Geometric Modeling
For Computer Graphics

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Hypothesis

• 3D models will become ubiquitous (eventually)
  ◦ Laser range scanners
  ◦ World Wide Web
  ◦ Fast graphics cards

When will 3D models be as common as images are today?
Challenges

• Usually only “raw” 3D data is available
  ◦ Low-level geometric primitives
  ◦ No semantic labeling, no structure
  ◦ Incomplete, invalid

What properties can be computed for this bunny?

Course Objective

• Develop algorithms for analysis of 3D shape

How can we use this chair in a 3D application?
Applications

- Computer-aided design
- Medicine
- Training
- Education
- Entertainment
- E-commerce
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Apo A-1
(Theoretical Biophysics Group, University of Illinois at Urbana-Champaign)

Human Skeleton
(SGI)

Applications

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- Medicine
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Driving Simulation
(Evans & Sutherland)

Interactive Kitchen Planner
(Matsushita)

Geri’s Game
(Pixar Animation Studios)

Desk Assembly
(Silicon Graphics, Inc.)
Goals

- Develop algorithms for analysis of 3D models
  - Reconstruction
  - Segmentation
  - Feature detection
  - Labeling
  - Matching
  - Classification
  - Retrieval
  - Recognition
  - Clustering

How can we fix up 3d data into solid models?
Goals

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  ◦ Reconstruction
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    ◦ Feature detection
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How can we decompose a 3D object into its parts?

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Can we identify tell-tale features?
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How can we use semantic tags in 3D applications?

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Are these the same chair?
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What geometric features define a chair?

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What query will retrieve these chairs?
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Is this blue chair in the database?

Blanz et al.

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Can we learn which 3D models are similar?
Related Work

• Analysis of 3D models shares ideas developed for other multimedia data types

Example: Image Analysis

Which is easier to analyze: a 2D image or a 3D model?
3D Shape Analysis

- Appropriate representation of 3D shape is key
  - Higher-level structures have more information

Example: skeleton

Syllabus

- Study 3D representations of shape
  - Surfaces
  - Solids
  - High-level reps

- Investigate 3D analysis algorithms
  - Reconstruction from raw data
  - Feature detection
  - Classification
  - Similarity queries

Students present papers for representations during each class
Example 1: Generative Models

- Reconstruct manifold meshes from range data

Partial Meshes

Ramamoorthy et al. (SIGGRAPH 99)

Example 1: Generative Models

Partial Mesh

Generative Model

Ramamoorthy et al.
Example 2: Building Block Models

- Reconstruct 3D model from 2D image

Reconstructed 3D Model

Parameterized Building Blocks

Coursework

- Lectures:
  - Present papers
  - Lead discussions

- Projects:
  - Acquire raw 3D data
  - Reconstruct high-level representation from raw 3D data
  - Analyze shape from high-level representation
First Assignment

• Acquire 3D data from World Wide Web
  ◦ Range images
  ◦ Polygonal models
  ◦ Volumetric data sets

• Build repository of interesting 3D data sets
  ◦ Gather test data
  ◦ Learn properties of currently available models
  ◦ Gain insight into interesting research problems

• Example:
  ◦ http://www.cc.gatech.edu/projects/large_models/

Summary

• Motivation:
  ◦ Automatic analysis of available 3D models

• Goals:
  ◦ Study and compare 3D object representations
  ◦ Develop tools for processing and analysis of 3D models
  ◦ Identify interesting research problems for later study