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Content-Aware Stereo Image/Video Retargeting

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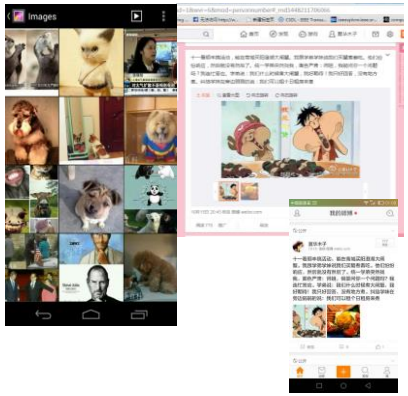
Outline

- Introduction
- Problems in Image/Video Retargteing
- Region-Based Stereo Image Retargeting
- Temporally Coherent Stereo Video Retargeting
- Summary & Discussions

Motivation

Various Displays

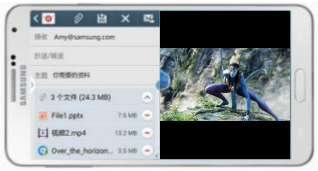
Various Layouts

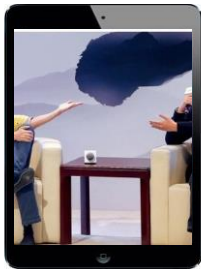


Interactions

Artifacts due to Image Resizing

- Problems with existing resizing schemes





Letter Boxing

Cropping

Uniform Scaling

Waste of Resolution

Informsation Loss

Shape Deformation

Artifacts due to Image Resizing

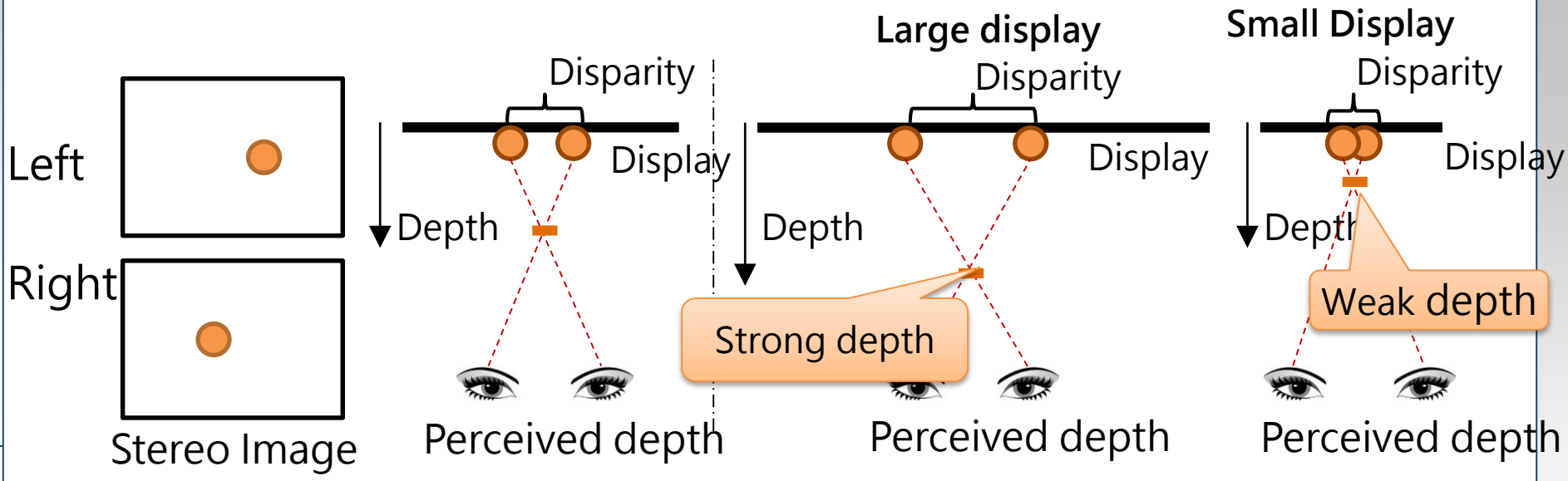
- Traditional Techniques: Uniform Scaling & Cropping
  - 3D Image & Video

Cropping -> “window violation”

Scaling changes the depth

Problems in Stereo Image/Video Retargeting

- Retargeting a stereo image/video will change the perceived depth of 3D scene, depending on the viewing distance and display size



How to adapt a stereo image/video to various displays to enrich the 3D viewing experience?

Video Retargeting for Display Adaptation

Uniform scaling

"Retargeting"

Video Retargeting for Display Adaptation

16:9
HDTV

4:3
SDTV

Content-Aware Image Retgargeting

- Image retargeting: content-aware image resizing
- Image retargeting usually consists of two steps：

Original Image

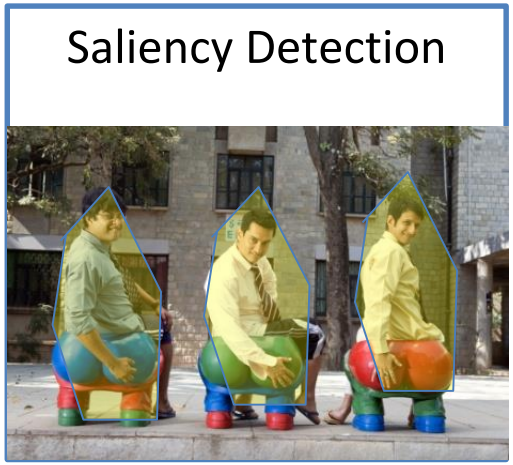
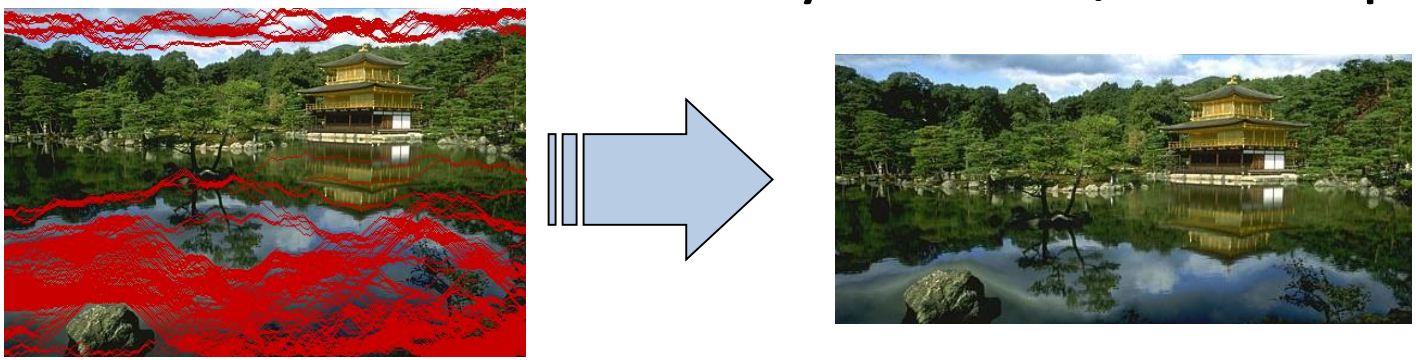


Image Retargeting Methods

- Two kinds of schemes : discrete & continuous methods
- Discrete methods : Iteratively remove/inserts pixels

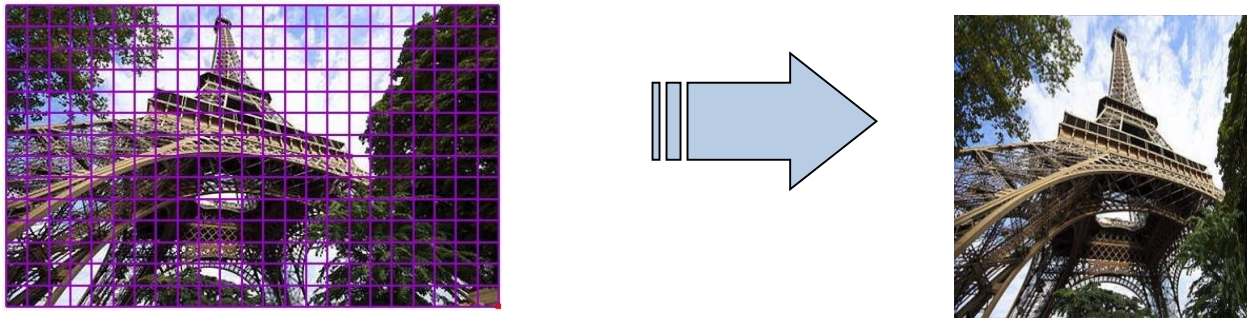


Seam Carving [Avidan et al. 2007]

- Pros & Cons :
  - Pros : high flexibility, suitable for image editing applications
  - Cons : discontinuous distortions

Image Retargeting Methods

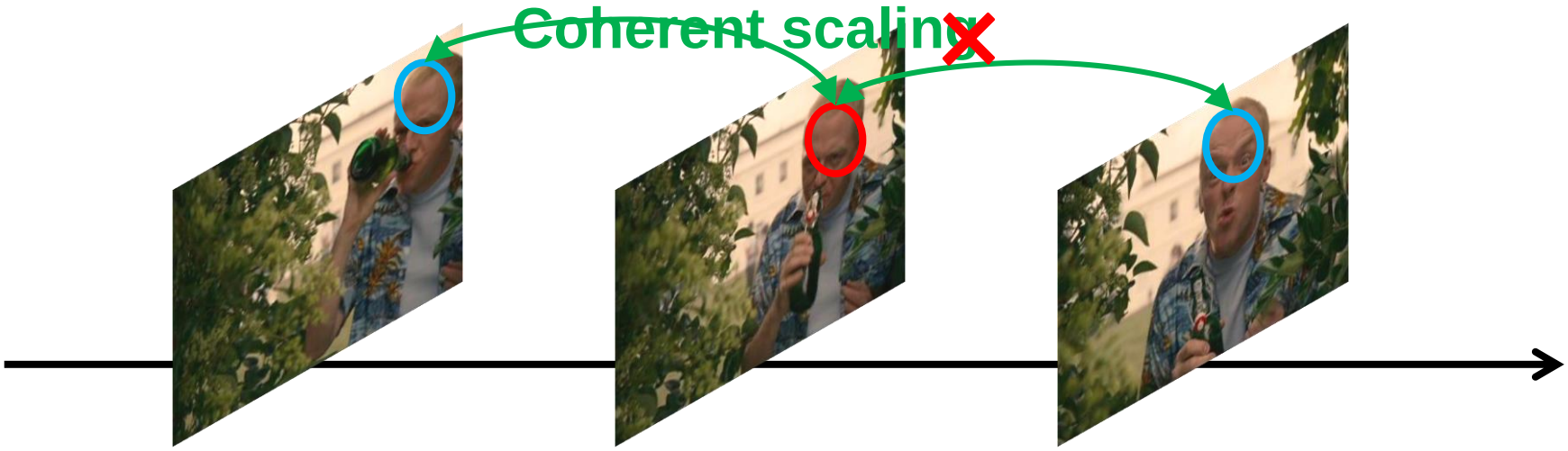
- Continuous Methods : Deriving continuous warping functions to transform an image



Warping [Wang et al. 2008]

- Pros & Cons :
  - Pros : smoother and continuous resizing
  - Cons : non-uniform deformation of an object

Temporal Coherence in Video Retargeting



The same object in neighboring frames should be resized coherently

Temporal Coherence in Video Retargeting

Content-Aware Retargeting

- Content-Aware Image/Video Retargeting

Content Analysis

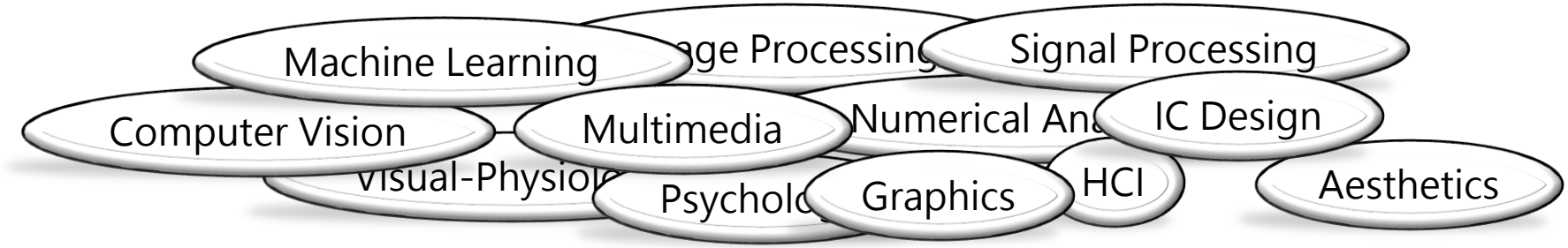
Saliency detection
Disparity Est.
…

Content Processing

Geometric Trans.
Optimization
…

Content Presentation

Quality Assessment
Coding
…



Journals：IJCV、PAMI、TIP 、TCSVT、 TMM 、TOG
Conferences：ICCV、ECCV、CVPR、Siggraph、 Eurographics、 MM

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Region-Based Stereo Image Retargeting

Chia-Wen Lin (林嘉文)

B. Li, L. Duan, C.-W. Lin, T. Huang, and W. Gao, “Depth-preserving warping for stereoscopic image retargeting,” *IEEE Trans. Image Process.*, vol. 24, no. 9, pp. 2811−2826, Sept. 2015.

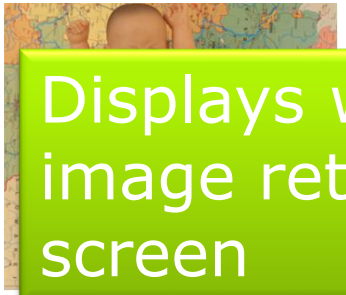
Background

- 3D is popular

Background

- We can view a stereo image pair on many devices

Left image



Right image

Displays with various sizes call for an efficient stereo image retargeting method to fit a stereo image to a screen

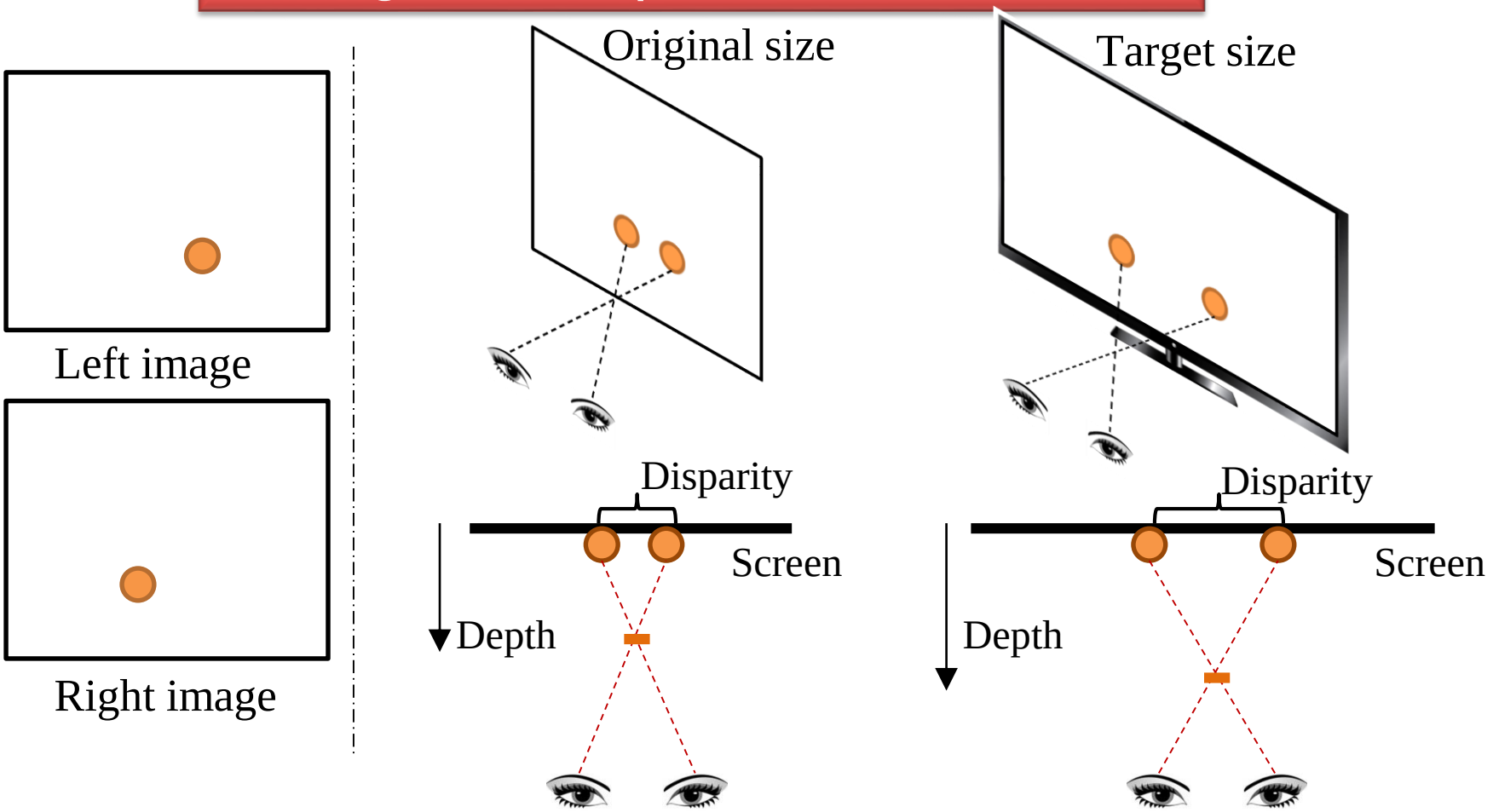
Background

- The simplest method : uniform scaling
  - Distorting the shapes of objects,

  - Distorting the depth of the 3D scene

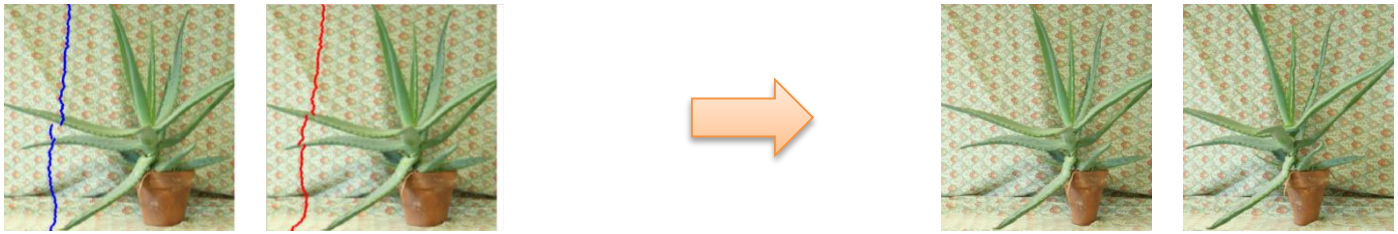
Background

- The simplest method : uniform scaling
  - Change the depth of a 3D scene



Related Work

- Content aware stereo image retargeting
  - Aim: shape preservation, disparity preservation
  - Stereo seam carving: [Utsugi et al. 2010], [Basha et al. 2013]
    - Inserting or removing pixels

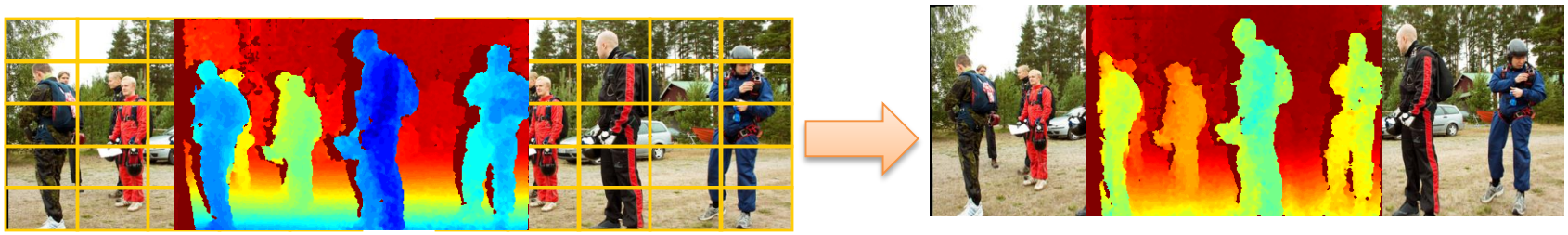


Noticeable shape distortion

K. Utsugi et al, “Seam carving for stereo images,” in 3DTV-Conference, 2010, pp. 1–4.
T. D. Basha, Y. Moses, and S. Avidan, “Stereo seam carving a geometrically consistent approach,” IEEE T-PAMI, vol. 35, pp. 2513–2525, 2013.

Spatial Coherence Constraints

- Region-based methods [Chang et al. 2011], [Lee et al. 2012], [Yoo et al. 2013]



  - Non-uniformly resizing regions

Do not explicitly consider the effect of resizing regions on the disparity/depth

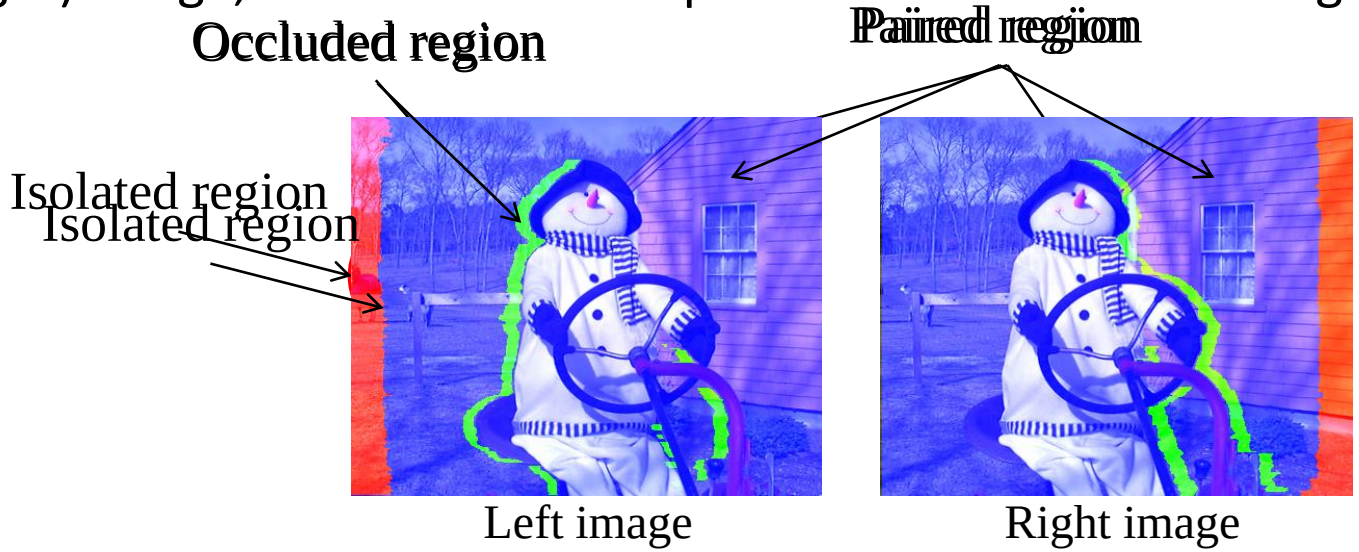
C.-H. C… e editing for stereoscopic images," *IEEE Trans. Multimedia*, vol. 13, pp. 589–601, 2011.
K.-Y. Lee, C.-D. Chung, and Y.-Y. Chuang, "Scene warping: Layer based stereoscopic image resizing," CVPR., 2012, pp. 49–56.
J. W. Yoo, S. Yea, and I. K. Park, "Content-driven retargeting of stereoscopic images," *IEEE Signal Process. Lett.*, pp. 519–522, 2013

Our Approach

- Analyze the effect of resizing different regions on the depth of 3D scene.
  - key finding: the scaling of various kinds of regions leads to **different effects** on the depth construction of 3D scene.
  - region classification: *isolated region, occluded regions, paired regions.*
  - Depth preservation constraints: considering the resizing effect of different regions on depth
- Region-based stereo image retargeting method
  - simultaneously preserving the shape of salient objects and maintaining the depth of 3D scene

Effect of Region Resizing on Scene Depth

- **Paired region**: a region in one image that can find a correspondence in the other image of a stereo pair
- **Occluded region**: a region in one image that cannot find any correspondence in the other image due to the occlusion by other objects.
- **Isolated region**: a region that lies in the left (right) boundary of the left (right) image, and has no correspondence in the other image



Effect of Region Resizing on Scene Depth

- Given a correspondence pair (f^L,f^R), the horizontal disparity is calculated by

$$d = x^R - x^L$$

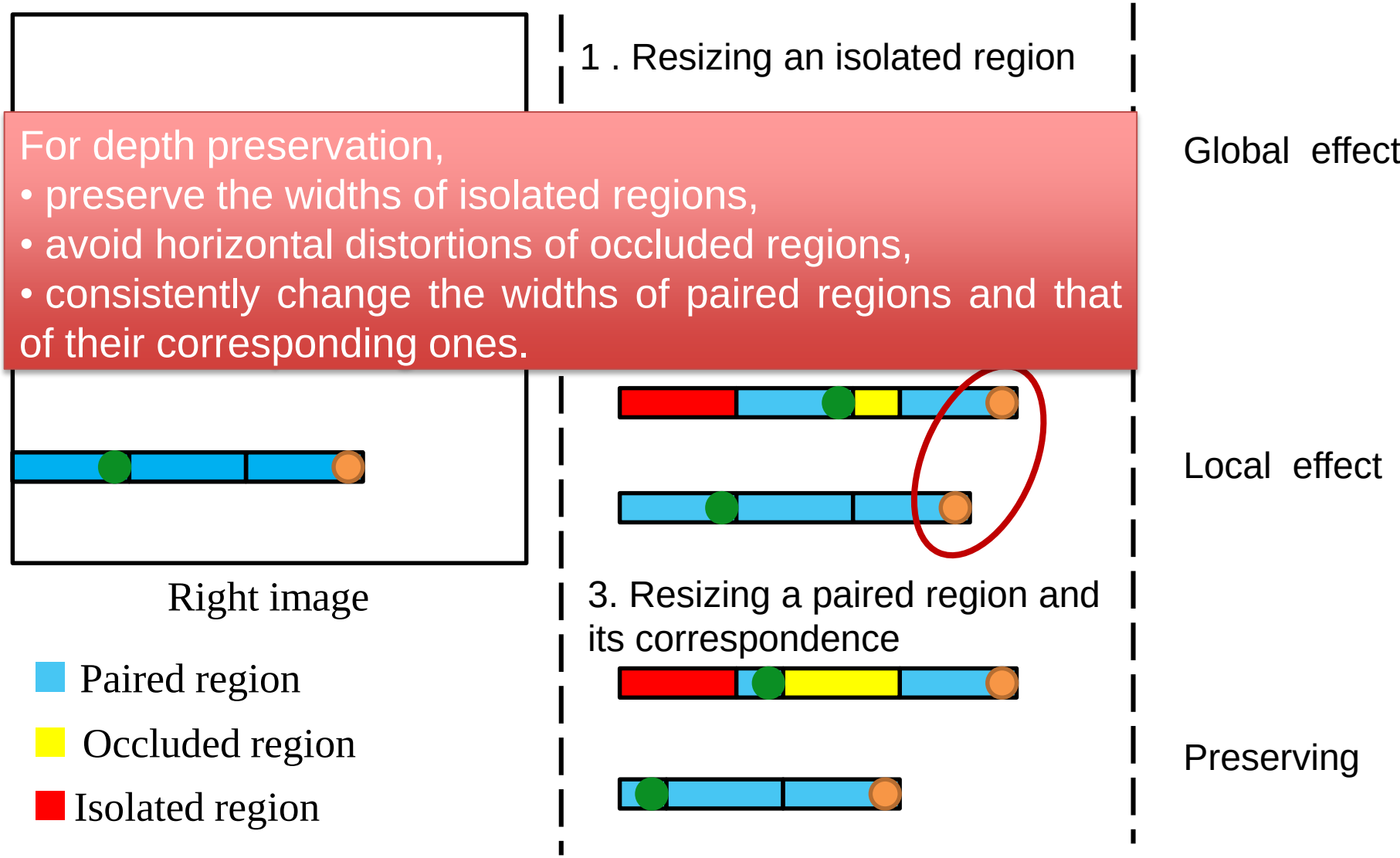
- Reformulating the equation in terms of the width of different region classes

$$d = \underbrace{\sum_{r_j^L, r_j^R \in \Upsilon_p} (w_{y,j}^R - w_{y,j}^L)}_{\text{Paired regions}} - \rho^z \underbrace{\sum_{r_j^z \in \Upsilon_o} w_{y,k}^z}_{\text{Occluded regions}} - \underbrace{\sum_{r_j^L \in \Upsilon_l} w_{y,j}^L}_{\text{Isolated regions}}$$

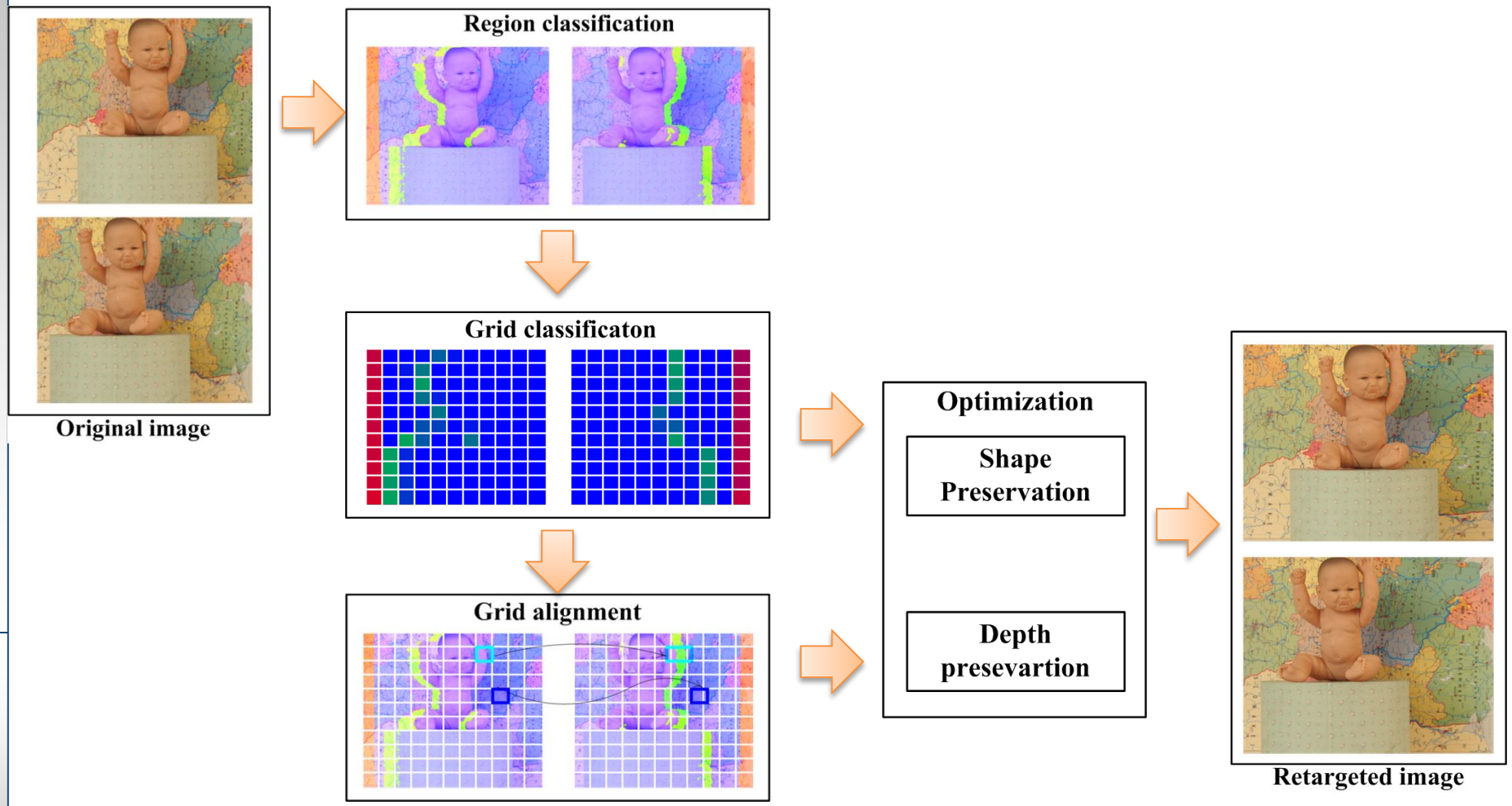
Effect of Region Resizing on Scene Depth

- Resizing an occluded region would affect the disparities of all regions to the right of it (**local effect**).
- Resizing an isolated region would change the disparities of all regions (**global effect**).
- Resizing a paired region has no effect on the disparity of any other region, provided that both the widths of the region and its correspondence are changed consistently

Intuition behind our Work



Proposed Framework



Problem Formulation

- Objective:
  - Simultaneously minimizing the overall shape distortions of salient objects and the depth distortions in stereo pairs

$$\min \ (1-\alpha)D^s + \alpha \cdot D^d$$

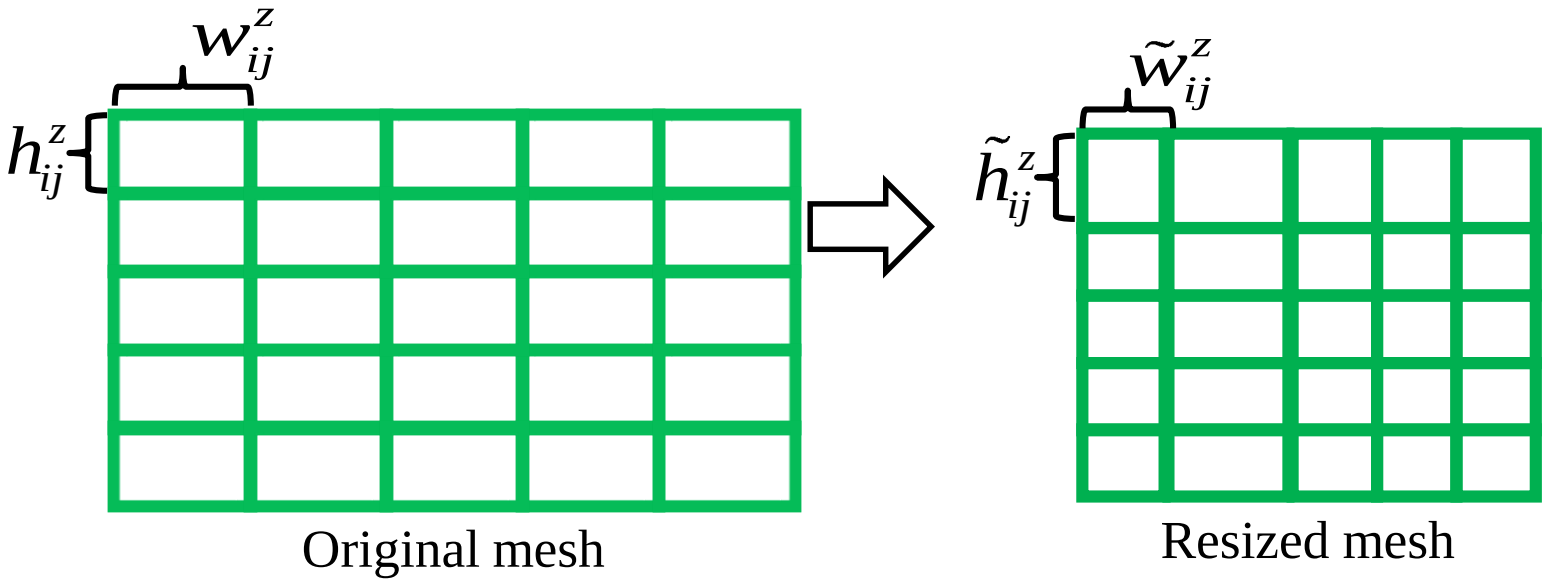
Shape distortion

Depth distortion

Characterizing Shape Distortion

- The weighted sum of individual grids' deformations

$$D^s = \sum_{z\in\{L,R\}} \sum_{i=1} \sum_{j=1} \underbrace{(w_{ij}^z \cdot \tilde{h}_{ij}^z - \tilde{w}_{ij}^z \cdot h_{ij}^z)^2}_{\text{grid's aspect ratio changes}} \underbrace{\cdot \eta_{ij}^z}_{\text{importance}}$$



Characterizing Depth Distortion

- To preserve depth:
  - preserve the widths of isolated regions and occluded regions
  - consistently change the widths of a paired region and its correspondence

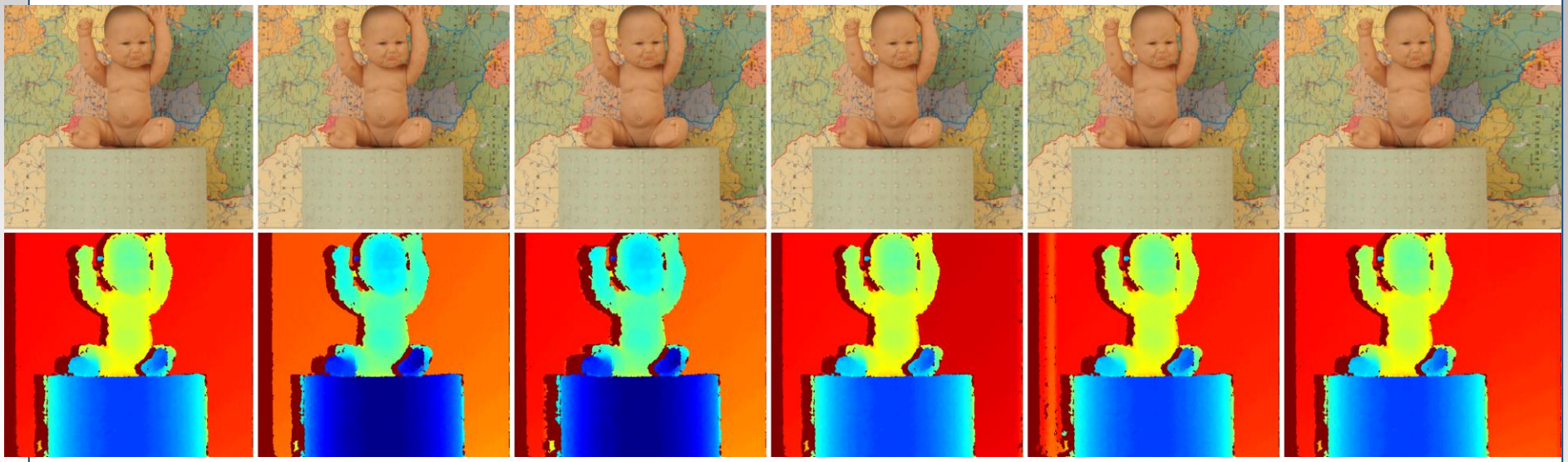
$$D^d = \beta_1 D^l + \beta_2 D^o + \beta_3 D^p =$$

$$\sum_{g_{ij}^z \in G_l} \beta_1 (w_{ij}^L - \tilde{w}_{ij}^L)^2 + \sum_{g_{ij}^z \in G_o} \beta_2 (w_{ij}^z - \tilde{w}_{ij}^z)^2 + \sum_{g_{ij}^z \in G_p} \sum_{g_{ik}^{z'} \in C_{ij}^z} \beta_3 (\tilde{w}_{ij}^z - \tilde{w}_{ik}^z)^2$$

Isolated regions Occluded regions Paired regions

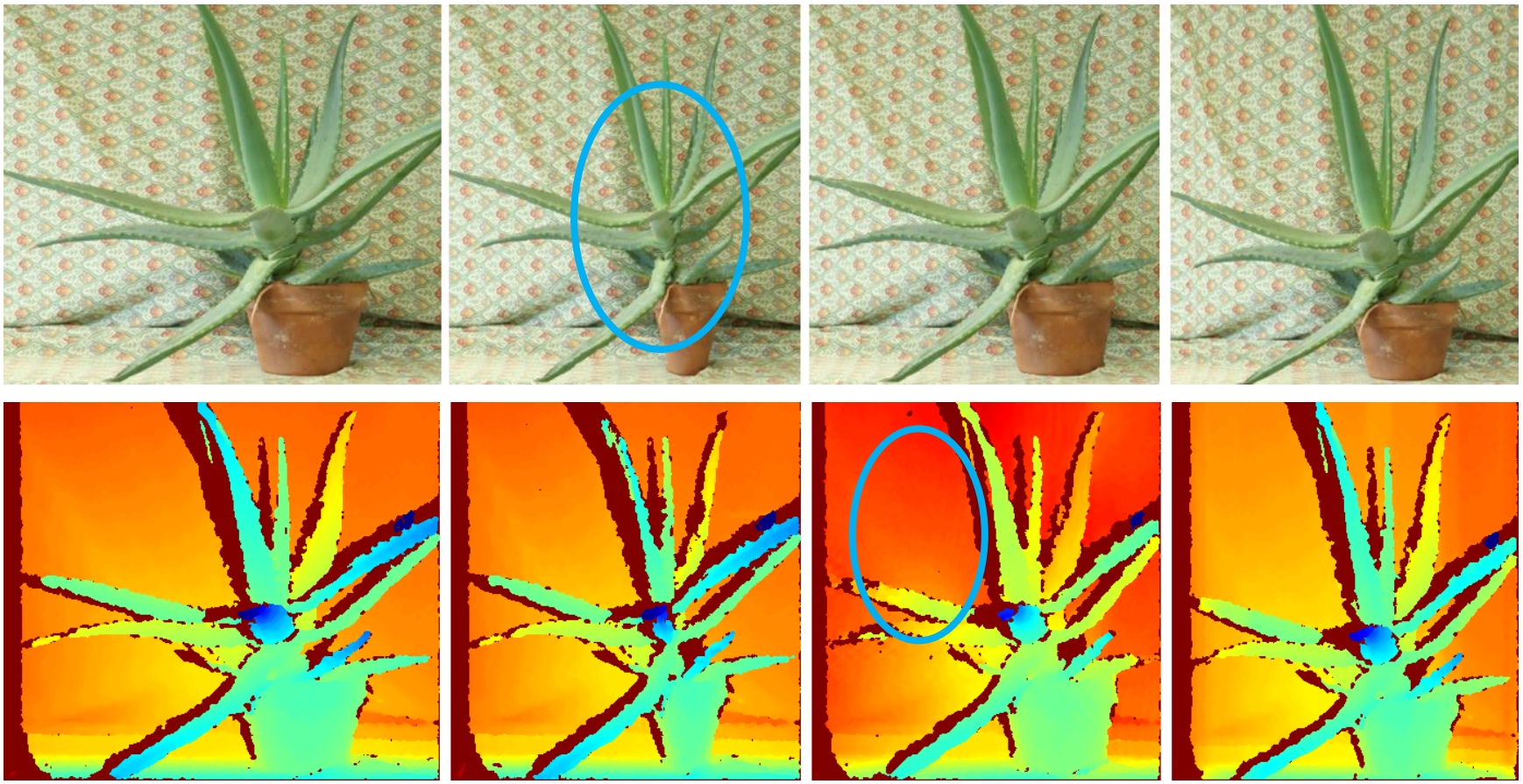
Experiments: Depth Distortion

Results of Resizing different classes of regions on Baby1



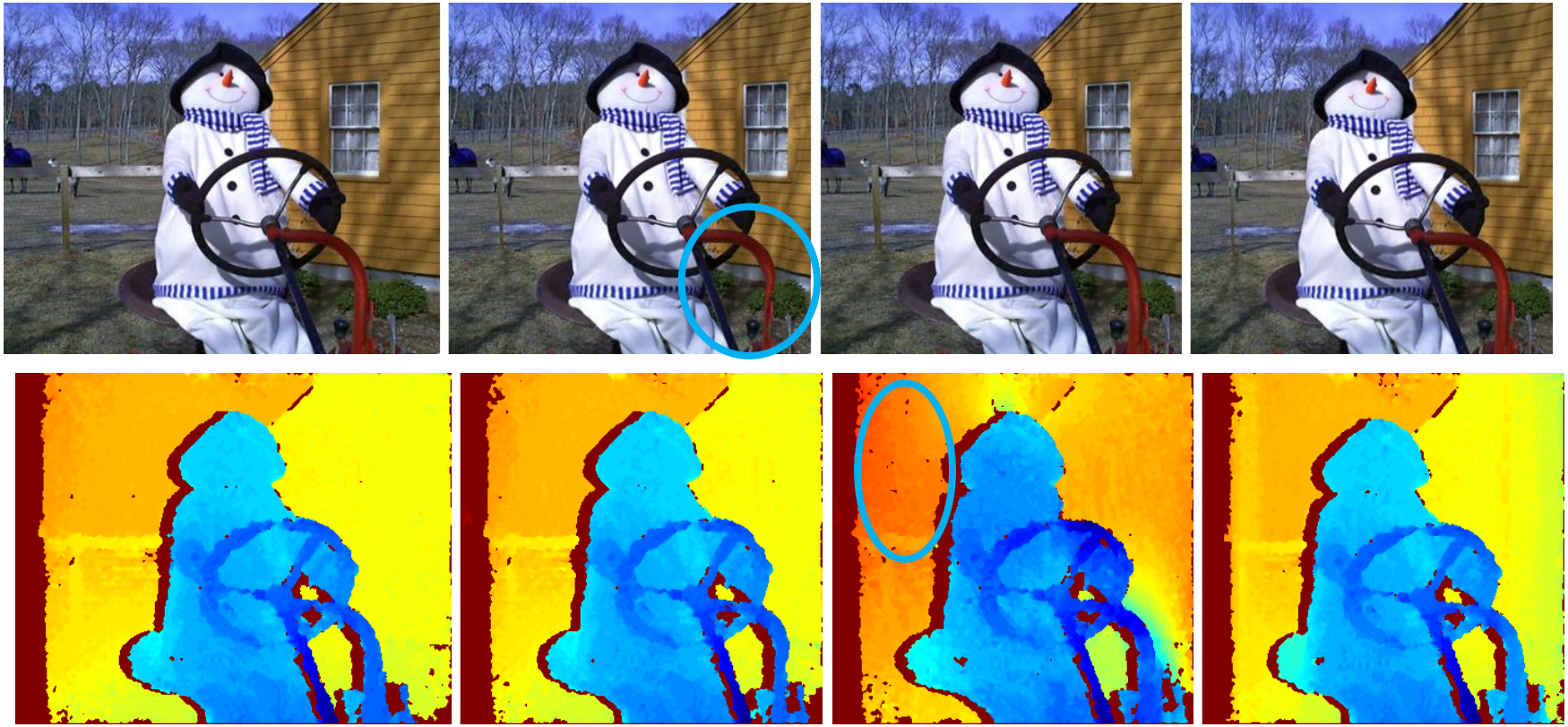
(a)	(b)	(c)	(d)	(e)	(f)
Original	Isolated Reg.	Occluded Reg. (Left Image)	Occluded Reg. (Right Image)	Inconsist. Resizing (Paired Region)	Consist. Resizing (Paired Region)

Experiments: Retargeting Quality



Original | Stereo Seam Carving | Multi-Level Warping | Ours

Experiments: Retargeting Quality



Original | Stereo Seam Carving | Multi-Level Warping | Ours

Summary

- Depth-Preserving Stereo Image Retargeting
  - We show that resizing different regions of a stereo image pair leads to different effects on the depth of 3D scene
  - We propose to maintain the depth of 3D scene via imposing different smoothness constraints on different classes of regions
- Temporally Coherent Stereo Video Retargeting
  - We propose a framework to achieve shape preservation, depth preservation and temporal coherence in stereo video retargeting