Pictures from Piles of Data
How Graphics, Multimedia, Vision, Visualization, Animation and Cartography All Connect

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Acknowledgements

• All of this work is done in collaboration with a great group of students.
• This talk is mainly work done with:

Feng Liu – multimedia, video (work supported by NSF, Adobe) 
Greg Cipriano – molecules, vis (work supported by NIH)
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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

• It involves large amounts of data

• It involves creating effective presentations

• It requires some understanding of the data in order to simplify it
Data abundance in the modern age

Is there any historical precedent?
The world, 1528. Birmingham Public Library Digital Collection.
Figura Del Mondo Universale, 1558
Talk Roadmap

- Molecular Surface Abstraction
- Surface Cartography
- Warping for 3D Video
- Re-Cinematography
- Odds and Ends
Talk Roadmap

Molecular Surface Abstraction

Surface Cartography

Warping for 3D Video

Re-Cinematography

Odds and Ends
A Protein Surface
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

Ribbon Diagram (internals)
An aside...

How do scientists look at proteins?

Molecular Surface (externals)
A Protein Surface
Molecular Surface Abstraction
What’s Happening?

• Simplification

• Stylized Display

• Surface Indications
Putting Information on Surfaces

Surface Parameterization
• Only for local regions
• Requires smoothness
• Artistic issues?
Patch Smoothing

Before

After
Put text on a surface?
Put text near the surface?

- Corpus Callosum
- Parietal Lobe
Put text near the surface?

Corpus Callosum

Text scaffold

Parietal Lobe
Text Scaffolds
Cartographic Labeling

Basic principles:

• Text should be legible
  – Smooth, likely straight, path

• Text should be visible
  – Always on top of other features

• Text may track important features
  – E.g. roads, rivers

• Text should be close to feature
Translate these goals into 3D!
Goals

• **Legibility**
  - Text must be readable
  - Surface must be smooth

• **Visibility**
  - Surface can’t enter occluded regions
  - Surface must bound object

• **Proximity**
  - Labels must lie as close as possible to corresponding region

• **Shape-conveying**
  - Scaffold should retain as much of the original shape as possible.
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How to meet these goals?

• Create a surface to put labels on a Text Scaffold

• Use 2D cartography methods on the scaffold
Creating Text Scaffolds

• Start with anything
• Convert to Distance Field
• Adapt field to meet goals
• Convert to mesh
Example
Results
Results
Examples
From Artistic and Perceptual Principles
To Computational Models
Motivation:
More video doesn’t mean better video

Good video takes effort!
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
Problem: Bad Camera Motion
Solution: Re-Cinematography

Re-Cinematography:
Post-process video clips so that the camera motions better follow the rules of good video.
Rubber duck races
Vail, CO, USA, 19 August, 2007
What the art of cinematography tells us about camera motion

Camera motions should be intentional

– Avoid movement if not necessary
– Move in directed ways

Re-Cinematography:
Post-process video clips so that the camera motions appear to better follow the rules.
Re-Cinematography Pipeline

Source Video → Motion Estimation → Motion Synthesis → Image Transform → Result Video
Re-Cinematography Pipeline (1)

Source Video → Motion Estimation → Motion Synthesis → Image Transform → Result Video

How did the camera move?
Re-Cinematography Pipeline (2)

Source Video → Motion Estimation → Motion Synthesis → Image Transform → Result Video

Figure out what motion we want in the result
Transform the source into the result
Motion Synthesis Steps

Source Video → Motion Estimation → Motion Synthesis → Image Transform → Result Video

Segment Video → Create Motions → Optimize Motions
3 Key Ideas

• Analyze motion estimates to break video into segments
• Use local mosaics to keyframe new camera motions
• Consider both motion and image quality to automatically keyframe cameras
Local Mosaics

Limit error and motion in each segment
Virtual camera does not have to be where the real camera was

Result frames shown in magenta

Source frames shown in yellow
What paths do we want?

1. Preserve the intent of the source
2. Obey the rule of cinematography:

   Camera motion should be intentional
The key insight: Translate cinematography to implementation

Motion should be intentional

- Static shots should be static
- Moving shots are goal directed
  - Constant velocity with ease in/out
Directed Paths

Interpolate with direct constant* velocity paths

* Possibly with ease-in and out.
Smooth Paths Depart from Original

Source motion

Result motion
Changing motion means transforming frames

Source motion

Result motion
Transforming frames might cause problems
Penalties for each frame

Offscreen
Uncovered
Distortion
Offscreen
Uncovered
Distorted
A contrived synthetic example to explain key insertion
Try the smooth motion first
Insert a key at the worst point
Examples

• 2X speed to emphasize motion
• Everything is full-frame
• Everything is from real home videos
Learning to run
Vail, CO, 19 August 2006

Source Video
Learning to run
Vail, CO, 19 August 2006

Re-Cinematography Result
2X speed comparison

Source Footage

Re-Cinematography Result
2X video
2X speed
comparison
Source Footage
Re-
Cinematography Result
A more interesting question:
To swing or not to swing
Artifacts

Input:

Output:

Where did she come from?
Sam’s First Steps, July 6th, 2006

Re-Cinematography Result
Talk Roadmap

Molecular Surface Abstraction

Surface Cartography

Warping for 3D Video

Odds and Ends

Re-Cinematography
How do you move the camera to a different place?

3D experiences
without 3D models
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
3D Video Stabilization

- Reconstruct 3D model of world
- Plan new camera path
- Synthesize new images
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
• **Show external mov file**
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Odds and Ends
But wait... There’s more!

Too many things to talk about...
Things we could talk about...

- Creating “abstracted” vector art from data
- Cartoons from data
- Adapting for small displays / interfaces
- Stylized drawing from other data
- Camera control during drives throughs
- Meaningful synthetic drive throughs
- Idealified geometry from real images
- ...
