CS 468
Data-driven Shape Analysis

Introduction

April 1, 2014
Instructors

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Course Info

Administrative

• We meet: Tu, Th, 9:30-10:45, Gates B12
• Website: http://cs468.stanford.edu
• Office Hours:
  - Vova: Tuesdays, 11:00am-noon, Clark S297
  - Peter: Friday, 1:00pm-2:00pm, Clark S297

Grading (tentative)

• Homework #1: Shape Descriptors - 20%
• Homework #2: Shape Matching / Correspondence - 20%
• Homework #3: Machine Learning for Shape Analysis - 20%
• Final Project: your choice, work in groups - 40%
Course Prerequisites

Expected Background

- Computer Graphics
- Programming
- Math
Course Prerequisites

Expected Background

- Computer Graphics
  - Point Clouds and Polygonal Meshes
  - Kd-Trees
  - Other basic data structures…

- Programming
- Math
Course Prerequisites

Expected Background

• Computer Graphics
  ➔ Programming
    - C++ / Matlab
    - OpenGL (a bit)
• Math
Course Prerequisites

Expected Background

- Computer Graphics
- Programming
- Math
  - Linear Algebra
  - Optimization
Motivation

Large and growing repositories of 3D Models
Motivation

Large and growing repositories of 3D Models

12,844 Results

- Office Desk
- Desk with inbuilt keyboard
- Bagalight 2 Desk Lamp
- Adelaide's Desk (V2 of Cynthia...)
- Wooden Desk
- Desk with Computer
- Herman Miller Airia Desk

Trimble 3D Warehouse
Motivation

Large and growing repositories of 3D Models
Motivation

Large and growing repositories of 3D Models

AutoCAD

TurboSquid

Digimation
Motivation

Large and growing repositories of 3D Models

ZBrush

TurboSquid

Digimation
Motivation

Large and growing repositories of 3D Models

Laser Scans
Motivation

Large and growing repositories of 3D Models

Laser Scans
Motivation

Large and growing repositories of 3D Models

Streetview Scans
Motivation

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Streetview Scans
Motivation

Large and growing repositories of 3D Models

RGB-D data
Motivation

Large and growing repositories of 3D Models

RGB-D data
Motivation

Lots of geometric data in different domains!

Molecular Biology

Medicine

Engineering

Cultural Heritage

Paleontology

Computer Graphics
Introduction

We need algorithms to:

• Organize Geometric Data
• Understand Relationships
• Represent Variations
• Interpret New Shapes
We need algorithms to:

→ **Organize Geometric Data**
  - Shape similarity
  - Browse, retrieve, and explore

• **Understand Relationships**
• **Represent Variations**
• **Interpret New Shapes**
Introduction

We need algorithms to:

• Organize Geometric Data
  ➡ Understand Relationships
    - Identify similar regions
    - Find recurring patterns

• Represent Variations
• Interpret New Shapes

Wang et al. SIGGRAPH Asia’12
Introduction

We need algorithms to:

• Organize Geometric Data
• Understand Relationships
  ➡ Represent Variations
    - Probabilistic models
    - Shape grammars
• Interpret New Shapes

Kalogerakis et al. SIGGRAPH’12
Introduction

We need algorithms to:

- Organize Geometric Data
- Understand Relationships
- Represent Variations

⇒ **Interpret New Shapes**
  - Recognition
  - Reconstruction

*Shen et al. SIGGRAPH Asia’12*
Today’s Lecture

Rest of today

- Basics: meshes & point clouds
- Shape Descriptors
Polygonal Mesh

Set of polygons representing a 2D surface embedded in 3D

Dodecahedron
Icosahedron
Tetrahedron
Cube
Octahedron
Set of polygons representing a 2D surface embedded in 3D
Polygonal Mesh

Set of polygons representing a 2D surface embedded in 3D
Mesh Representation

Datastructures

- List of faces
- Vertex and face tables
- Adjacency lists
- Partial adjacency lists

[Diagram of a mesh model]
Mesh Representation

Datastructures

- List of faces
  - Vertex and face tables
  - Adjacency lists
  - Partial adjacency lists

![Diagram of mesh with labeled vertices and face table]

<table>
<thead>
<tr>
<th>FACE TABLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
</tr>
<tr>
<td>F2</td>
</tr>
<tr>
<td>F3</td>
</tr>
</tbody>
</table>

No Adjacency Info
Mesh Representation

Data structures
- List of faces
  - Vertex and face tables
- Adjacency lists
- Partial adjacency lists

Adjacency is expensive to compute
Mesh Representation

Datastructures

- List of faces
- Vertex and face tables

⇒ Adjacency lists
- Partial adjacency lists

Extra storage
Mesh Representation

Datastructures
- List of faces
- Vertex and face tables
- Adjacency lists
  ➔ Partial adjacency lists

All adjacency info  Winged edge
Mesh Representation

Datastructures

- List of faces
- Vertex and face tables
- Adjacency lists

⇒ Partial adjacency lists

All adjacency info

Winged edge

Implement with caution
Point Cloud & Voxel Grids

Datastructures

- Voxel Grid
- Point Cloud
- 3D k-d Tree

Expensive

Voxel Grid

$N_x \times N_y \times N_z$ entries
Datastructures

- Voxel Grid
  - Point Cloud
- 3D k-d Tree

Voxel Grid

\[ N_x \times N_y \times N_z \] entries

Expensive

Point list

\[ <x_1, y_1, z_1> \]
\[ <x_2, y_2, z_2> \]
\[ \ldots \]
\[ <x_n, y_n, z_n> \]
Datastructures

- Voxel Grid
- Point Cloud

→ 3D k-d Tree

Fast Neighbors
Geometry Processing

Analysis
- Normals
  - Curvature

Warps
- Rigid x-form
- Deform
Geometry Processing

Analysis
- Normals
  - Curvature

Warps
- Rigid x-form
- Deform

Also possible with point clouds
Geometry Processing

Analysis
• Normals
  ➡ Curvature

Warps
• Rigid x-form
• Deform
Geometry Processing

Analysis
- Normals
- Curvature

Warps
- Rigid x-form
- Deform

Related by Rotation + Translation

E.g. same model scanned from different viewpoints
Geometry Processing

Analysis
- Normals
- Curvature

Warps
= Rigid x-form
- Deform

NOTE: plenty of transformations!

Related by Rotation + Translation

E.g. same model scanned from different viewpoints
Geometry Processing

Analysis
- Normals
- Curvature

Warps
- Rigid x-form

→ Deform

NOTE: plenty of transformations!

Including higher-dimensional free-form deformations
Rest of today

• Basics: meshes & point clouds

→ Shape Descriptors (start)