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

multi-view result
Single view

multi-view result
Single view

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

David Hockney, Place Furstenberg, (1985)
Why multi-view?

Multiple viewpoints

David Hockney,
Place Furstenberg, 1985

Single viewpoint

Melissa Slemin,
Place Furstenberg, 2003
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: \((m+n)\alpha\)
- \(m = \# \text{ images}\)
- \(n = \# \text{ overlaps}\)
- \(\alpha = \# \text{ acyclic orders}\)
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
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,
This Class Project from 2007

http://www.cs.cmu.edu/afs/andrew/scs/cs/5-463/f07/proj_final/www/echuangss/