

Virtualized reality model-based benchmarking of AR/MR camera tracking methods in TrakMark

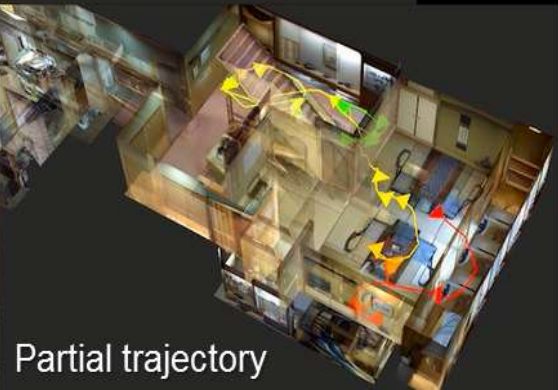
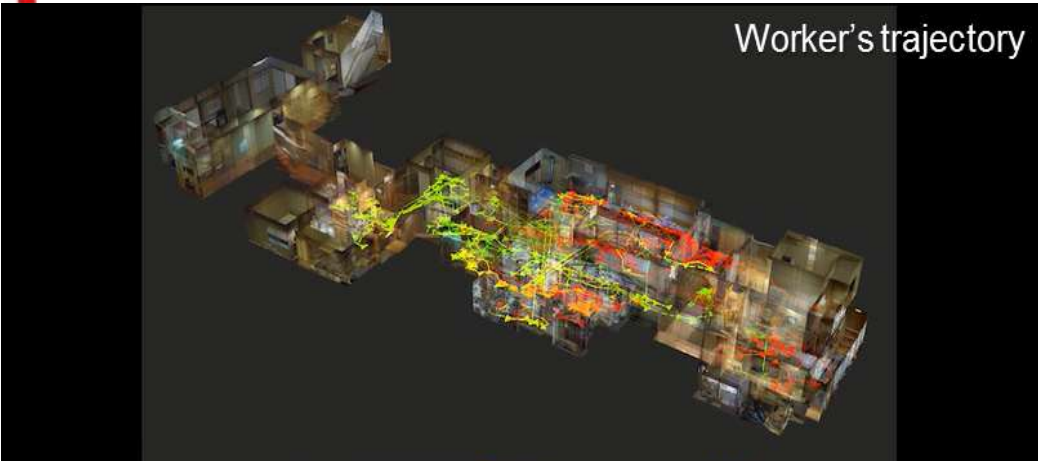
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Virtualized reality models in service research



Worker's trajectory in "Ryokan"
(Japanese traditional hotel)



PDR (Pedestrian dead reckoning)
demonstration

Image Based Tracking for AR



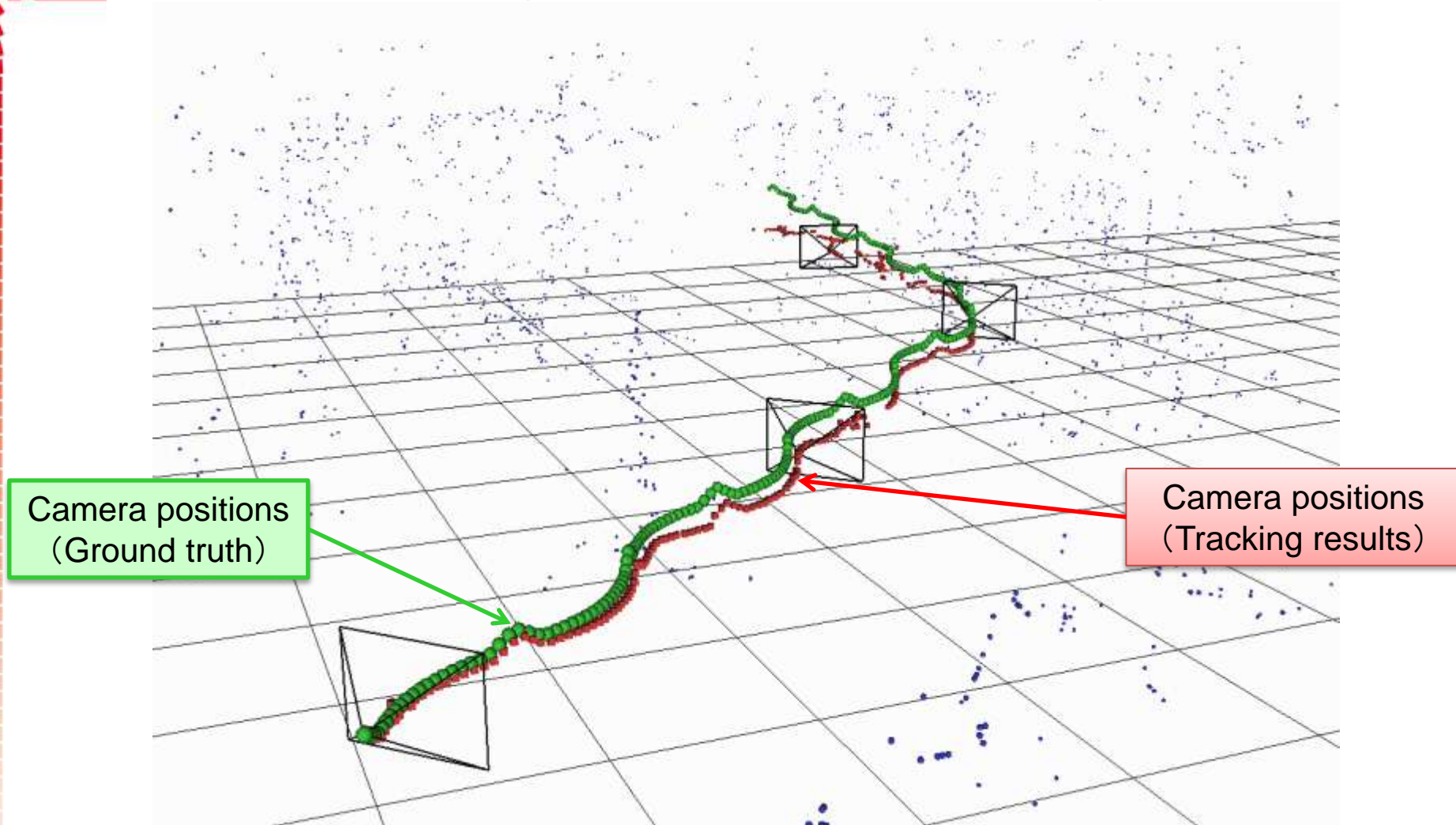
Tracking with artificial markers
“ARToolKit”(Kato, et al)



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

Camera parameter estimation is needed for AR

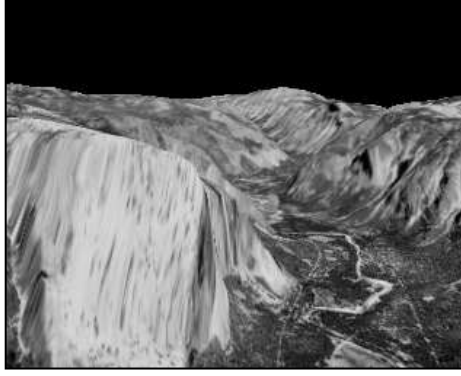
Benchmarking of camera tracking methods



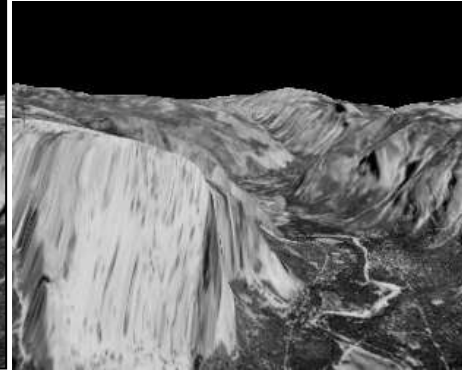
Issues in the benchmarking

- 1 : Ground truth of camera parameters is needed for accuracy evaluation.
- 2 : Set up of other method is needed for comparative evaluation.

Related works : Benchmark data set for camera tracking



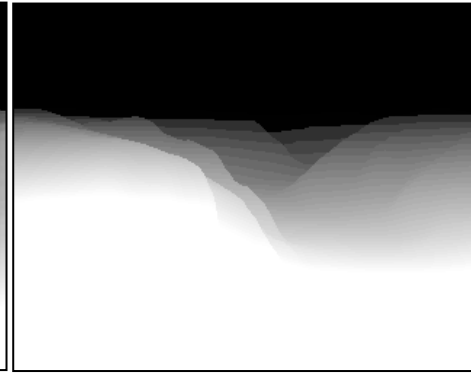
Image_00



Image_01

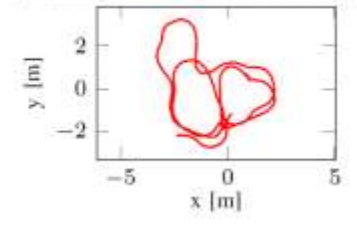
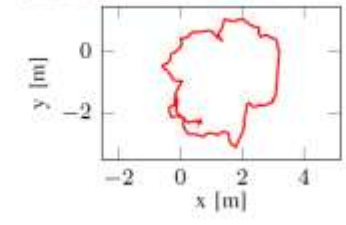
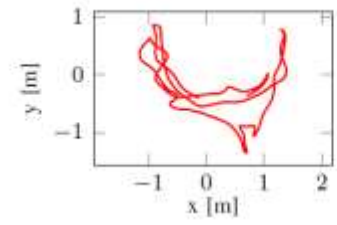
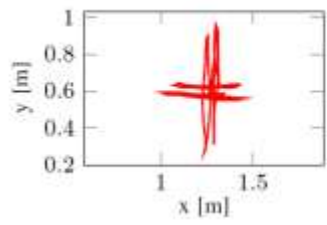


Flow_x



Flow_y

The Yosemite sequence (by Lynn Quam)



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

Activity in TrakMark: Data set distribution



Benchmark

Image Sequence Set No.2 were uploaded on April 28, 2011.

* If download speed is too slow, please contact the following address. We can send a blu-ray disk that contains all of

E-Mail: info@trakmark.net

- [Image Sequence Set No.1](#)
 - [Film Studio Package 01](#)
 - [NAIST Campus Package 01](#)
 - [Conference Venue Package 01](#)
- [Image Sequence Set No.2](#)

Provision of our data set
on website

<http://trakmark.net/>



Distribution of data discs
in conferences / social
events

Examples of data set in TrakMark

Film
Studio
Package



NAIST
Campus
Package



Conference
Venue
Package



Data set created by AIST
(Images in data set are generated by virtualized reality models)

Standardization of benchmarking camera tracking method

■ Objective

Supports for users to understand abilities and features of multiple tracking methods with benchmark data set.

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

■ Approach

- 1 : Construction of standards in two categories
 - Dataset-format
 - Indexes for benchmarking camera tracking method
- 2 : Construction of benchmarking environment
 - Development of a benchmark suite

An outline of our proposed framework

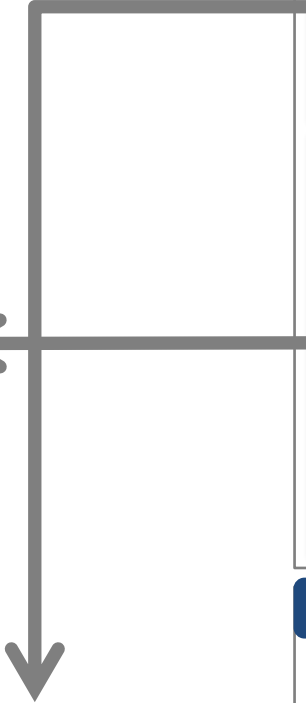
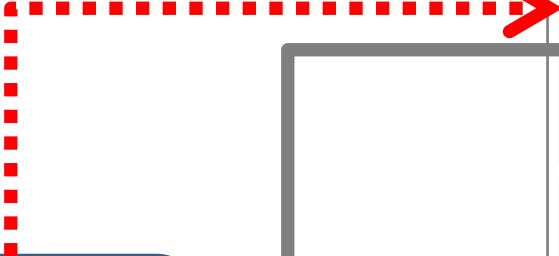


Server



User

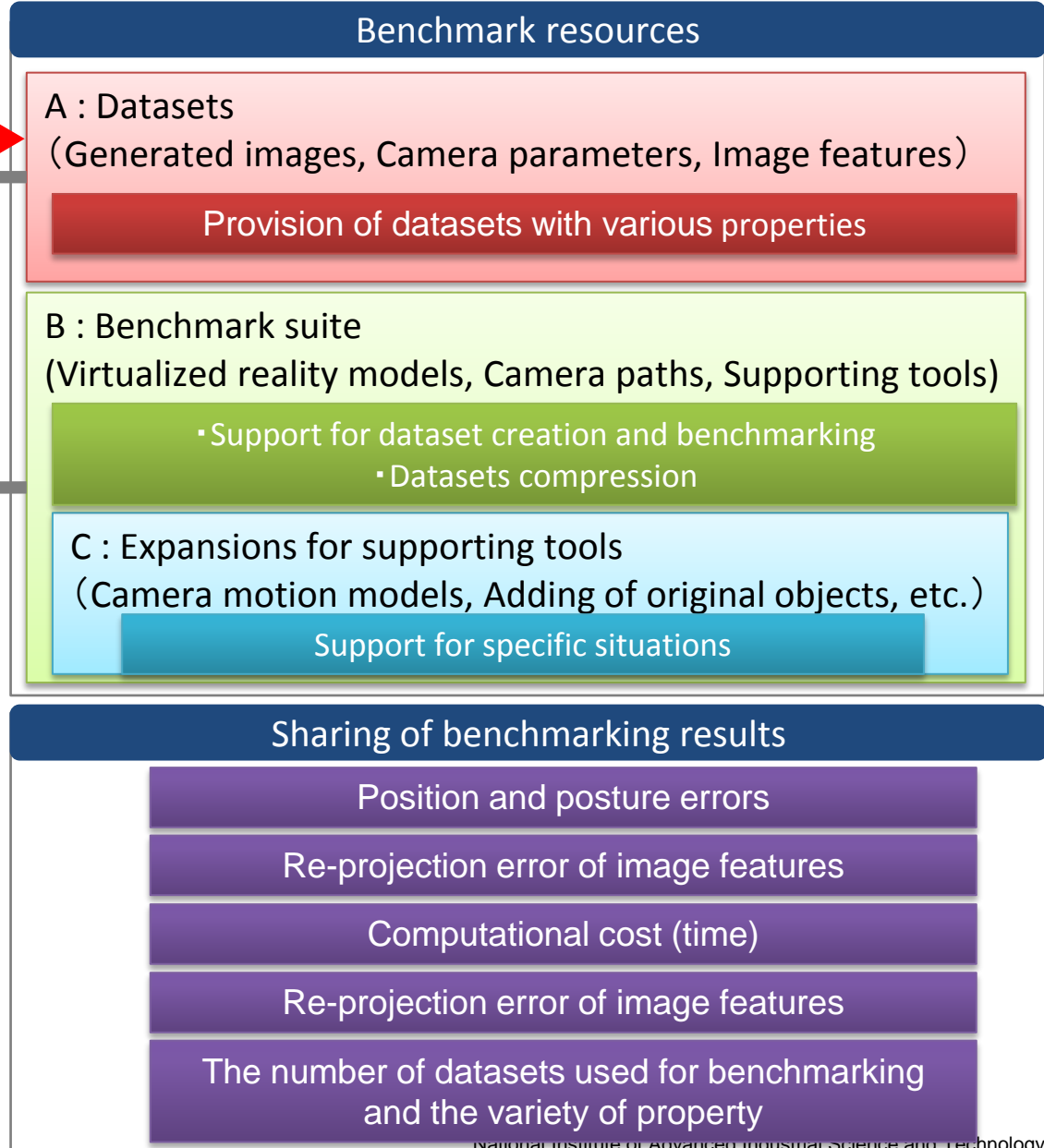
Registration of new datasets



Benchmarking of tracking methods (with benchmark suite)



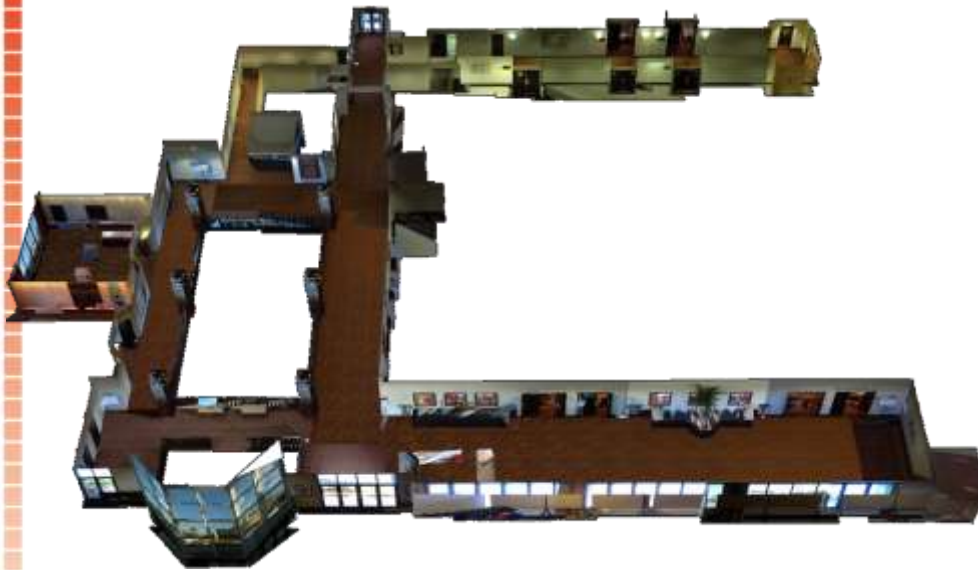
Submission of the result



Data set generation with virtualized reality models

By applying virtualized reality models . . .

- ✓ Ground truth data are available.
- ✓ Users can generate arbitrary camera path.

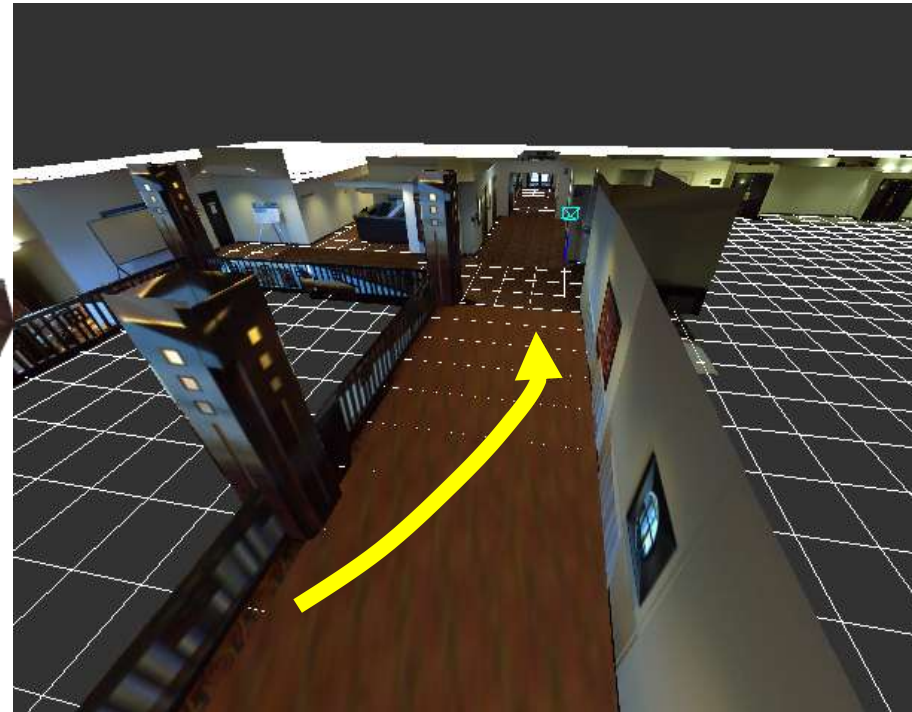


An example of virtualized reality model
(Venue of ISMAR2009)

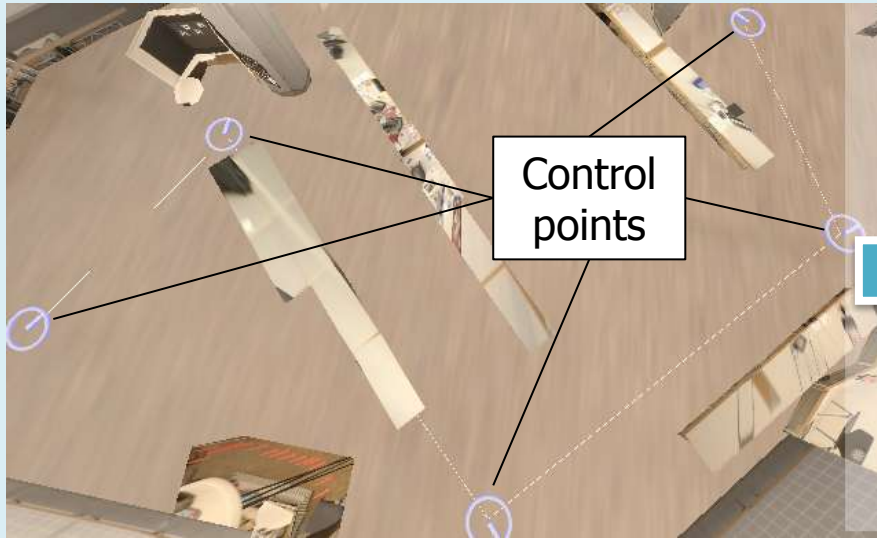
Area : 1217 [m²]

Time for shooting pictures : 45 [min]

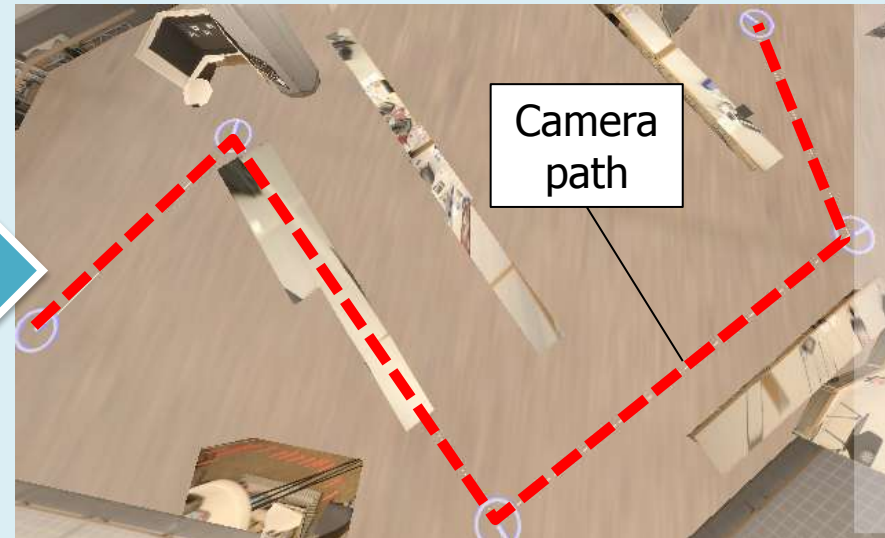
Time for modeling : 6.5 [h]



Outline of 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

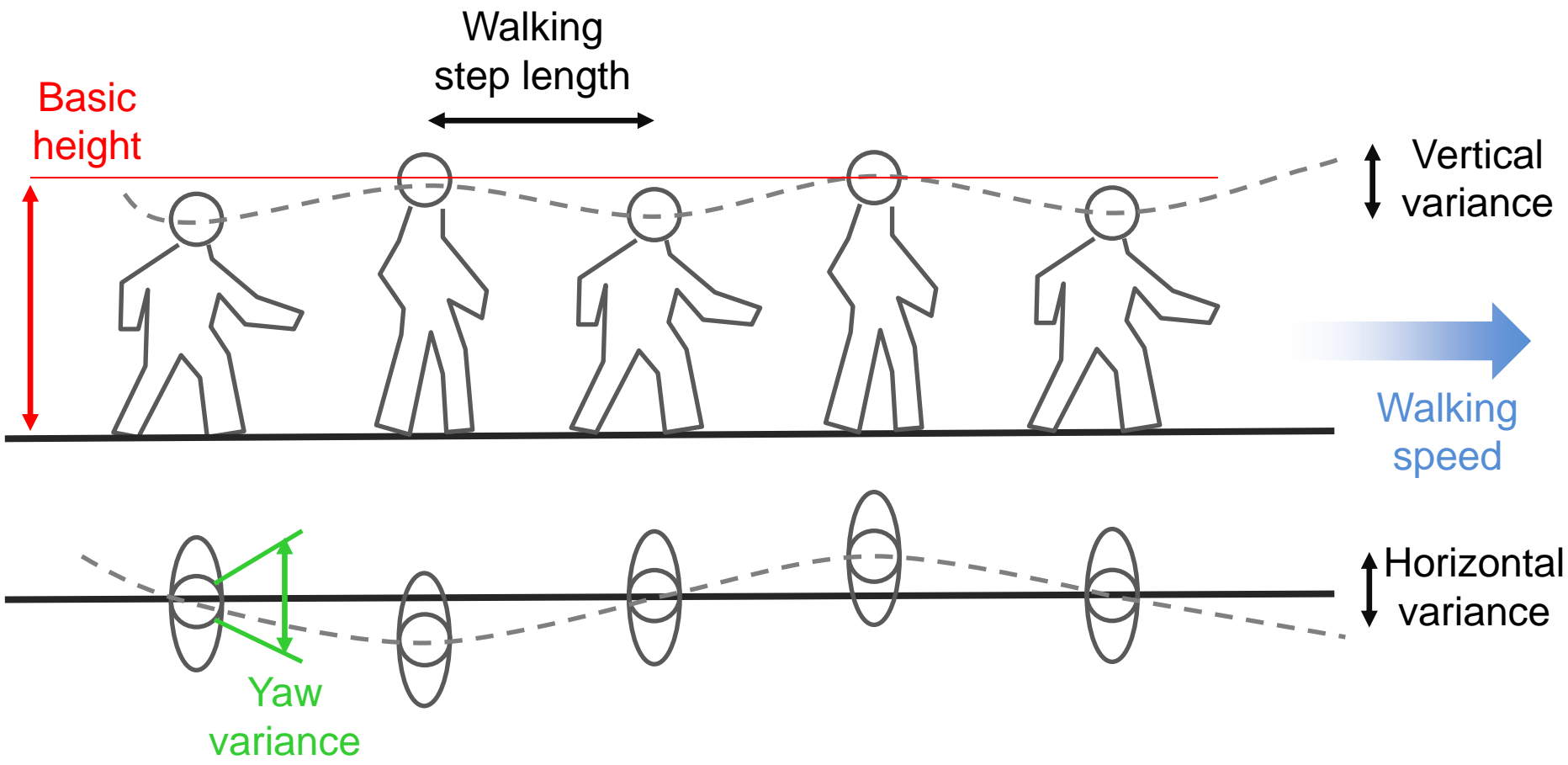


Head Mounted Camera



Hand Held Camera

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

000



0:000 (1/1950)



Play



PREVIEW

EXTRACT

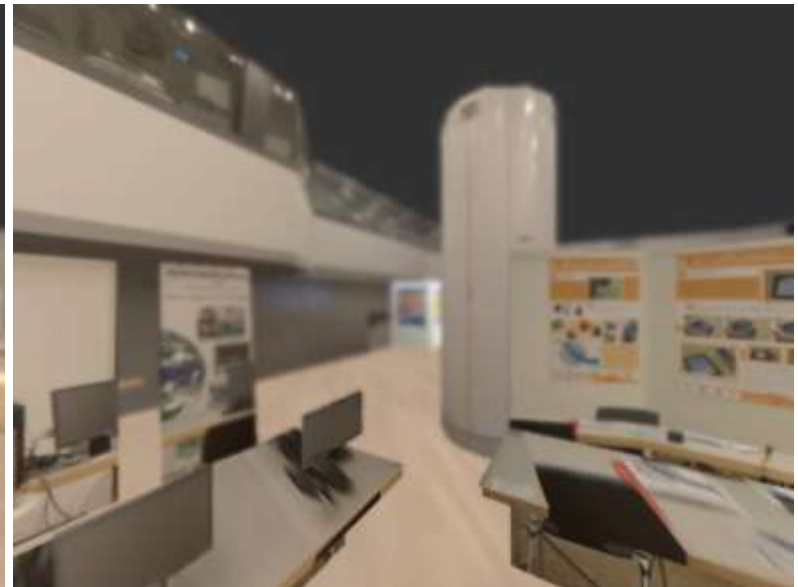
RETURN

Functions for applying defocus blur and motion blur (Under construction)

Normal
images



Images with
defocus blur





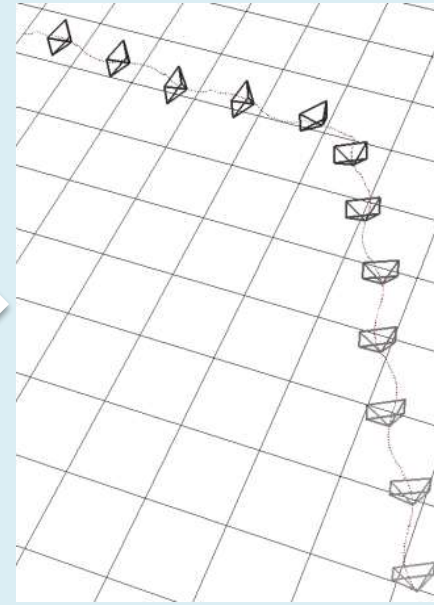


Experiment (user's own benchmarking)

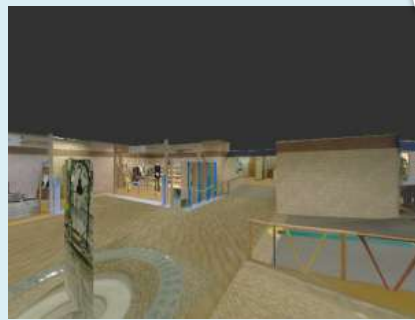


Virtualized reality model used in the experiment.
(Shopping mall in Osaka, Japan)

1. Data set generation

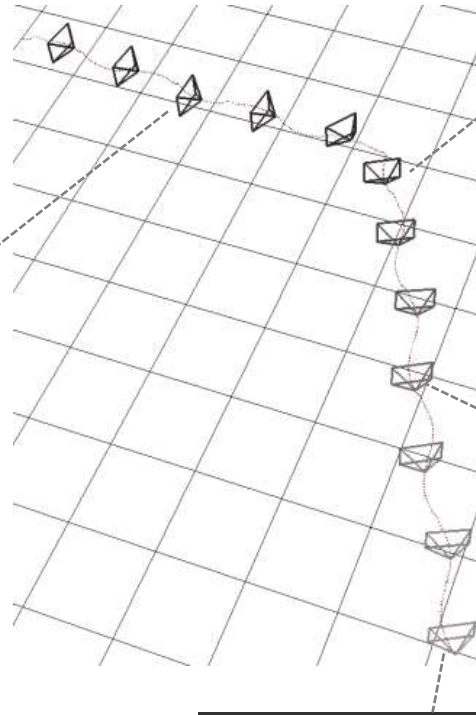


Camera path creation with walking motion



Generated images with virtualized reality models

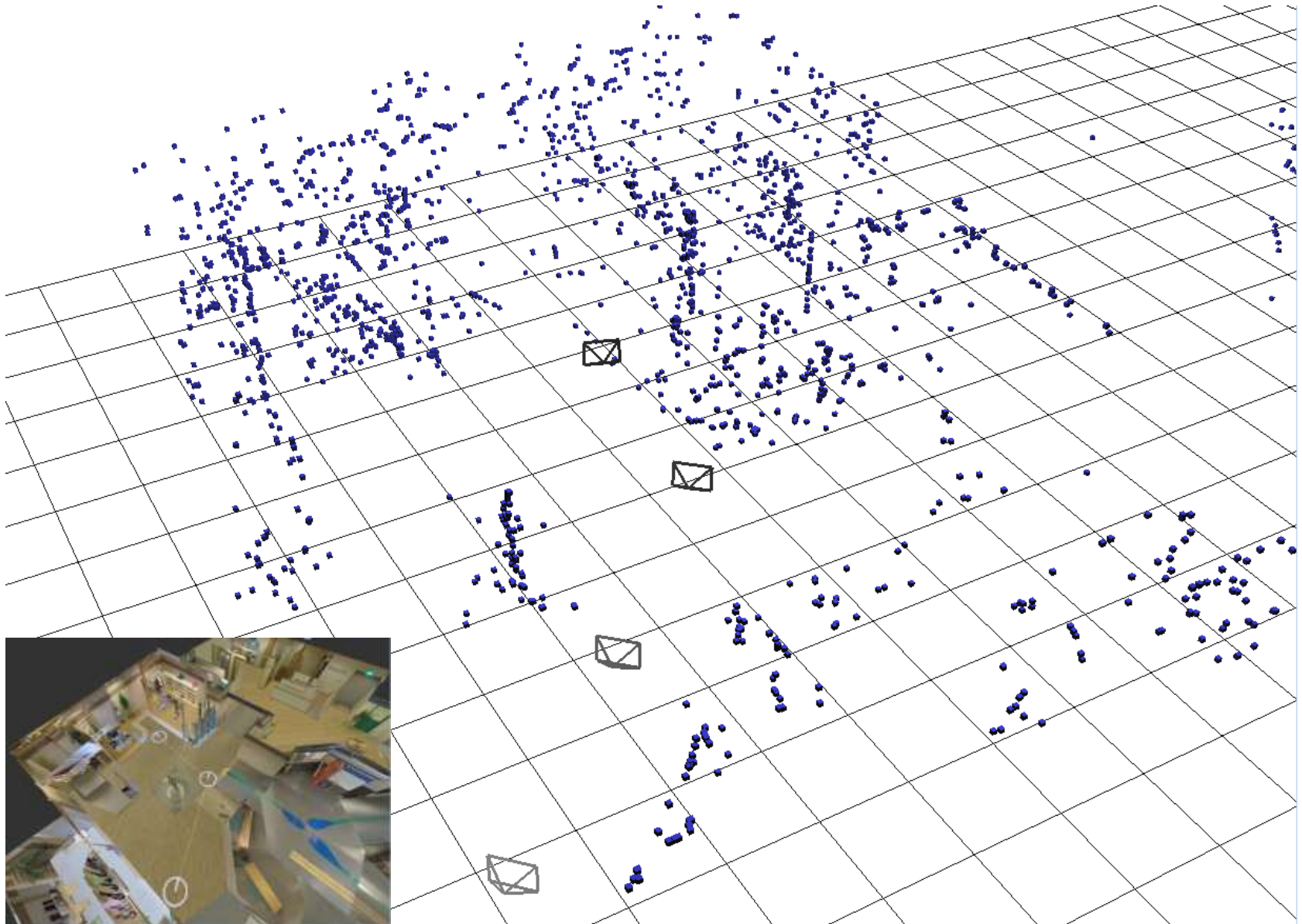
2. Creation of key frames



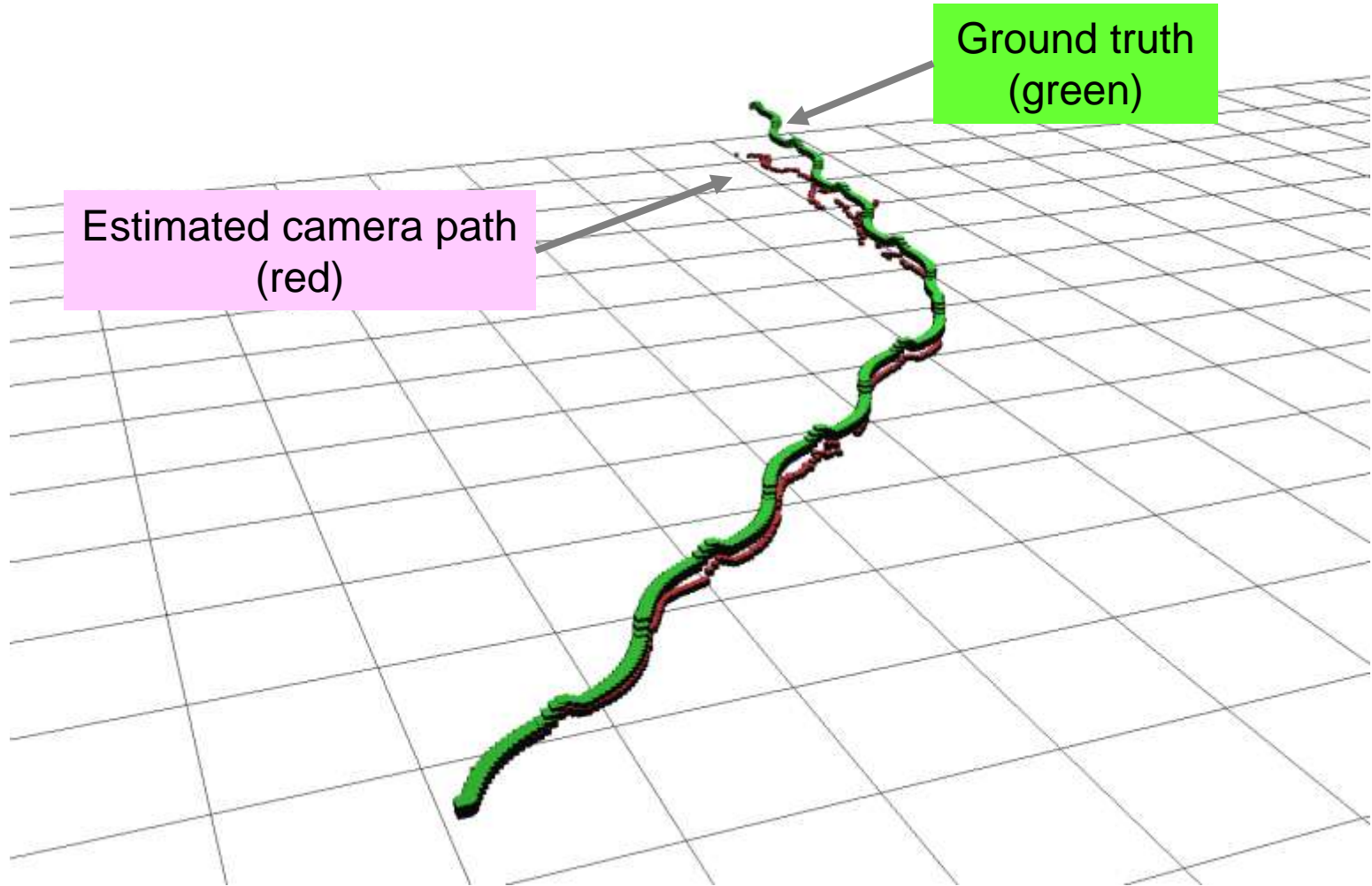
We manually selected four images as key frames used by the tracking method.



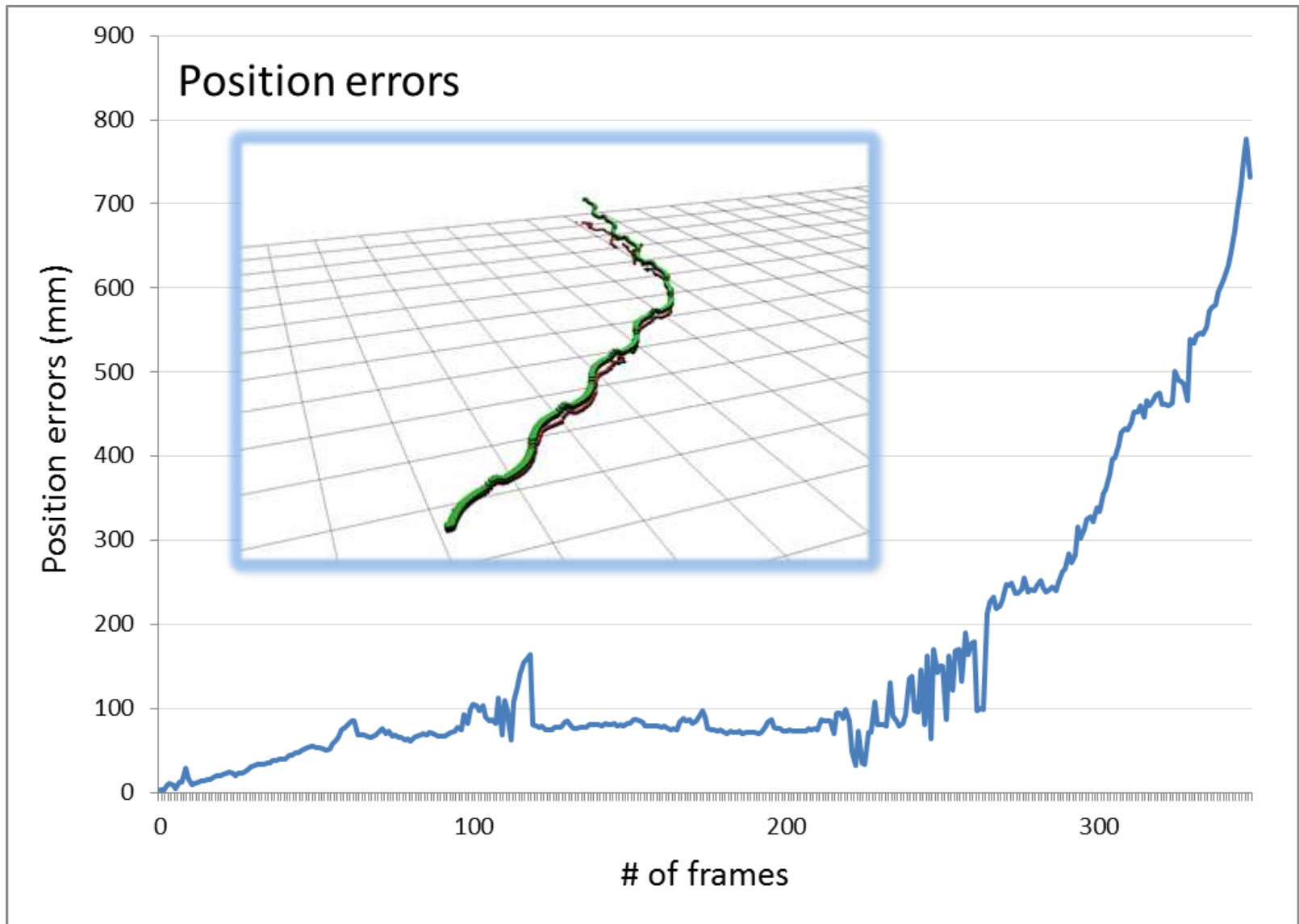
3. Generation of interest points



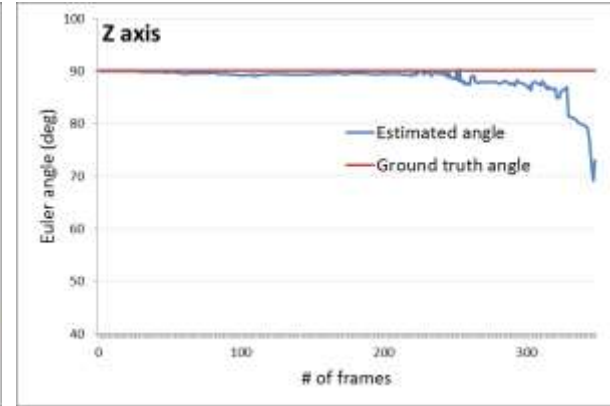
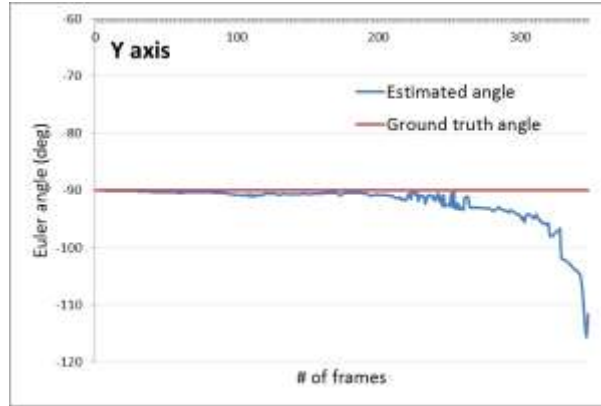
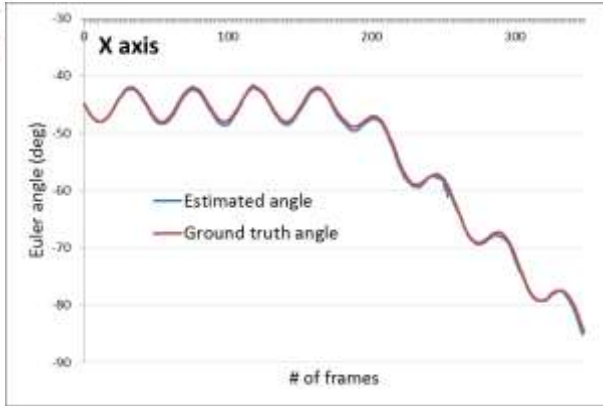
4. Camera tracking with generated images



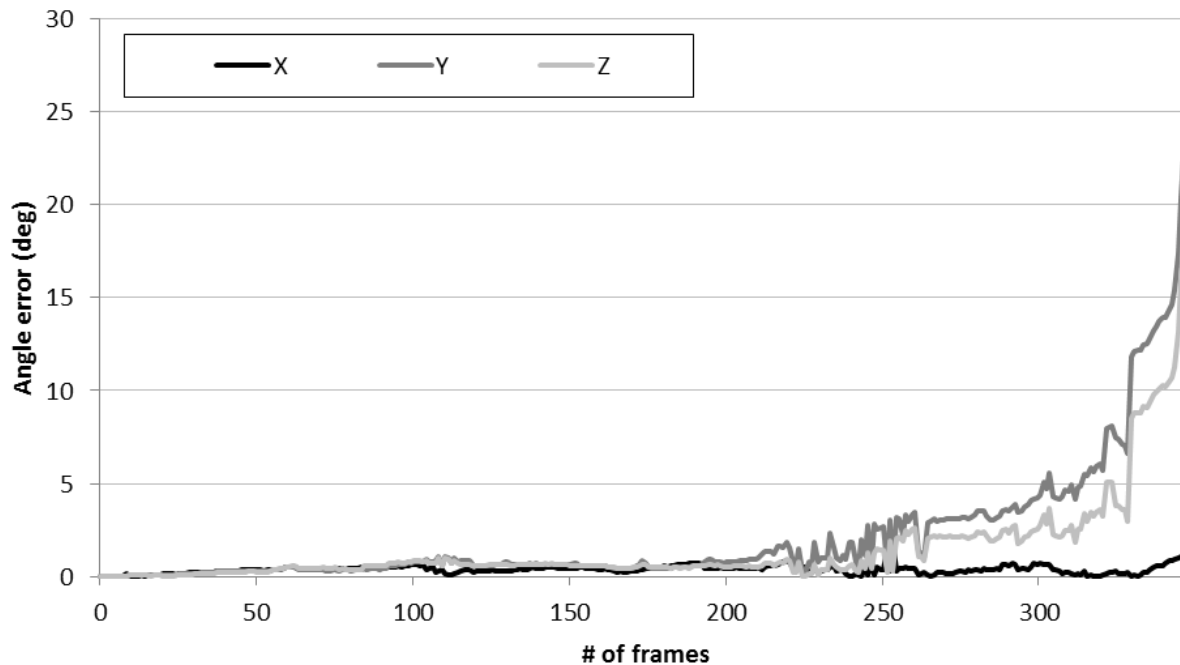
5. 1 Evaluation of camera positions



5. 2 Evaluation of rotation error (Euler angle)



Euler angle (raw values)

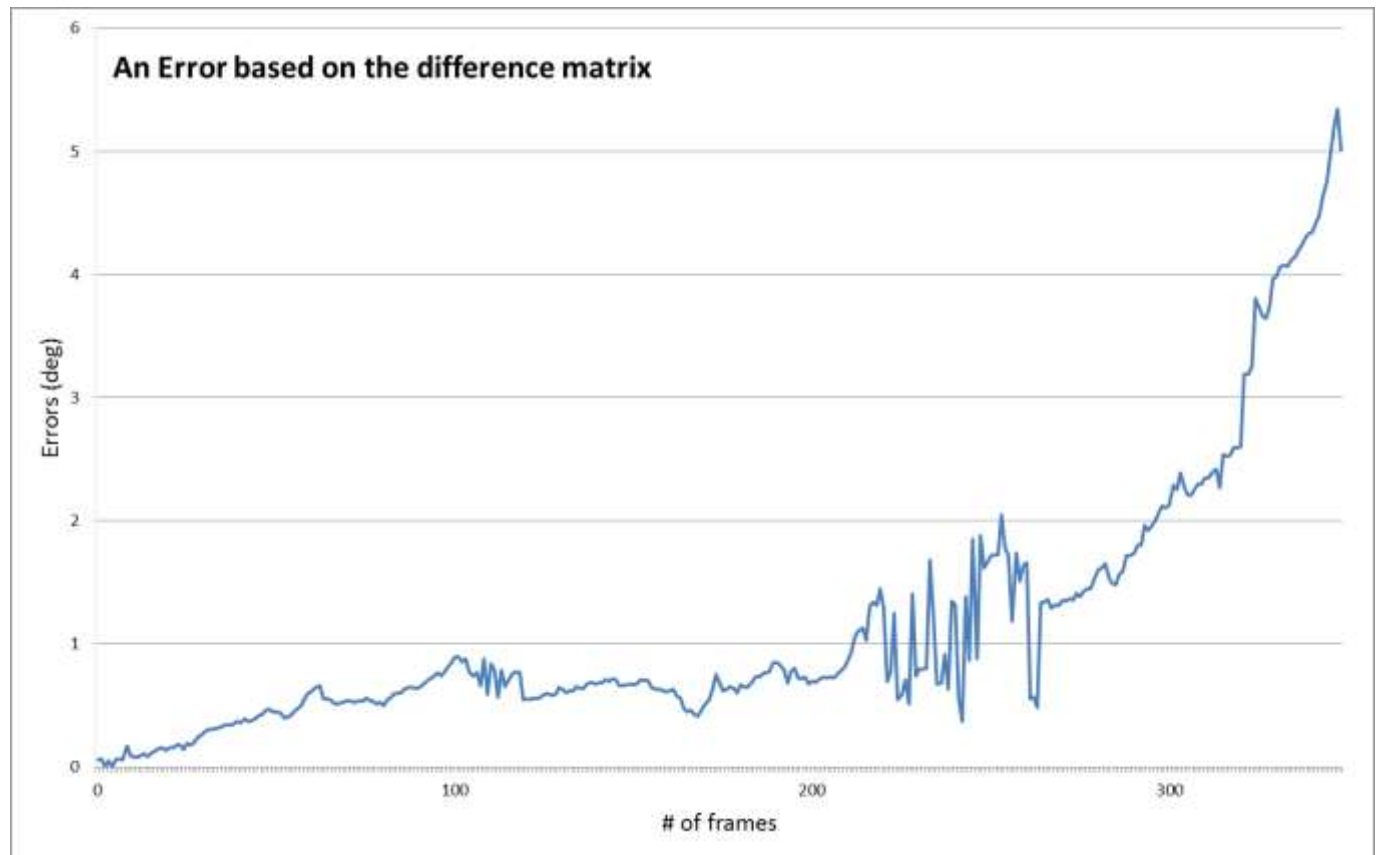


Errors of euler angle

5.2 Rotation errors calculated by using difference Matrix

$$R_d = R_g R_e^T$$

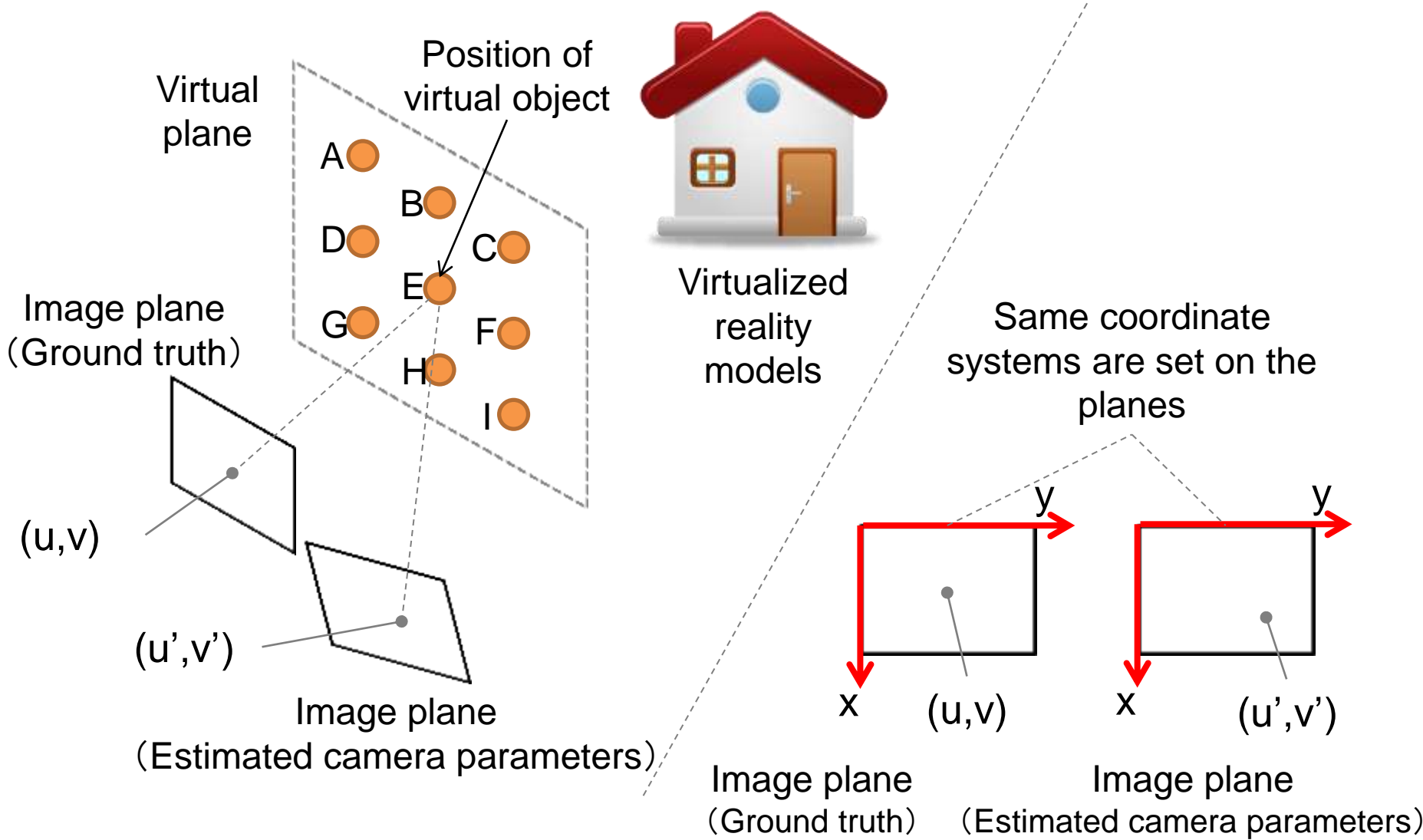
$$\theta_{R_d} = \arccos((\text{tr}(R_d) - 1)/2)$$



Rotation errors calculated by using difference Matrix

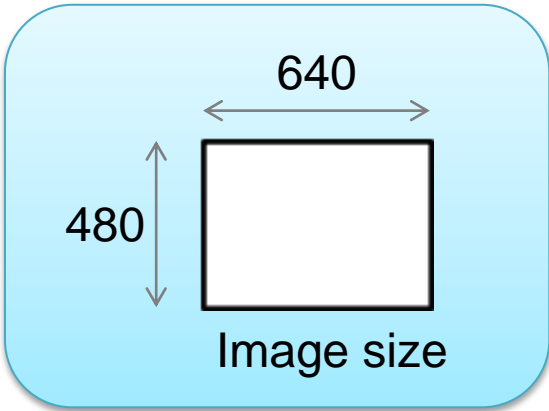
5.3 Projection error of virtual objects

Calculation procedure

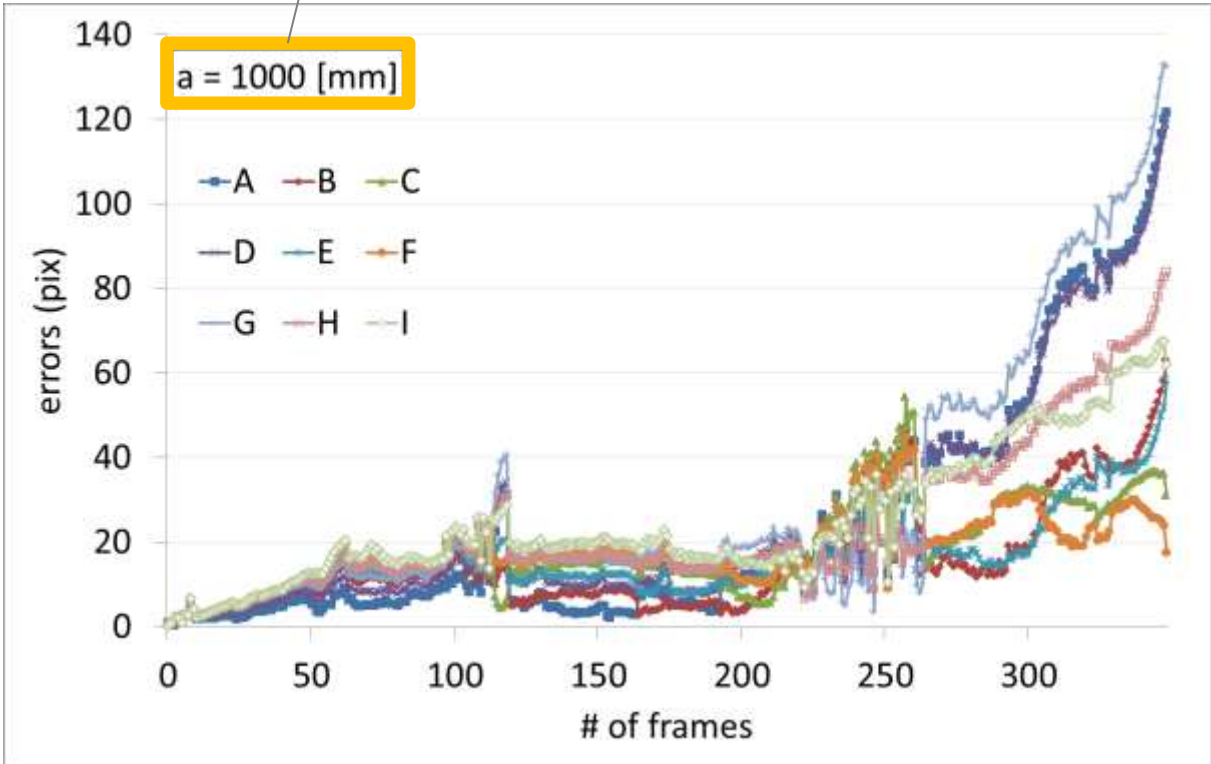
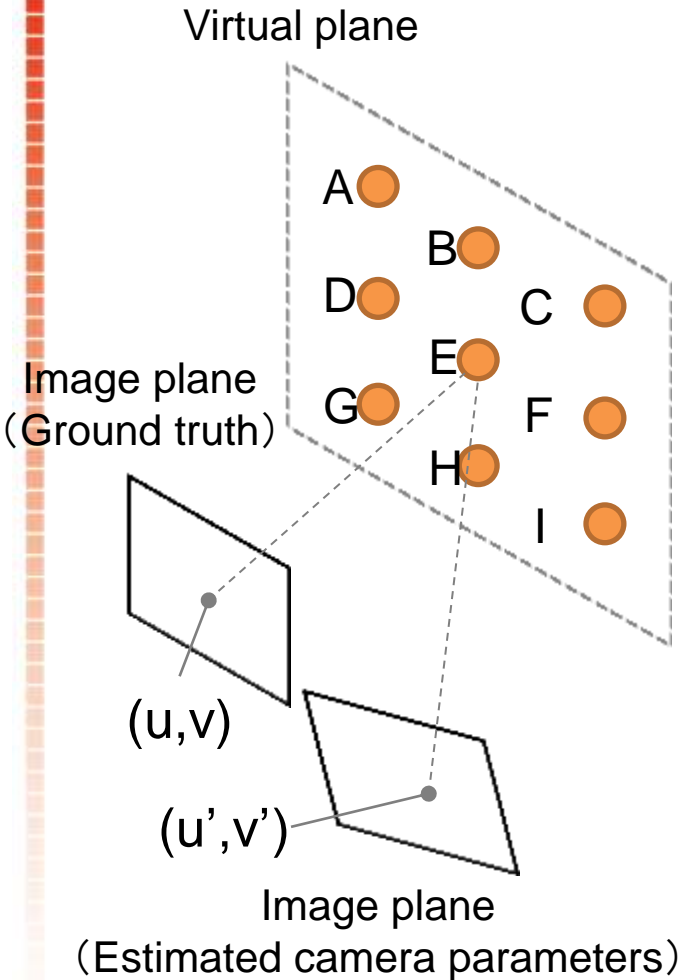


5.3 Projection errors of virtual objects

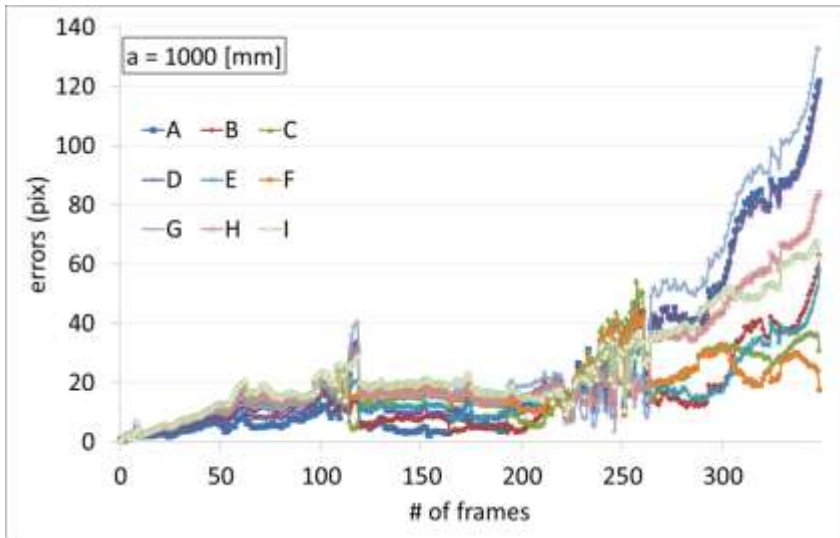
Calculation result



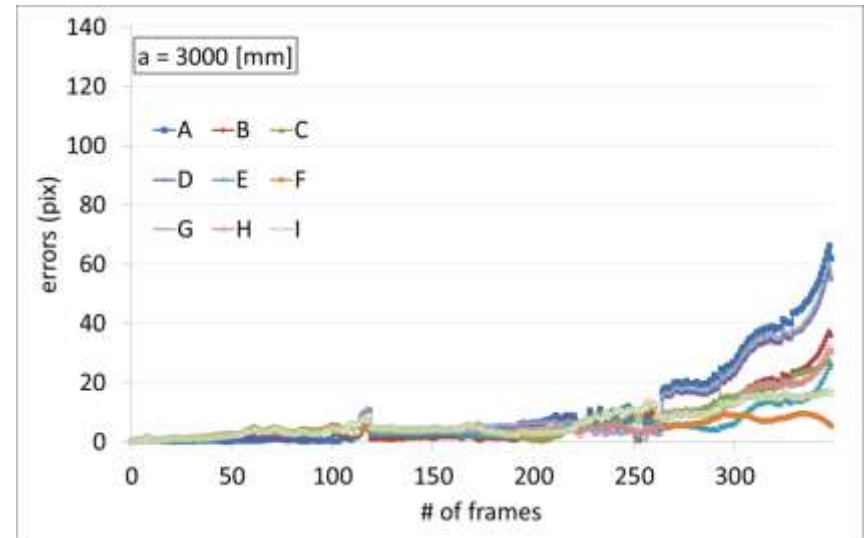
A distance from the camera to the virtual plane



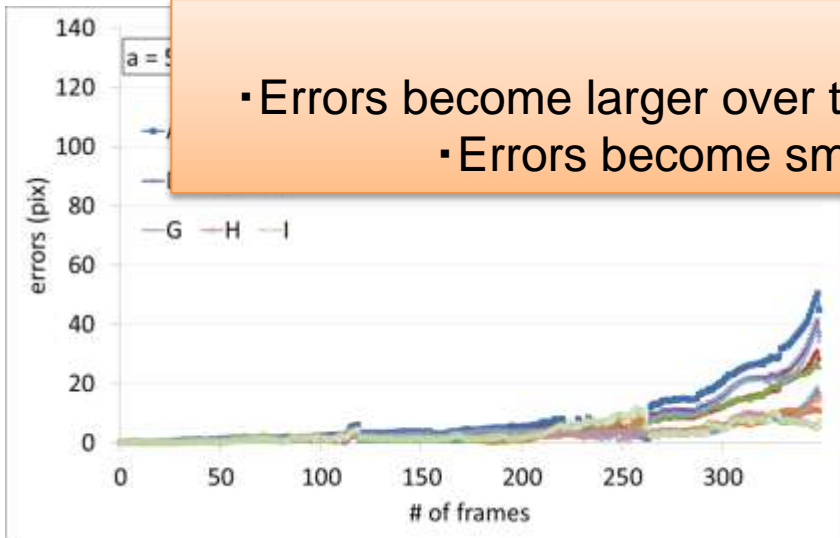
5.3 Projection errors of virtual objects (with various distances)



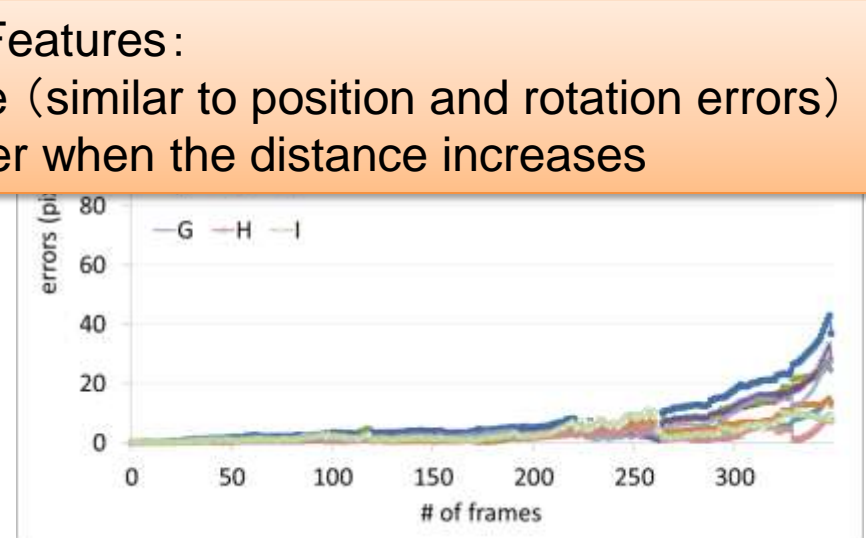
a = 1000 [mm]



a = 3000 [mm]



a = 5000 [mm]

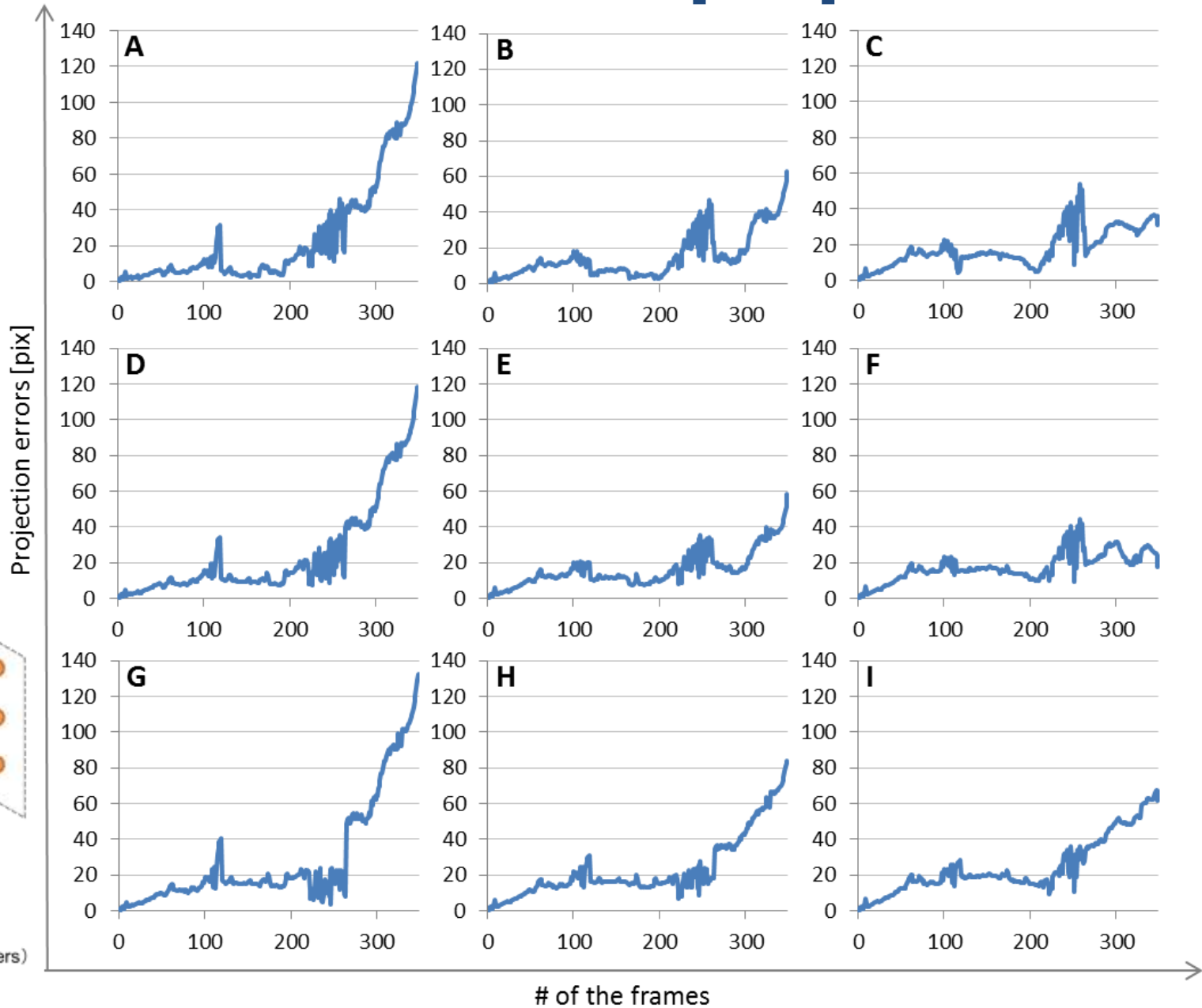


a = 7000 [mm]

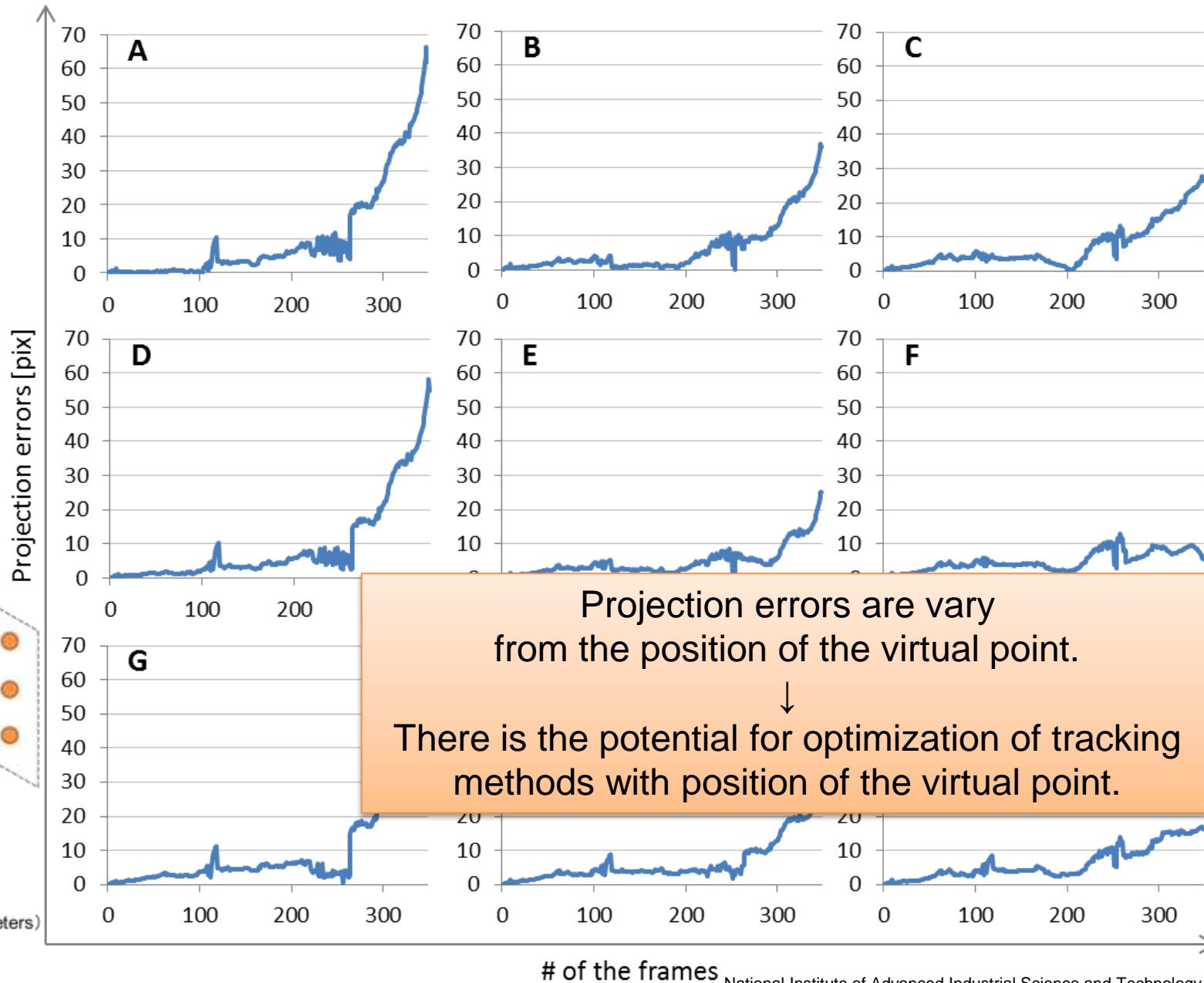
Features:

- Errors become larger over time (similar to position and rotation errors)
- Errors become smaller when the distance increases

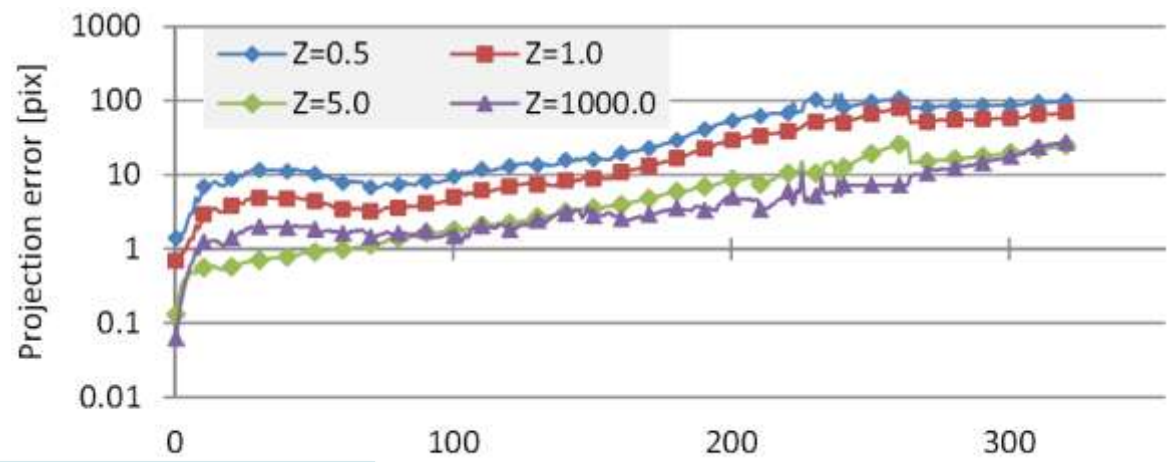
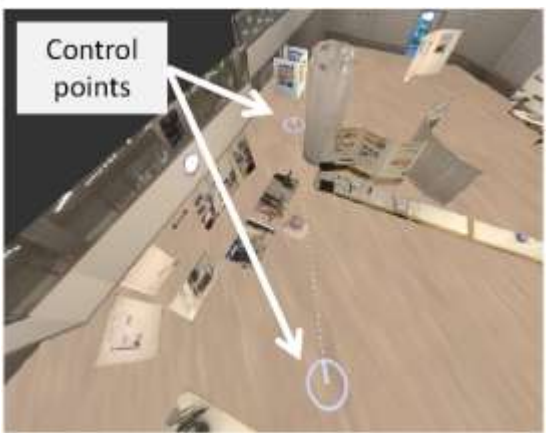
Projection errors ($a = 1000$ [mm])



Projection errors (a = 3000 [mm])

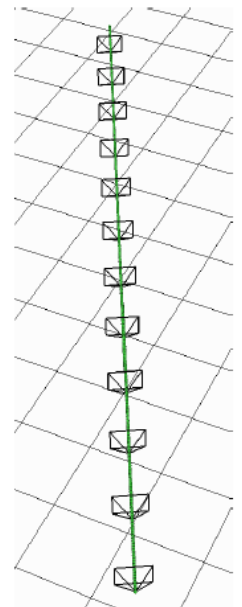


Effects of the walking motion

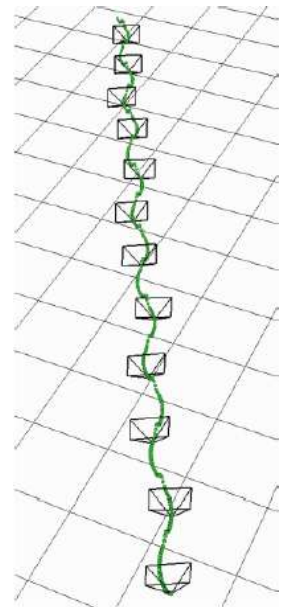


Projection errors (average of nine points)

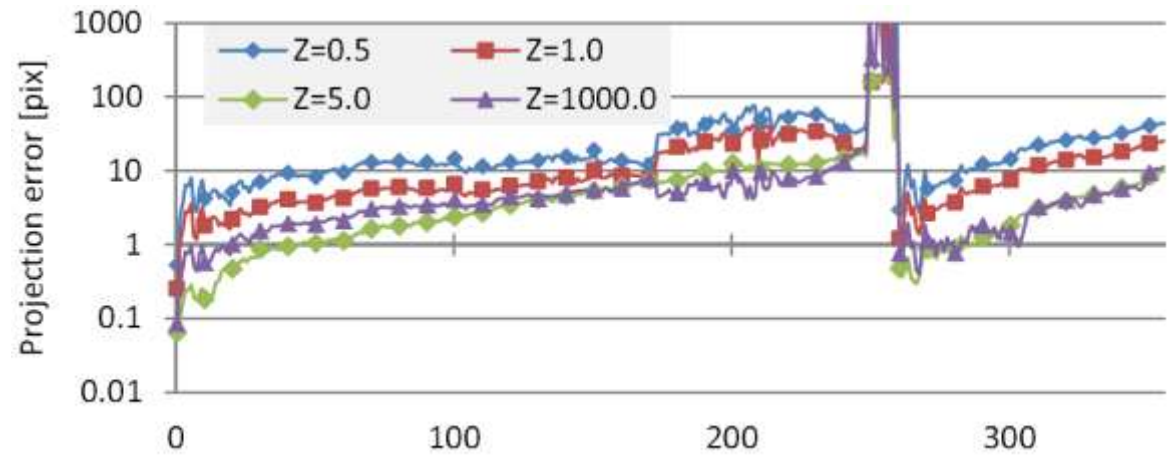
Walking motion : OFF



Walking motion OFF



Walking motion ON



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)