



**Graphics Interface 2010**  
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# Interactive Content-Aware Zooming

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# Context

- Easy-to-produce high-resolution images
- Wide range of display devices
- Traditional zooming has limitations



# Problem statement

- How can we *effectively* navigate into high-resolution images using small display devices?
- How can we do better than Traditional Zooming?
  - Remove black bands
  - Easily locate significant regions
  - Should remain intuitive

# State of the Art

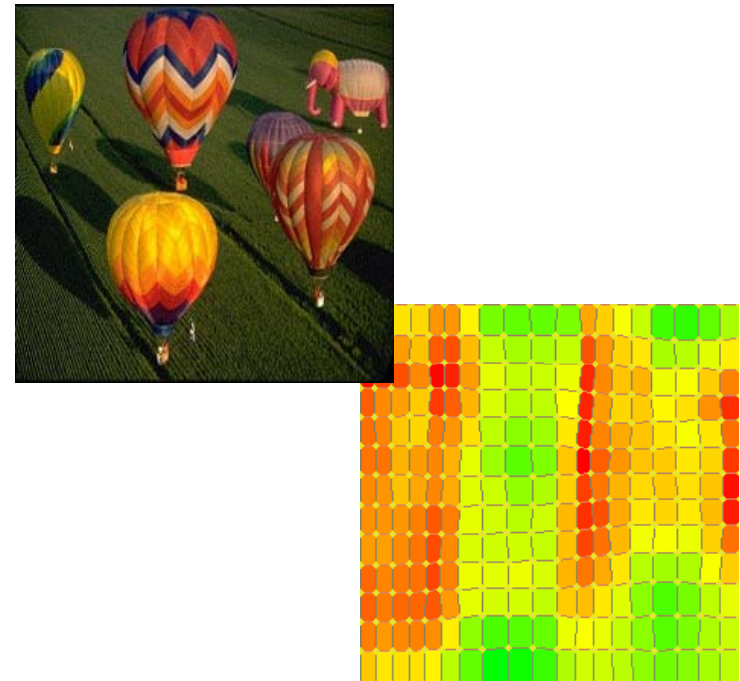
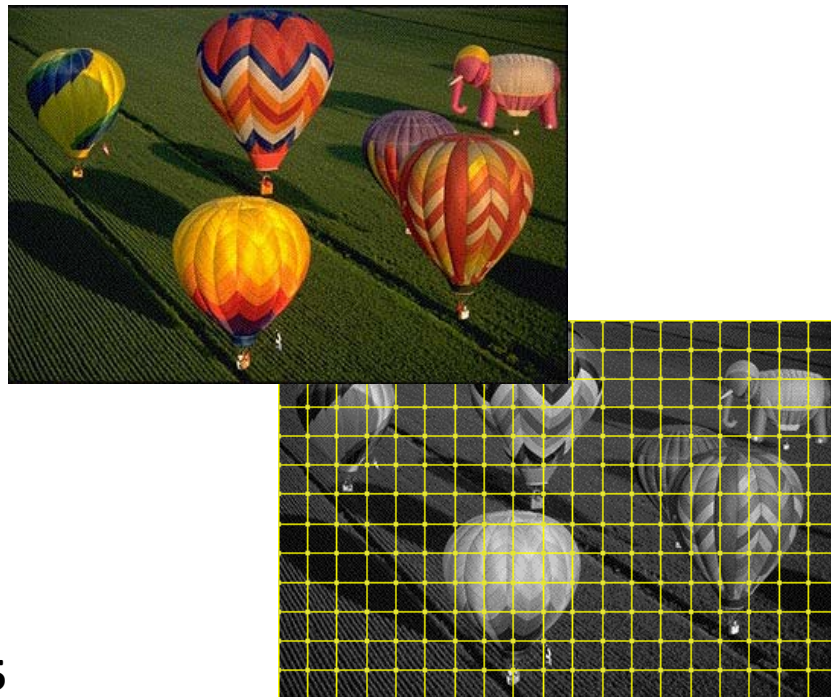
- Content-Aware Image Retargeting
  - Re-arrange image content to fit target size
  - Seam Carving

[Avidan 2007]



# State of the Art

- Content-Aware Image Retargeting
  - Re-arrange image content to fit target size
  - Seam Carving [Avidan 2007]
  - Mesh Warping [Wang 2008]



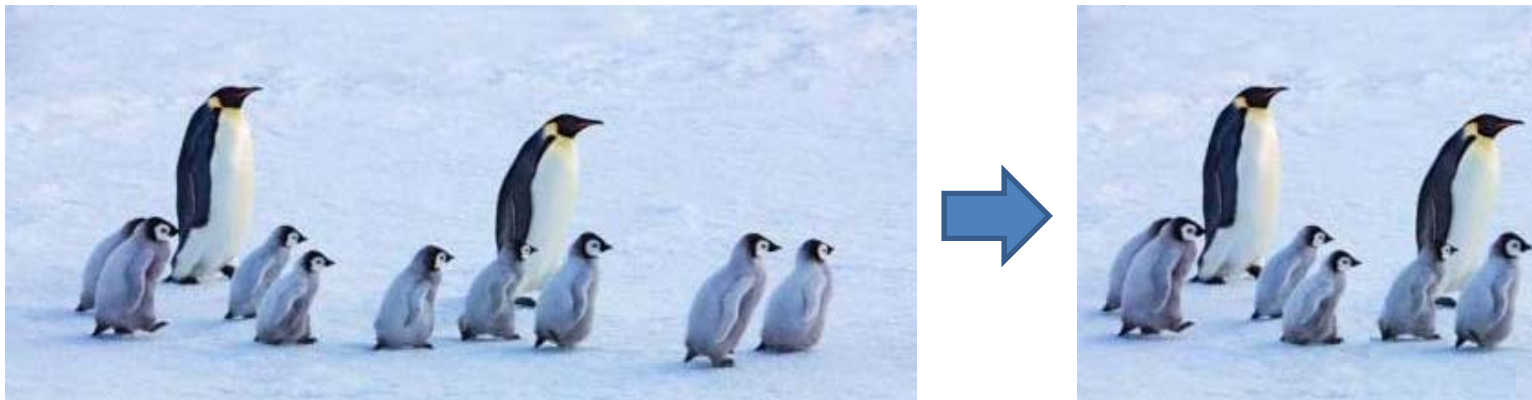
# State of the Art

- Content-Aware Image Retargeting
  - Re-arrange image content to fit target size
  - Seam Carving
  - Mesh Warping
  - Patch-Based approaches

[Avidan 2007]

[Wang 2008]

[Pritch 2009]



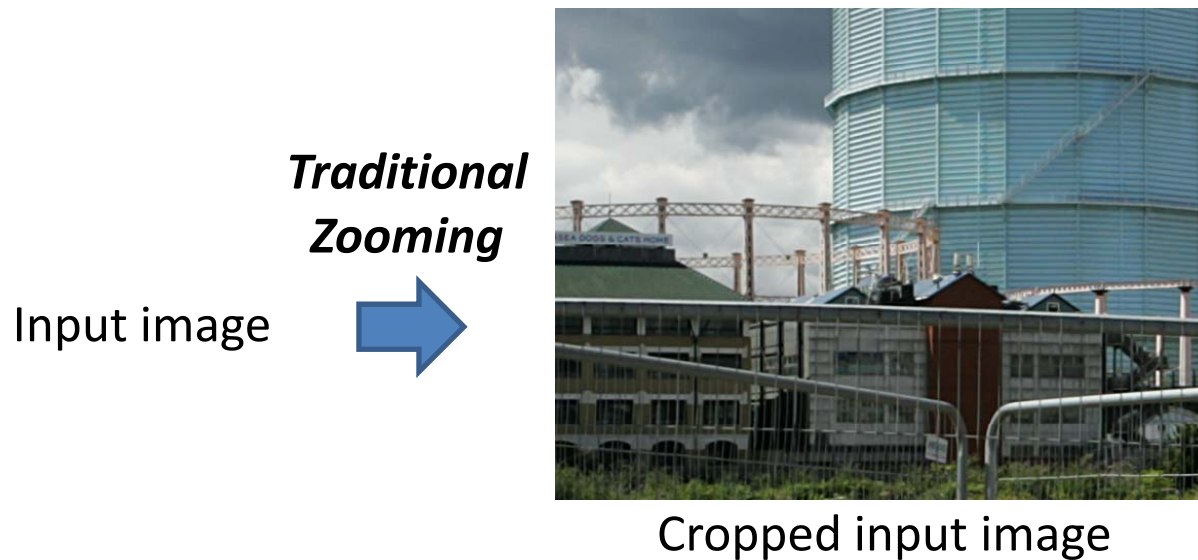
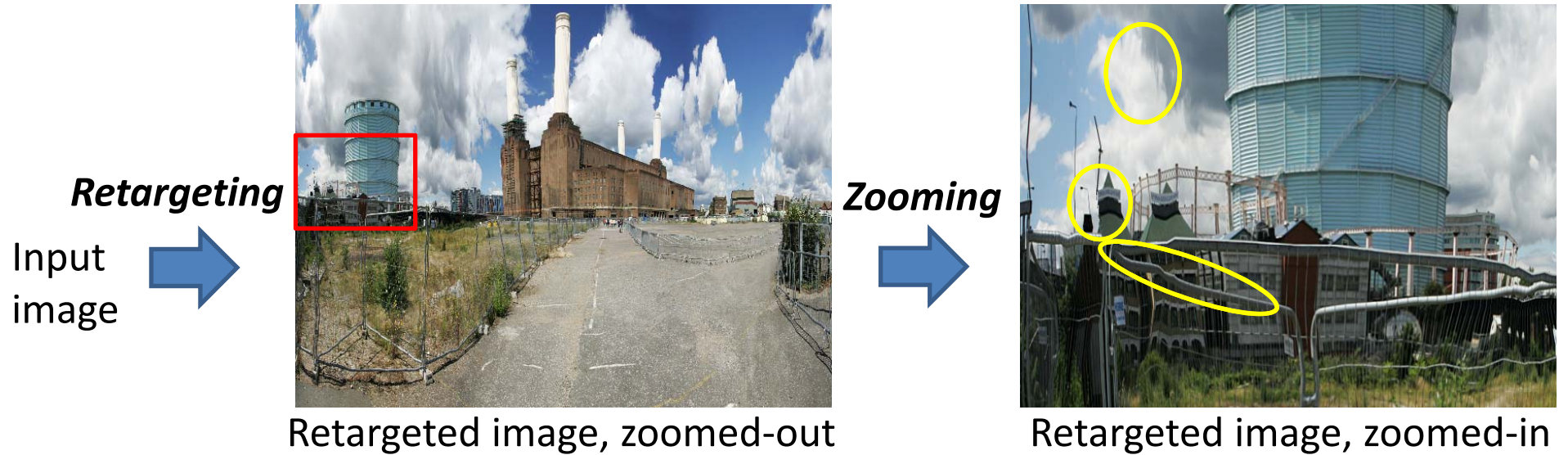
# Shortcomings of Retargeting

- Good for resizing images
- Not intended for exploring high-resolution images



Input image

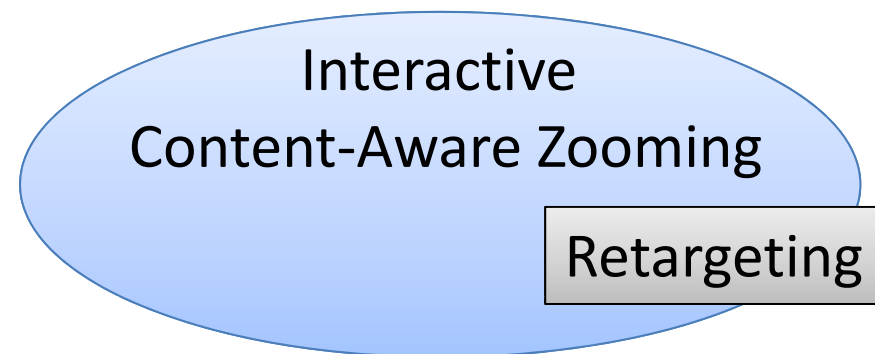
# Shortcomings of Retargeting





# Key idea

- Traditional Zooming and Retargeting are complementary
  - Traditional Zooming: good at higher zoom levels
  - Retargeting: good at lower zoom levels
- Interactive Content-Aware Zooming
  - hybrid operator that combines advantages of both approaches



# Our Mesh Warping block

- Inputs:



Input image



Significance map

- Set of line constraints
- Target size

- Mesh construction:



Conforming Delaunay triangulation

# Our Mesh Warping block

- Optimization:

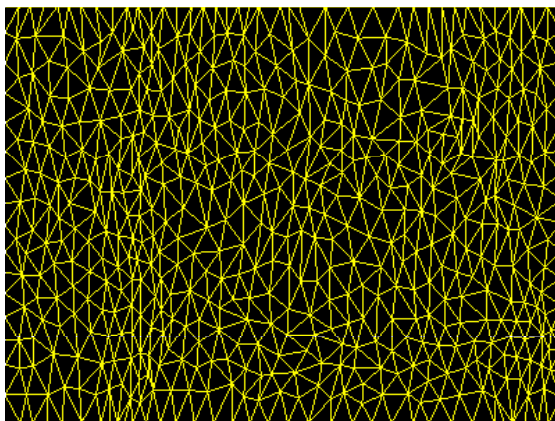
- Distortion energy [Wang 2008]
- Line constraint energy [Carroll 2009]
- Iterative solver

$$D_{Shape} = \sum_{\mathbf{f} \in \mathbf{F}} w_f \sum_{\mathbf{e}_{ij} \in \mathbf{E}(\mathbf{f})} \left\| (\mathbf{v}'_i - \mathbf{v}'_j) - s_f(\mathbf{v}_i - \mathbf{v}_j) \right\|^2$$

$$D_{Line_D} = \sum_{\mathbf{l} \in \mathbf{L}} \sum_{\mathbf{v}'_i \in \mathbf{V}'(\mathbf{l})} \left\| (\mathbf{v}'_i - \mathbf{v}'_{start(\mathbf{l})}) - r_{i(\mathbf{l})}(\mathbf{v}'_{end(\mathbf{l})} - \mathbf{v}'_{start(\mathbf{l})}) \right\|^2$$

$$D_{Line_O} = \sum_{\mathbf{l} \in \mathbf{L}} \sum_{\mathbf{v}'_i \in \mathbf{V}'(\mathbf{l})} ((\mathbf{v}'_i - \mathbf{v}'_{start(\mathbf{l})})^T \mathbf{n}(\mathbf{l}))^2$$

- Image reconstruction:



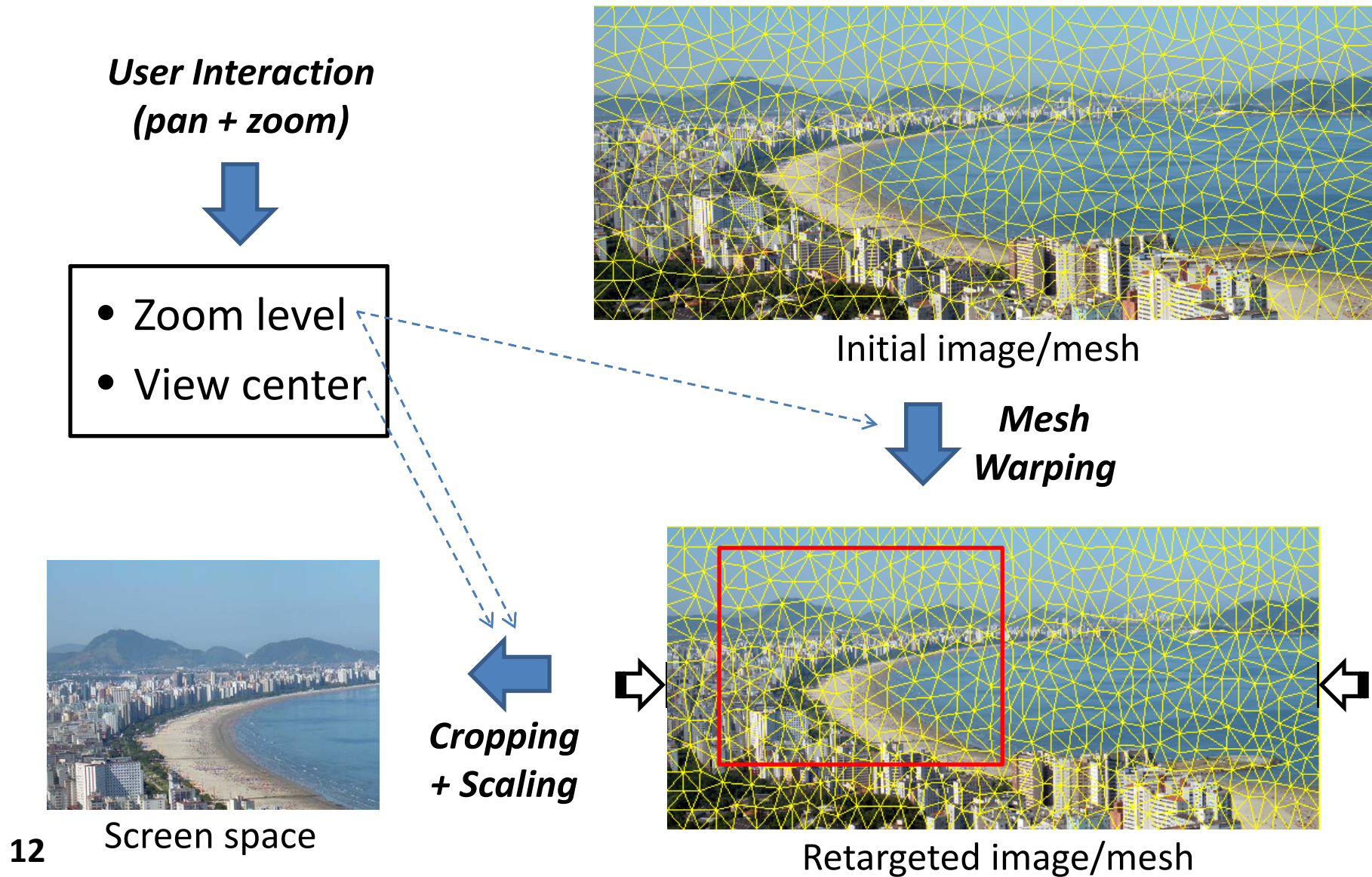
Deformed mesh

*Texture  
mapping*



Reconstructed image

# ICAZ: Overview



# ICAZ: Video







- Top: screen space
- Bottom: retargeted image
  - red rectangle:  
*viewing area*







# ICAZ: Parameter values

- Zoom level affects two parameters
  - Target aspect ratio: *controls distortion*
  - Viewing area size: *controls amount of information shown*

Zoom level	Retargeted image	Screen image
Highest	 A wide aerial view of a coastal city with a large bay. A red rectangular box highlights a small section of the city and beach.	 A zoomed-in view of the city and beach, showing more detail than the retargeted image.
Lowest	 A zoomed-in view of the city and beach, showing more detail than the retargeted image. A red rectangular box highlights the entire image.	 A zoomed-in view of the city and beach, showing more detail than the retargeted image.

# ICAZ: Parameter values

- Zoom level affects two parameters
  - Target aspect ratio: *controls distortion*
  - Viewing area size: *controls amount of information shown*

Zoom level	Retargeted image	Screen image
Highest		
Intermediate	<i>Interpolate the parameters</i>	
Lowest		

# ICAZ: Complexity

- Need to retarget full image at each viewpoint
- Computation time depends on vertex count
  - Image size
  - Mesh density
- Mesh density affects the result quality



# ICAZ: View-dependent mesh

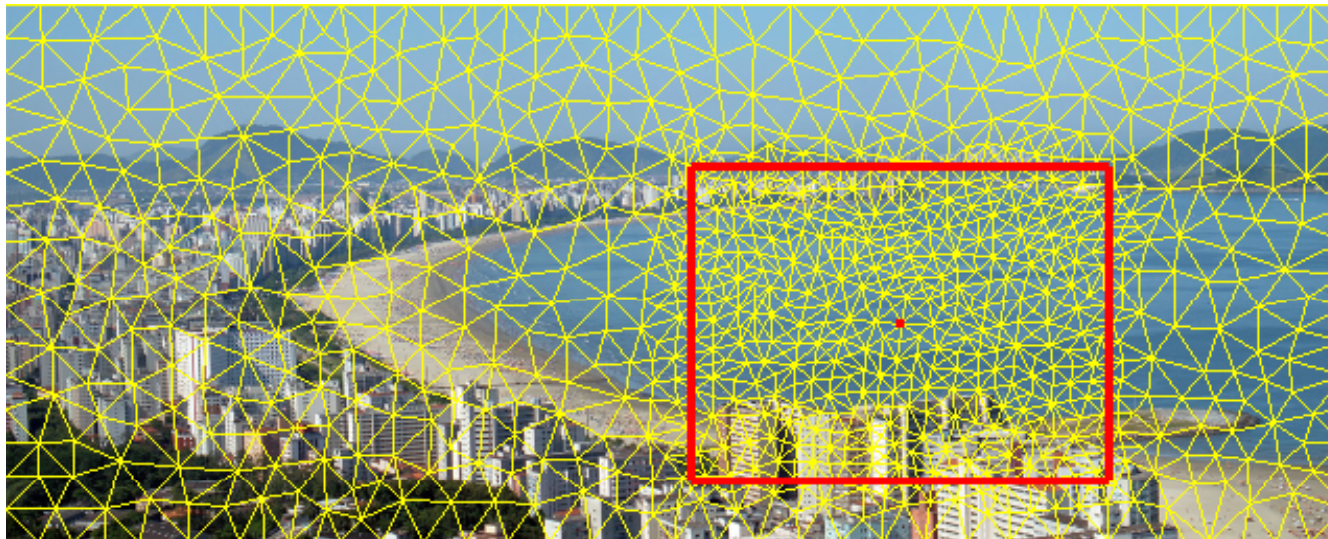


- Top: screen space
- Bottom: retargeted image
  - red rectangle:  
*viewing area*



# ICAZ: View-dependent mesh

- Preprocess
  - build multi-level hierarchy from initial triangulation
- At runtime
  - refine mesh portion within the viewing area



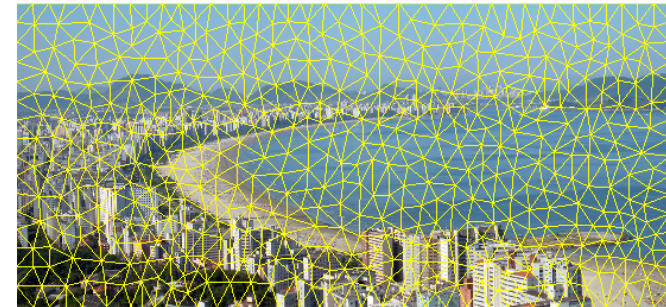
# ICAZ: Final pipeline



Coarse mesh



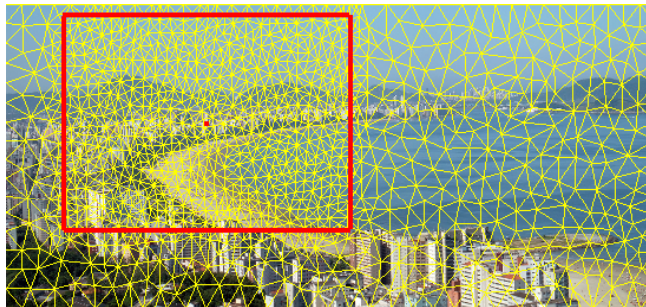
*Coarse-level  
Mesh Warping*



Coarse deformed mesh



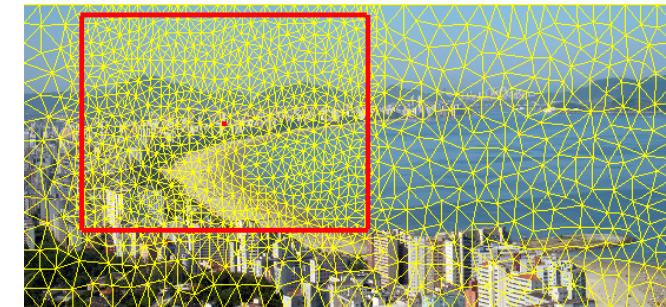
*Mesh refinement*



Fine deformed mesh



*Fine-level  
Mesh Warping*



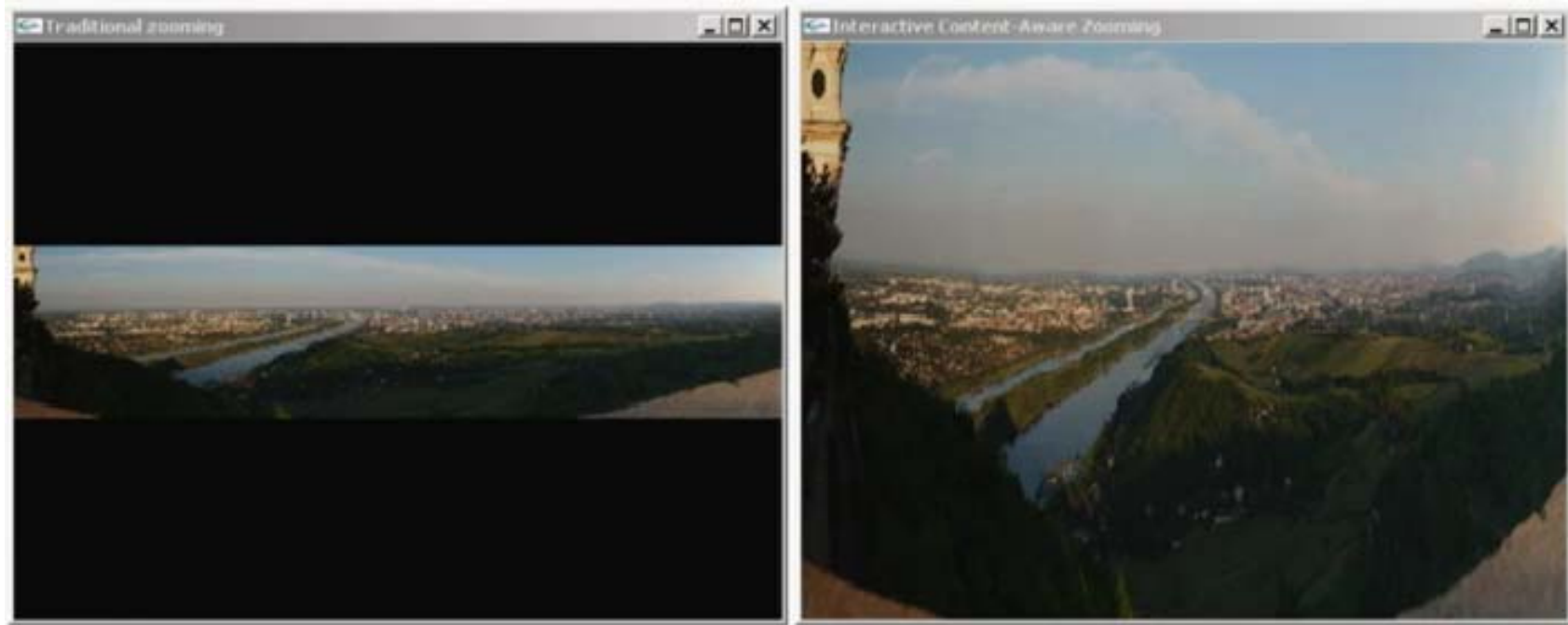
Coarse deformed mesh - refined

*Cropping  
+ Scaling*



Final image on screen

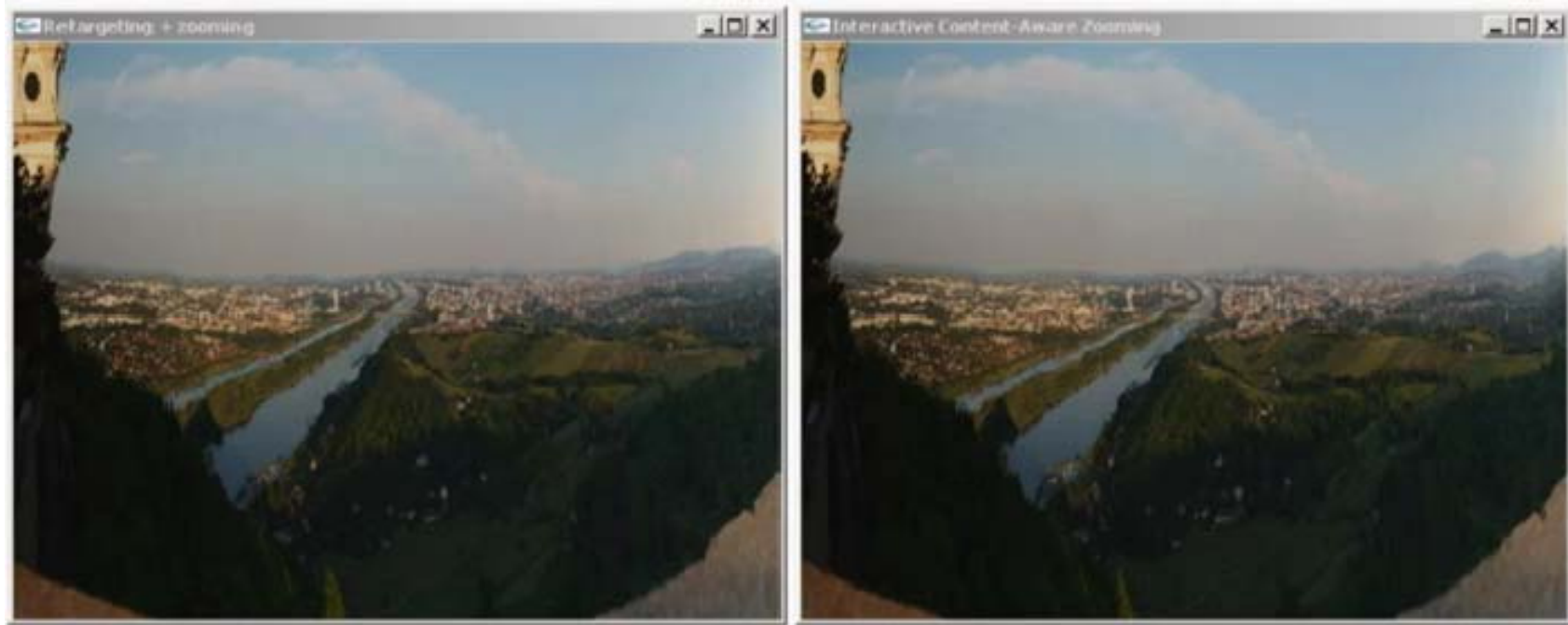
# Results: video comparison



Traditional Zooming

Interactive Content-Aware Zooming

# Results: video comparison



Retargeting + Zooming

Interactive Content-Aware Zooming

# Results: computation time

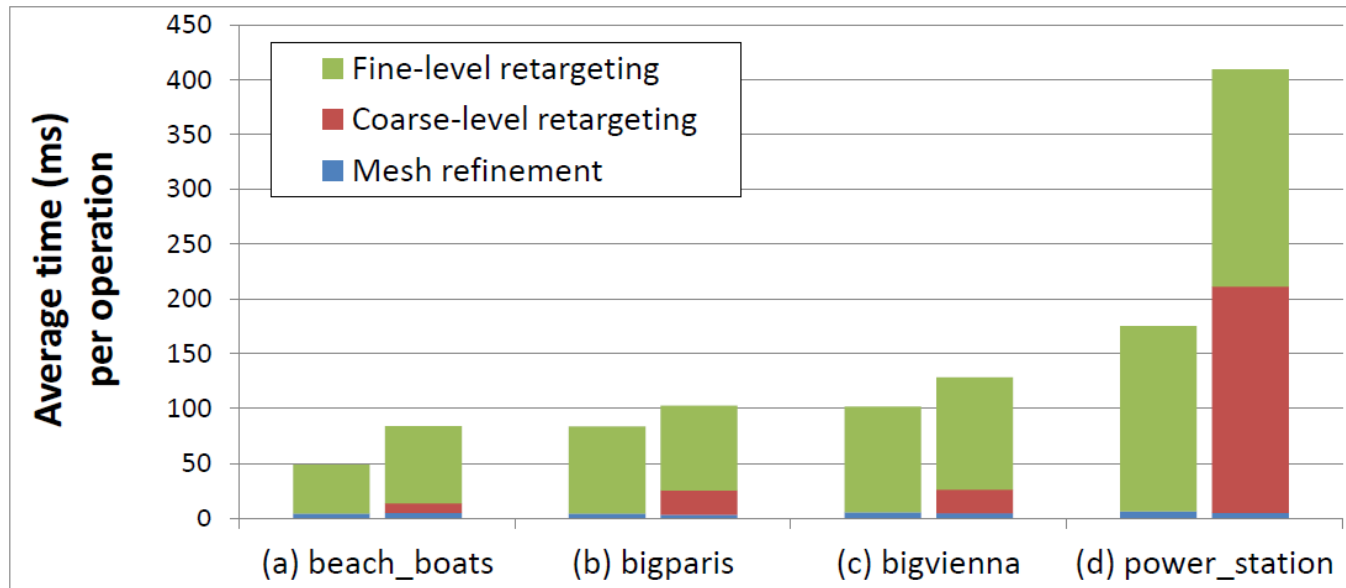


Image name	Resolution	Line constraints?
power station	7475 × 1999	yes
bigparis	7203 × 2247	no
beach boats	5530 × 1799	no
bigvienna	8000 × 1811	no

# Results: computation time

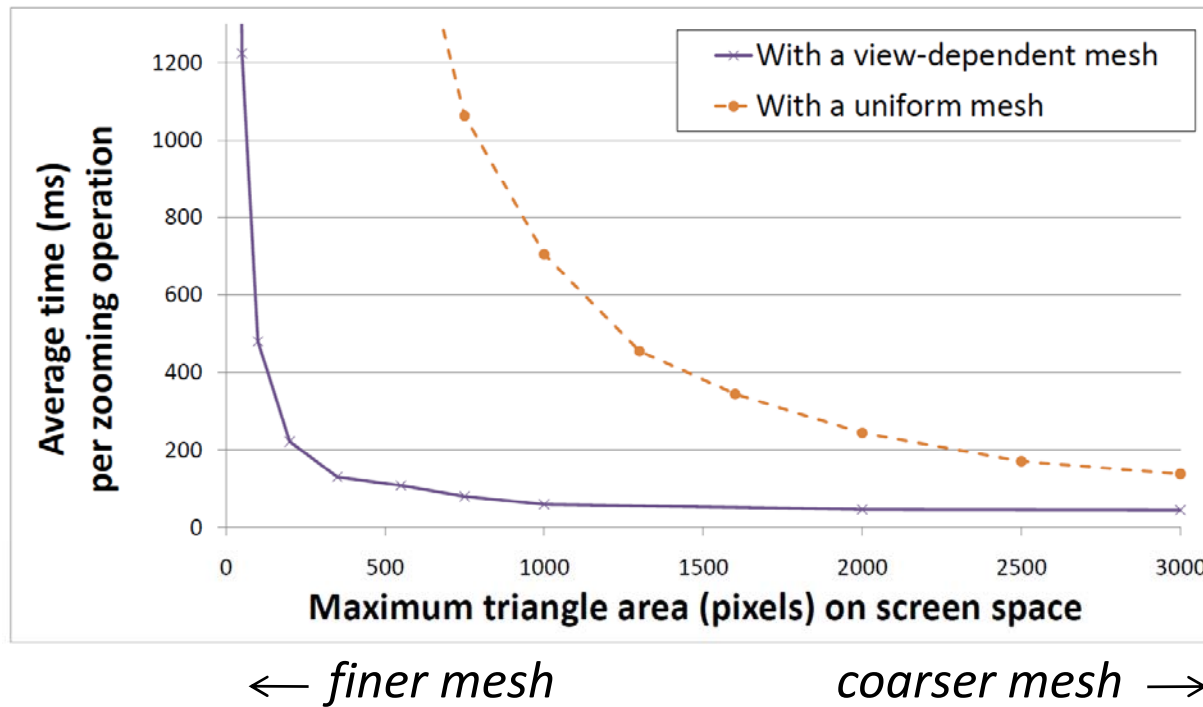


Image name	Resolution	Line constraints?
bigvienna	8000×1811	no

# Limitations

- Limitations:
  - inherits artifacts from mesh warping methods
  - slow with line constraints
  - depends on the significance map and line constraints



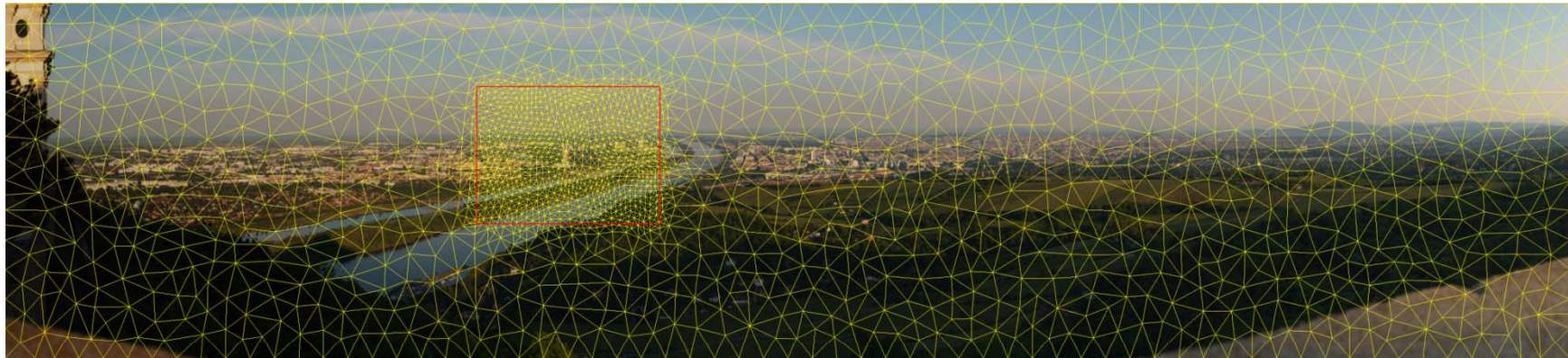
# Summary

- Contributions:
  - Interactive Content-Aware Zooming operator
  - View-dependent mesh, adaptive mesh warping process
- Future work:
  - Significance-aware initial mesh
  - Adaptation to gigapixel images, mobile devices
  - Content-aware image manipulation & visualization



# Questions

Thank you for your attention.



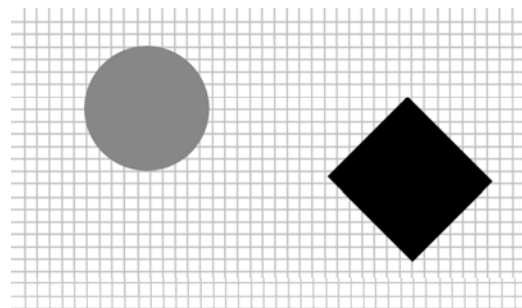
## Acknowledgements:

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- This work was supported in part by MKE/MCST/IITA [2008-F-033-02], MKE/IITA u-Learning, and KRF-2008-313-D00922

# Bonus slides

# Influence of mesh density

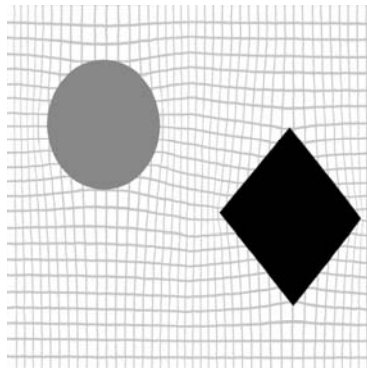
- Mesh density influences the quality of retargeting
  - smaller triangles help better distribute the distortion
  - higher vertex count will slow down the retargeting process



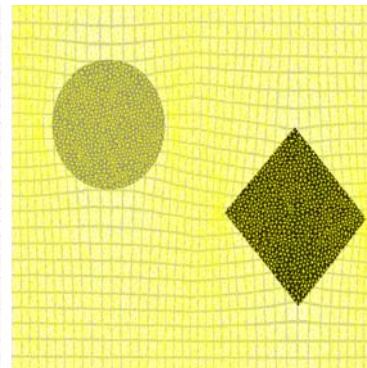
Input Image



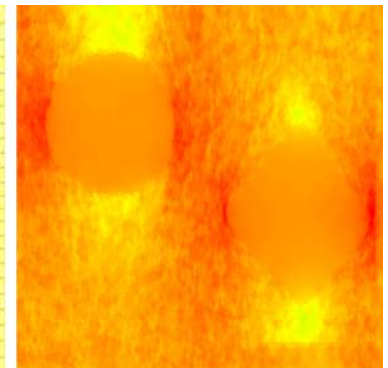
Significance map



Final image

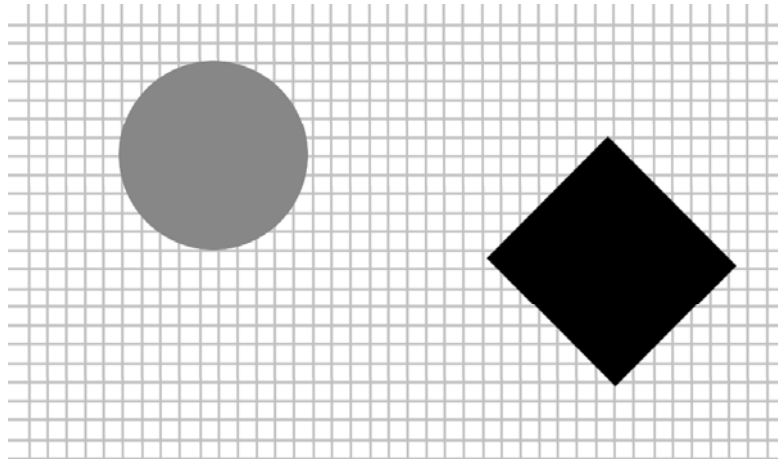


Mesh

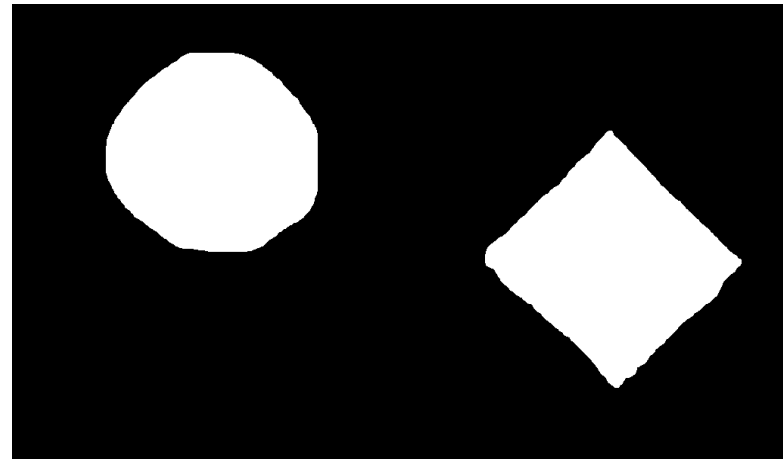


Scaling factors

# Results: synthetic case

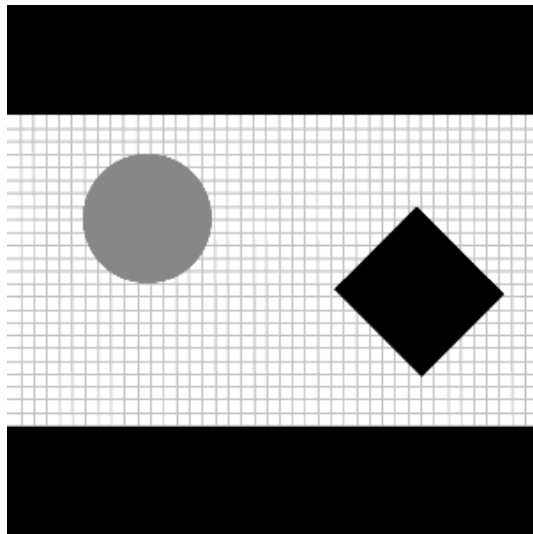


Input Image

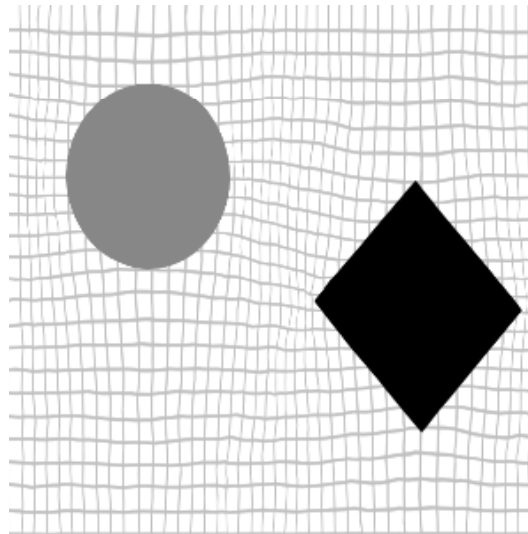


Significance map

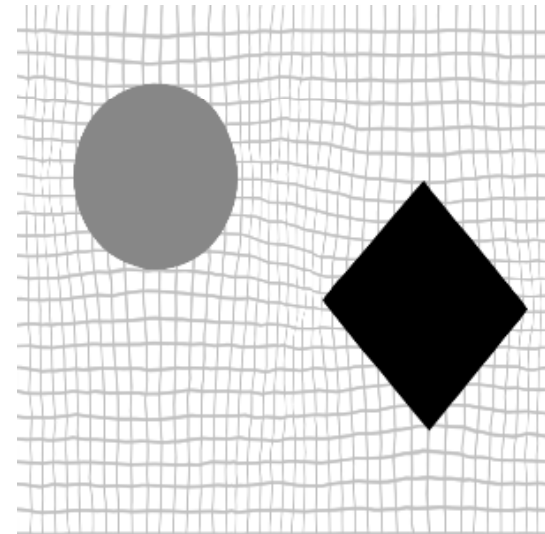
Zoom level 0%



Traditional Zooming

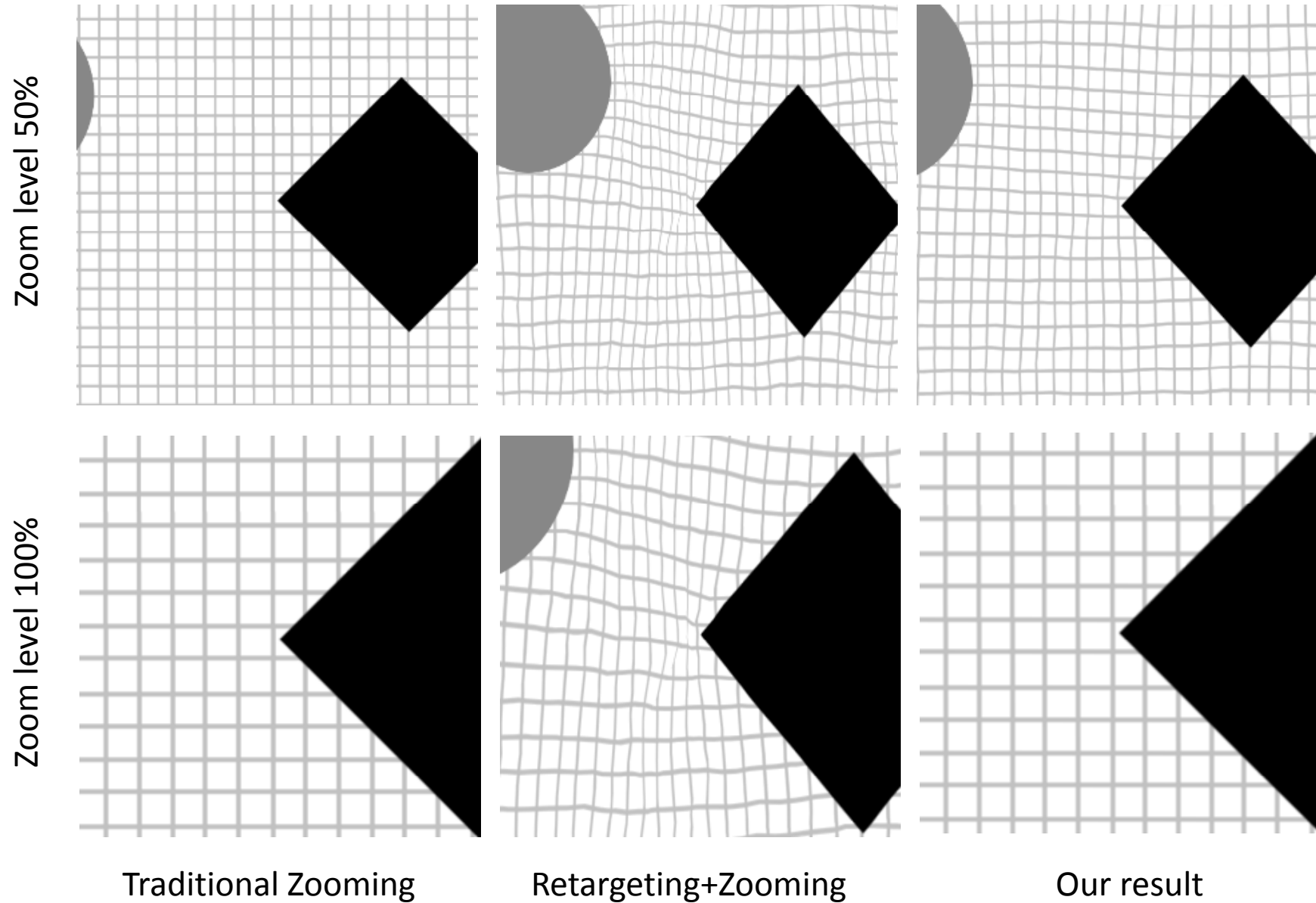


Retargeting+Zooming



Our result

# Results: synthetic case



# Results: image comparison

