Cost Volume Refinement Filter for Post Filtering of Visual Corresponding

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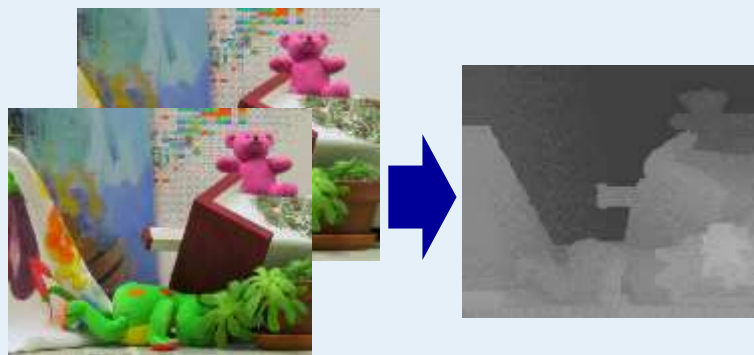Nagoya Institute of Technology

Feb. 8-12, 2015   IS&T/SPIE Electronic Imaging,

Overview

- Background

- Cost Volume Refinement Filter

- Experimental Environment

- Experimental Results

- Conclusion and Future Work
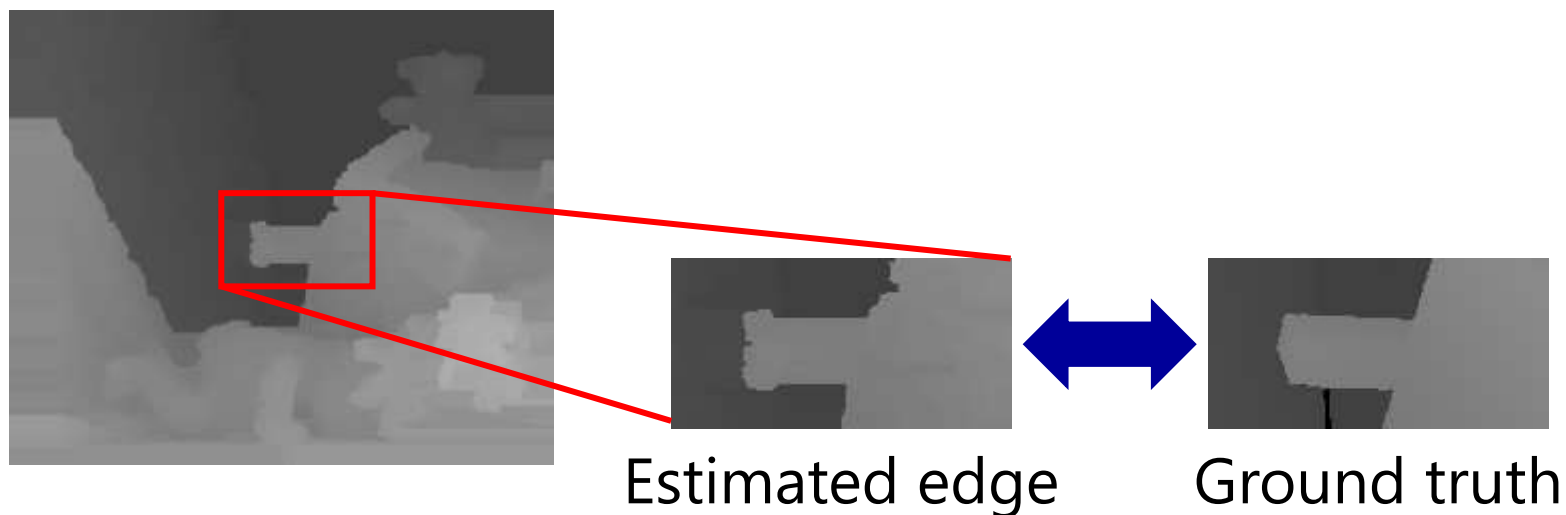
Background

Labeling problems

Depth map

Optical flow

Segmented image

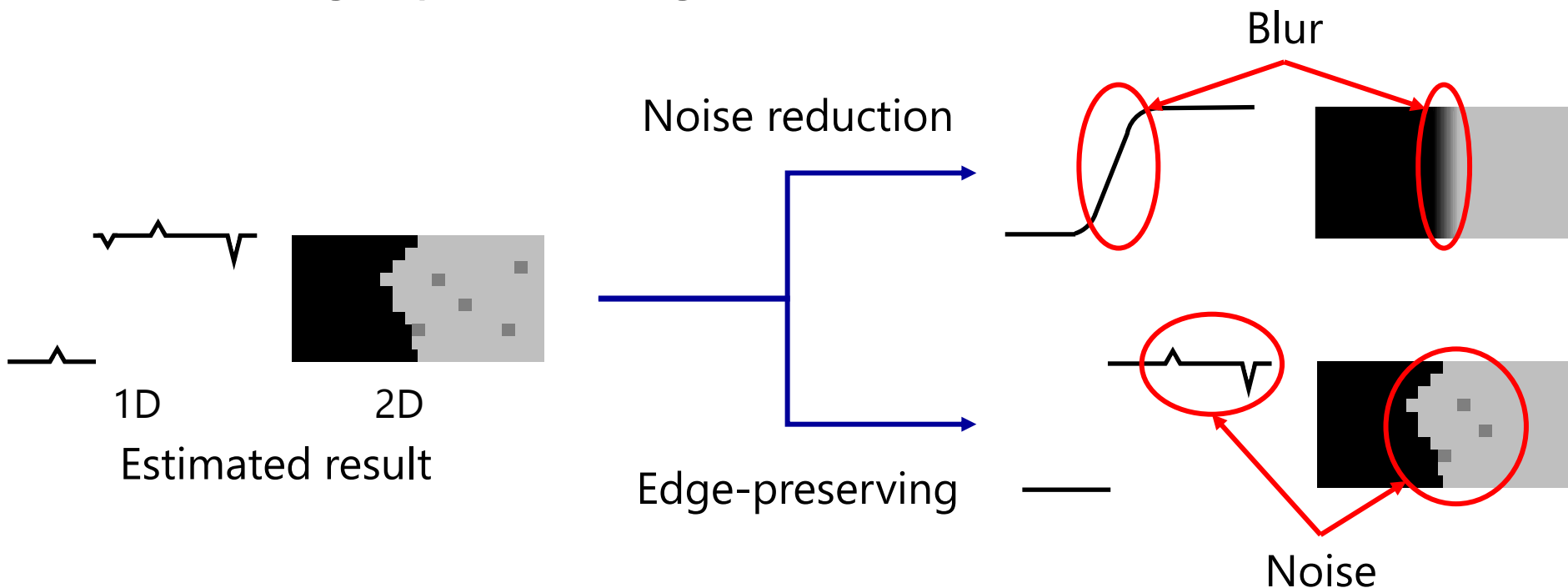# Background

Estimated edge

Ground truth

Noises are included

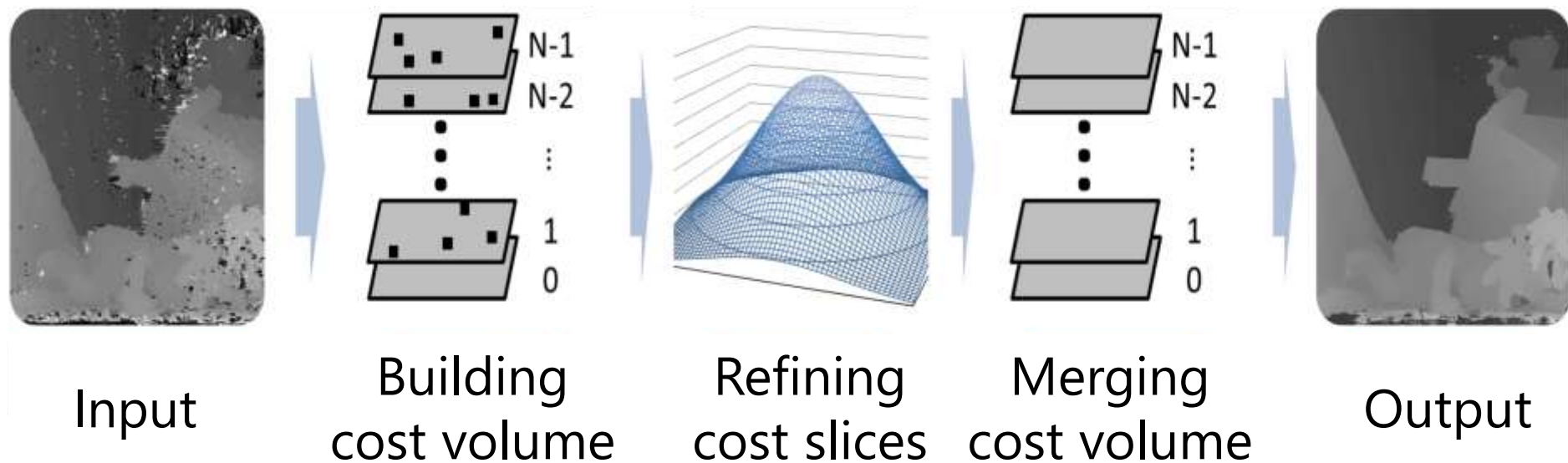Refinement method can improve edges and reduce noises.

Background

- Refinement by edge-preserving filtering
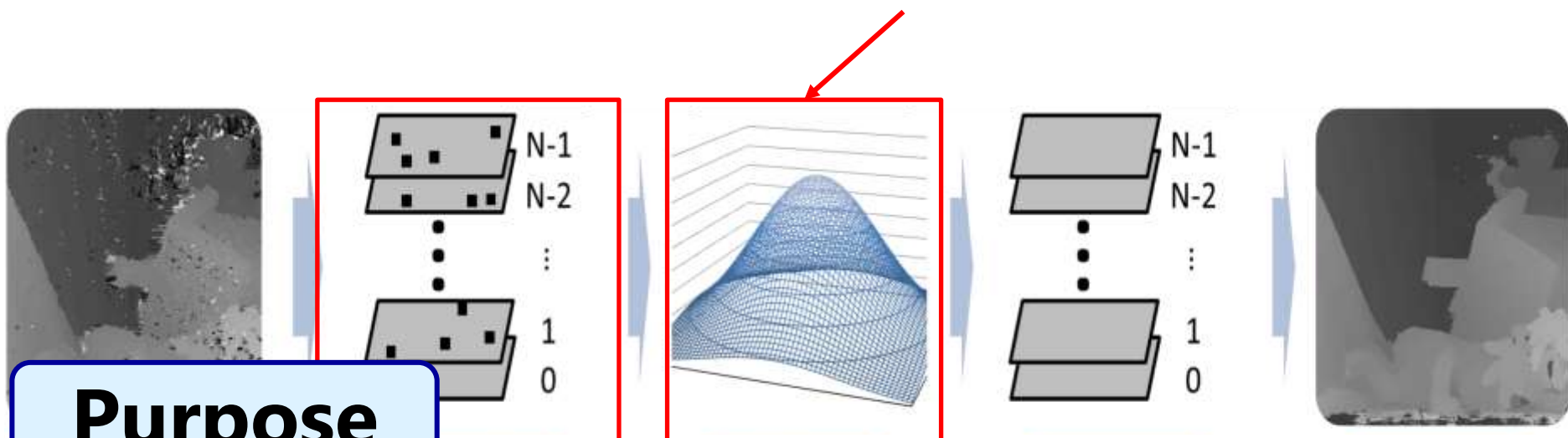 - Trade-off between smoothing effect and edge-preserving effect

Background

One of the effective solutions

Input   Building cost volume   Refining cost slices   Merging cost volume   Output

Cost volume refinement filtering

Background

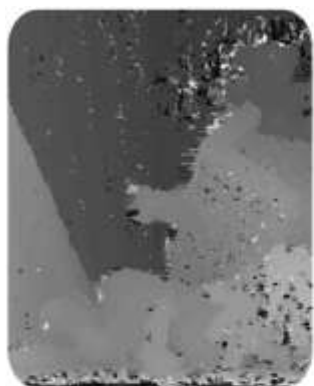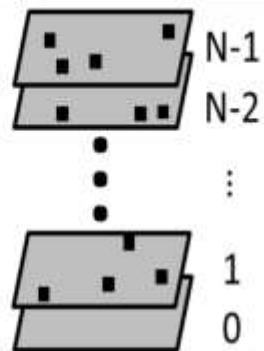## What is the best refinement method?

Purpose

Evaluation and generalization of cost volume refinement filtering

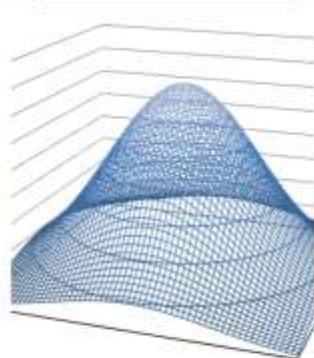# Cost Volume Refinement Filter

- Building cost volume
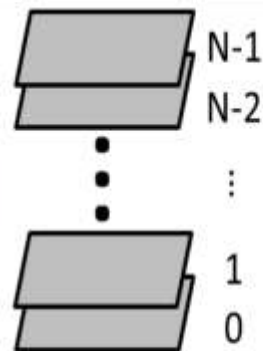- Refining cost slices
- Merging cost volume

Input   Building cost volume   Refining cost slices   Merging cost volume   Output

Cost Volume Refinement Filter

- Building cost volume
- Refining cost slices
- Merging cost volume
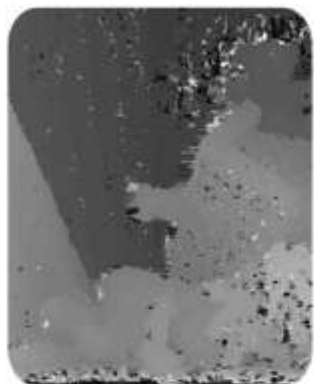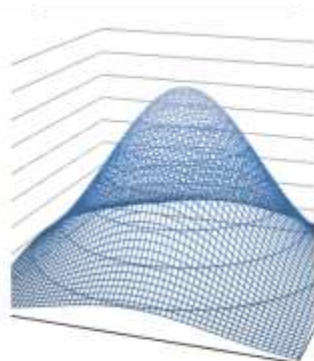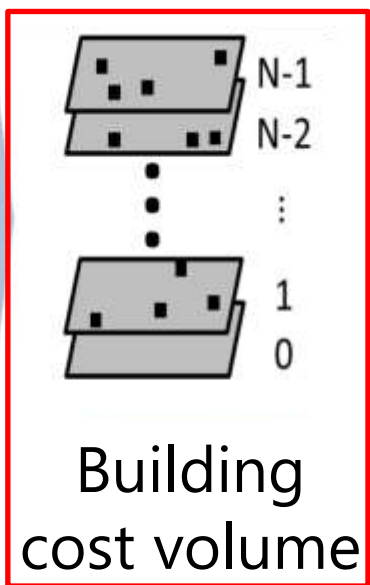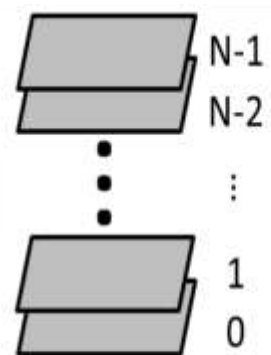

Input | Building cost volume | Refining cost slices | Merging cost volume | Output

Building Cost Volume

$$\text{Cost} = L_x \left(\text{Slice's label} - \text{Estimated label} \right)$$

Depth map

Label 0

Label 1

Label 2

Label 5

Cost slice

Building Cost Volume

Cost $= \boxed{L_x} ($ Slice's label $-$ Estimated label $)$

Examples of cost function

L_{L1}
(L1 norm function)

L_{L2}
(L2 norm function)

L_{exp}
(exp function)

Cost Volume Refinement Filter

- Building cost volume
- Refining cost slices
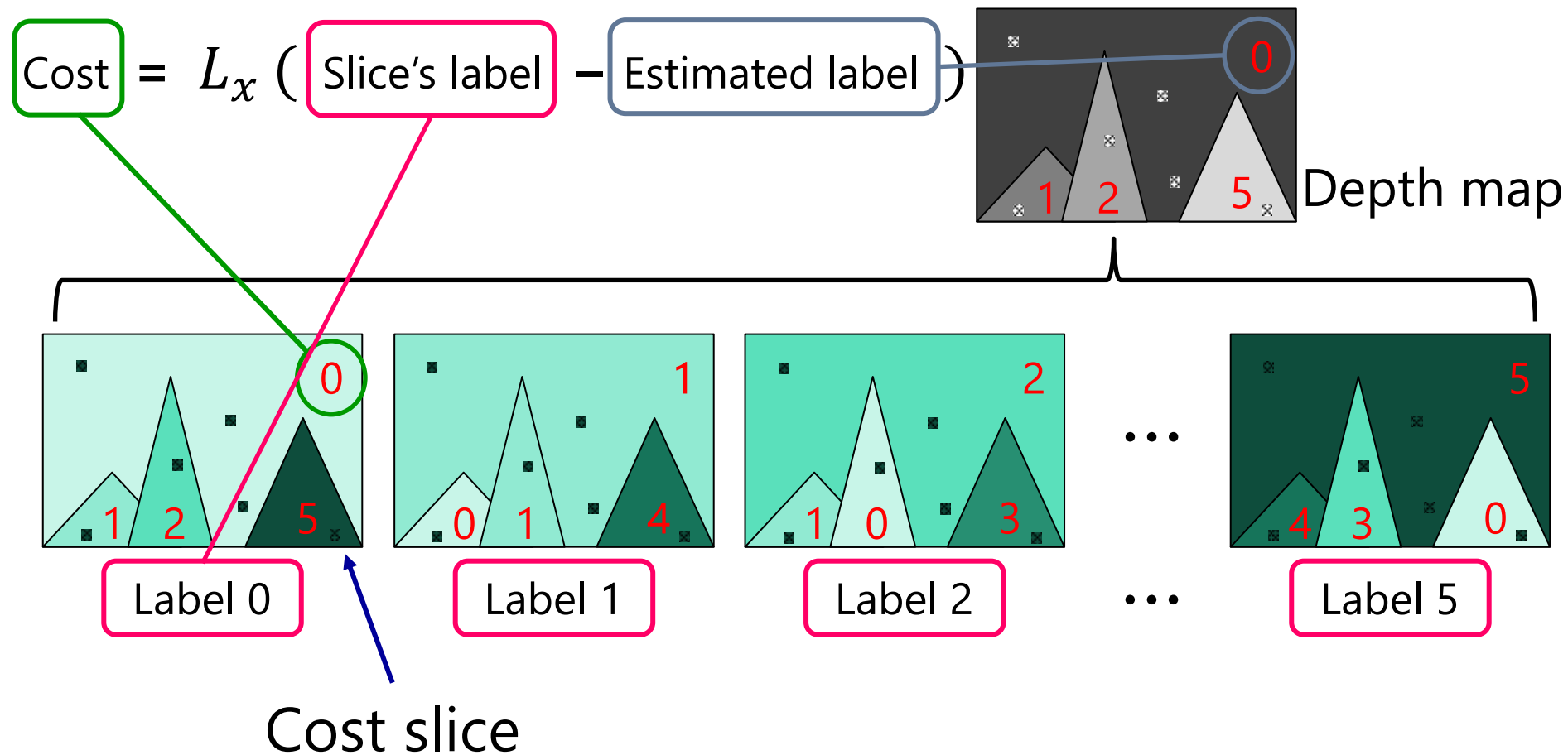- Merging cost volume

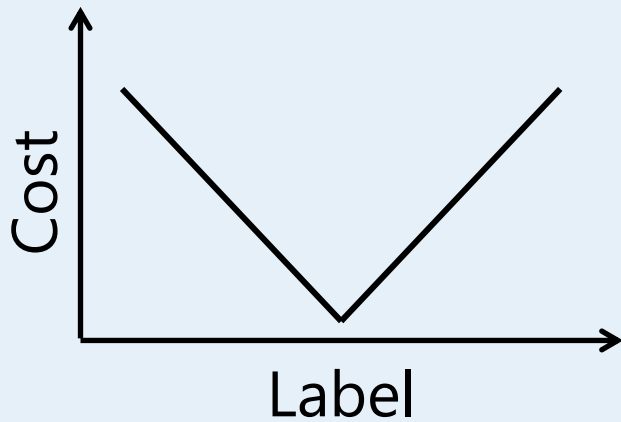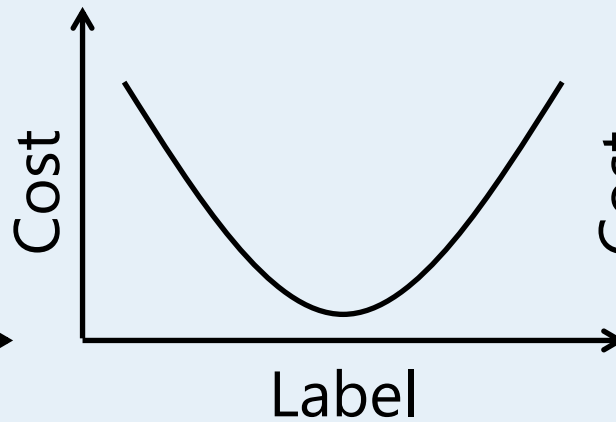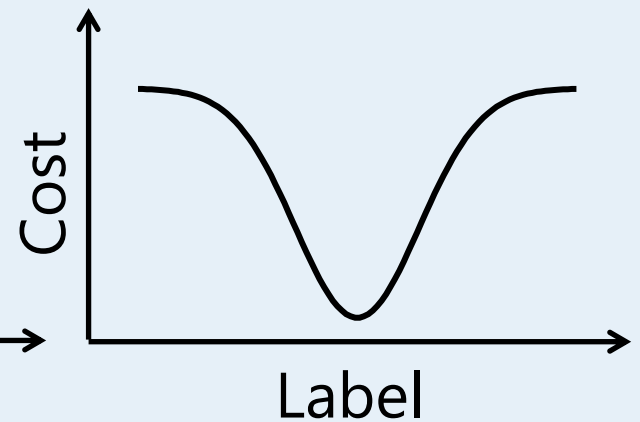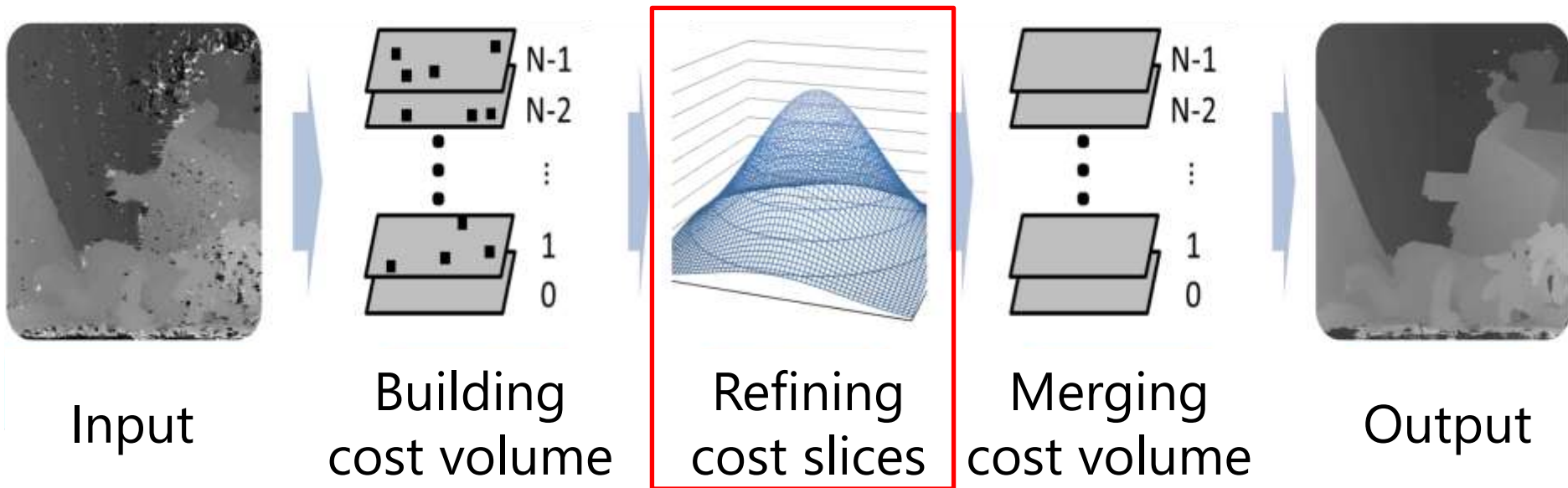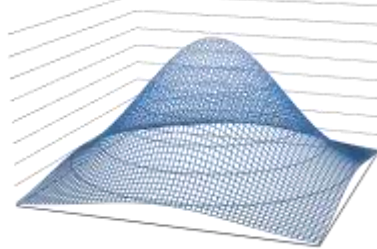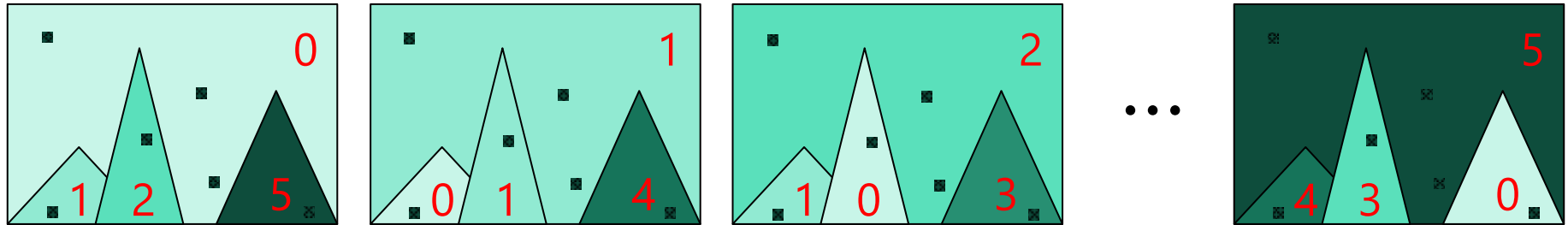Input   Building cost volume   Refining cost slices   Merging cost volume   Output

[1] Petschnigg, G., *et al.*, *ACM TOG 2004.*
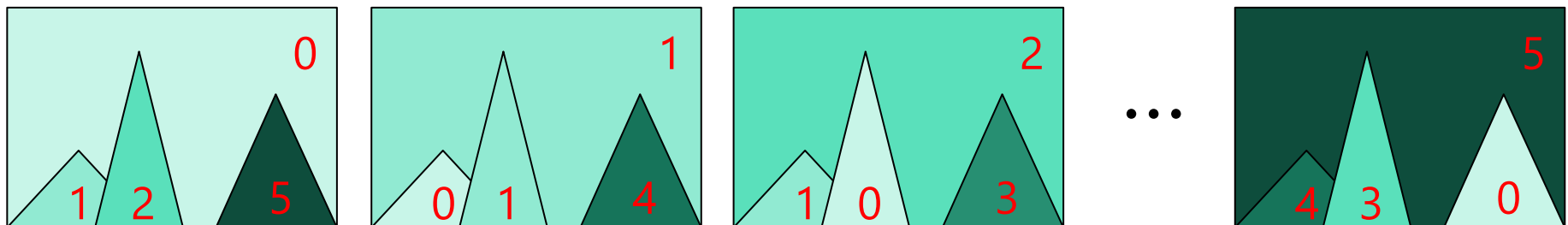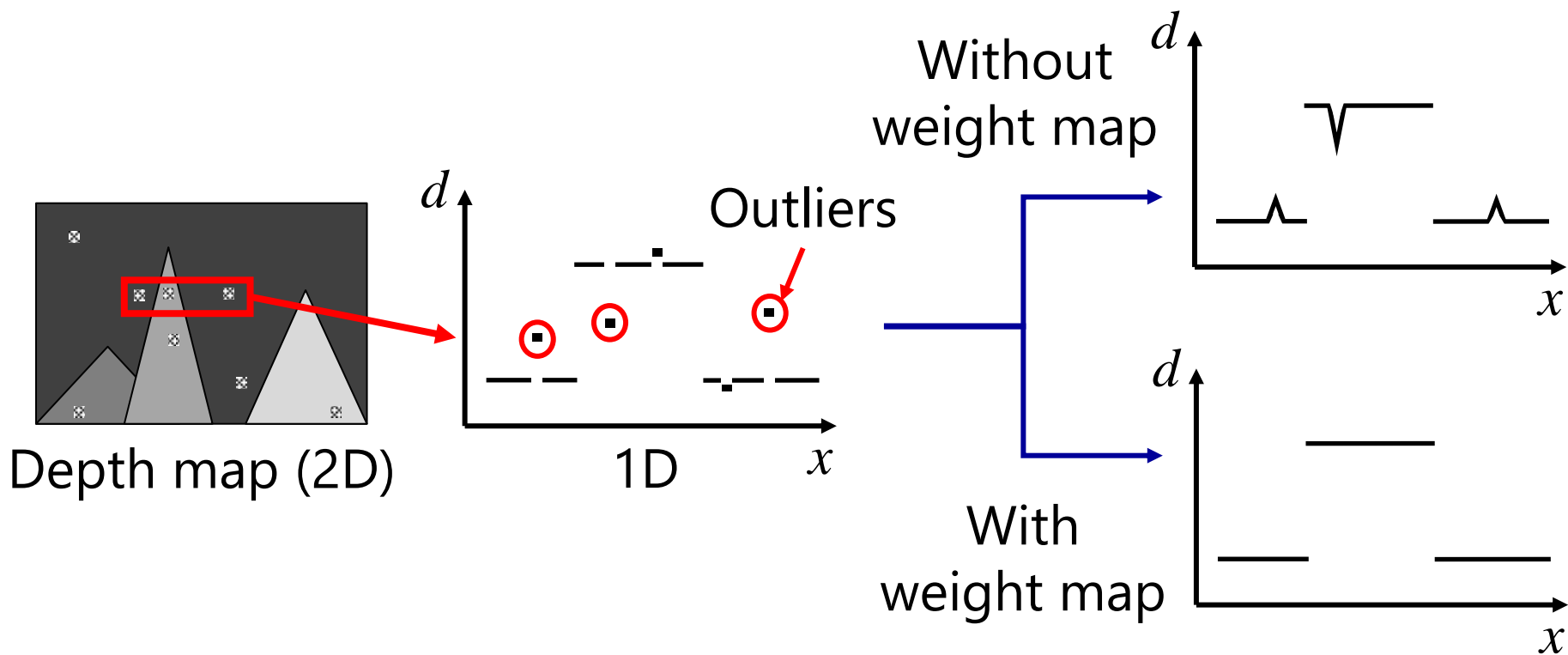[2] He, K., *et al.*, *ECCV 2010.*

Refining Cost Slices

Examples of filtering method:
- Gaussian filtering
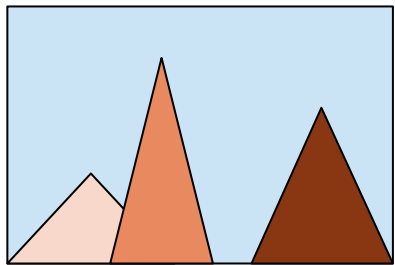- Joint bilateral filtering [1]
- Guided filtering [2]
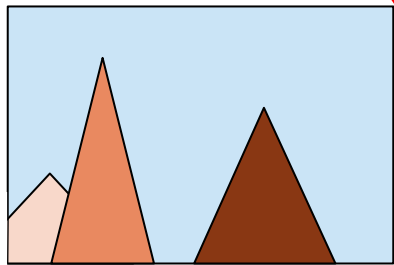
Refining Cost Slices

- Refinement with weight map

Depth map (2D)

1D

Outliers

Without weight map

With weight map

[3] Matsuo, T., *et al.*, *VISAPP 2013.*
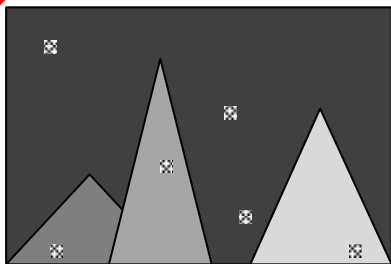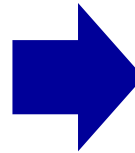
Refining Cost Slices

- Refinement with weight map

Left image

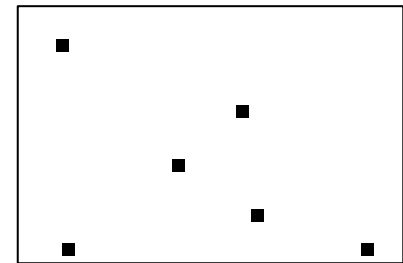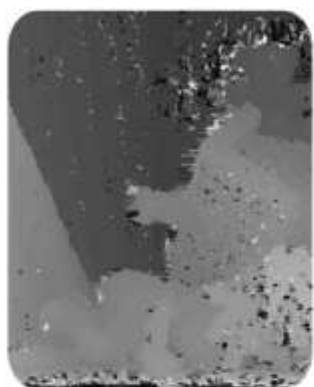Right image

Depth map
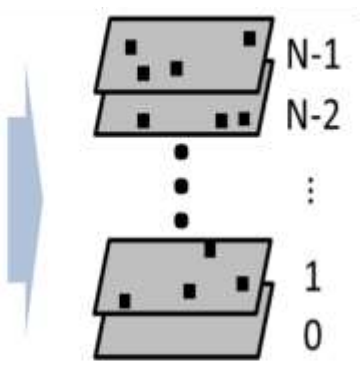
Trilateral weight map [3]

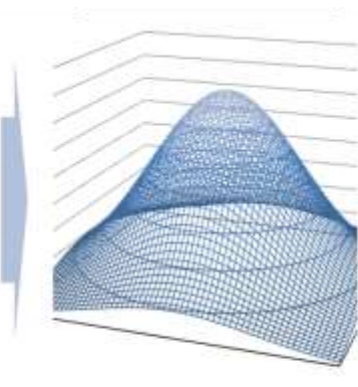LR consistency map

Speckle map

Cost Volume Refinement Filter

- Building cost volume
- Refining cost slices
- Merging cost volume

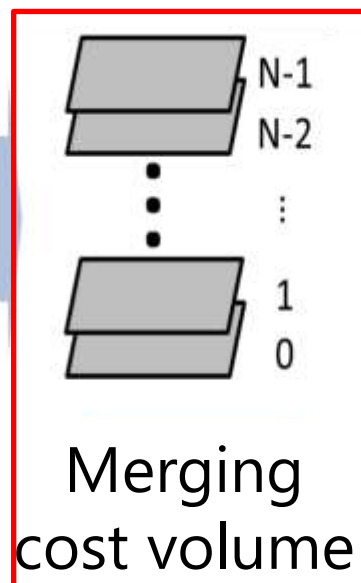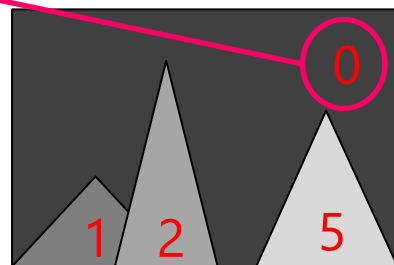Input   Building   Refining   Merging   Output
           cost volume   cost slices   cost volume

Merging Cost Volume

Experimental Environment

Refining method	→	Building method	→	Various input

Ex. 1: Filtering method
Ex. 2: Weight map

Ex. 3: Cost function

Ex. 4: Dynamic range
Ex. 5: Image resolution
Ex. 6: Depth registration
Ex. 7: Multiple dimension

- Input (depth map)
  - Dataset: Tsukuba, Venus, Teddy and Cones
  - Estimation method: Block Matching (BM) and
    Semi-Global Matching (SGM)

- Evaluation method
  - Average error rate of 4 datasets (non-occluded region)

Experimental Environment

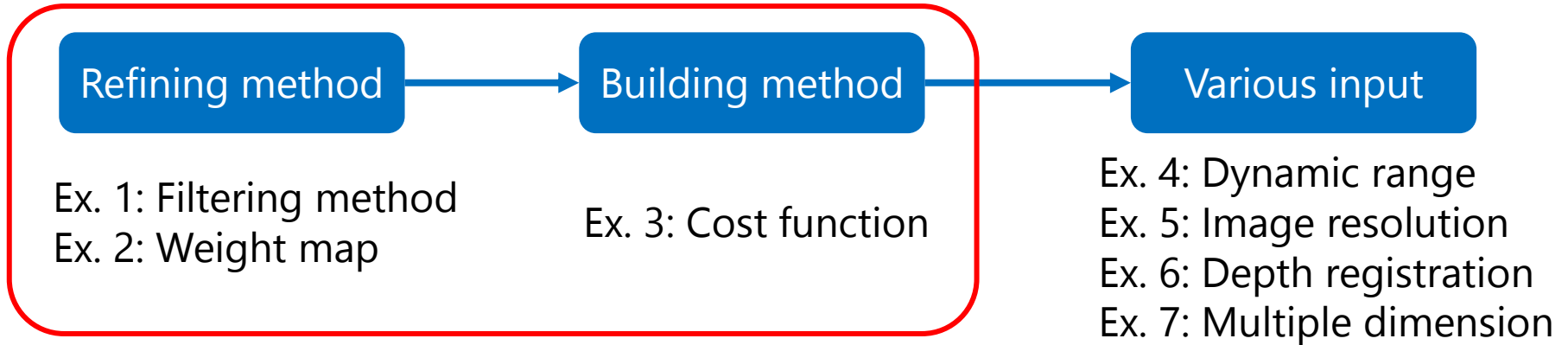| Refining method	→	Building method	→	Various input

Ex. 1: Filtering method
Ex. 2: Weight map

Ex. 3: Cost function

Ex. 4: Dynamic range
Ex. 5: Image resolution
Ex. 6: Depth registration
Ex. 7: Multiple dimension

- Ex. 1
  - Gaussian filter (GaF), Guided filter (GuF) and
    Joint bilateral filter (JBF)
- Ex. 2
  - With/Without weight map (trilateral weight map)
- Ex. 3
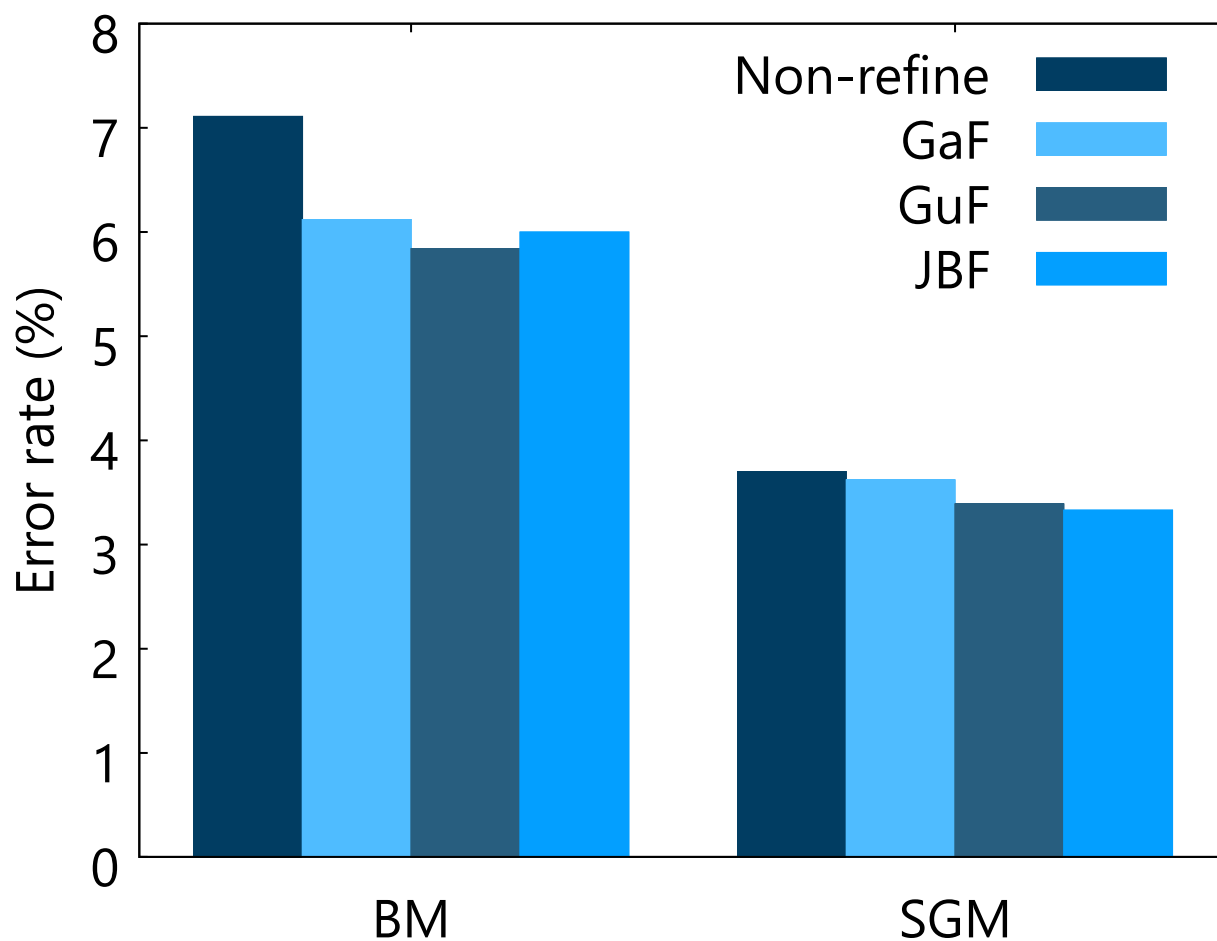 - L1 norm, L2 norm and exponential function

Experimental Results

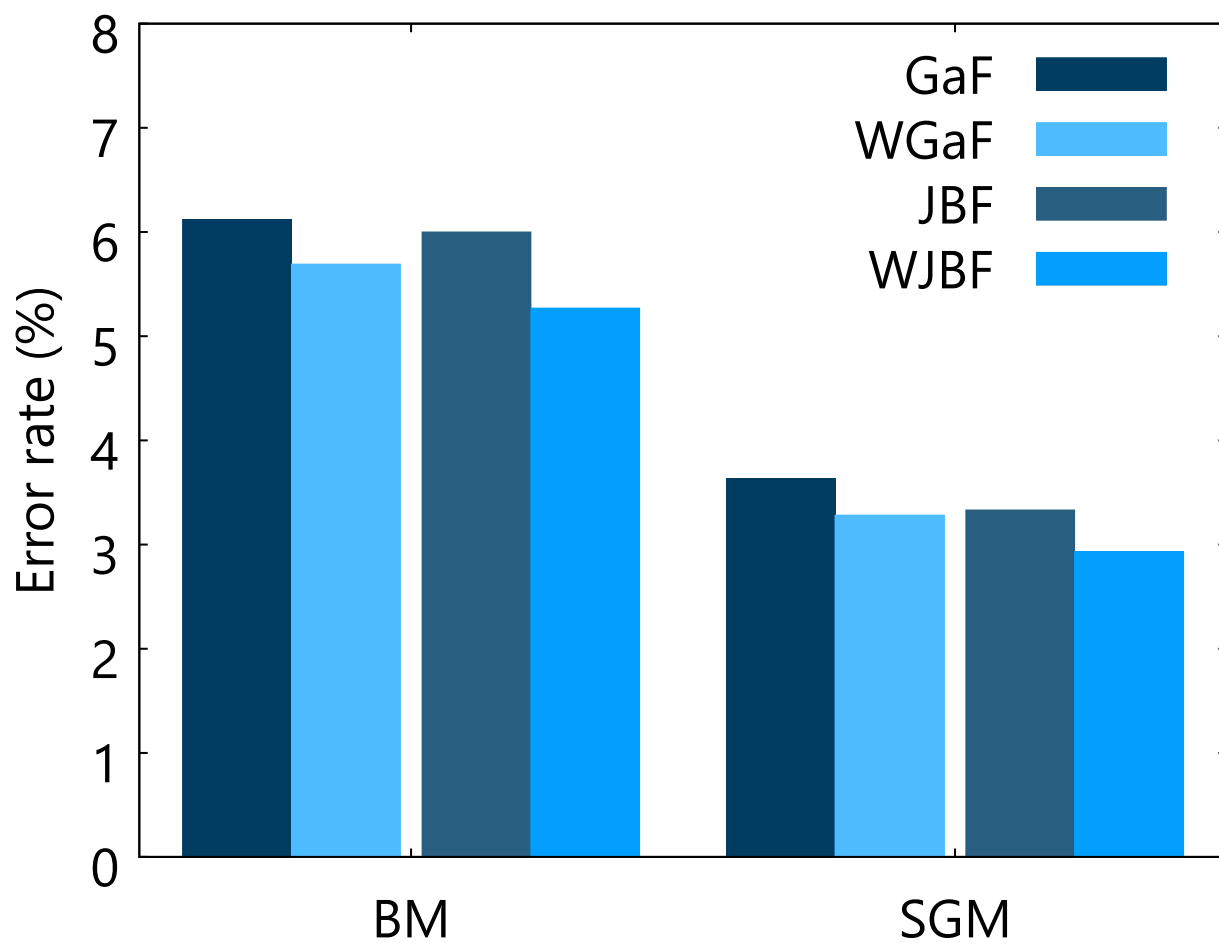## Ex. 1: Difference of filtering methods
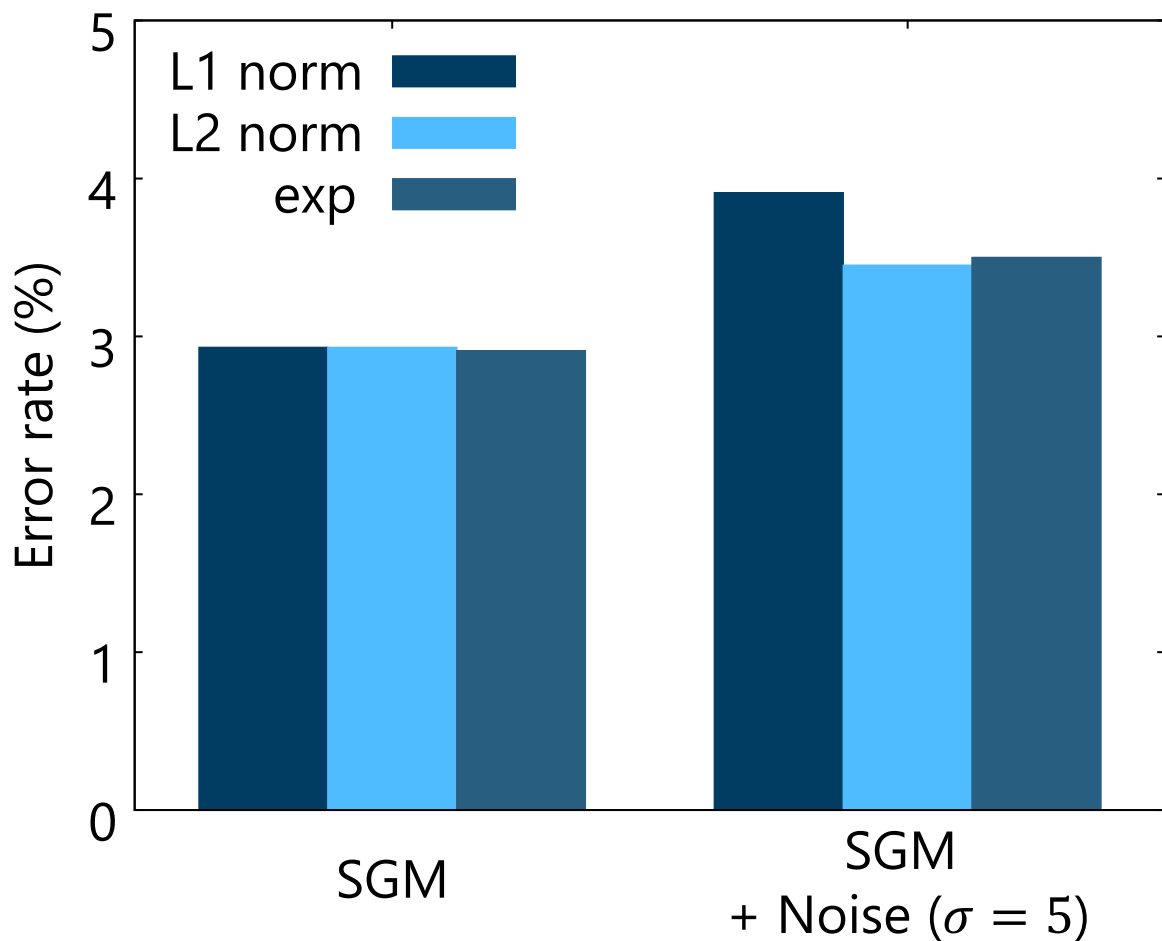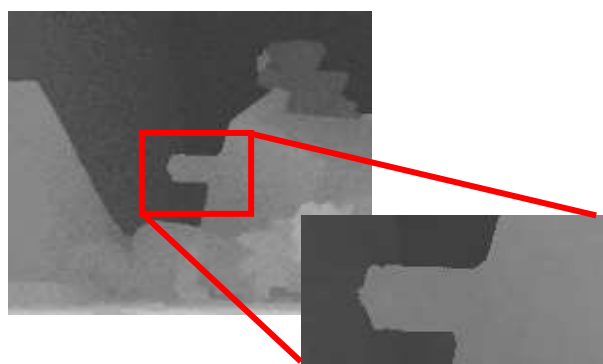

BM (Non-refine)

BM (JBF)

Experimental Results

Ex. 2: With/Without weight map

BM (JBF)

BM (WJBF)

Experimental Results

Ex. 3: Difference of cost functions

SGM+Noise (input)

SGM+Noise (L2 norm)

Conclusion

- Evaluating cost volume refinement filtering
  - Using edge-preserving filtering and weight map is the best for refining cost slices.
  - L1 norm function for building cost volume is not robust to noises.

Future Work

Investigation of the difference in refinement performance between weight maps