Projective indices for AR/MR benchmarking in TrakMark

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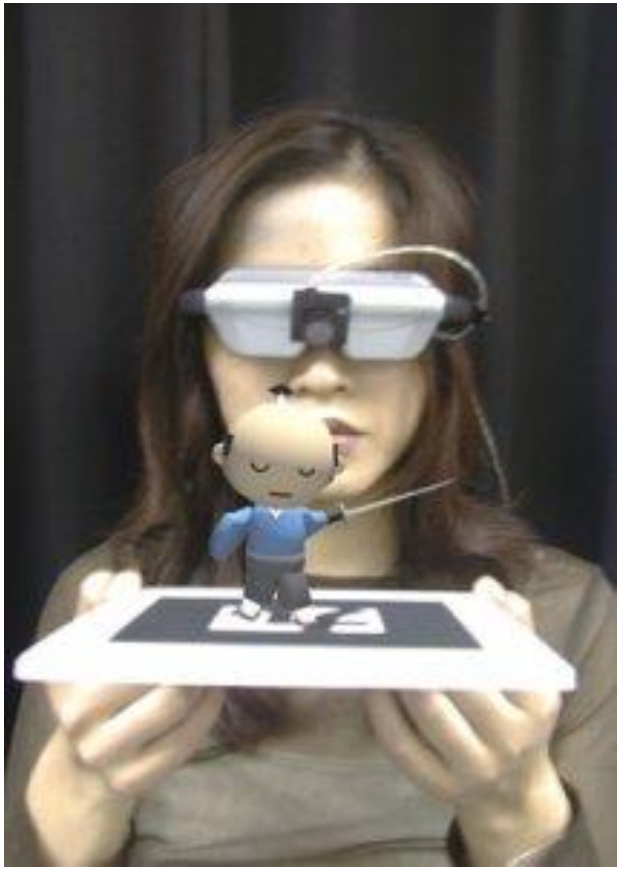
ISMAR2013WS（TMA&TrakMark2013）30min
（Oct. 1. 2013@Adelaide, Australia）

Image based tracking for AR/MR

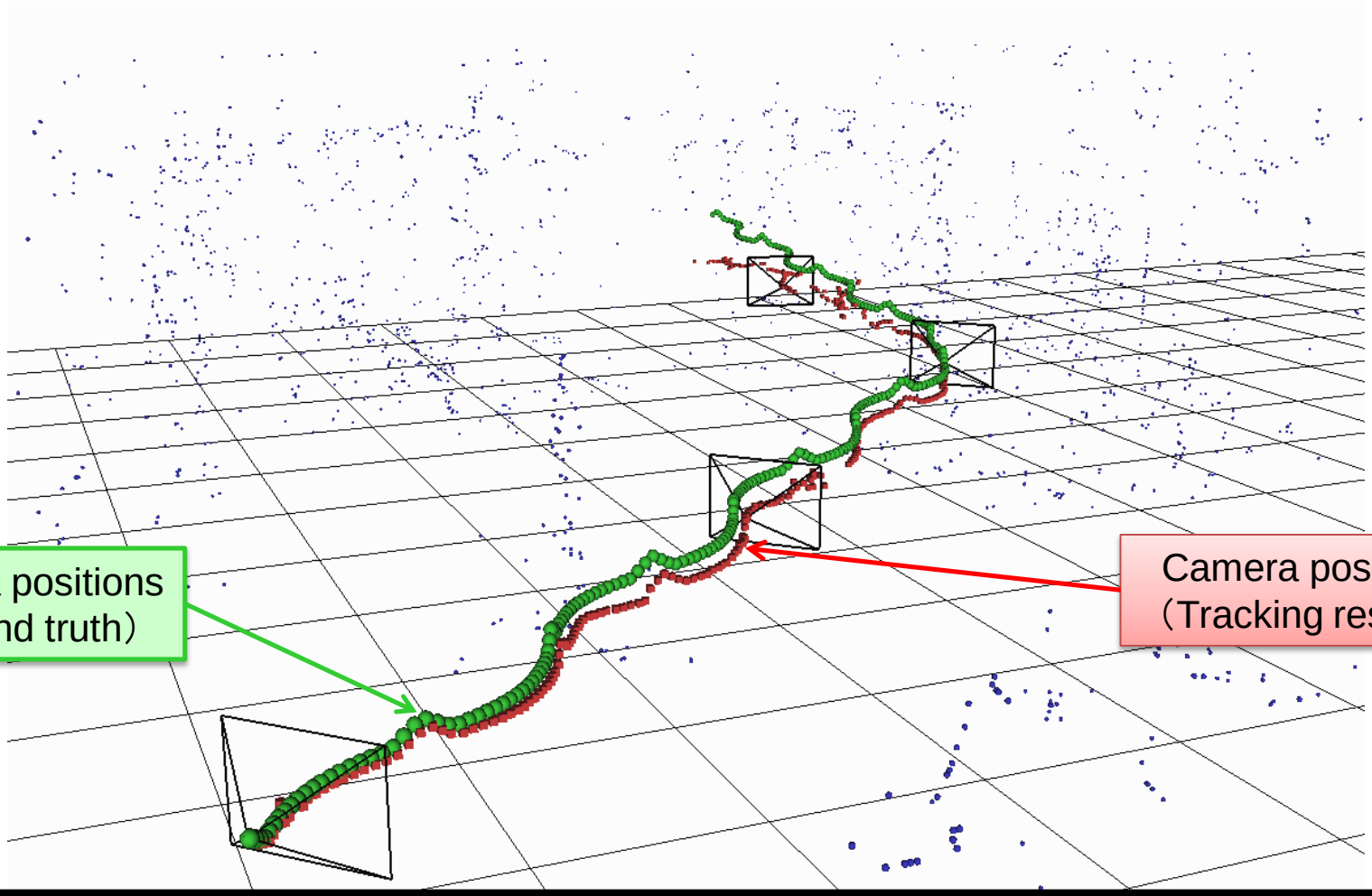


Tracking with artificial markers
“ARToolKit”(Kato, et al)

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.

Data set with ground truth (or reference data)

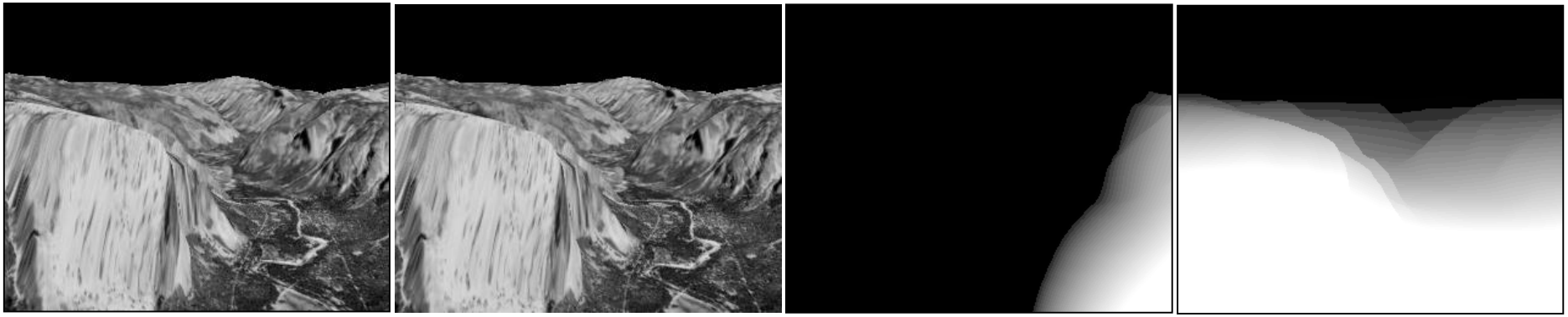
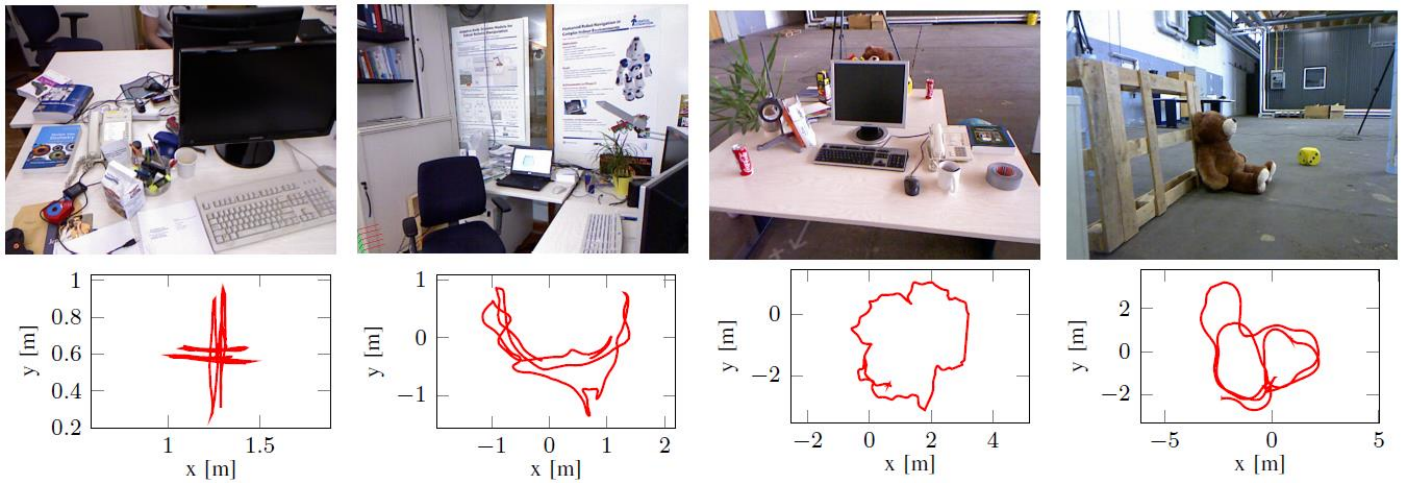


Image_00 Image_01 Flow_x Flow_y

The Yosemite sequence (by Lynn Quam)

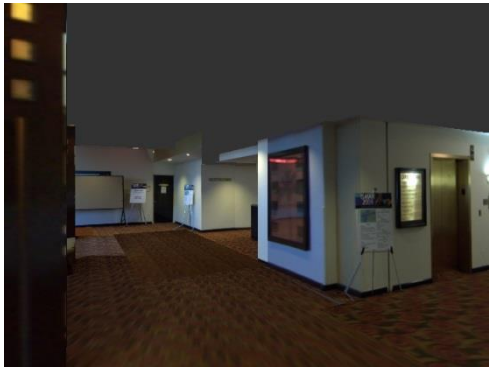


A Benchmark for the Evaluation of RGB-D SLAM Systems
(J. Sturm et al, IROS2012)

TrakMark benchmark

Outdoor

Indoor



Virtualized reality

Sequences provided with ground truth (or reference) of extrinsic camera parameter

Issues in the benchmarking

- Common (customizable) data set
- Ground truth (or reference)

- Common indices?

Virtualized reality model
(Shopping mall in Osaka, Japan)

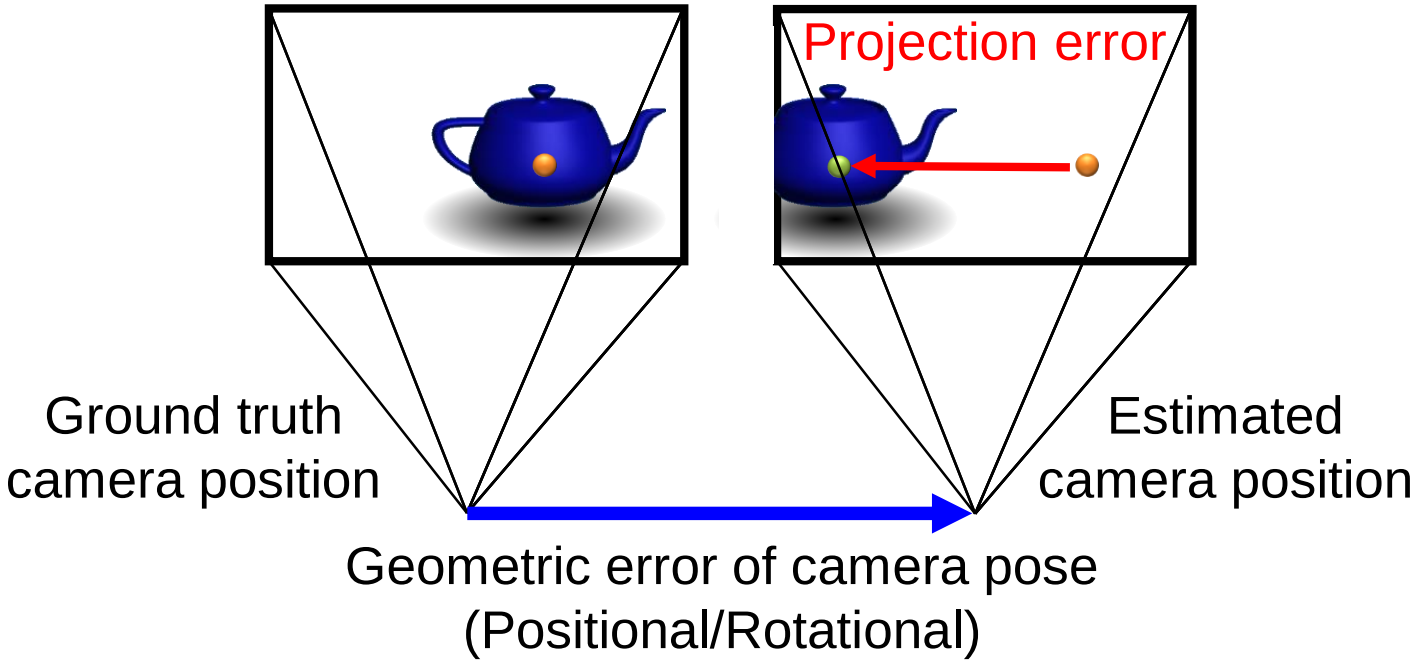
Objective

- Common indices
  - Positional / Rotational error of camera pose
  - Re-projection error of interest points
  - (Add) Projective indices of virtual points

for AR/MR applications

- Two stage projective indices
  - Visibility indices of virtual points
  - Projection errors of virtual points

Projective indices: Projection error of virtual objects



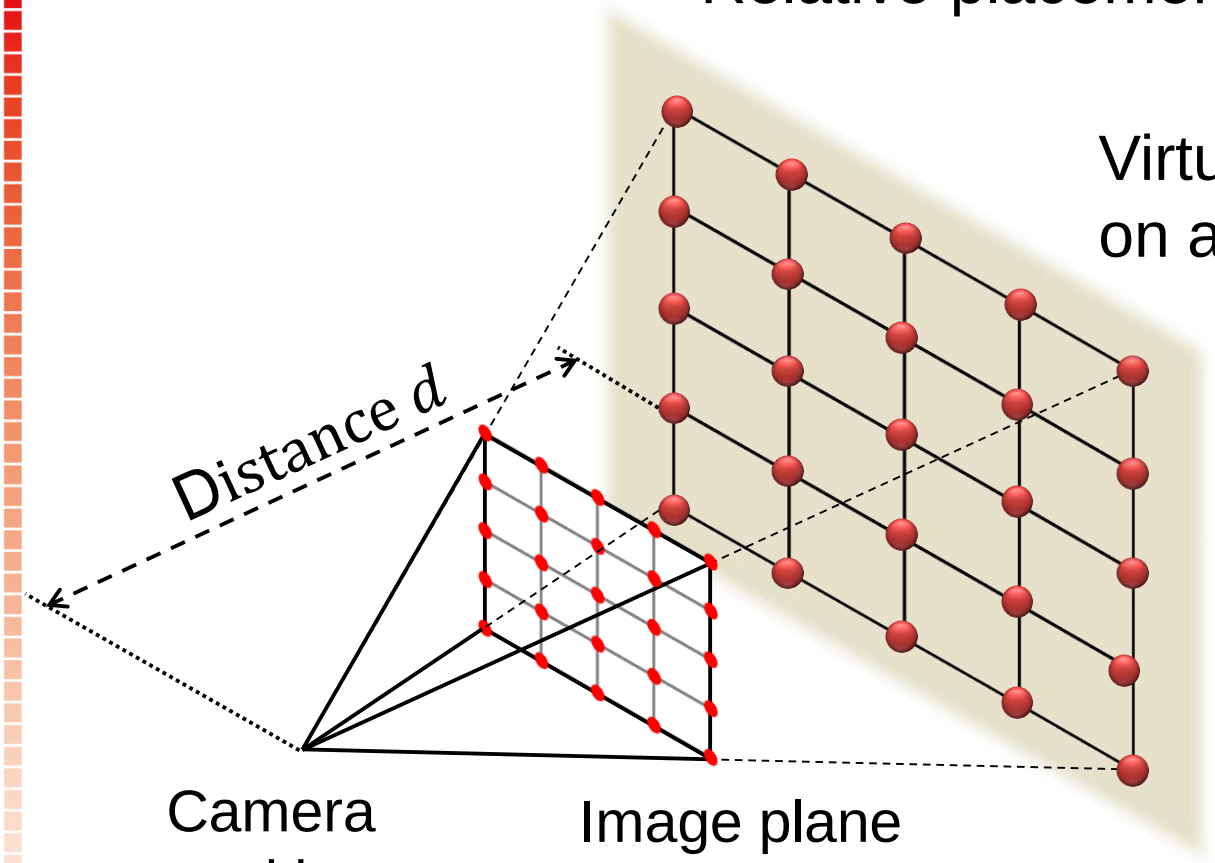
- Projection error is important for AR/MR applications
- We discuss appropriate parameters of "Projective indices" for easy and fair compa

How many objects? Where to place?

Placement strategy of virtual objects

Object = point
Relative placement: points in the view

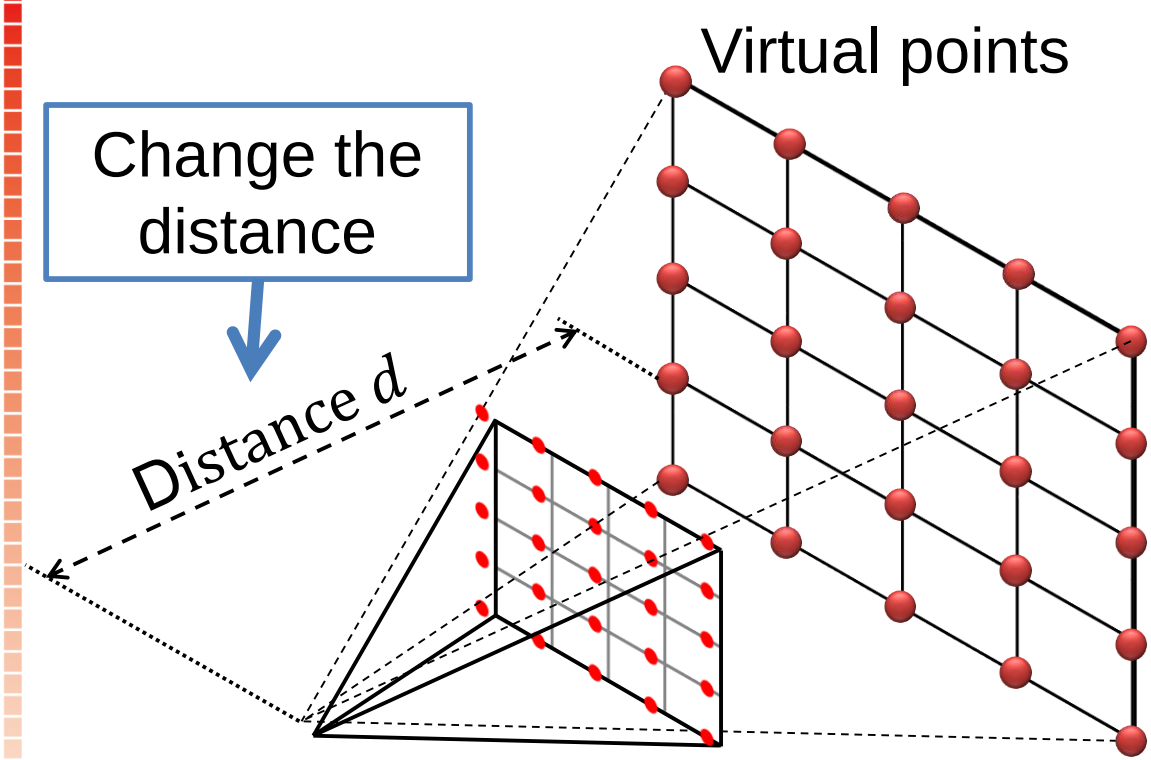
Virtual points are placed on a Virtual plane



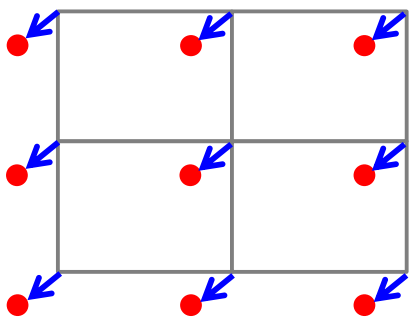
(Ground truth camera)

Placement strategy of virtual objects

Change the distance



(Estimated camera)



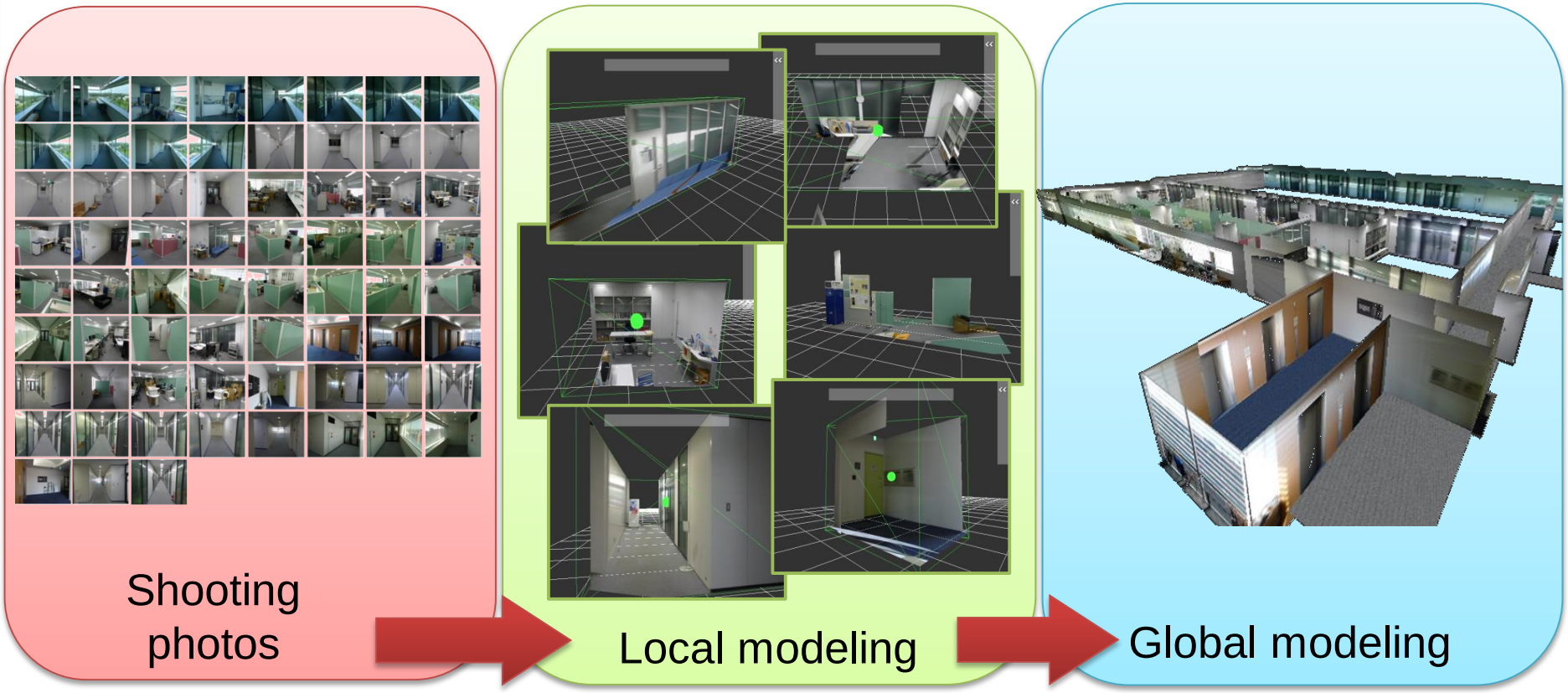
- Individual error
- Detailed examination

- Mean error
- Single (comparable) index

Evaluation of SLAM

- Mean projection error of 3x3=9 points
- Distances: 1, 2, 5, 10, 50, 100 [m]
- Virtualized reality and outdoor sequences
- SLAM implementation is available online

Model creation for virtualized reality

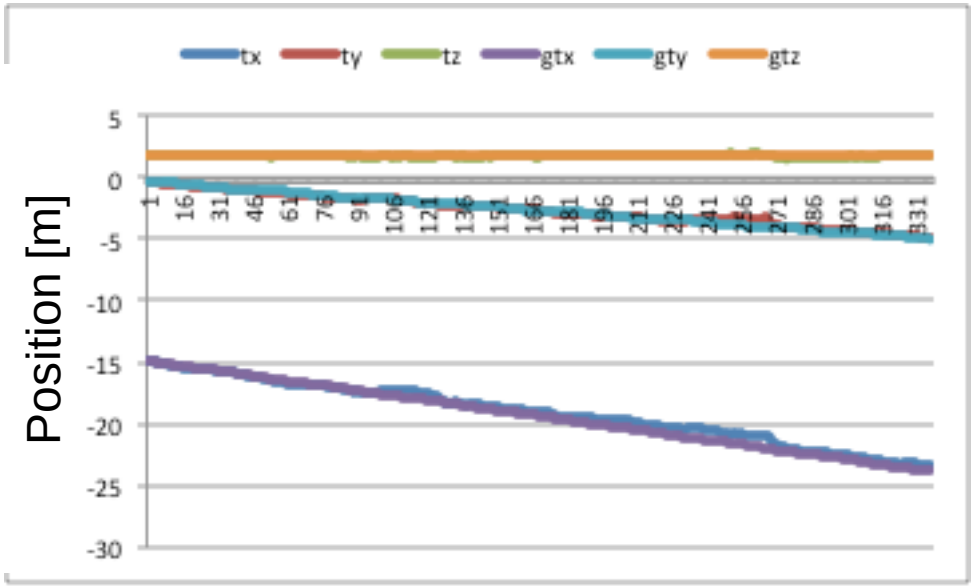


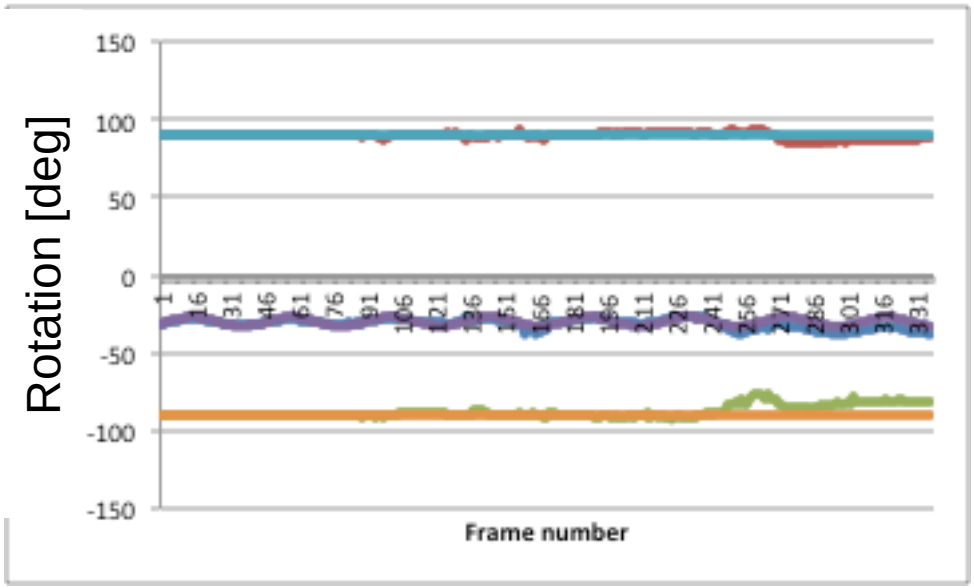
T. Ishikawa, et al: “In-Situ 3D Indoor Modeler with a Camera and Self-Contained Sensors”, In Proc. of HCII2009, pp.454-464, 2009.

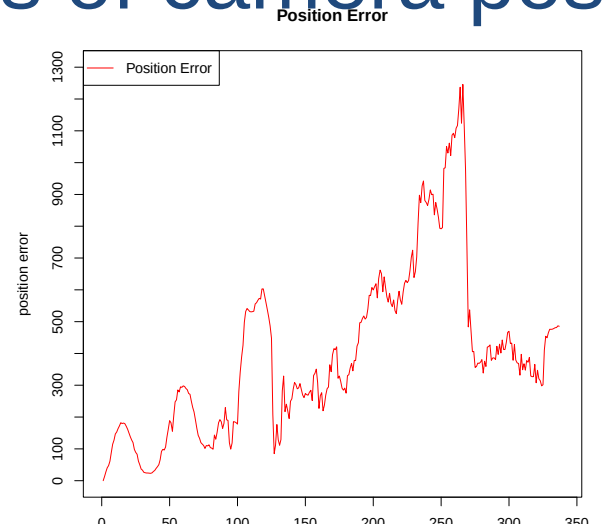
Virtualized reality sequence

Image size:
640x480 pix

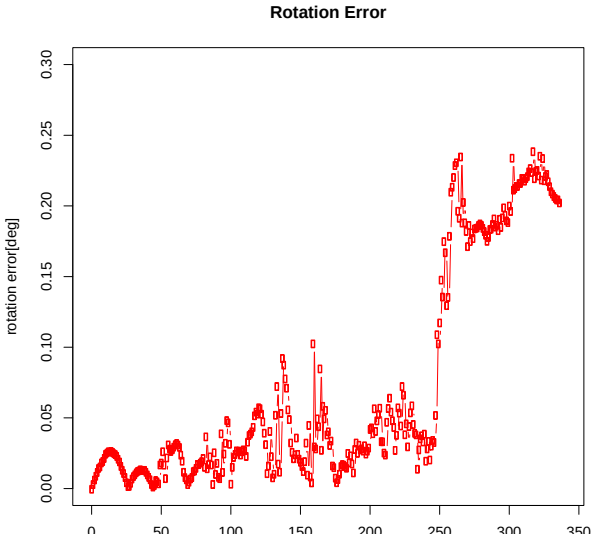
Result: geometric indices of camera pose



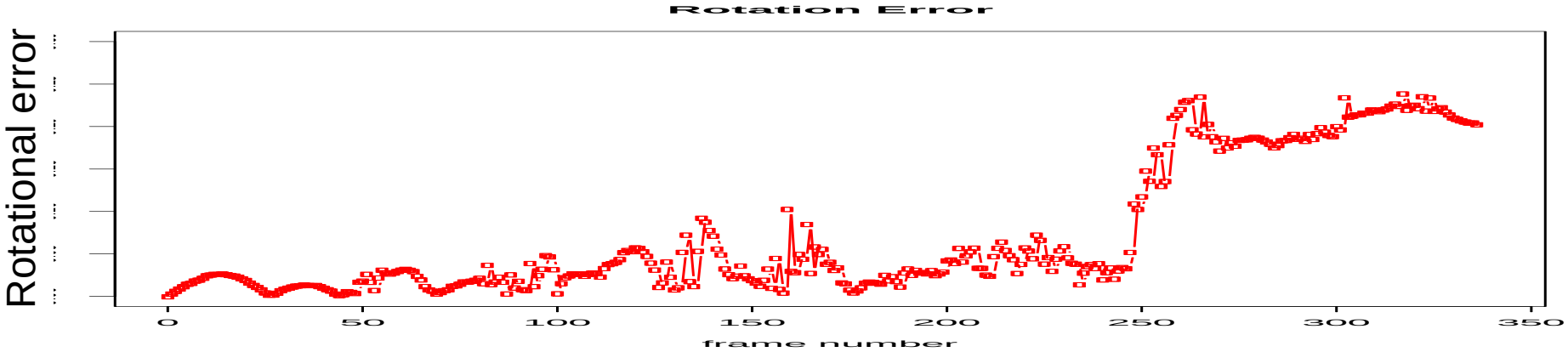




Euclidean distance



Rotational error



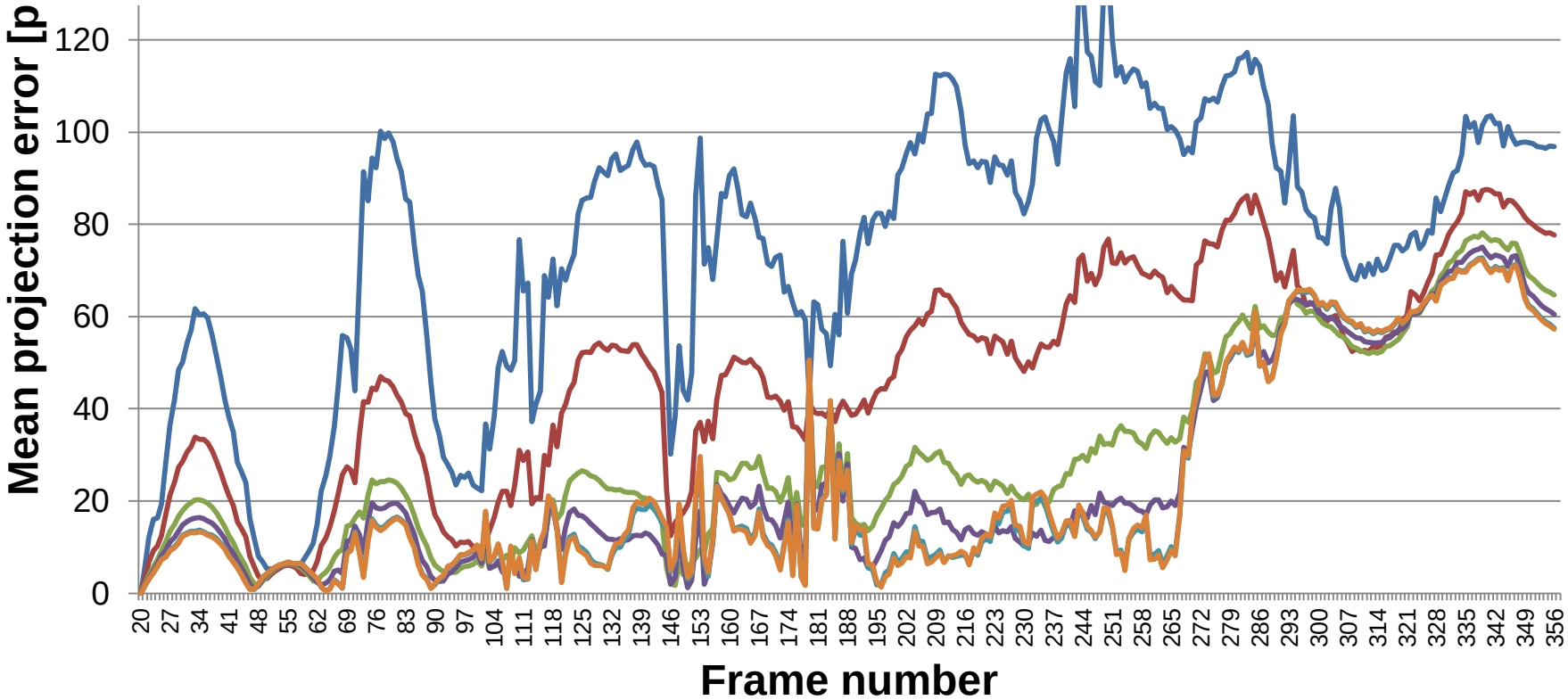
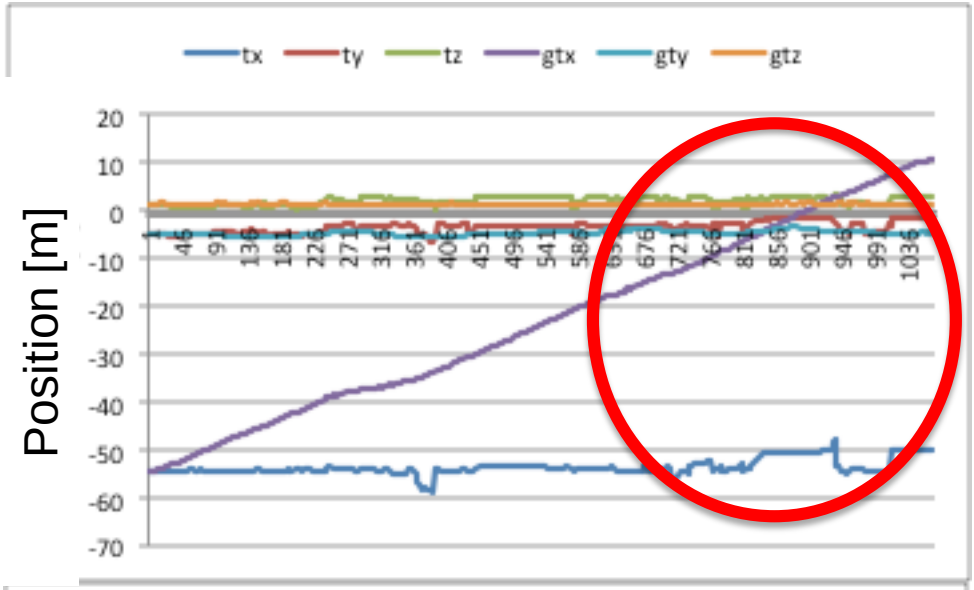


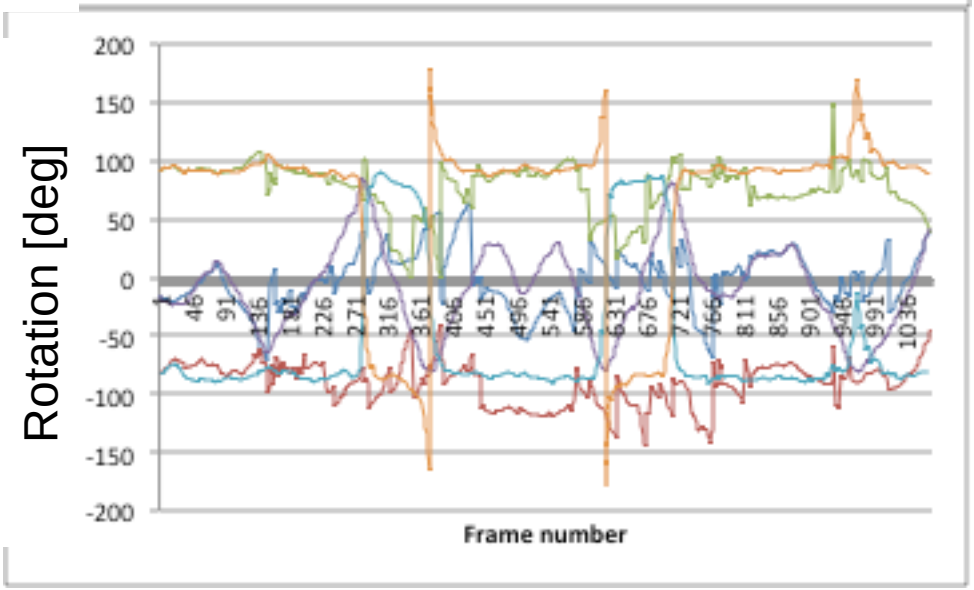
Image size: 640x480 pix

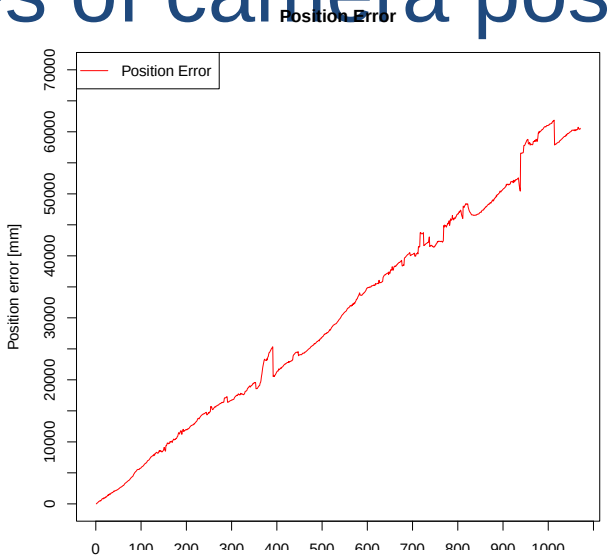
Outdoor sequence

Image size: 720x480 pix

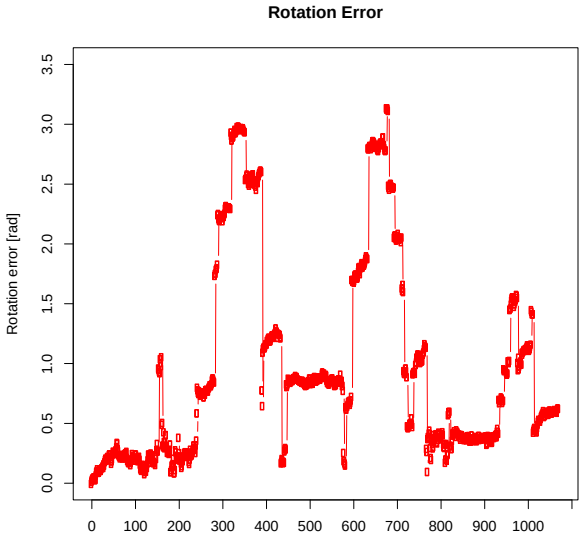
Result: geometric indices of camera pose





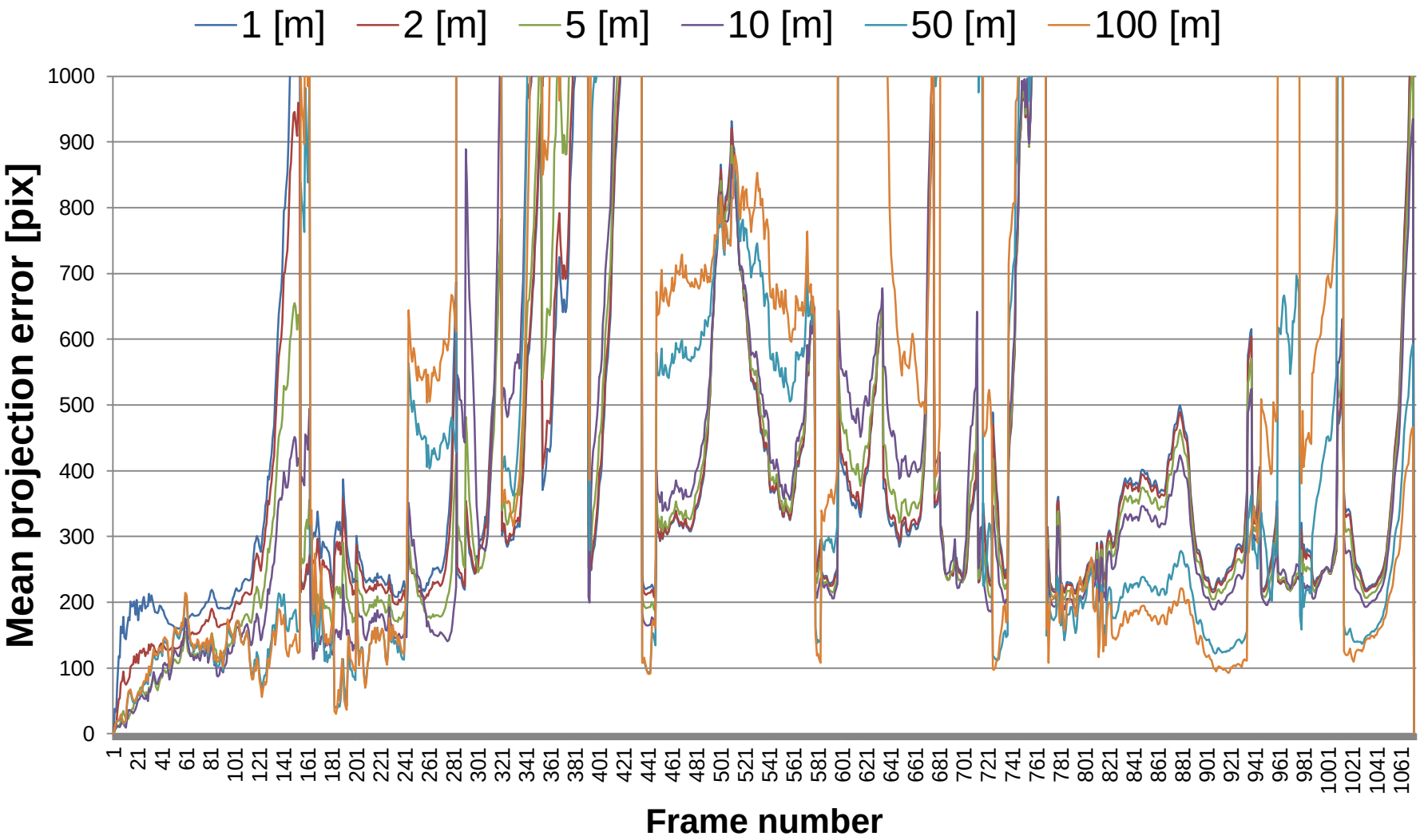


Euclidean distance

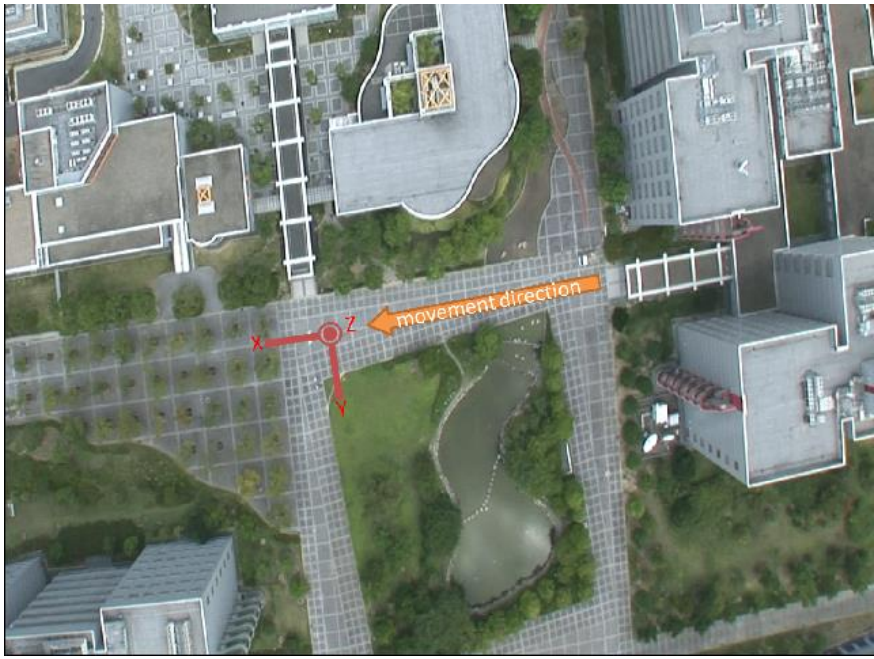


Rotational angle

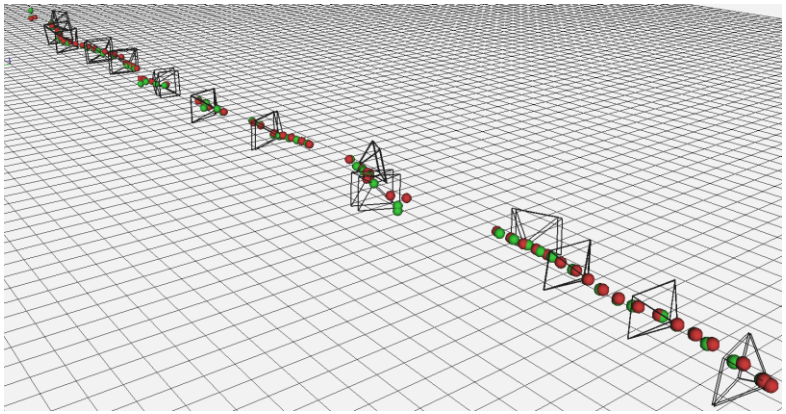
Mean projection error of 3x3 points



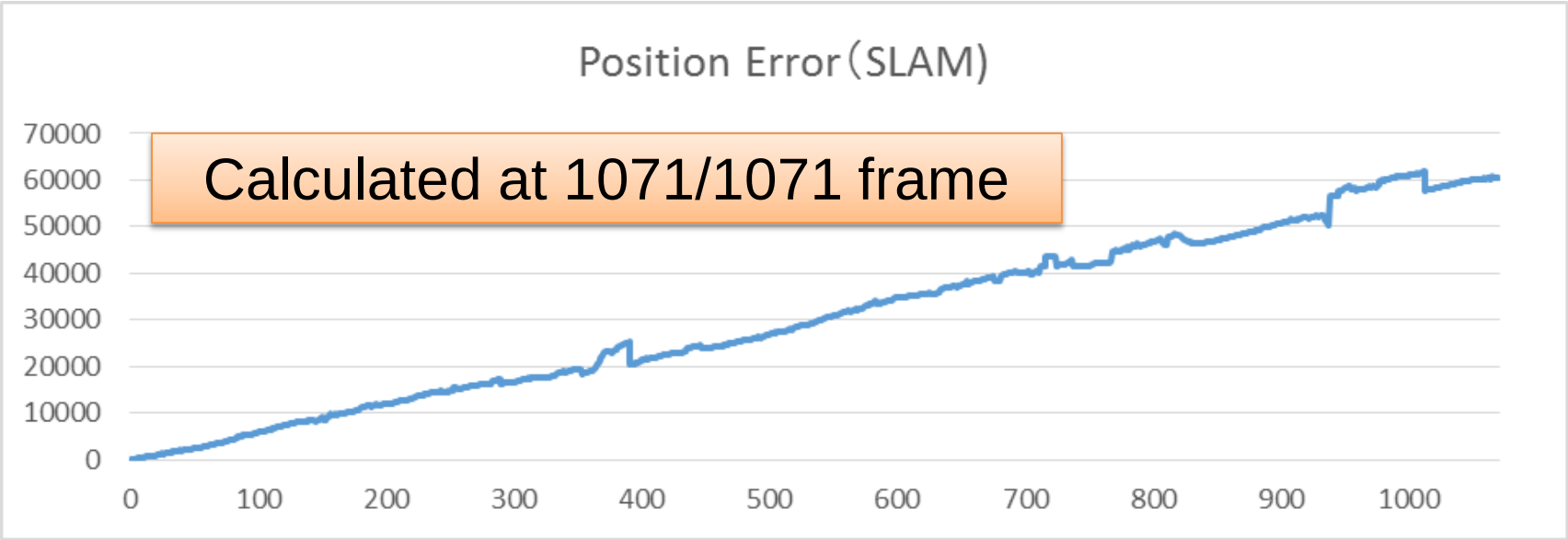
Comparison of camera tracking results

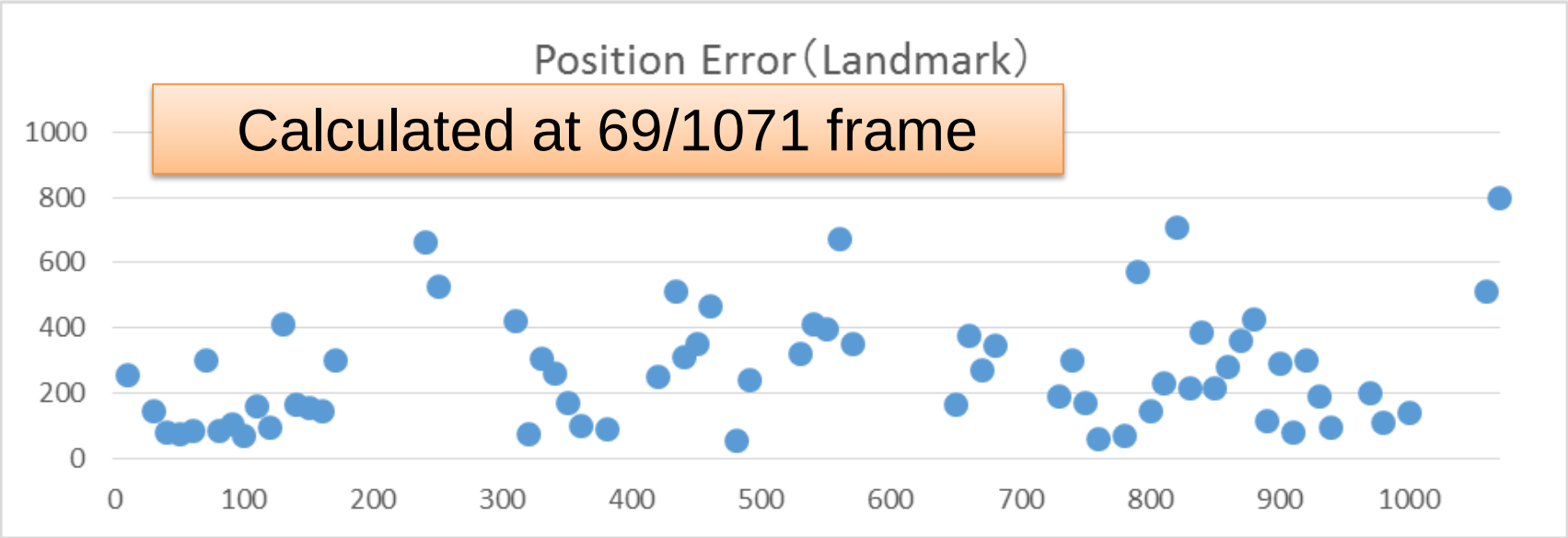


- Landmark based method
- SLAM based method

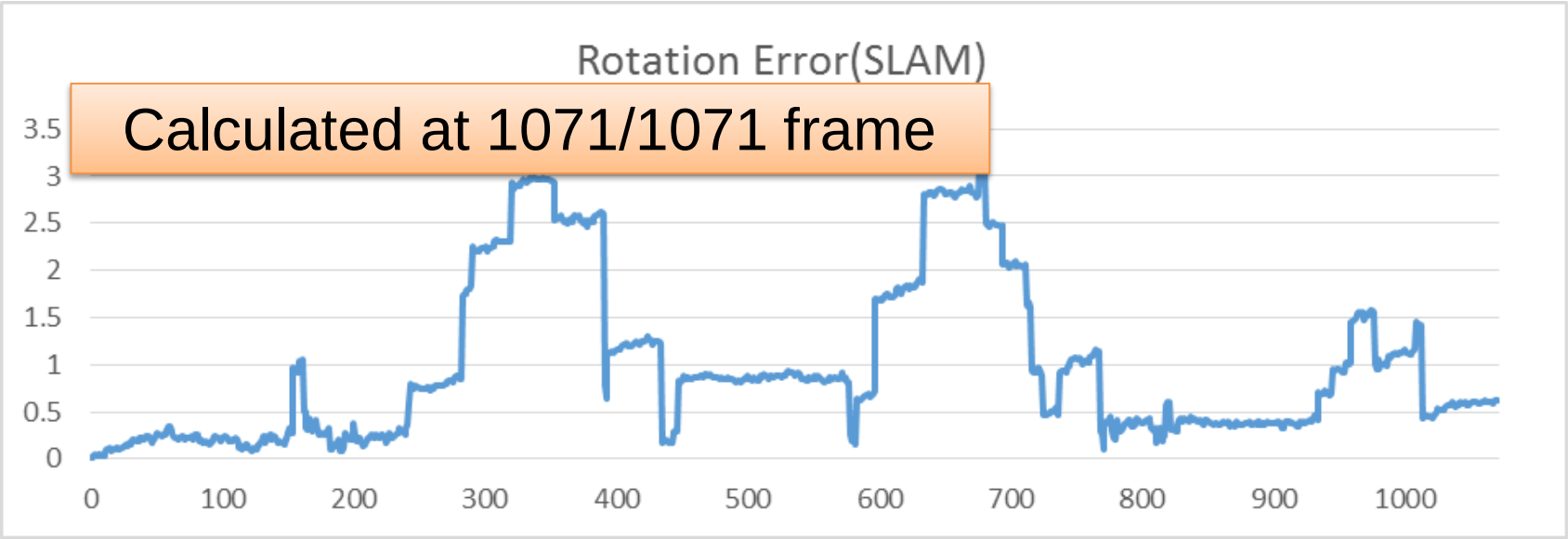


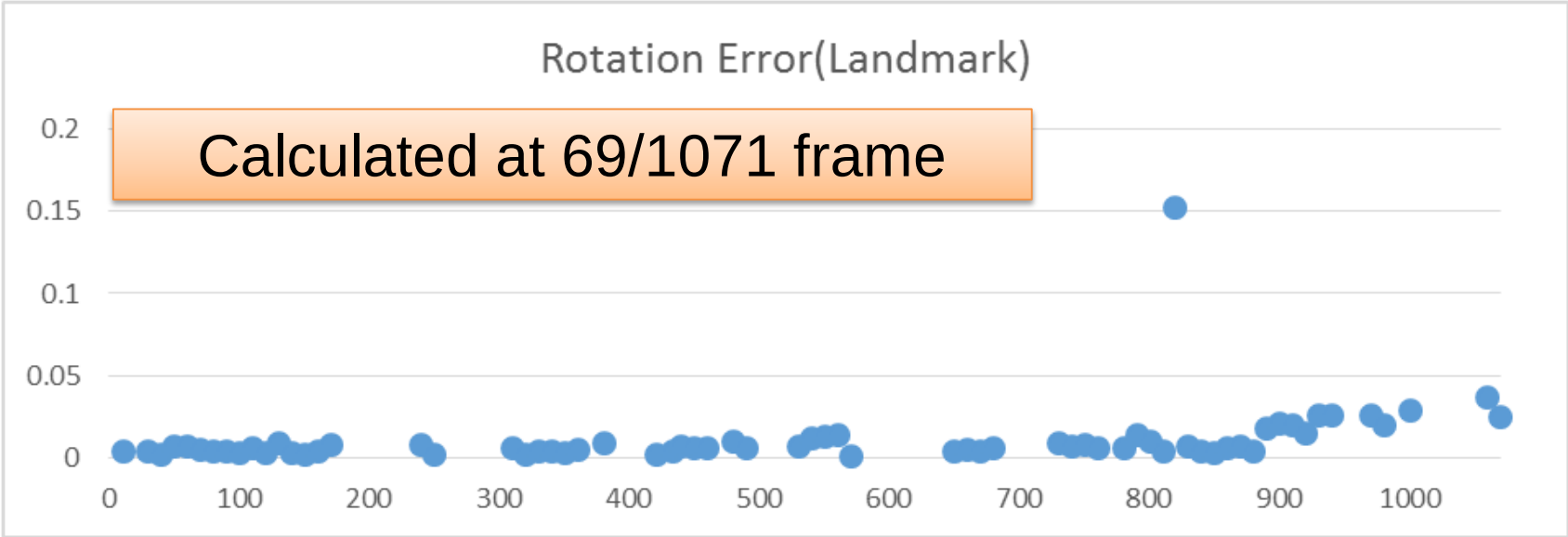
Position error



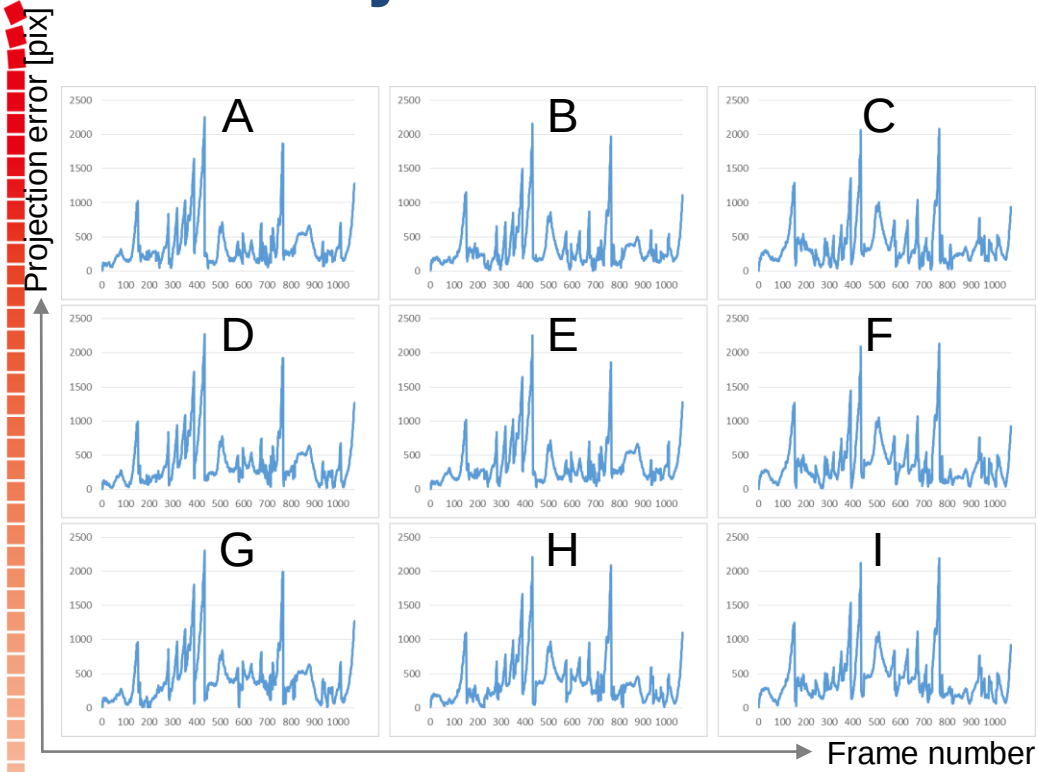


Rotation error

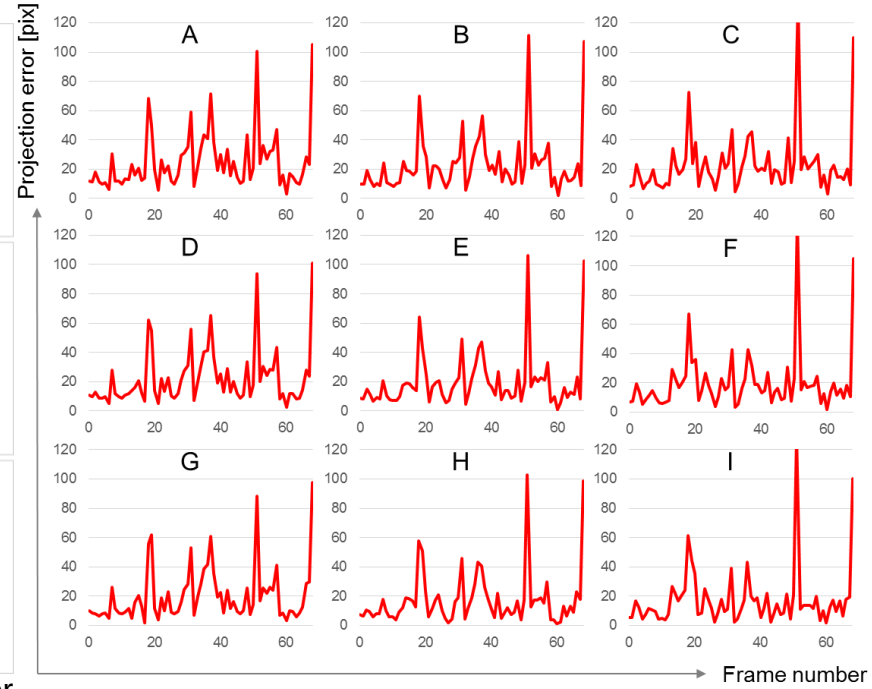




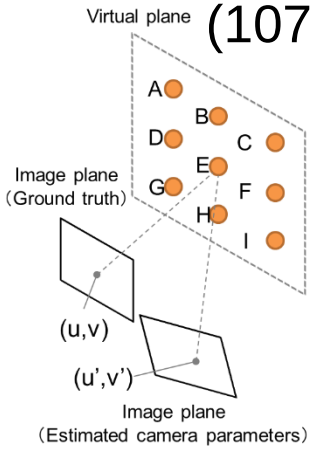
Projection error of virtual objects



SLAM based method
(1071/1071 frame)



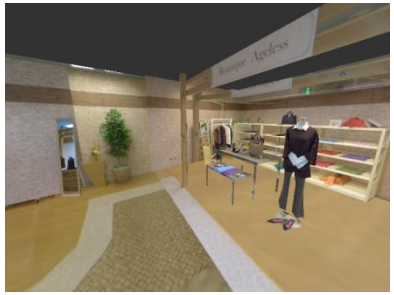
Landmark based method
(69/1071 frame)



Projection errors are not so vary from the position of the virtual point.

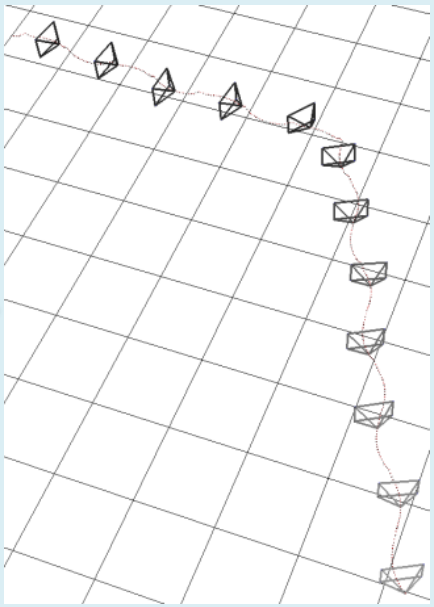
How can we evaluate a number of tracked frames?

Experiment with 3D model

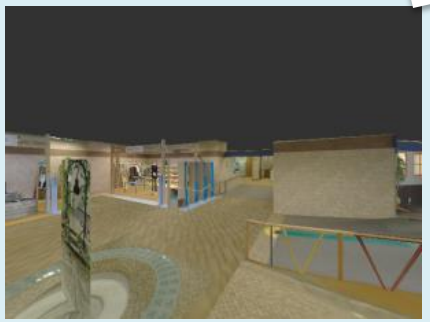


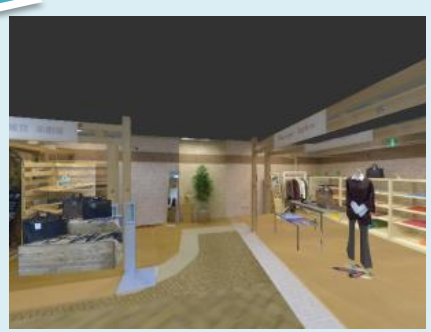
Virtualized reality model used in the experiment.
(Shopping mall in Osaka, Japan)

1. Data set generation



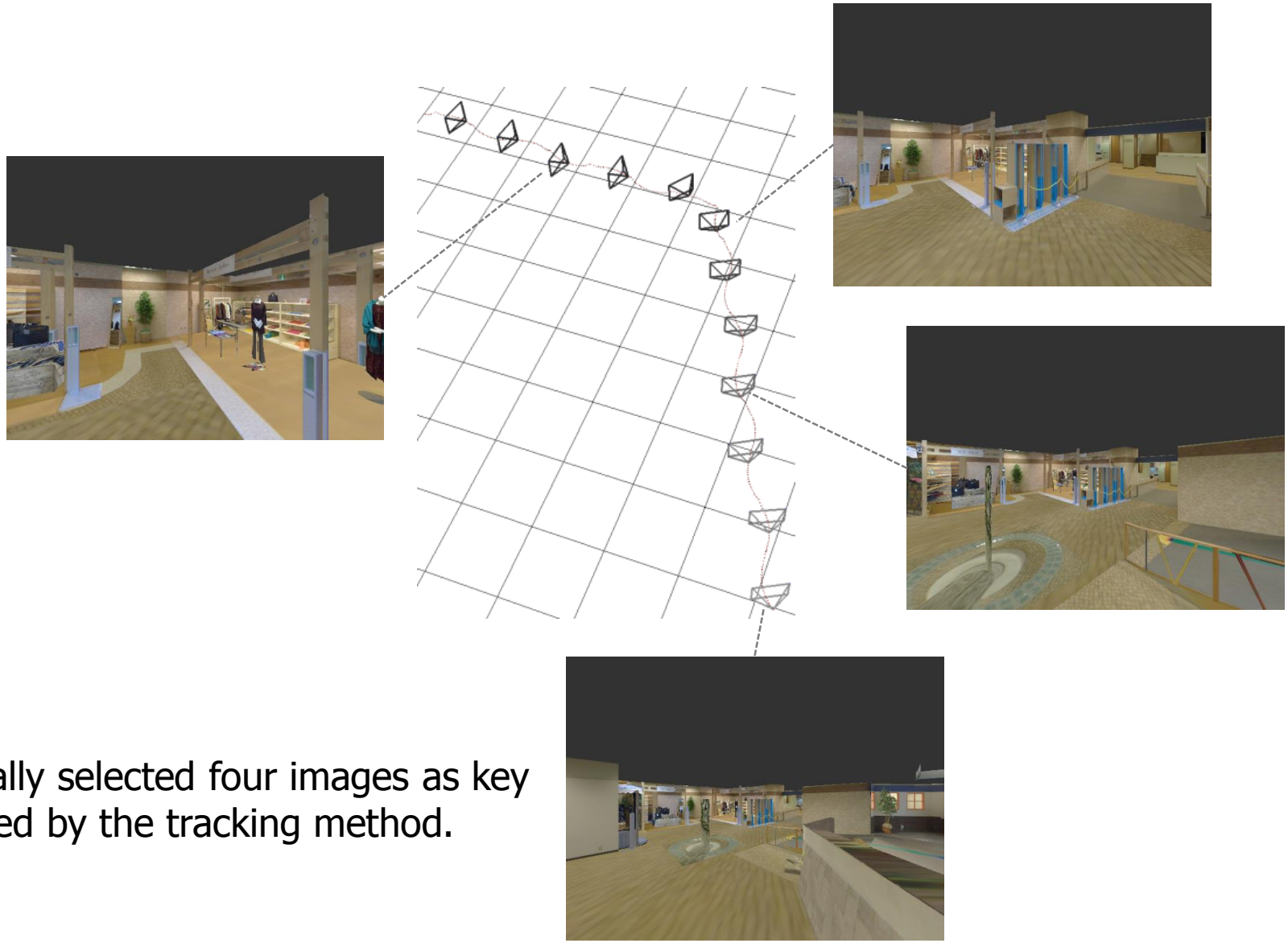
Camera path creation with walking motion





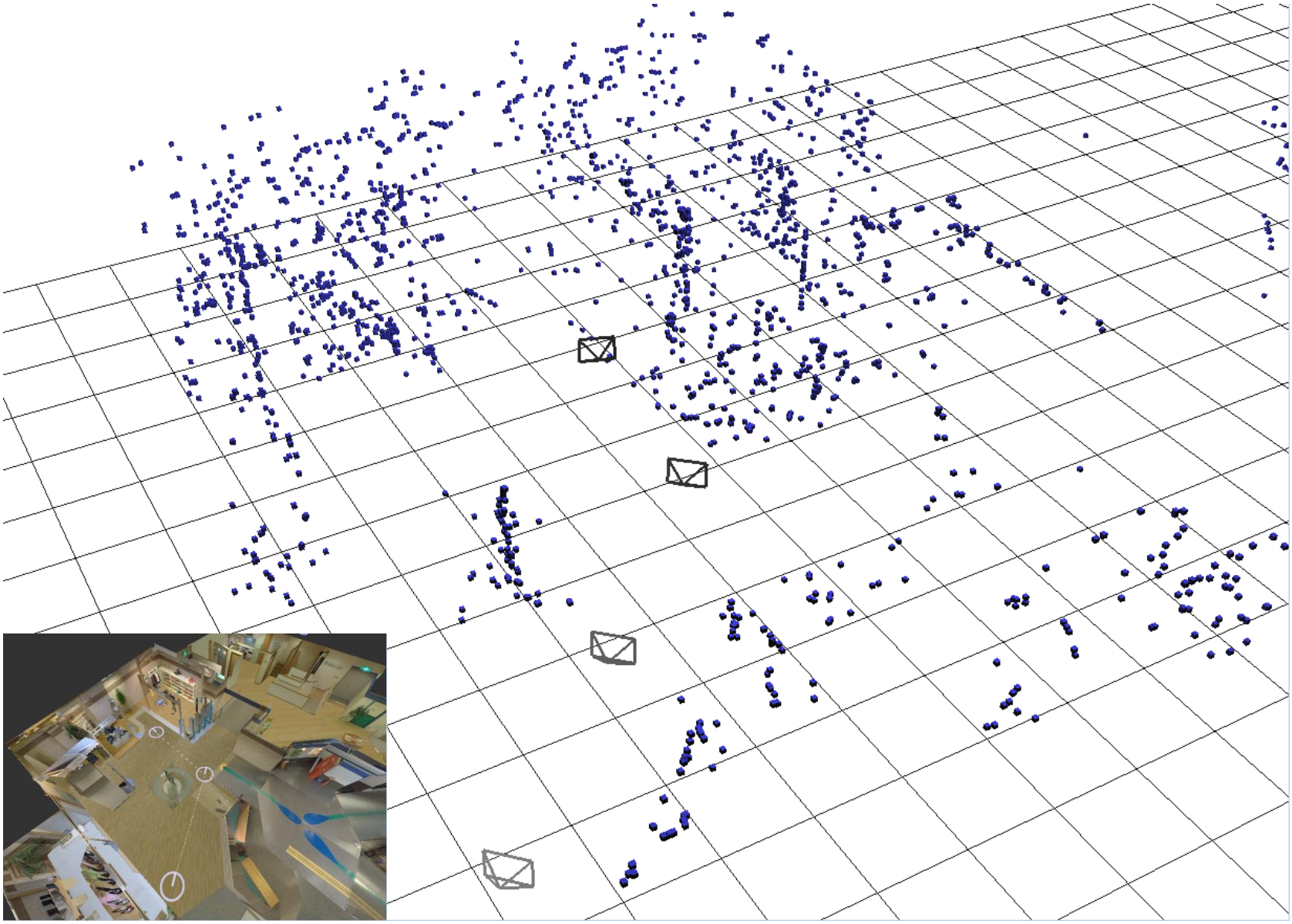
Generated images with virtualized reality models

2. Creation of key frames

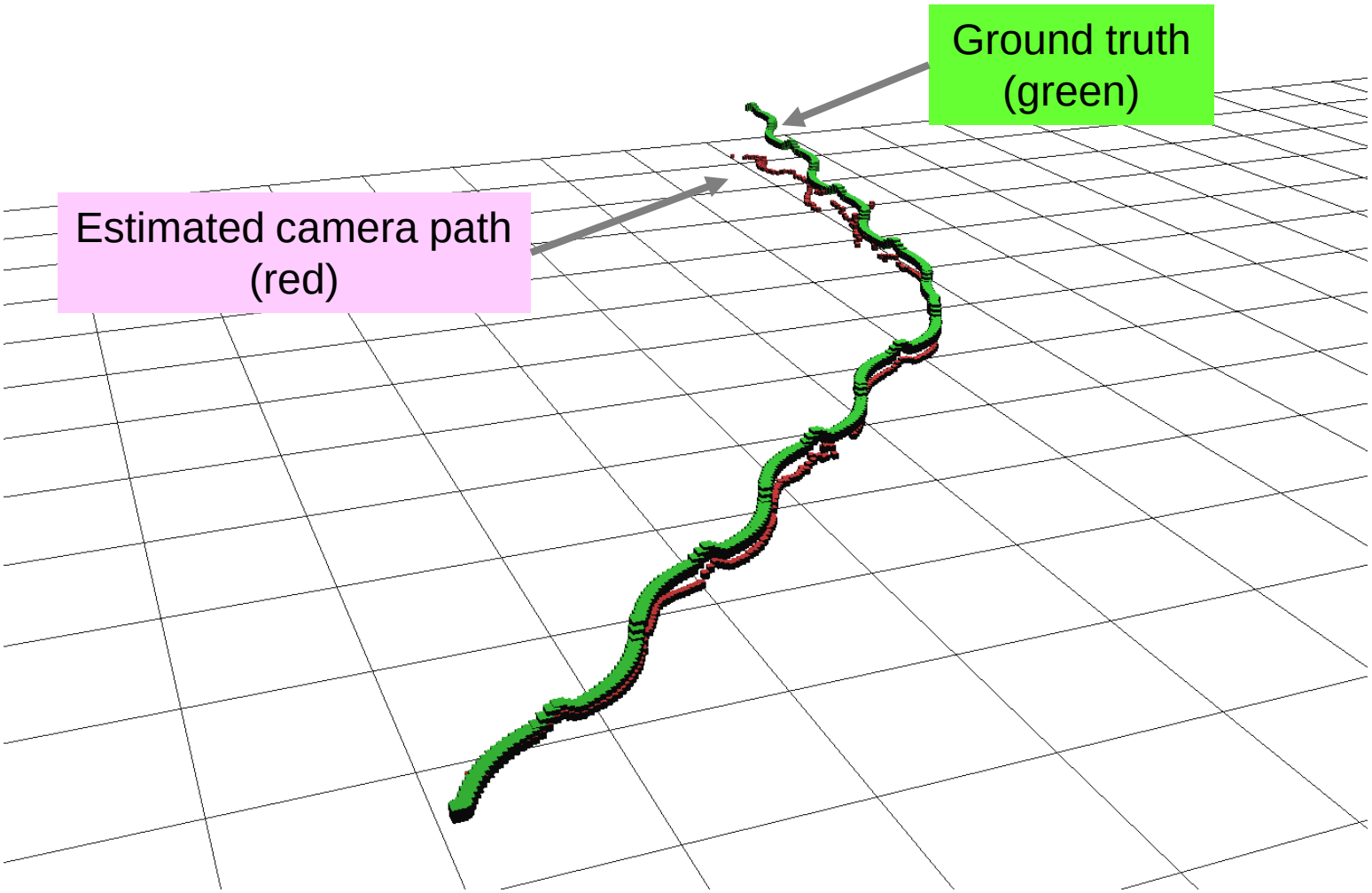


We manually selected four images as key frames used by the tracking method.

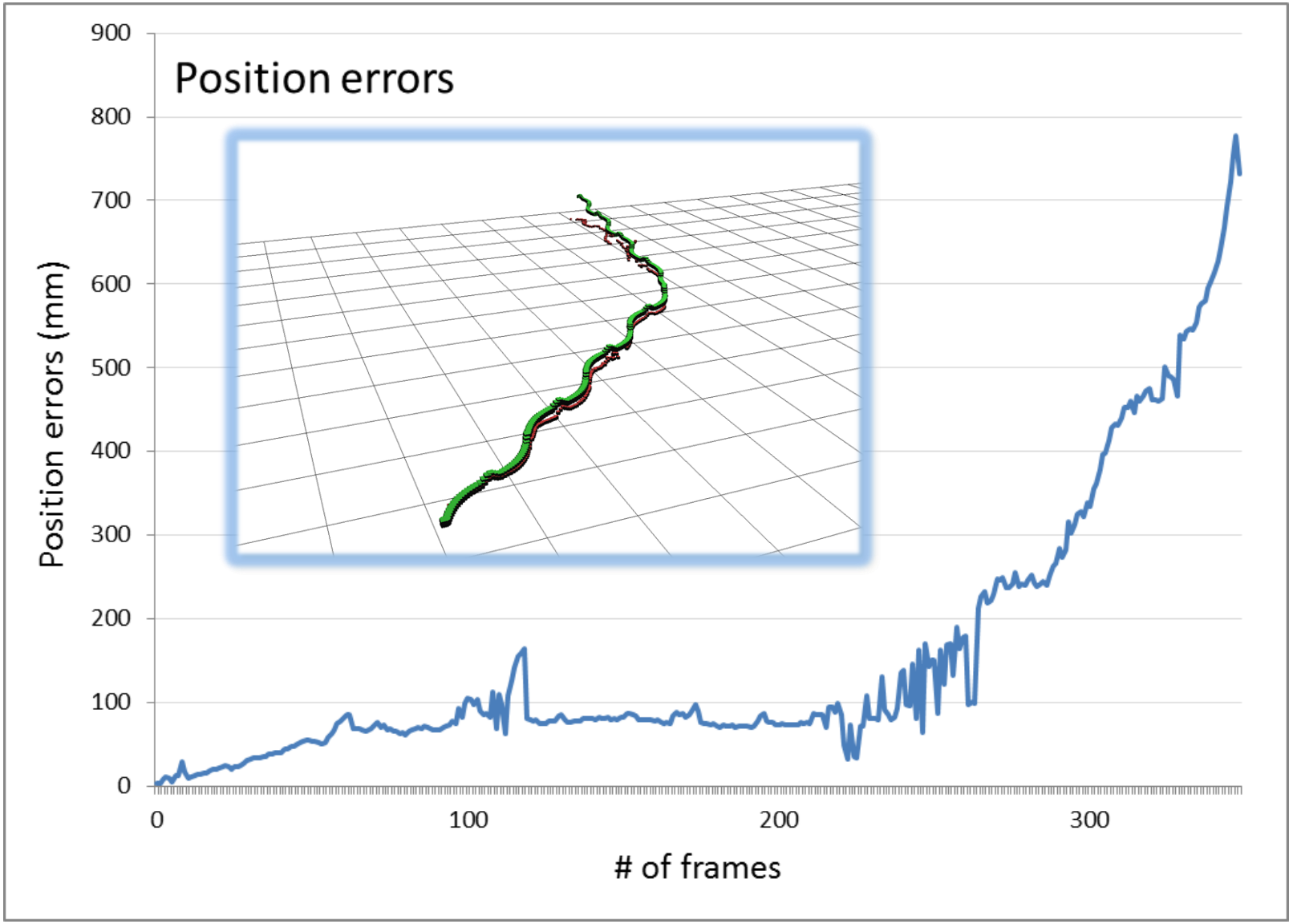
3. Generation of interest points



4.Camera tracking with generated images



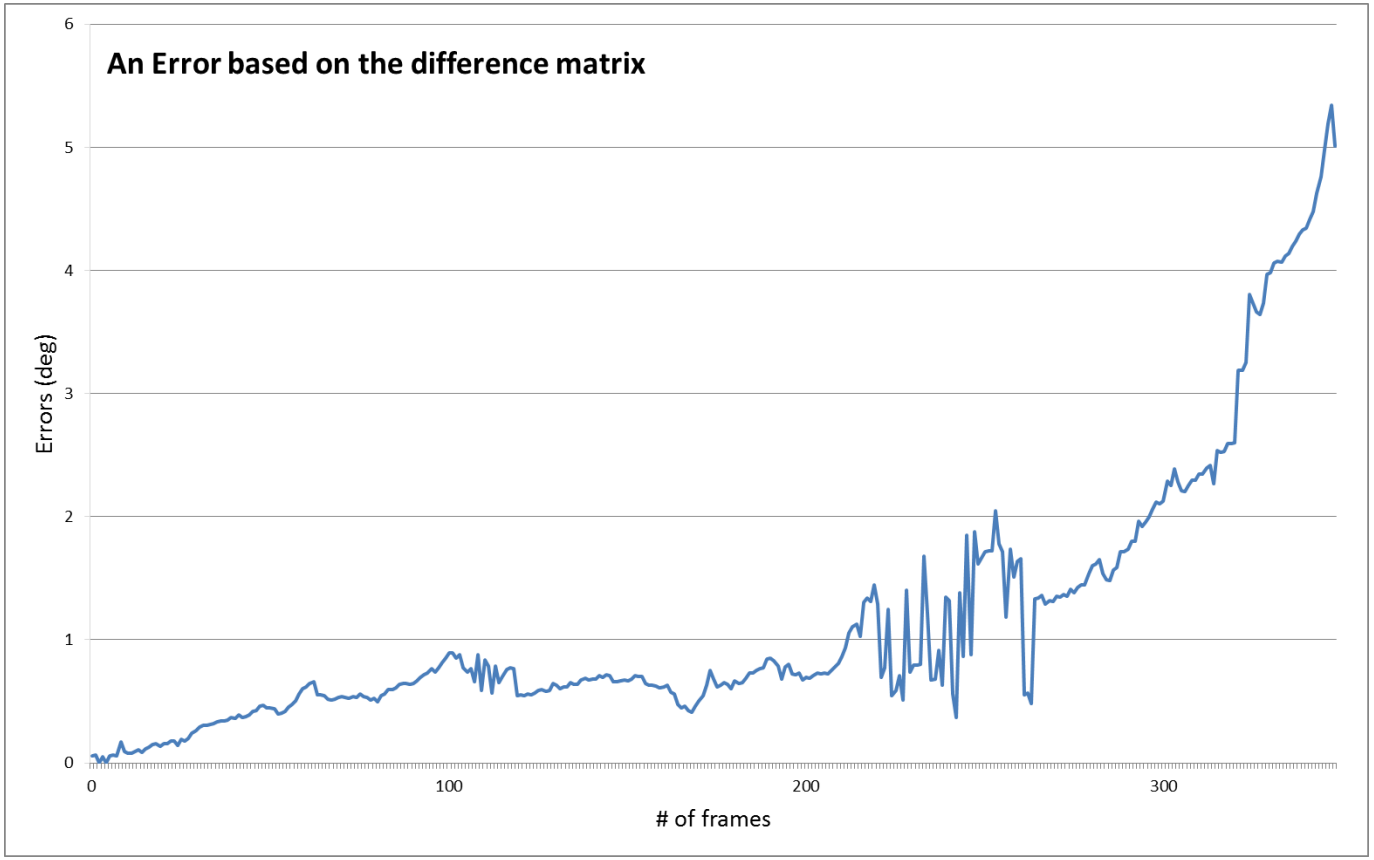
5. 1 Evaluation of camera positions



5.2 Rotation errors calculated by using difference Matrix

$$R_d = R_g R_e^T$$

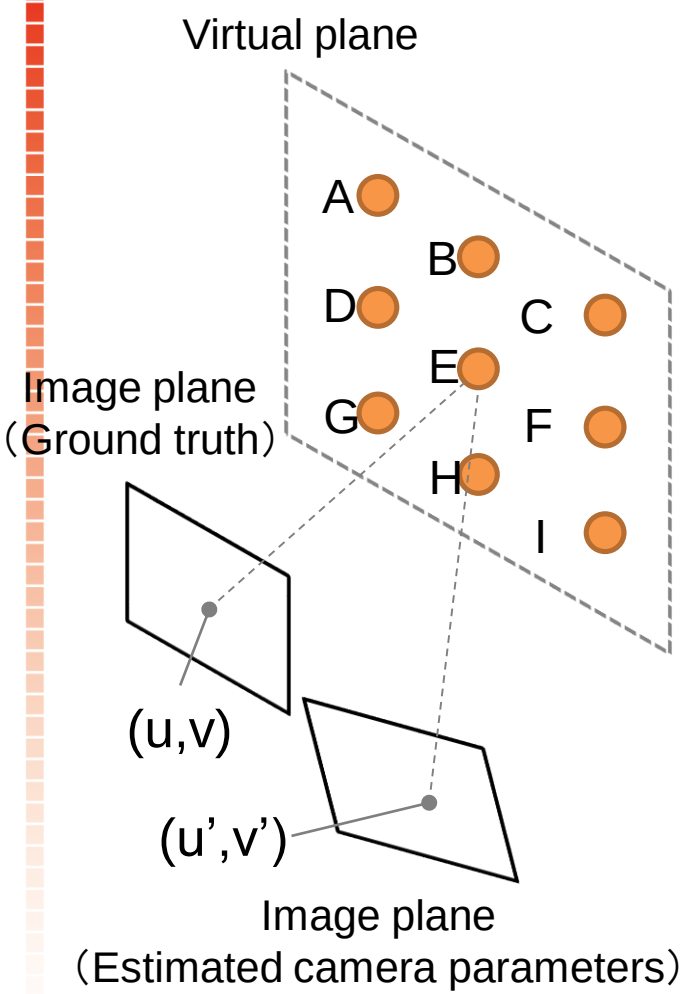
$$\theta_{R_d} = \arccos((\mathrm{tr}(R_d) - 1)/2)$$

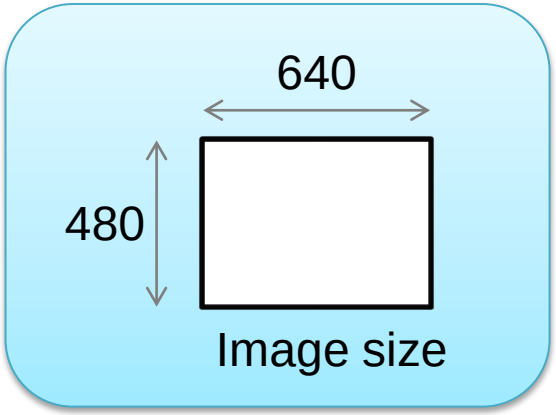


Rotation errors calculated by using difference Matrix

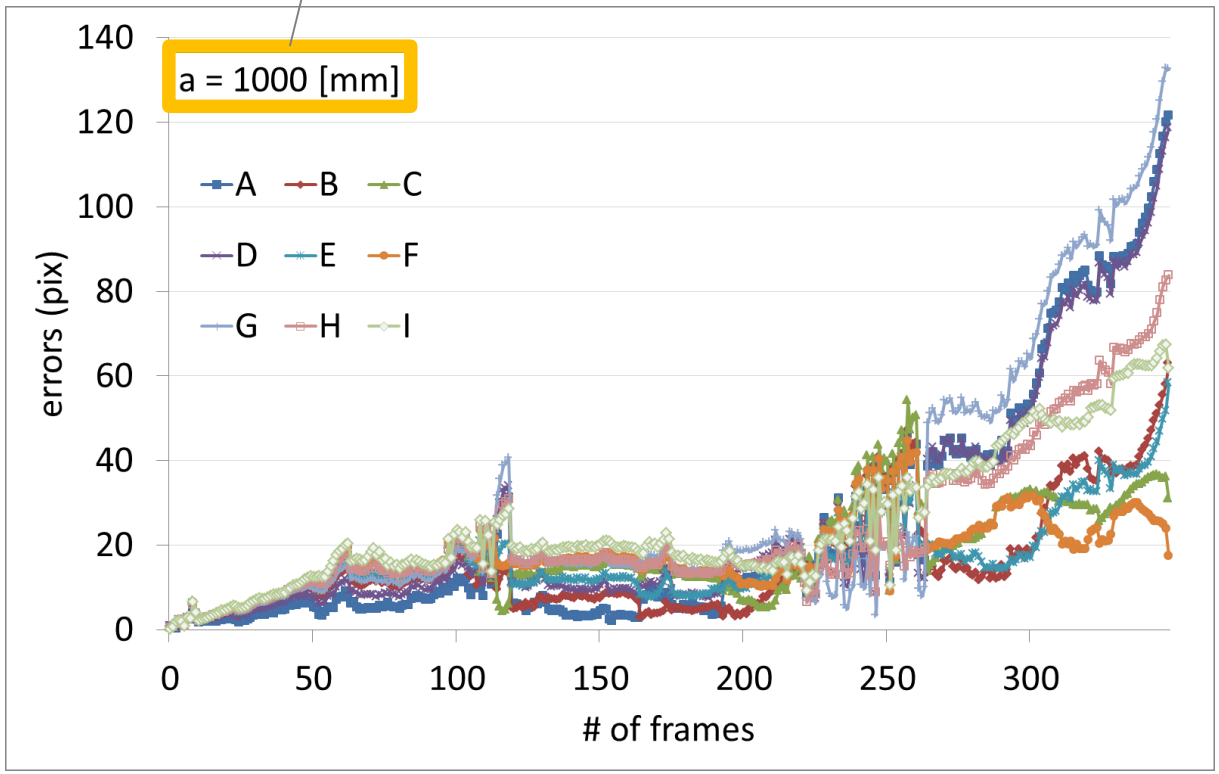
5.3 Projection errors of virtual objects

Calculation result

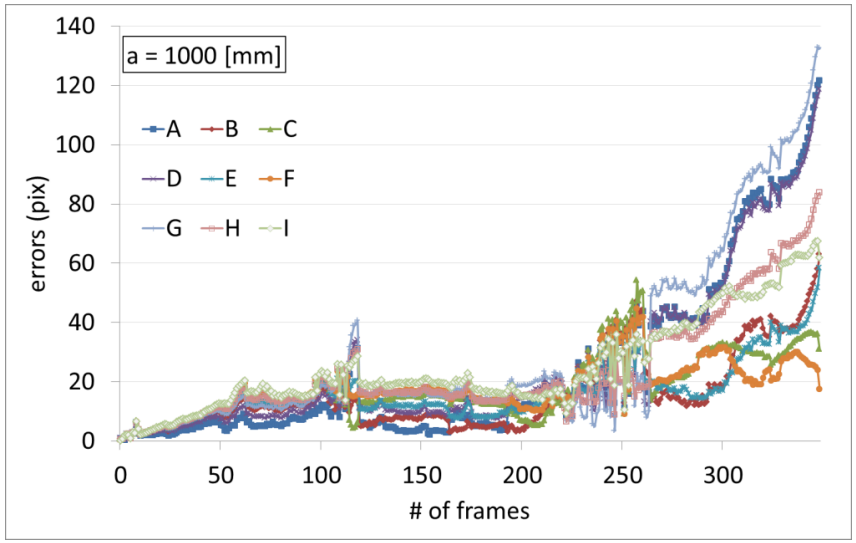




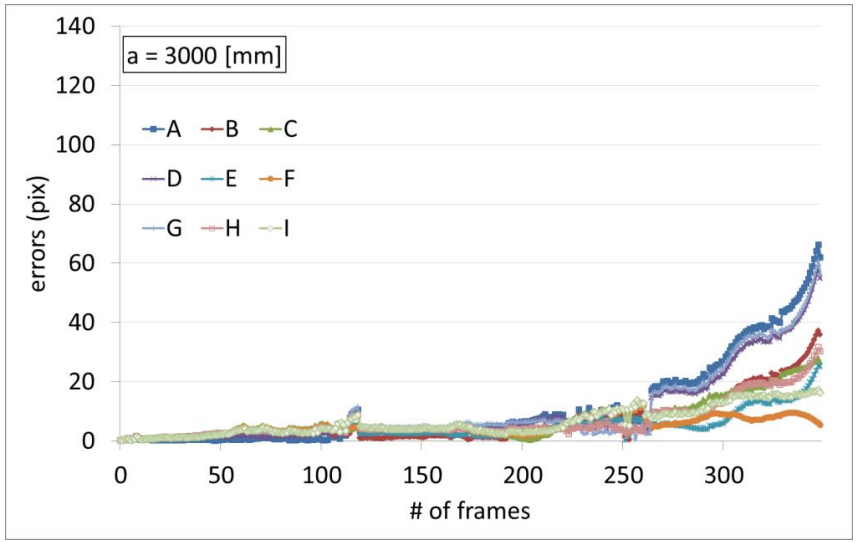
A distance from the camera to the virtual plane



5.3 Projection errors of virtual objects （with various distances）



a = 1000 [mm]

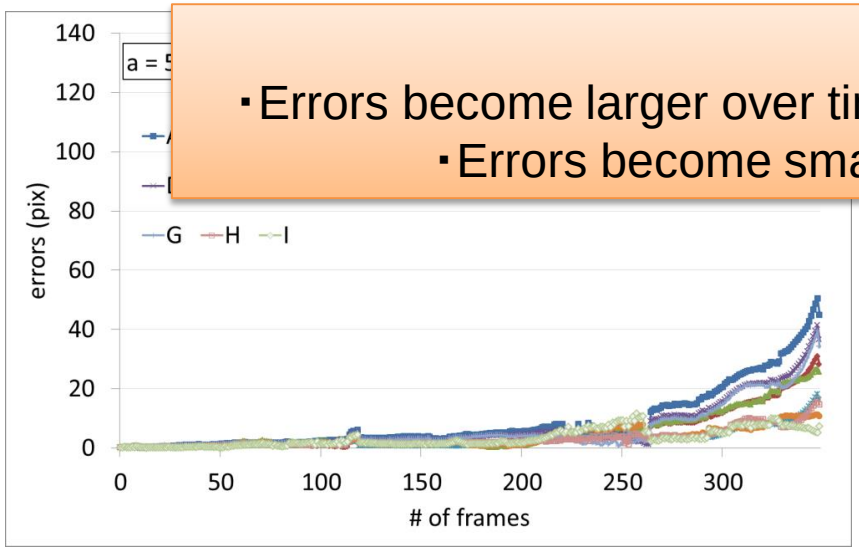


a = 3000 [mm]

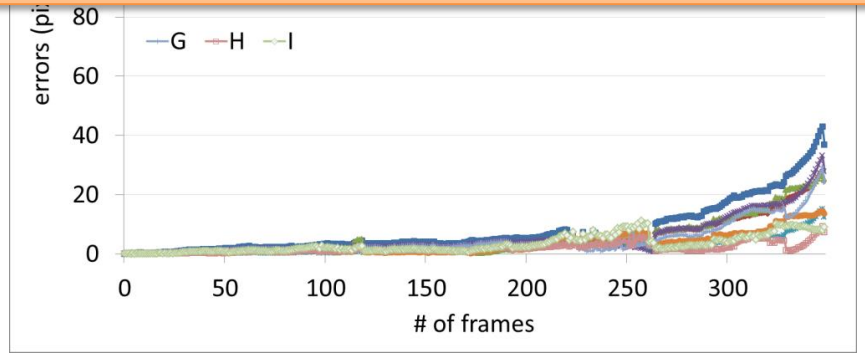
Features：

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

・Errors become smaller when the distance increases

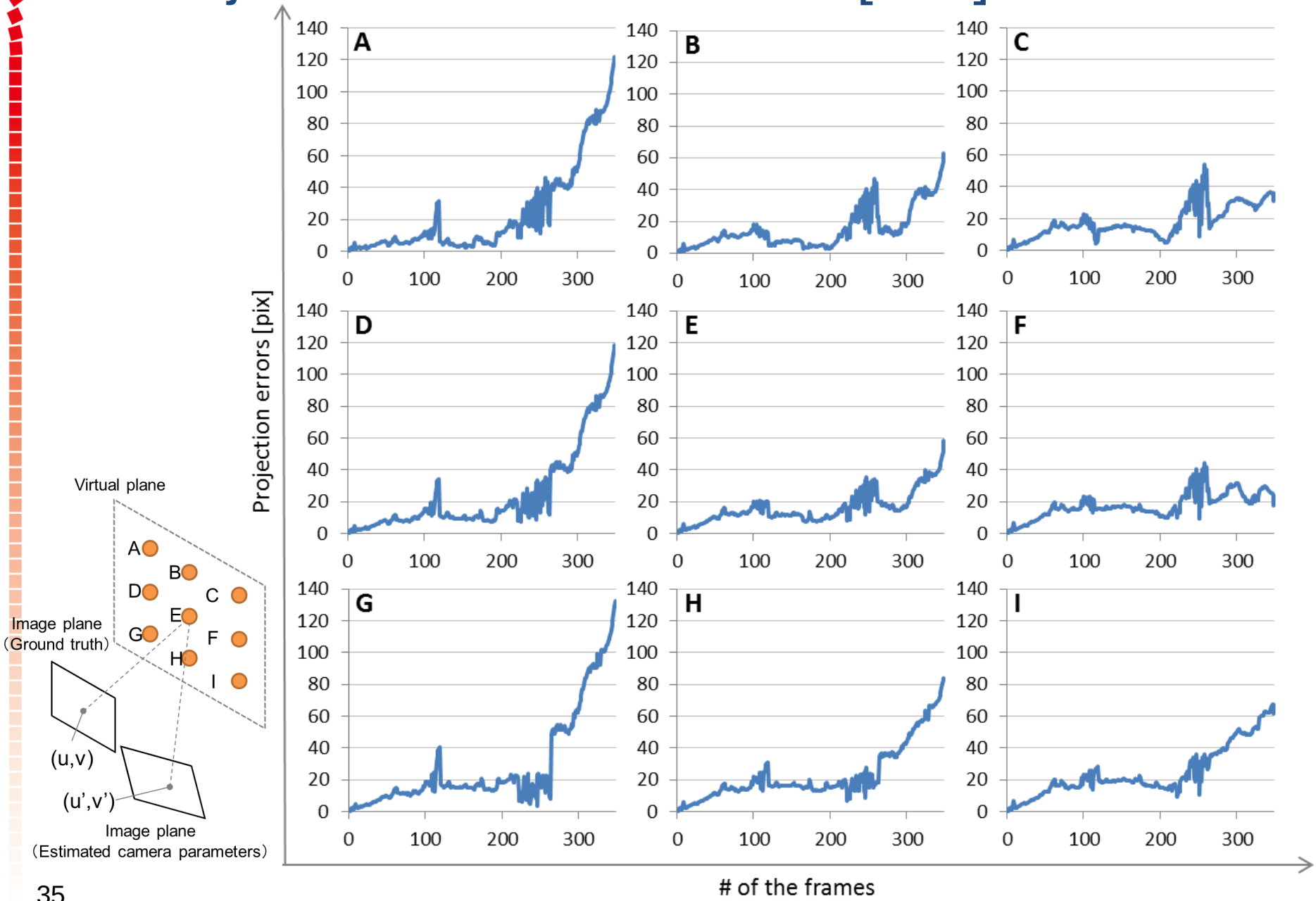


a = 5000 [mm]

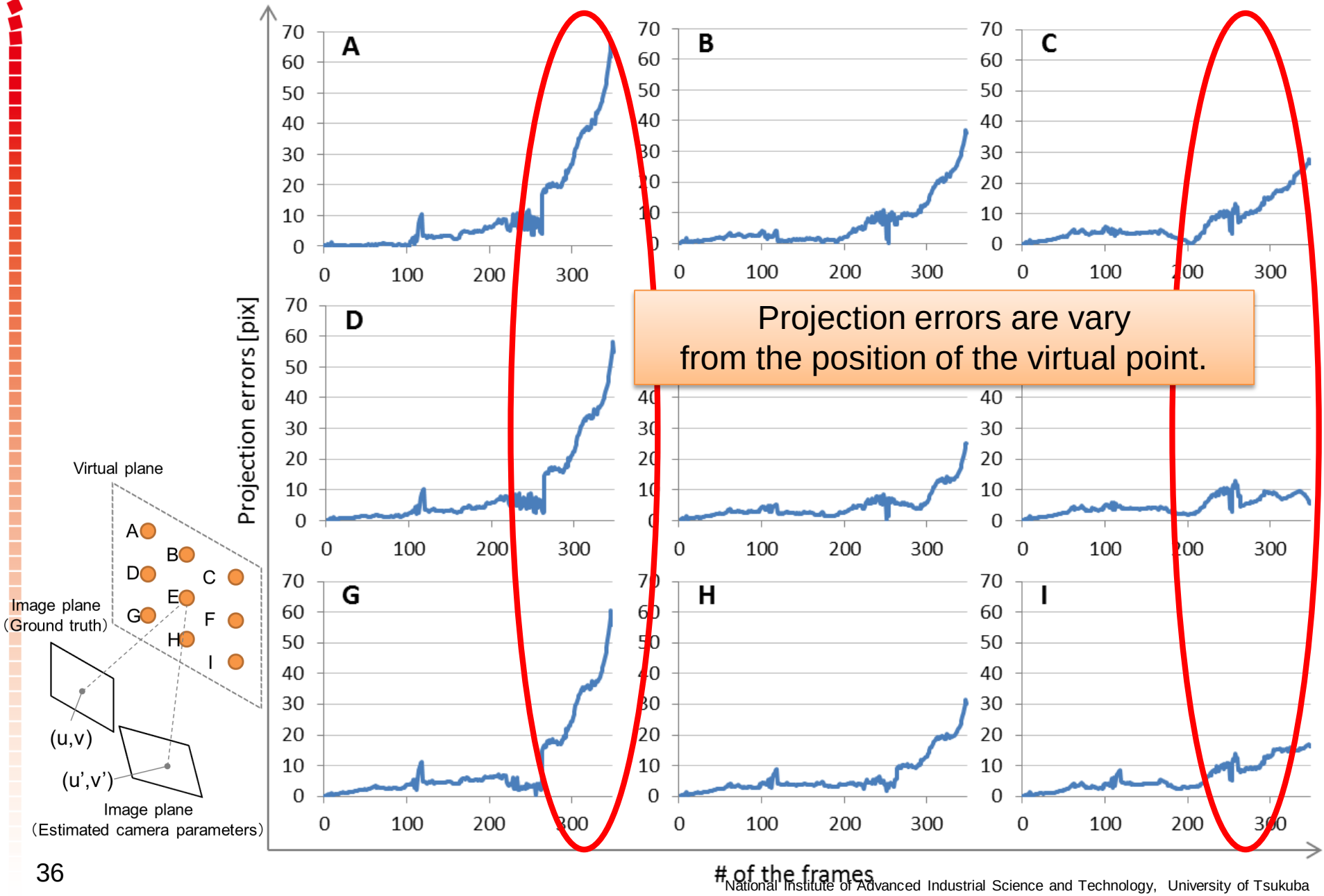


a = 7000 [mm]

Projection errors（a = 1000 [mm]）



Projection errors（a = 3000 [mm]）



Projection errors are vary
from the position of the virtual point.

A number of feature points on the image plane

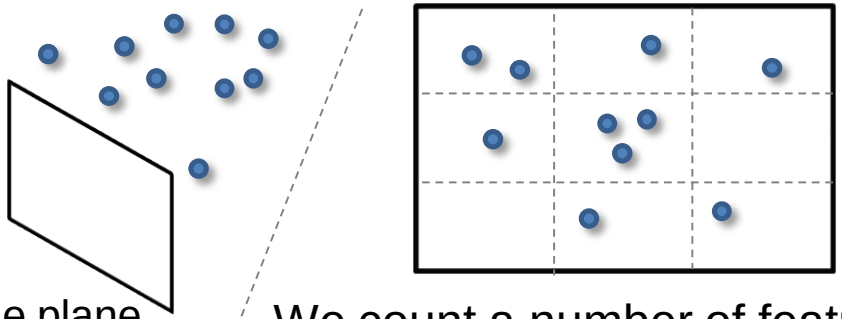
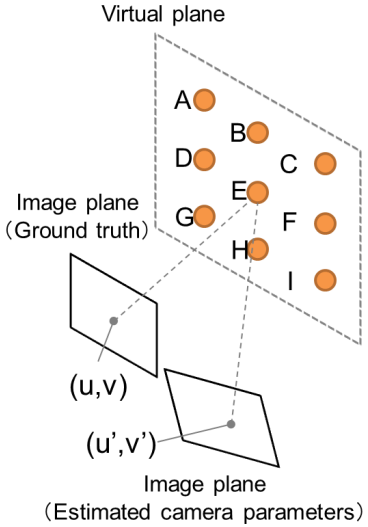
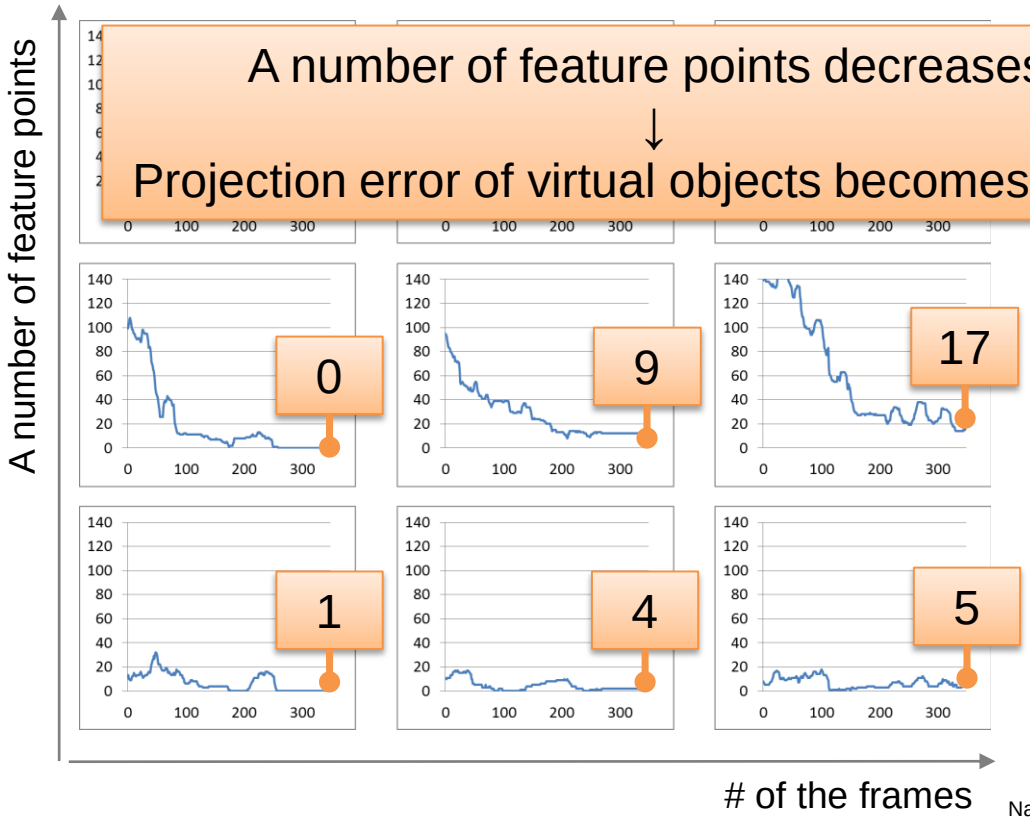


Image plane
（Ground truth）

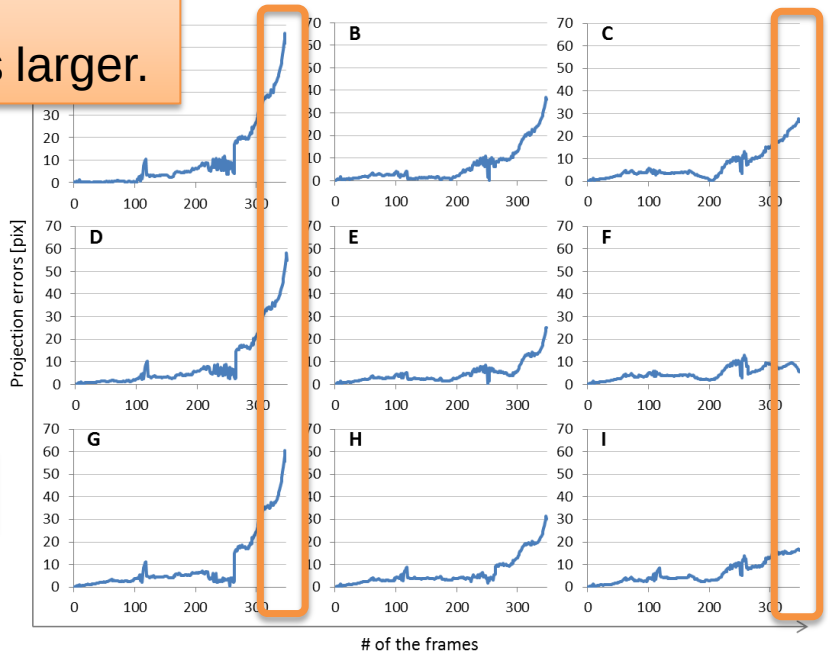
We count a number of feature points on the image plane (9 areas).



A number of feature points decreases.
↓
Projection error of virtual objects becomes larger.



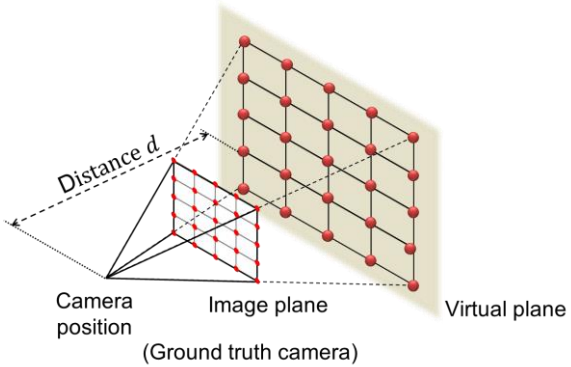
ection error of virtual objects

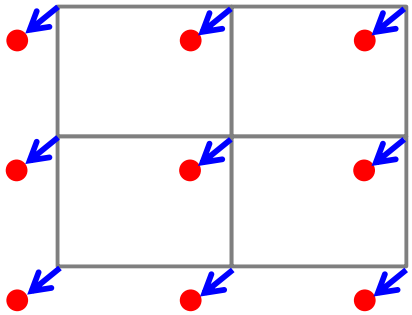


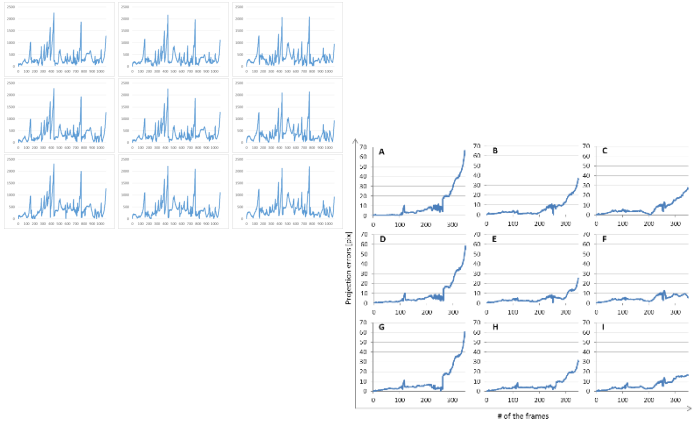
Conclusion

Projective indices for AR/MR benchmarking in TrakMark

- Projective indices of virtual points for AR/MR applications
- Two stage projective indices
  - Visibility index of virtual points
  - Projection errors of virtual points
- Relative placement strategy of virtual objects







～Future works～

- Standardization of projective indices
- Expansions of benchmarking results in TrakMark

Thank you !

- TrakMark
  http://trakmark.net/
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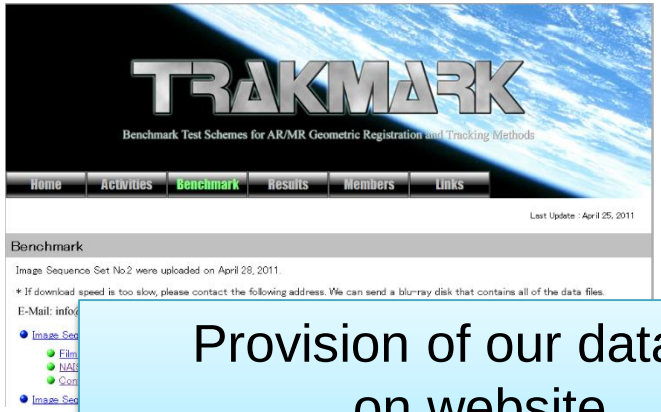

Provision of our data set
on website
http://trakmark.net/

Data discs
(distributed in ISMAR2013)