Using Perception to Make Better Pictures

How Graphics, Multimedia, Vision, Visualization, Animation, Art and Perception All Connect

Michael Gleicher
Dept of Computer Sciences
University of Wisconsin - Madison
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• This talk is mainly work done with students:

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  Greg Cipriano – molecules, vis
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  Danielle Albers, David He – genomics
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Stuff I do, and why you might be interested
What do these have in common?

- Analysis of Proteins
- Scientific Data Display
- Motion Synthesis for Characters
- Video Quality Improvement
- Multimedia Database
- Information Extraction
- Image and Video Retargeting
What do these have in common?

• It’s all stuff I’ve done in the past few years
What do these have in common?

• It’s all stuff I’ve done in the past few years

Does this all tie together?
How can we use our understanding of human perception and artistic traditions to improve our tools for communicating and data understanding.
What do these have in common?

• It’s all stuff I’ve done in the past few years

• It involves large amounts of data

• It involves creating effective presentations

• It requires some understanding of the data in order to simplify it
Where does perception/art fit in?

• Understand visual cues to design easier to interpret scientific displays

• Understand perceptual and cognitive resource limits to present more information

• Understand perceptual pliability to create better multimedia
Example 1: Molecular Surfaces

• Understand visual cues to design easier to interpret scientific displays

• Understand perceptual and cognitive resource limits to present more information

• Understand perceptual pliability to create better multimedia
A Protein Surface

Work with Greg Cipriano and George Phillips
An aside...

How do scientists look at proteins?

Stick and Ball Model (internals)
An aside...

How do scientists look at proteins?

- Stick and Ball Model (internals)
- Ribbon Diagram (internals)
An aside...

How do scientists look at proteins?
A Protein Surface

Quiz:
What shape is this?
How does that shape effect what this molecule does?
Molecular Surface Abstraction

Work with Greg Cipriano and George Phillips
What’s Happening?

• Simplification

• Stylized Display

• Surface Indications
Art
• Abstraction
• Good Lighting
• Line Drawings
• Non-Photorealism

Visual Cognitive Science
• Cue reduction
• Provide Depth Cues
• Enhance Contours
• Tolerance of Shading
Need to get people to use it

Provide it on the web!

grape.uwbacter.org
Why does B fight cancer?
Example 2: Genomics

- Understand visual cues to design easier to interpret scientific displays

- Understand perceptual and cognitive resource limits to present more information

- Understand perceptual pliability to create better multimedia
Whole-Genome Sequence Comparison Visualization

Work with Danielle Albers, David He, Colin Dewey, Nicole Perna, ...
Current Tools

MAUVE (Perna lab)
Genome Sequence Comparison

• No single view is sufficient for the large and complex data encountered in comparative genomics!
A Multi-View Approach
Perception to the rescue?

• Pre-attentive phenomena
• Resource limits
  – foveation, visual working memory, ...

Emerging Perceptual Science

• Ability to sense summary statistics
• Ability to summarize outside of fovea
• Design for effective visual search
A common thread: Visual Comparisons
A “science” of Visual Comparison?

• Just starting out

• Case studies

• Beginning to see general principles
  – Common strategies
  – Cognitive limitations
How do we do this?

• Pick some sample problems
• See if we can learn some general ideas
Who is interested?
Example 3: Video Stabilization

- Understand visual cues to design easier to interpret scientific displays

- Understand perceptual and cognitive resource limits to present more information

- Understand perceptual pliability to create better multimedia
How can we use our understanding of human perception and artistic traditions to improve our tools for communicating and data understanding.
Video Stabilization

Problem:
• Shaky video in, less shaky (good?) video out

Perception and Art
• What is good camera movement?
• How can we avoid the impossible?
Motivation:

More video doesn’t mean better video

Good video takes effort!

(But cameras are everywhere)
Problem: Bad Camera Motion

- No planning
- No tripod
Problem: Bad Camera Motion
Prior Work: Image Stabilization

One part of the problem:
  jitter
Helped by
  Image Stabilization
Three Projects

• **Re-Cinematography**
  – What can you do beyond removing jitter?

• **Stabilization by 3D Warping**
  – How can you make bigger changes?

• **Stabilization by Subspace Constraints**
  – How do you make it practical?

Work with Feng Liu and Adobe
Video Stabilization

• Existing approach: 2D stabilization

  • Track a bunch of points
  • Fit full-frame warps that best smooth point motion

• Limited!

  • Doesn’t model parallax
  • Can’t reason about camera motions in 3D
Re-Cinematography

• A 2D stabilization approach

• A model of Computational Cinematography
  – What is a good camera motion?

• Cannot deal with large viewpoint changes
A more interesting question: To swing or not to swing

Source Footage

Re-Cinematography Result
Artifacts

Input:

Output:

Where did she come from?
3D Video Stabilization

- Reconstruct 3D model of world
- Plan new camera path
- Synthesize new images
How do you move the camera to a different place?

3D experiences without 3D models
Novel viewpoint rendering

How to make a video-quality image?

• **Build a really high-quality 3D model?**
  Too hard
  Not enough input data

• **Image-Based Rendering using other frames?**
  Violates temporal constraints
  Computationally expensive
Novel view from one frame

Impossible?

• Incomplete geometric model (sparse)
• Occlusions / Dis-occlusions
Novel view from one frame

Impossible?

• Incomplete geometric model (sparse)
• Occlusions / Dis-occlusions

Impossible! So Fake it!

• Just need visually plausible, not accuracy
• Viewpoint shifts will be small
• Avoid artifacts
3D Stabilization by Image Warping

- Structure from motion gives sparse points
- 3D camera planning gives motion of points
- Use sparse points to warp image
Results & Comparisons

**Input**

**Our Output**
Is this a good reconstruction? NO!

Camera position

Output points
One frame isn’t so bad...
Especially if you crop
Perception for better pictures!

• Understand visual cues to design easier to interpret scientific displays

• Understand perceptual and cognitive resource limits to present more information

• Understand perceptual pliability to create better multimedia
How can we use our understanding of human perception and artistic traditions to improve our tools for communicating and data understanding.
Thanks!

• To you for listening

• To my students and collaborators

• To the folks who pay the bills
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