National Institute of Advanced Industrial Science and Technology
AIST

A benchmark suite with virtualized reality models for supporting tracking evaluation and data set generation

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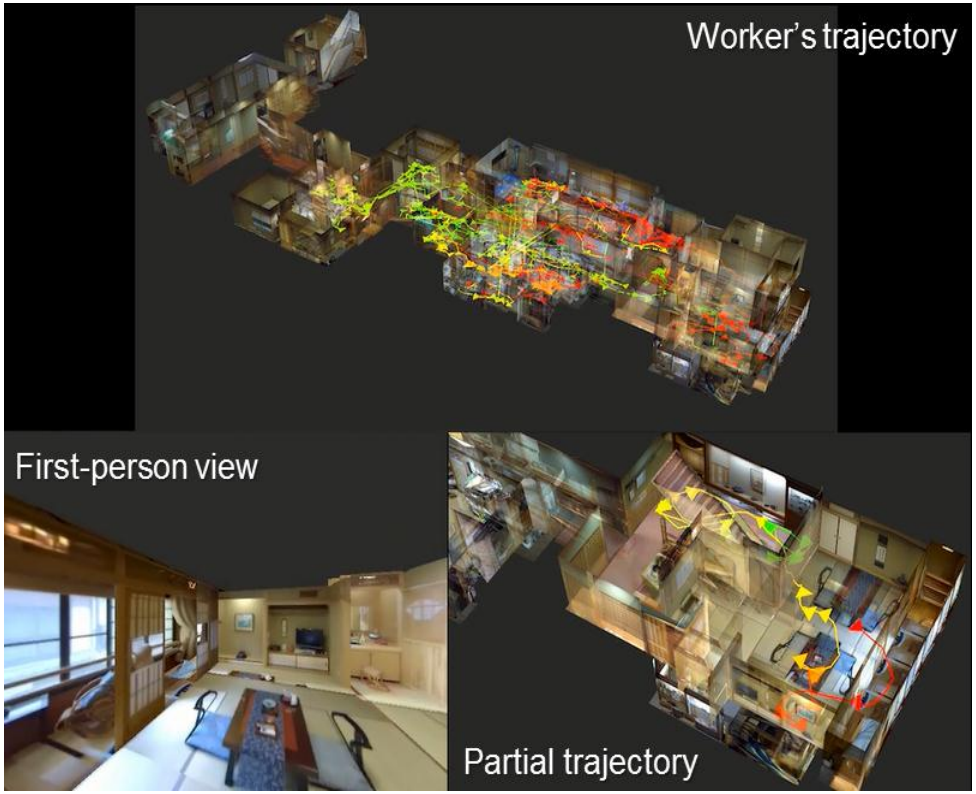
ICPR2012WS（TrakMark2012）20min
（Nov. 11. 2012@Tsukuba, Japan）

Our background : Virtualized reality models in service research

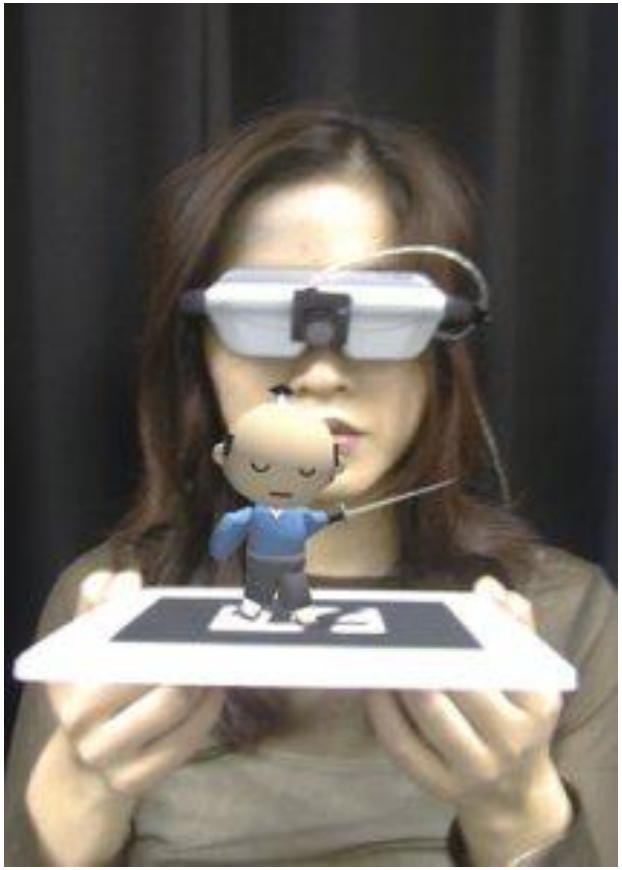
PDR (Pedestrian dead reckoning) demonstration in a social event



Visualization of worker's trajectory in "Ryokan" (Japanese traditional hotel)

Many opportunities to create virtualized reality models

Image Based Tracking for AR

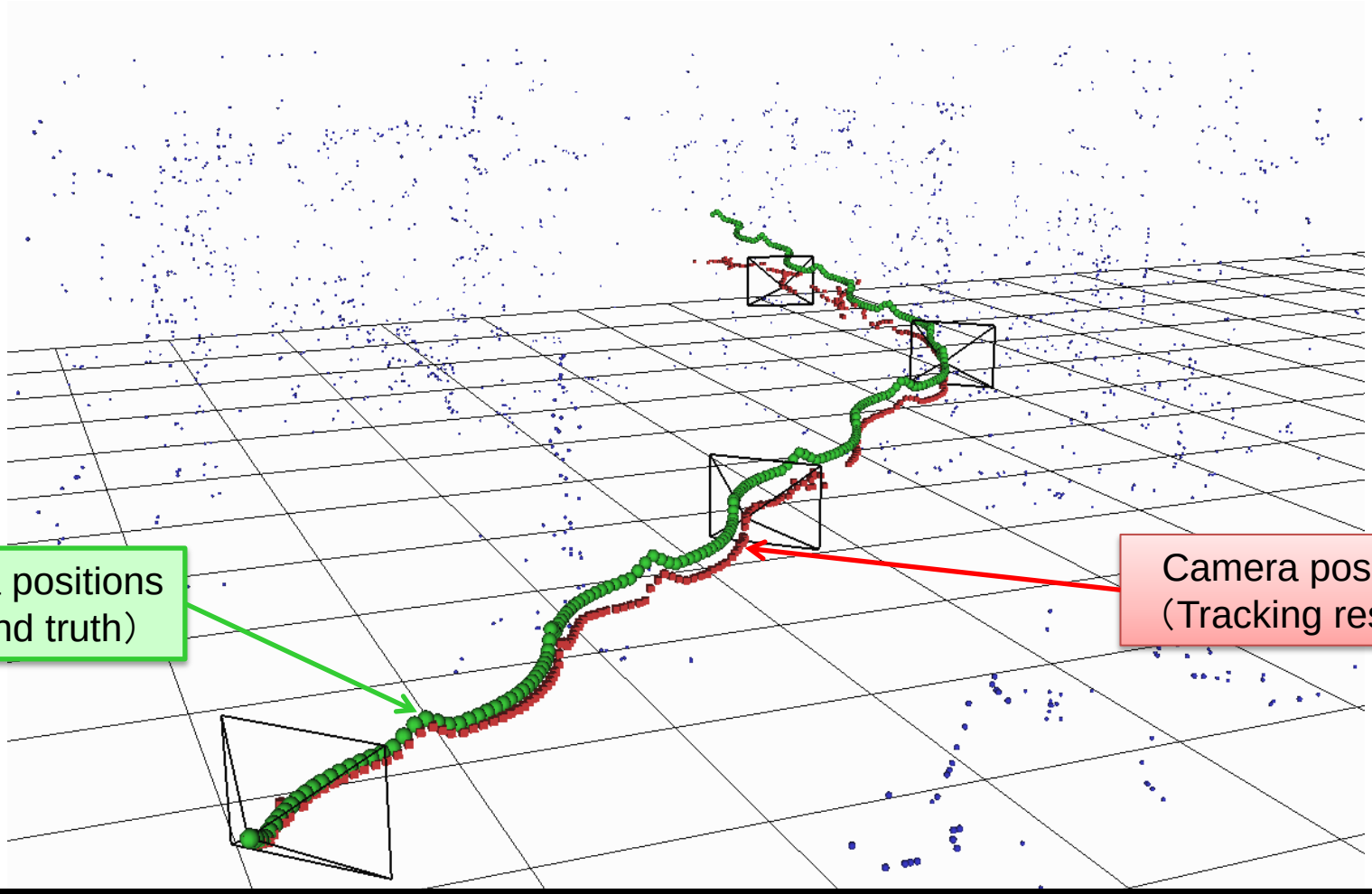


Tracking with artificial markers
“ARToolKit”(Kato, et al)

Tracking with interest points
“PTAM” (G. Klein, et al)

How do we benchmarking the estimated camera parameters?

Benchmarking of camera tracking methods



Issues in the benchmarking

1：Ground truth of camera parameters is needed for accuracy evaluation.
2：Common data set and indices are needed for comparative evaluation.
3：Data set should able to be customized for users' own situations.

Objective

Construction of a benchmark suite for supporting tracking evaluation and data set generation

■Approach

<u>We apply virtualized reality models.</u>

✔Ground truth data are available.

✔Users can generate arbitrary camera path.

<u>We construct standards in two categories.</u>

- ●Dataset-format
- ●Indices for benchmarking camera tracking method

We plan to standardize benchmarking methods in “ISO / JTC1 / SC24 / WG9（Augmented reality continuum concepts and reference model）”

Related works：
Data set with ground truth (or reference data)

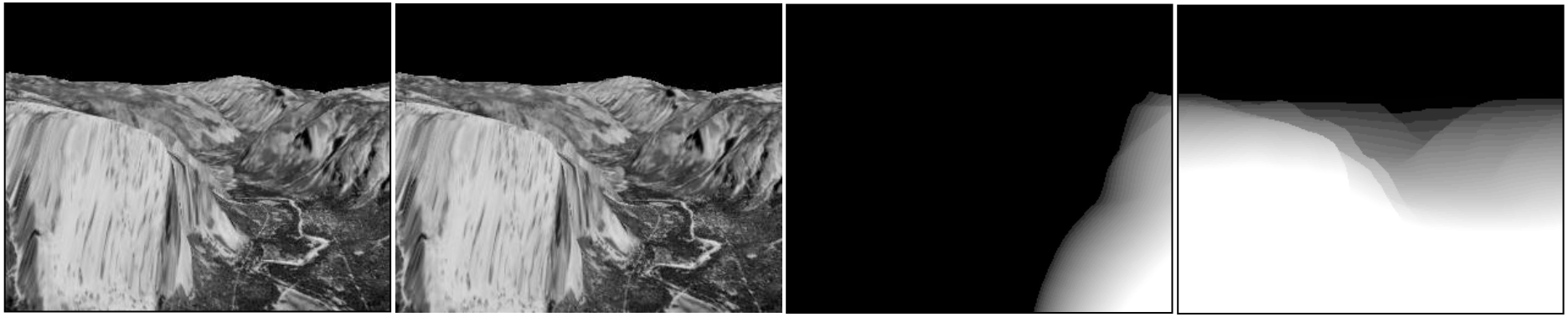
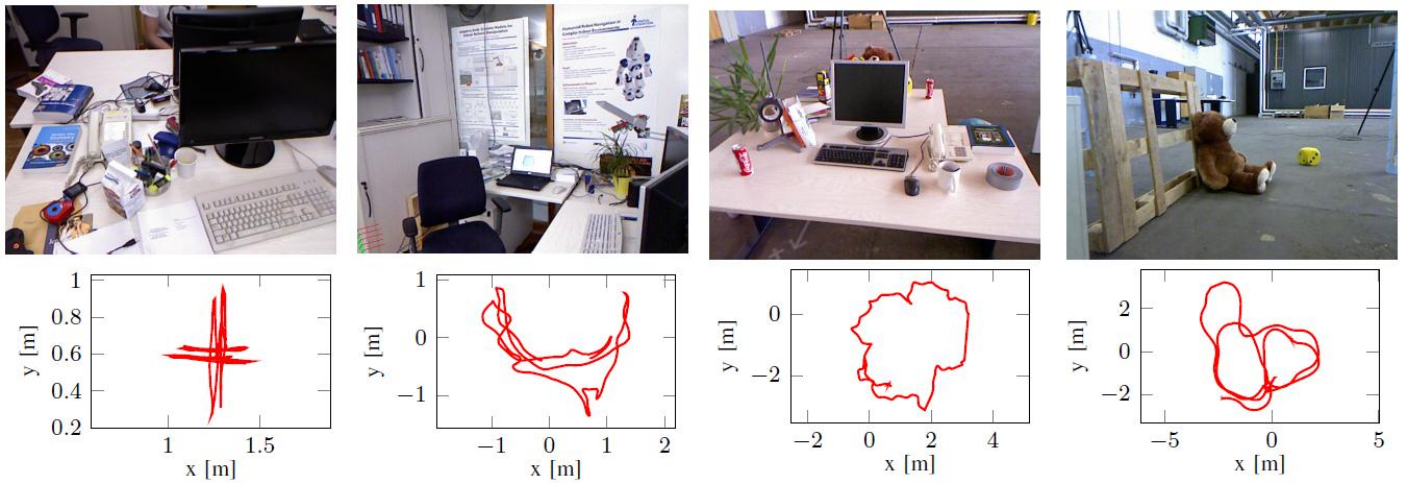


Image_00 Image_01 Flow_x Flow_y

The Yosemite sequence (by Lynn Quam)



A Benchmark for the Evaluation of RGB-D SLAM Systems
(J. Sturm et al, IROS2012)

Proposed framework

User

Server

Benchmark resources

A : Datasets
（Generated images, Camera parameters, Image features）

Provision of datasets with various properties

B : Benchmark suite
(Virtualized reality models, Camera paths, Supporting tools)

・Support for dataset creation and benchmarking
・Datasets compression

C : Expansions for supporting tools
（Camera motion models, Adding of original objects, etc.）

Support for specific situations

Sharing of benchmarking results

- Position and posture errors
- Re-projection error of image features
- Computational cost (time)
- Re-projection error of image features
- The number of datasets used for benchmarking and the variety of property

Benchmarking for comparison purposes

User

Server

Download

Download

Benchmark resources

A : Datasets
（Generated images, Camera parameters, Image features）

Provision of datasets with various properties

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・Support for dataset creation and benchmarking
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Support for specific situations

Benchmarking of tracking methods (with benchmark suite)

Submission of the result

Sharing of benchmarking results

- Position and posture errors
- Re-projection error of image features
- Computational cost (time)
- Re-projection error of image features
- The number of datasets used for benchmarking and the variety of property

User's own benchmarking

User

Registration of new datasets

Server

Benchmark resources

A : Datasets
（Generated images, Camera parameters, Image features）

Provision of datasets with various properties

B : Benchmark suite
(Virtualized reality models, Camera paths, Supporting tools)

・Support for dataset creation and benchmarking
・Datasets compression

C : Expansions for supporting tools
（Camera motion models, Adding of original objects, etc.）

Support for specific situations

Download

Dataset creation

Benchmarking of tracking methods (with benchmark suite)

Submission of the result

Sharing of benchmarking results

- Position and posture errors
- Re-projection error of image features
- Computational cost (time)
- Re-projection error of image features
- The number of datasets used for benchmarking and the variety of property

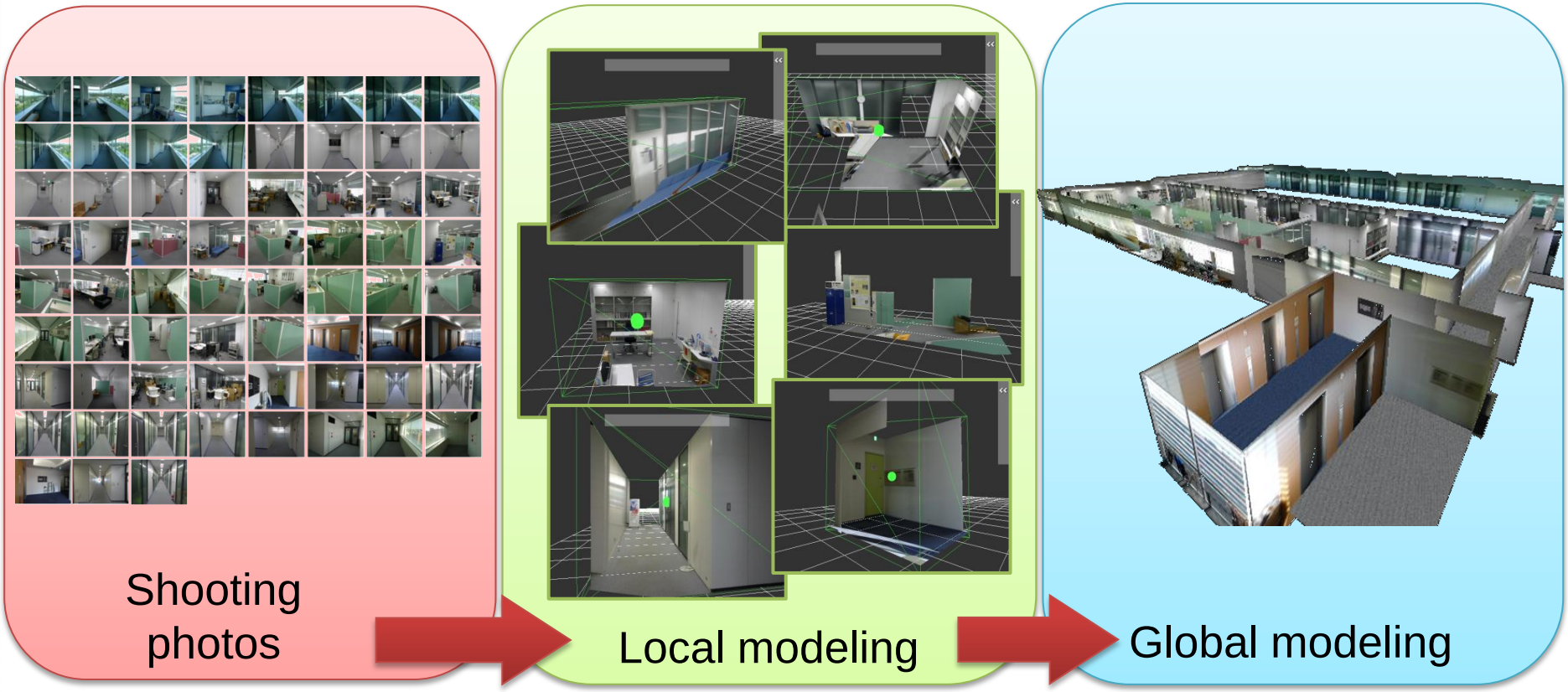
Classification

	Reality	Cost of modeling	Cost of creating reference data
Real world	High	None	High
Virtualized reality model	Mid	High	Mid
Virtual reality model	Low	Low	Mid

Issues in our research

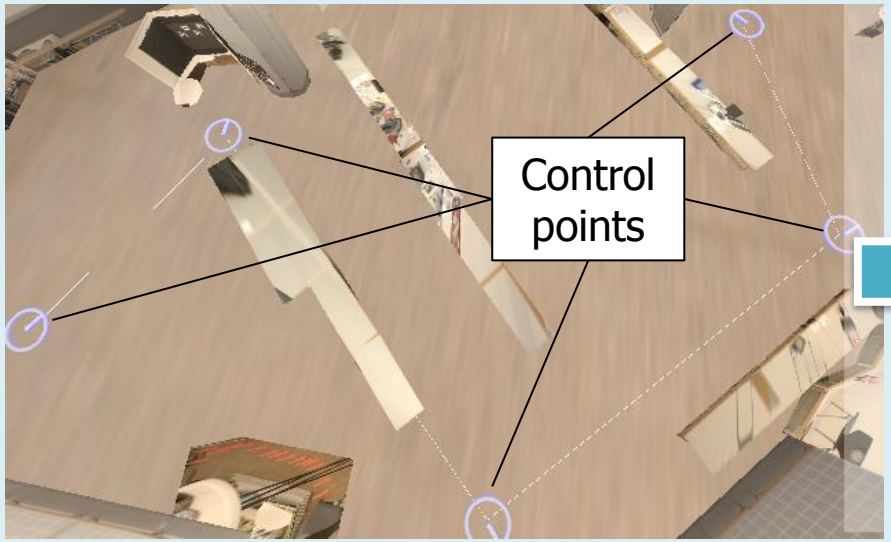
	Reality	Cost of modeling	Cost of creating reference data
Real world	High	None	High
Virtualized reality model	High	High	Mid
	▲	▼	▼
	Mid	Low	Low
Virtual reality model	Low	Low	Mid

Model creation in our laboratory

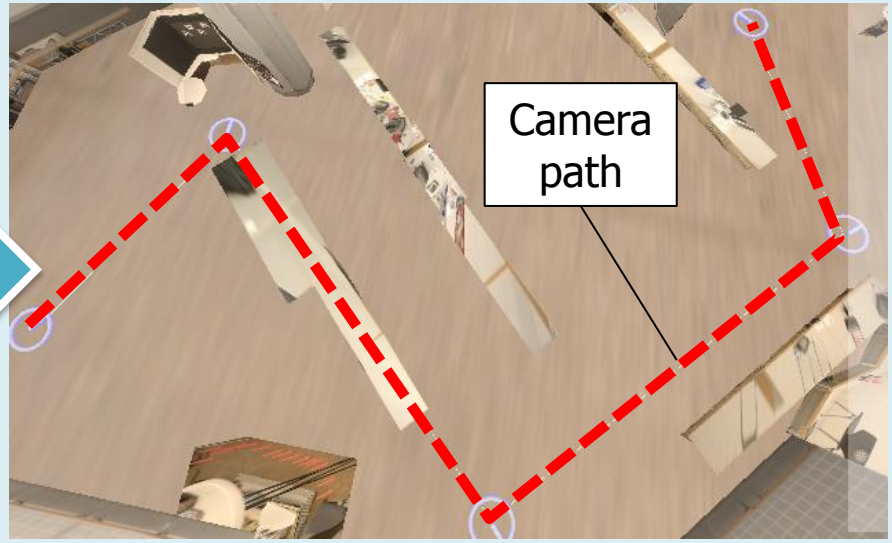


T. Ishikawa, et al: “In-Situ 3D Indoor Modeler with a Camera and Self-Contained Sensors”, In Proc. of HCII2009, pp.454-464, 2009.

Proposed tool for generating data set

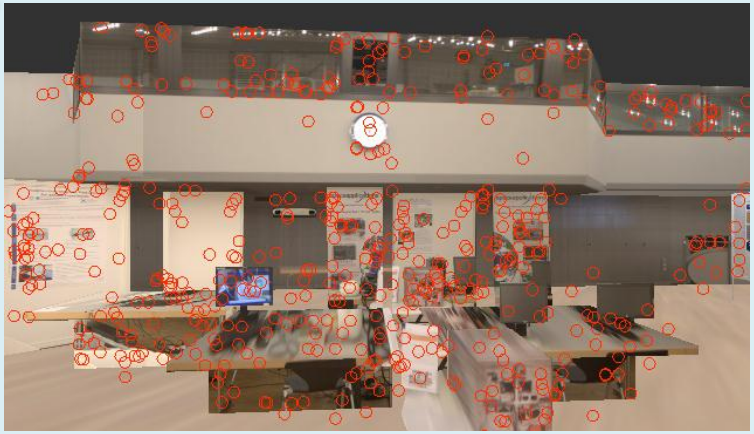


Setting up of control points.



Camera path creation with linear interpolation.

Generated images.
(Camera parameters of the images are available.)



Data of interest points.
(3D-2D correspondences are known.)

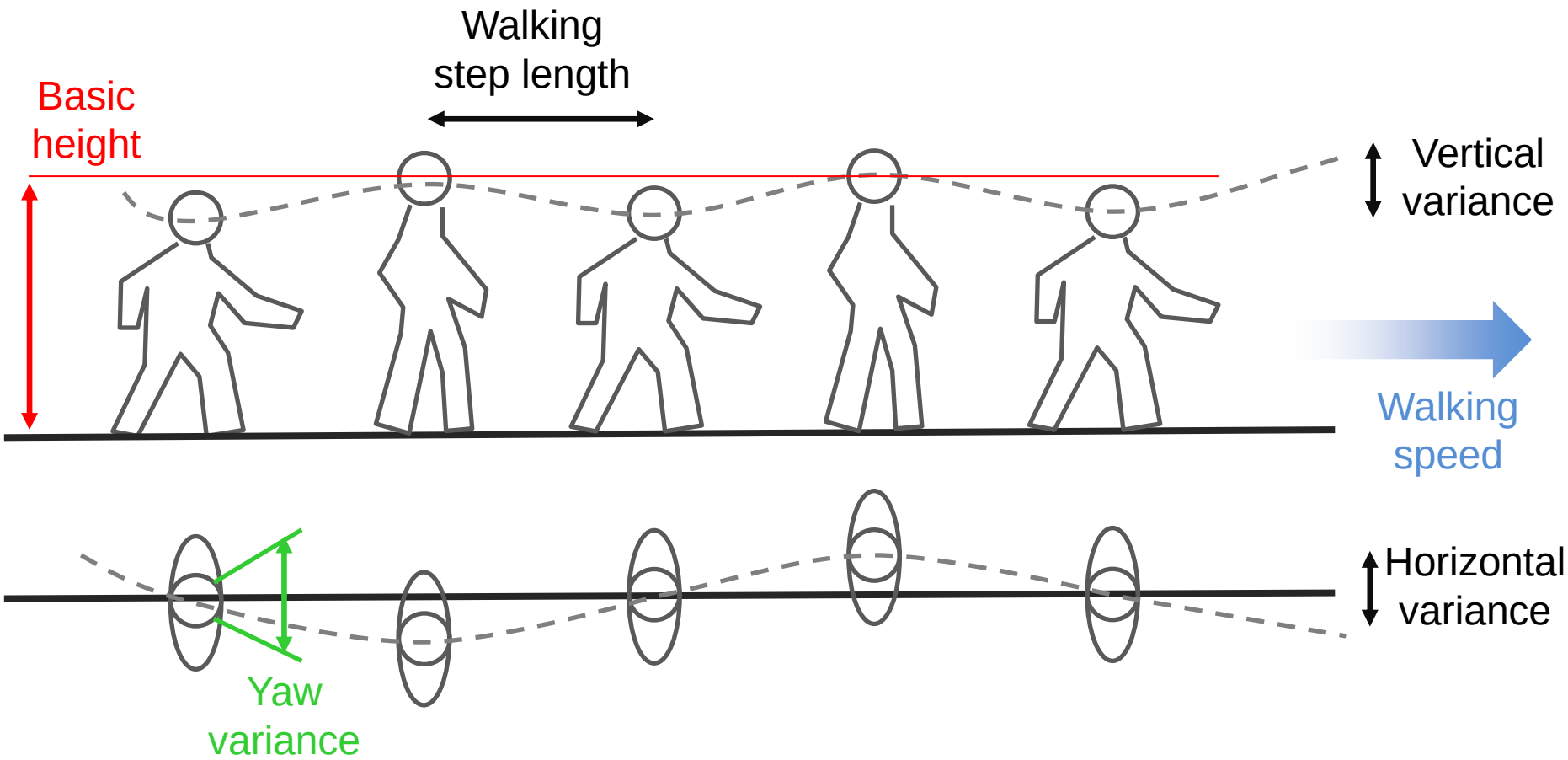
Appearance of generating data set with the tool

Videos captured by Head Mounted Camera and Hand Held Camera

Walking motion

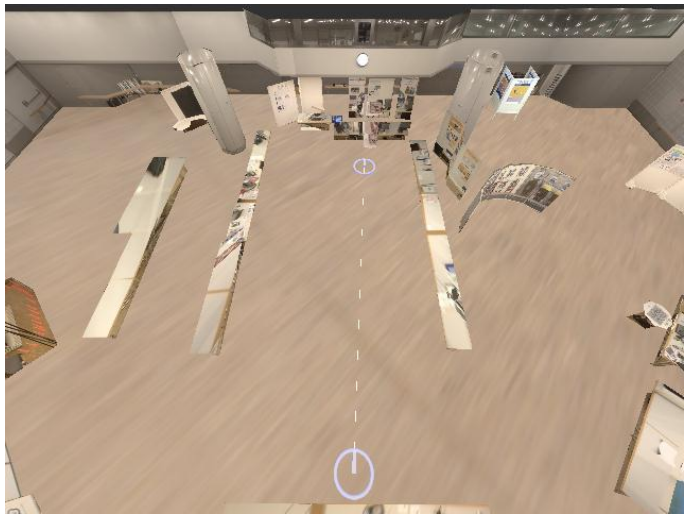
Blur

Modelization of walking motion



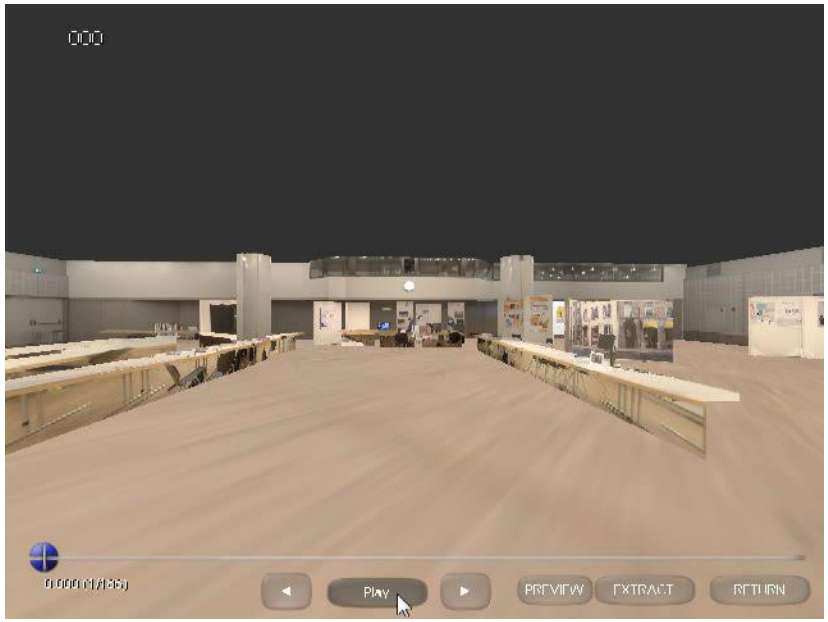
Walking motion model is introduced to the tool
for simulating a motion of head-mounted camera.

Results of applying walking motion models



Settings of parameters

- Basic height
  1600 [mm]
- Vertical variance
  50 [mm]
- Horizontal variance
  80 [mm]
- Yaw variance
  1 [degree]
- Walking step length
  650 [mm]
- Walking speed
  900 [mm]



Without walking motion

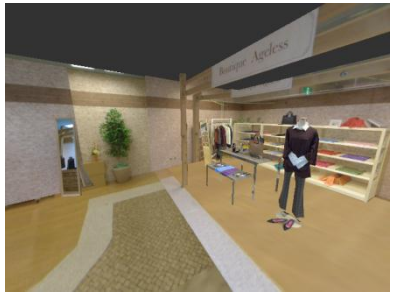
With walking motion

Functions for applying defocus blur and motion blur

Normal images

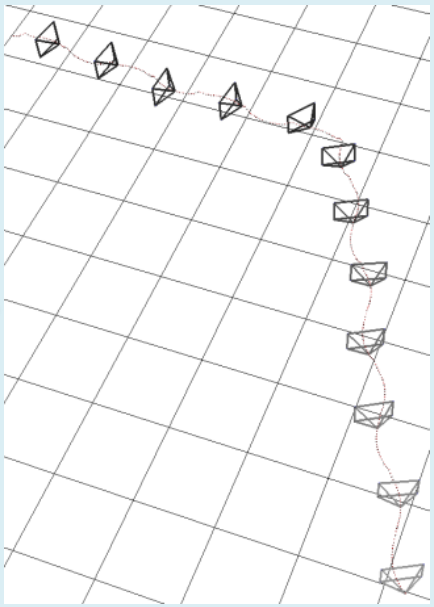
Images with defocus blur

Experiment (user's own benchmarking)

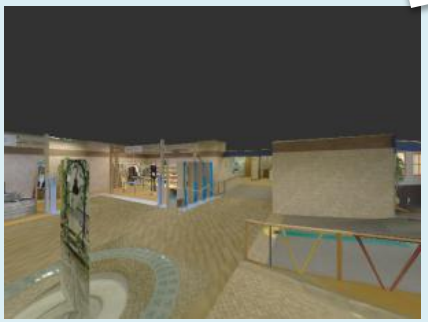


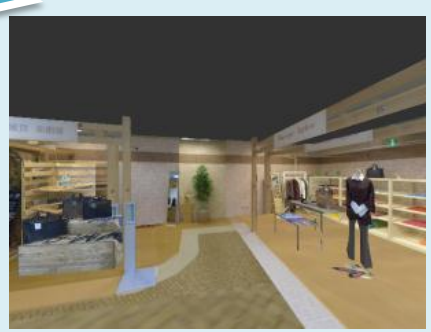
Virtualized reality model used in the experiment.
(Shopping mall in Osaka, Japan)

1. Data set generation



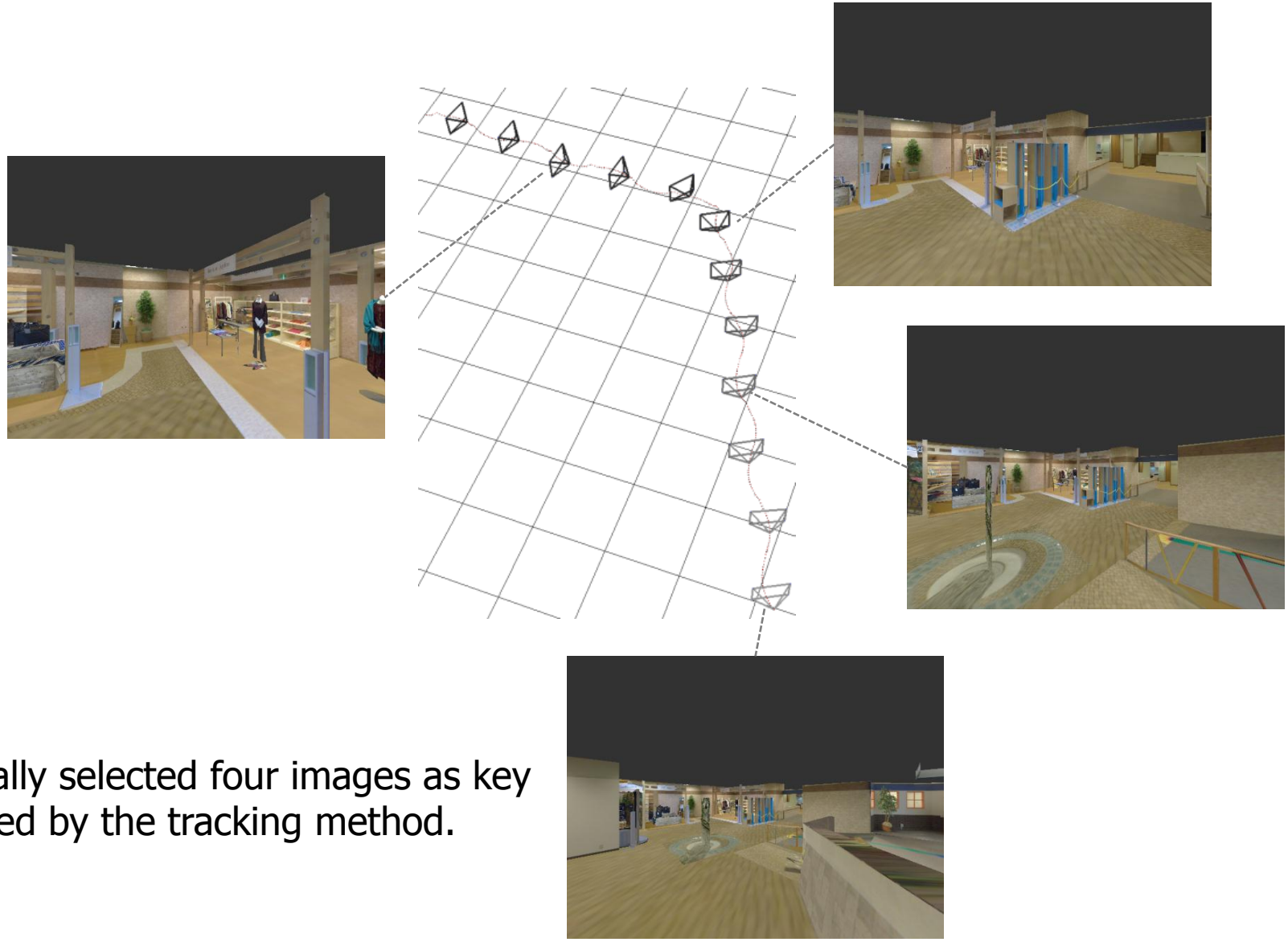
Camera path creation with walking motion





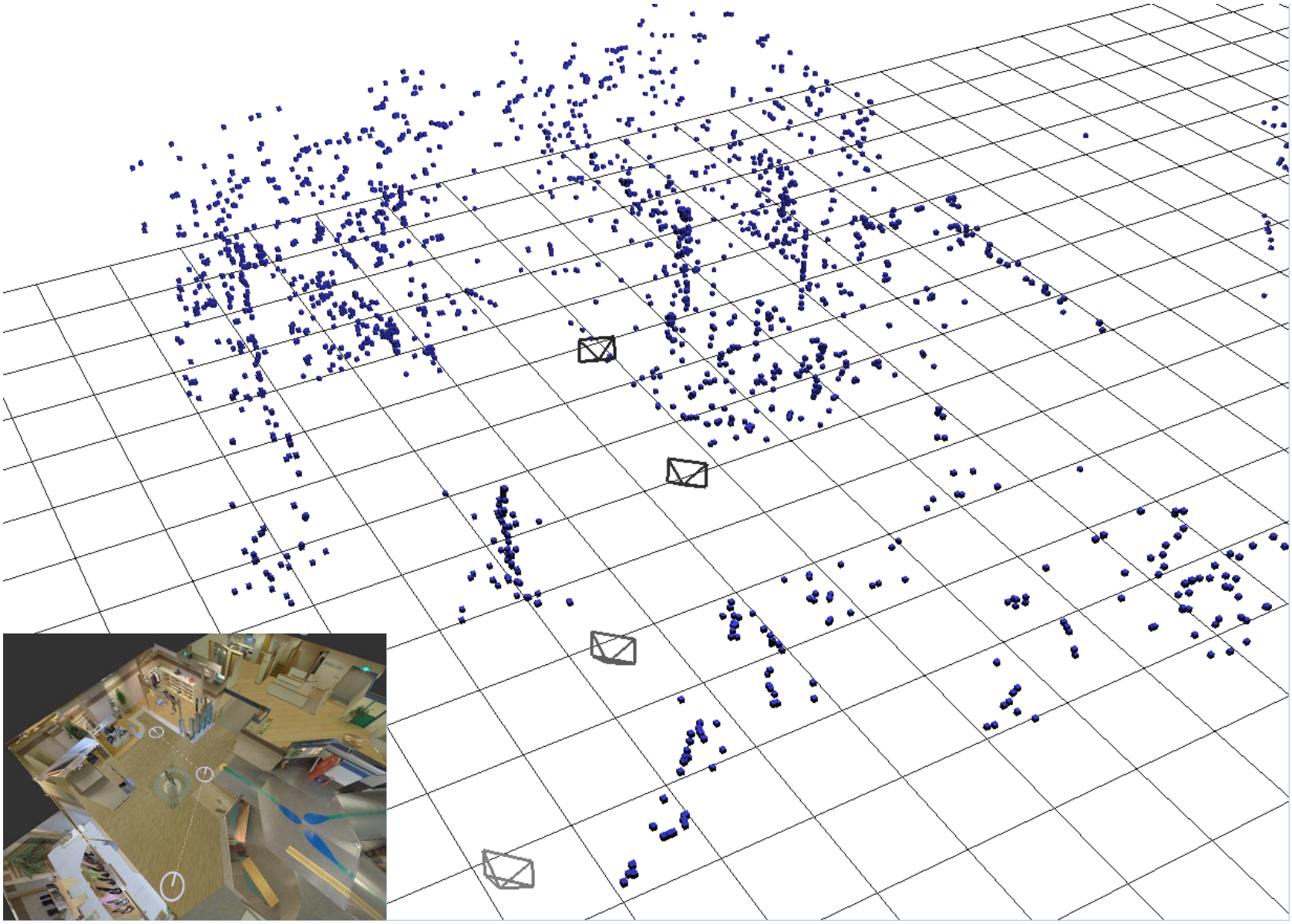
Generated images with virtualized reality models

2. Creation of key frames

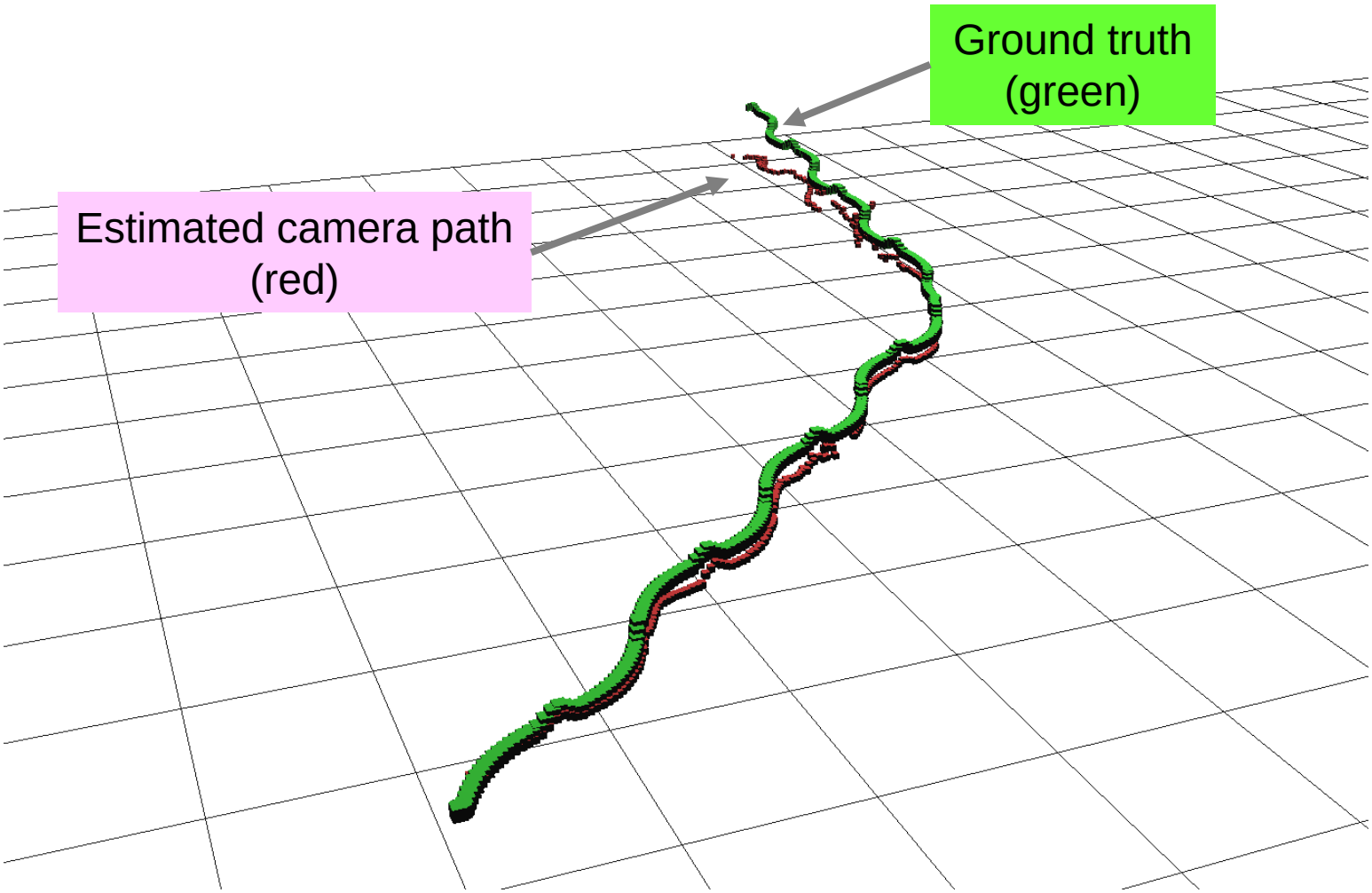


We manually selected four images as key frames used by the tracking method.

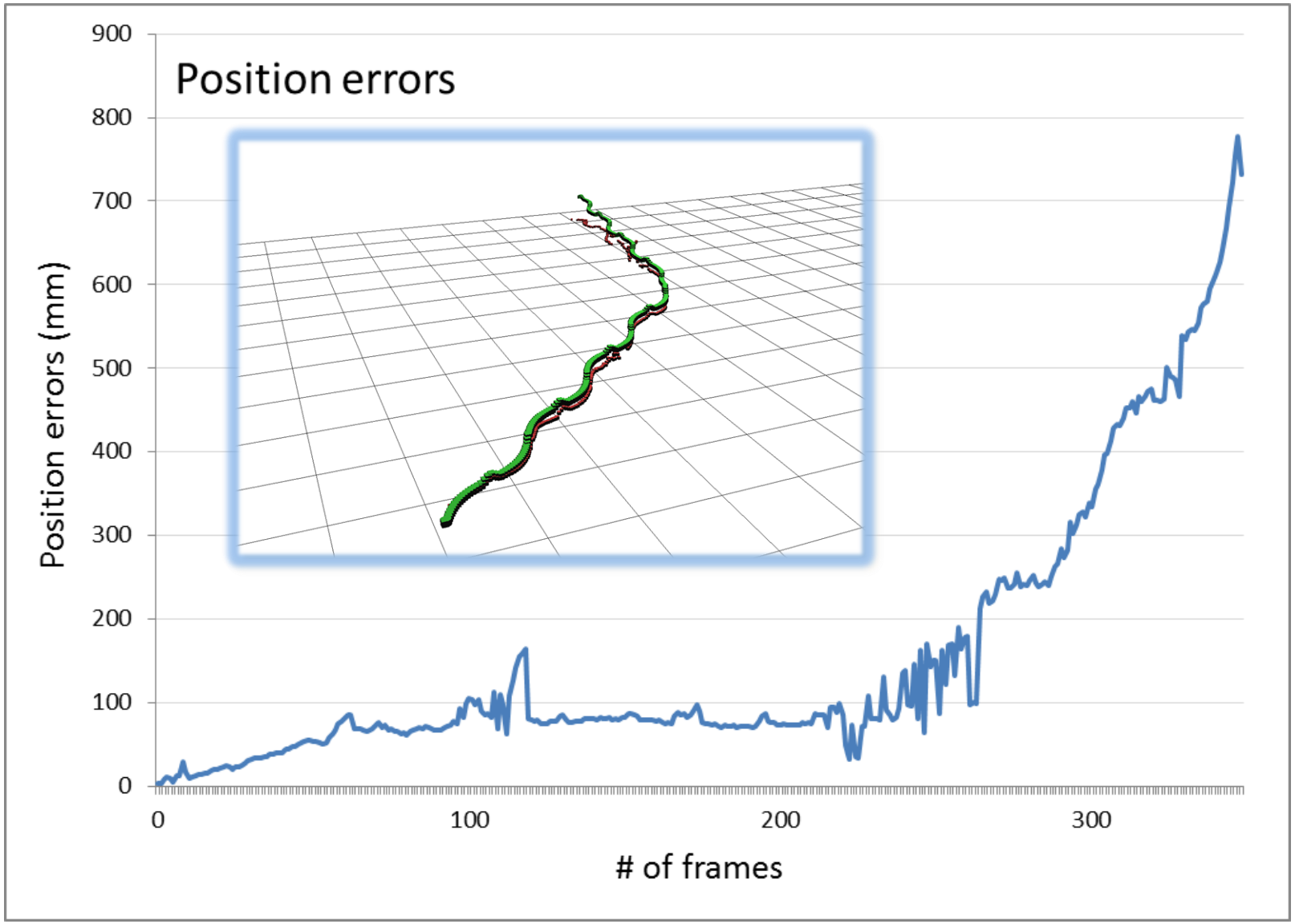
3. Generation of interest points



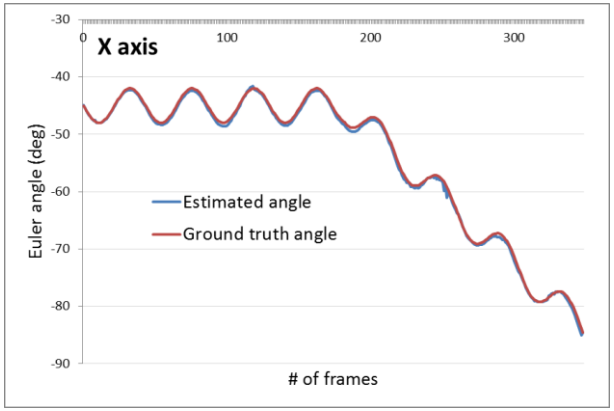
4.Camera tracking with generated images

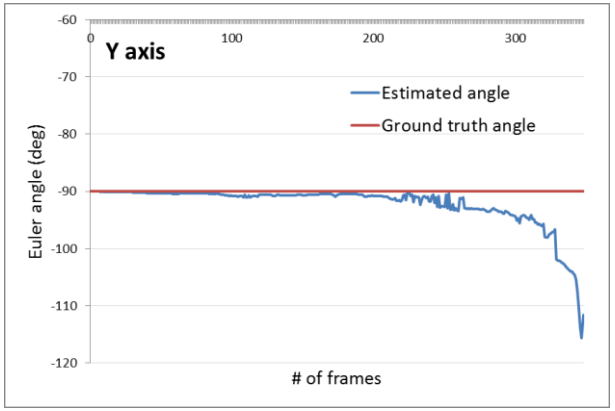


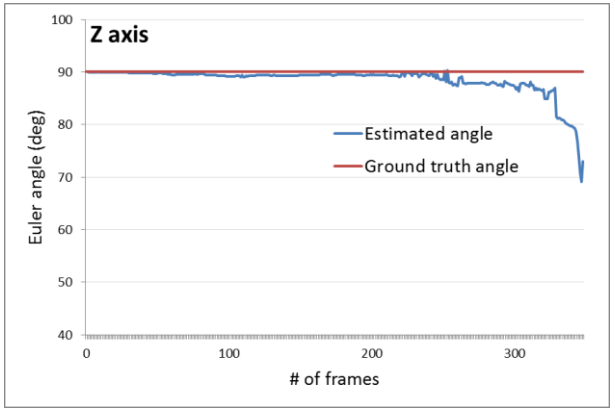
5. 1 Evaluation of camera positions



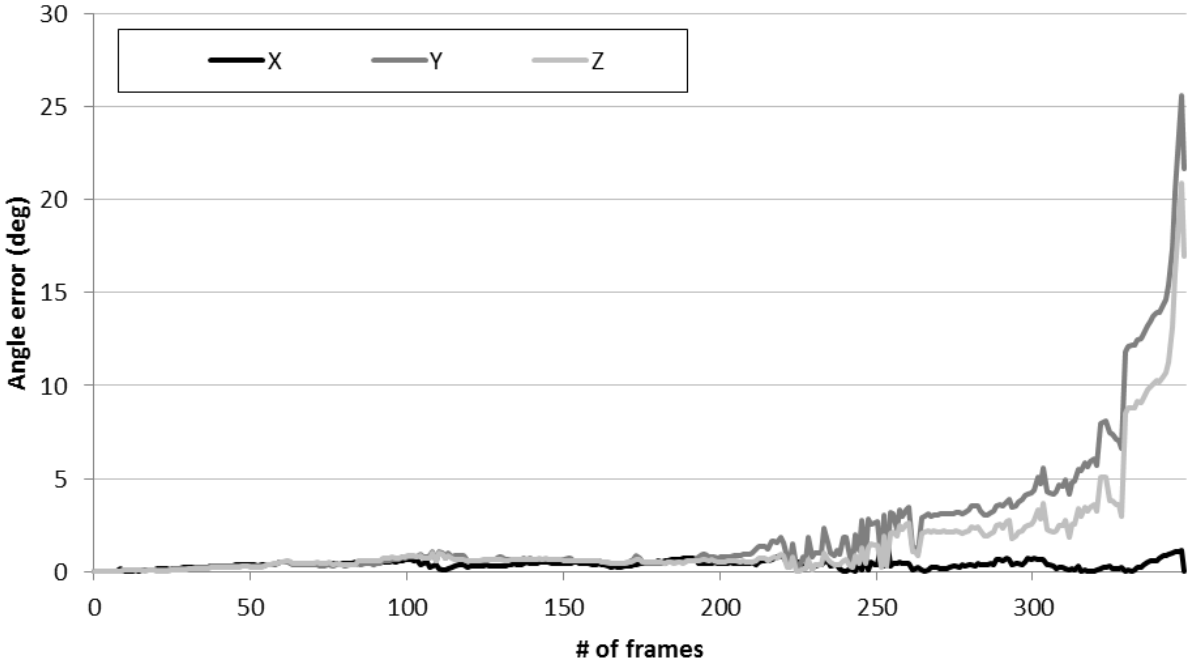
5．2 Evaluation of rotation error（Euler angle）







Euler angle（raw values）

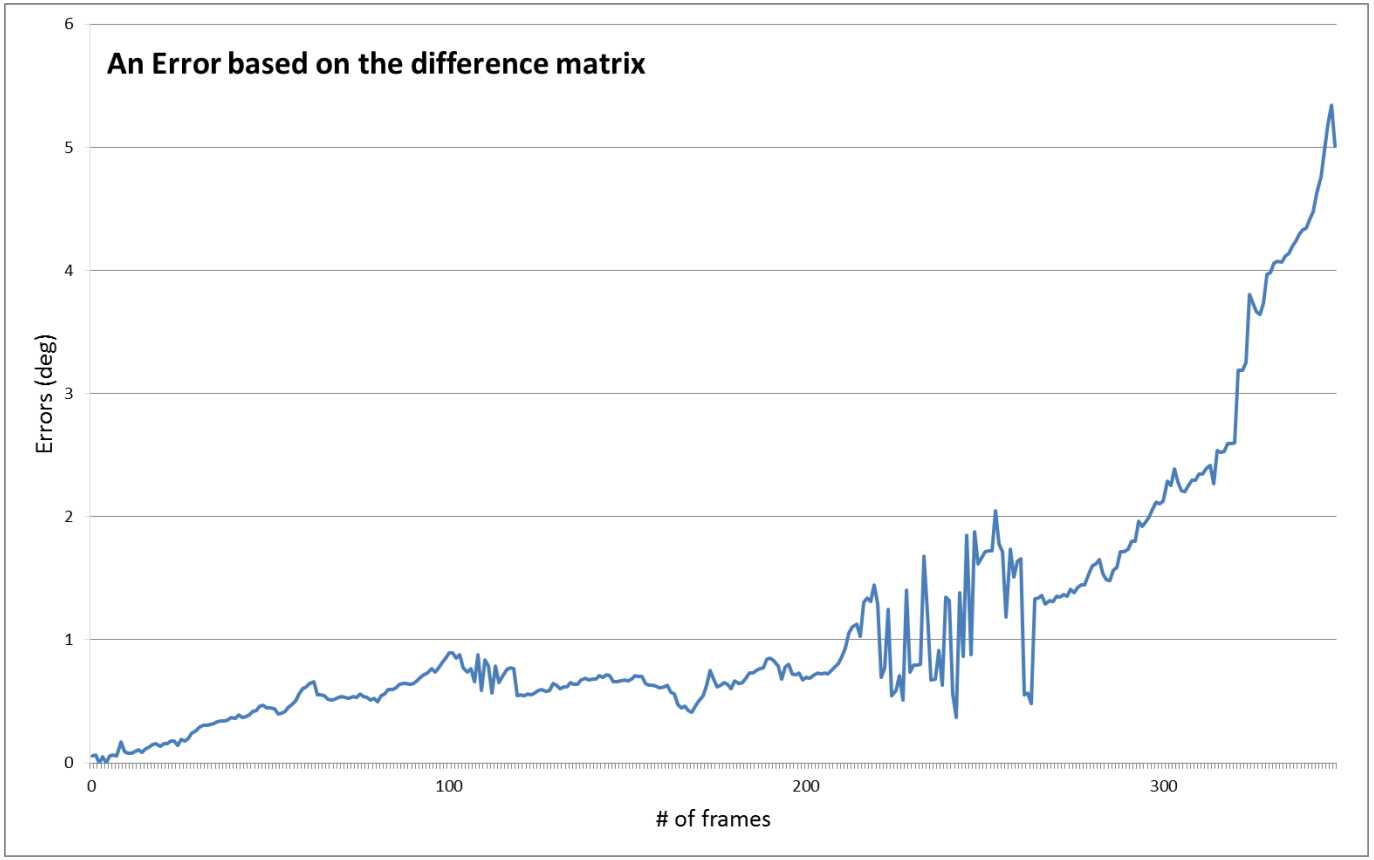


Errors of Euler angle

5.2 Rotation errors calculated by using difference Matrix

$$R_d = R_g R_e^T$$

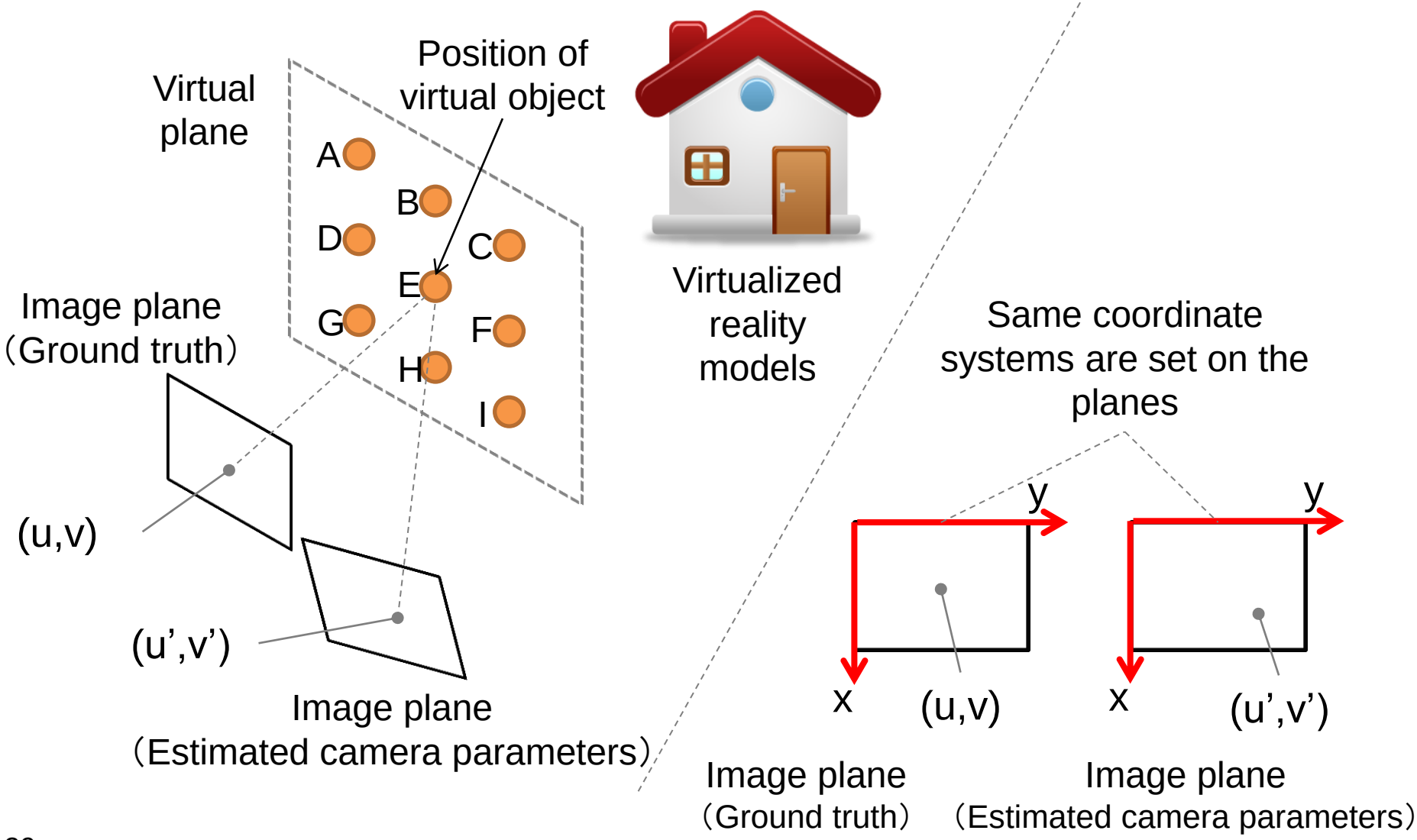
$$\theta_{R_d} = \arccos((\mathrm{tr}(R_d) - 1)/2)$$



Rotation errors calculated by using difference Matrix

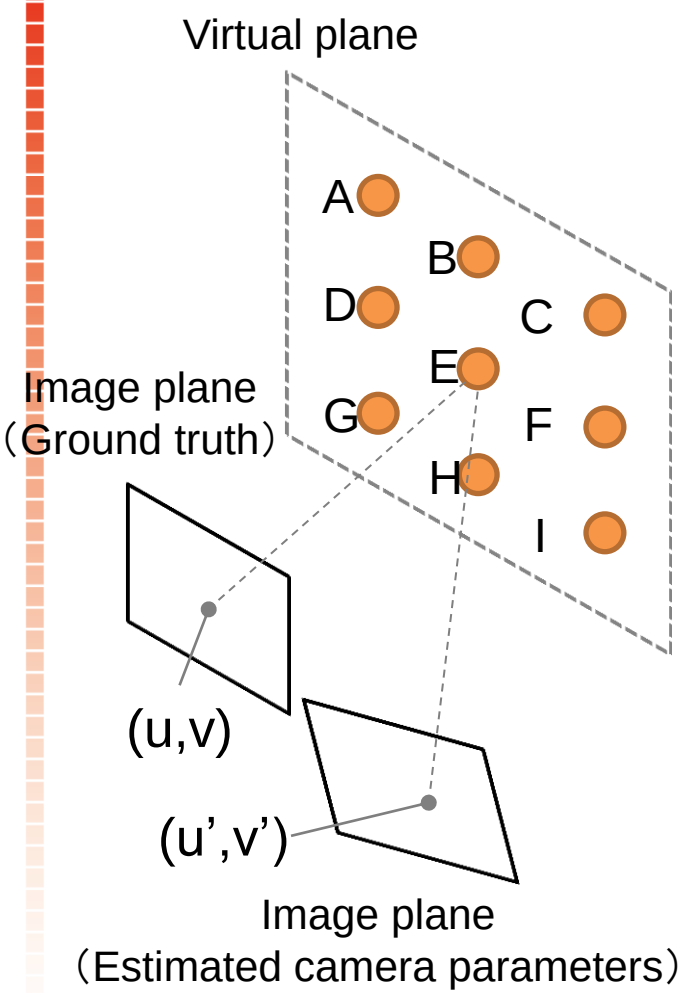
5.3 Projection error of virtual objects

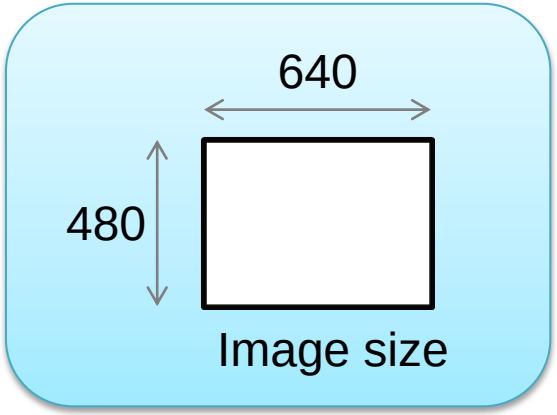
Calculation procedure



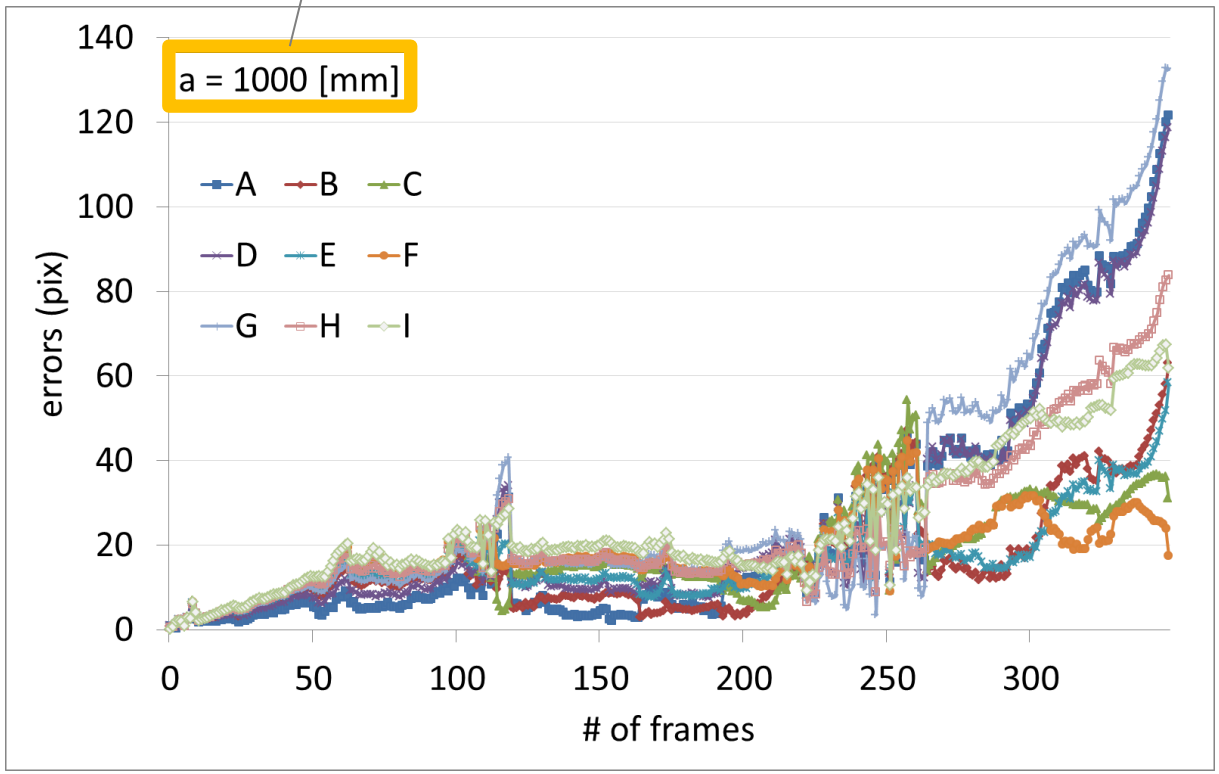
5.3 Projection errors of virtual objects

Calculation result

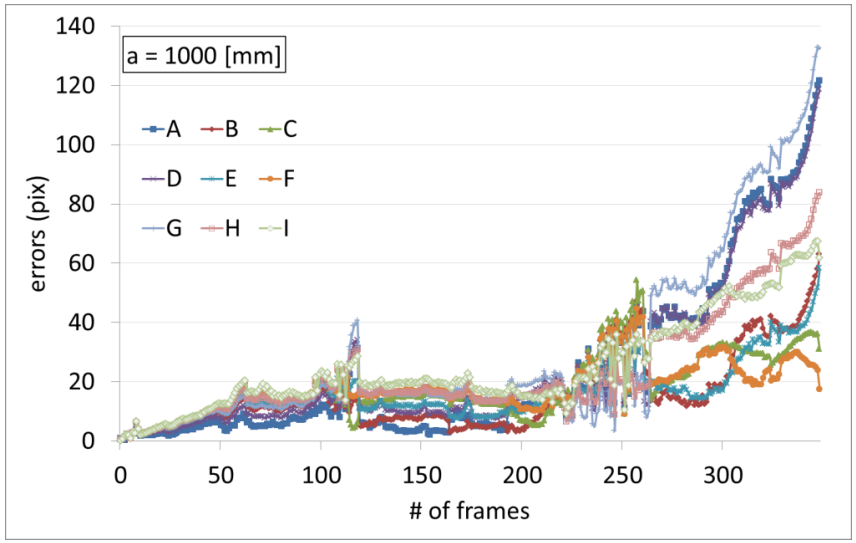




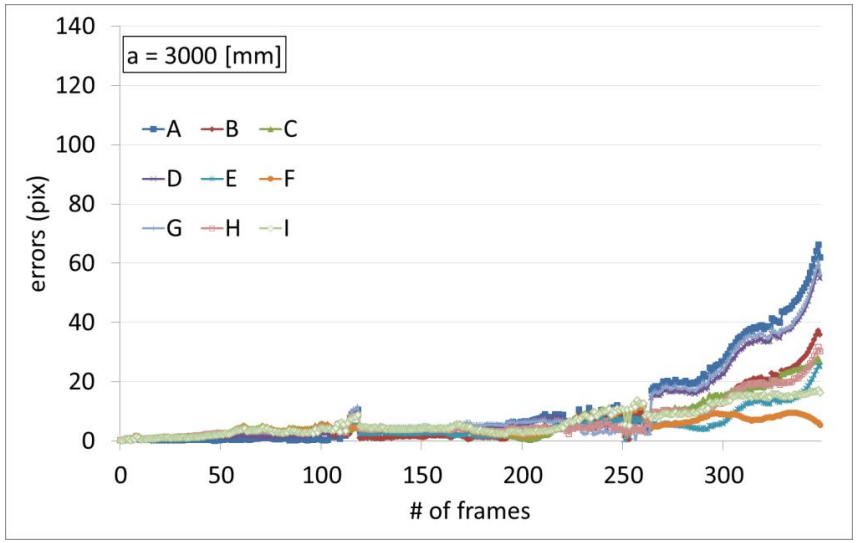
A distance from the camera to the virtual plane



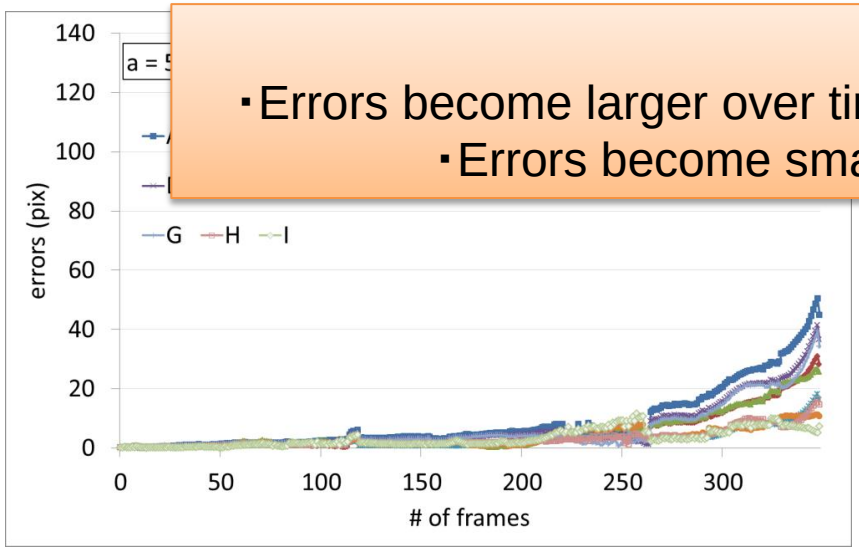
5.3 Projection errors of virtual objects （with various distances）



a = 1000 [mm]



a = 3000 [mm]

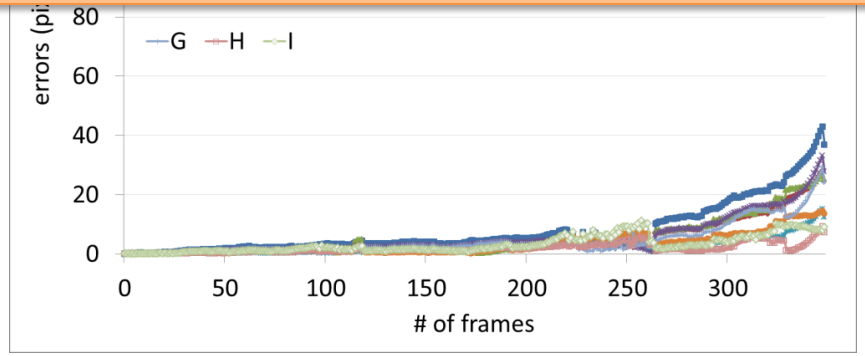


a = 5000 [mm]

Features：

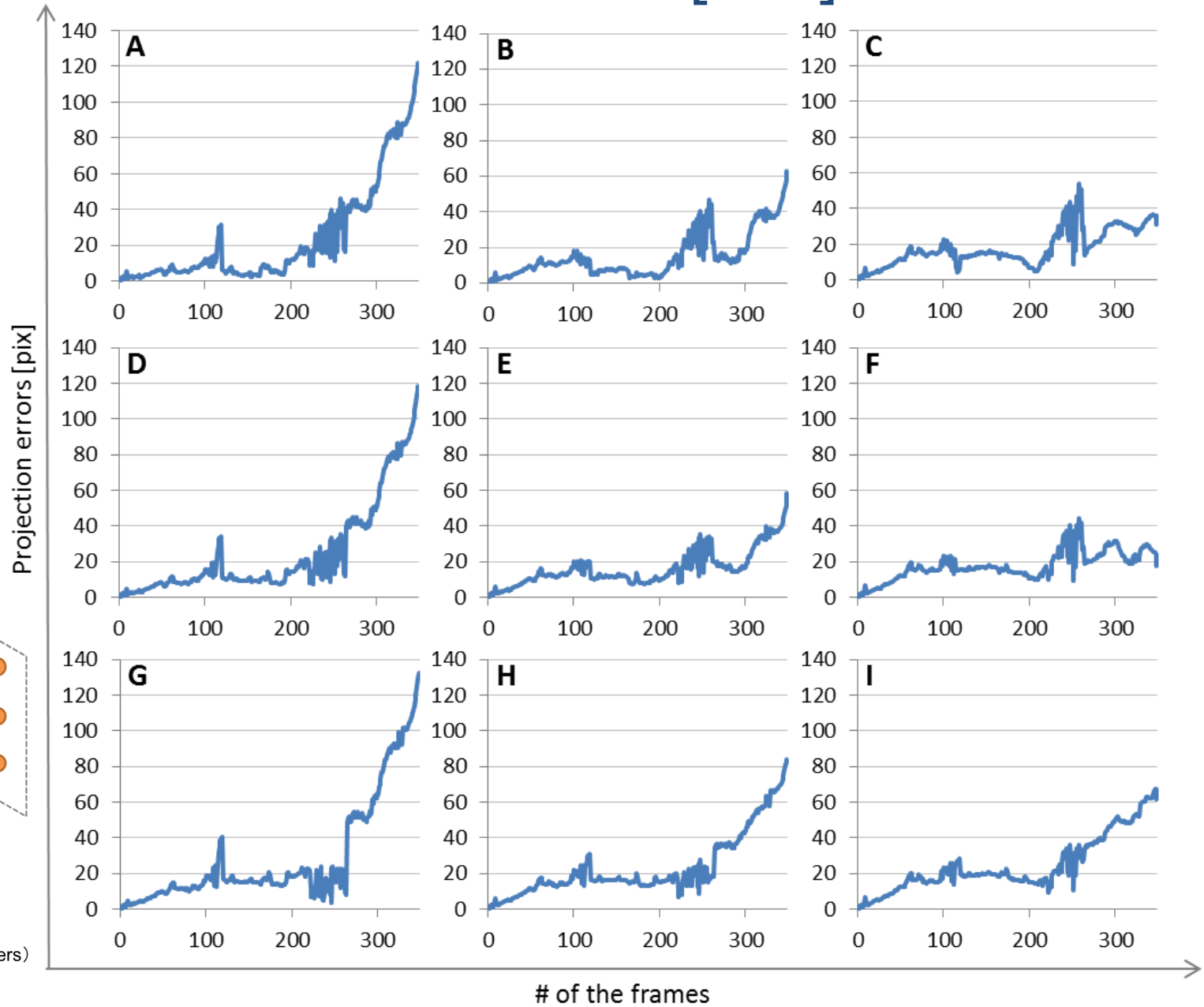
・Errors become larger over time（similar to position and rotation errors）

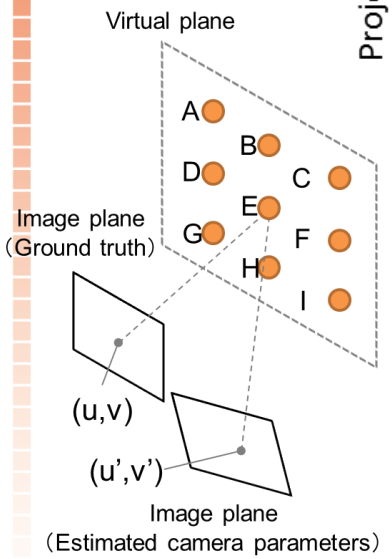
・Errors become smaller when the distance increases



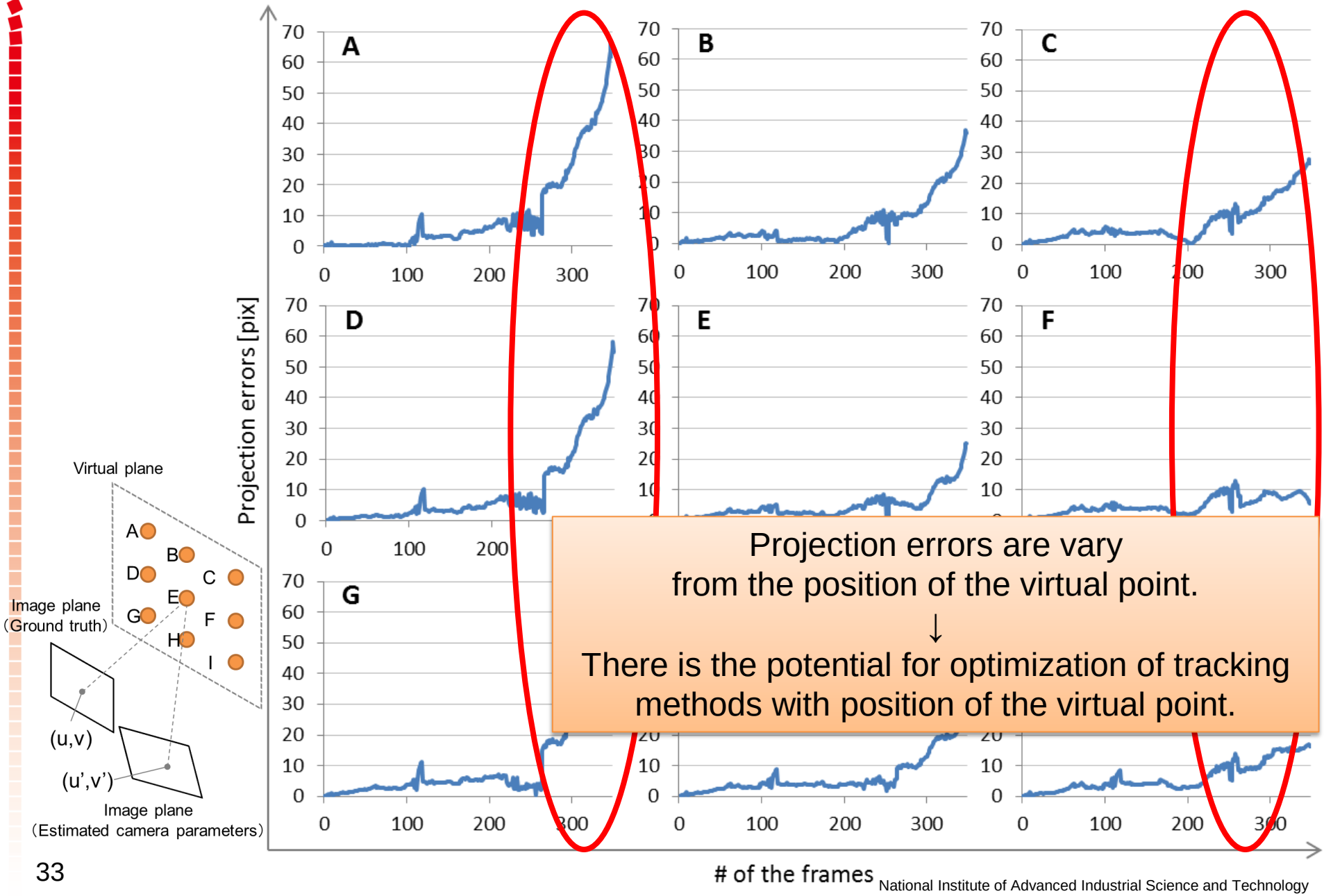
a = 7000 [mm]

Projection errors（a = 1000 [mm]）



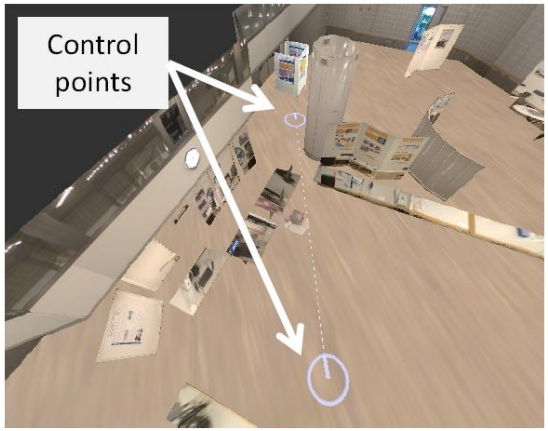


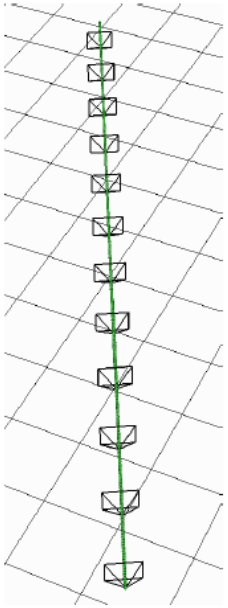
Projection errors（a = 3000 [mm]）



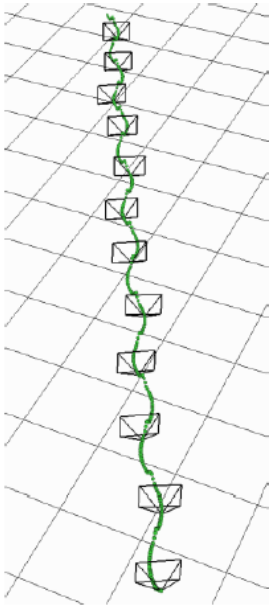
Projection errors are vary
from the position of the virtual point.
↓
There is the potential for optimization of tracking methods with position of the virtual point.

Effects of the walking motion



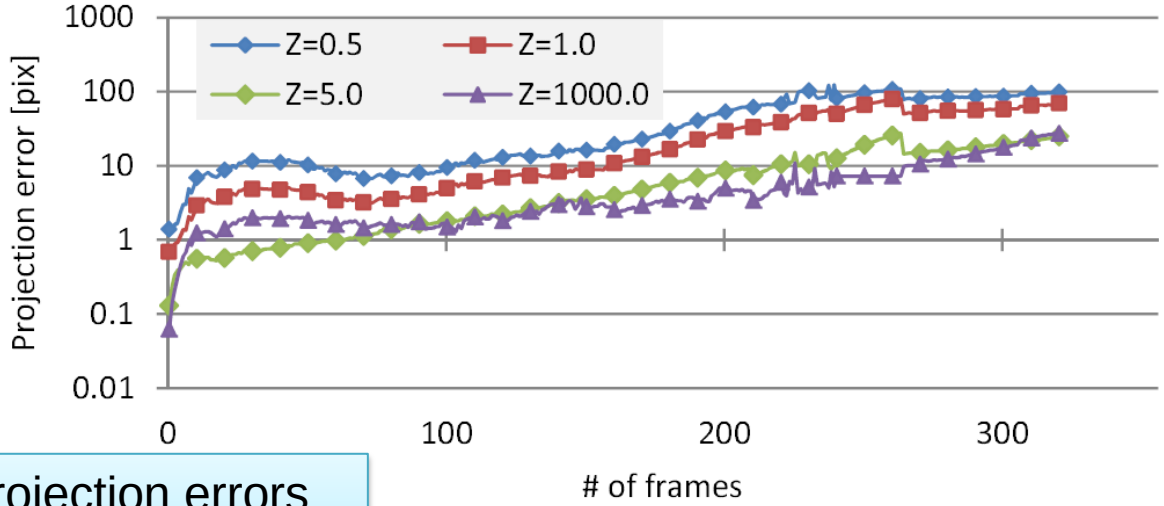


Walking motion OFF

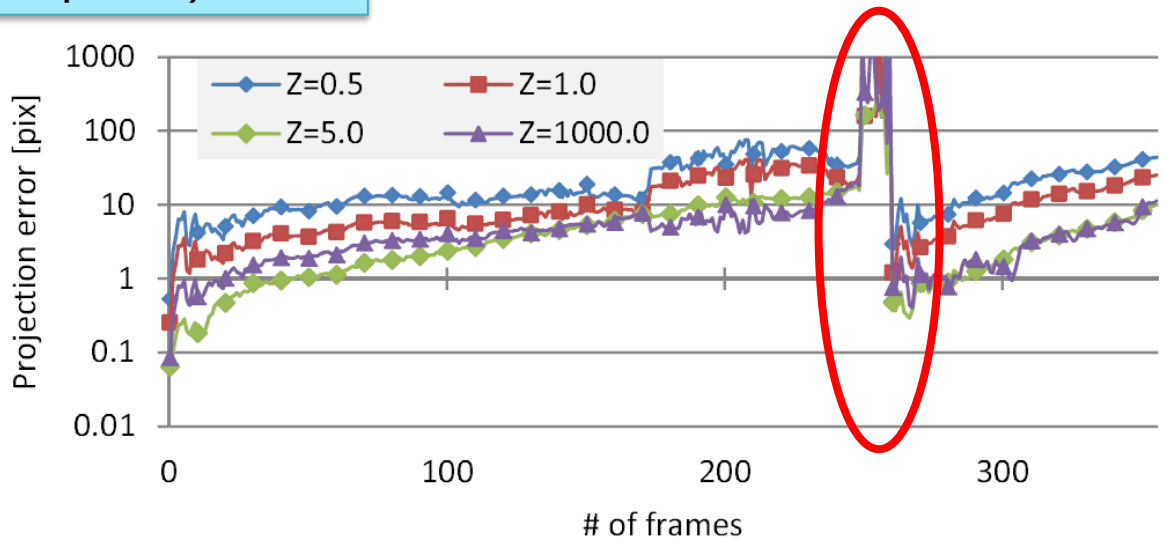


Walking motion ON

Projection errors (average of nine points)



Walking motion : OFF



Walking motion : ON

Conclusion

Virtualized reality model-based benchmarking of camera tracking methods in TrakMark.

- Standardization in two categories
  - Dataset-format
  - Indexes for benchmarking camera tracking method
- Development of the benchmark suite for supporting
  - Dataset creation
  - Benchmarking process

～Future works～

- Provision of benchmarking results
- Additional expansions for the tool
  （Additional camera motion models, Introduction of motion capture data, Change of lighting, … etc）

Thank you !

- TrakMark
  http://trakmark.net/

- Center for Service Research, AIST
  http://unit.aist.go.jp/cfsr/en/

- Koji Makita (Post doctoral research scientist)
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