



Content Aware Retargeting

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The Retargeting Problem

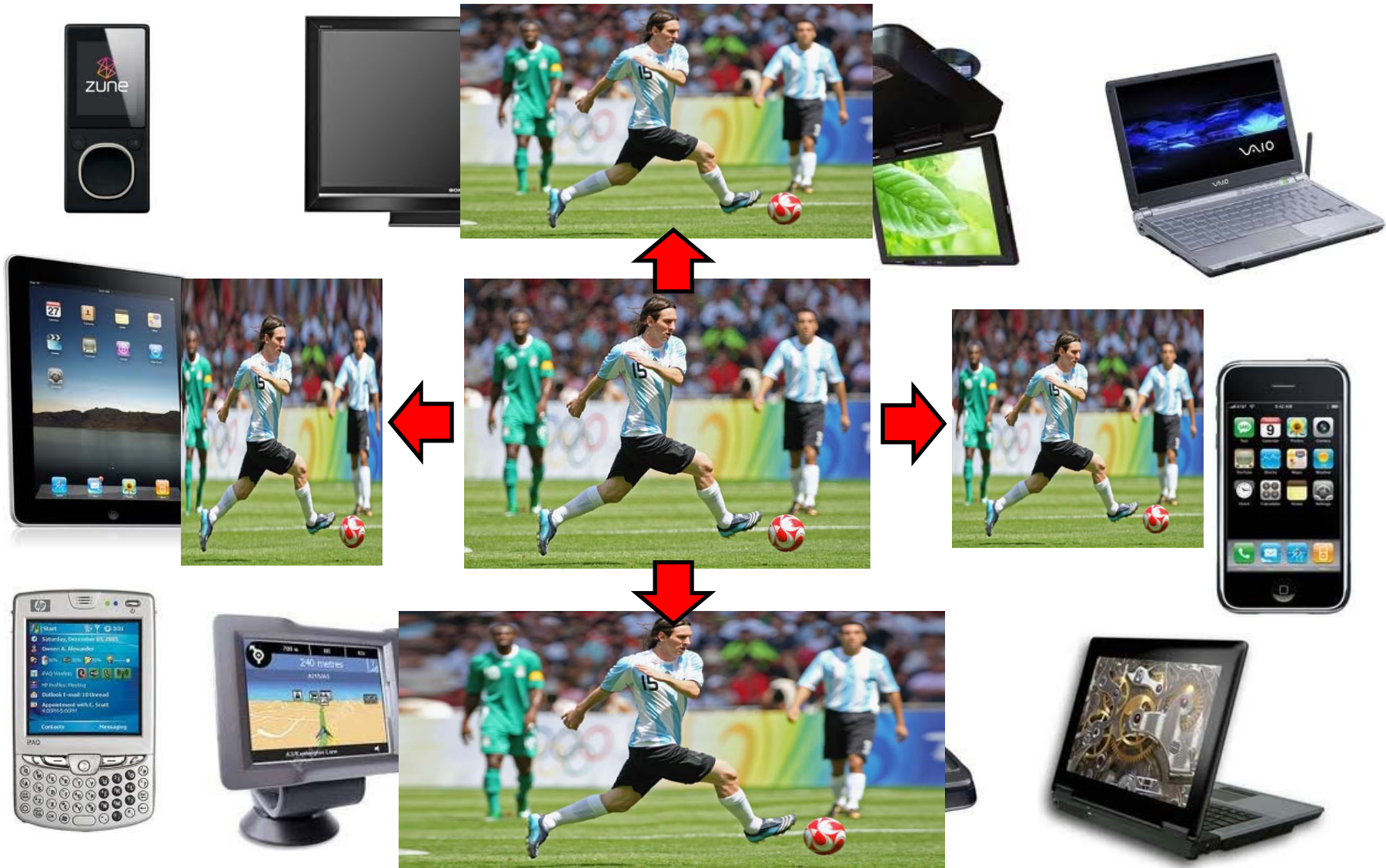
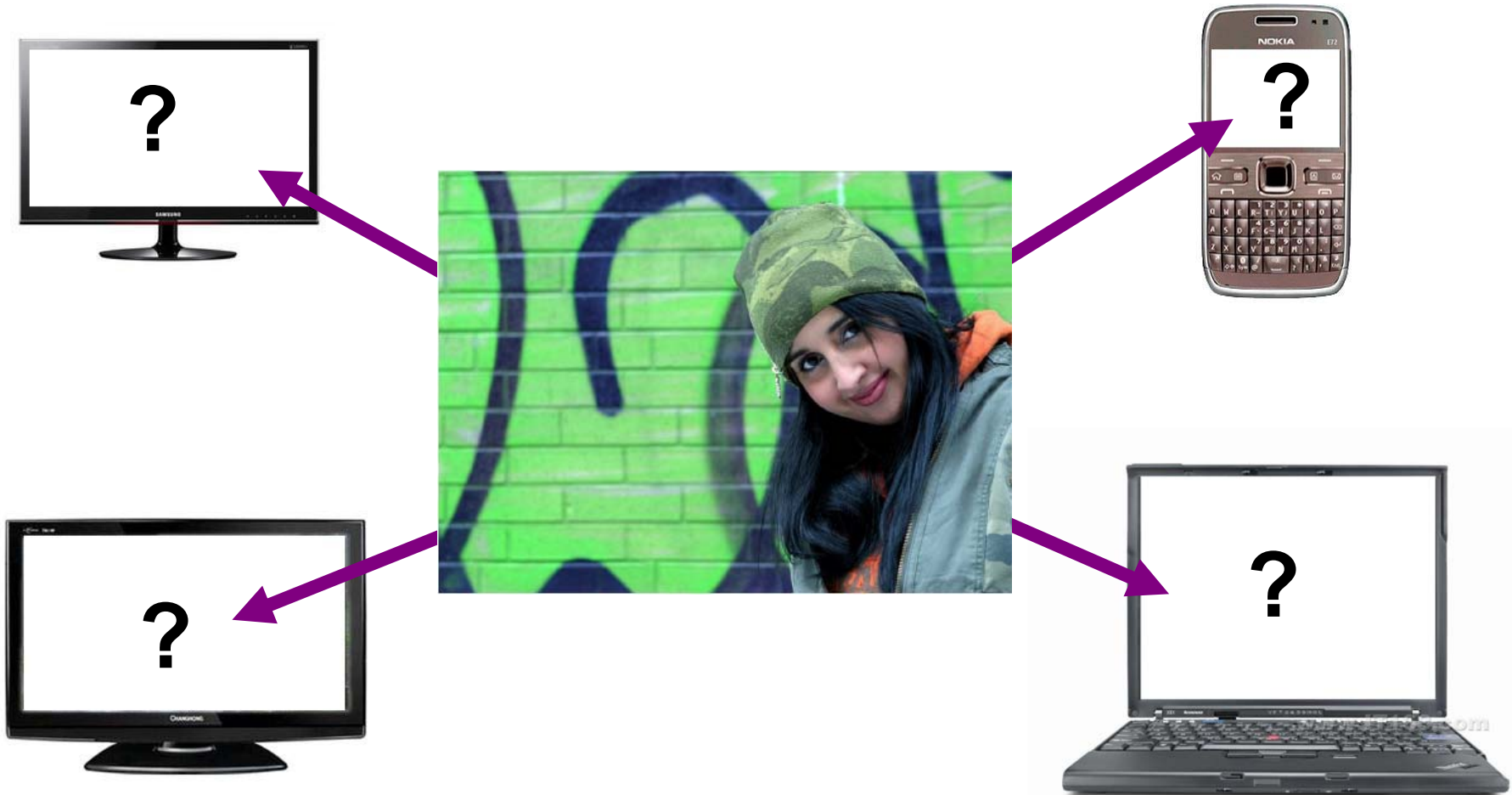


Image Retargeting



- Diversity of display devices
- Different aspect ratios

Uniform Resizing

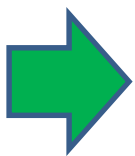


Content-aware Resizing





Compare



Content-Aware Image Retargeting

- Preserving visual appearance of salient objects
 - Important content
 - Important structure
- Free of visual artifacts
- A hot topic during 2007 and 2011!

Hot Topic

- Many many publications in SIGGRAPH, SIGGRAPH Asia, Eurographics, CVPR, **CV, ...
 - [Gal et al. 2006]
 - [Avidan and Shamir 2007, Wolf et al. 2007]
 - [Cho et al. 2008, Rubinstein et al. 2008, Wang et al. 2008]
 - [Barnes et al. 2009, Guo et al. 2009, Karni et al. 2009, Huang et al. 2009, Rubinstein et al. 2009, Dong et al. 2009, Shamir and Sorkine 2009]
 - [Jin et al. 2010, Rubinstein et al. 2010]
 - [Lin et al., 2011, Seol et al., 2011]
 - [Panozzo et al. 2012]

Classifications

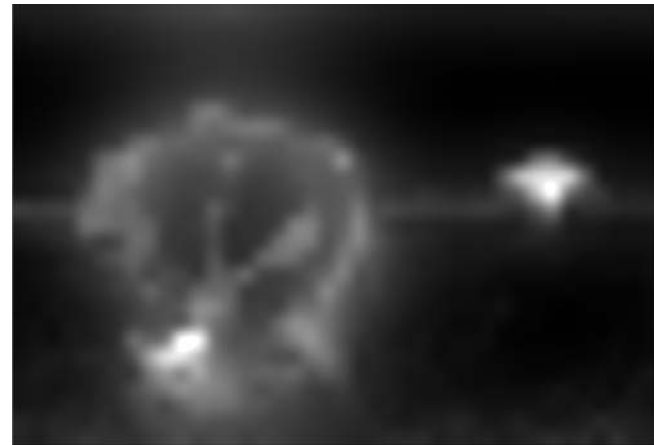
- Synthesis-based methods
- Warping-based methods
- Combined methods

- Different disciplines
 - Smart cropping [e.g. Liu and Gleicher]
 - Discrete deformations [Seam-carving, shift-maps]
 - Continuous deformations [scale&stretch, Streaming Video]
 - Non-local means [Bidirectional similarity]
 - Saliency measures

Saliency Detection

Saliency Measure

- Identifying important image regions
- Usually represented as a map in $[0,1]$
 - Saliency map
 - Importance map



What Is Saliency?

- Hard to define
- Related to human perception
 - Perception variance




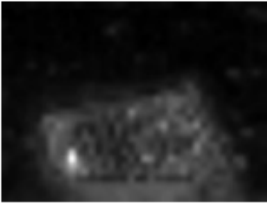
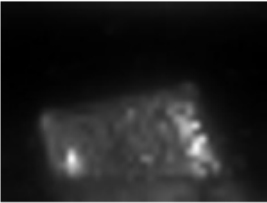

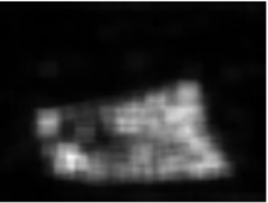


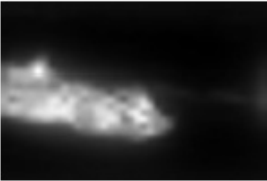
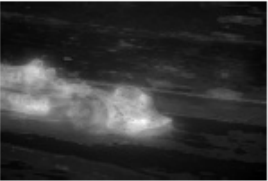
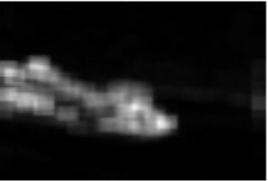



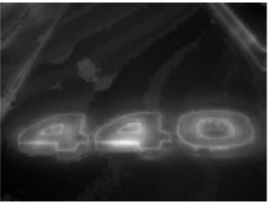
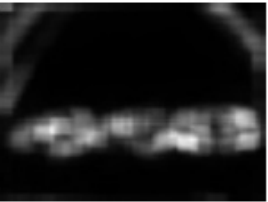



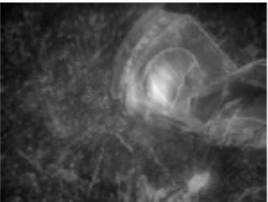

Visual Cues

- Low level
 - High local intensity gradients
 - Other local features
- Middle level
 - Salient lines
- High level
 - Faces, structures, symmetries

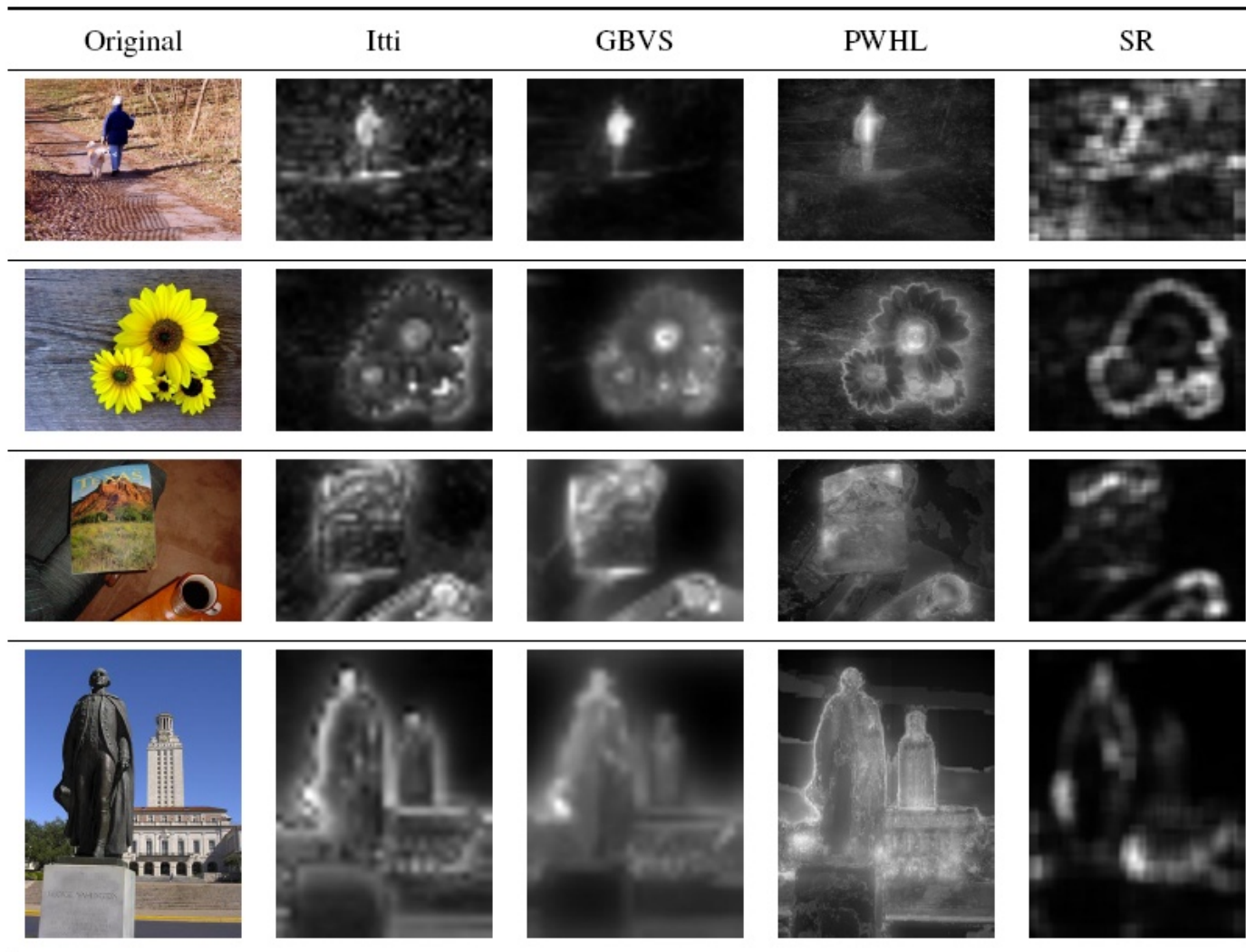
Methods

- Classic methods
 - [Itti et al. 1998, Harel et al. 2006]
- Learning-based methods
 - [Liu et al. 2007, Judd et al. 2009]
- Spectral residual method
 - [Hou and Zhang 2007]
- Context-aware method
 - [Goferman et al. 2010]


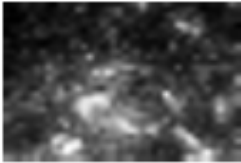

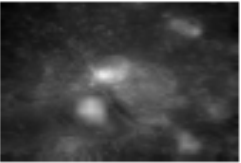



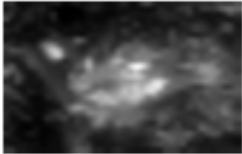
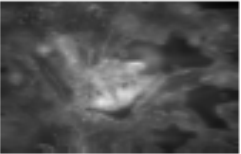
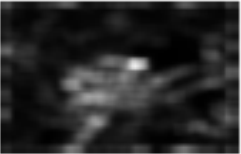


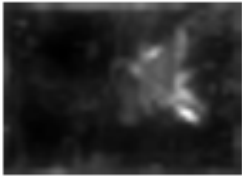
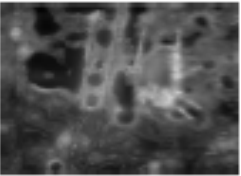


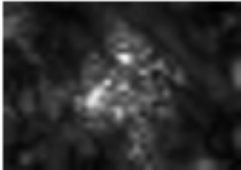
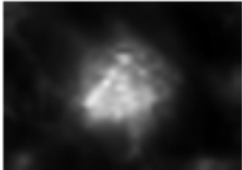
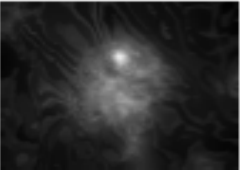
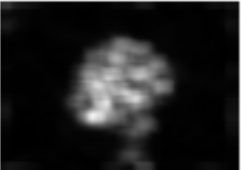

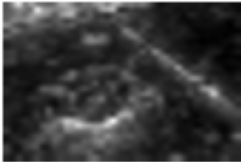
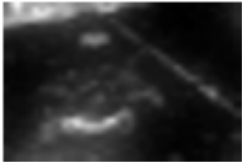
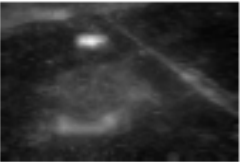
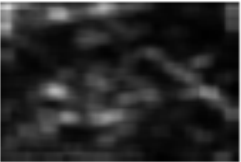


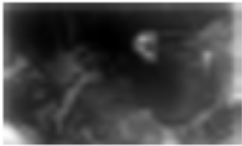
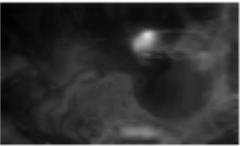
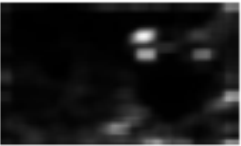
Results

Original	Itti	GBVS	PWHL	SR
				
				
				
				


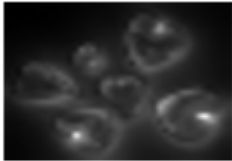
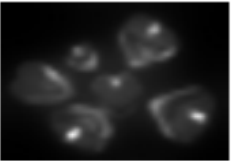
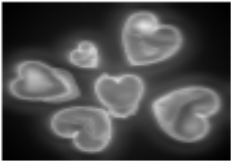
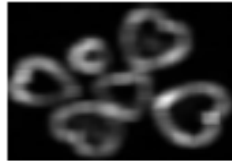




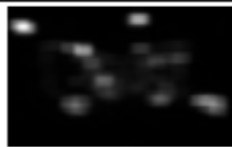






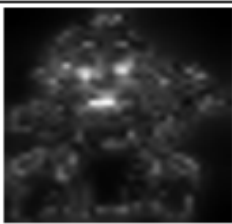




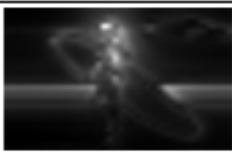
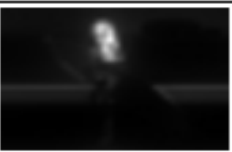
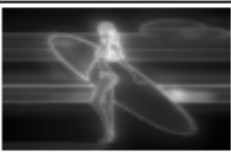
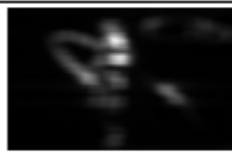



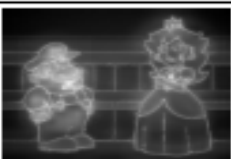
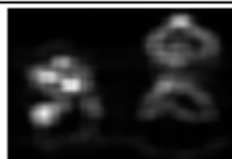
Results



Results

Original	Itti	GBVS	PWHL	SR
				
				
				
				
				
				

Results

Original	Itti	GBVS	PWHL	SR
				
				
				
				
				
				

Saliency Detection

- Learning based method seems work better
- Still an unsolved problem

Synthesis-based Methods

Synthesis-based Methods

- Pixels in the result are copied from the original image
 - Cut and paste
 - Remove unimportant pixels
 - Keep consistency

Seam Carving

- Removing/adding unimportant seams
 - [Avidan and Shamir 2007]
 - [Rubinstein et al. 2008]





Seam carving



Scaling



Cropping

Limitation

- Line features



Shift Map

Input



Shift-Map
Output



Our Approach : Shift-Map

- Shift-Maps represent a *mapping* for each pixel in the output image into the input image

Output : $R(u,v)$

Input : $I(x,y)$

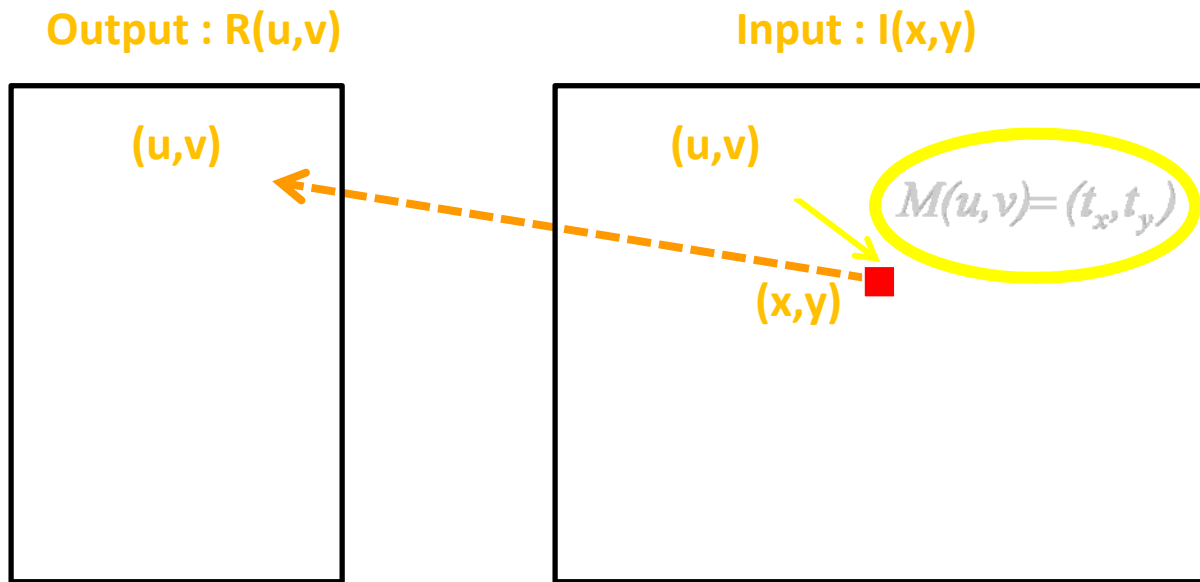


$$M(u,v) = (t_x, t_y)$$

- The color of the output pixel is copied from corresponding input pixel

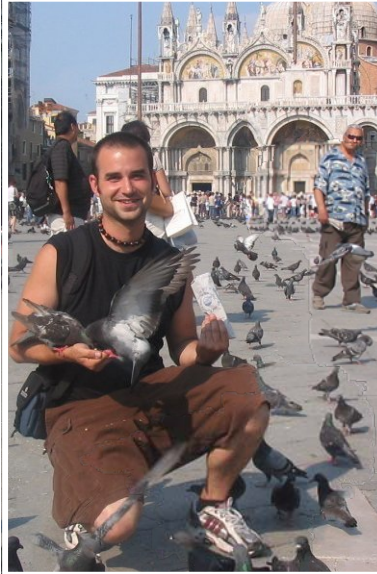
$$M(u, v) = (t_x, t_y)$$

$$R(u, v) = I(u + t_x, v + t_y) = I(x, y)$$



- We use relative mapping coordinate (like in Optical Flow)

Output



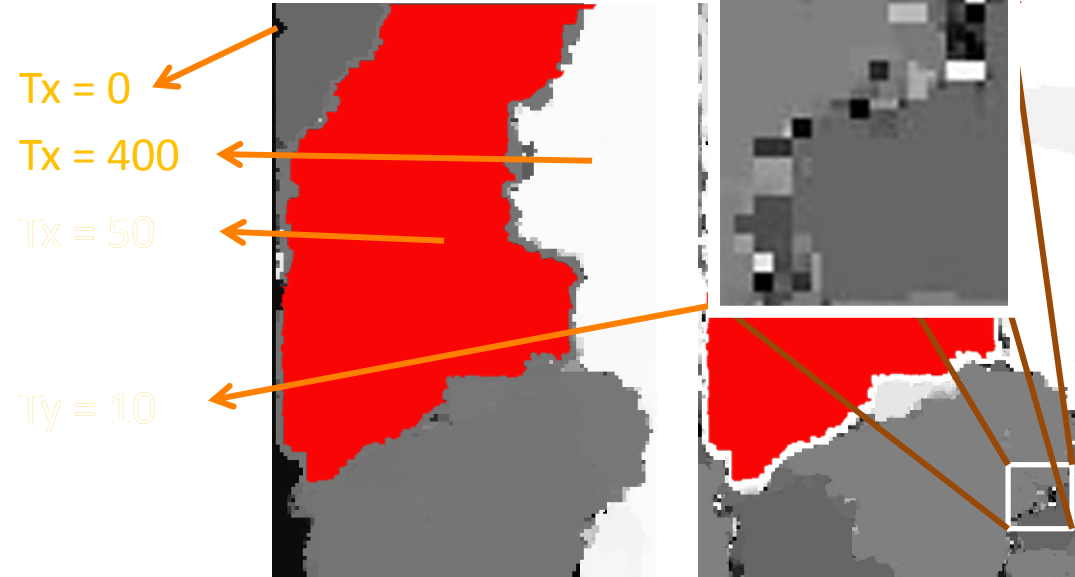
Input



Shift-Map
Output Image

Horizontal Shifts

Vertical Shifts



- Minimal distortion
- Adaptive boundaries
- Fast optimization

Energy Minimization

- We look for the **optimal mapping** - can be described as an Energy Minimization problem

$$E(M) = \alpha \sum_{p \in R} E_d(M(p)) + \sum_{p, q \in N} E_s(M(p), M(q))$$

Data term :
External Editing Requirement

Compute For Each Pixel

Smoothness term :
Avoid Stitching Artifacts

Compute For Each Pair
of Neighboring pixels

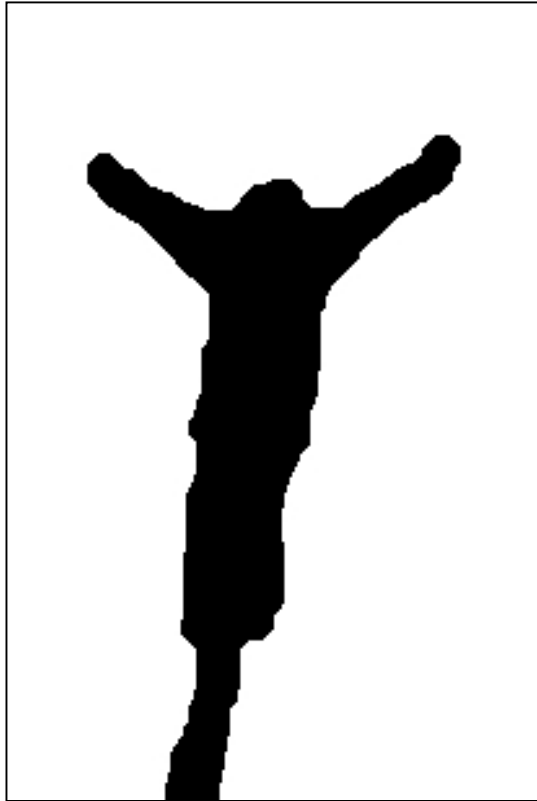
- Unified representation for geometric editing applications
- Solved using a graph labeling algorithm

Retargeting Result



Image Inpainting

Mask



Input



Image Inpainting

Mask



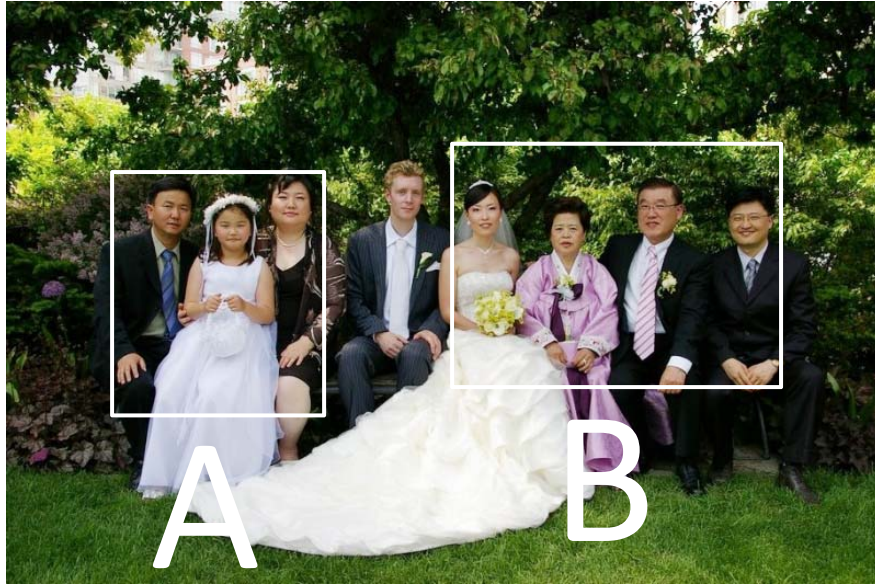
Input



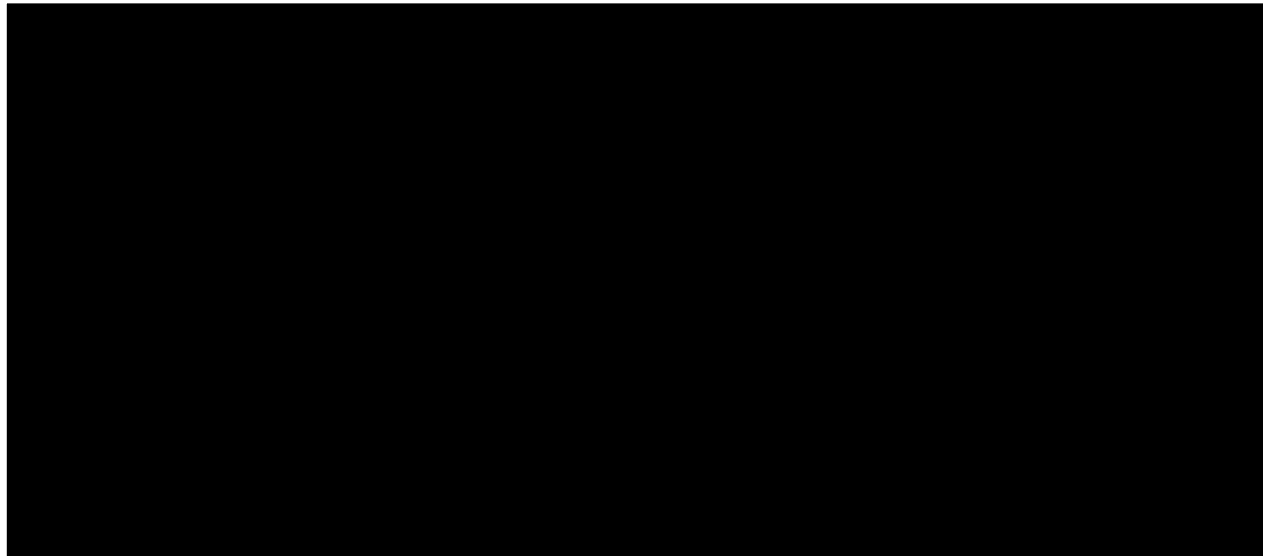
Shift-Map Composition



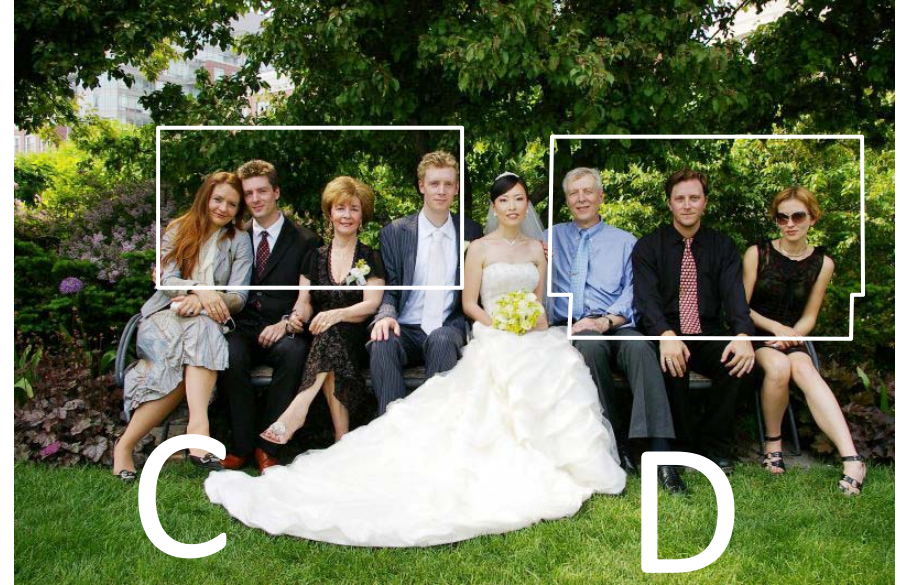
Shift-Map Composition



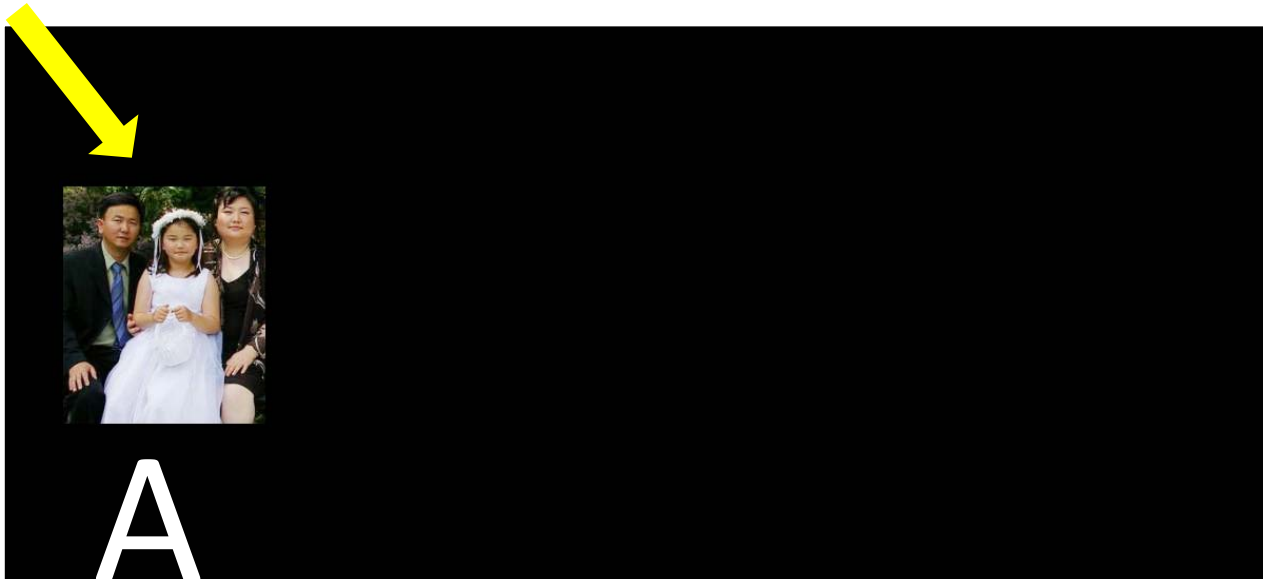
User
Constraints



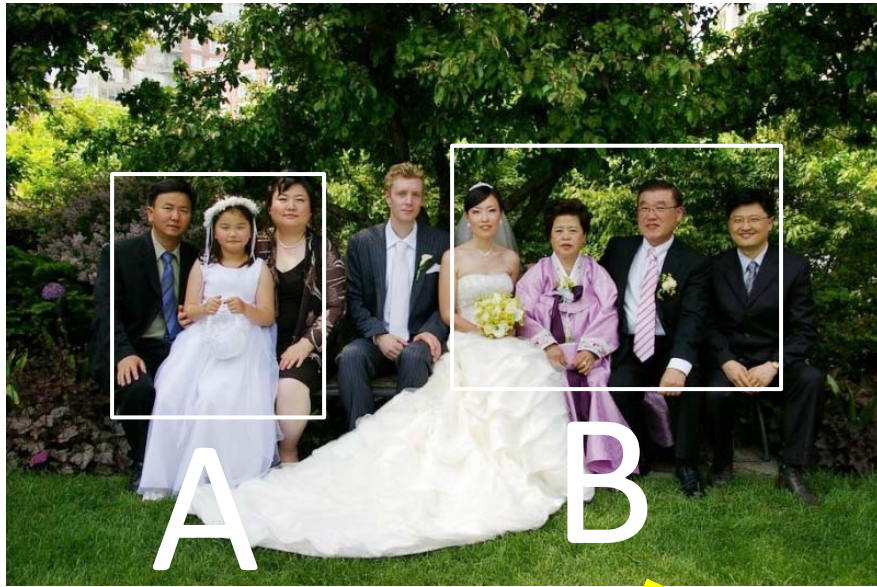
Shift-Map Composition



User
Constraints



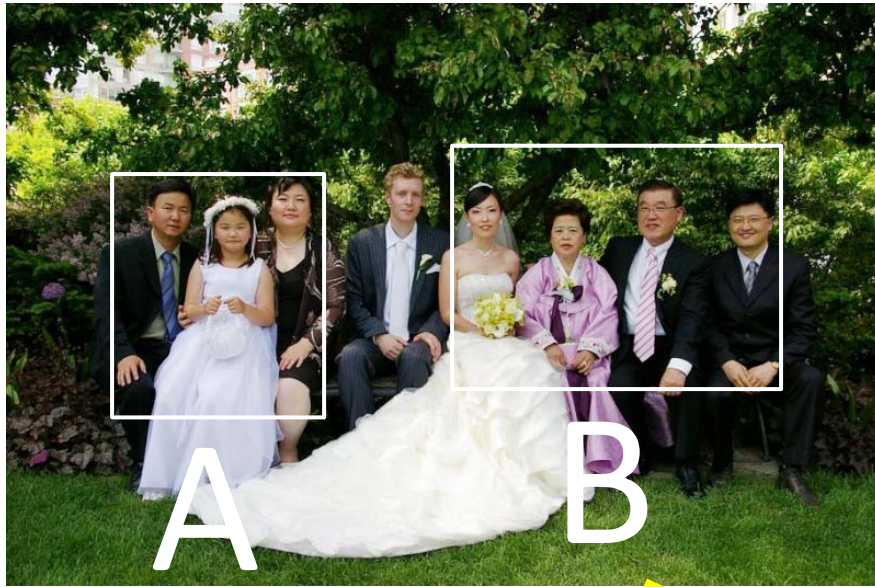
Shift-Map Composition



User
Constraints



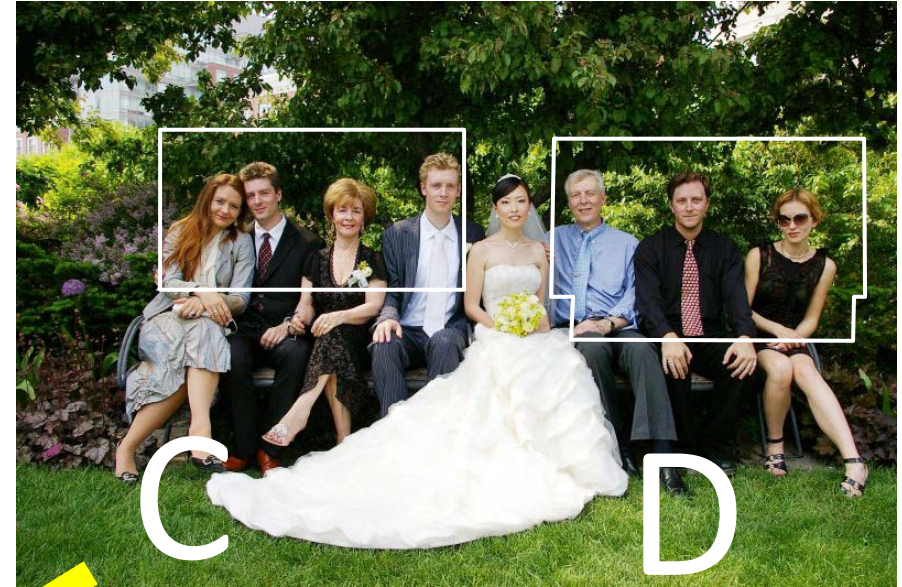
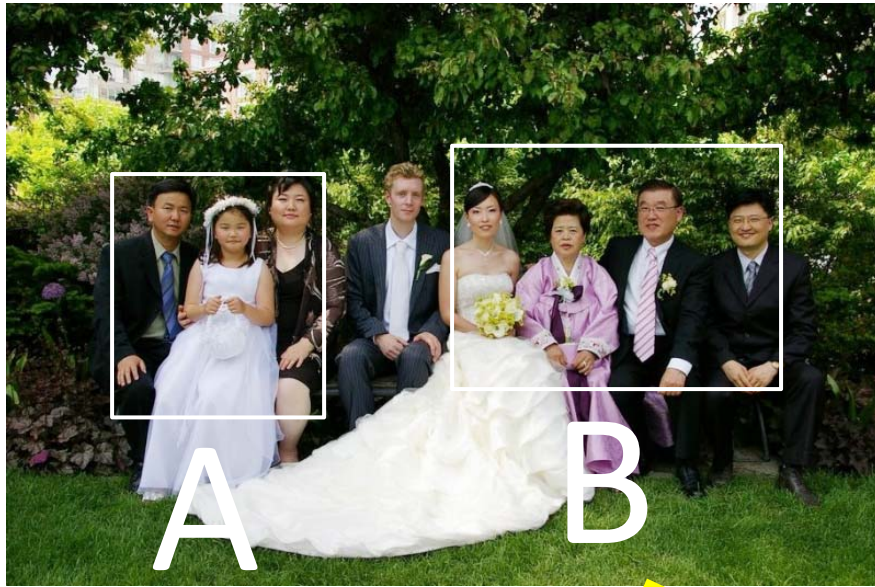
Shift-Map Composition



User
Constraints



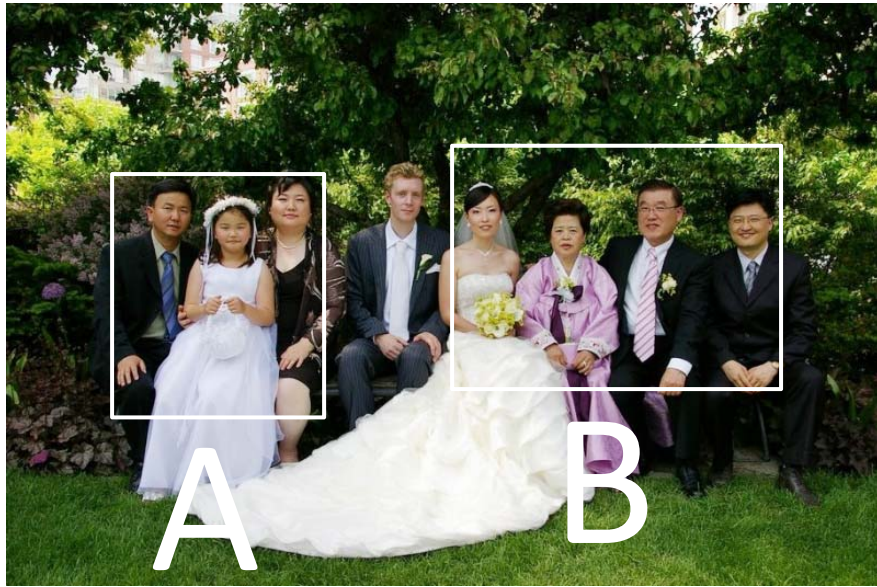
Shift-Map Composition



User
Constraints



Shift-Map Composition



User
Constraints



PatchMatch (Patch-based)

- [Barnes et al. 2009]

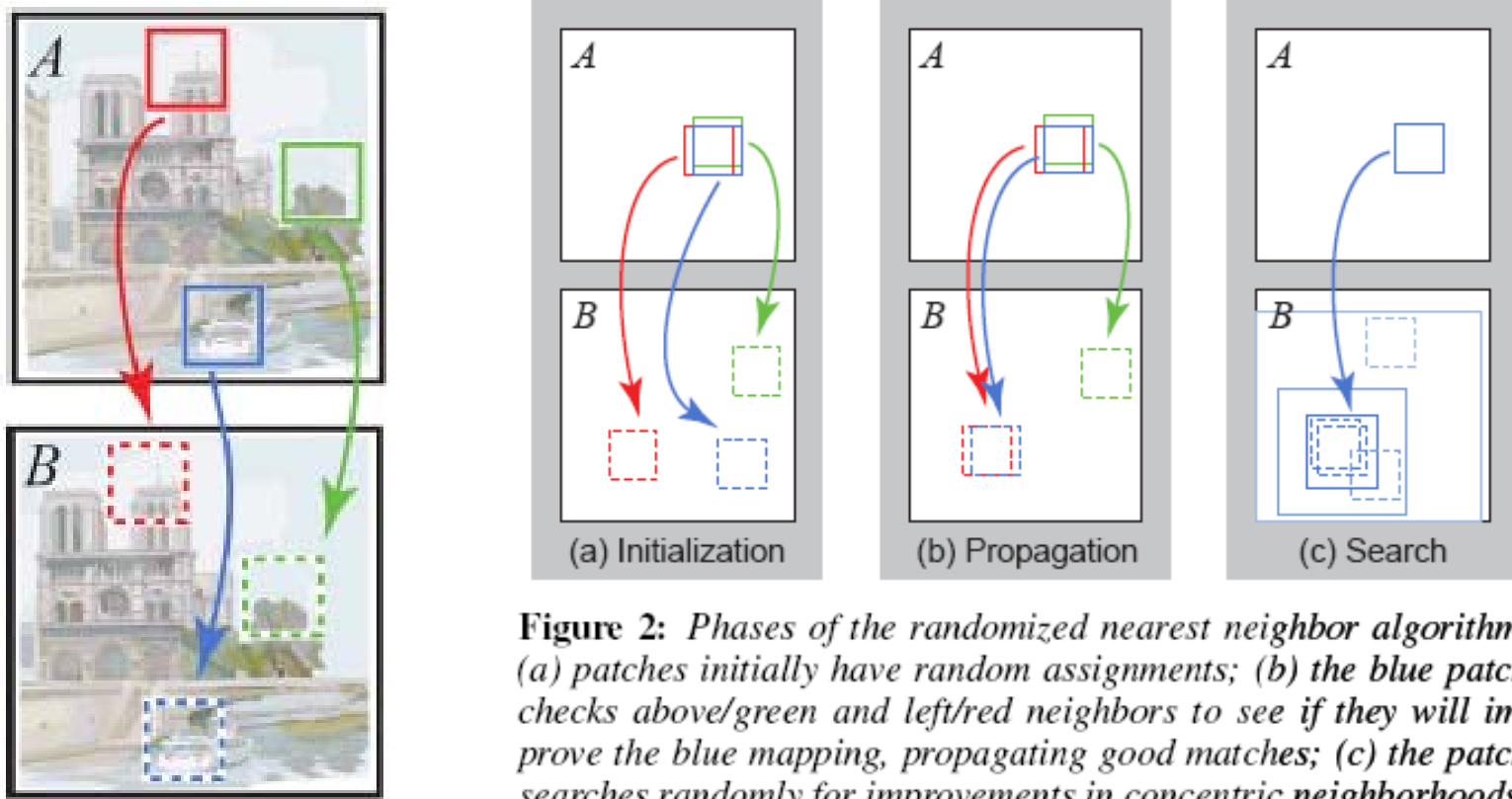


Figure 2: *Phases of the randomized nearest neighbor algorithm: (a) patches initially have random assignments; (b) the blue patch checks above/green and left/red neighbors to see if they will improve the blue mapping, propagating good matches; (c) the patch searches randomly for improvements in concentric neighborhoods.*

...with constraints



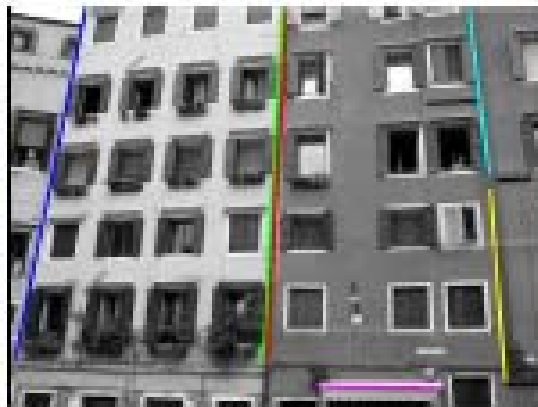
(a) original



(b) retargeted



(c) with constraints



(a) original



(b) retargeted



(c) with constraints

Warping-based Methods

Warping-based Methods

- View the image as a continuous domain
- Performs a continuous geometric deformation to fit the image into the new desired shape
- *Non-homogeneous* warps that are adapted to the image content

Discretization

- Quad mesh
- Triangular mesh

Quad Mesh

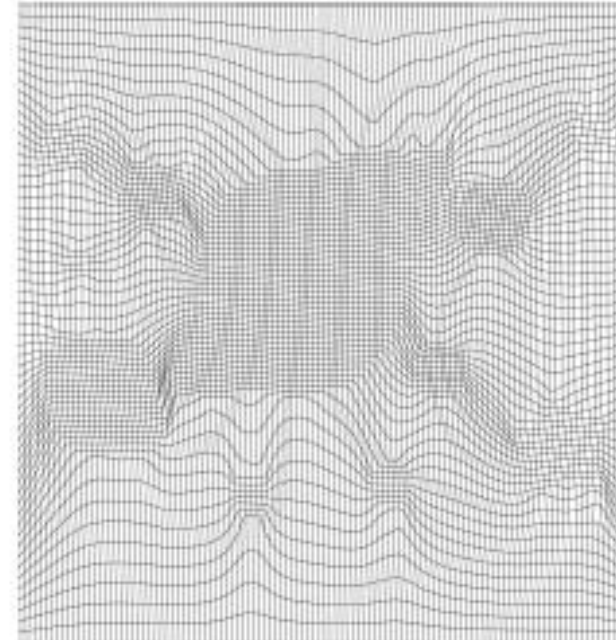
- [Gal et al. 2006]



input image and its feature mask



vertical stretch $\times 2$



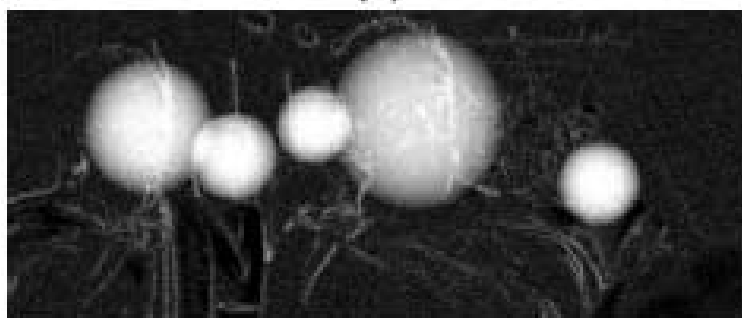
underlying grid



(a)



(c)



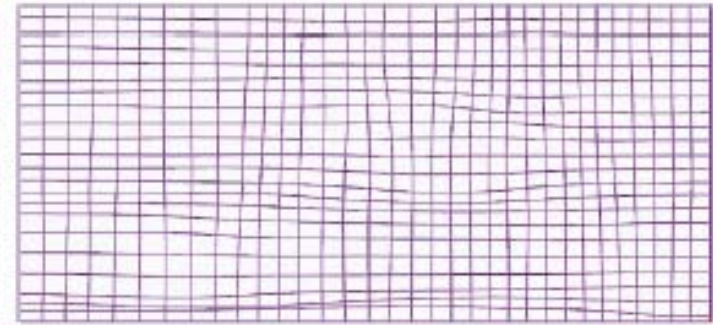
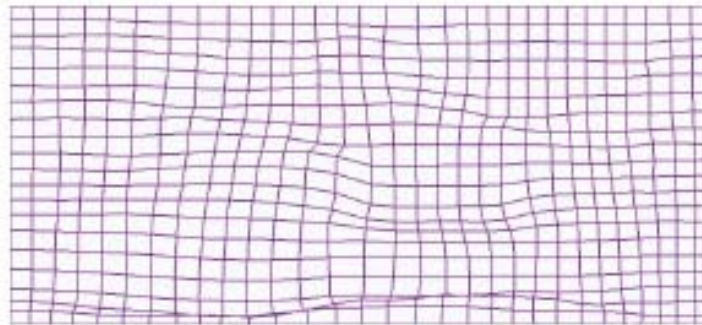
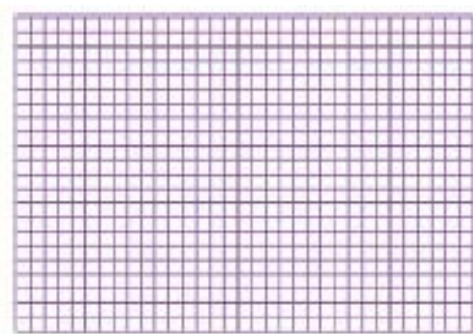
(b)



(d)

Quad Mesh

- [Wolf et al. 2007, Wang et al. 2008, Karni et al. 2009]



original image and mesh grid

scale-and-stretch [Wang et al. 2008] result without line bending energy

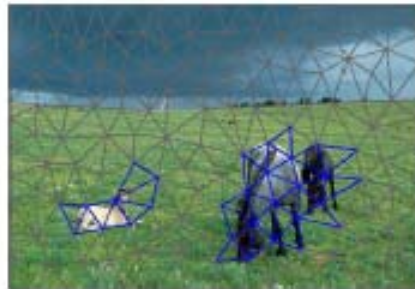
scale-and-stretch with added line bending term

Triangular Mesh

- Based on mesh parameterization
 - [Guo et al. 2009]



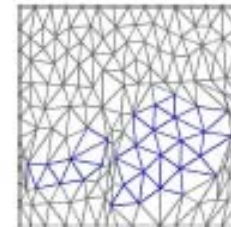
(a)



(b)



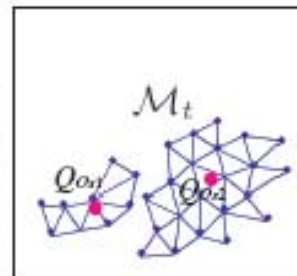
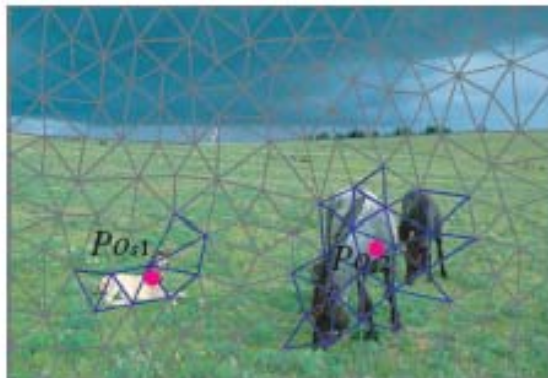
(c)



(d)



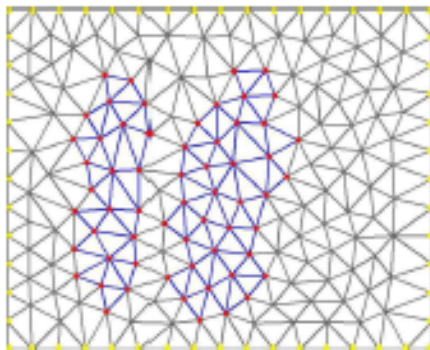
(e)



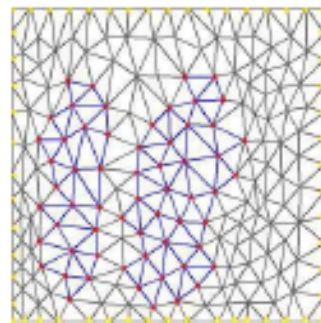
Input



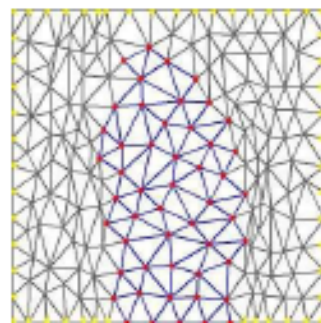
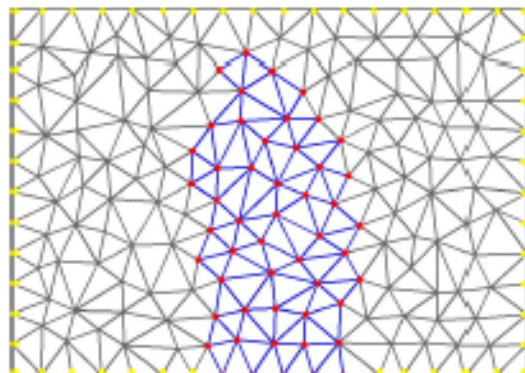
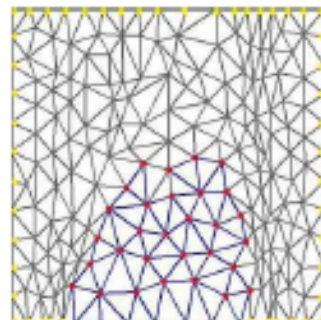
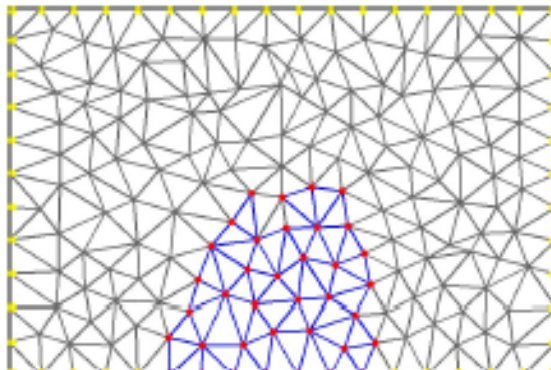
Mesh



Target mesh

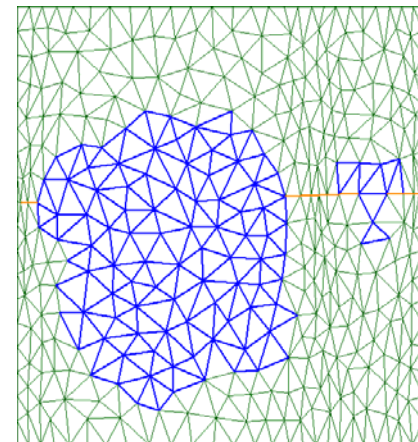
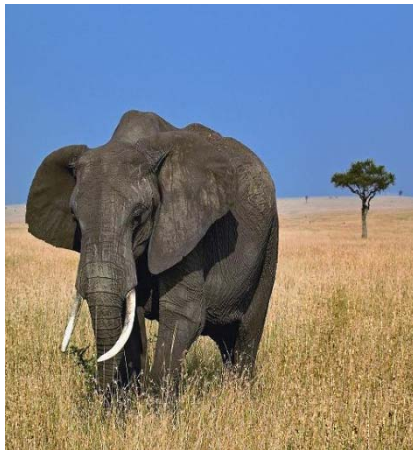
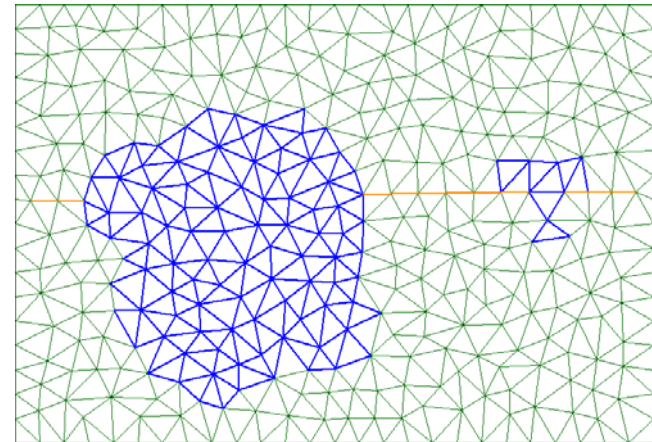


Our result



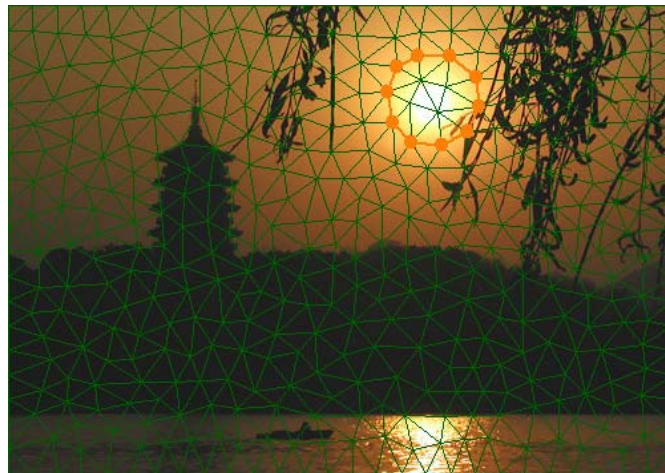
Scaling Optimization

- [Jin et al. 2010]

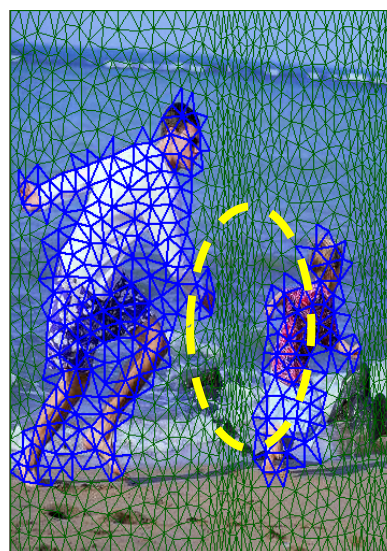
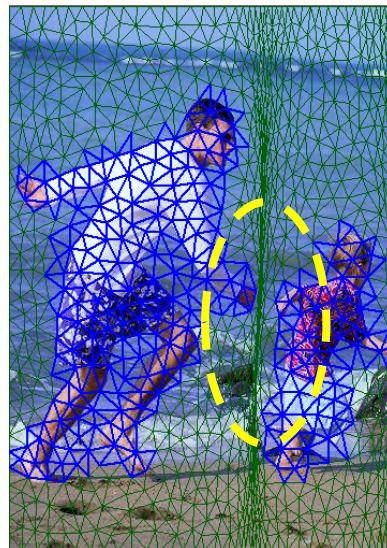


Feature Constraints

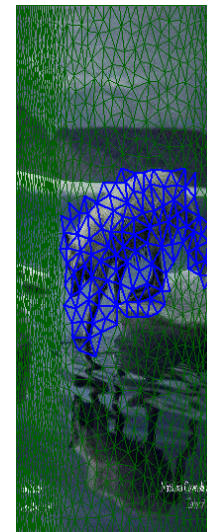
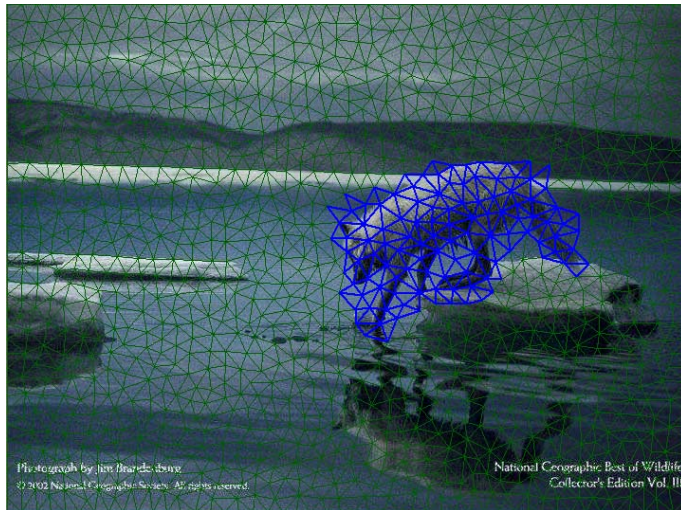
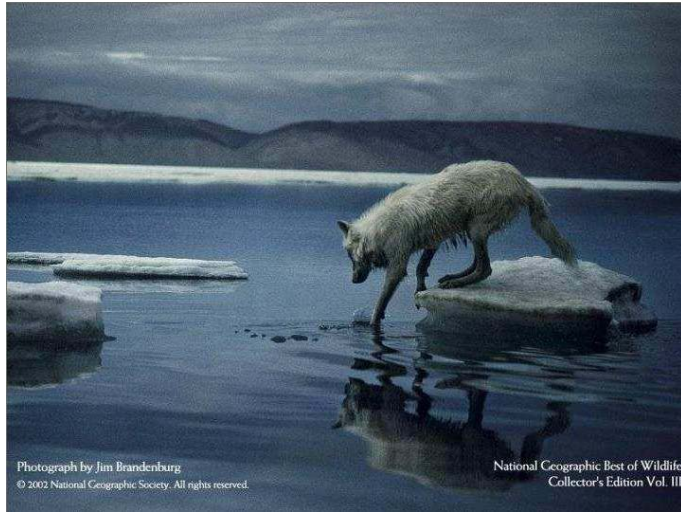
- Lines
- Circles
- Curves



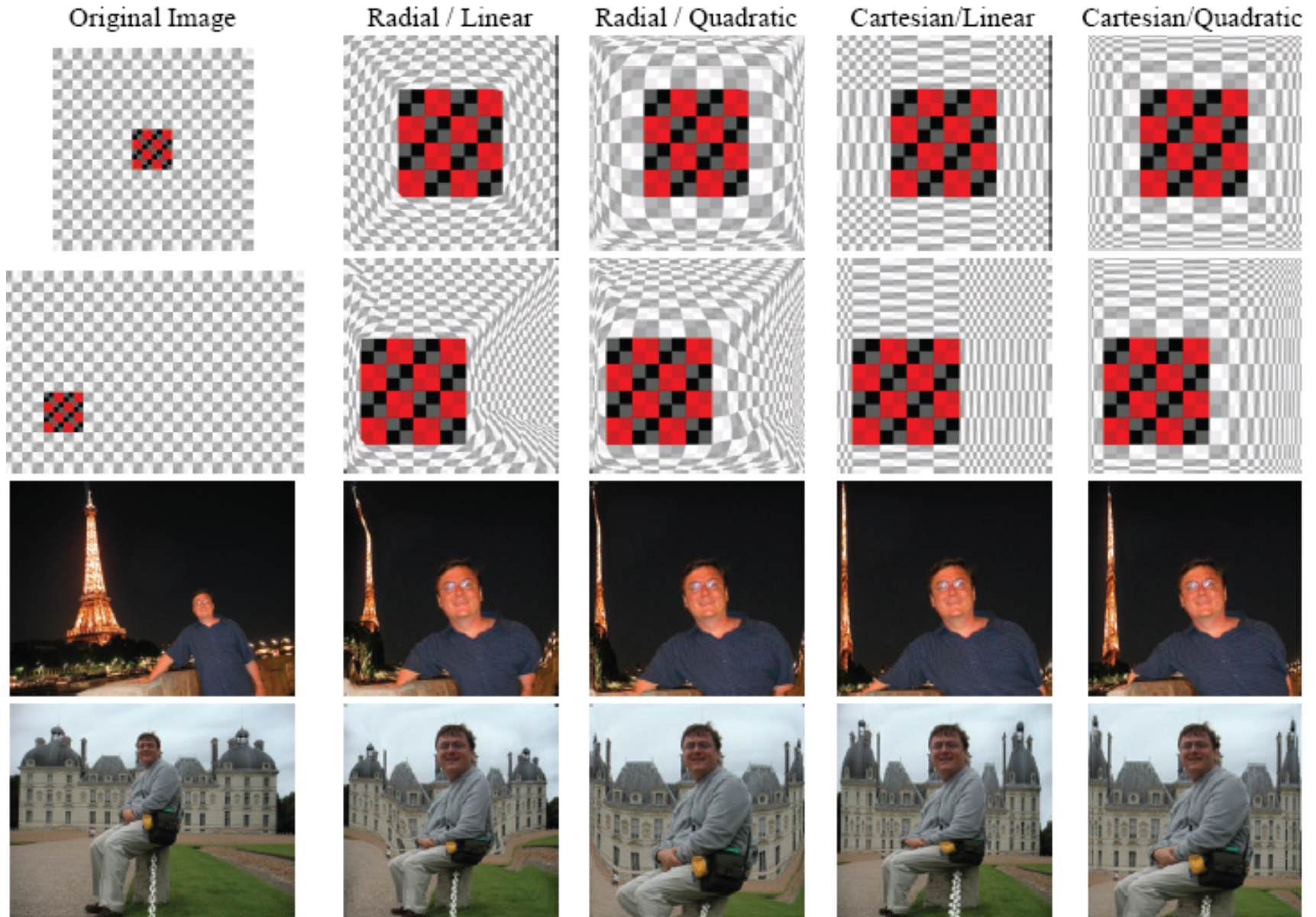
Foldover Free



Extreme Resizing



Fisheye-view Warping



Symmetry Preserving [Huang et al. 2009]

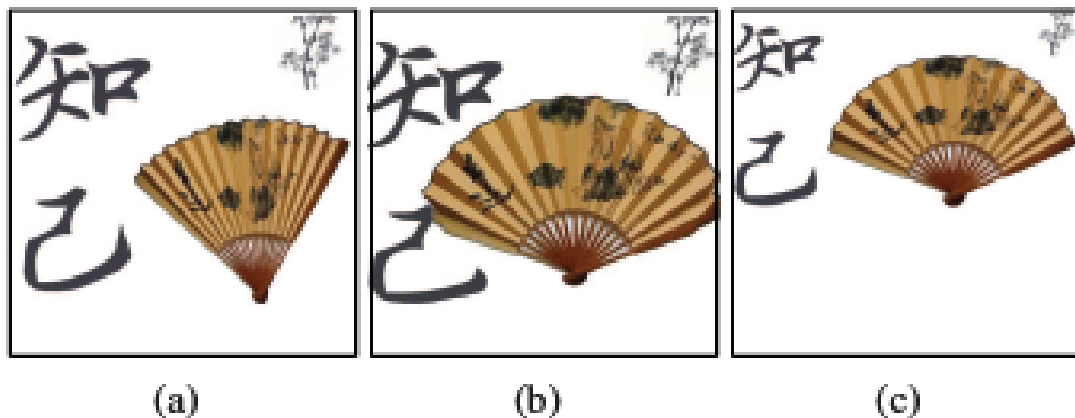


Figure 8: Comparison on resizing the Chinese art shown in Fig. 5(a). (a) Ours. (b) [AS07]. (c) [WTSLO8].

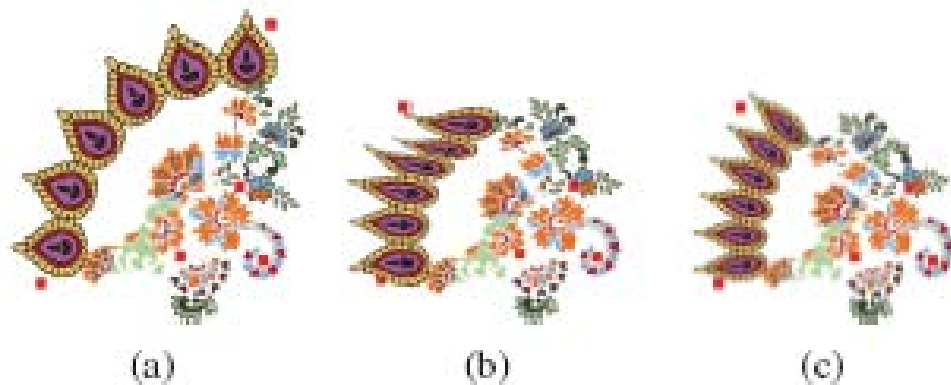


Figure 12: Warping a vector art that has a partial rotation symmetry. (a) Input. (b) Without preserving symmetry. (c) Preserving symmetry.

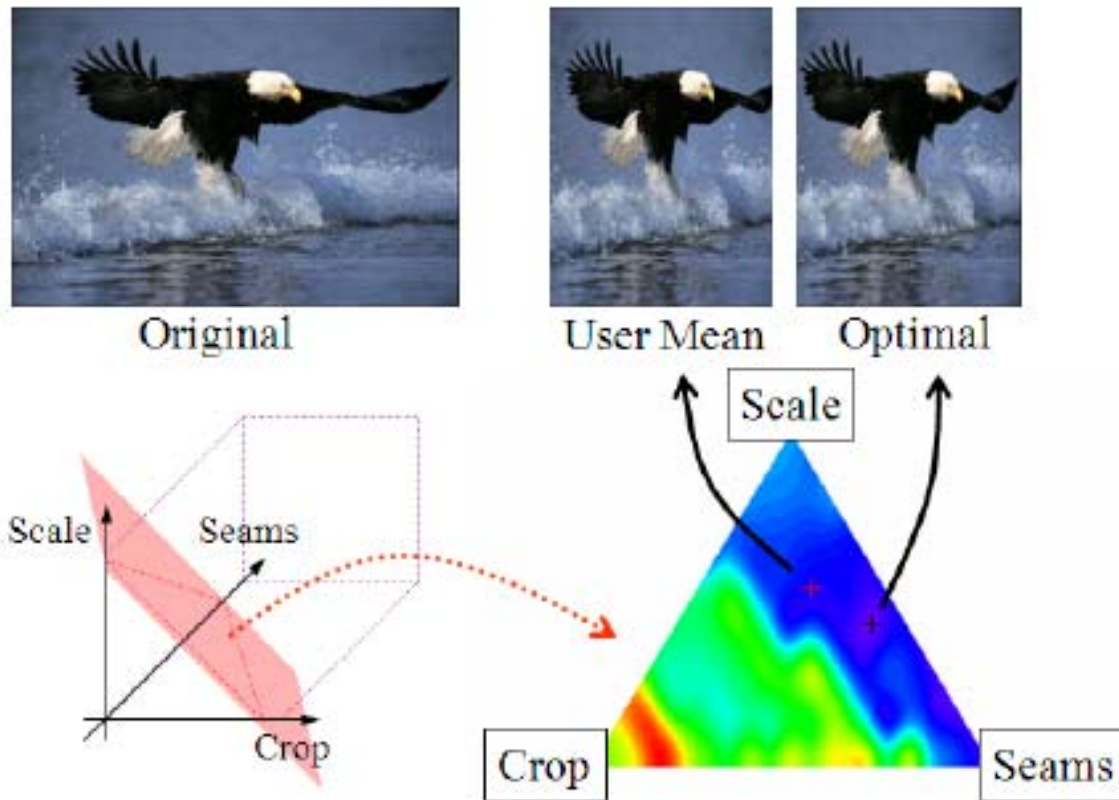
Combined Methods

Combined Methods

- Combine both warping-based and synthesis-based methods

Multi-operator Media Retargeting

- [Rubinstein et al. 2009]



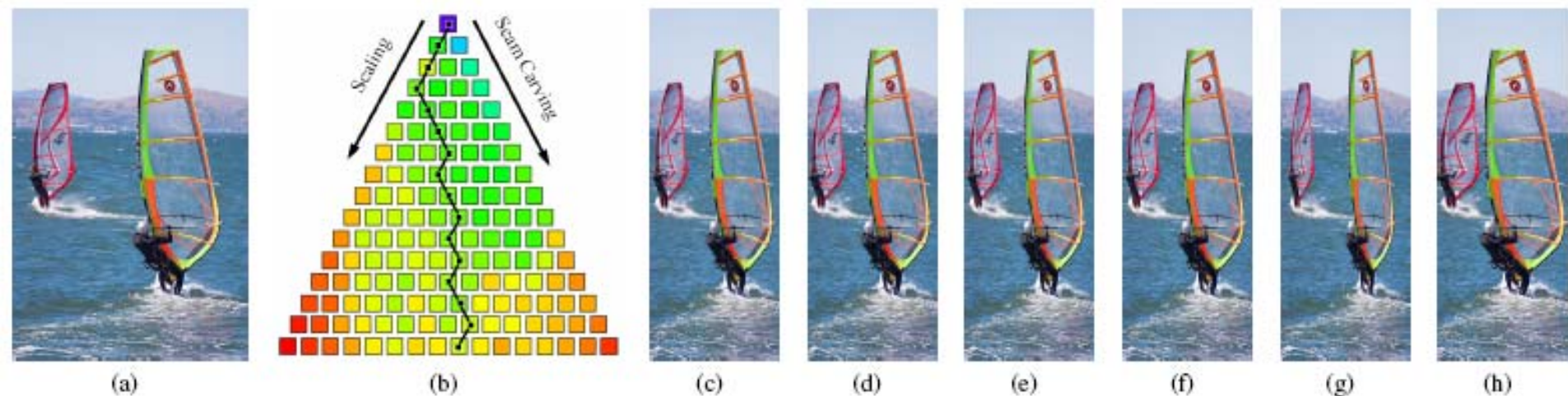


Figure 9: An illustration of the dynamic programming table used to optimize the search for the best *mixed* path using two operators only - seam carving (SC) and scaling (SL). The colors in table (b) indicate the BDW distance of the best image in each step. The original image is shown in (a) and the retargeted result is shown in (c) - this is the best result using a *mixed* path (i.e. the algorithm automatically determines the order of operators and how much each should contribute). The optimal operator sequence found is $\langle -30SL, -30SC, -10SL, -20SC, -10SL, -10SC, -10SL, -20SC, -10SL \rangle$. For comparison, we show the results of using two *regular* paths (d) $\langle -70SL, -80SC \rangle$ and (e) $\langle -80SC, -70SL \rangle$, and the optimal *regular* path (f) $\langle -90SC, -60SL \rangle$. (g) uses scaling and (h) seam carving.



Input



Multi-op



Scaling



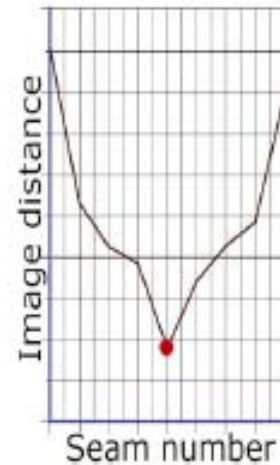
Seam Carving

Optimized Image Resizing Using Seam Carving and Scaling

- [Dong et al. 2009]



(a) Original



(f) Distance



(b) Seam carving



(c) Scaling



(d) Ours



(e) Dominant color

Results



(a) Original image

(b) Seam carving

(c) Scaling

(d) Our result

Aesthetic Retargeting

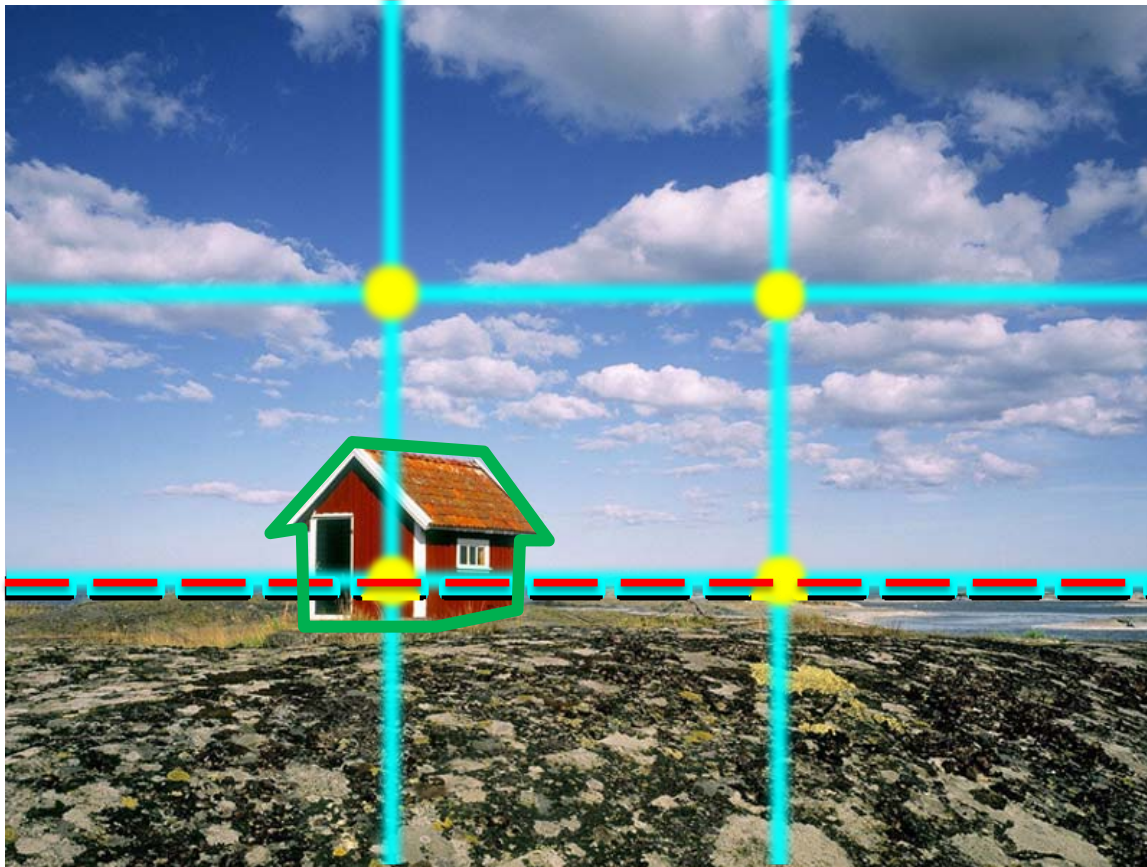
[Liu et al. 2010]

- Considering aesthetics (photo composition)
 - The pleasing selection and arrangement of visual elements within the picture frame
- Cropping-retargeting operator



Basic Composition Guidelines (1)

- Rule of thirds

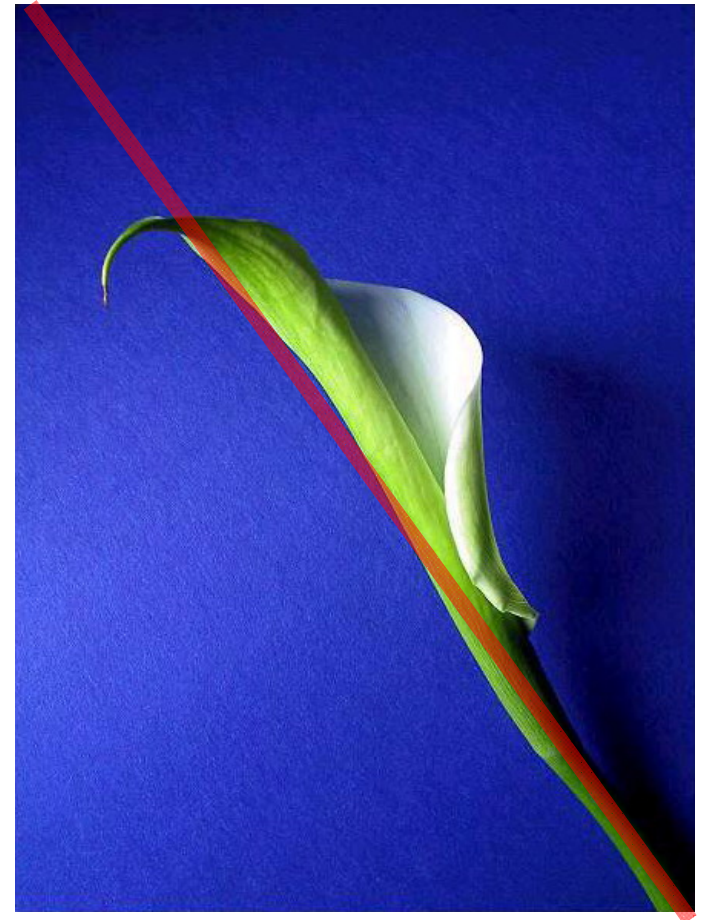
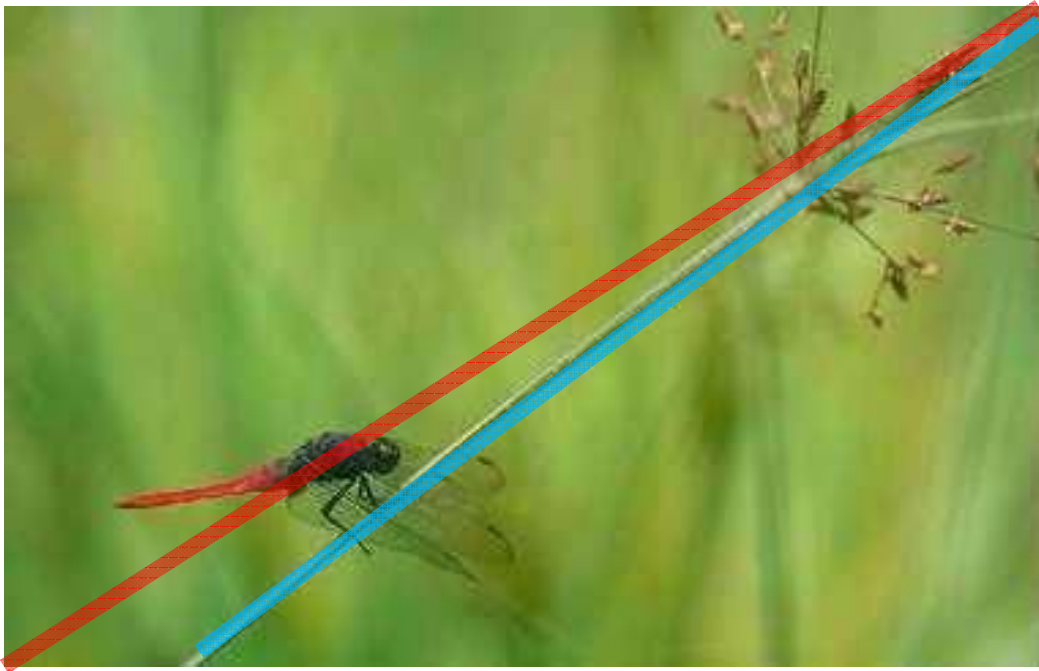


Power lines

Power points

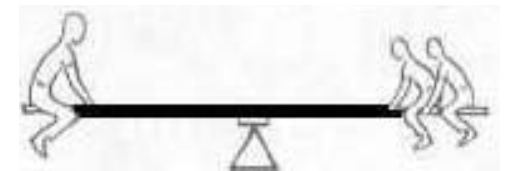
Basic Composition Guidelines (2)

- Diagonal dominance



Basic Composition Guidelines (3)

- Visual balance



Basic Composition Guidelines (4)

- Sizes of visual elements



Cropping+Retargeing

Cropping



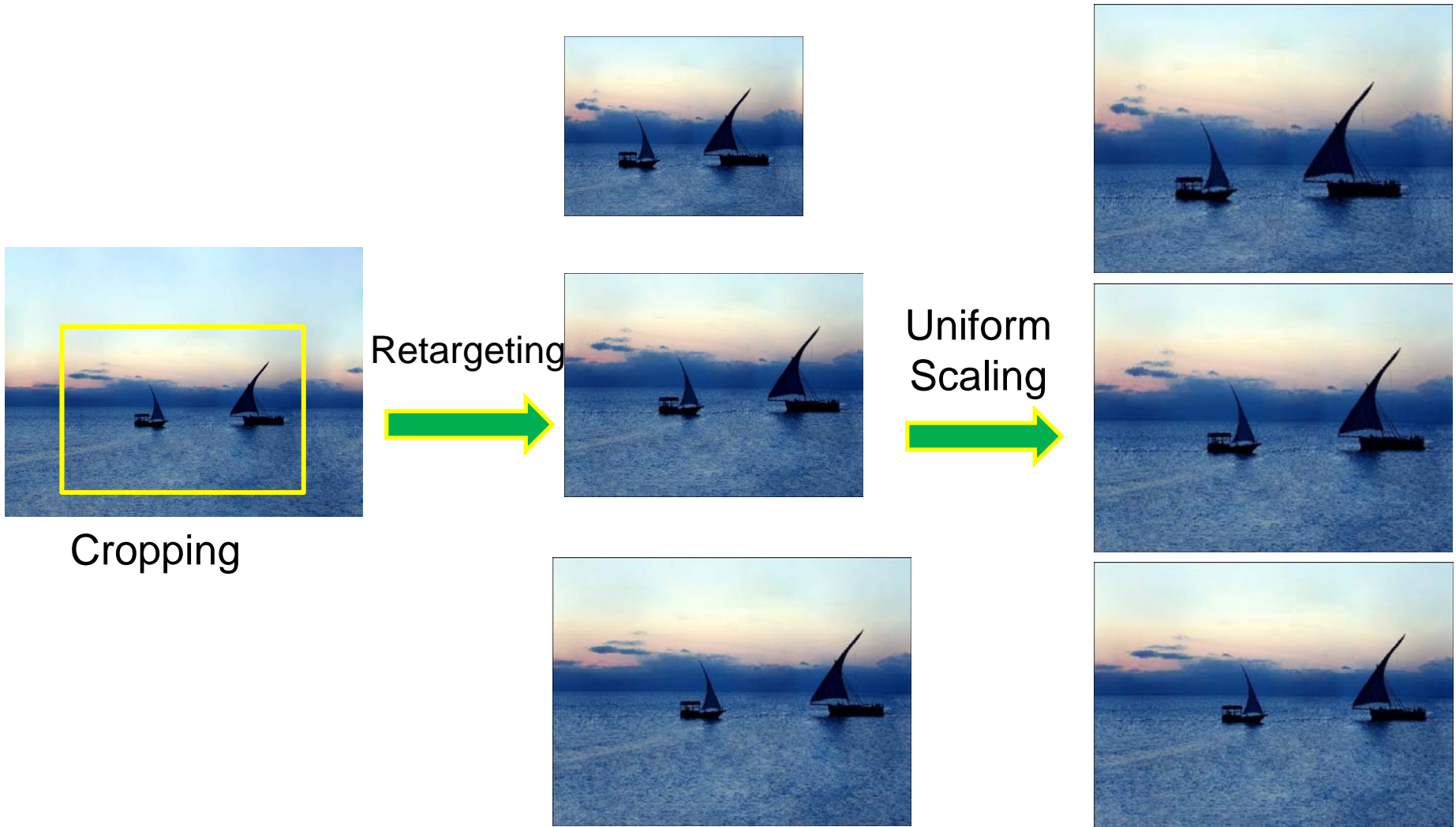
Removing
superfluous
regions

Retargeting

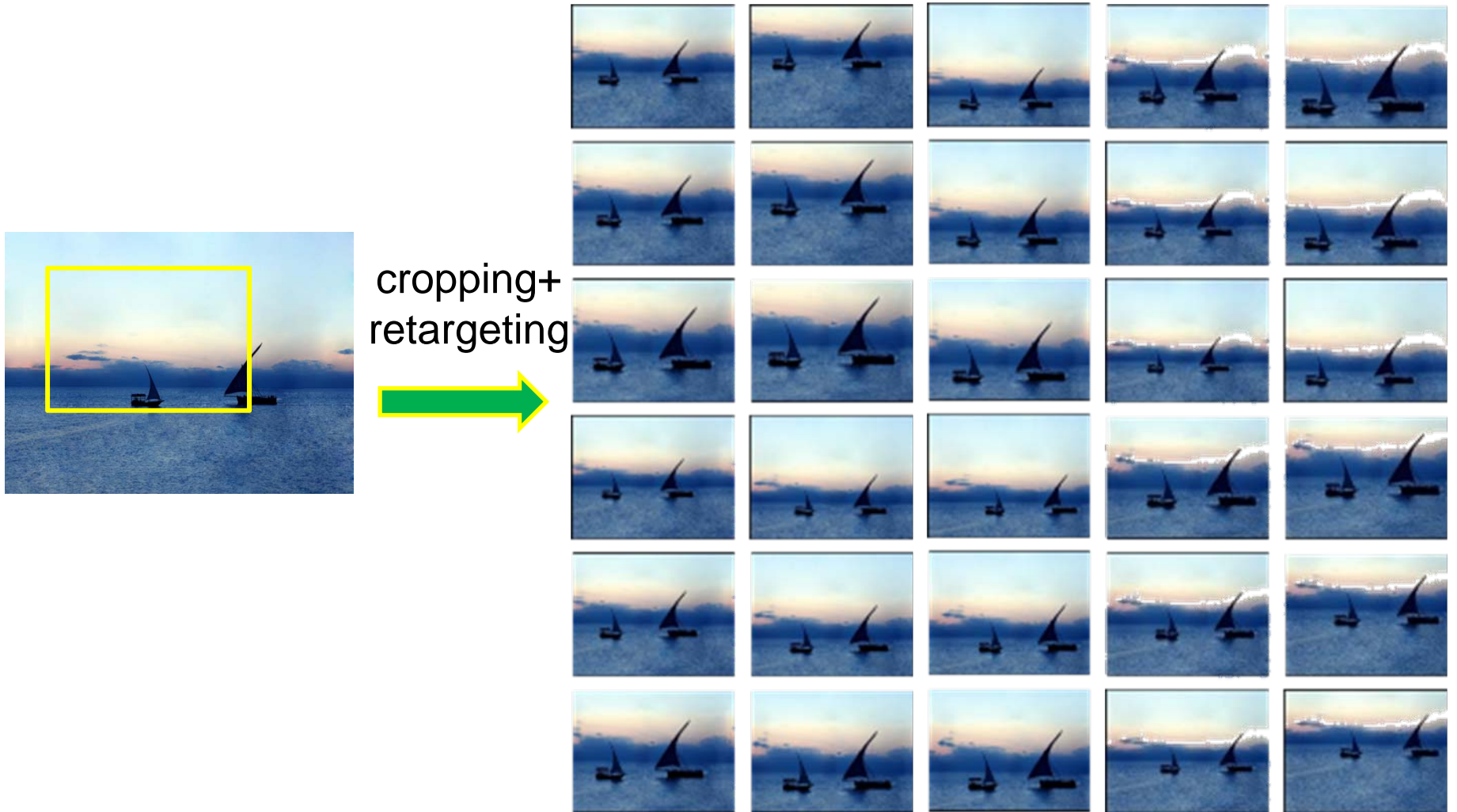


Changing
distances and
sizes

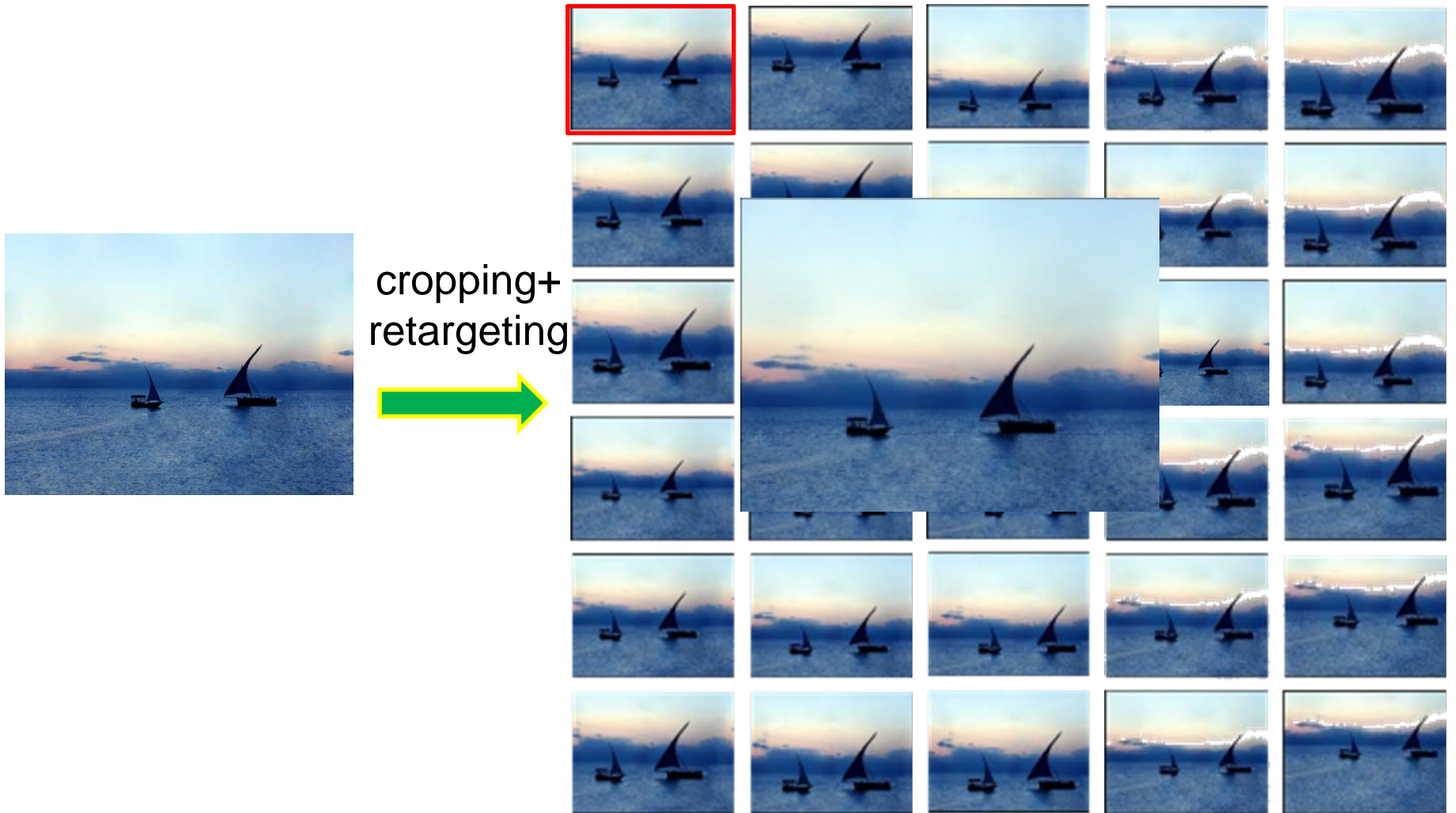
Cropping+Retargeting Operator



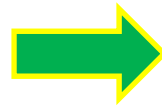
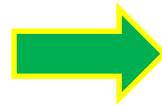
All Possible Cropping+Retargeting



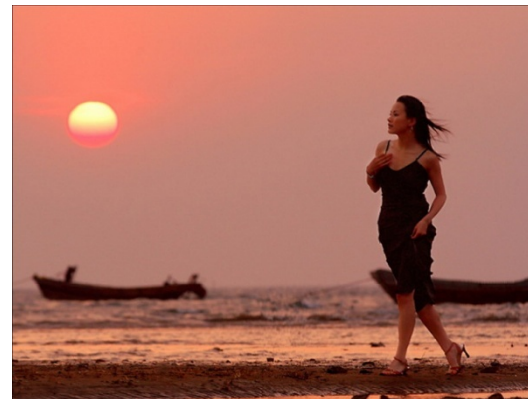
Searching the Optimal Result



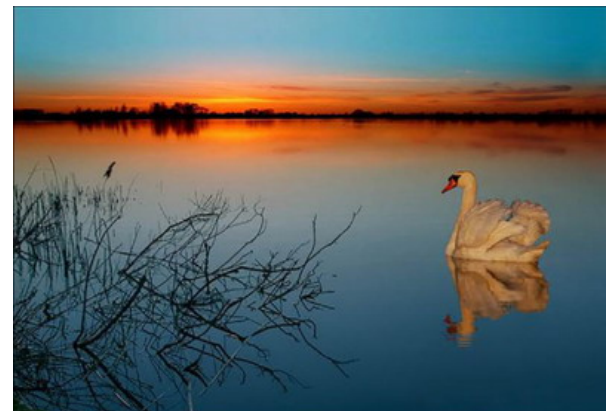
Results



More Results



More Results



More Results



A Comparative Study of Image Retargeting

- [Rubinstein et al., Siggraph Asia 2010]
- Benchmark and evaluation methodology for image retargeting
 - 80 (classified) images
 - 8 retargeting operators, 6 objective measures
 - 600+ participants and counting
 - 400+ human hours, 28000+ user votes
 - 1 graduate student...



<http://people.csail.mit.edu/mrub/retargetme/>

Retargeting Operators

- | | | |
|-------------------------------------|--------------------------|------------|
| • Seam Carving [SC] | [Rubinstein et al. 2008] | Discrete |
| • Shift Map [SM] | [Pritch et al. 2009] | |
| • Multi-Operator [MULTIOP] | [Rubinstein et al. 2009] | |
| • Warping [WARP] | [Wolf et al. 2007] | Continuous |
| • Streaming Video [SV] | [Krähenbühl et al. 2009] | |
| • Scale-and-Stretch [SNS] | [Wang et al. 2008] | |
| • Cropping [CR] | [Manual] | Reference |
| • Scaling [SCL] | [Cubic interpolation] | |

Comparative Analysis

Source	CR	SV	MULTIOP	SC	SCL	SM	SNS	WARP
								
[1] ArtRoom (0.75width)	CR				SCL	SM	SNS	WARP
								
[3] Brasserie L Aficion (0.50width)	CR	SV	MULTIOP	SC	SCL	SM	SNS	WARP



CR SV MULTIOP SC SCL SM SNS WARP

Summary

- Dataset and evaluation methodology for image retargeting
- Analysis of 8 retargeting operators
 - SV, CR, MULTIOP methods more favorable than others
 - Viewers highly sensitive to deformations
 - Optimal cropping is still a valid research direction!
 - Invariant to presence of source content
- Analysis of 6 image distance measures
 - More work needed on retargeting measures
 - EMD, SIFT-flow showed better correlation with users' choices
 - Optimize retargeting w.r.t EMD SIFT-flow and EMD?
 - Training a metric?

Using the Dataset

- Images, retargeting results, user data and metric data freely available online
- Objective measure can be evaluated directly against ground truth
- Perceptual evaluation of retargeting operator requires a user study
 - Survey system source code available online
 - Supports MTURK, as well as additional experiment designs
- Share your (published) results!

More Retargeting Content

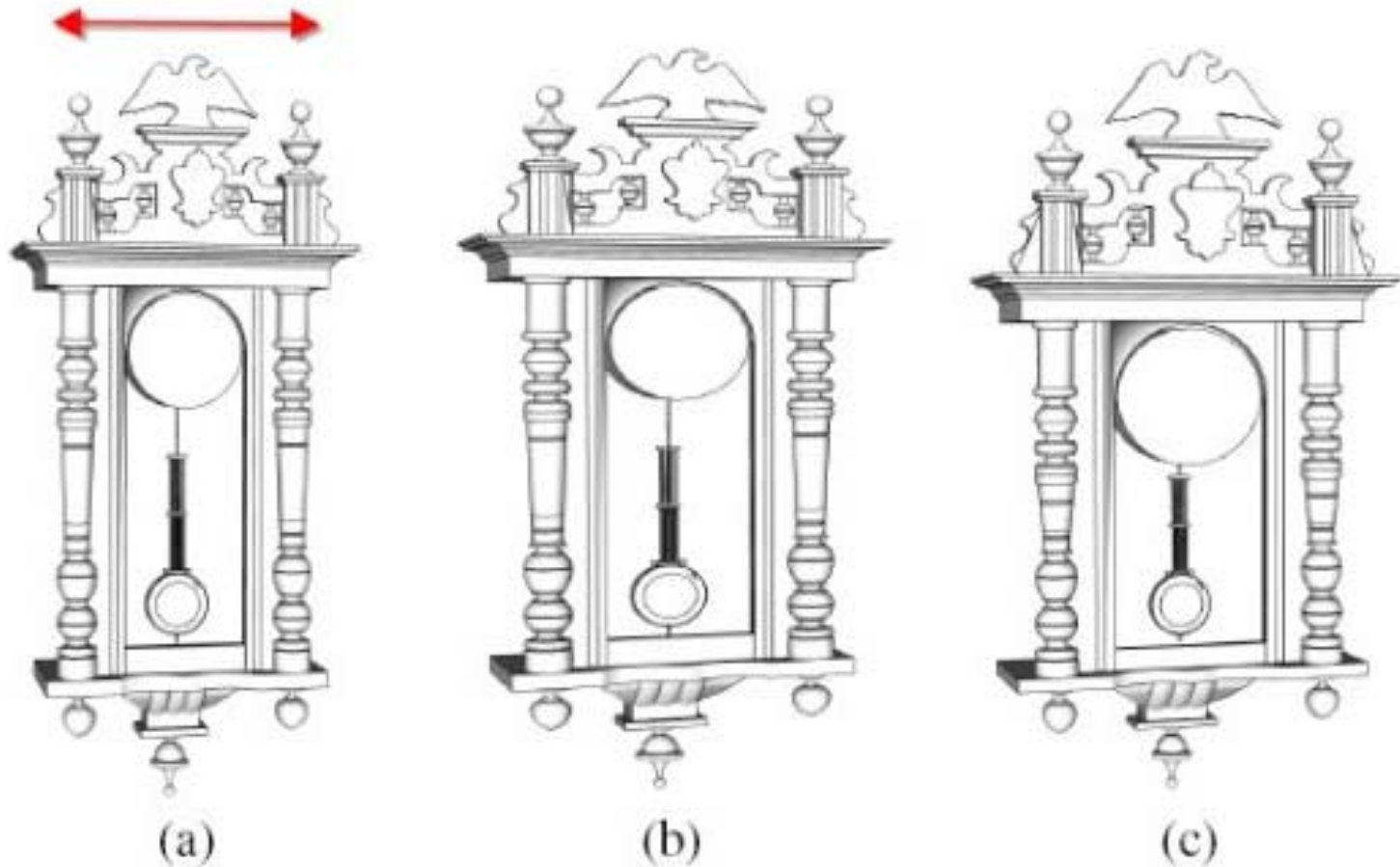
Video Retargeting

- Lots of papers!!
 - Siggraph (Asia), Eurographics, CVPR, ICCV...
- Extend image retargeting into video content
 - Key: frame coherences

Geometry Retargeting

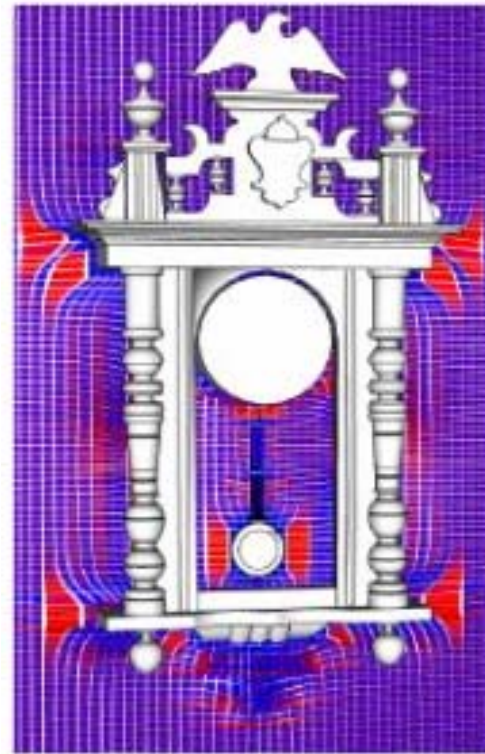
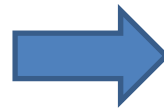
Non-homogeneous Resizing of Complex Models

- [Siggraph Asia 2008]

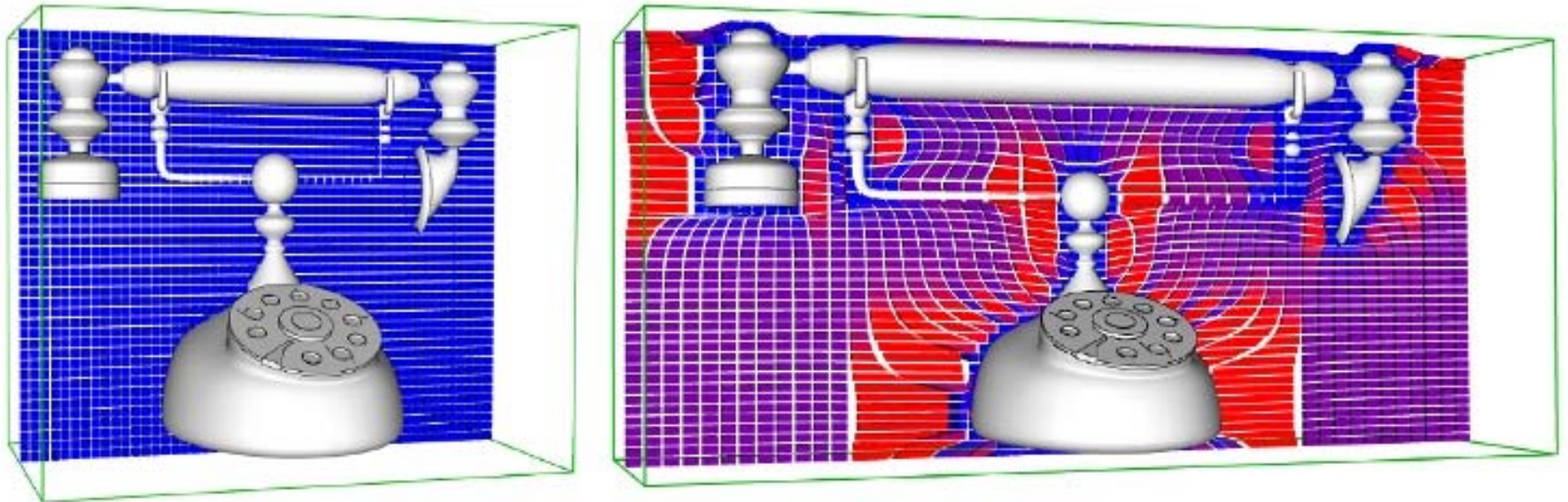


Mechanism

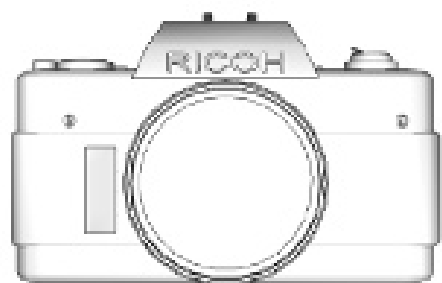
- Embedding the object into a protective grid
- Deform the protective grid



Protective Grid



Example

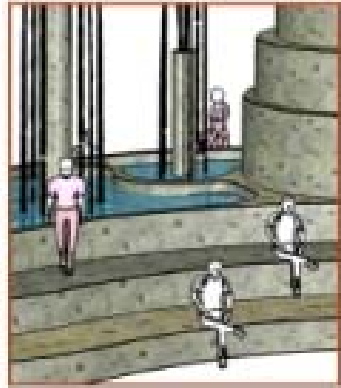
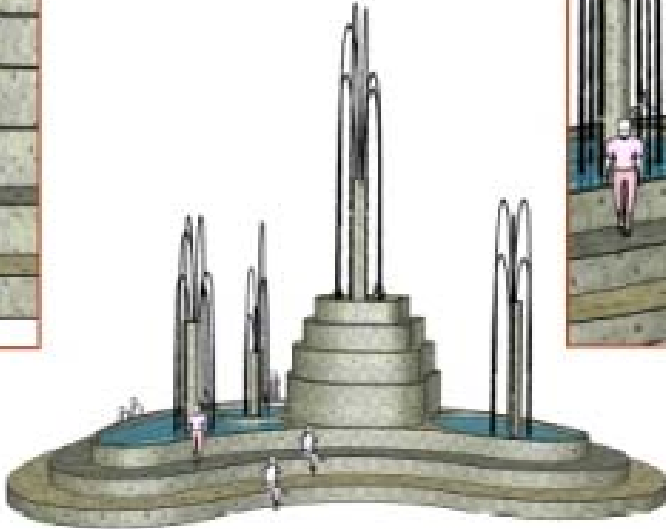
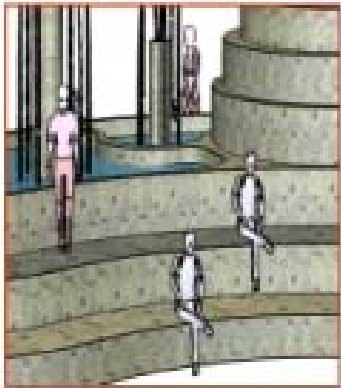
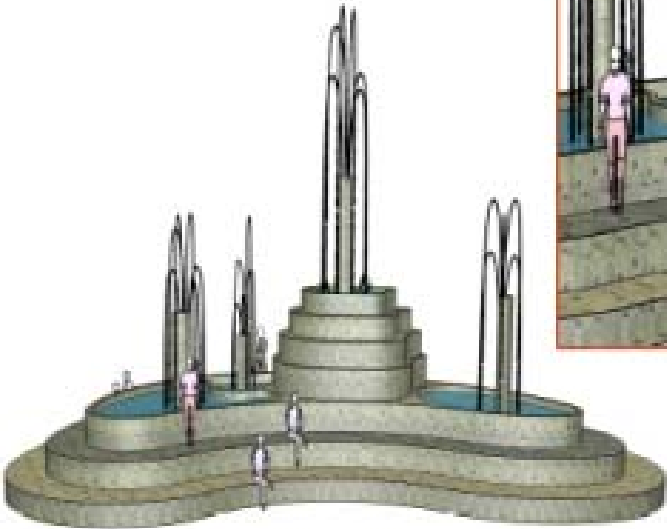
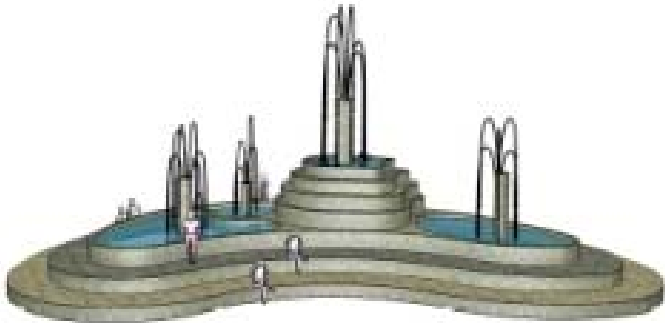


Original

Scaled

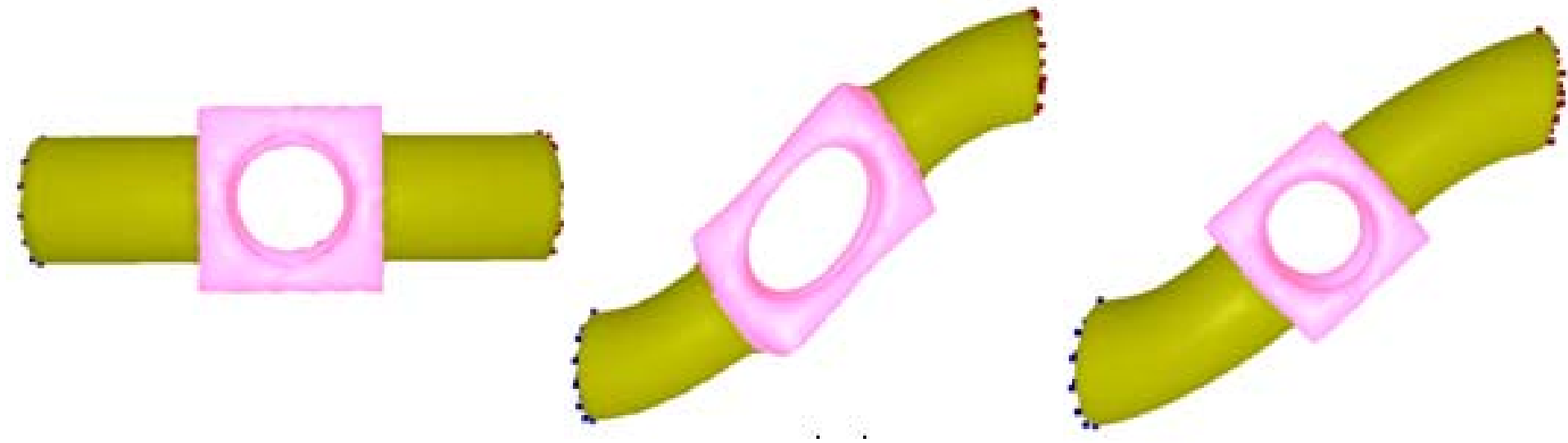
Shape-aware

Example



保持特征区域的曲面编辑方法

- [CAD学报2011]



Laplacian method

Feature aware

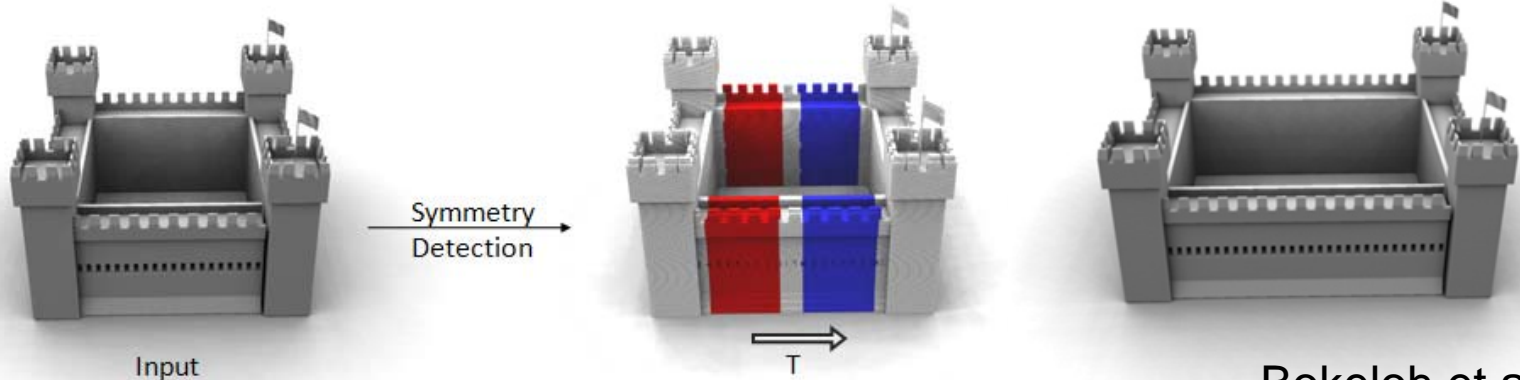


Laplacian method



Feature aware

Retargeting of regular structures



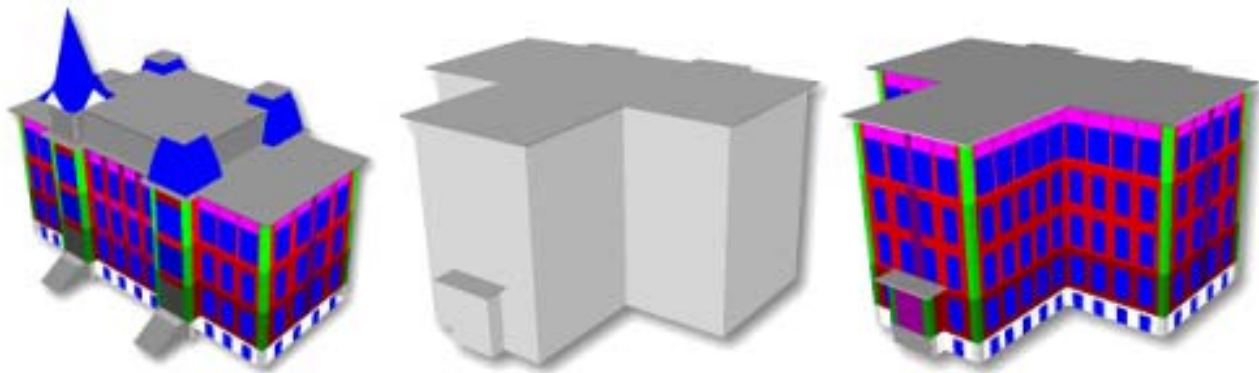
Bokeloh et al. 2010



Bokeloh et al. SIGA 2011

Rely on the dominant regularity in the input structure

Retargeting of regular structures



Aliaga et al. 2007

Model $M \rightarrow$ (base) (ground) $\{ S_0 S_1 \dots S_{N-1} \}$ (roof)

Floor $S \rightarrow \{ F_1 F_2 \dots F_M \}$

Face $F \rightarrow \{ C_1 C_2 \dots C_P \}$

Column $C \rightarrow \{ T_1 T_2 \dots T_R \}.$

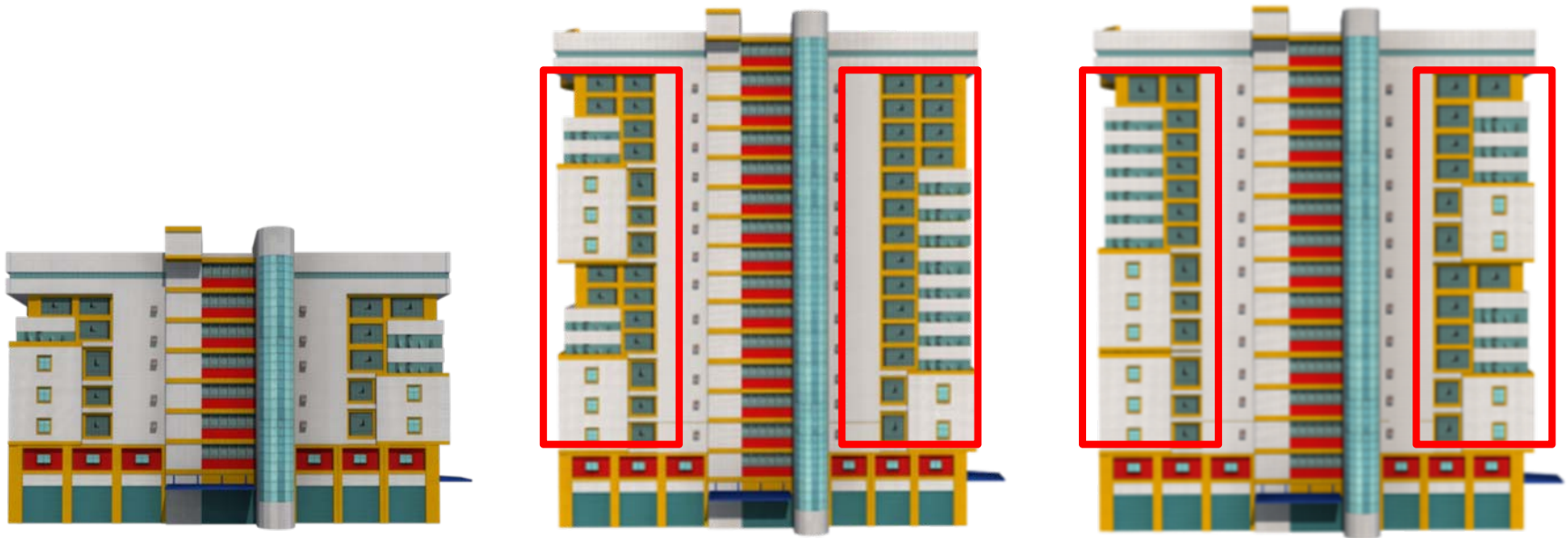
Retargeting of irregular structures



The input irregularity is not easy to predefine



Retargeting of Irregular Structures



The output irregularity relies on the semantic understanding of the structure

Retargeting of Irregular 3D Architecture

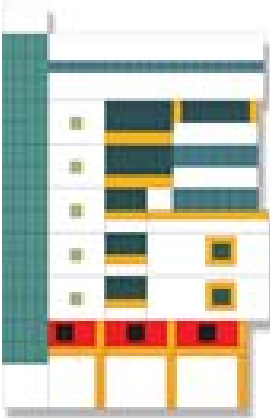
- [Lin et al. Siggraph Asia 2011.]



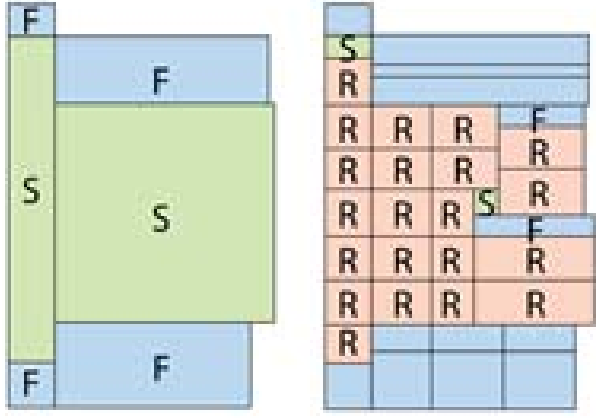
Create variations by structure-preserving retargeting



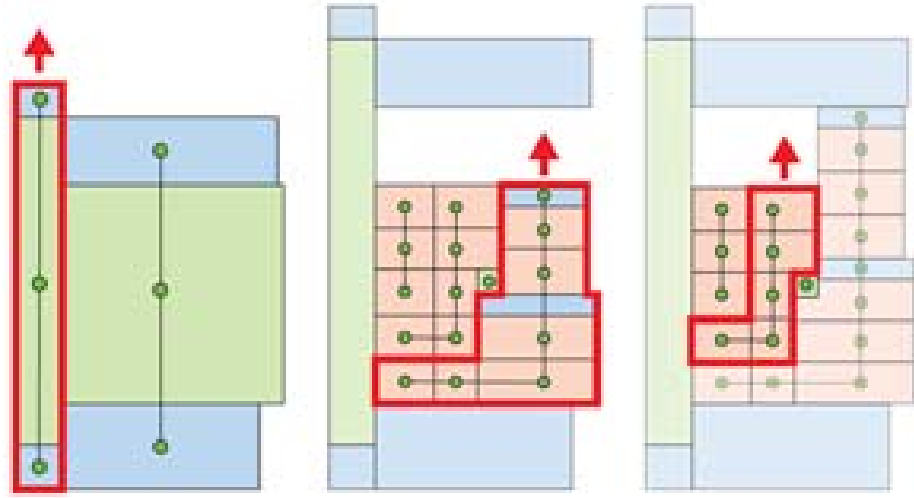
Algorithm



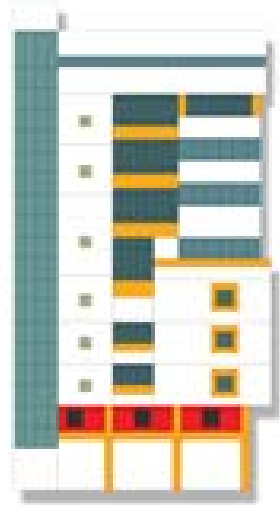
(a) Input



(b) Box hierarchy & Behavior attributes

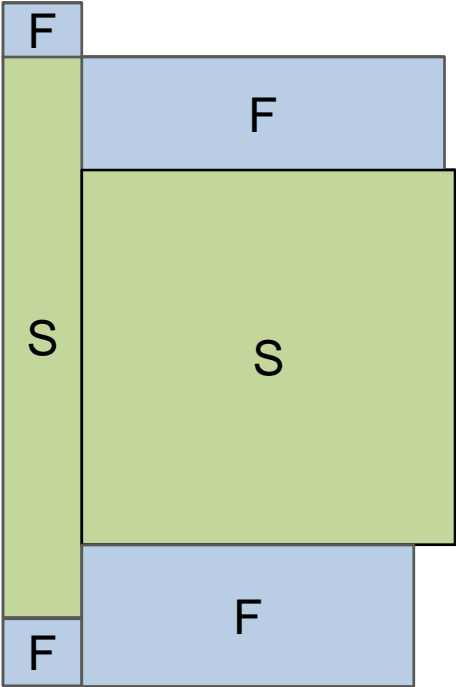
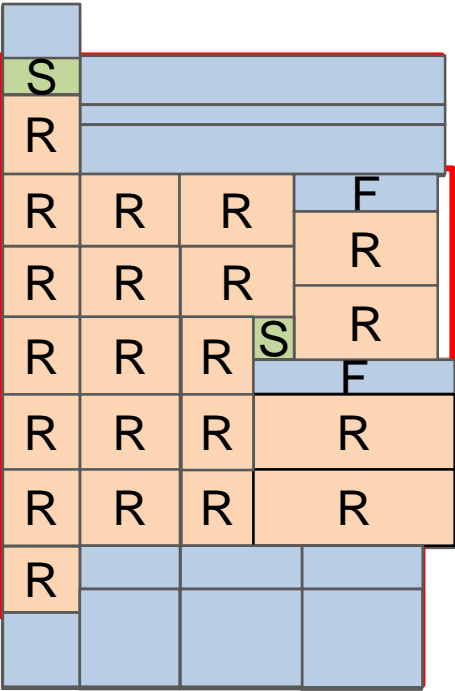


(c) Retargetable sequences & Retargeting order



(d) Retargeting results

Construct tagged box hierarchy



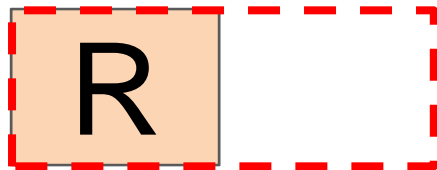
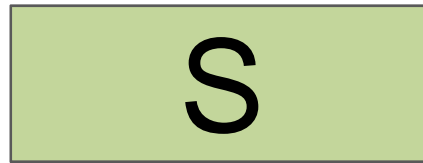
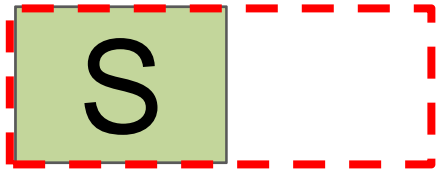
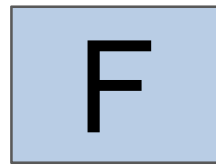
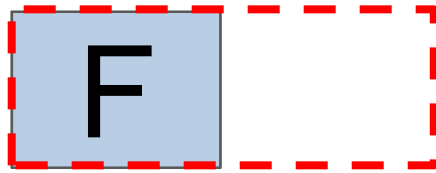
Partitioning

Grouping

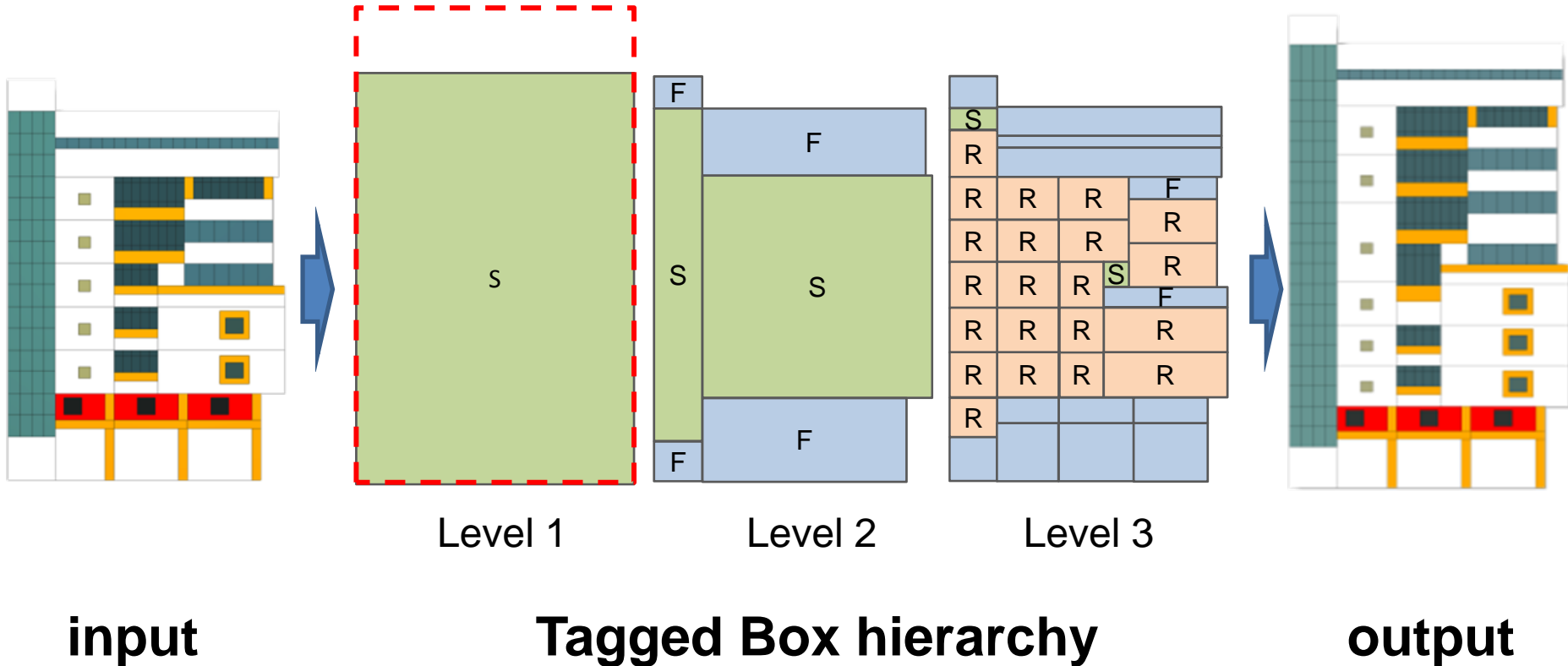
Tagging

Retargeting behavior attributes

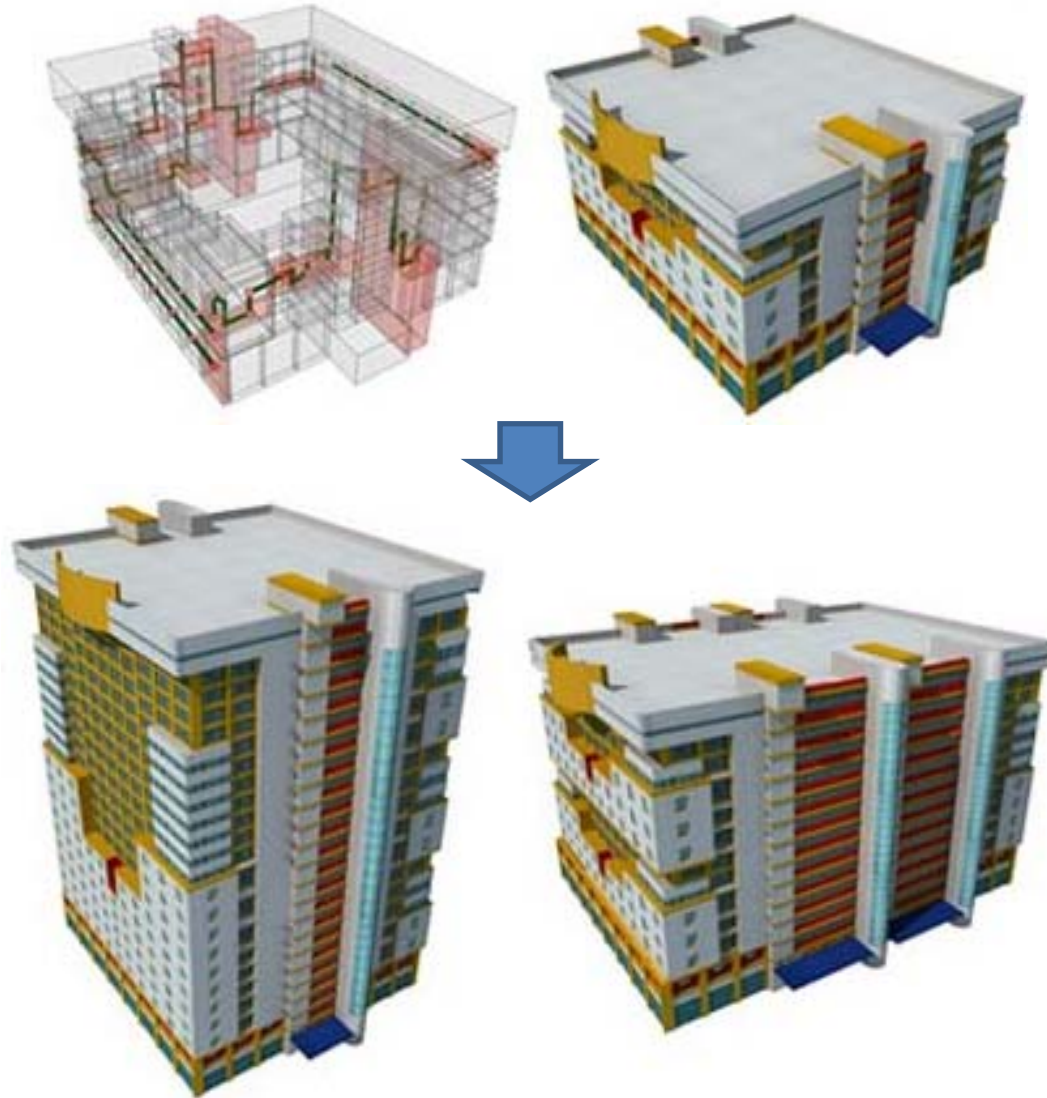
- **F**-box: stay intact
- **S**-box: can only be scaled
- **R**-box: can be replicated or deleted

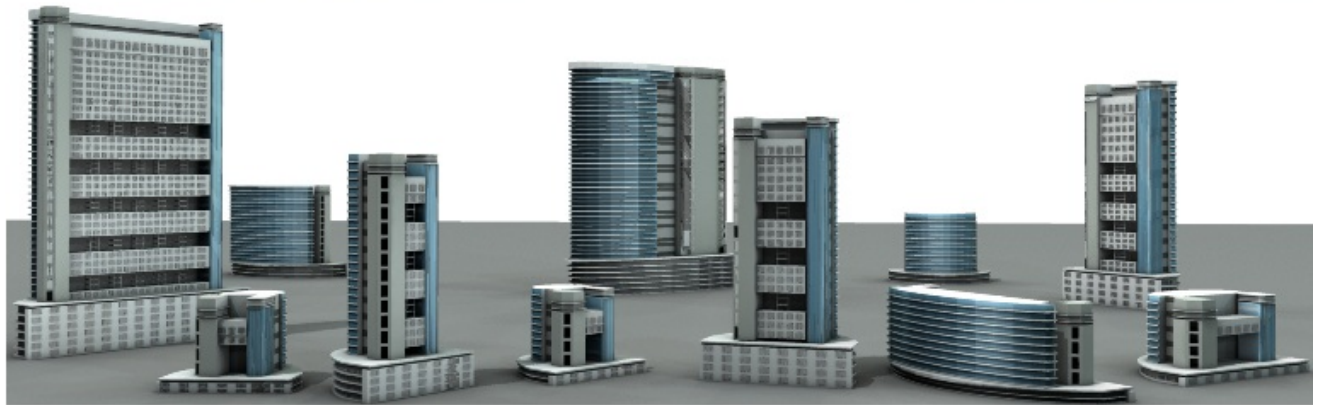


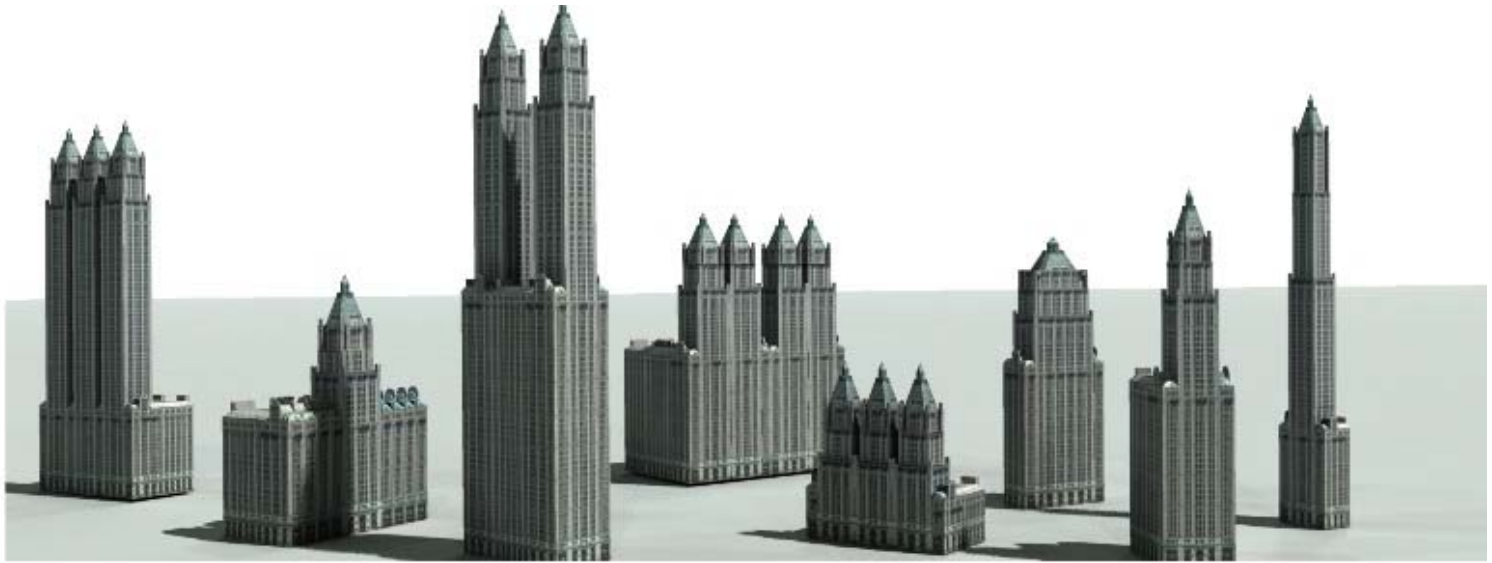
The retargeting problem



Example



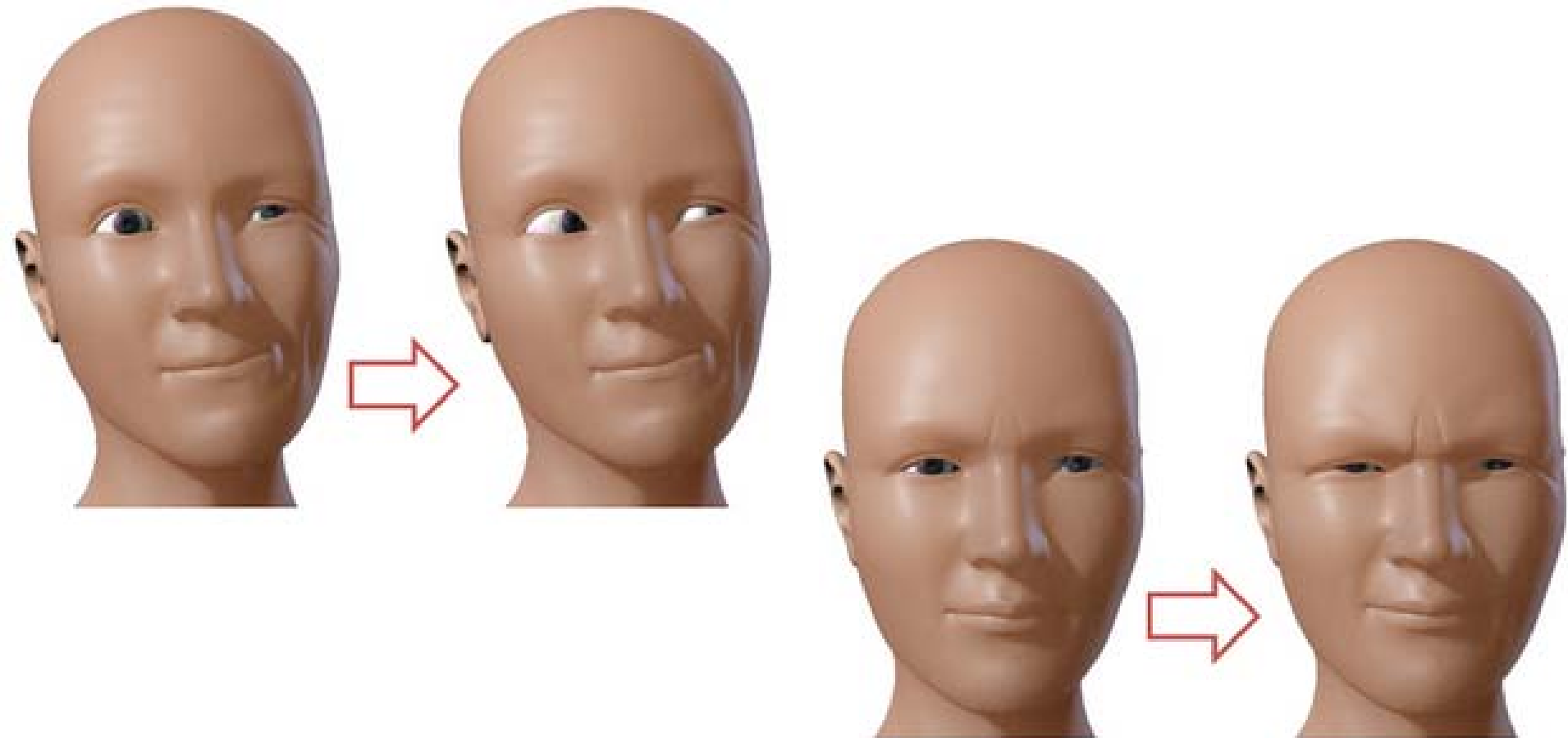




Animation Retargeting

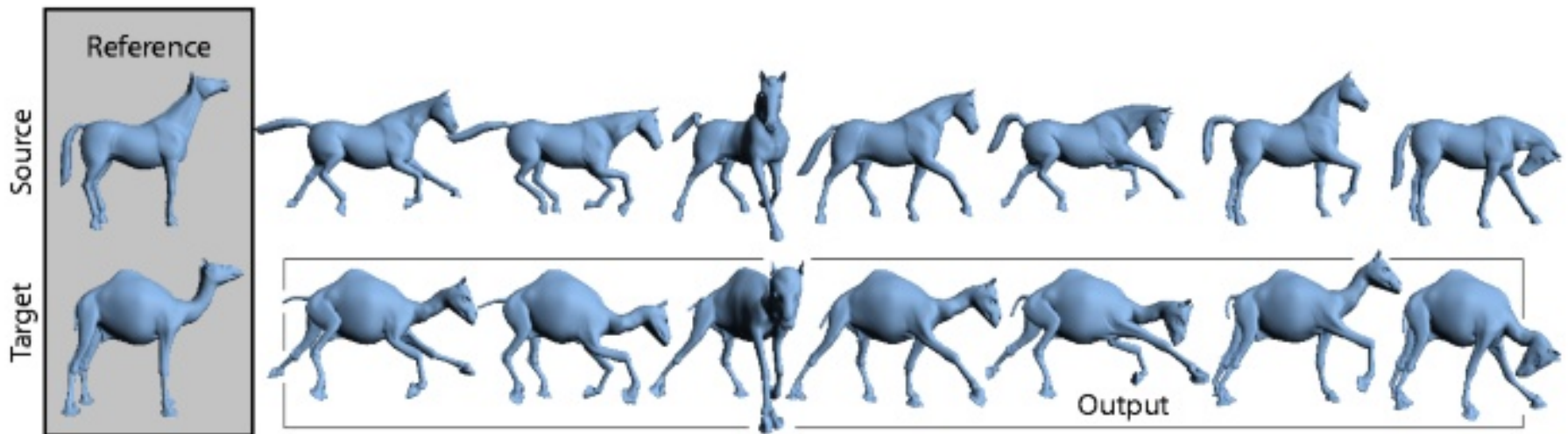
Facial Animation Retargeting

- [Seol et al. Siggraph Asia 2011]



Deformation Retargeting

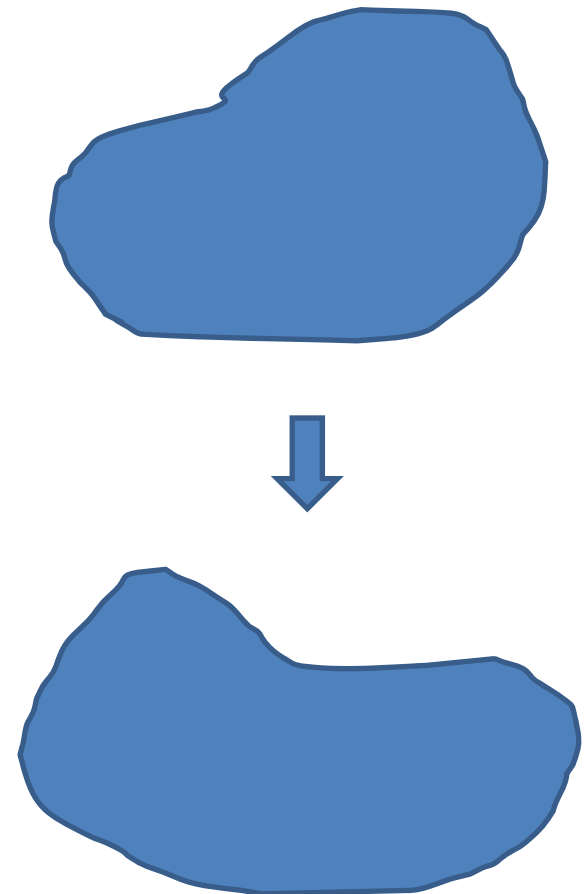
- [Deformation transfer, Siggraph 2004]



Summary

Retargeting Problems

- Various retargeting problems
 - Different **domains**
 - **Content** preserving
- Domains and contents
 - Image
 - Video
 - Geometry
 - Animation
 - Volume
 - ...



Discussions