Motivation

Large repositories of 3D data are becoming available

Lecture Outline

Introduction
Problems
Applications
Simple example

Shape Analysis Problems

Examples:
- Feature detection
- Segmentation
- Labeling
- Registration
- Matching
- Recognition
- Classification
- Clustering
- Retrieval
- Matching

“How can we find significant geometric features robustly?”

Shape Analysis Problems

Examples:
- Feature detection
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“How can we decompose a 3D model into its parts?”
Shape Analysis Problems

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*How can we decompose a 3D model into its parts?*

Semantic Labels
(Golovinskiy, Lee, et al.)

Shape Analysis Problems

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*How can we align features of 3D models?*

Shape Analysis Problems

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*How can we compute a measure of geometric similarity?*

Shape Analysis Problems

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*How can we find 3D models best matching a query?*

Shape Analysis Problems

Examples:
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*How can we find a given 3D model in a large database?*

Shape Analysis Problems

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*How can we determine the class of a 3D model?*
Shape Analysis Problems

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How can we learn classes of 3D models automatically?

A Quick Diversion ...

Which is harder to analyze?

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Shape Analysis Applications

Examples:
- Computer graphics
- Geometric modeling
- Mechanical CAD
- Archaeology
- Virtual worlds
- Paleontology
- Molecular bio
- Medicine
- Forensics
- Art

Simple example

Shape Analysis Applications

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Reconstructing Frescoes from Thera
(Weyrich, Brown, Rusinkiewicz, et al.)

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Hippocampus-amygdala study in schizophrenia
Shape Analysis Applications

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Shape Retrieval Challenges

Need shape descriptor & matching method that is:
- Concise to store
- Quick to compute
- Efficient to match
- Discriminating

Simple Example

Shape-based retrieval:

Query

Ranked Matches

“How can we find 3D shapes best matching a query?”
Shape Retrieval Challenges

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Different Articulated Poses

Shape Retrieval Challenges

Need shape descriptor & matching method that is:
- Concise to store
- Quick to compute
- Efficient to match
- Discriminating

Invariant to transformations
- Invariant to deformations
- Insensitive to noise
- Insensitive to topology
- Robust to degeneracies

Different Transformations
(translation, scale, rotation, mirror)

Shape Retrieval Challenges

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Different Articulated Poses

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Scanned Surface
We are starting with discussion of a simple method to introduce the basic ideas.
Shape Distributions
Key idea: map 3D surfaces to common parameterization by randomly sampling shape function

Which Shape Function?
Implementation: simple shape functions based on angles, distances, areas, and volumes

D2 Shape Distribution
Properties
- Concise to store?
- Quick to compute?
- Invariant to transforms?
- Efficient to match?
- Insensitive to noise?
- Insensitive to topology?
- Robust to degeneracies?
- Invariant to deformations?
- Discriminating?

D2 Shape Distribution
Properties
Concise to store
Quick to compute

D2 Shape Distribution
Properties
Translation
Rotation
Mirror
Scale (w/ normalization)

D2 Shape Distribution
Properties
Concise to store
Quick to compute
Invariant to transforms
Efficient to match?
- Insensitive to noise?
- Insensitive to topology?
- Robust to degeneracies?
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D2 Shape Distribution
Properties
Concise to store
Quick to compute
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**D2 Shape Distribution**

Properties:
- Concise to store
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- Invariant to deformations?
- Discriminating?

**D2 Shape Distribution Results**

Question:
- How discriminating are D2 shape distributions?

Test database:
- 133 polygonal models
- 25 classes

D2 distributions are different across classes

D2 distributions reveal gross shape of object
D2 Shape Distribution Results

D2 distributions reveal gross shape of object

Circle

D2 shape distributions for 15 classes of objects

D2 Shape Distribution Results

D2 distributions reveal gross shape of object

Cylinder

D2 shape distributions for 15 classes of objects

D2 Shape Distribution Results

D2 distributions reveal gross shape of object

Sphere

D2 shape distributions for 15 classes of objects

D2 Shape Distribution Results

But … are D2 distributions discriminating?

D2 shape distributions for 15 classes of objects

D2 Shape Distribution Results

D2 distributions reveal gross shape of object

Two Spheres

D2 shape distributions for 15 classes of objects

D2 Shape Distribution Results

D2 distributions reveal gross shape of object

Distance

D2 distributions for 5 tanks (gray) and 6 cars (black)
Next Lectures …
Better shape representations
More shape analysis methods