# Geometric Modeling For Computer Graphics

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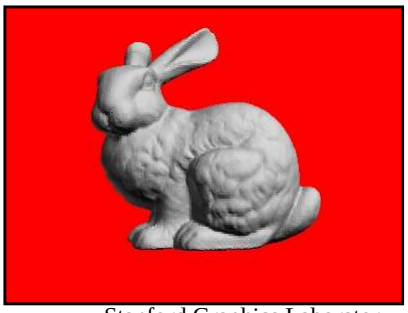
Princeton University
C0S 598B, Spring 2000

## Hypothesis

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

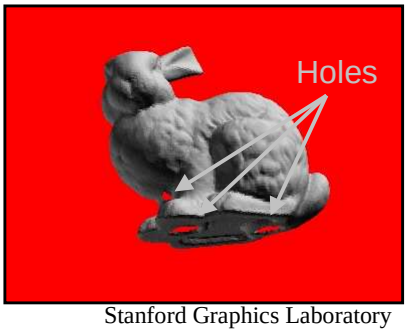


Stanford Graphics Laboratory

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

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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

## Applications

- **Computer-aided design**
- Medicine
- Training
- Education
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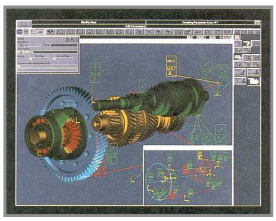
- E-commerce

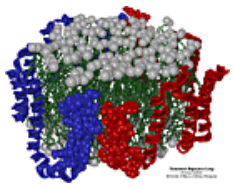


Gear Shaft Design
*(Intergraph Corporation)*

Boeing 777 Airplane
*(Boeing Corporation)*

## Applications

- Computer-aided design
- **Medicine**
- Training
- Education
- Entertainment
- E-commerce



Apo A-1
*(Theoretical Biophysics Group, University of Illinois at Urbana-Champaign)*

Human Skeleton
*(SGI)*

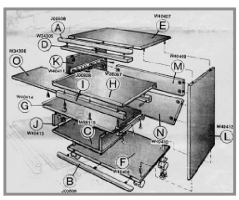
## Applications

- Computer-aided design
- Medicine
- **Training**
- **Education**
- **Entertainment**
- **E-commerce**

Driving Simulation
*(Evans & Sutherland)*

Interactive Kitchen Planner
*(Matsushita)*

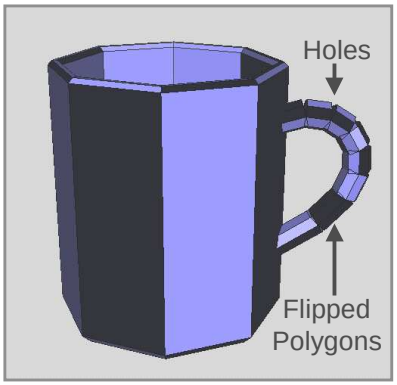
Geri's Game
*(Pixar Animation Studios)*



Desk Assembly
*(Silicon Graphics, Inc.)*

## Goals

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




## Goals

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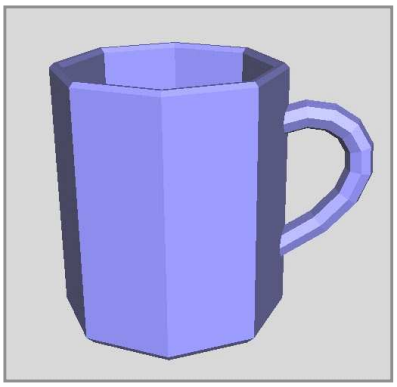

How can we fixup 3d data into solid models?

## Goals

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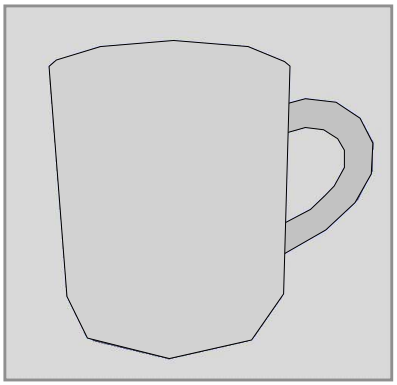

How can we decompose a 3D object into its parts?

## Goals

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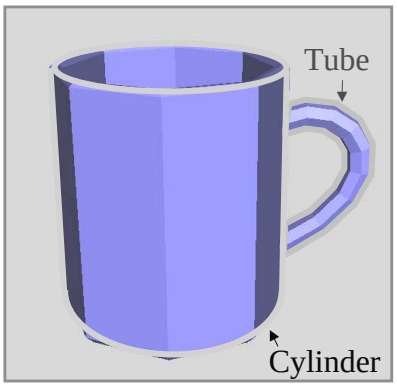


Can we identify tell-tale features?

## Goals

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How can we use semantic tags in 3D applications?

## Goals

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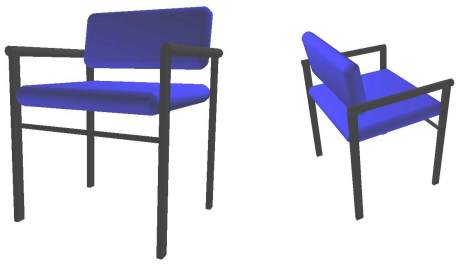

Are these the same chair?

## Goals

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

Blanz et al.

What geometric features define a chair?

## Goals

- Develop algorithms for analysis of 3D models
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  - Recognition
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Blanz et al.

What query will retrieve these chairs?

# Goals

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

Blanz et al.

Is this blue chair in the database?

# Goals

- Develop algorithms for analysis of 3D models
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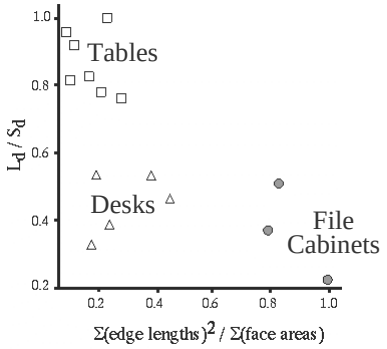
  - Recognition
  - **Clustering**




Can we learn which 3D models are similar?

## Related Work

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

Registered Saddlebred out of Famous Sultan Supreme line. 100% sound. 16 year old, flashy, chestnut w/white, loving, high energy horse, needs experienced rider. Was shown professionally in early years as gaited saddlebred. Most recently shown and always placed in training and first level dressage shows.Currently used as dressage/pleasure horse, jumps, loves trailriding.

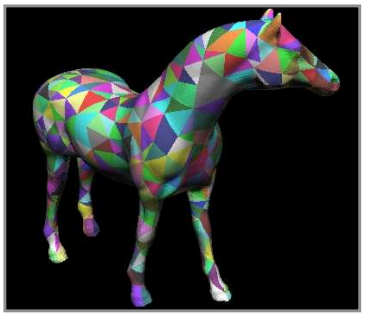
Text

2D Image

Audio

## Example: Image Analysis

2D Image of Horse

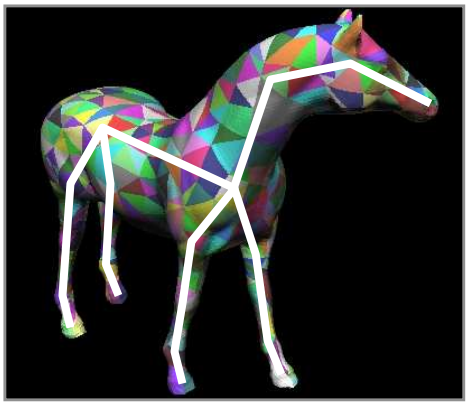


3D Model of Horse

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

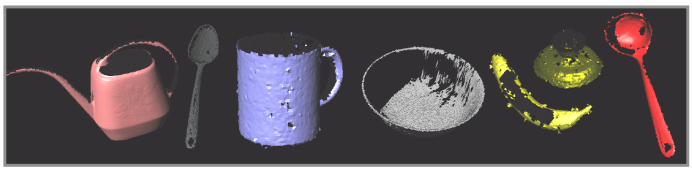
## Syllabus

- Study 3D representations of shape
  - Surfaces
  - Solids
  - High-level reps
- Investigate 3D analysis algorithms
  - Reconstruction from raw data
  - Feature detection
  - Classification
  - Similarity queries

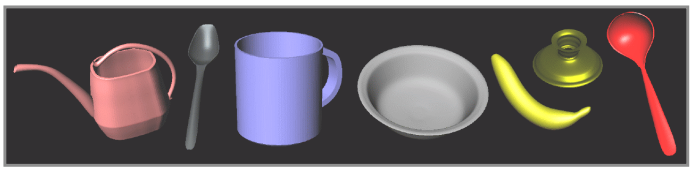
Students present papers for representations during each class

# Example 1: Generative Models

- Reconstruct manifold meshes from range data



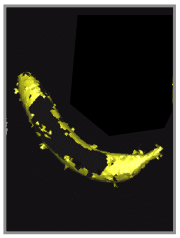
Partial Meshes



Manifold Meshes

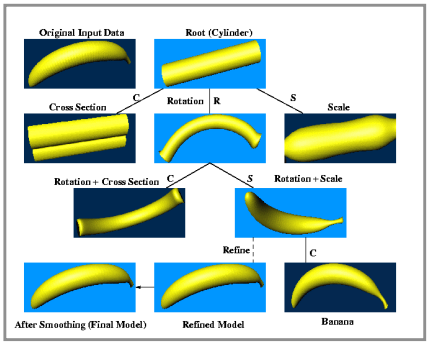
Ramamoorthy et al. (SIGGRAPH 99)

# Example 1: Generative Models



Partial Mesh

Manifold Mesh




Generative Model

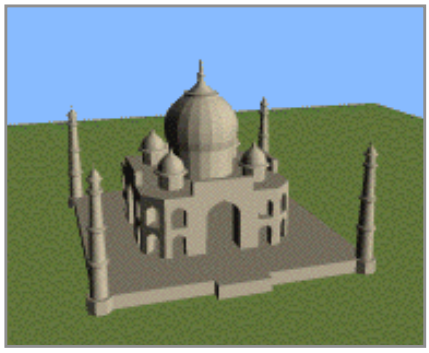
Ramamoorthy et al.

## Example 2: Building Block Models

- Reconstruct 3D model from 2D image

2D Image

Reprojected 3D Model



Parameterized Building Blocks

Debevec et al.

## 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