

Estimation of Photo-Shoot Location with a Mobile-Phone Camera Based on Virtualized-Reality Environment Models

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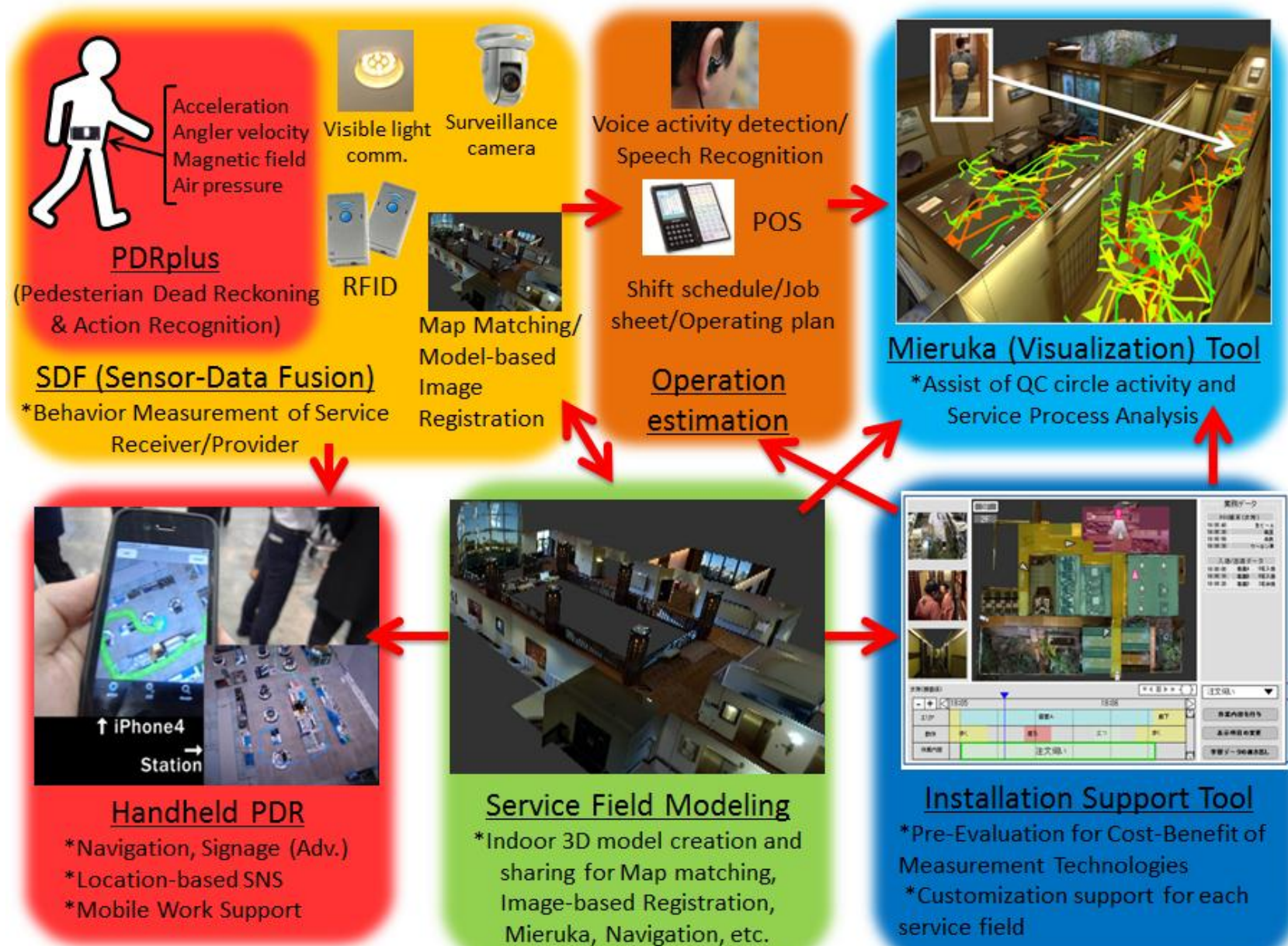
²University of Tsukuba, Japan

EBS, Post POS, MR Information Sharing

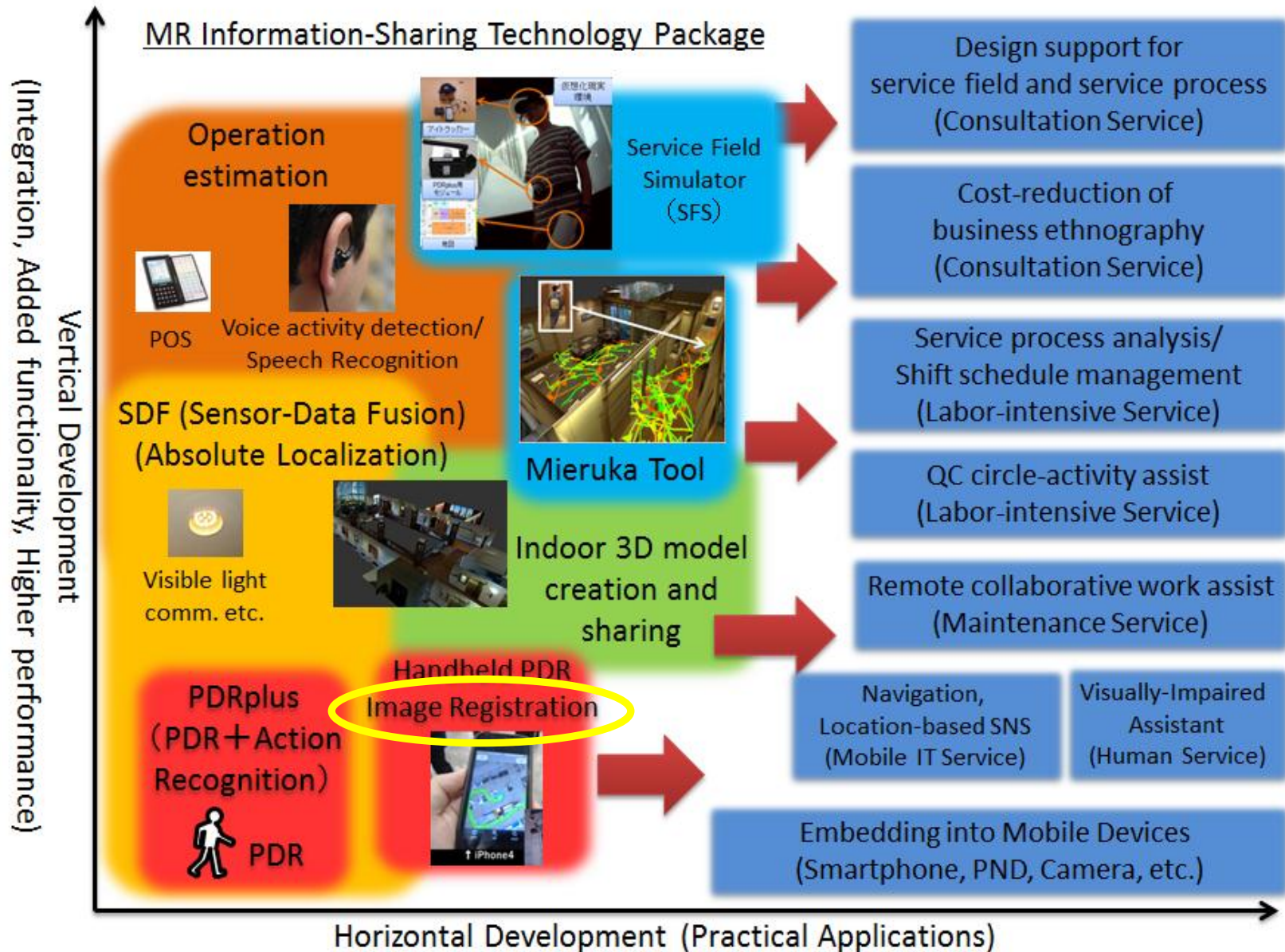
- Real-virtual correspondences of products with POS (Point-Of-Sales) systems
 - Facilitate modeling and designing the flow of the products by not strongly relying on tacit knowledge.
 - Brought about drastic changes in retail, chain restaurant, logistics, etc.
 - Realized EBS (Evidence-Based Service) 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.
 - Mixed-Reality Information Sharing technologies!



MR Information Sharing Technologies in Human-Behavior Sensing and Visualization Research Team



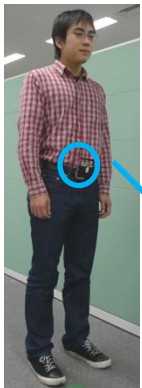
Horizontal-Vertical Development of MR Information Sharing Technologies



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 shoe-mounted PDR based on Zero Velocity Updates (ZUPTs)

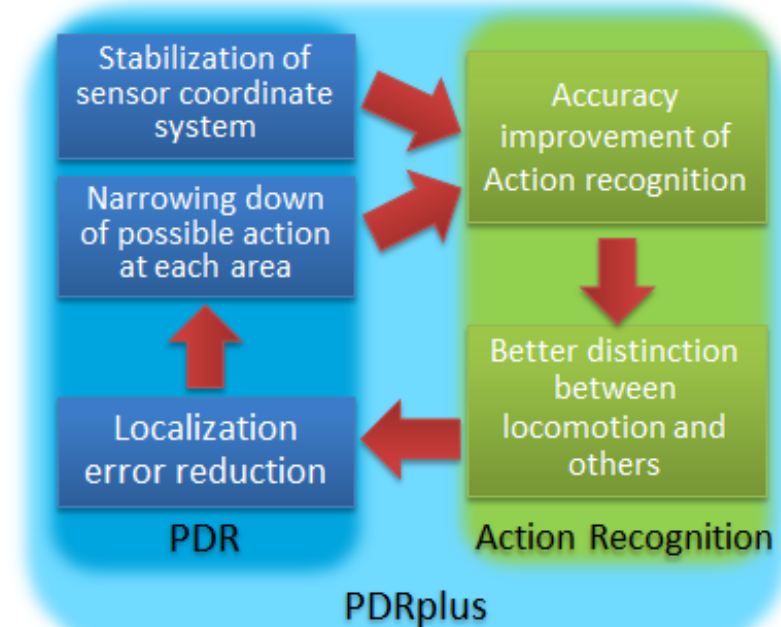


Sensor module

- Accelerometers
- Gyro-sensors
- Magnetometers
- Barometer

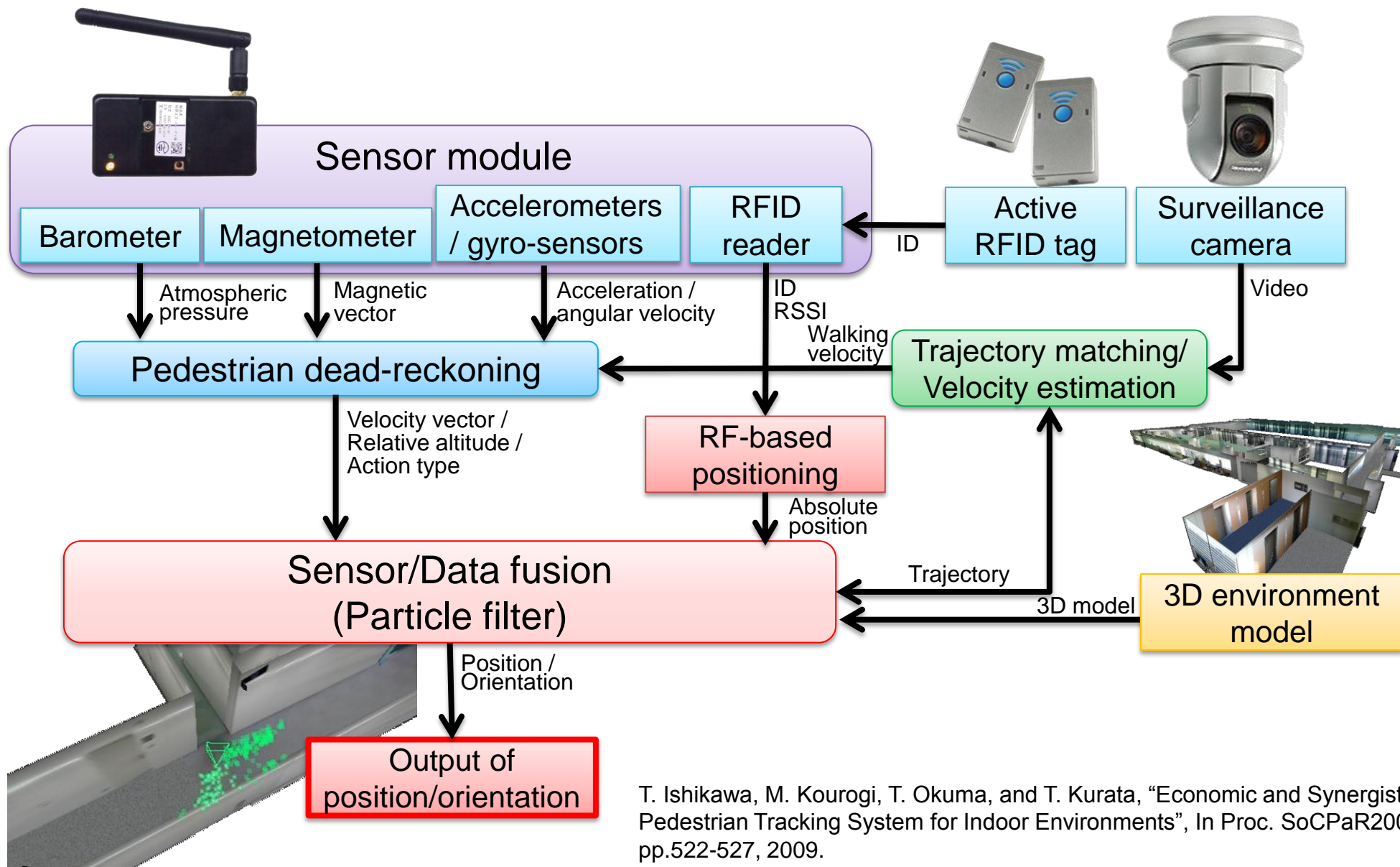


Handheld PDR



From PDR to PDRplus

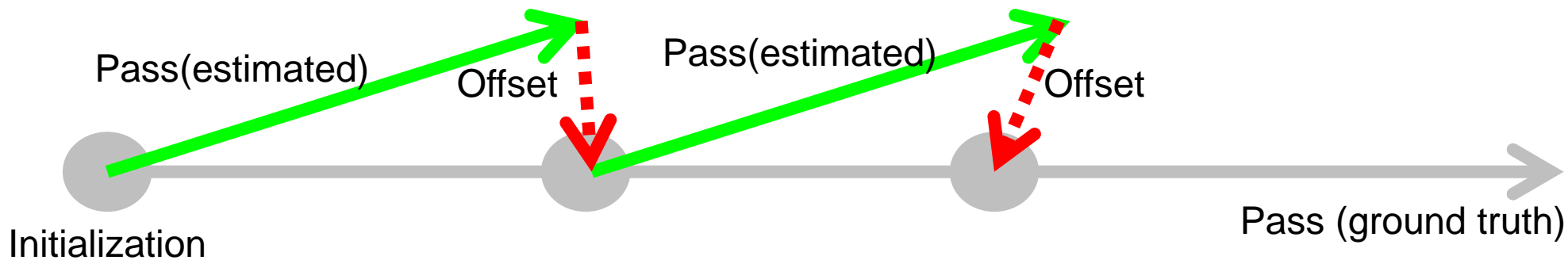
Pedestrian Tracking System



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.

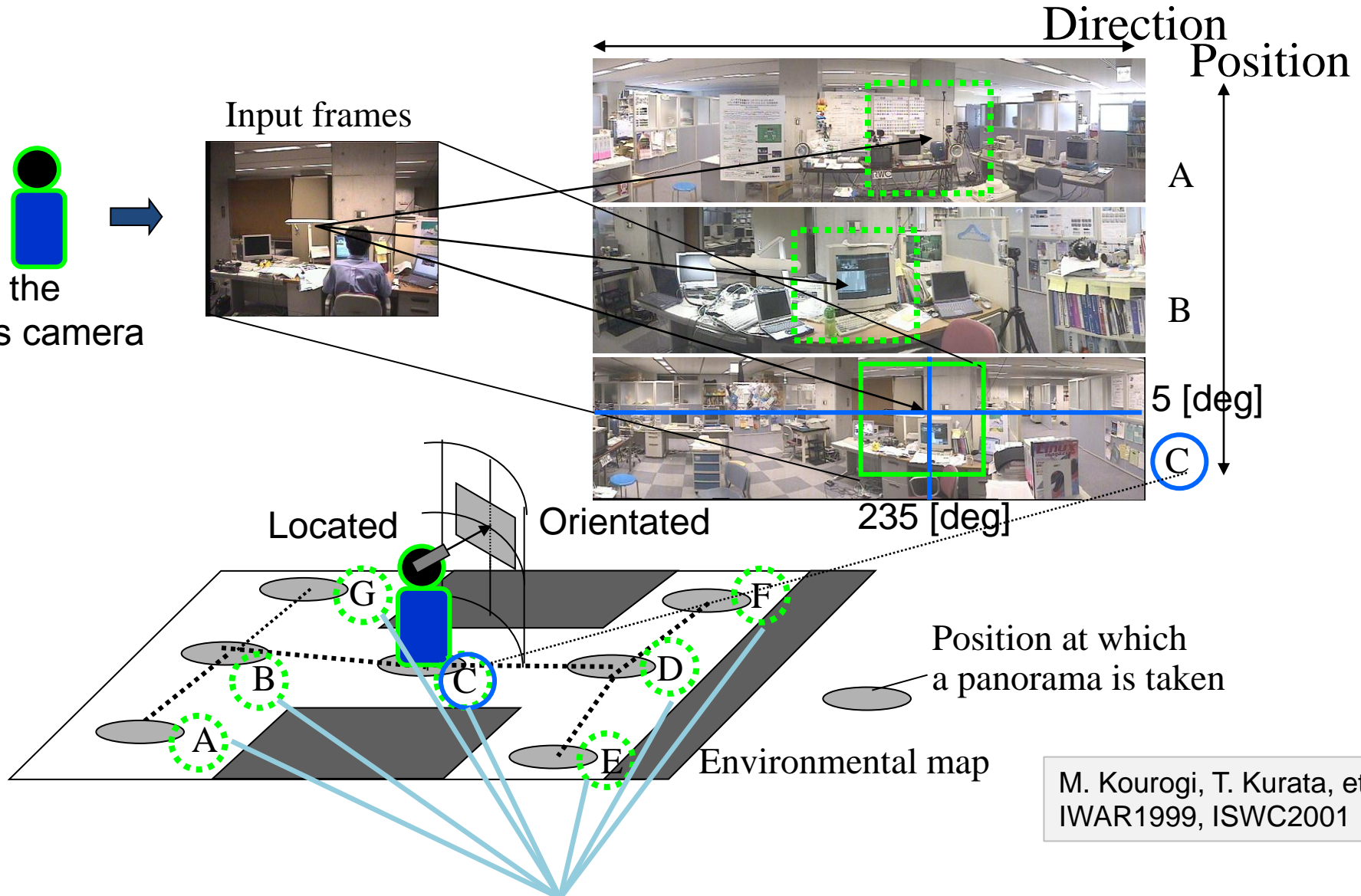
Our goal

Estimation of **photo-shoot location** with mobile-phone camera for
Initialization and Offset



Previous works~ Panorama-Based Annotation

From the
user's camera



Position at which
a panorama is taken

Environmental map

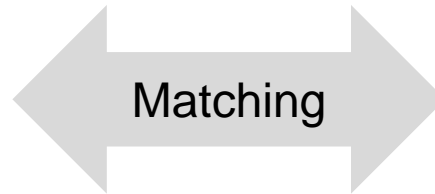
M. Kourogi, T. Kurata, et al.,
IWAR1999, ISWC2001

✓ A lot of panoramic images are needed for wide environments

Panorama-Based to Model Based



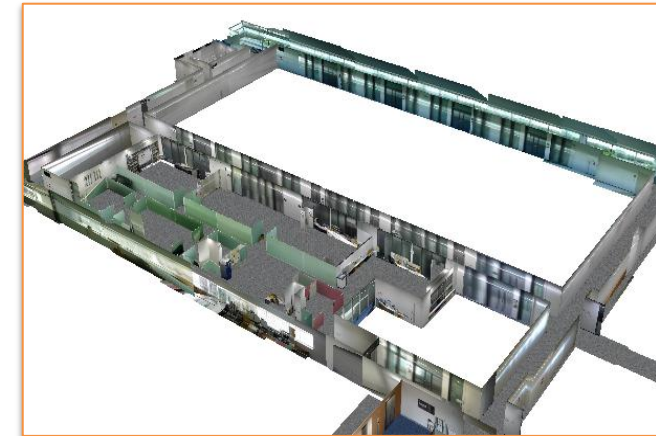
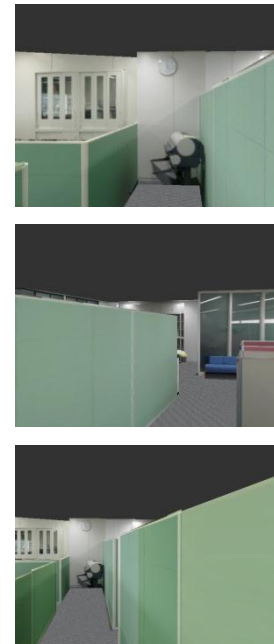
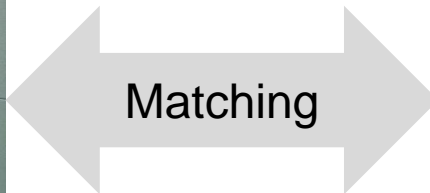
Input image



Panoramic images

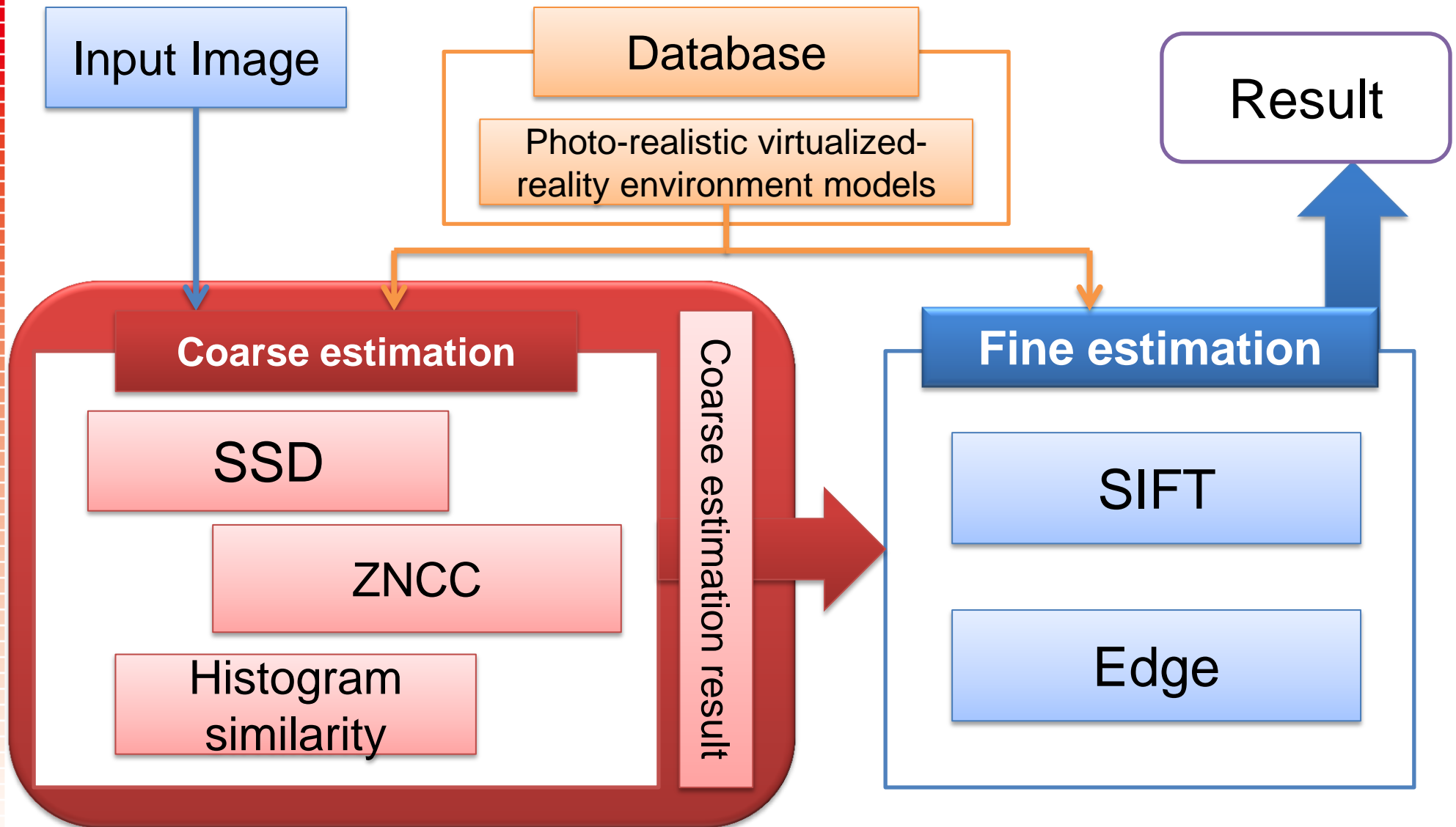


Input image



Virtualized-Reality
Environment Models

Design for coarse to fine localization



Set up for experiments

- Similarities for coarse estimation
 - Histogram similarity in the HSV space (using H and S)
 - Sum of Squared Difference (SSD)
 - Zero-mean Normalized Cross-Correlation (ZNCC)
- Feature for fine estimation
 - Scale-Invariant Feature Transform (SIFT)
- Images for experiments
 - Real images (photos taken with an iPhone)
 - Generated images from a virtualized-reality model

Real images and generated images for experiments

Real images



Generated images

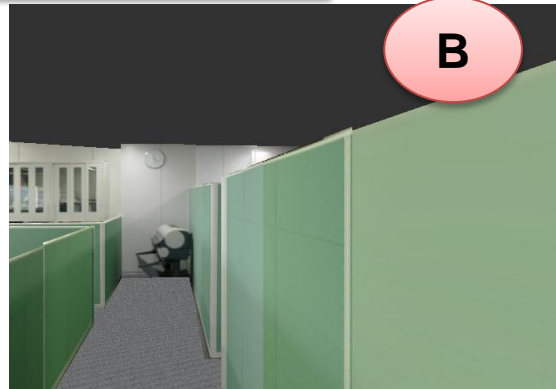
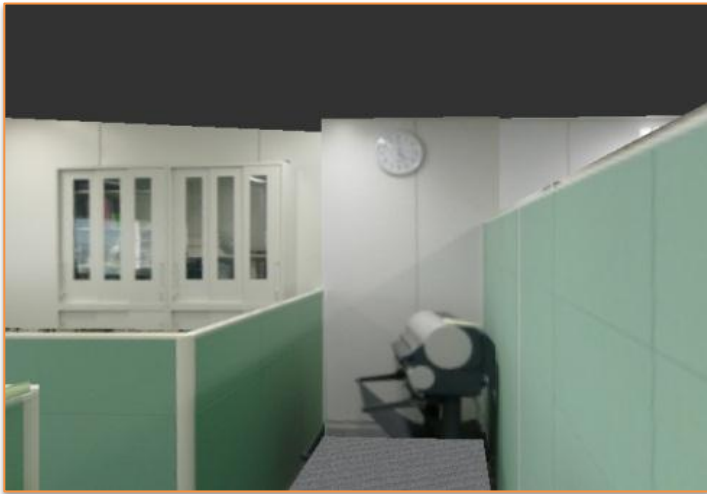
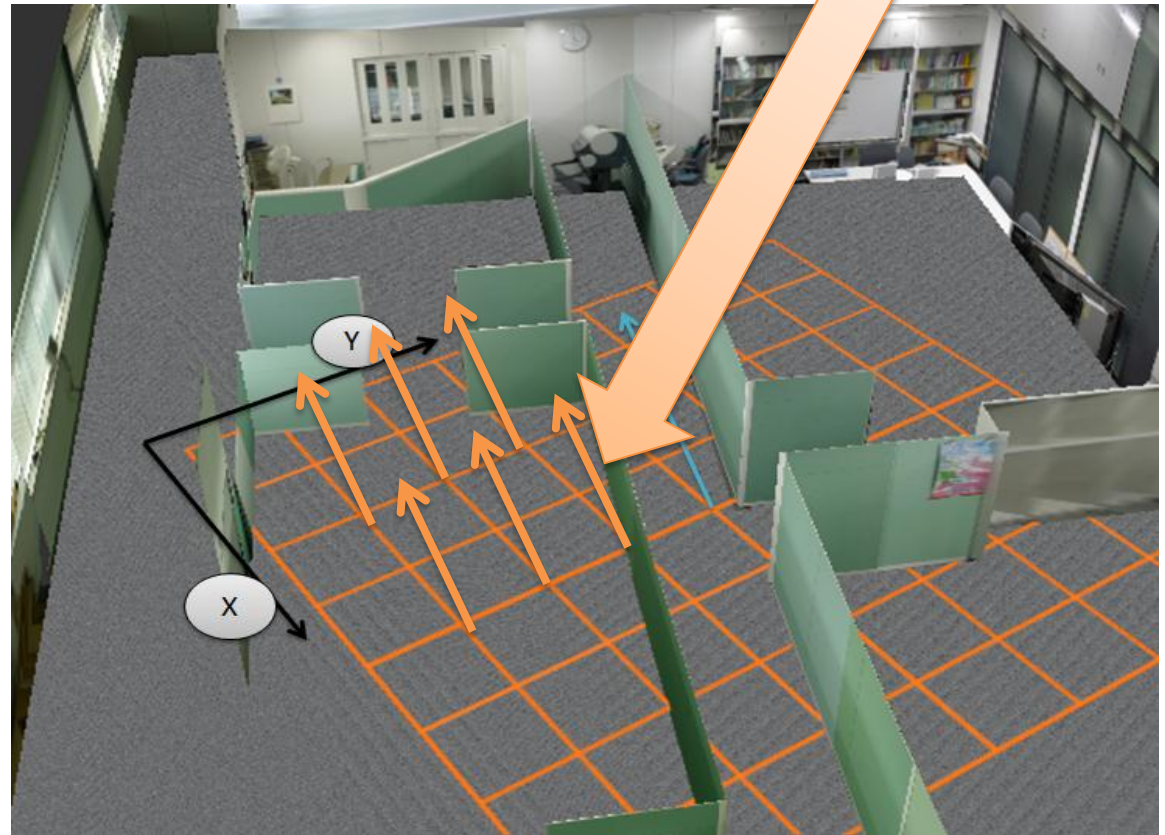


Image generation from a virtualized-reality model

Position and orientation
used for image generation



Generated image from a
virtualized-reality model

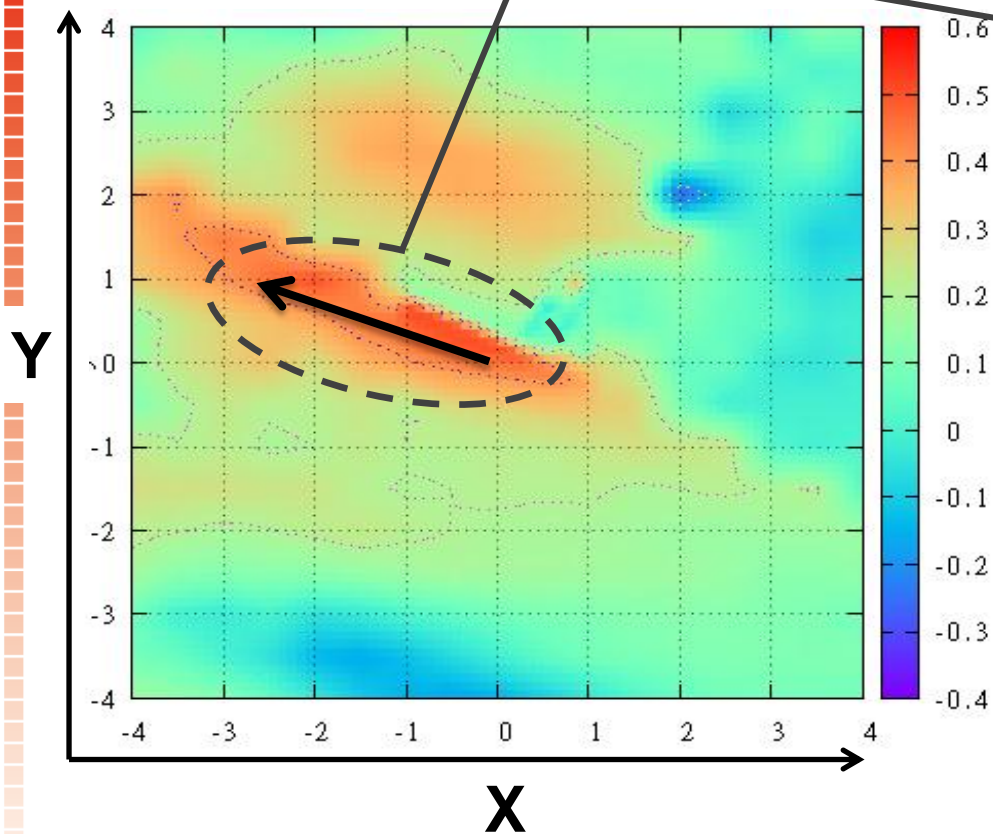


Generated image from a virtualized-reality model (generated by changing camera position)

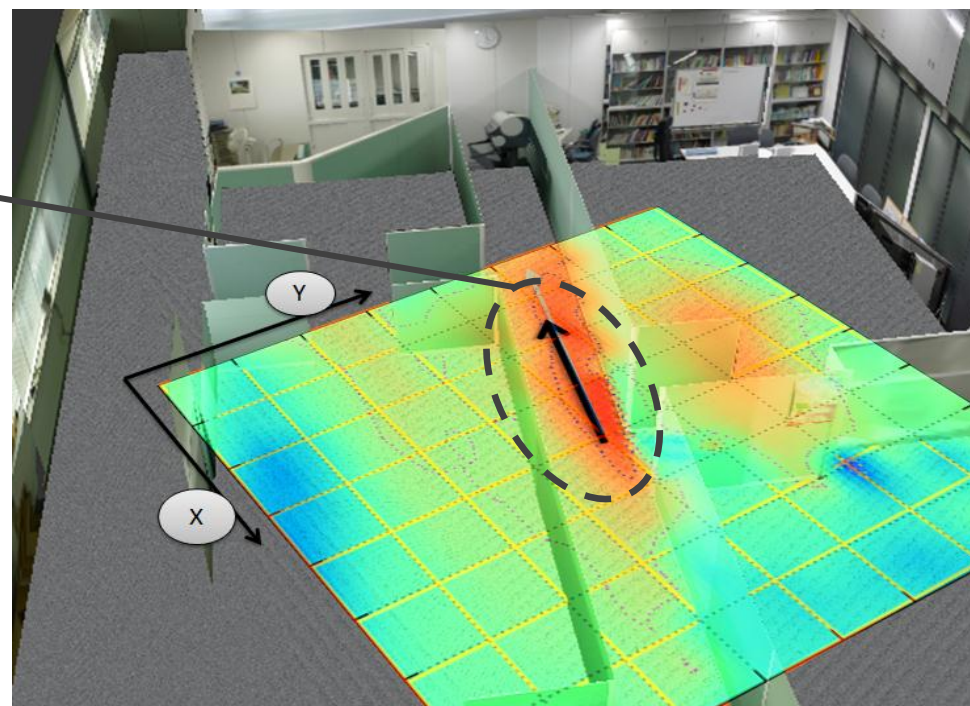


Similarity map

Shooting position and orientation
of a real image



Similarity map (ZNCC)



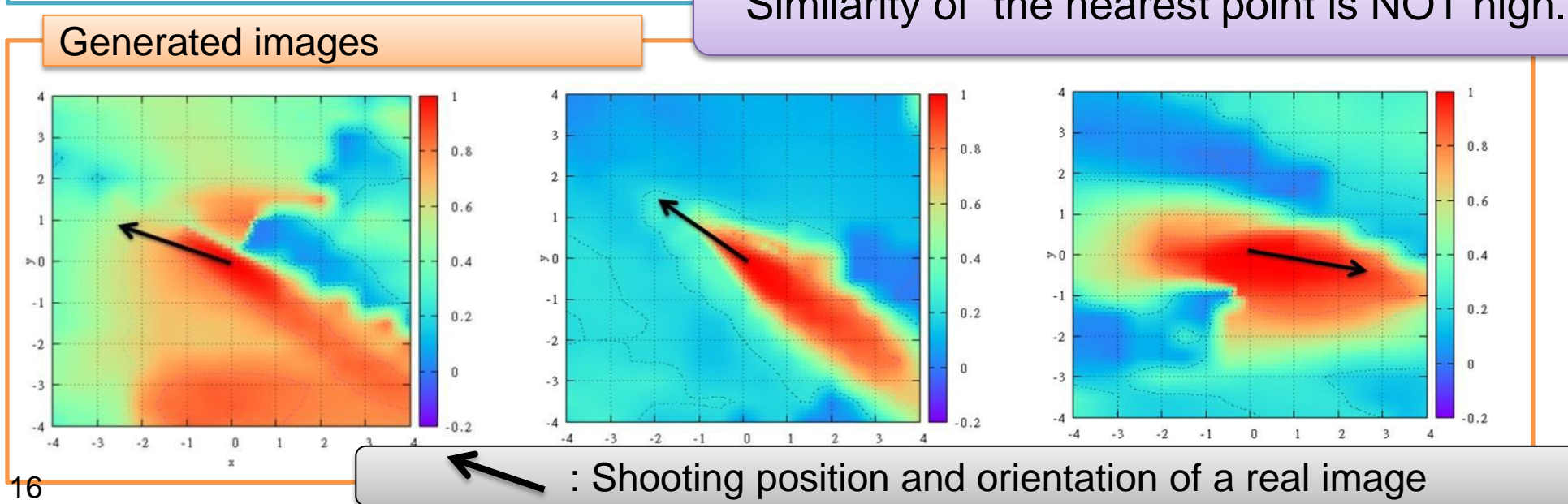
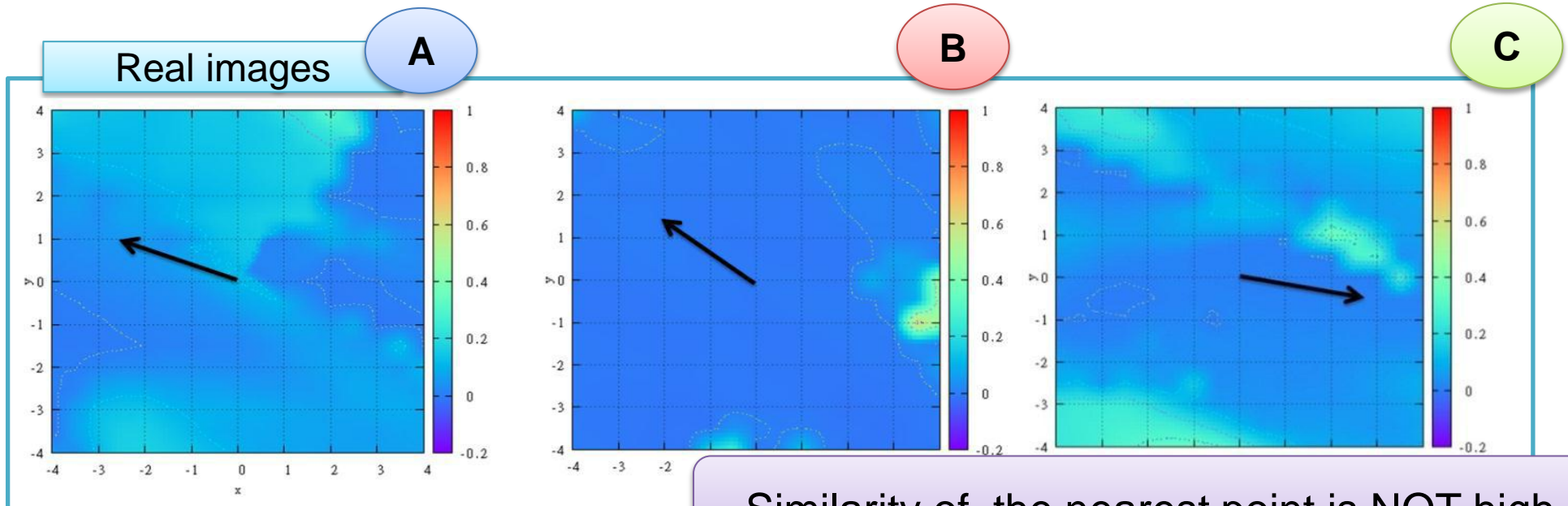
Real image taken with an
i-Phone



Generated image from a
virtualized-reality model

Experimental result :

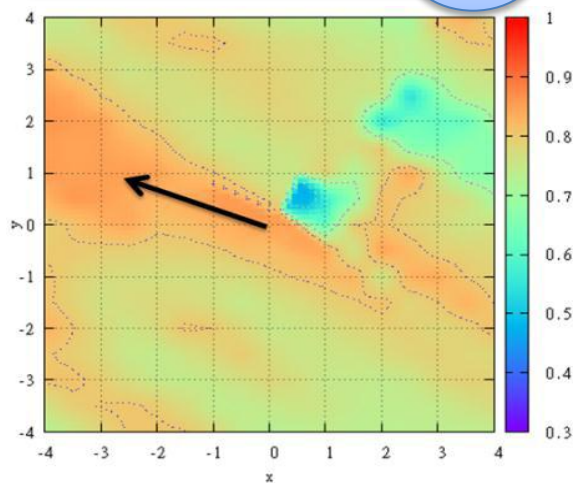
Histogram similarity in the HSV space (using H and S)



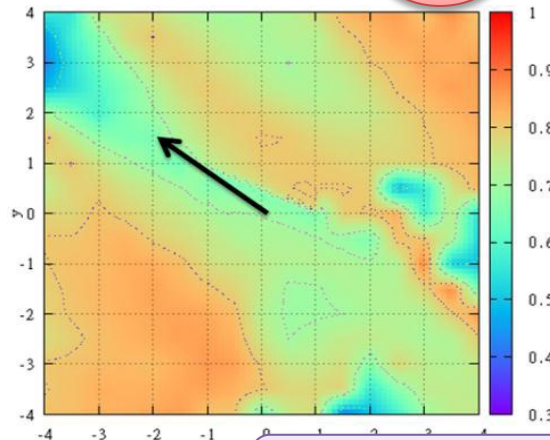
Experimental result : Similarity of Sum of Squared Difference (SSD)

Real images

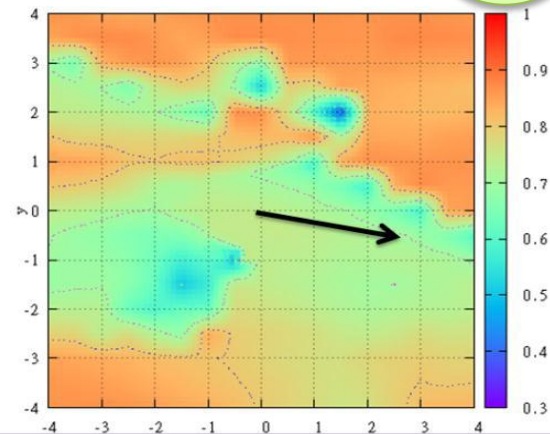
A



B

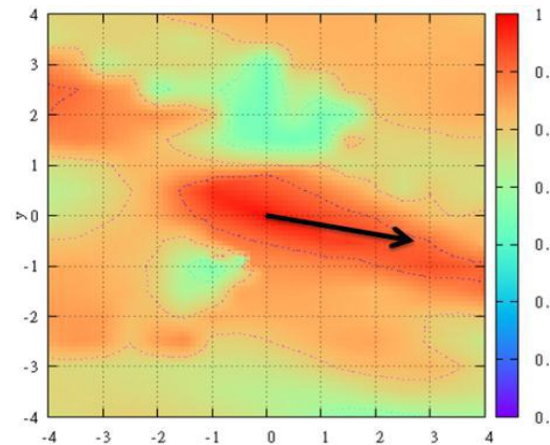
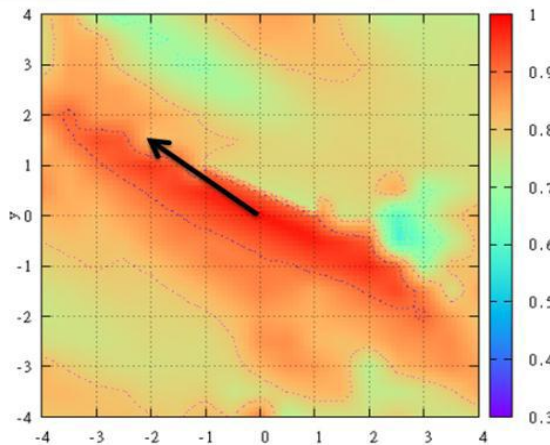
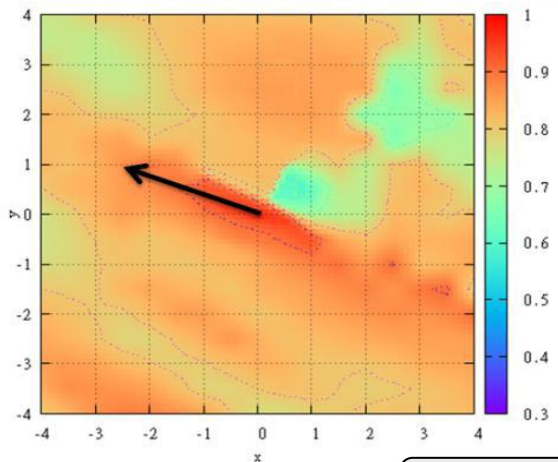


C



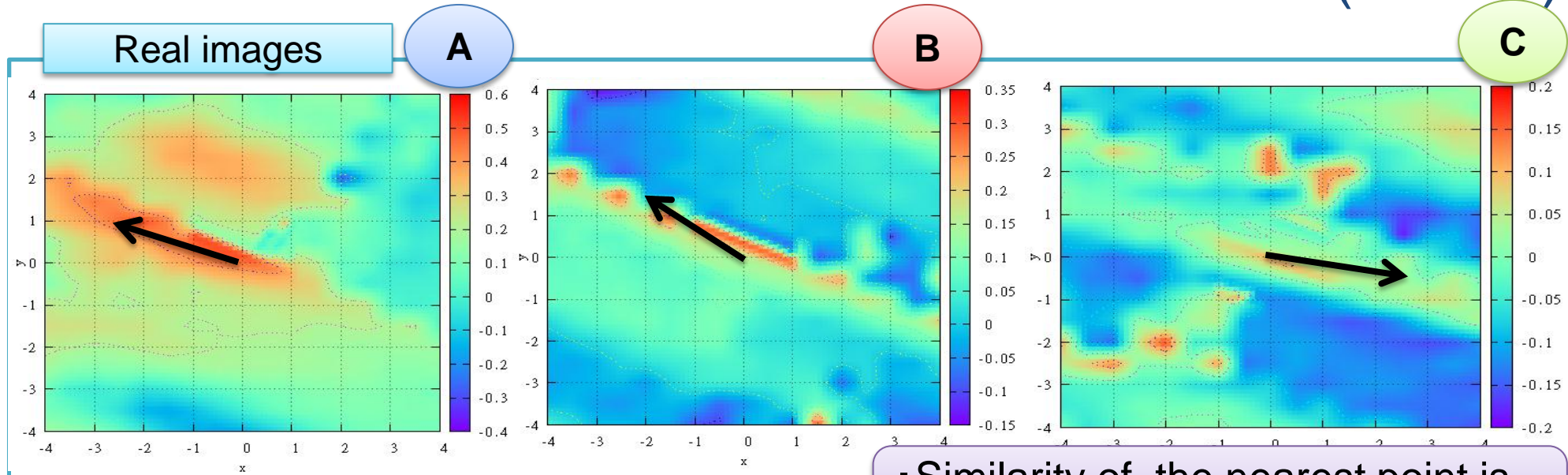
Similarity of the nearest point is low.

Generated images

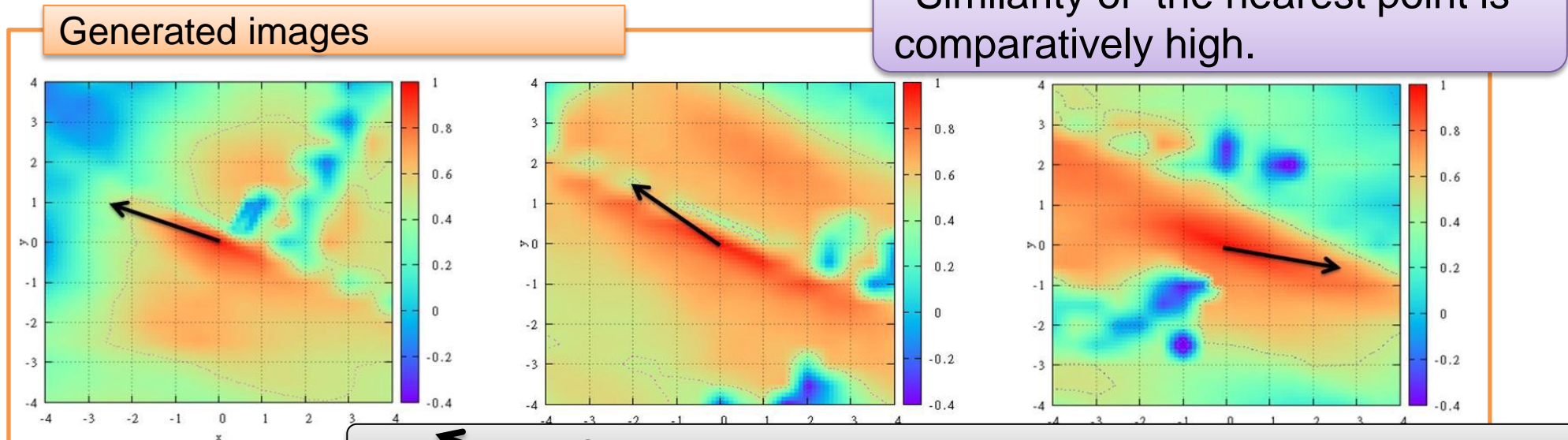


: Shooting position and orientation of a real image

Experimental result : Similarity of Zero-mean Normalized Cross-Correlation (ZNCC)



• Similarity of the nearest point is comparatively high.

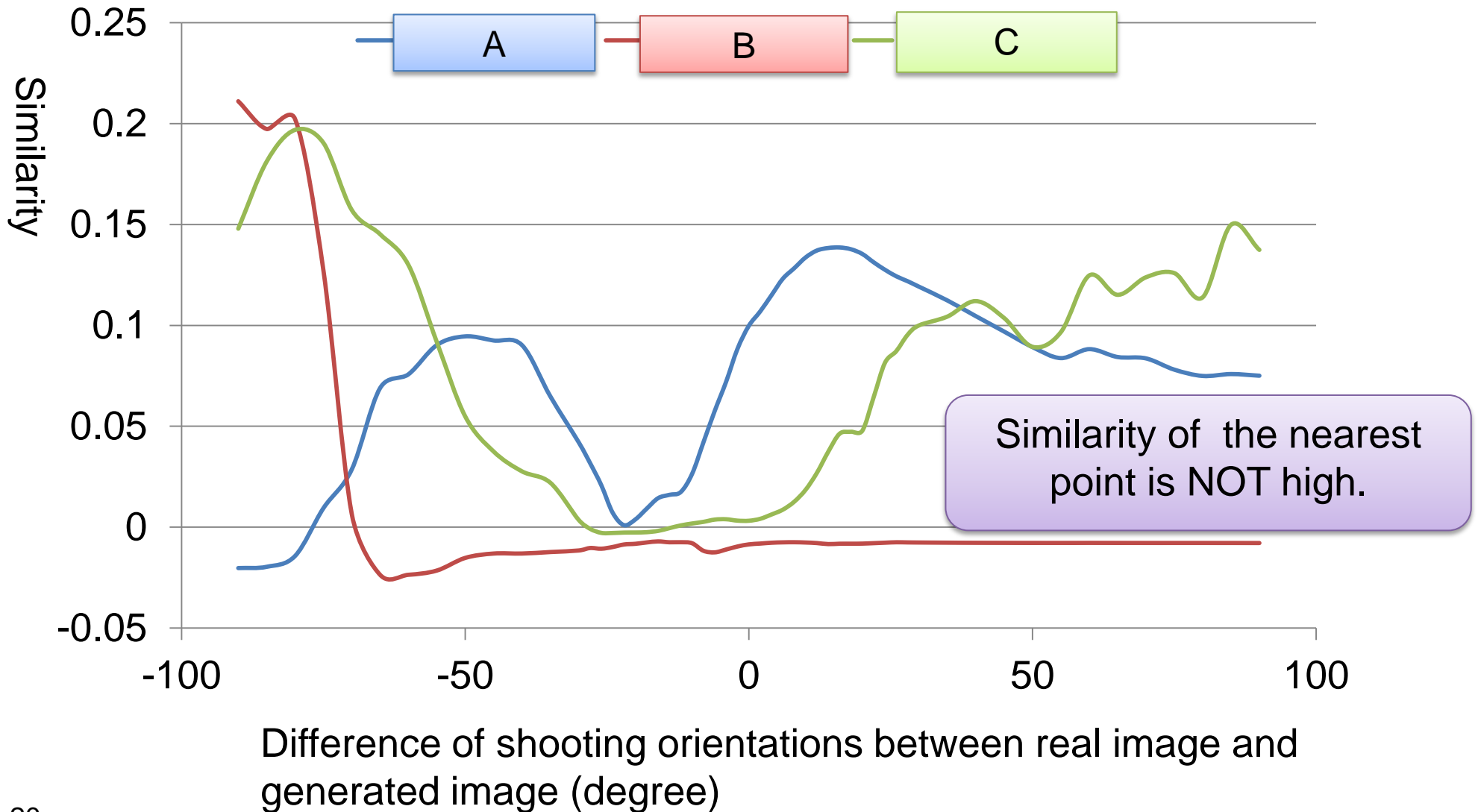


Generated image from a virtualized-reality model (generated by changing camera position)

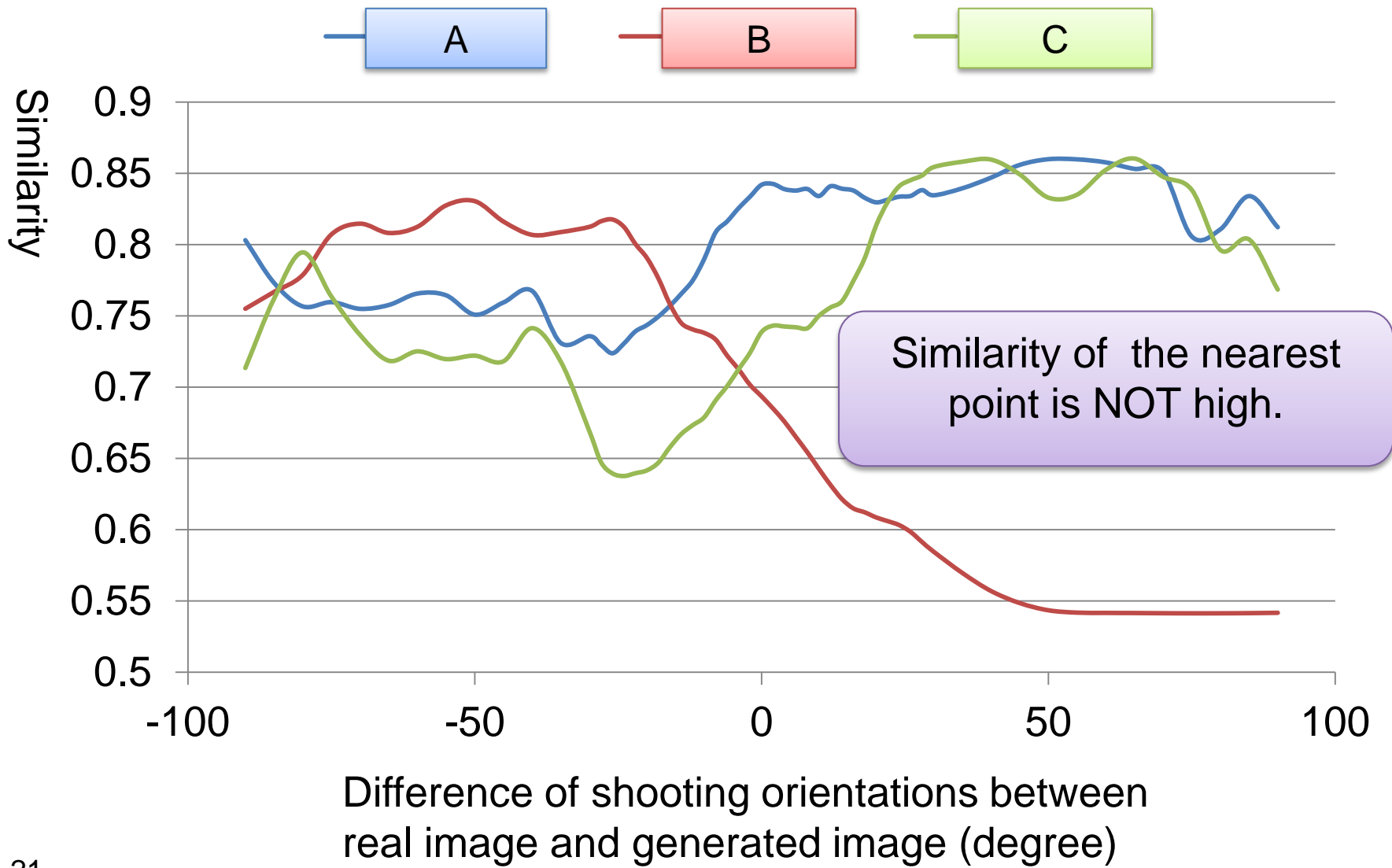


Experimental result :

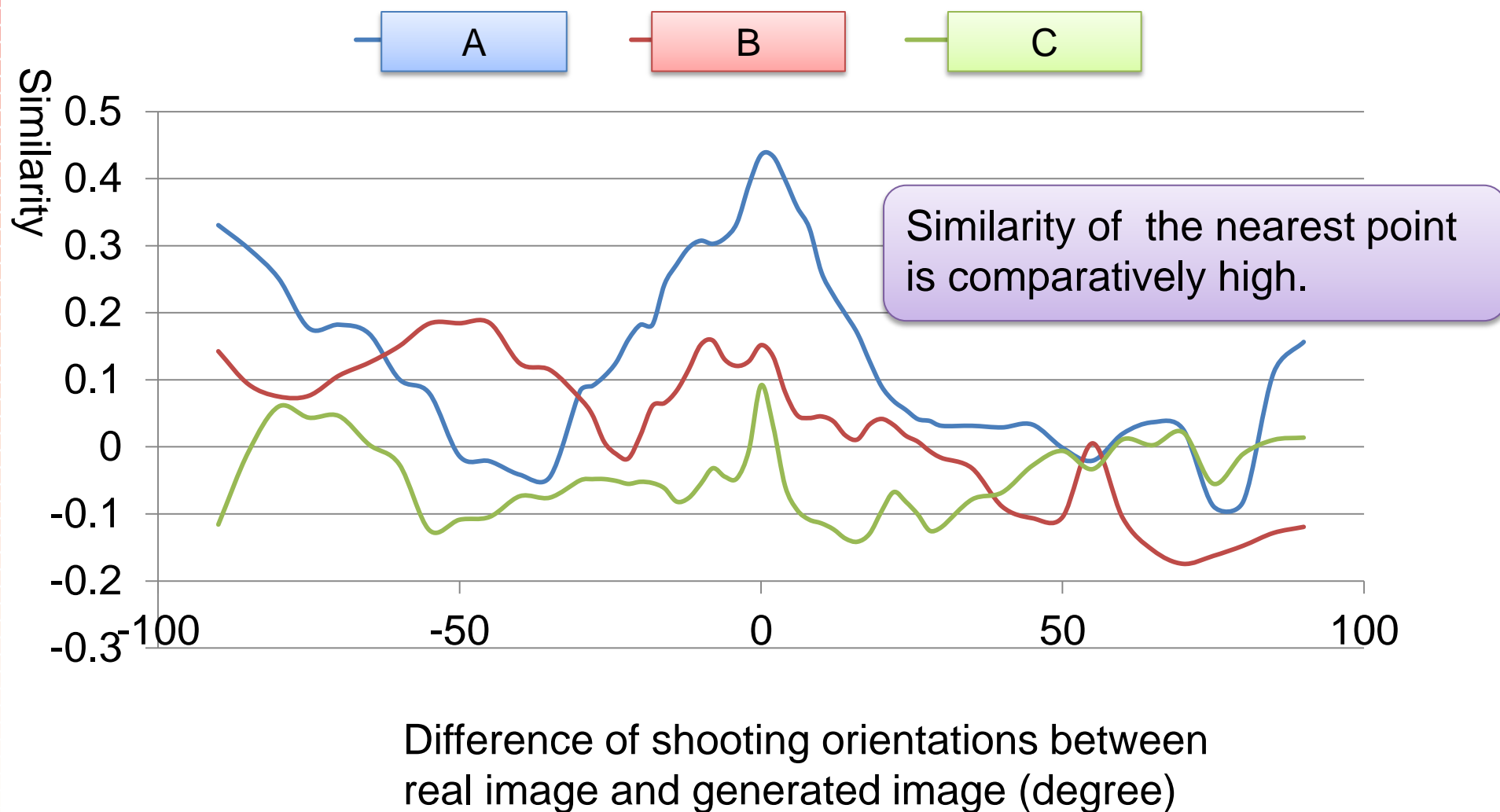
Histogram similarity in the HSV space (using H and S)



Experimental result : Similarity of Sum of Squared Difference (SSD)

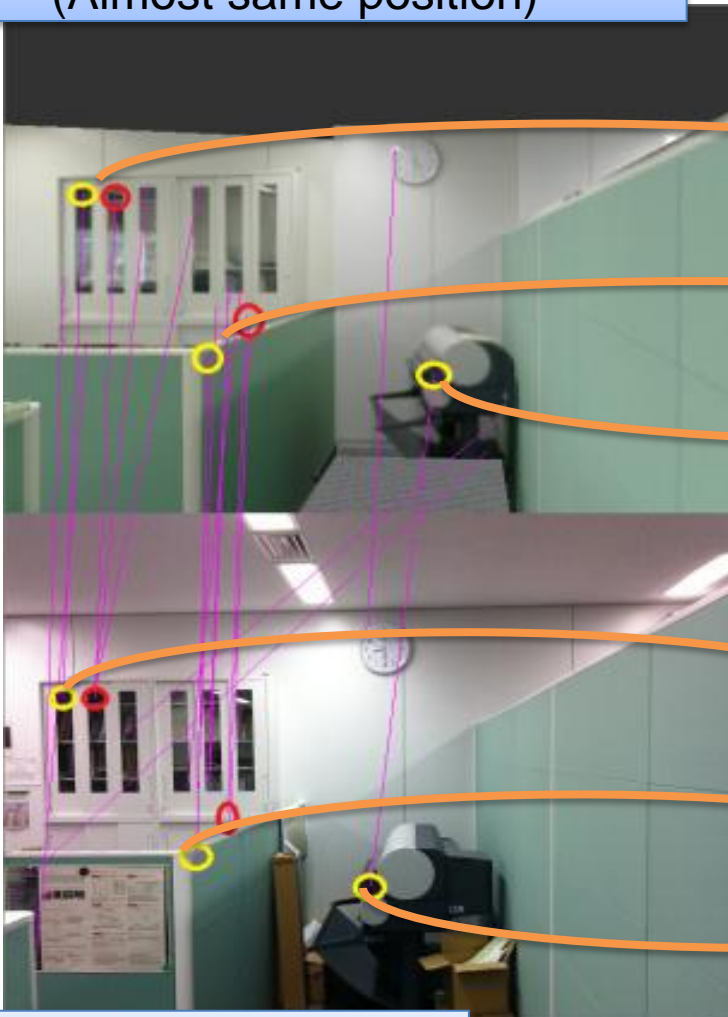


Experimental result : Similarity of Zero-mean Normalized Cross-Correlation (ZNCC)

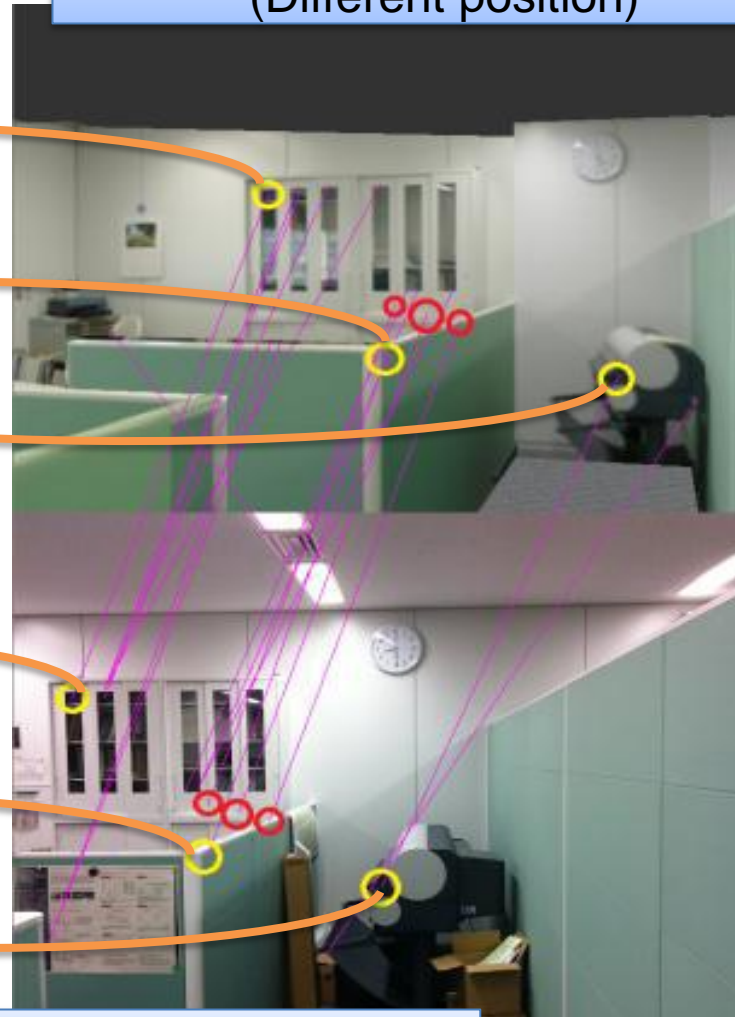


Sample result of SIFT matching

Generated image
(Almost same position)



Generated image
(Different position)



Real image

Real image

Conclusion of coarse estimation

- HSV : NOT Appropriate
 - Similarity of the nearest point is NOT high.
- SSD : NOT Appropriate
 - Similarity of the nearest point is NOT high.
- ZNCC : Appropriate
 - Similarity of the nearest point is local maximal.

Future works

- More Experiments
 - in wide environments
 - with changing position and orientation in same time
- Observational study for fine estimation
 - More study with SIFT
 - Study with edge based method

Appendix 1 :

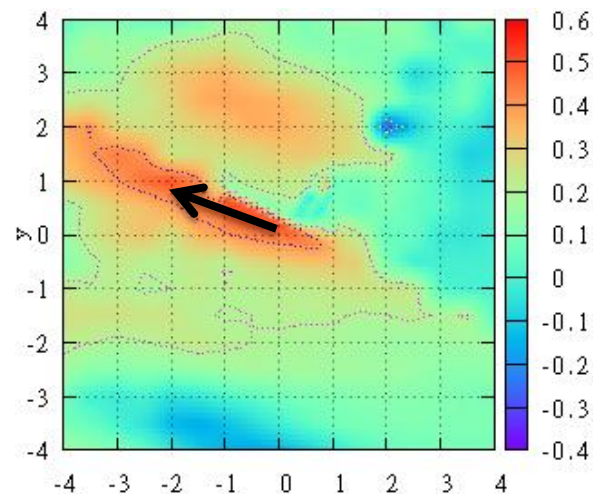
Definitions of similarities

- $SSD = \sum_{j=0}^{N-1} \sum_{i=0}^{M-1} (I_1(i,j) - I_2(i,j))^2$
- $R_{SSD} = 1 - \frac{SSD}{Pix * 255 * 255}$
- $R_{ZNCC} = \frac{\sum_{j=0}^{N-1} \sum_{i=0}^{M-1} ((I_1(i,j) - \bar{I}_1)(I_2(i,j) - \bar{I}_2))}{\sqrt{\sum_{j=0}^{N-1} \sum_{i=0}^{M-1} (I_1(i,j) - \bar{I}_1)^2 * \sum_{j=0}^{N-1} \sum_{i=0}^{M-1} (I_2(i,j) - \bar{I}_2)^2}}$
- $R_{Hist} = \frac{\sum_{j=0}^{32-1} \sum_{i=0}^{30-1} (H_1(i,j) - \bar{H}_1) \sum_{j=0}^{32-1} \sum_{i=0}^{30-1} (H_2(i,j) - \bar{H}_2)}{\sqrt{\sum_{j=0}^{32-1} \sum_{i=0}^{30-1} (H_1(i,j) - \bar{H}_1)^2 \sum_{j=0}^{32-1} \sum_{i=0}^{30-1} (H_2(i,j) - \bar{H}_2)^2}}$

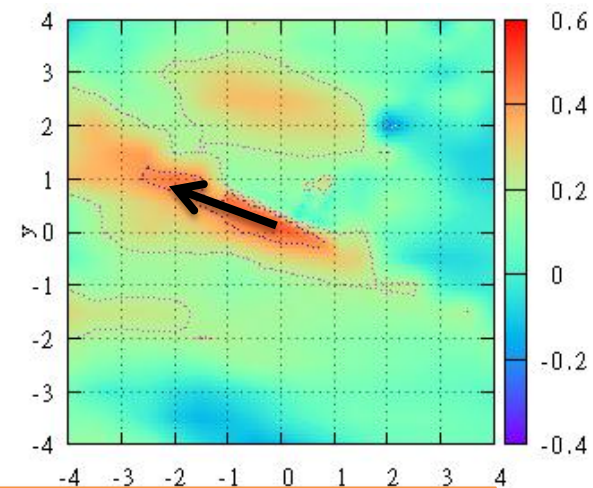
Appendix 2 :

Similarity maps of ZNCC before and after the earthquake

A



Before

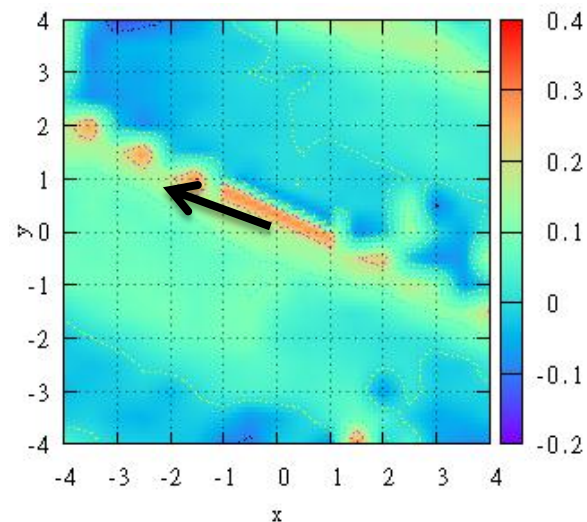
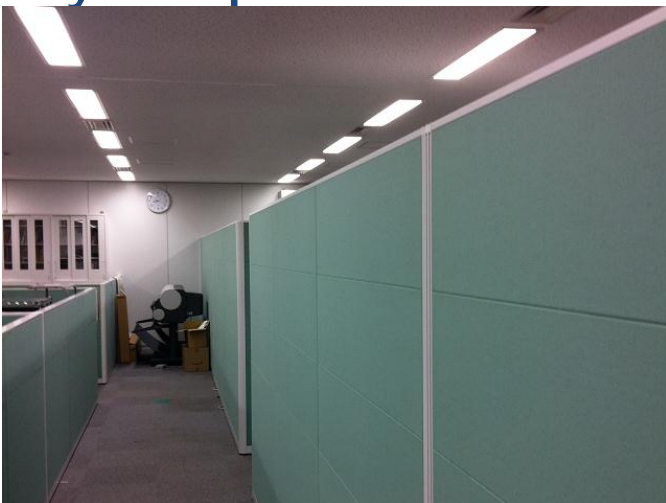


After

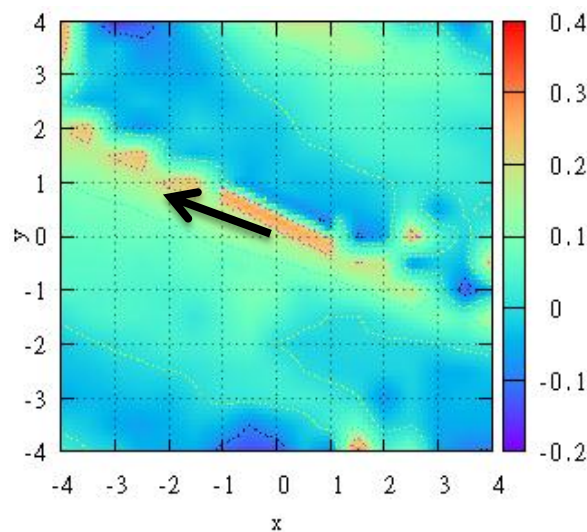
Appendix 2 :

Similarity maps of ZNCC before and after the earthquake

B



Before



After

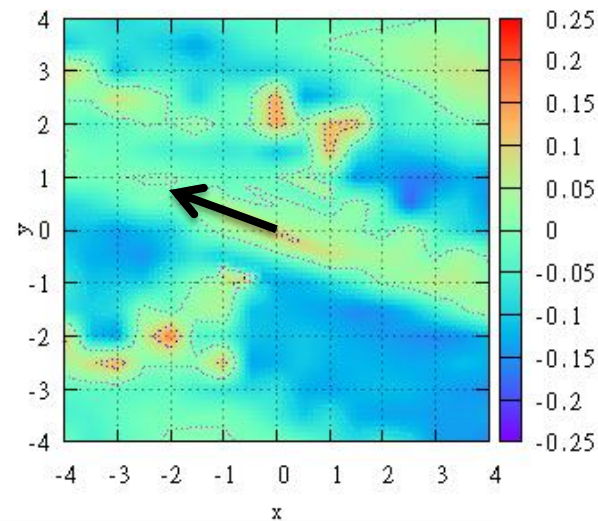
Appendix 2 :

Similarity maps of ZNCC before and after the earthquake

C



Before



After

