

# Multi-perspective Panoramas



Slides from a talk by Lihi Zelnik-Manor  
at ICCV'07 3DRR workshop

# Pictures capture memories



# Panoramas



Registration: Brown & Lowe, ICCV'05

Blending: Burt & Adelson, Trans. Graphics, 1983

Visualization: Kopf et al., SIGGRAPH, 2007

# Bad panorama?



Output of Brown & Lowe software

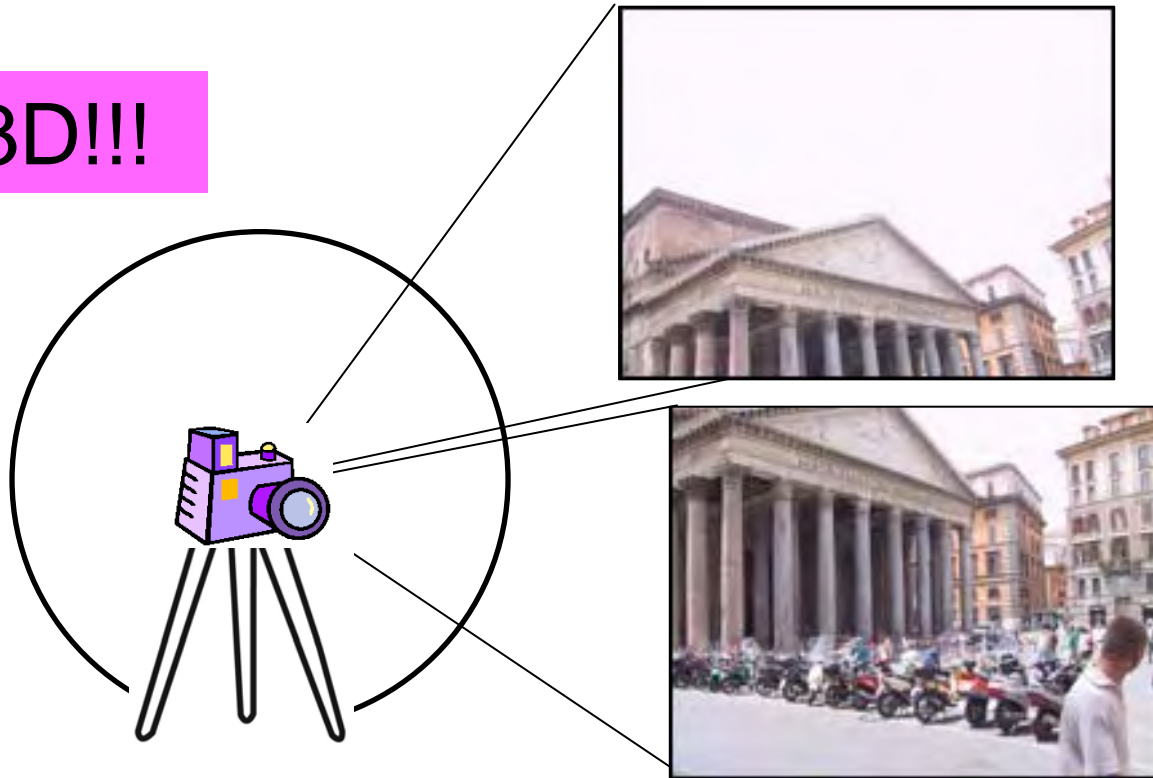


# No geometrically consistent solution



# Scientists solution to panoramas: Single center of projection

No 3D!!!

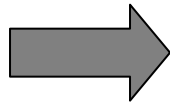


Registration: Brown & Lowe, ICCV'05

Blending: Burt & Adelson, Trans. Graphics, 1983

Visualization: Kopf et al., SIGGRAPH, 2007

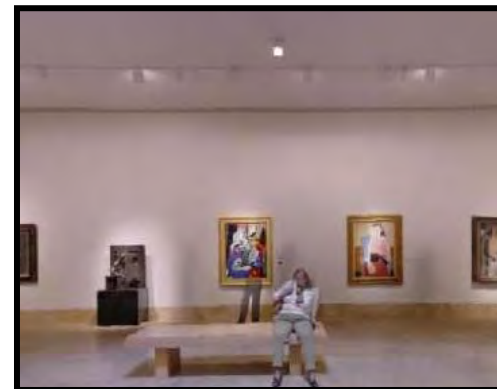
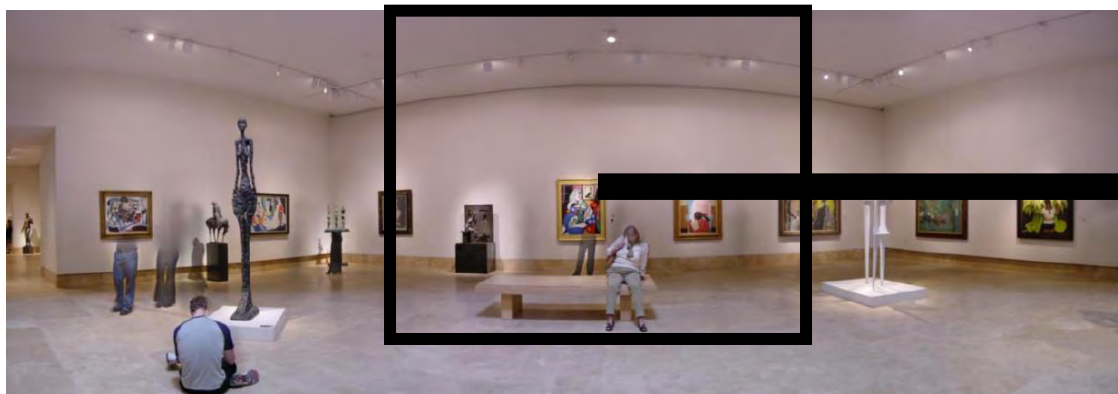
# From sphere to plane



Distortions are unavoidable

# Distorted panoramas

Actual appearance



Output of Brown & Lowe software



# Objectives

1. Better looking panoramas
2. Let the camera move:
  - Any view
  - Natural photographing

# Stand on the shoulders of giants

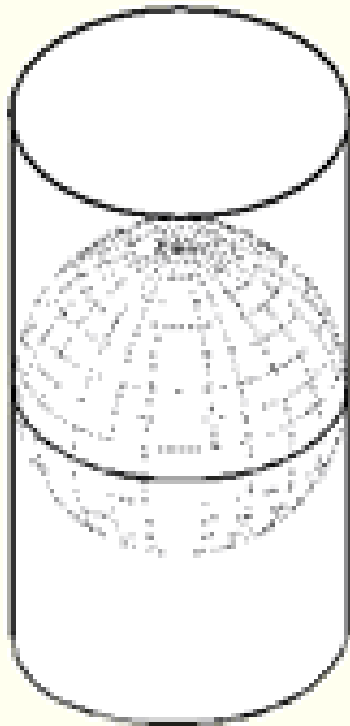
Cartographers



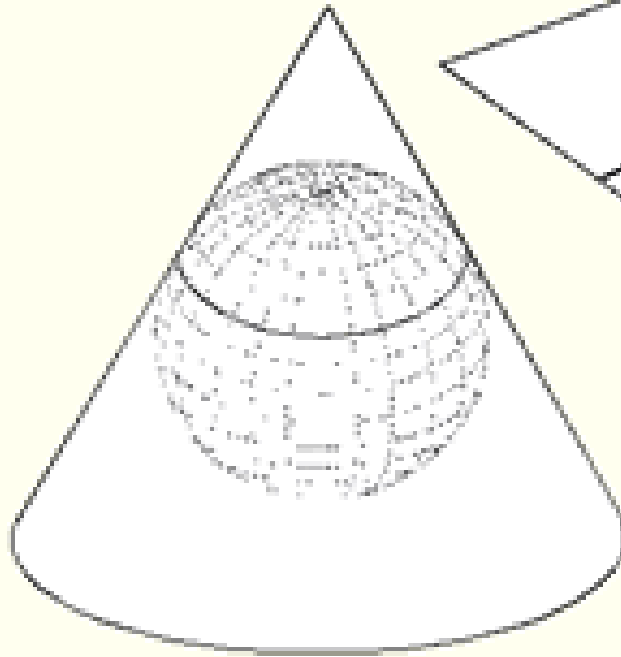
Artists



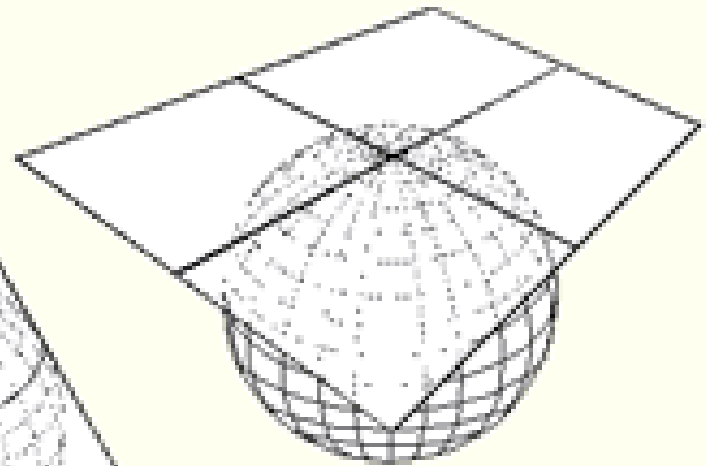
# Cartographic projections



Cylindrical



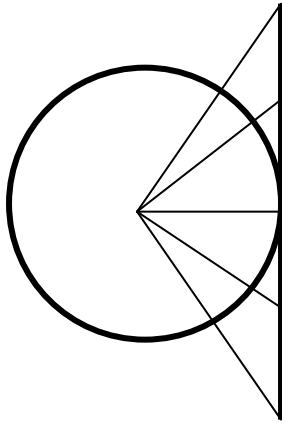
Conical



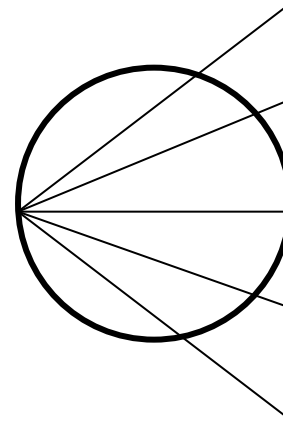
Azimuthal

# Common panorama projections

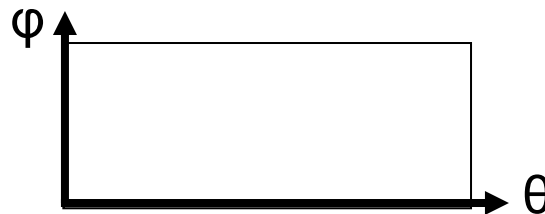
Perspective



Stereographic



Cylindrical





# Global Projections

Perspective



Stereographic

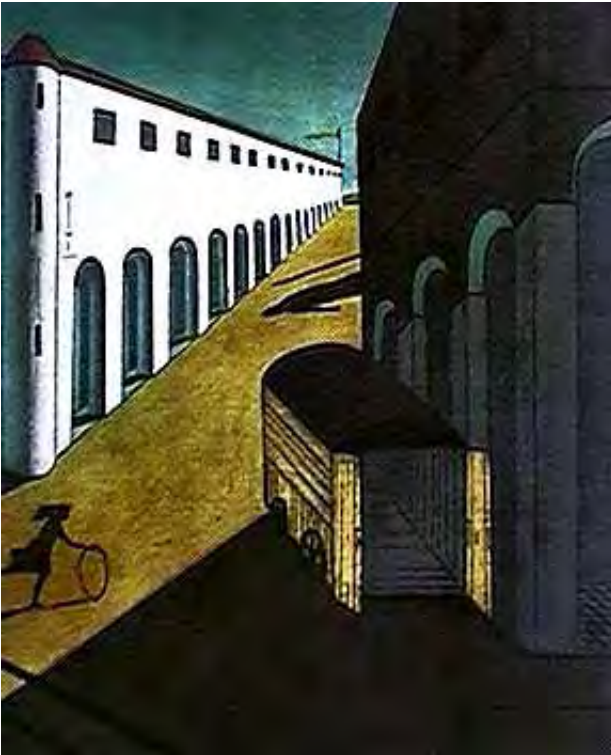


Cylindrical

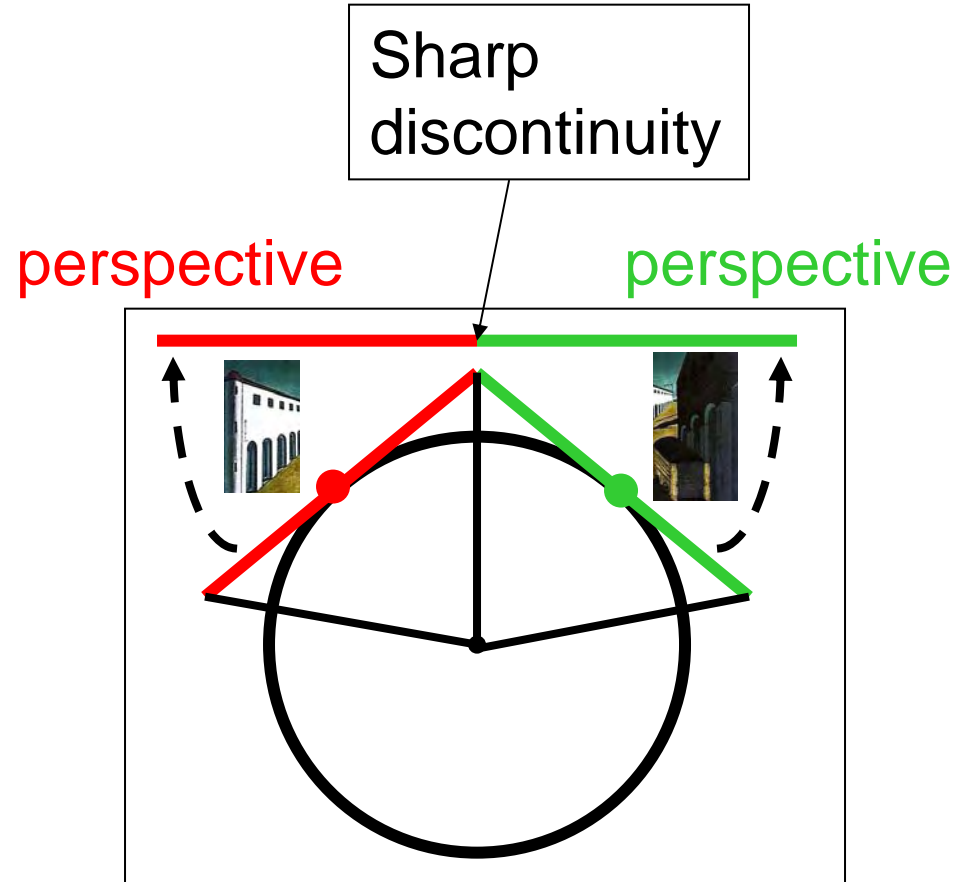


# Learn from the artists

Multiple view points



De Chirico "Mystery and Melancholy of a Street", 1914





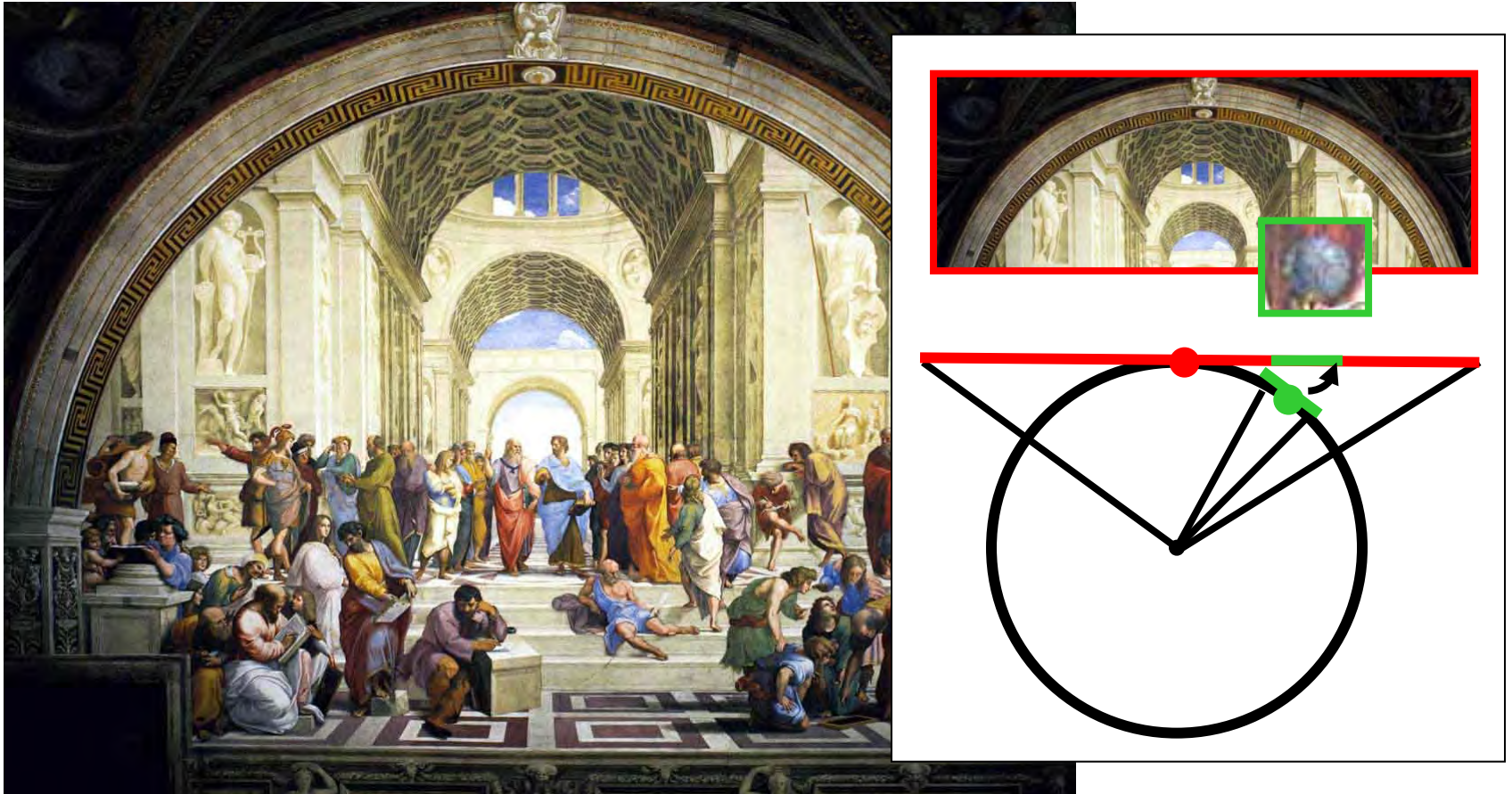
# Renaissance painters solution



“School of Athens”, Raffaello Sanzio ~1510

Give a separate treatment to different parts of the scene!!

# Personalized projections



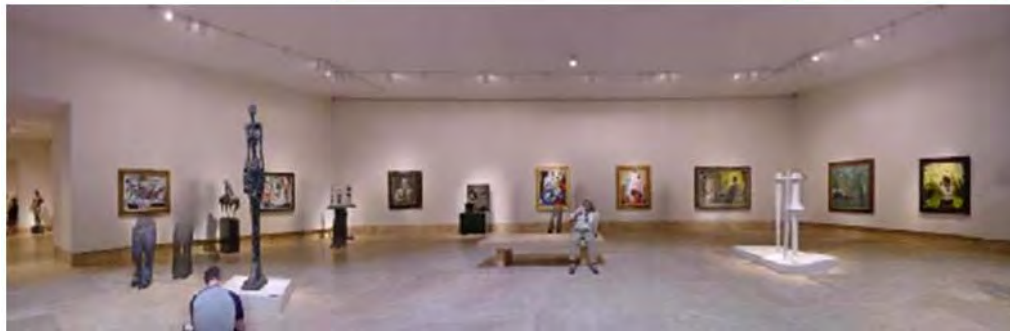
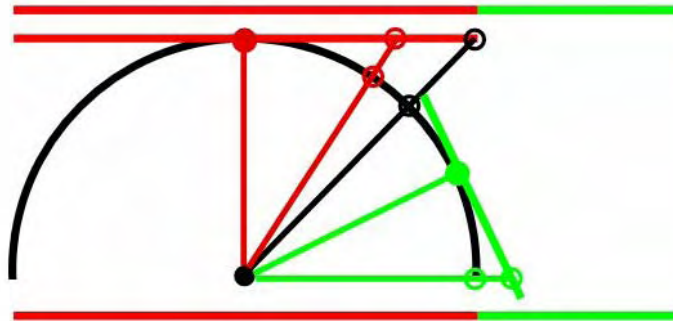
"School of Athens", Raffaello Sanzio ~1510

Give a separate treatment to different parts of the scene!!



# Multiple planes of projection

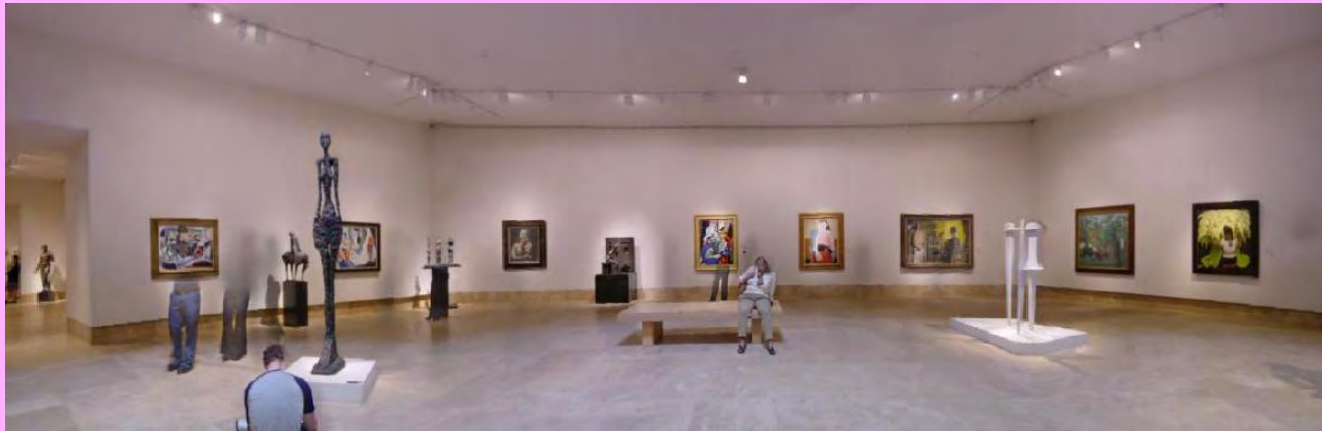
Sharp discontinuities can often be well hidden



# Single view



# Our multi-view result



## Single view



## Our multi-view result



## Single view



## Our multi-view result





# Applying personalized projections

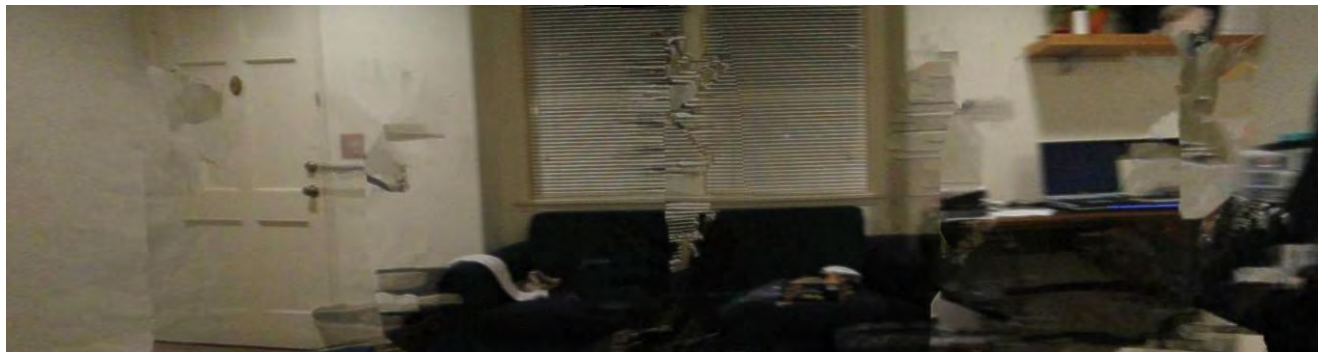
Input images



Foreground



Background  
panorama



## Single view



## Our multi-view result





## Single view



## Our multi-view result



# Objectives - revisited

1. Better looking panoramas
2. Let the camera move:
  - Any view
  - Natural photographing

Multiple views can live together

# Multi-view compositions

3D!!



David Hockney, Place Furstenberg, (1985)



# Why multi-view?

Multiple viewpoints



David Hockney,  
Place Furstenberg, 1985

Single viewpoint



Melissa Slamin,  
Place Furstenberg, 2003



# Multi-view panoramas

Single view



Multiview



Zomet et al. (PAMI'03)

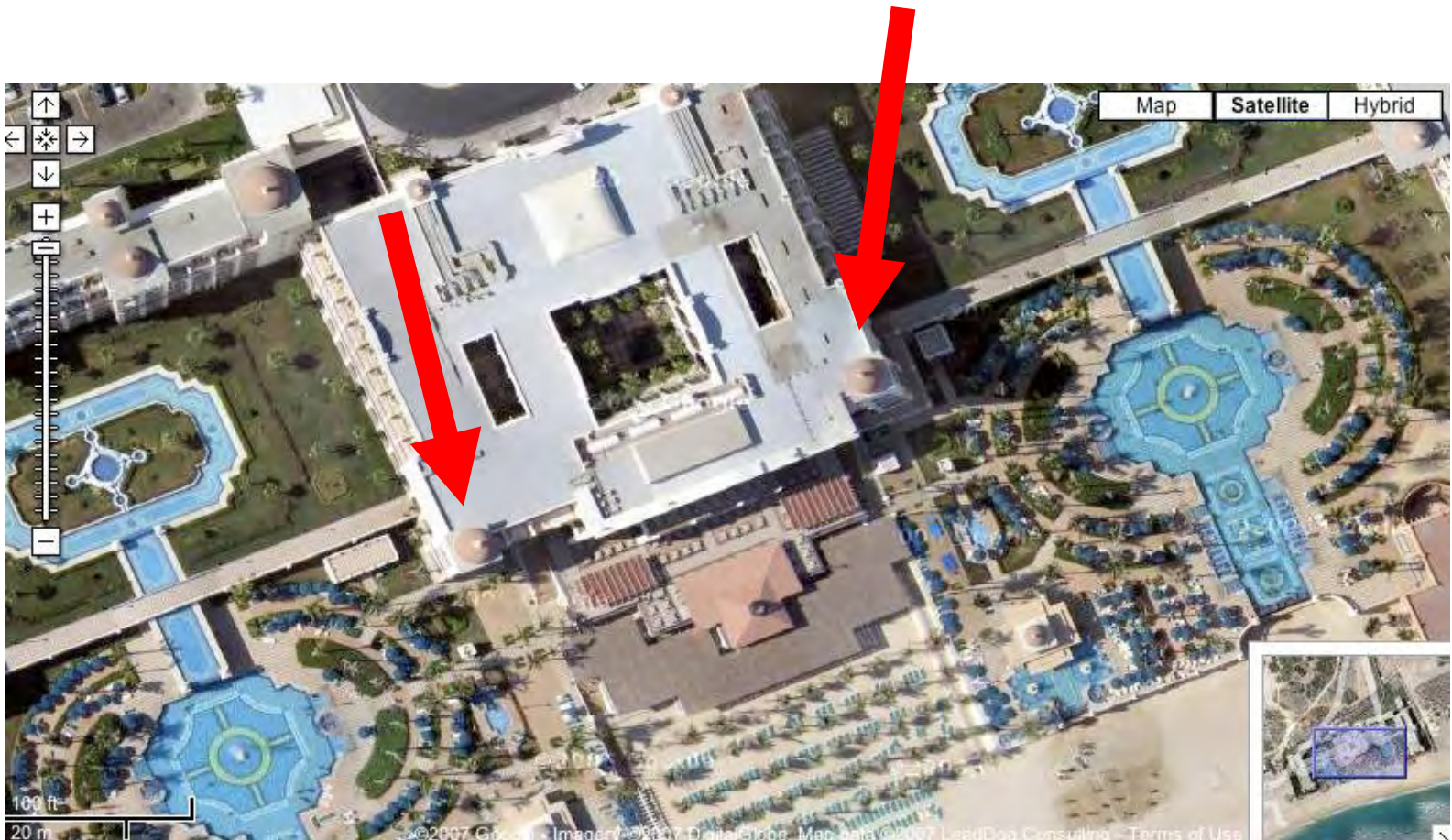
Requires video input

# Long Imaging



Agarwala et al. (SIGGRAPH 2006)

# Smooth Multi-View



Google maps



# What's wrong in the picture?



Google maps

# Non-smooth



Google maps



# The Chair



David Hockney (1985)



# Joiners are popular

Flickr statistics (Aug'07):

4,985 photos matching **joiners**.

4,007 photos matching **Hockney**.

41 groups about **Hockney**

Thousands of members



Main goals:

Automate joiners

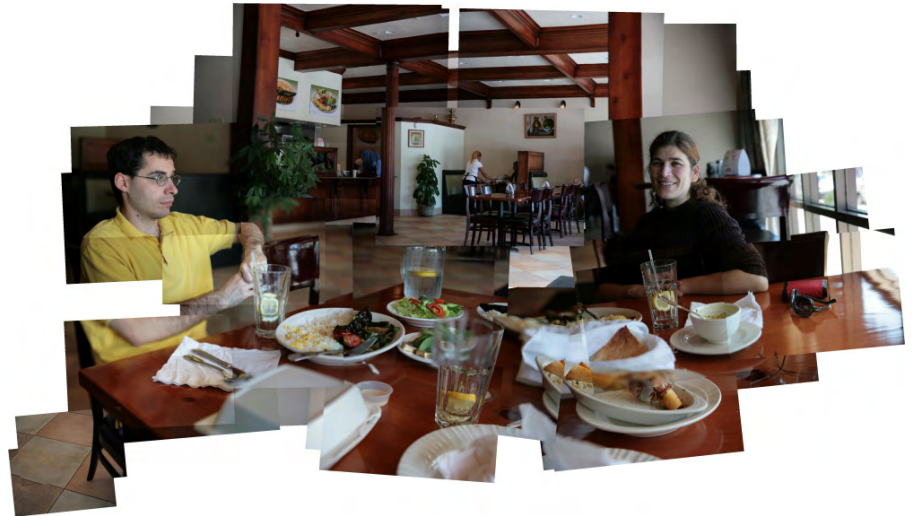
Generalize panoramas to general  
image collections

# Objectives

- For Artists:  
Reduce manual labor



Manual: ~40min.



Fully automatic

# Objectives

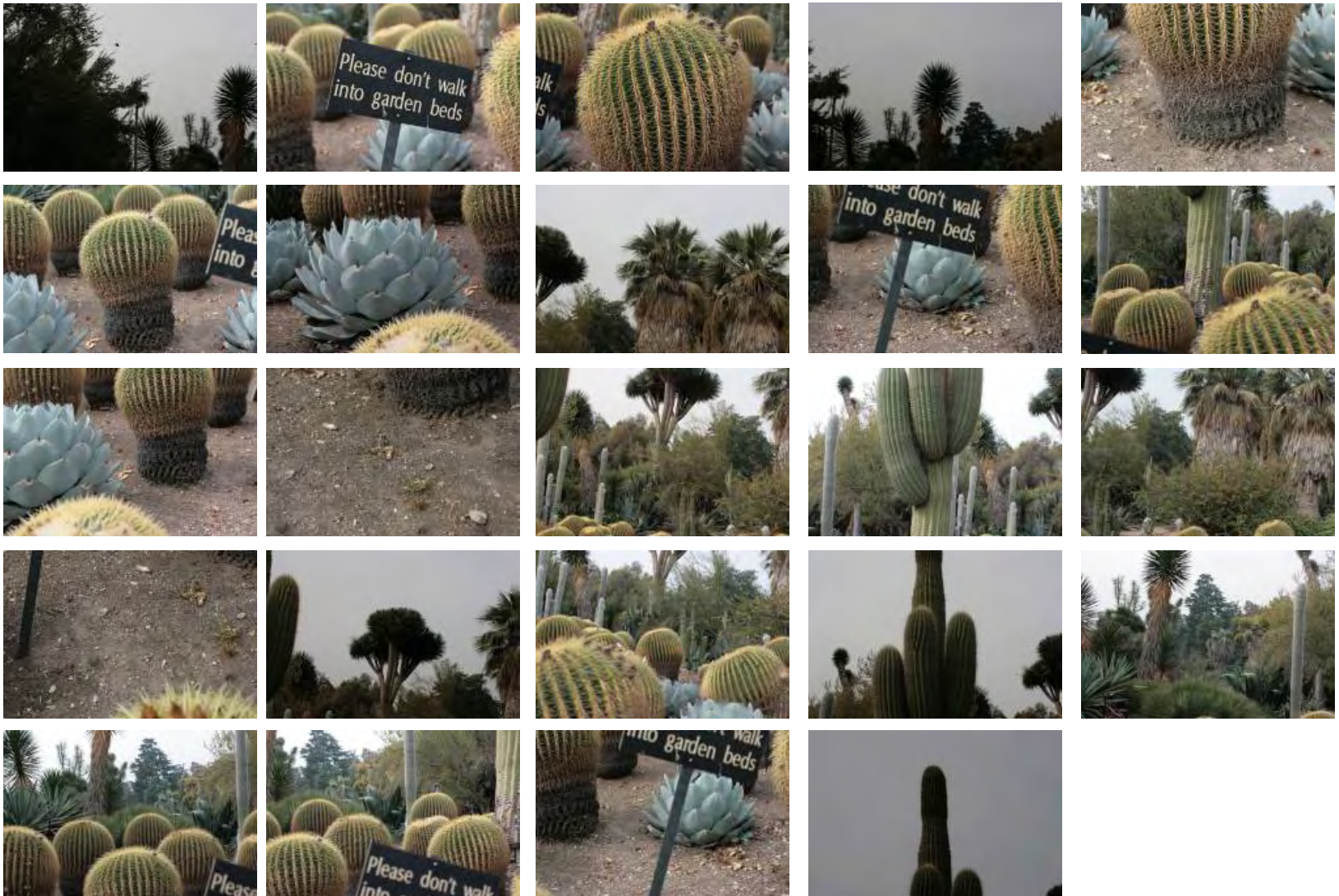
- For Artists:  
Reduce manual labor
- For non-artists:  
Generate pleasing-to-the-eye joiners



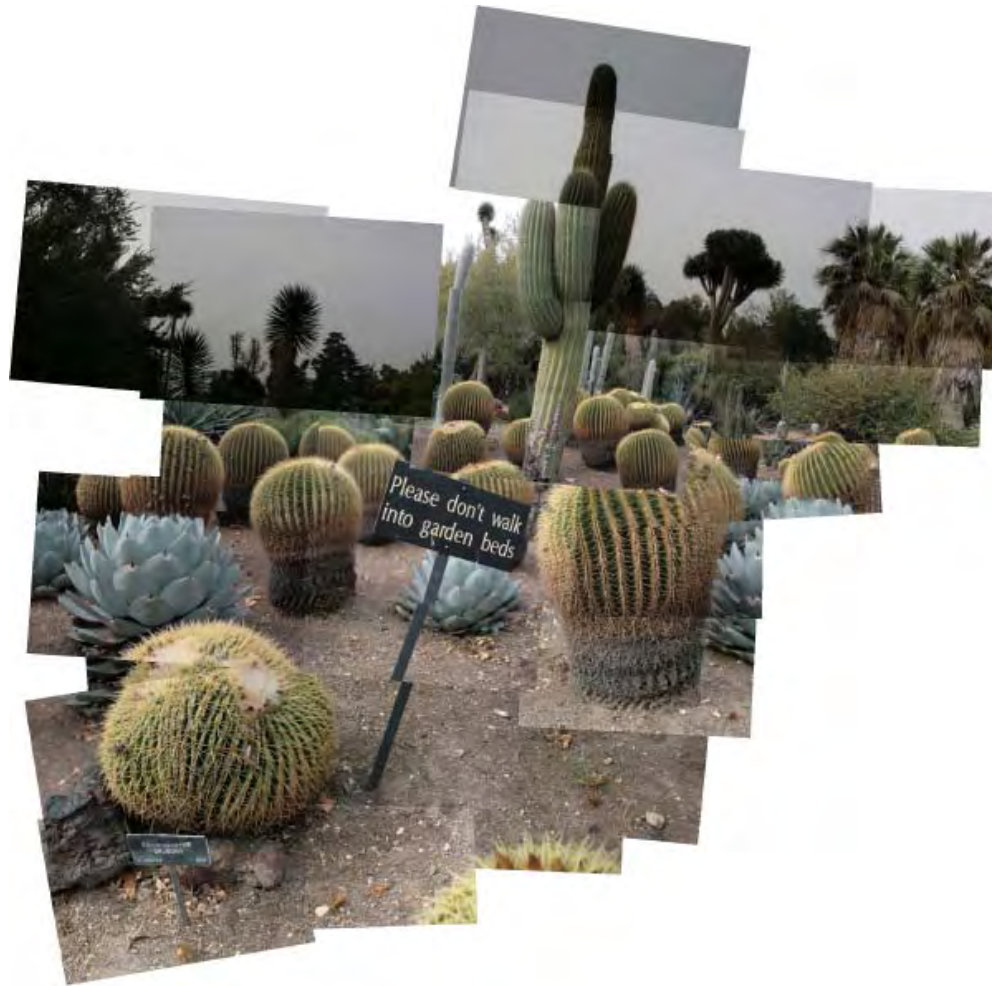
# Objectives

- For Artists:  
Reduce manual labor
- For non-artists:  
Generate pleasing-to-the-eye joiners
- For data exploration:  
Organize images spatially

# What's going on here?



# A cacti garden



# Principles



# Principles

- Convey topology



Correct



Incorrect

# Principles

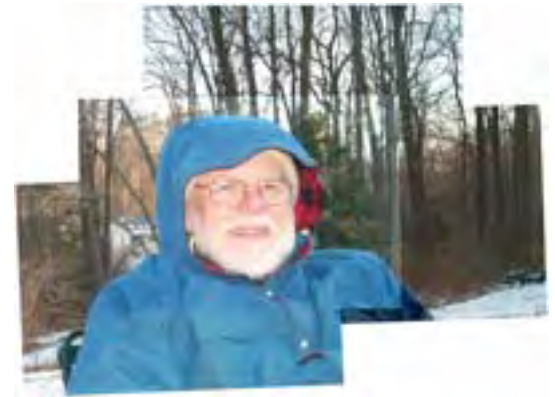
- Convey topology
- A 2D layering of images



Blending:  
blurry



Graph-cut:  
cuts hood



Desired joiner

# Principles

- Convey topology
- A 2D layering of images
- Don't distort images



translate



rotate



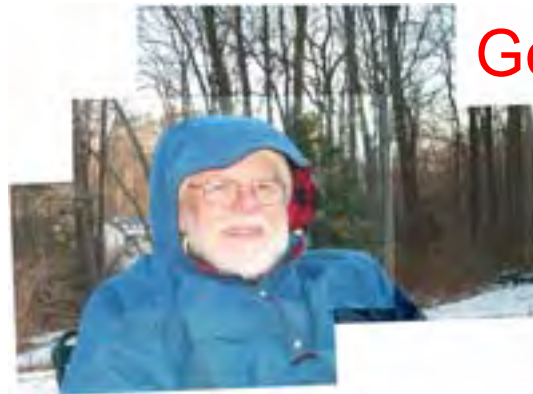
scale

# Principles

- Convey topology
- A 2D layering of images
- Don't distort images
- Minimize inconsistencies



Bad



Good



# Algorithm

# Step 1: Feature matching



Brown & Lowe, ICCV'03

# Step 2: Align



Large inconsistencies

Brown & Lowe, ICCV'03

# Step 3: Order



Reduced inconsistencies



# Ordering images

Try all orders: only for small datasets

# Ordering images

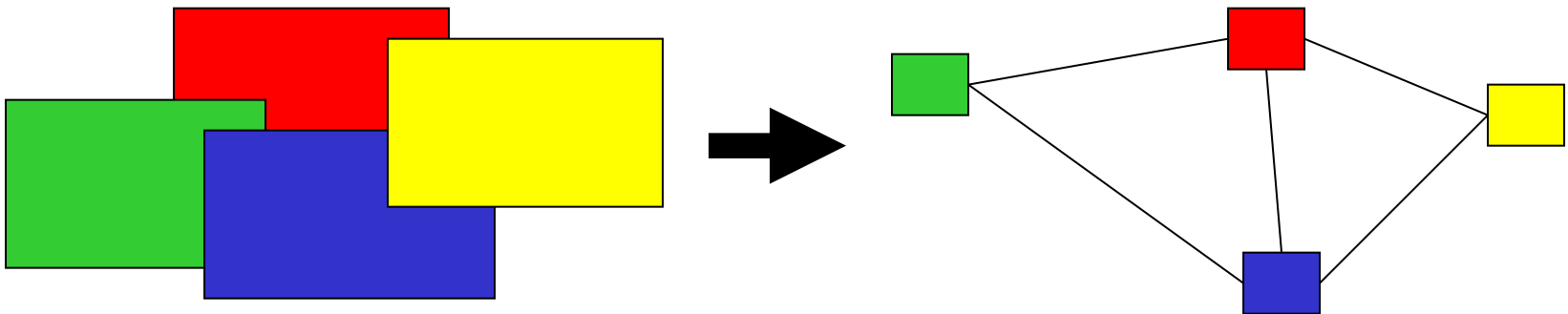
Try all orders: only for small datasets

complexity:  $(m+n)\alpha$

$m$  = # images

$n$  = # overlaps

$\alpha$  = # acyclic orders



# Ordering images

## Observations:

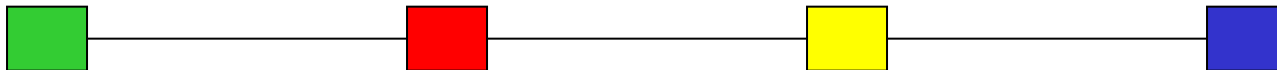
- Typically each image overlaps with only a few others
- Many decisions can be taken locally



# Ordering images

Approximate solution:

- Solve for each image independently
- Iterate over all images

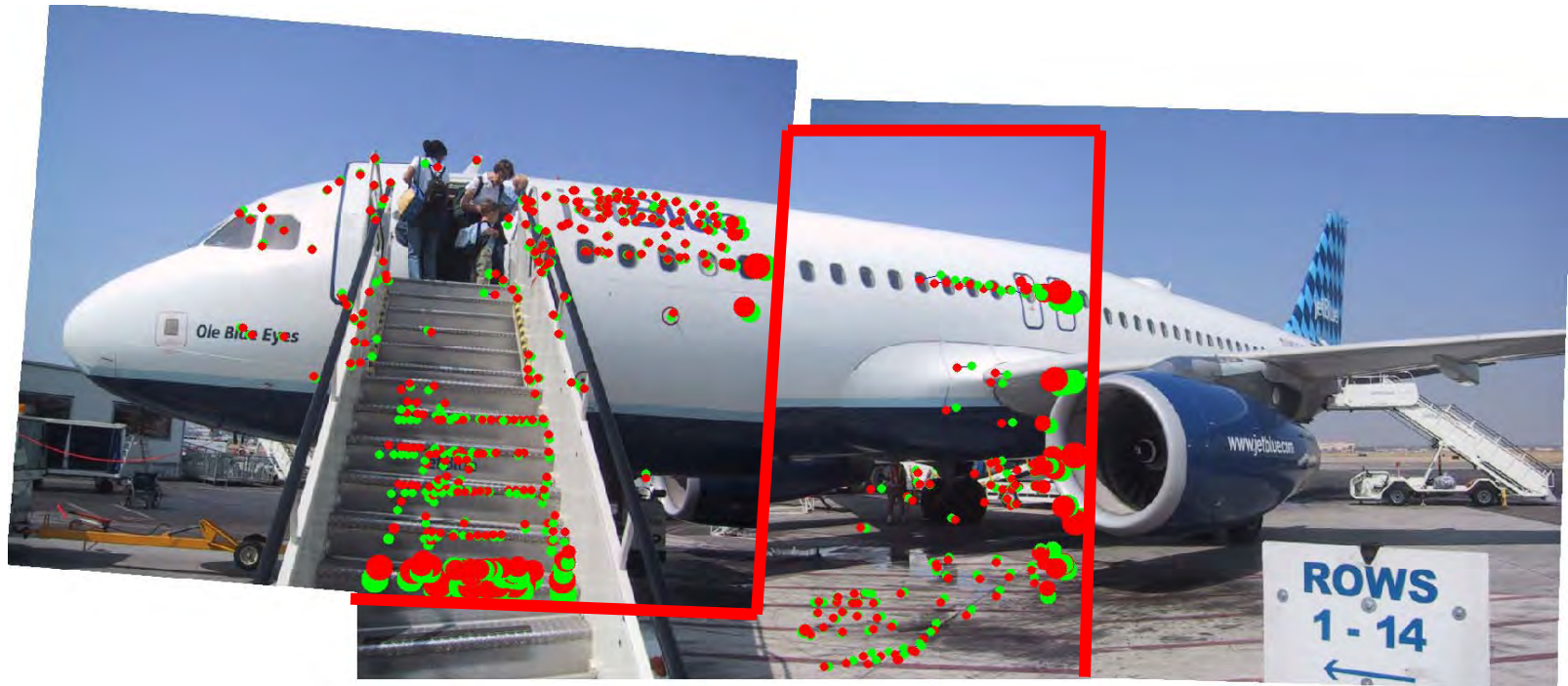




# Can we do better?



# Step 4: Improve alignment



# Iterate Align-Order-Importance



# Iterative refinement

Initial



Final





# Iterative refinement

Initial



Final



# Iterative refinement

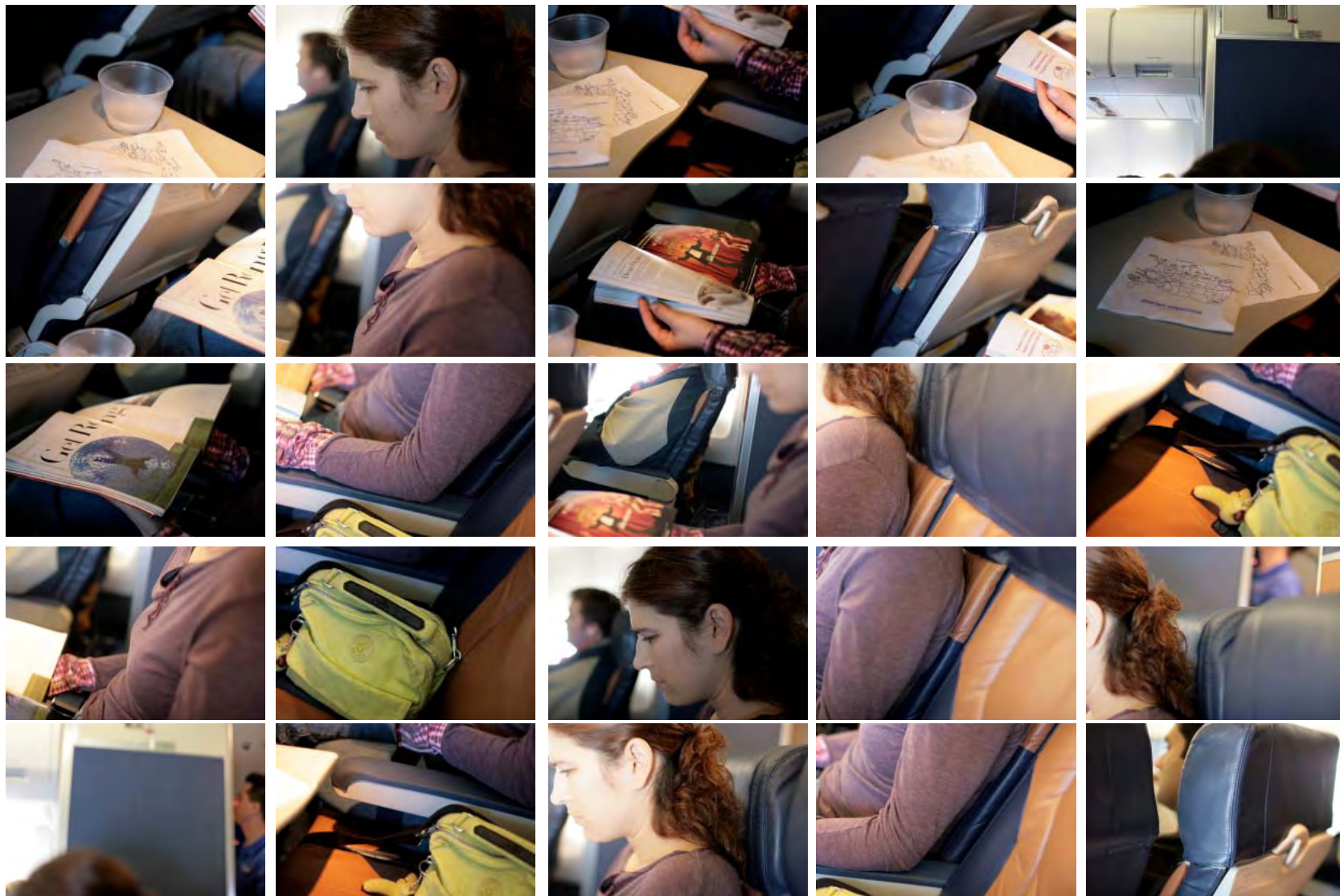
Initial



Final



# What is this?





That's me reading





# Anza-Borrego



# Tractor



# Art reproduction



Paolo Uccello, 1436



# Art reproduction



Paolo Uccello, 1436



Zelnik & Perona, 2006



# Art reproduction



Single view-point



Zelnik & Perona, 2006

# Manual by Photographer



# Our automatic result

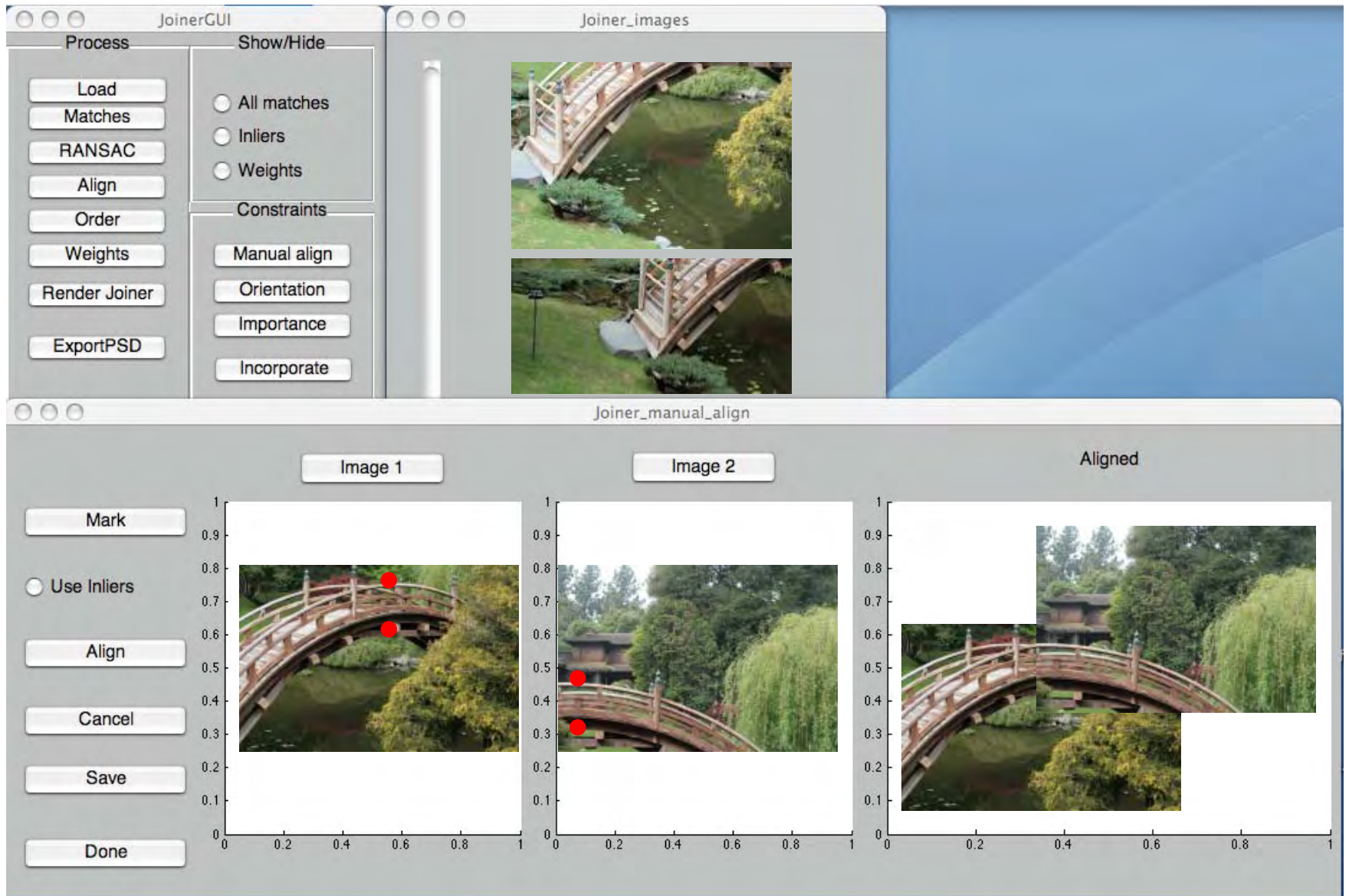


# Failure?





# GUI



# The Impossible Bridge





# Homage to David Hockney



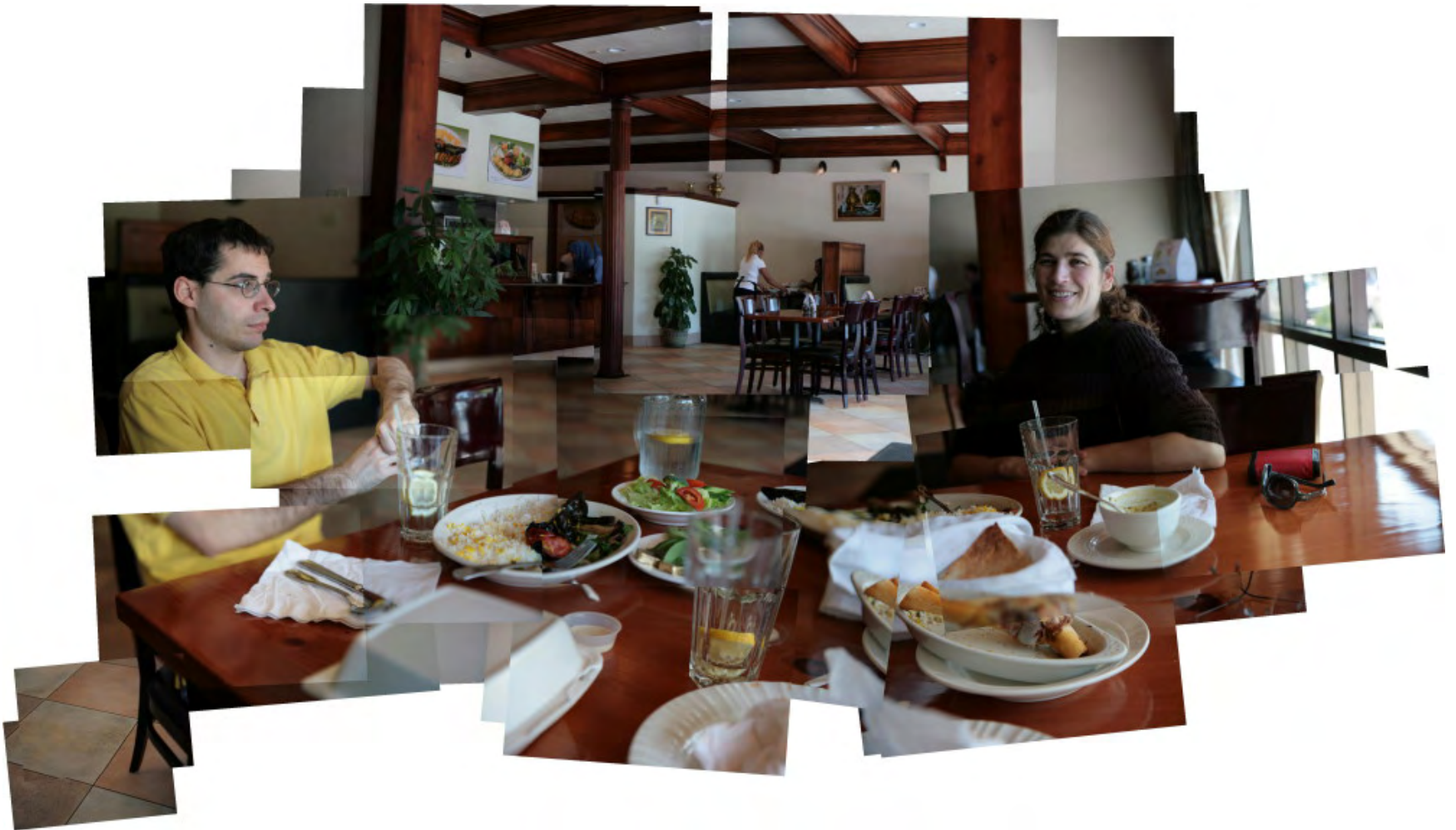
# Take home



- Incorrect geometries are possible and fun!
- Geometry is not enough, we need scene analysis

- A highly related work:  
"Scene Collages and Flexible Camera Arrays,"  
Y. Nomura, L. Zhang and S.K. Nayar,  
Eurographics Symposium on Rendering, Jun, 2007.





Thank You