Computer Graphics and Applications

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What is Computer Graphics?

- Modeling
- Rendering
- Animation
- Simulation
- Interaction
Where is it used?

- Entertainment
- Industrial design
- Cultural heritage
- Education
- Bio-medicine
- …
Modeling

- Modeling from real-world data

- From 3D volumes (e.g., MRI/CT)
- From cross-sections
- From point cloud
- From curve networks
Modeling

- Shape analysis

Segmentation

Skeletonization

Feature curve extraction

Feature matching
Modeling

- Interactive modeling from images

Modeling a chair
Modeling

- Interactive shape analysis
Modeling

Stylizing images

Texturing surfaces

Making pop-up cards
Animation

- 2D cage-based image deformation
Animation

- 3D cage-based character animation

Model at a resting pose and its cage (black lines)

Moving the cage deforms the model
Animation

- 3D cage-based character animation
Bio App: Structural Biology

• Study of 3D protein structures
  – Protein: a sequence of amino acids folded into a unique 3D shape
    • One protein may exhibit different shapes in different environments
  – Protein function derived from its structure
    • Key to understanding biological processes and developing drugs
Bio App: Structural Biology

• Cryo-EM imaging of large protein complexes (e.g., virus)

3D image of a virus
A single protein
Molecular Structure

Challenge: building protein structures from low-resolution images
Bio App: Structural Biology

- Using shape analysis

Cryo-EM Volume

Protein Structure
Bio App: Structural Biology

- Using shape analysis

Cryo-EM Volume

Plate

Tube

β-sheet

α-helix

Coarse Protein Structure
Bio App: Structural Biology

- Using shape analysis

Cryo-EM Volume → Plate → Curve → Surface → α-helix → β-sheet → Coarse Protein Structure
Bio App: Structural Biology

- Skeleton-based detection of secondary structure elements

Skeleton Score + Helix Score = Scored Psuedo-atoms → Located SSE elements
Bio App: Structural Biology

- Connectivity among helices based on the skeleton
  - Using graph matching with protein primary sequence
  - Current work: connectivity among sheets

Protein sequence with helix annotation + Cryo-EM skeleton with identified helices → Connected helices
Bio App: Structural Biology

- **Gorgon**
  - Interactive protein modeling tool for low-resolution density maps
  - Co-developed by WashU and Baylor College of Medicine
  - 500+ registered users in 40+ countries, 3 training workshops in Houston

http://gorgon.wustl.edu (Google: “Gorgon”)
Bio App: Others

- Neuroscience
  - Comparing expression patterns of different genes in the mouse brain using geometric model of the brain

- Radiology
  - Monitoring bone shape and density changes using geometric models of the foot bones
Graphics Courses @ WU

• CSE 452: Computer Graphics
  – Basics in image processing, modeling and rendering
  – Prerequisite: 247, 332

• CSE 554: Geometric computing for bio-medicine
  – Algorithms in geometric modeling with biomedical examples
  – Prerequisite: 247, 332 (452 recommended)

• CSE 546: Computational Geometry
  – Data structure and algorithms for spatial data
  – Prerequisite: 247 (347 recommended)