Rectangling Panoramic Images via Warping

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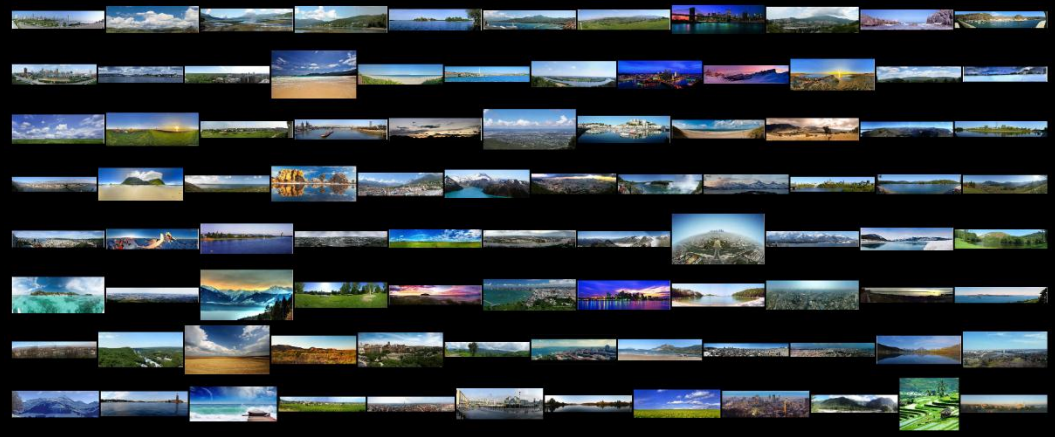
Introduction

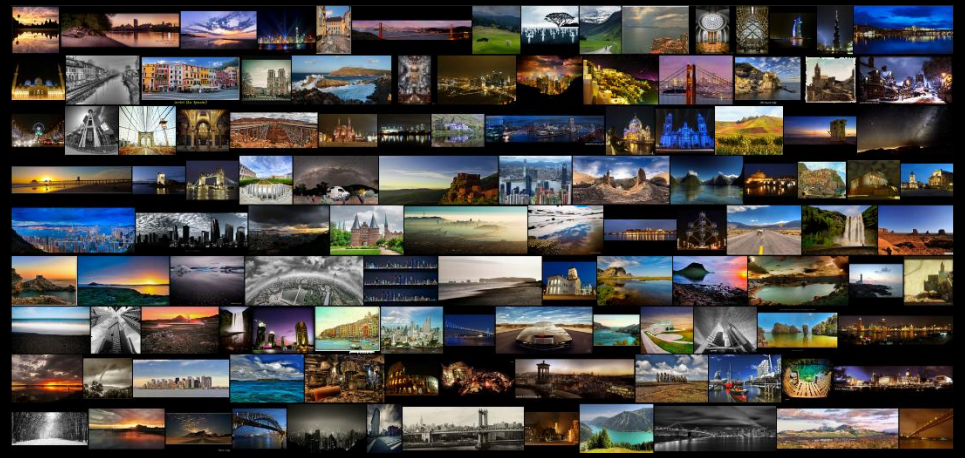
- Panoramas are irregular

Introduction

- Panoramas are irregular
- Rectangles are favored



panoramas in bing



panoramas in flickr

Introduction

- Panoramas are irregular
- Rectangles are favored
- “Rectangling” the panoramas

Introduction

- Panoramas are irregular
- Rectangles are favored
- “Rectangling” the panoramas
  - Cropping

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- Panoramas are irregular
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- “Rectangling” the panoramas
  - Cropping
  - Inpainting

content-aware fill

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Introduction

- Panoramas are irregular
- Rectangles are favored
- “Rectangling” the panoramas
  - Cropping
  - Inpainting
  - Warping ***new***

our warping

Why Warping?

- Panoramas are often distorted

distortion

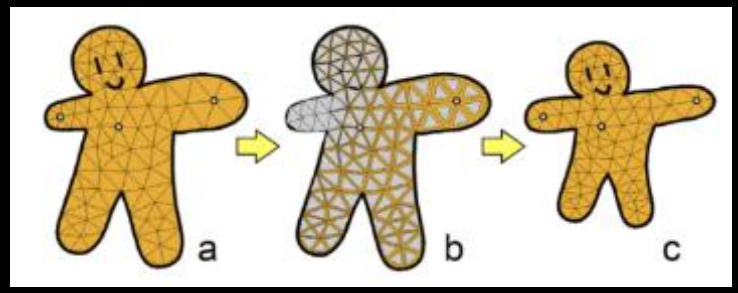
Why Warping?

- Panoramas are often distorted
- Warping can be unnoticeable

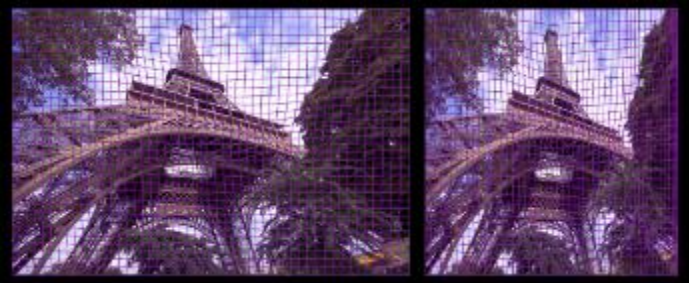
our warping

Why Warping?

- Panoramas are often distorted
- Warping can be unnoticeable
- Warping is robust
  - shape manipulation
  - image retargeting
  - image projection
  - video stabilization



[Igarashi et al, SIGGRAPH 05] …



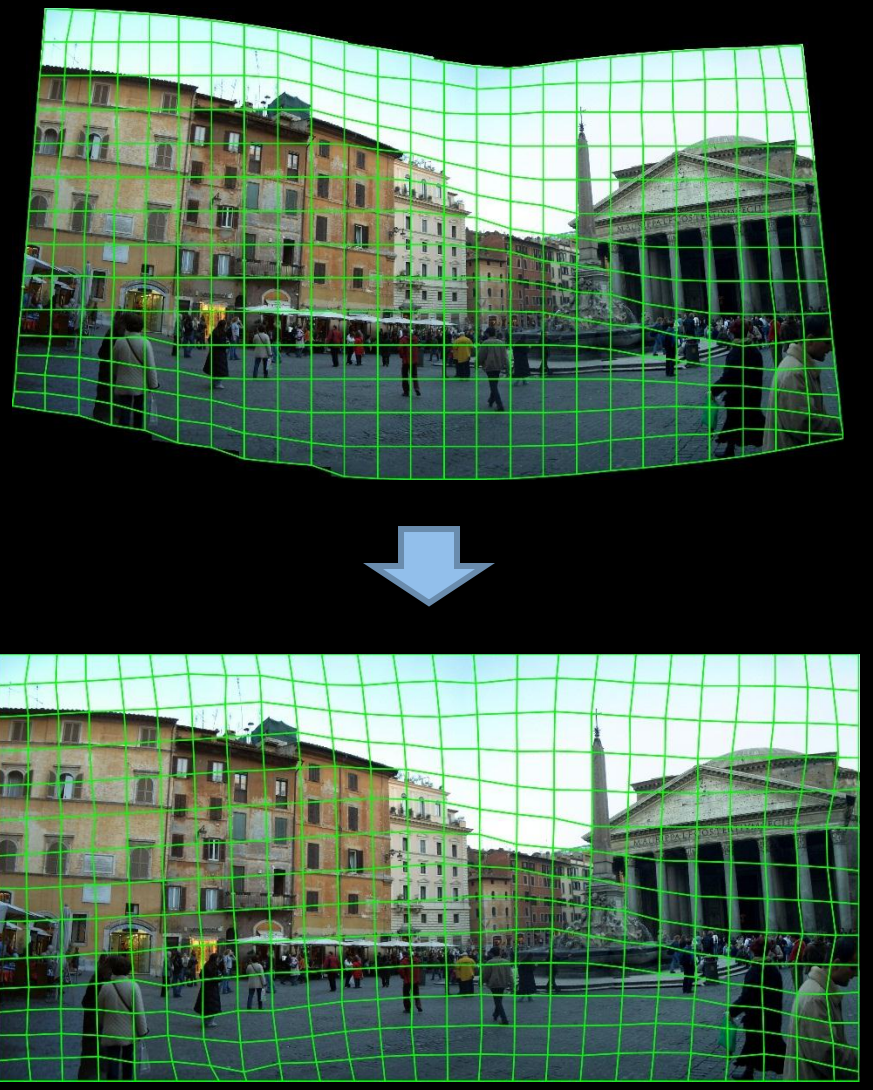
[Wang et al, SIGGRAPH Asia 08] …

[Carroll et al, SIGGRAPH 09] …

[Liu et al, SIGGRAPH 09] …

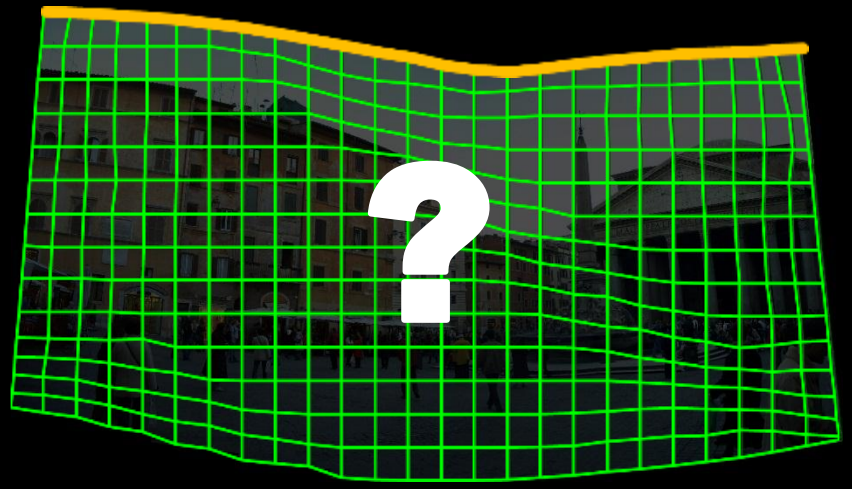
Why Warping?

- Panoramas are often distorted
- Warping can be unnoticeable
- Warping is robust
- Rectangling via warping



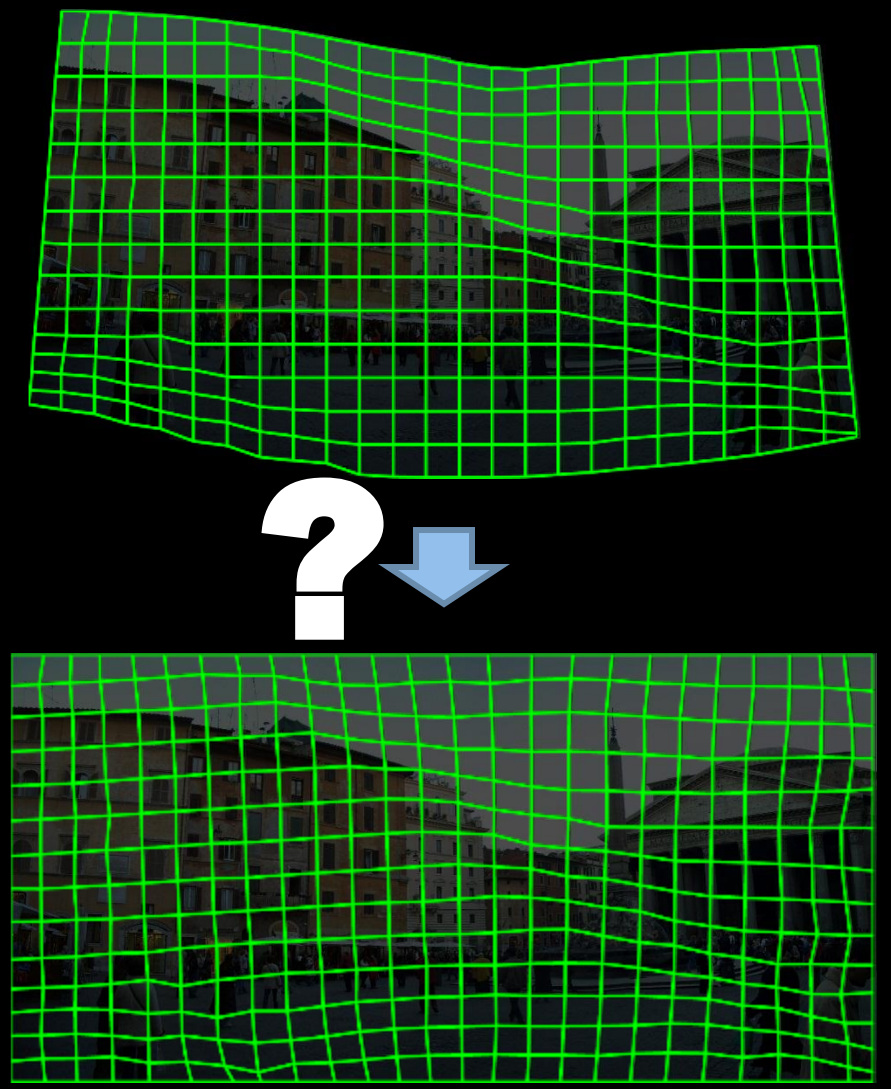
Challenges

- Meshing
  - irregular input
  - boundary conditions



Challenges

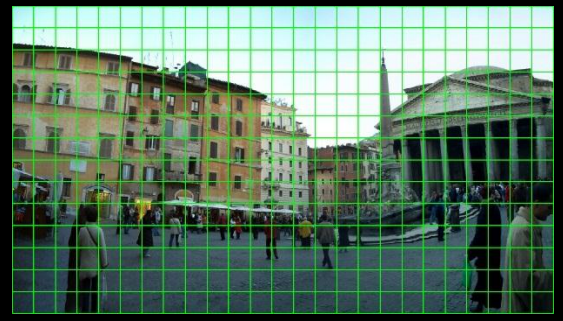
- Meshing
  - irregular input
  - boundary conditions
- Content-preserving
  - boundary constraints
  - shapes
  - straight lines



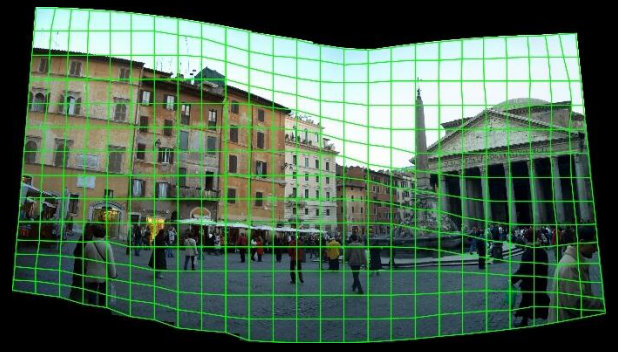
Solution: Local + Global

local warping

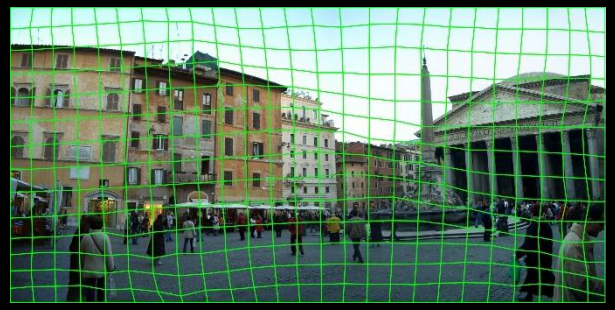
mesh



warped back



global warping

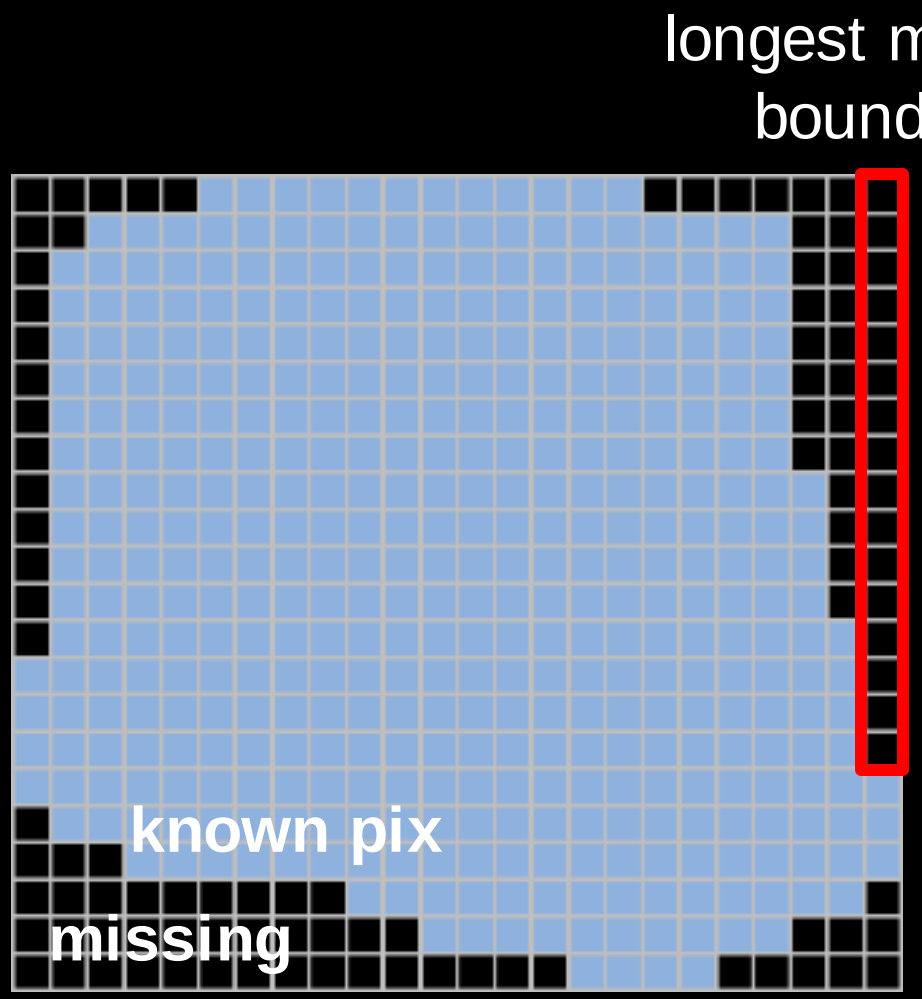


Local Warping

- Mesh-free

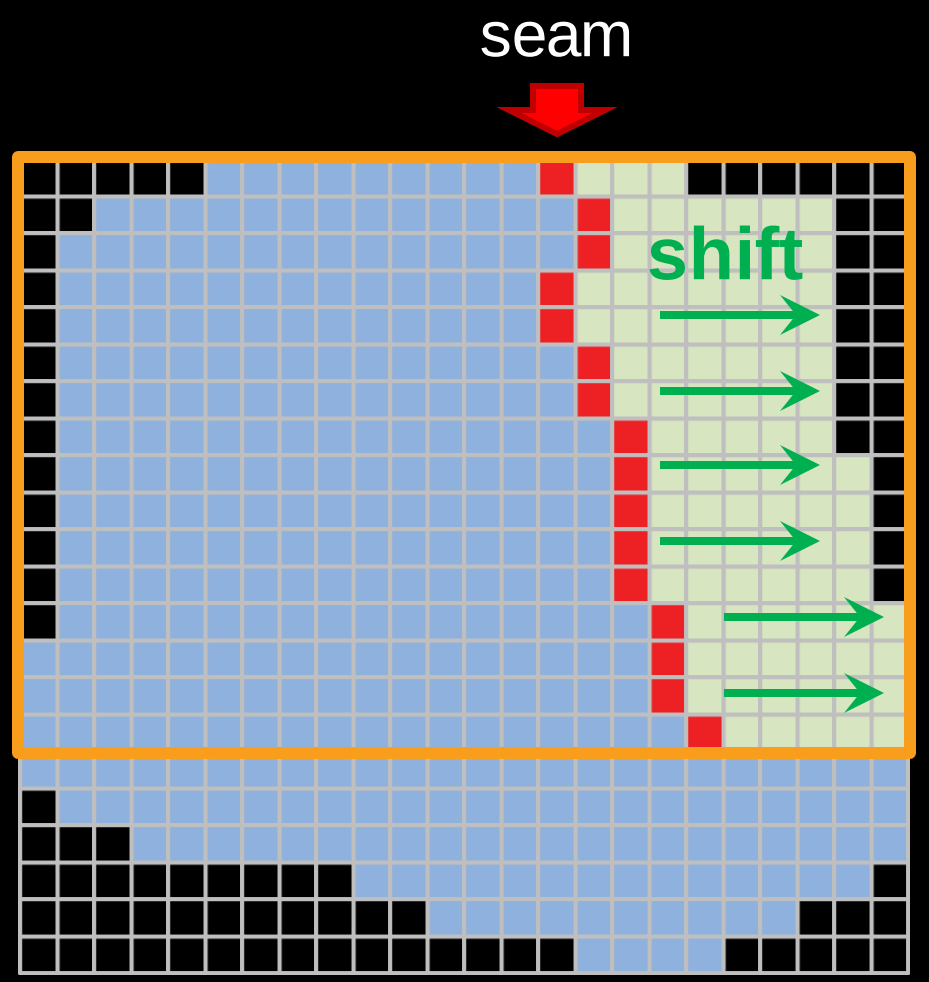
Local Warping

- Mesh-free
- Seam Carving [Avidan & Shamir 07]



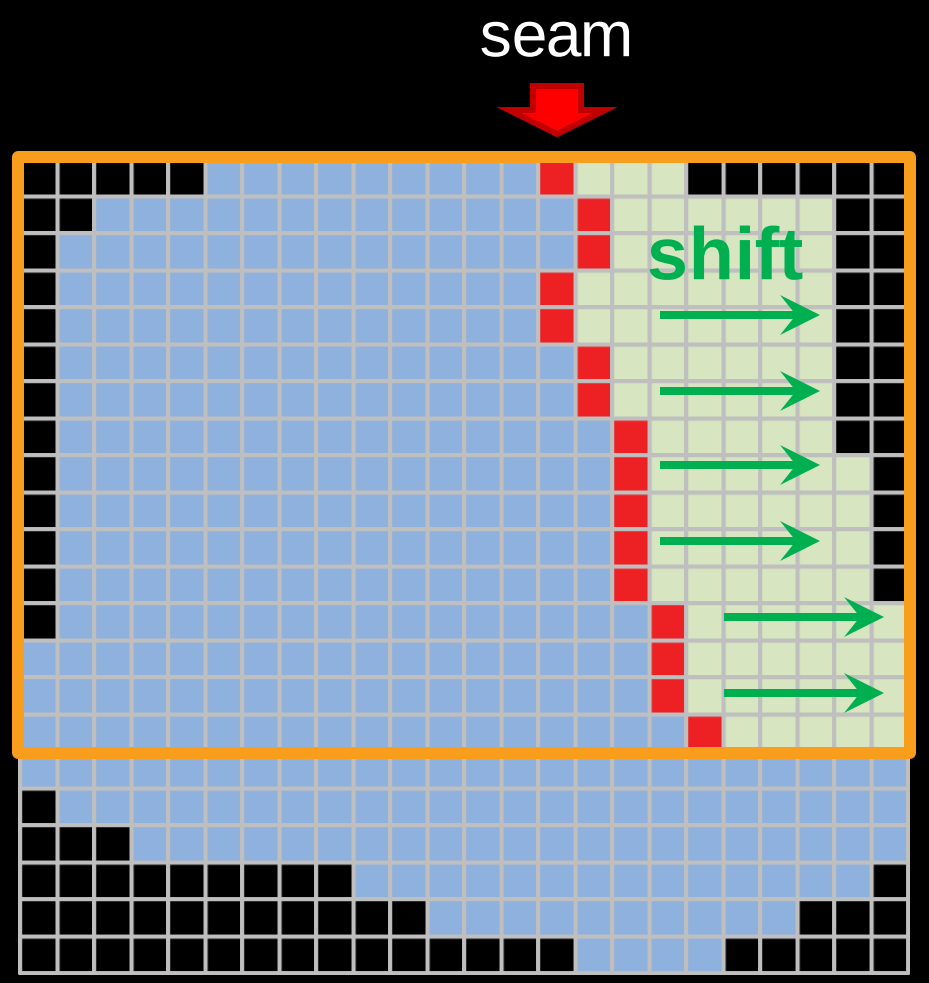
Local Warping

- Mesh-free
- Seam Carving [Avidan & Shamir 07]
  - insert a seam
  - shift pixels



Local Warping

- Mesh-free
- Seam Carving [Avidan & Shamir 07]
  - insert a seam
  - shift pixels
- Seam Carving = Warping



Local Warping

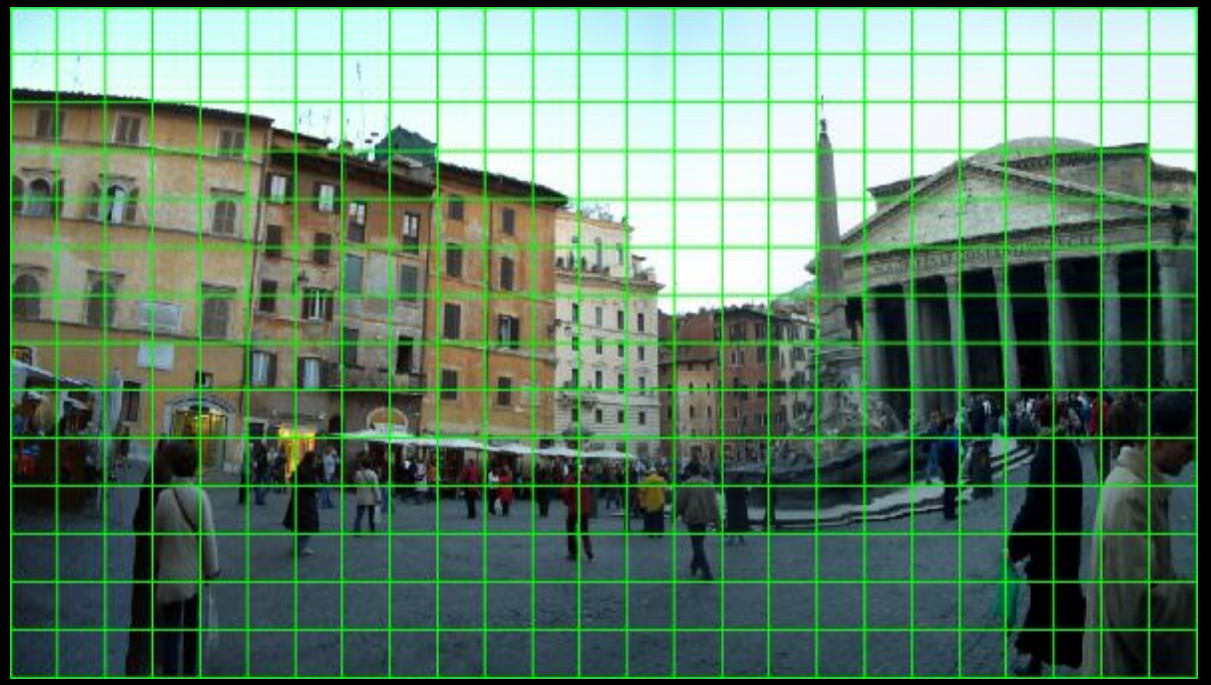
- Mesh-free
- Seam Carving [Avidan & Shamir 07]
  - insert a seam
  - shift pixels
- Seam Carving = Warping

seam carving

(A video was removed when converting this ppt to pdf.)

Local Warping

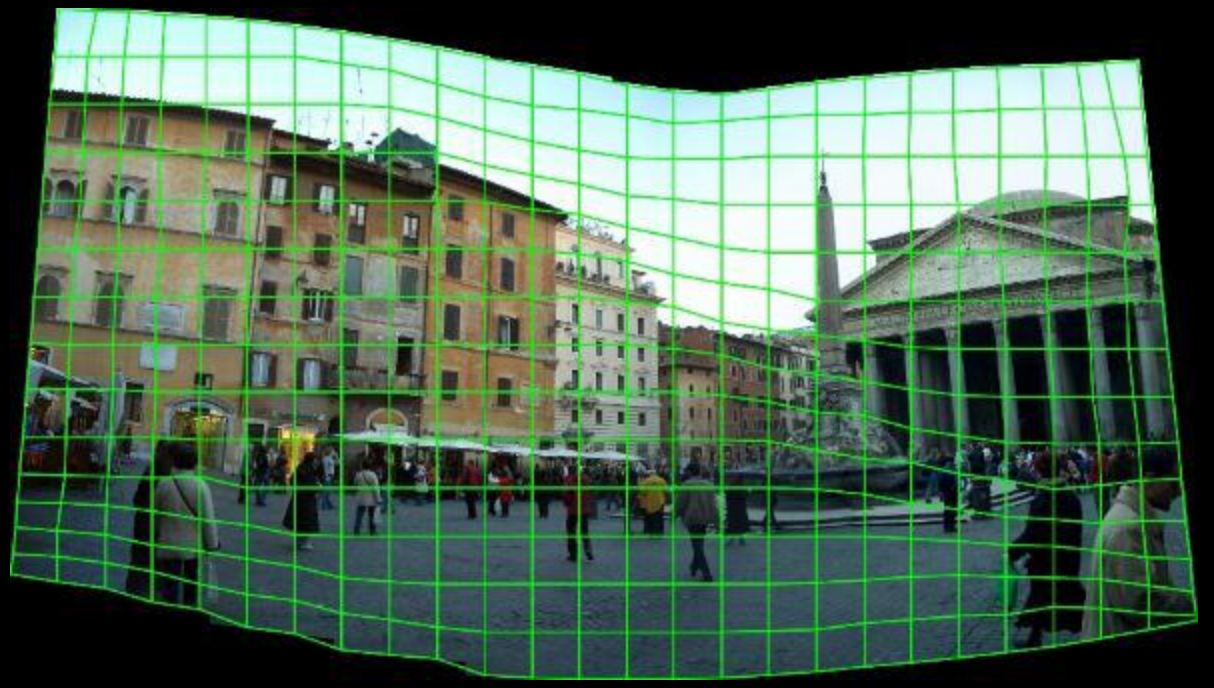
- Mesh-free
- Seam Carving [Avidan & Shamir 07]
  - insert a seam
  - shift pixels
- Seam Carving = Warping



grid mesh

Local Warping

- Mesh-free
- Seam Carving [Avidan & Shamir 07]
  - insert a seam
  - shift pixels
- Seam Carving = Warping



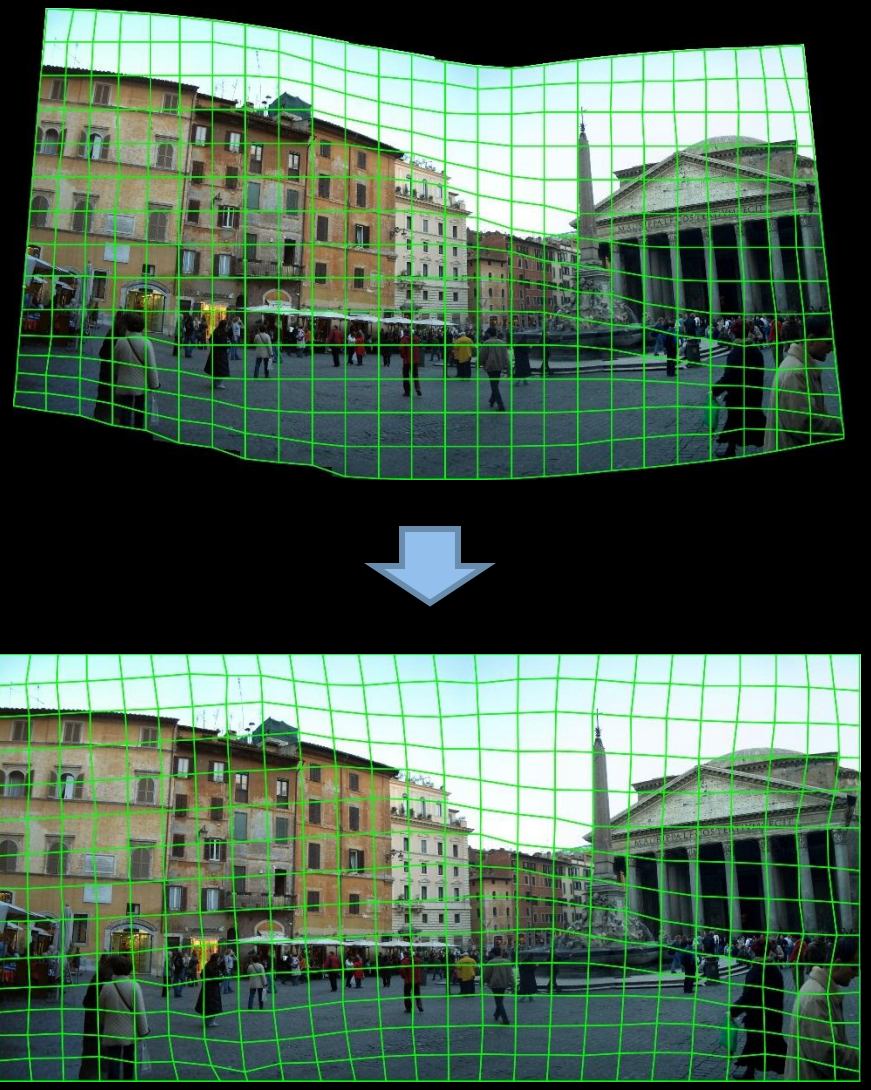
warped back

Global Warping

- Mesh optimization

$$\min E(V)$$

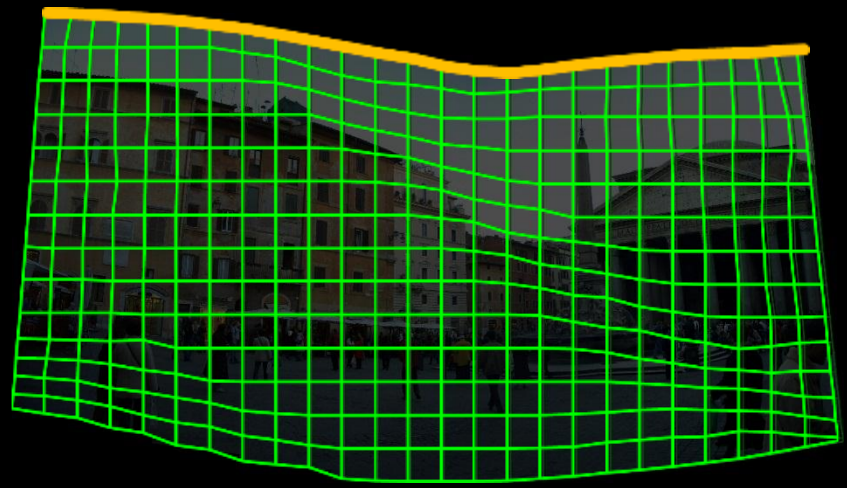
V: all vertexes

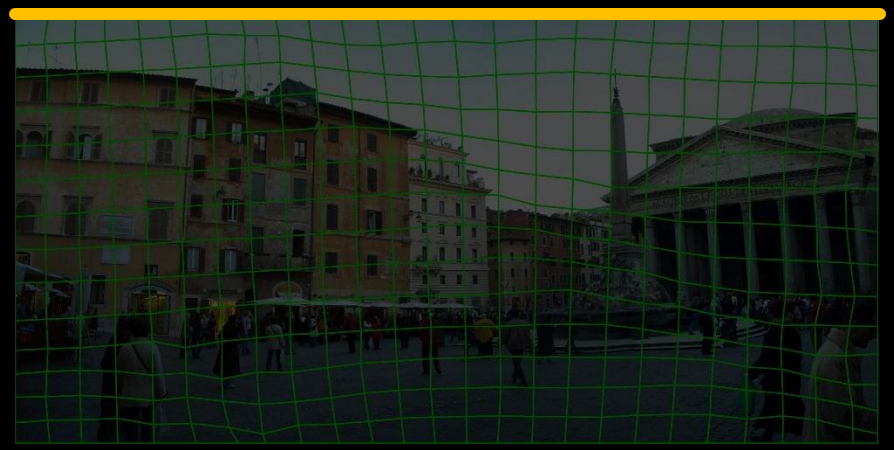


Global Warping

- Mesh optimization
  - Boundary constraints

$E_B(V)$: hard data term





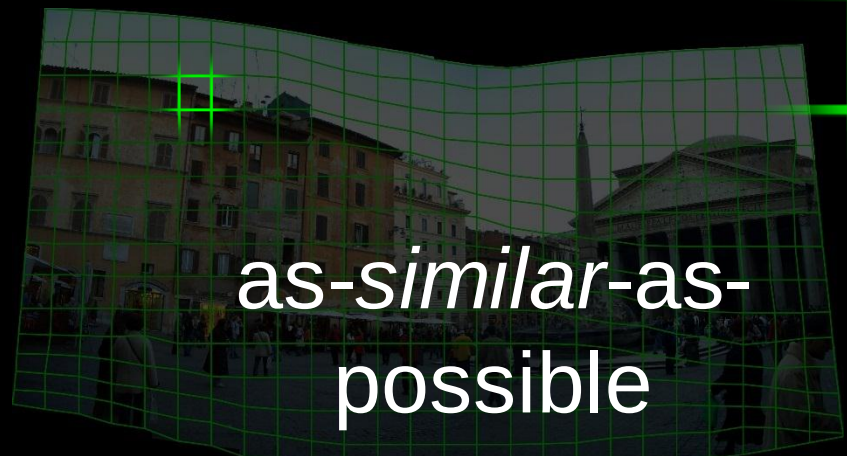
Global Warping

- Mesh optimization
  - Boundary constraints
  - Shape preservation

$$E_S(V) = V^T L V$$

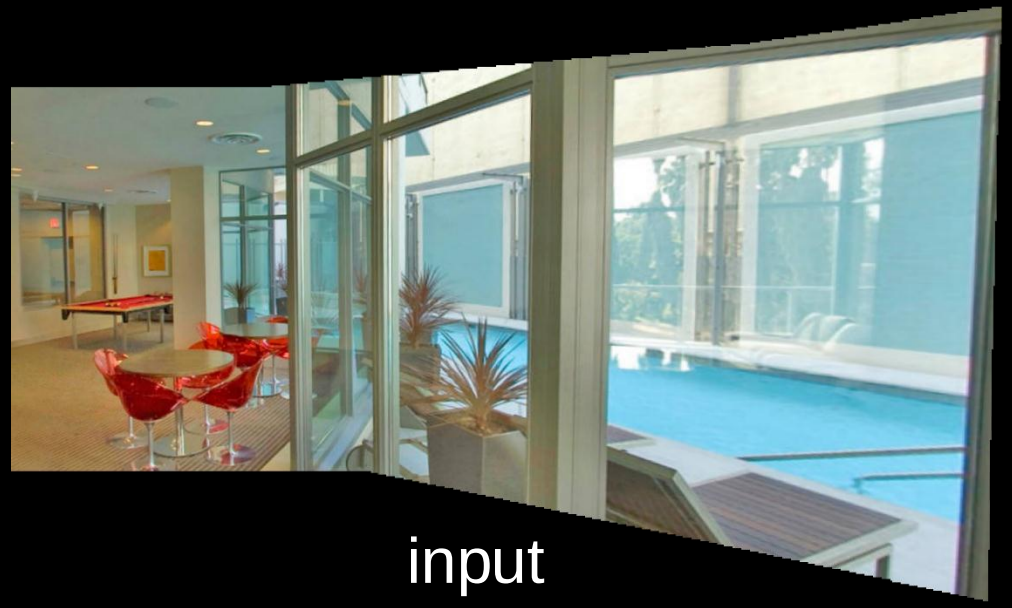
L: *Laplacian*

smoothness term
in warping



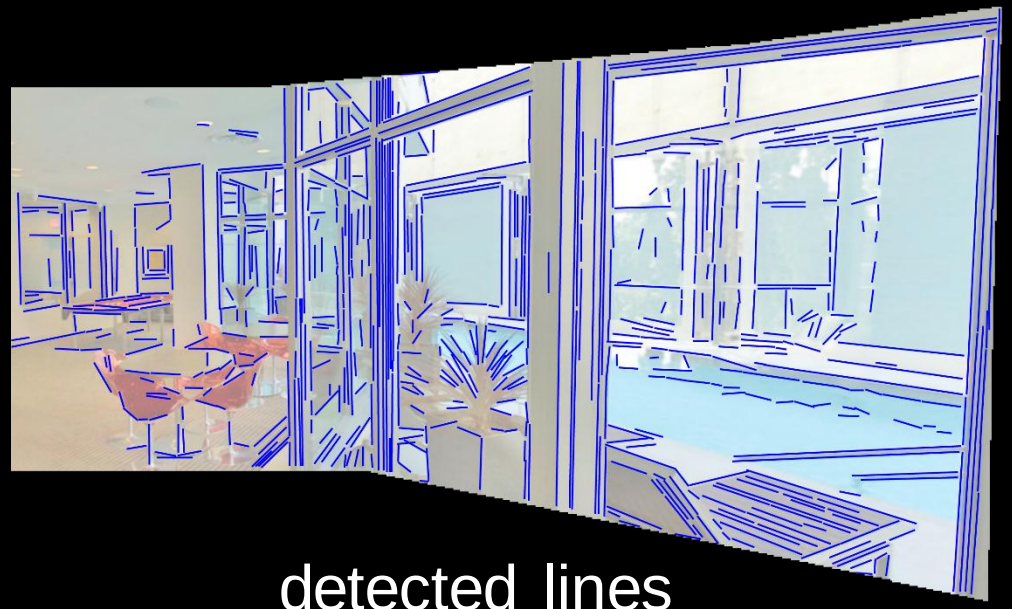
as-*similar*-as-possible

[Igarashi et al, SIGGRAPH 05]
[Liu et al, SIGGRAPH 09]
[Wang et al, SIGGRAPH 10] …



input

boundary + shape

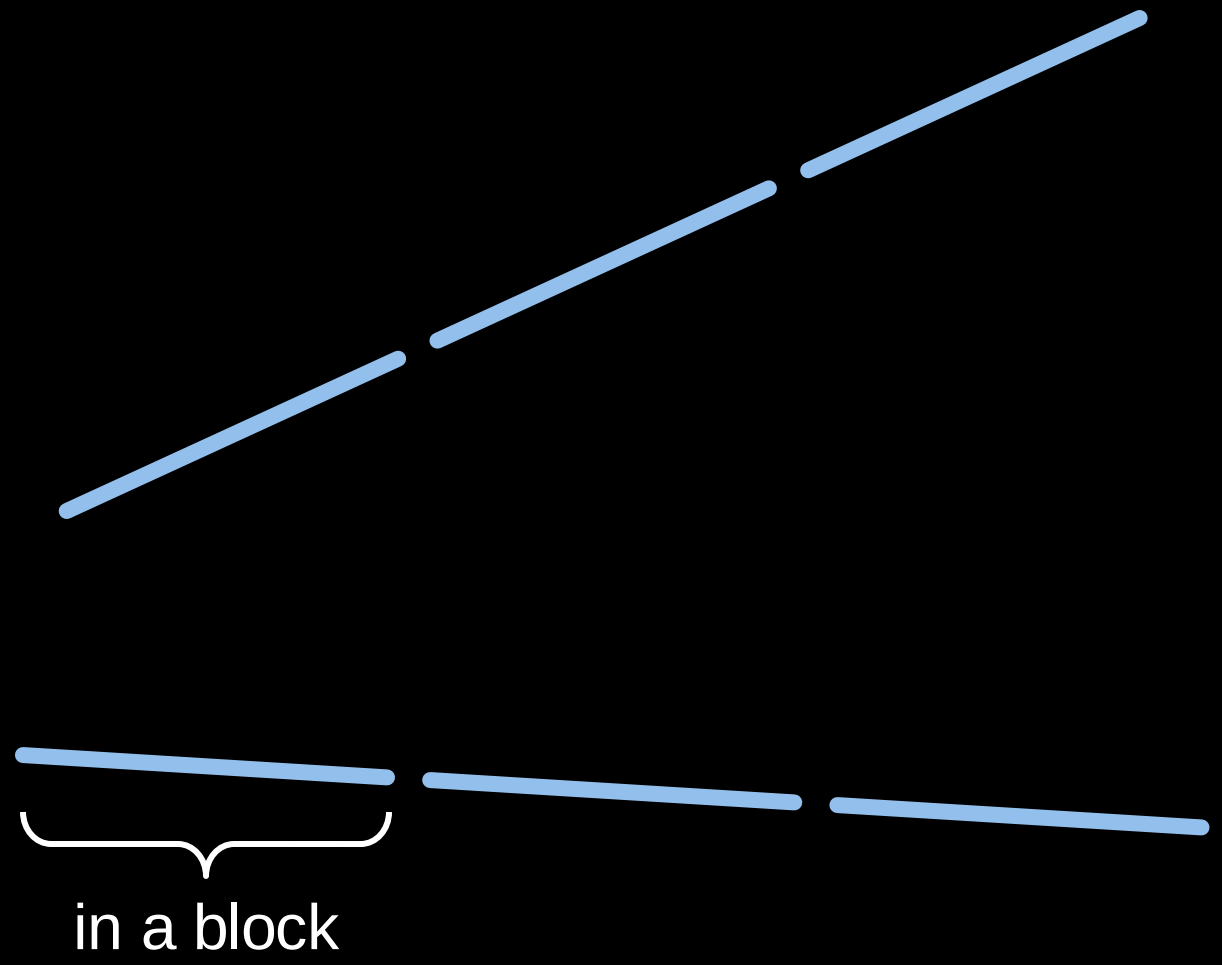


detected lines
[PAMI 10]

boundary + shape + line

Line Preservation

- Lines in the same direction are rotated by the same θ
  [Chang & Chuang, CVPR 12]



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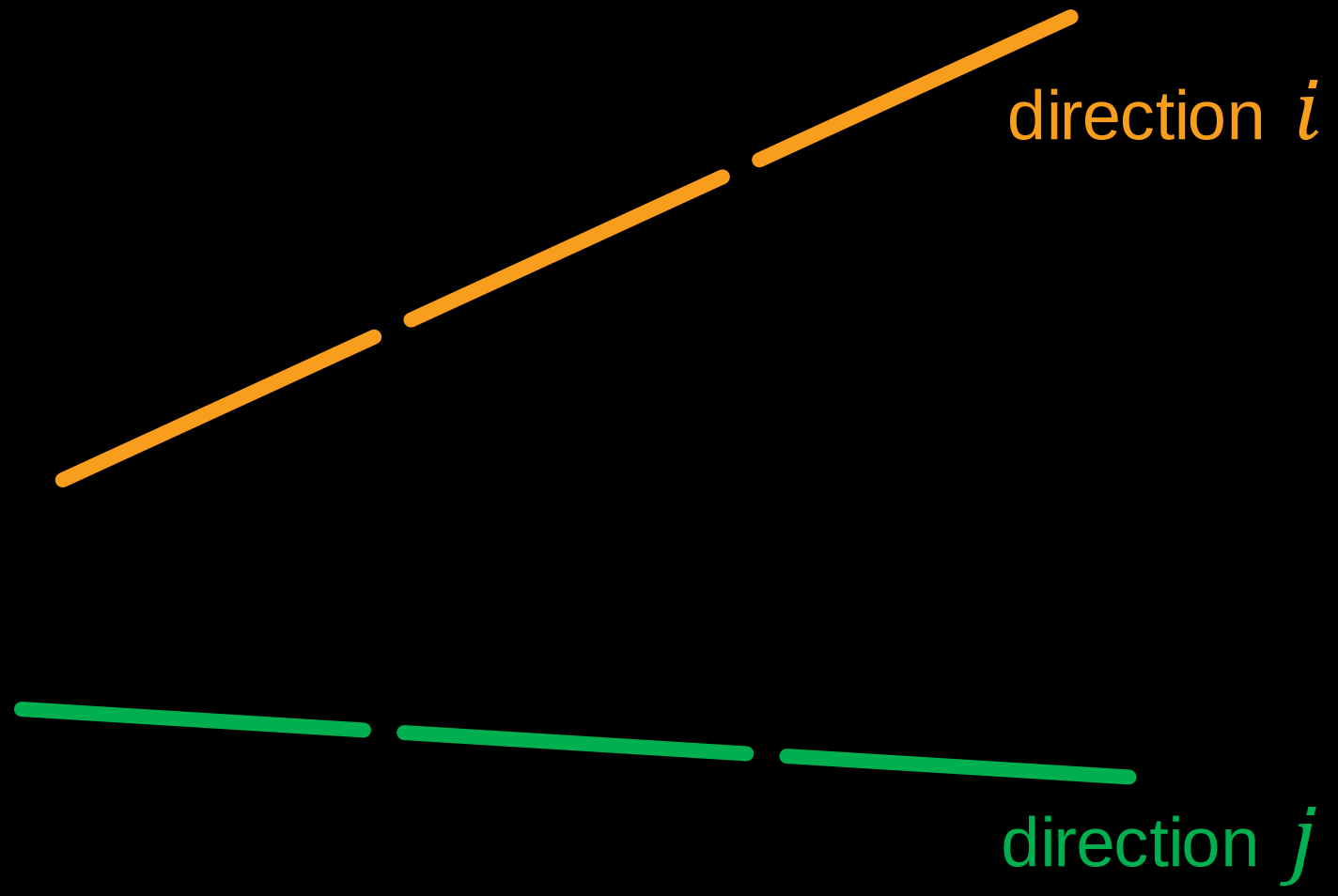
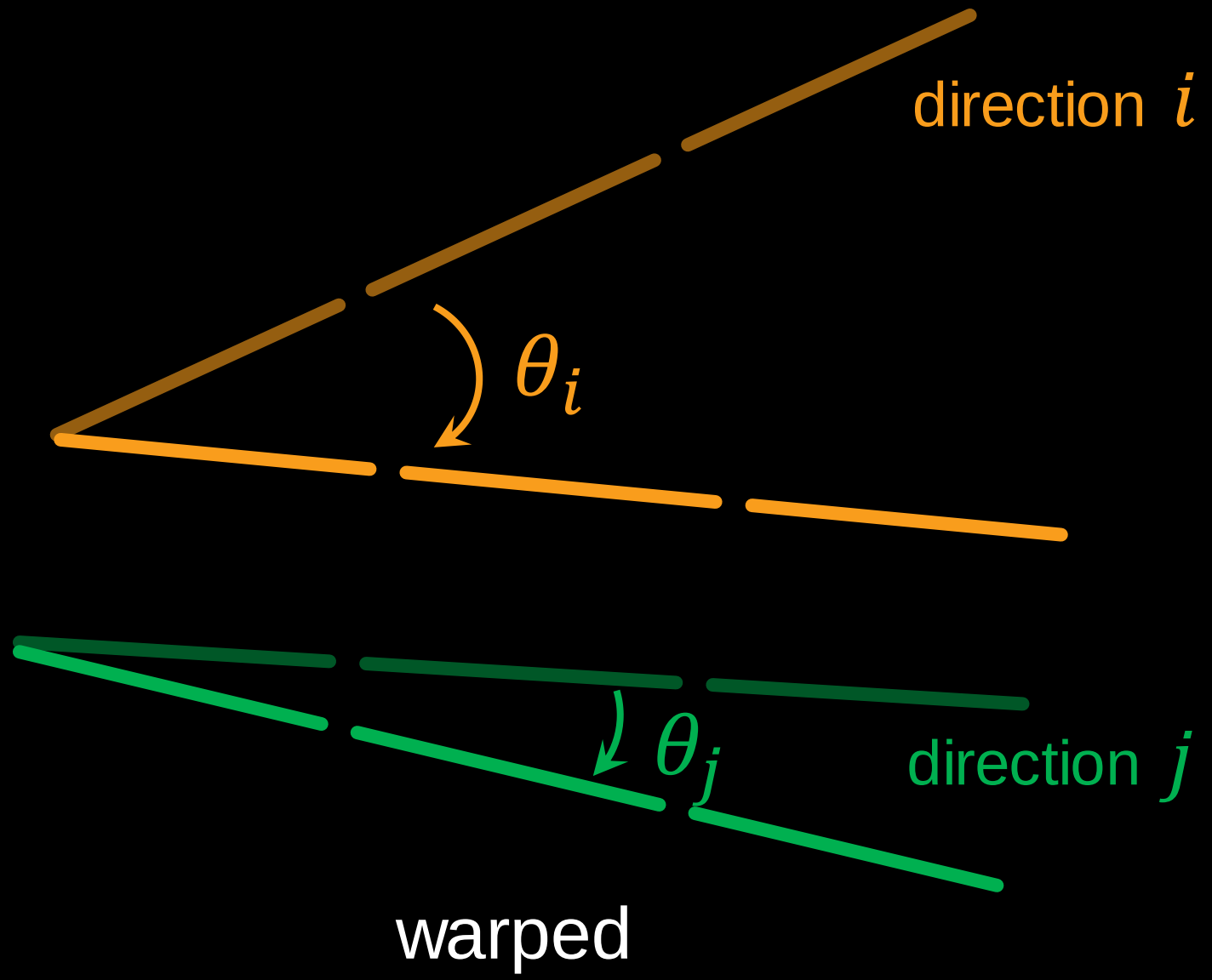


quantized directions
(50 bins)

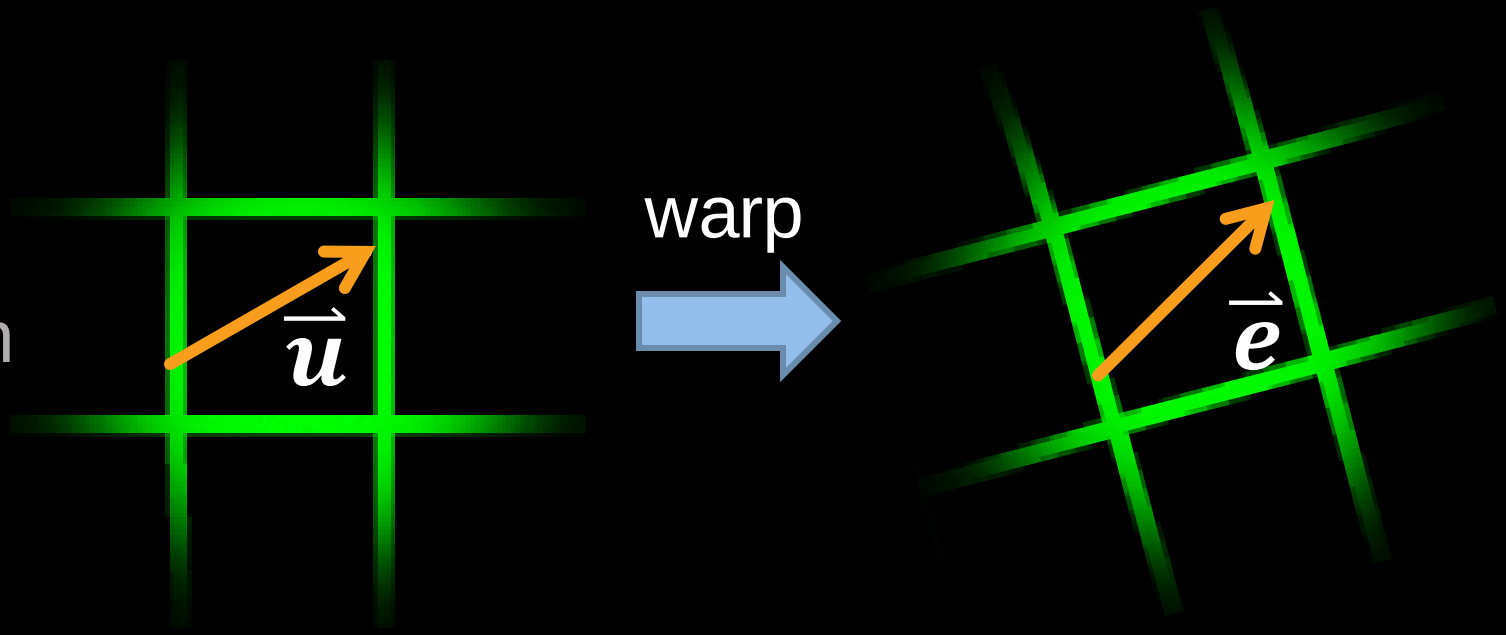
Line Preservation

- Lines in the same direction are rotated by the same θ
  [Chang & Chuang, CVPR 12]



Line Preservation

- Lines in the same direction are rotated by the same θ
  [Chang & Chuang, CVPR 12]
- Bind lines to mesh



$\vec{u}$ **rotate θ** $\vec{e}$ **bilinear** V

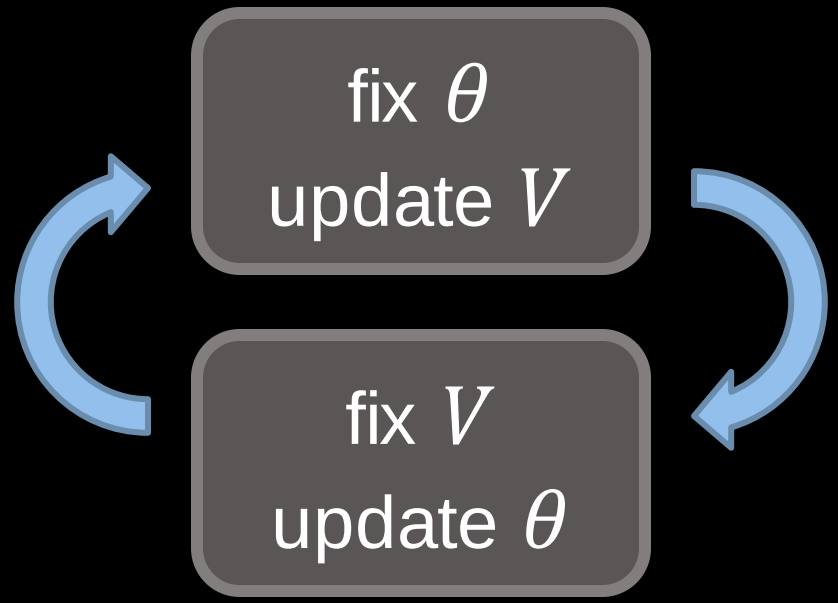
$$E_L(V,\theta) = V^T L_\theta V$$

L_θ: *Laplacian*

Global Warping

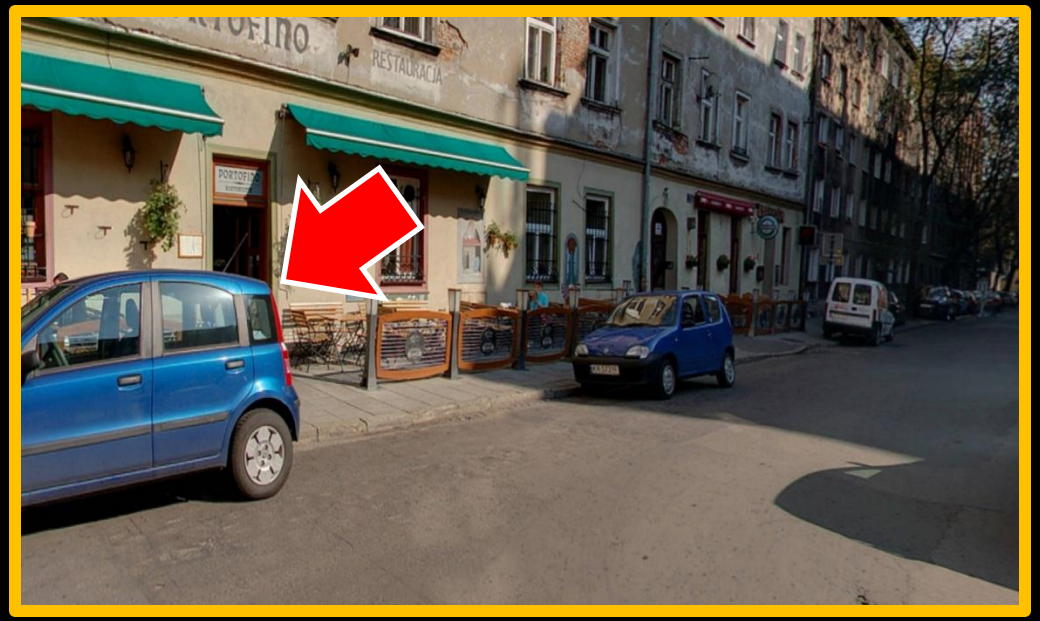
- Mesh optimization
  - Boundary constraints
  - Shape preservation
  - Line preservation
  - Total energy

$$E(V,\theta) = E_B + E_S + E_L$$

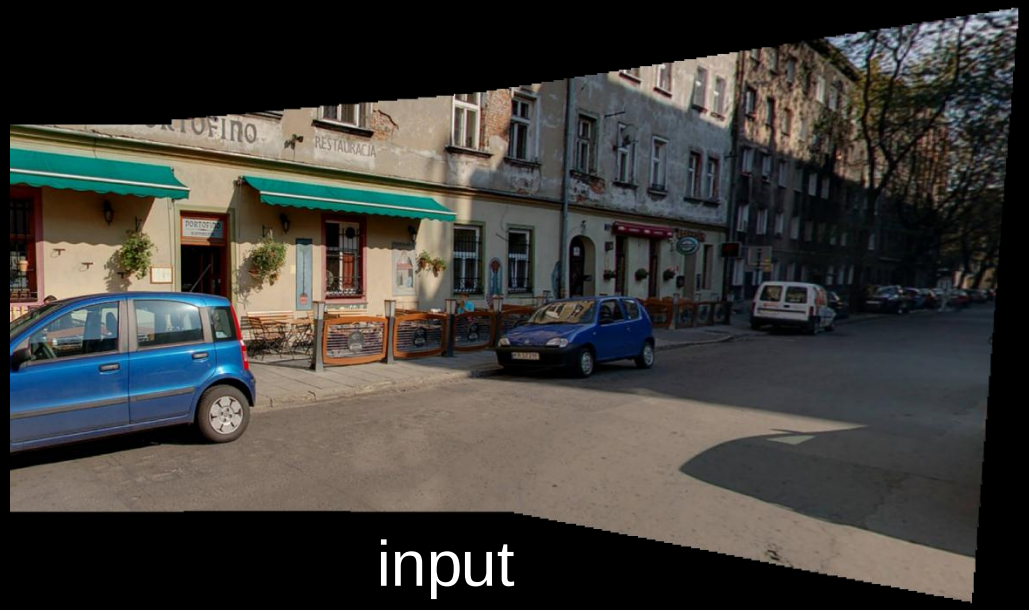


Global Warping

- Target rectangle



bounding box



input

normalized
scaling x : y ≈ 1:1

Results

input

Results

warp

Results

input

Results

warp

Results

input

Results

warp

crop

content-aware fill

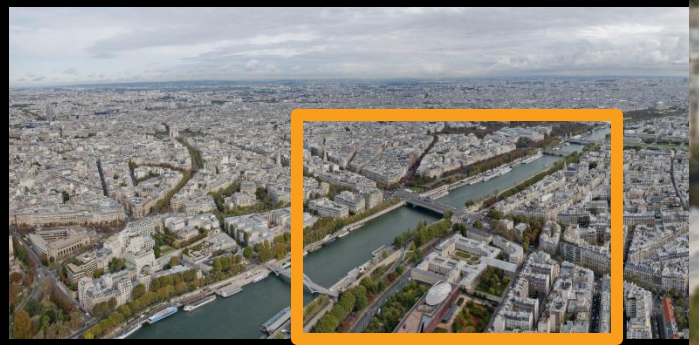
Results

input

Results

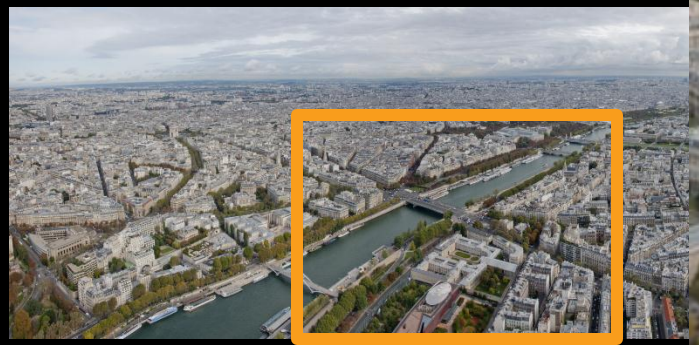
warp

Results



zoom-in output

Results

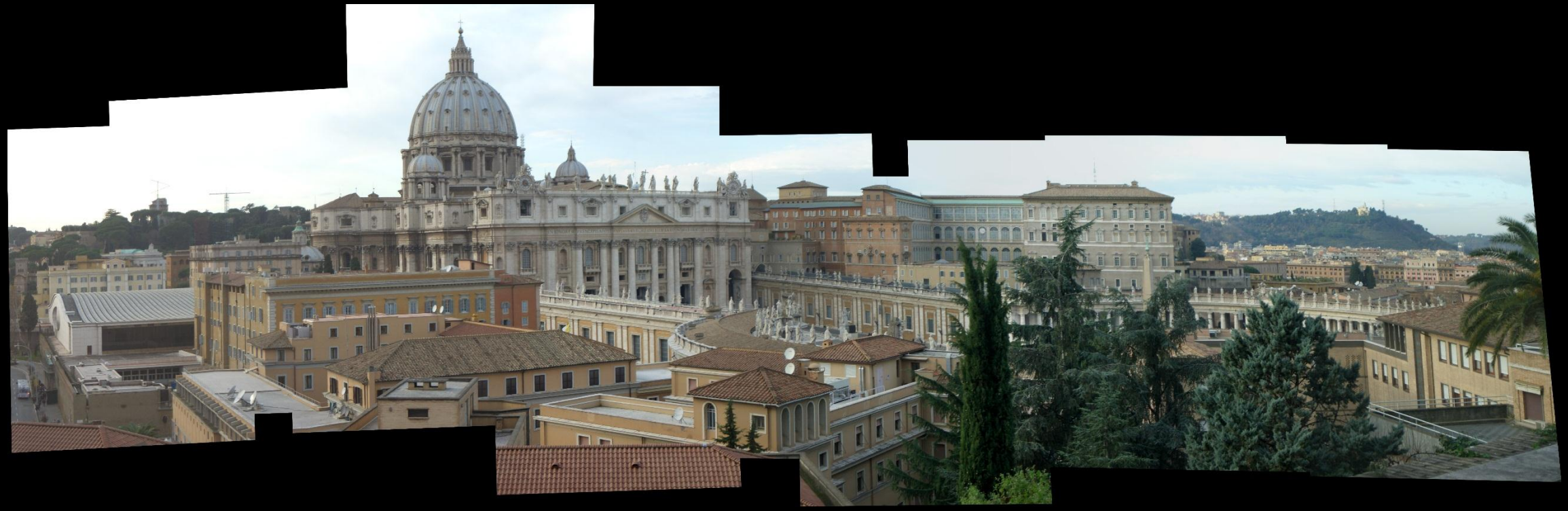


zoom-in input

Results

16-Mp
CPU 1-core
2s

Failure



input

Failure

warp

Conclusion

- New concept - rectangling via warping
- Unnoticeable, robust, and fast