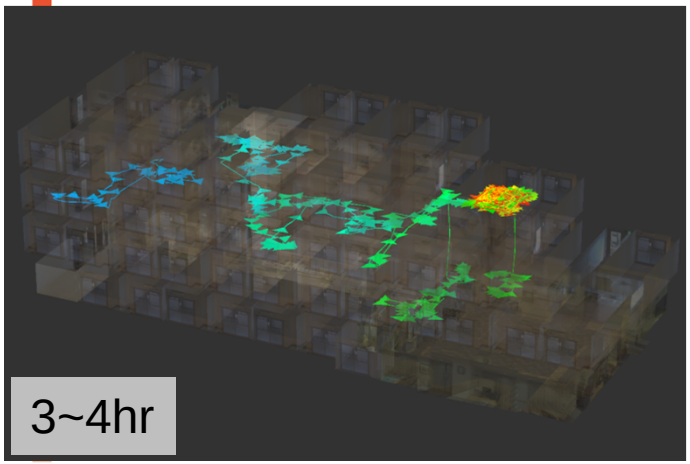
Behavior Measurement of workers at Nursing facility (Supercourt Hirano)

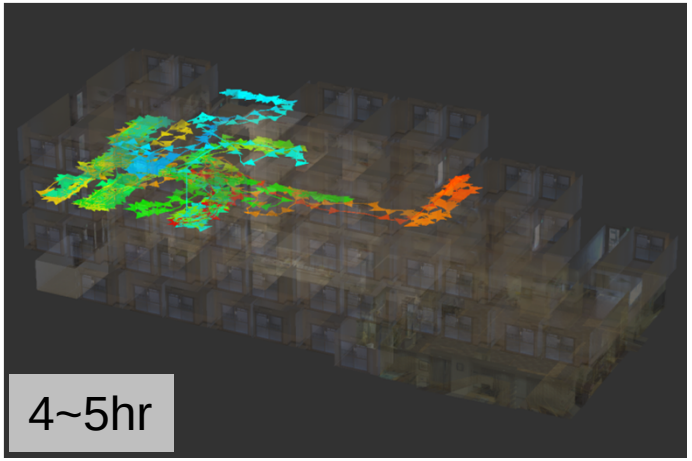


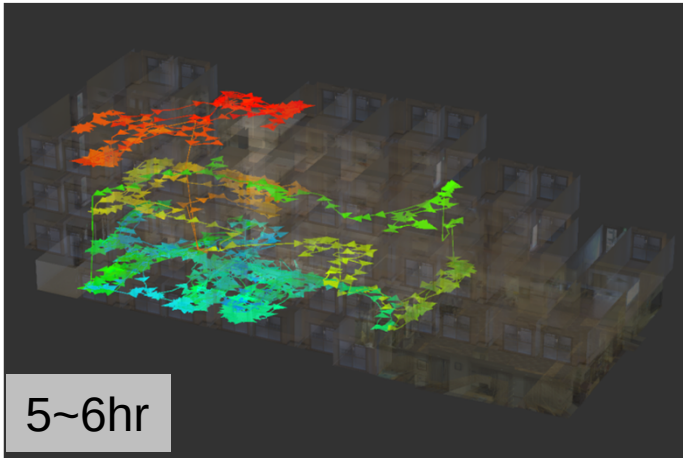


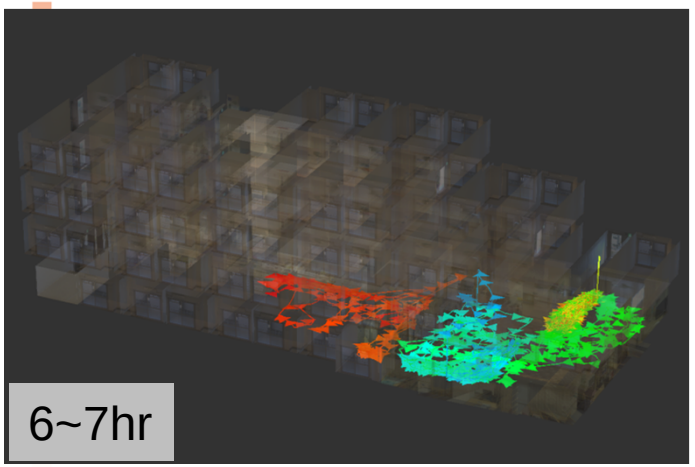






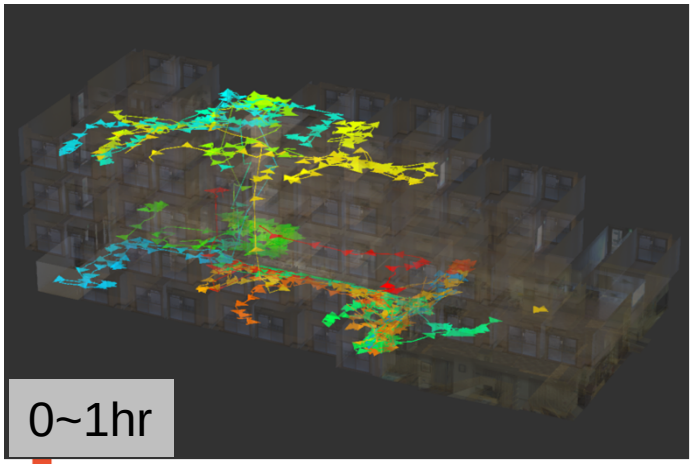


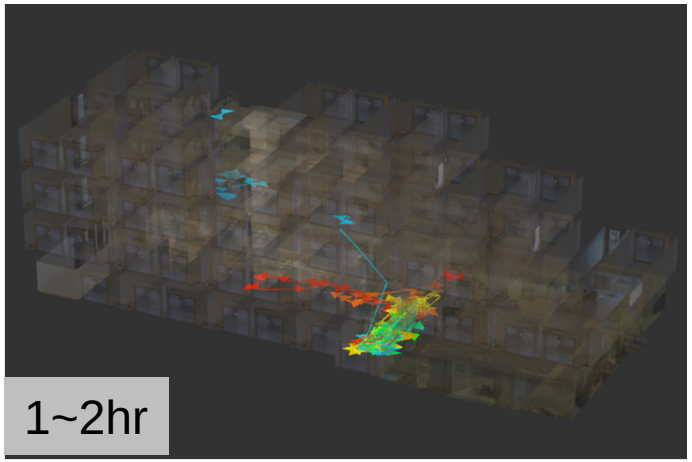


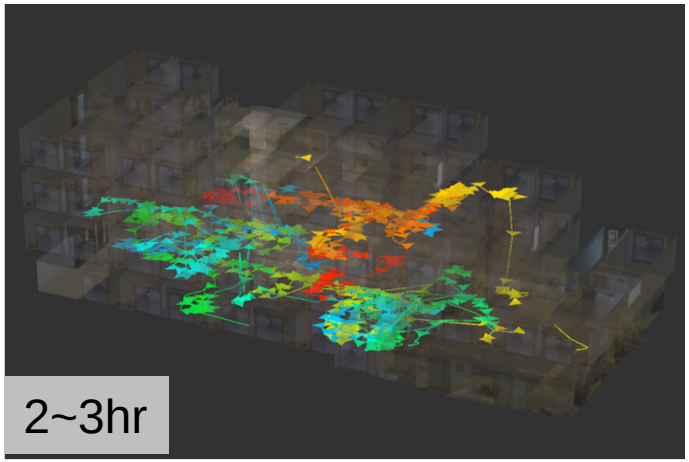


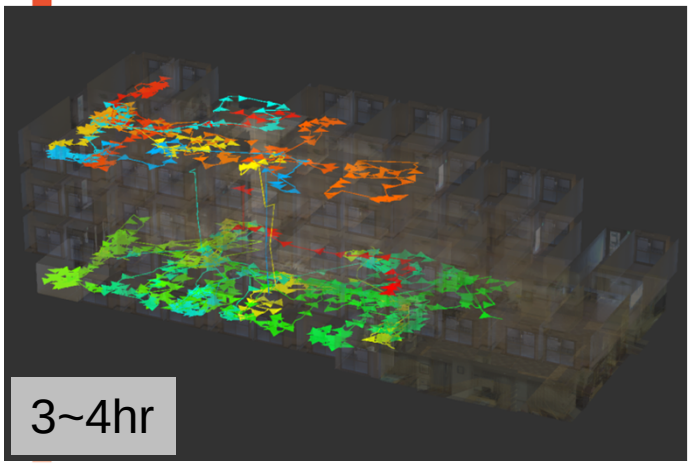
- Helper
- Night shift

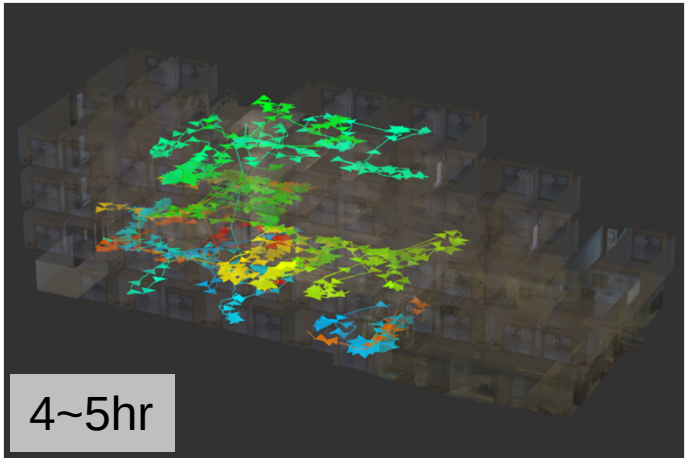
Time flow: RYGSB

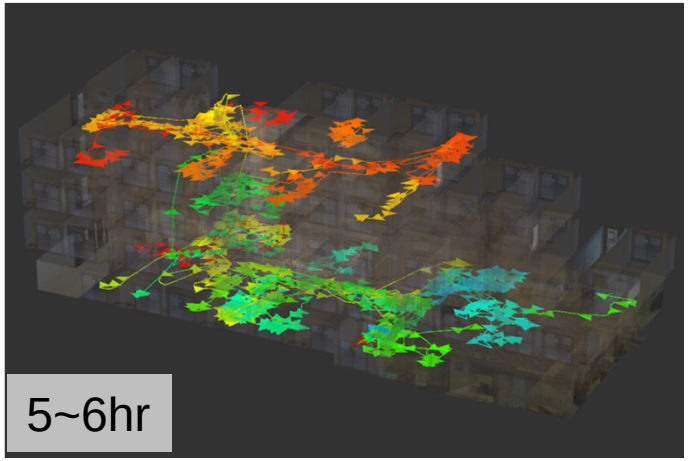


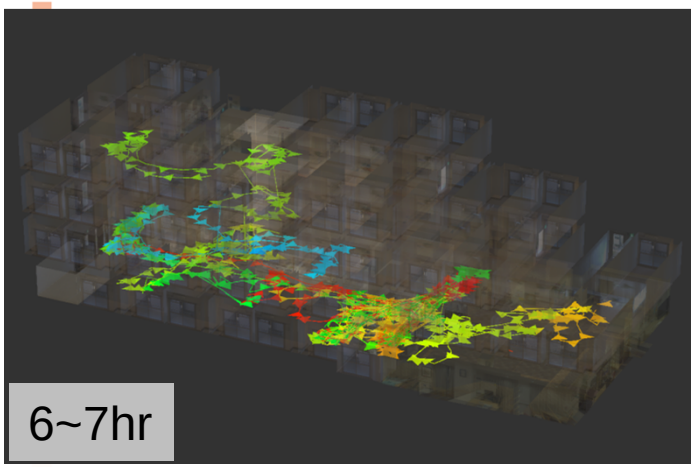






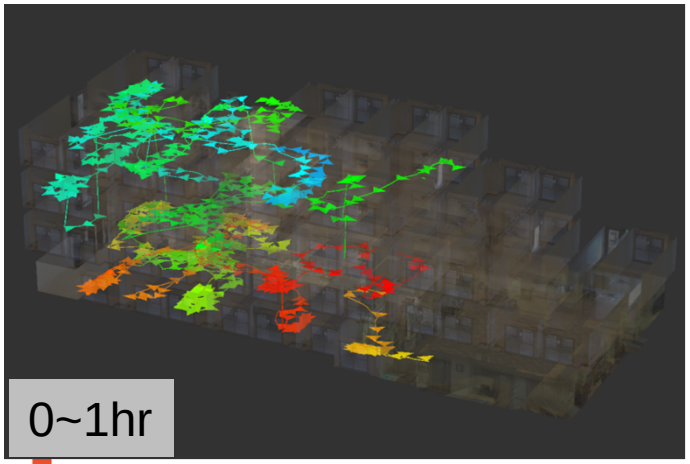


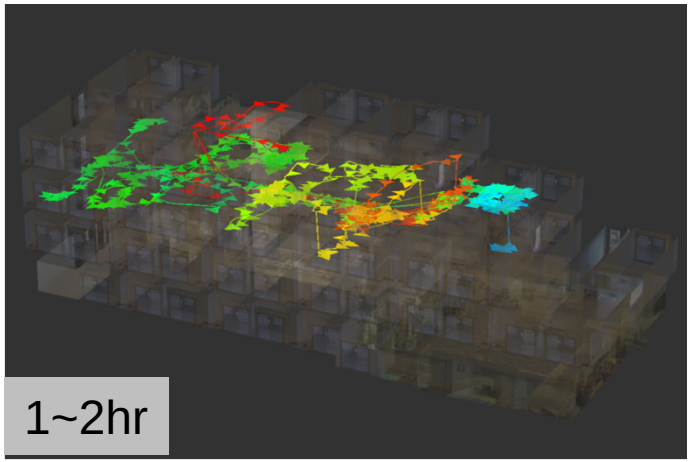


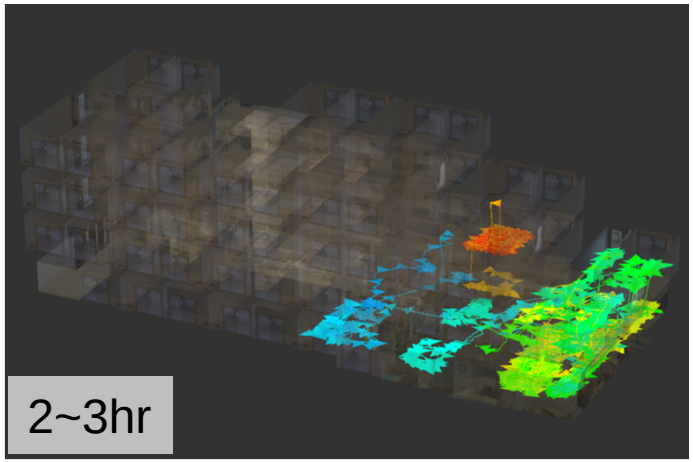


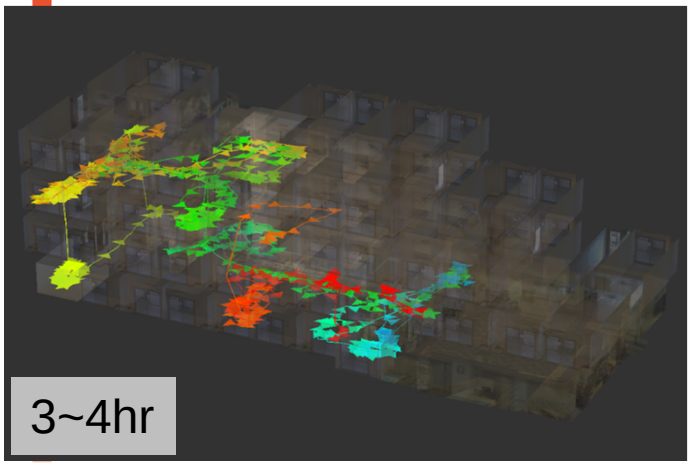
- Helper Leader
- Night shift

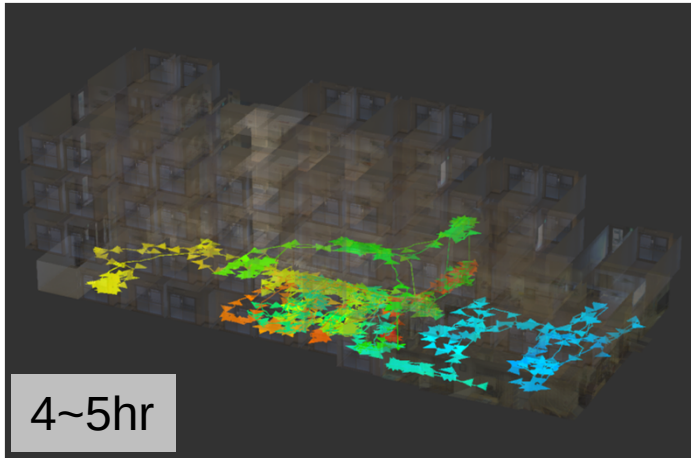
Time flow: RYGSB

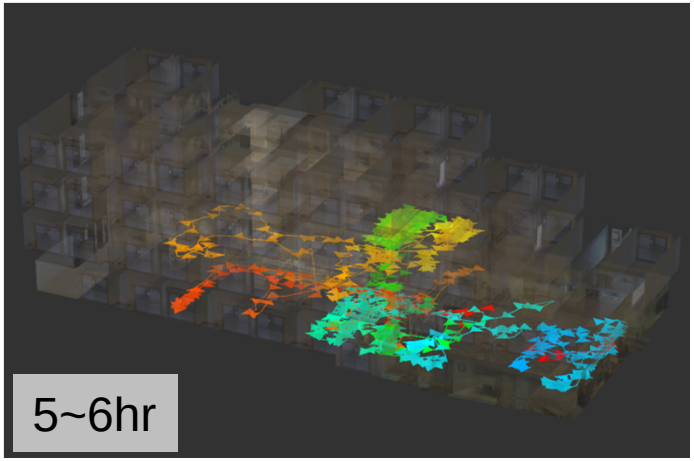


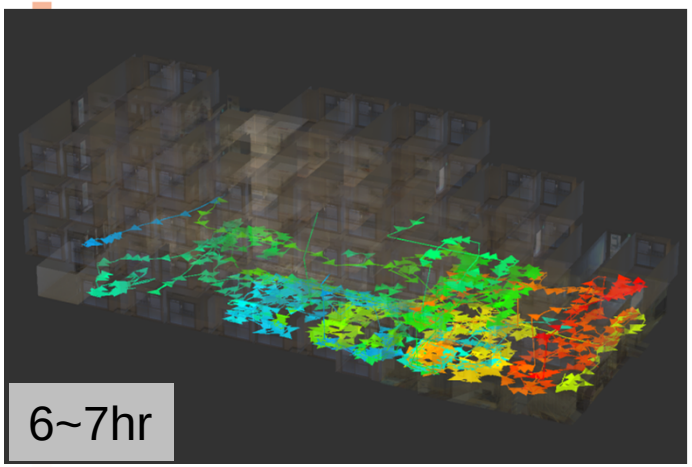












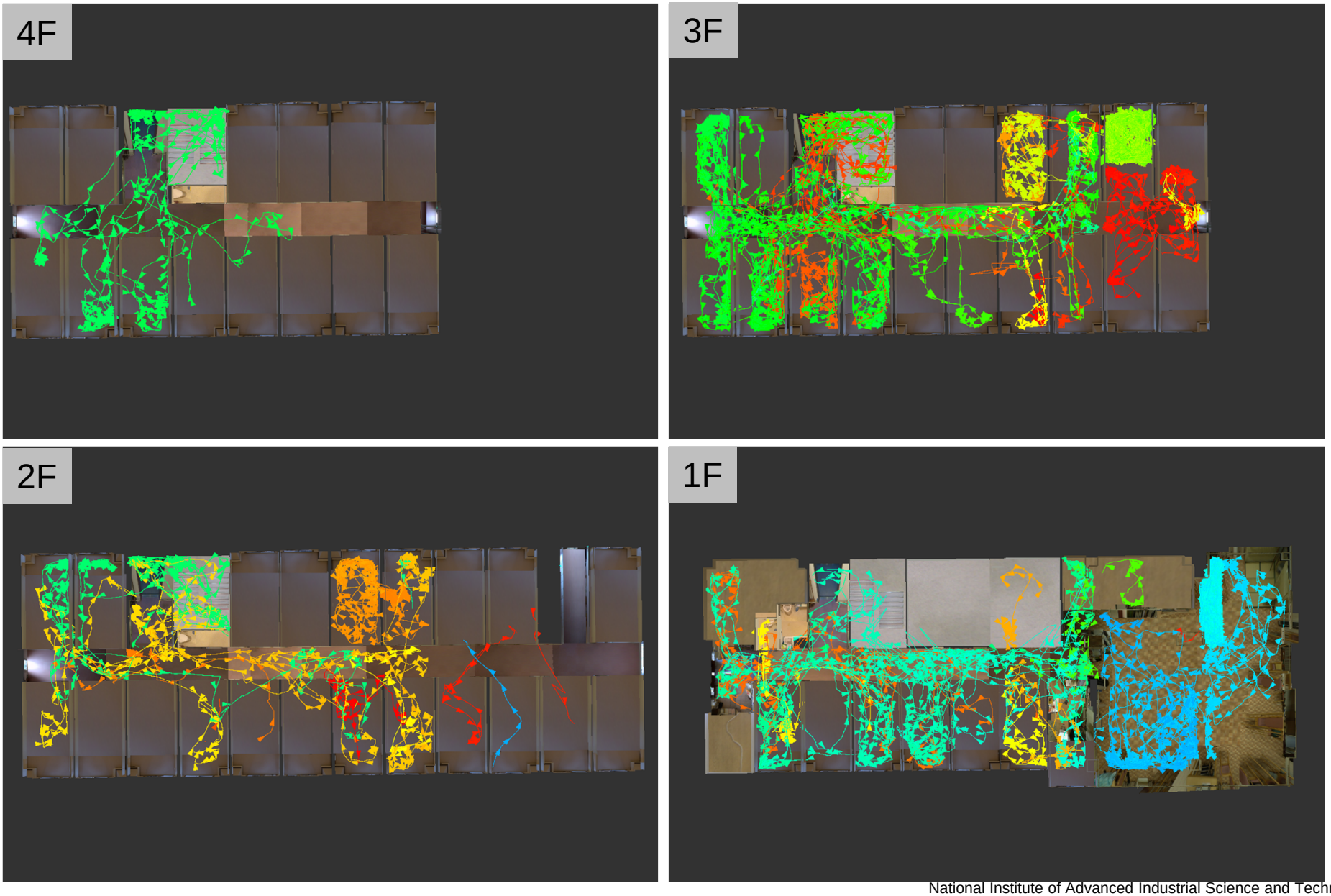
- Helper Leader
- Day shift

Time flow: RYGSB

Center for Service Research

- Helper
- Night shift

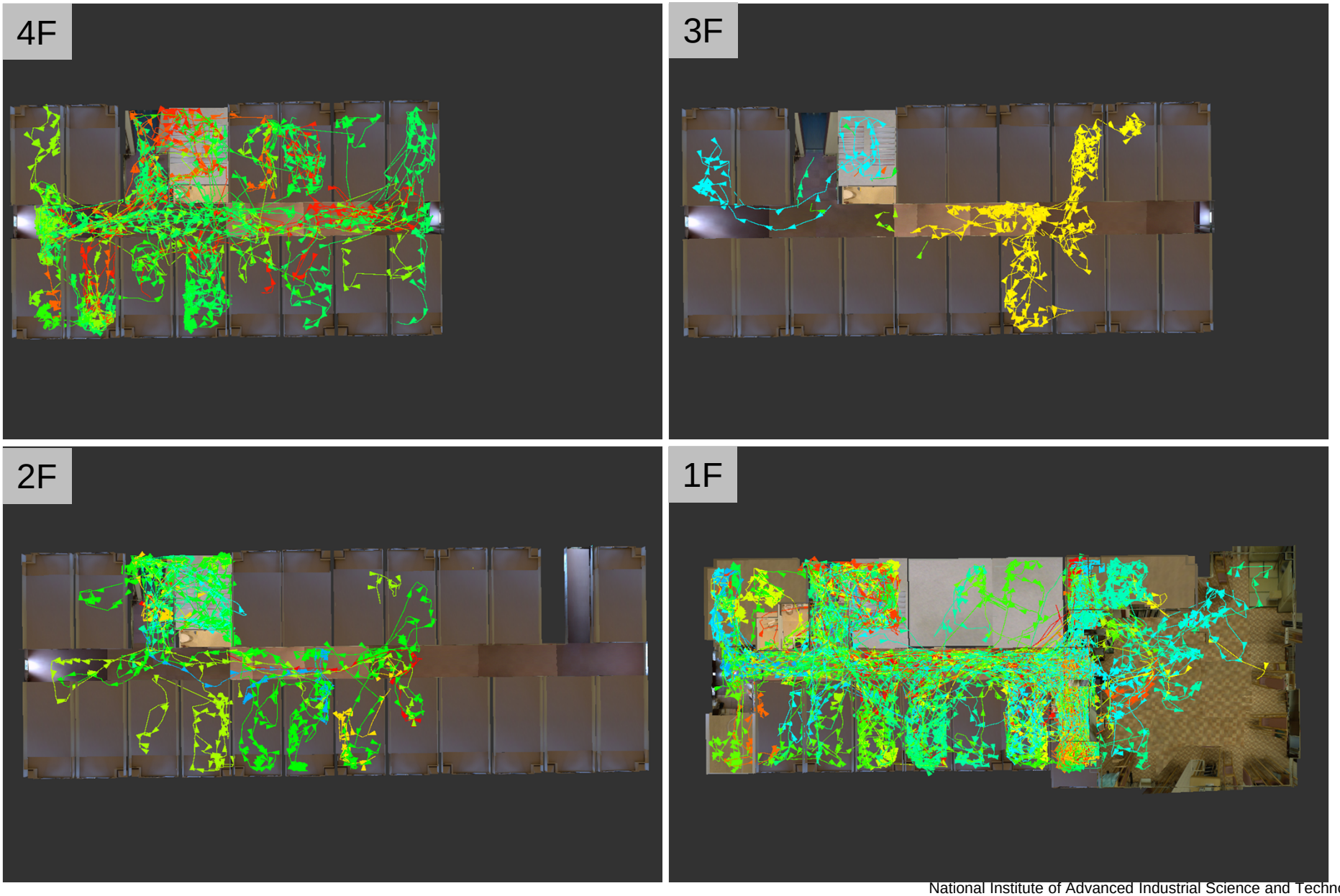
Time flow: RYGSB



Center for Service Research

•Helper Leader
•Night shift

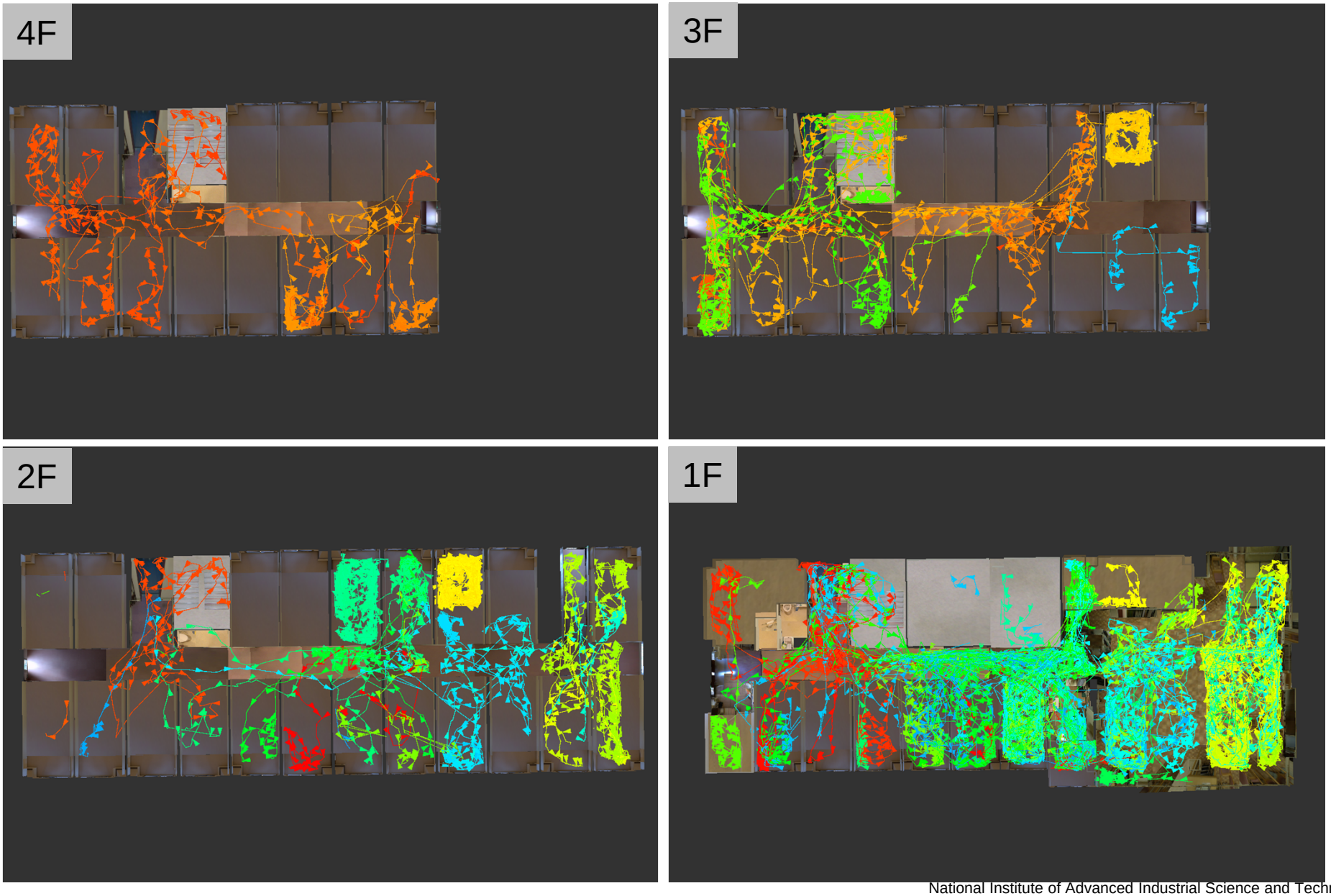
Time flow: RYGSB



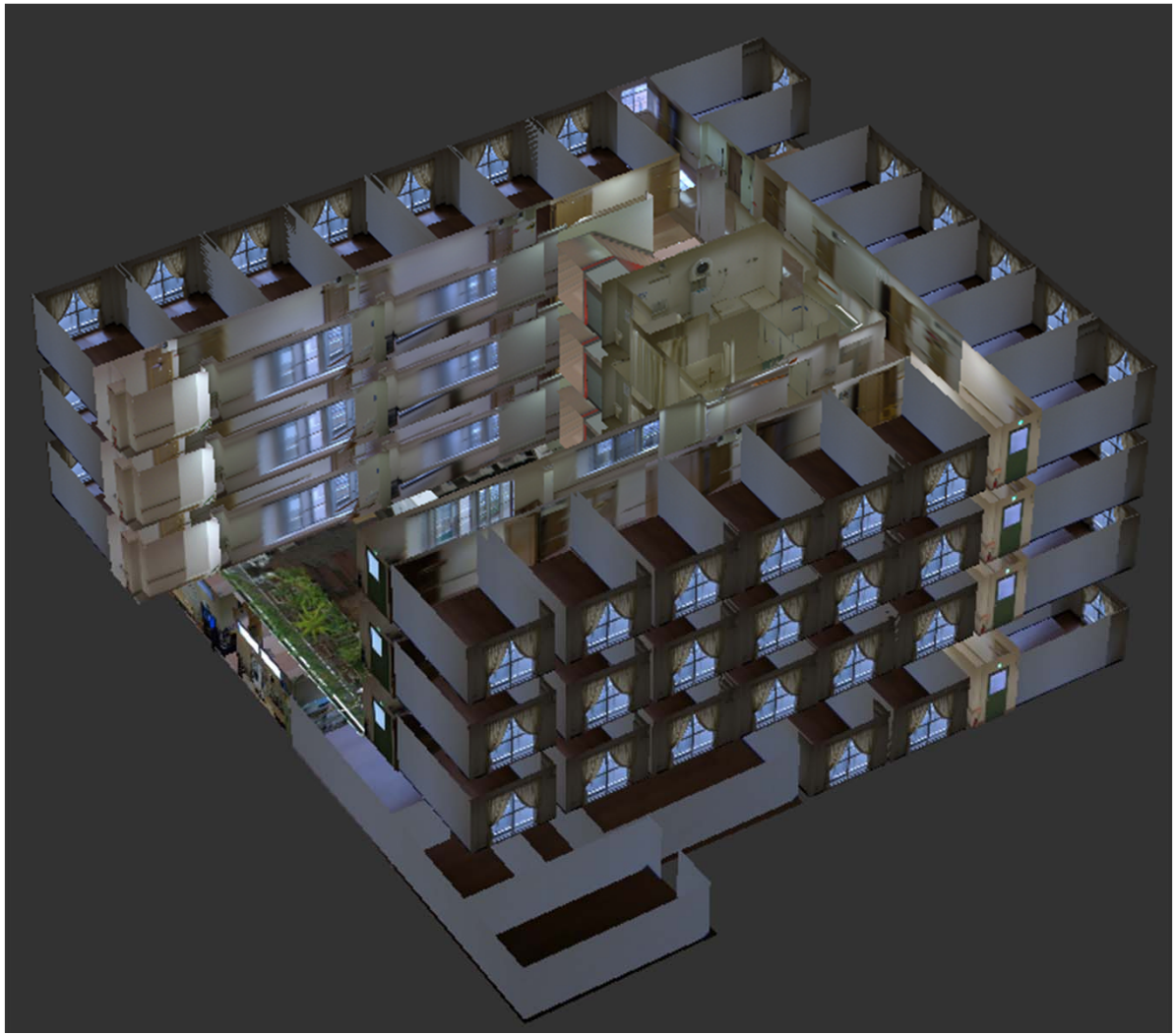
Center for Service Research

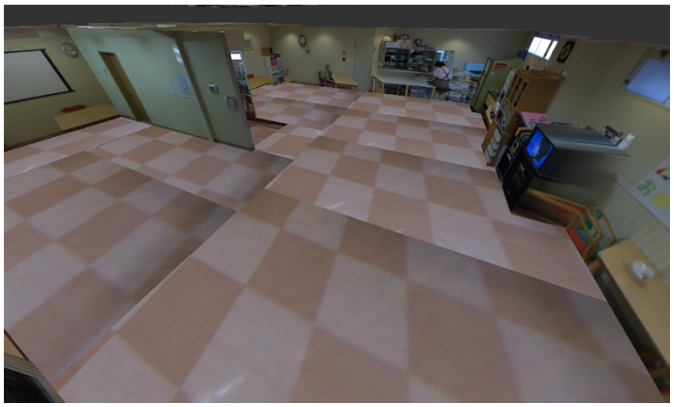
- Helper Leader
- Day shift

Time flow: RYGSB

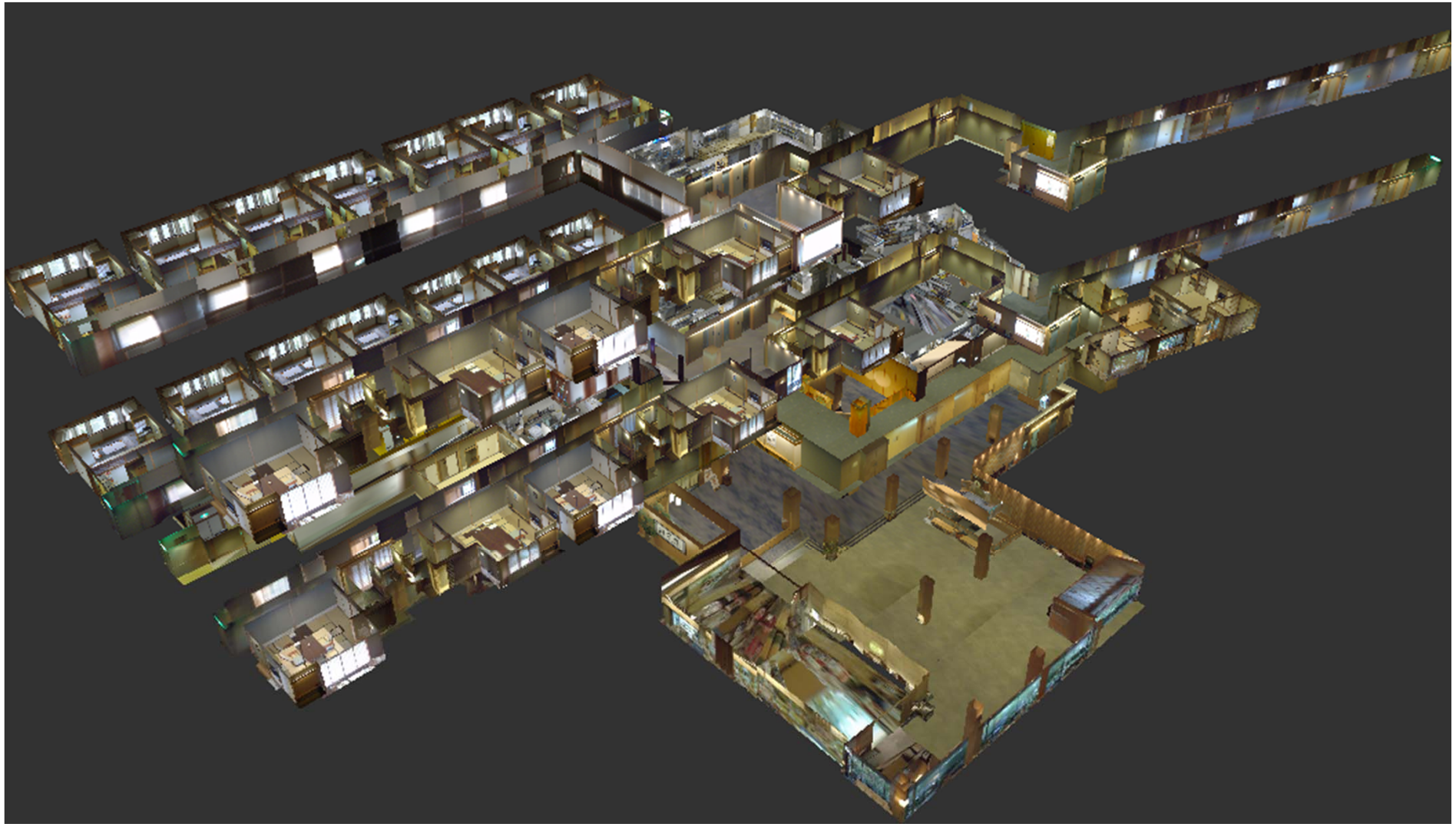


Nursing facility: Supercourt Minami-hanayashiki

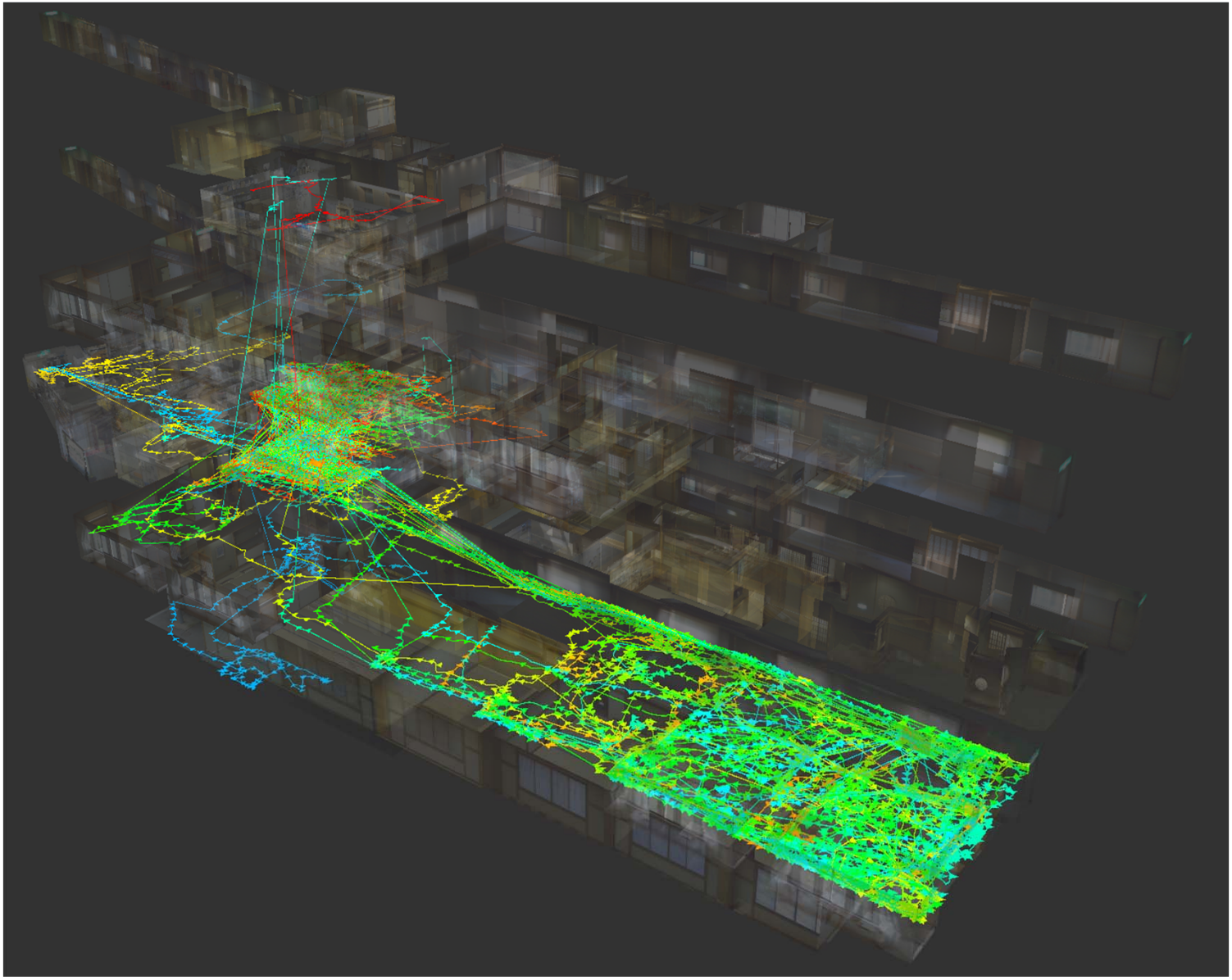




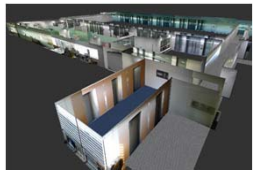
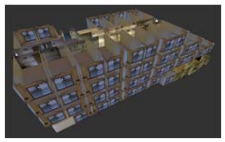
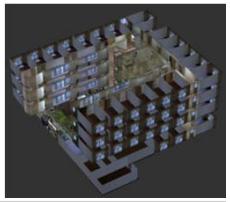
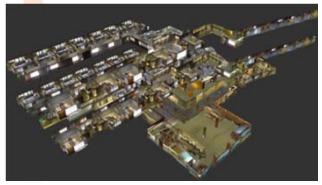
Shogetu-tei, KINOSAKI Hotspring



Shogetu-tei, KINOSAKI Hotspring

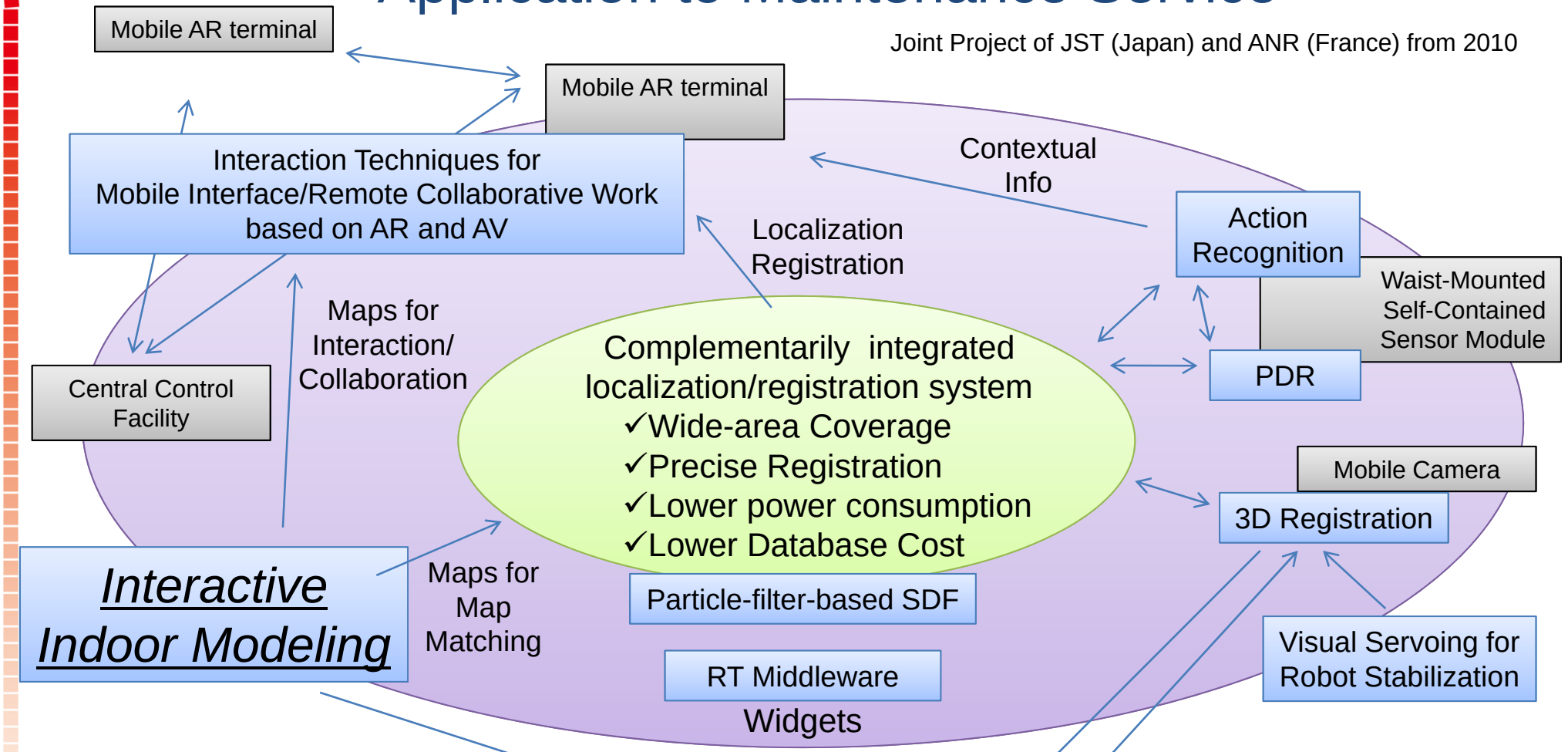


Modeling Cost

	# of photo shot	# of photo used	Time of photo shooting (hrs)	Time of model making (hrs)	Area
 AIST 6F	253	68	0.5	9.5	
 ISMAR09	149	57	0.75	6.25	
 Ganko Nanba	396	41	1.75	15	
 Ganko Hankyu	159	68	0.5	15	400
 Supercourt Hirano	359	65	1	22	1800
 Supercourt Minamihana yashiki	351	47	2	20	
 Shogetu-tei, KINOSAKI Hotspring	1798	388	6.9	105	

Augmented Mobile Interactive Experience (AMIE) : Application to Maintenance Service

Joint Project of JST (Japan) and ANR (France) from 2010

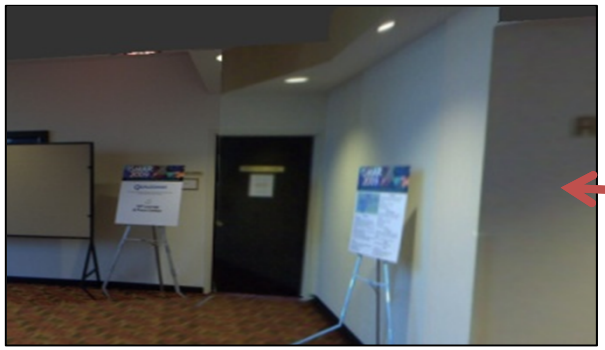


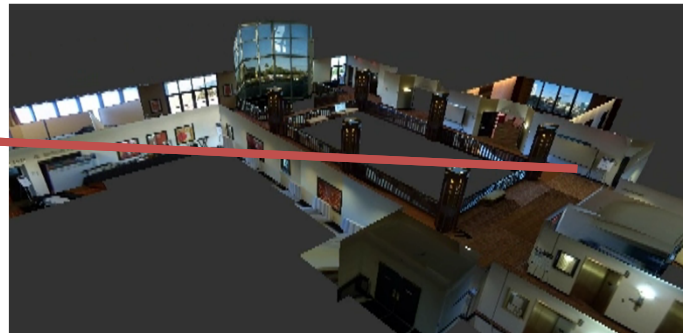
SDF: Sensor-Data Fusion
PDR: Pedestrian Dead-Reckoning
RT: Robotic Technology
TrakMark WG: 3D tracking benchmark activity proposed in ISMAR2009

Conclusions and Future Works

- MR models for multipurpose
- MR model/information sharing can facilitate EBS.
- More service cooperation with MR models!
  - Alignment b/w photorealistic 3D models and input images in addition to instead of b/w panoramic image DB and input images?!

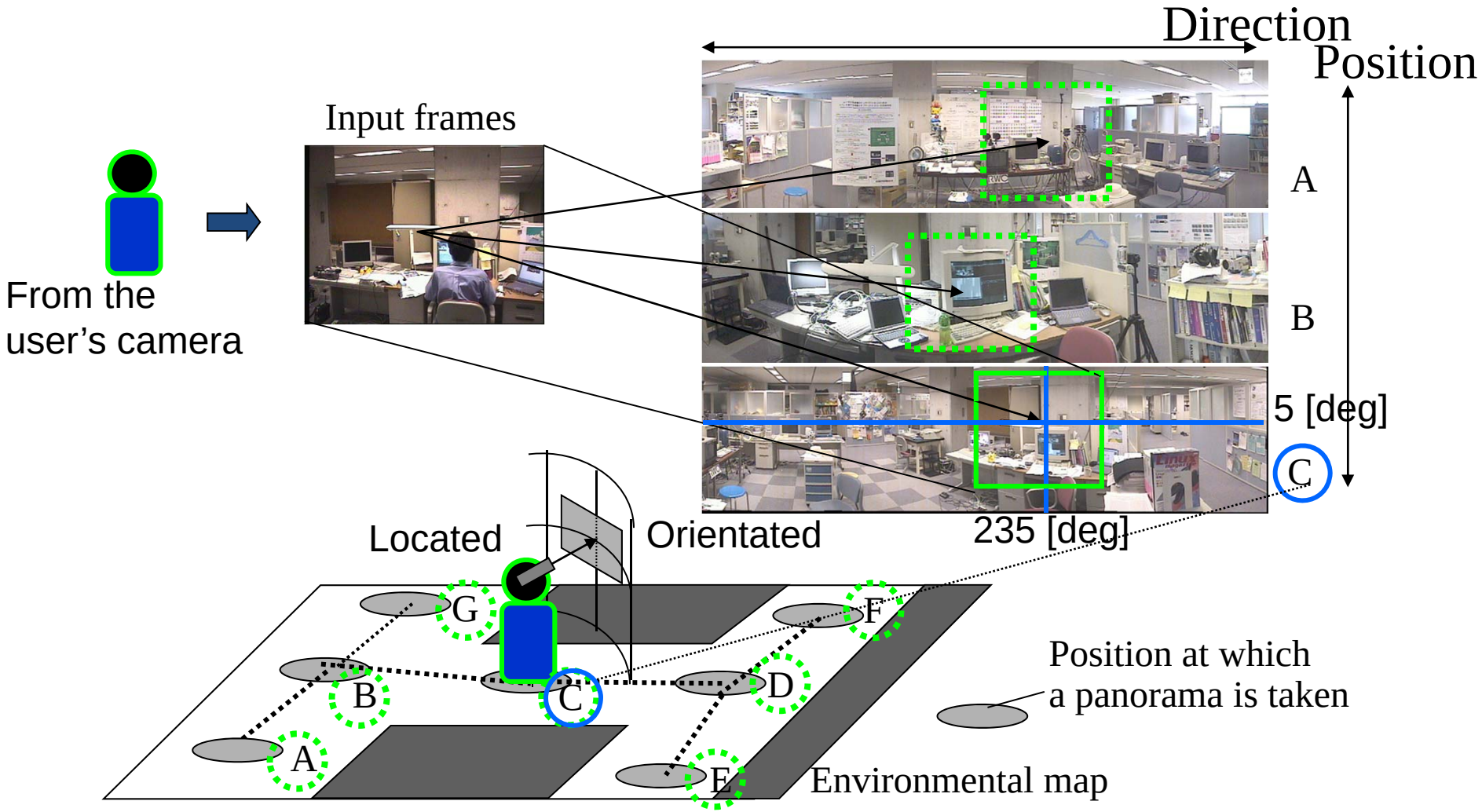
Input Image





Virtualized-Reality Model

Panorama-Based Annotation



M. Kourogi, T. Kurata, et al.,
IWAR1999, ISWC2001

Center for Service Research

Thank you for your attention.
Questions?