Geometric Modeling and Processing

Tutorial of 3DIM&PVT 2011
(Hangzhou, China)

May 16, 2011
8. Surface Segmentation

Interactive algorithms
A number of meshes...
Shape Retrieval

3D Query → 3D Database → Best Match(es)
Shape Analysis and Matching

• How similar do they look?
Surface Segmentation

• How does a shape consist of the subparts?
Segmentation of Meaningful Parts

• Automatic method will not always do right
• Interactive
  – User intension
  – Application dependent
User Interfaces

• How can users express their intension?
• User interfaces should be
  – Easy to use
  – Intuitive
Sketching User Interfaces
A Case: What is PCA?
Sketch-based UI

• People always use sketches to express their idea and intention
Sketch-Based Interfaces in Computer Graphics

• (Some) previous work
  – SKETCH [Zeleznik et al. 96]
  – Teddy [Igarashi et al. 99 and 03]
  – Variational implicitss [Karpenko et al. 02]
  – Relief [Bourguignon et al. 04]
  – Sketching mesh deformations [Kho and Garl]
  – Parametrized objects [Yang et al. 05]

  – Many, many more... to come!
Recap: Sketching Editing

[Nealen et al. Siggraph 2005]
Another Example: Lazy Snapping

[Li et al. Siggraph 2004]

Demo
Sketching Mesh Cutting

• “I want to cut out the head part of the bunny model”
1. Foreground/Background Sketches

[Ji et al., Eurographics 2006]
I want to cut out the head part from the bunny model...
Live Demo
Minimal Rule

• Psychological study [Hoffman et al. 84]
  – All *negative minima* of the principal curvatures form boundaries between parts
  • decompose 3D shapes at concave creases
Region Growing Algorithm
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Experimental Results
Experimental Results
Experimental Results
Experimental Results
Many follow-up Works

- Foreground/background sketches

<table>
<thead>
<tr>
<th>Method</th>
<th>Algorithms</th>
<th>Abbreviation</th>
</tr>
</thead>
</table>
| Region growing                | Easy mesh cutting [13]  
A sketch-based interactive framework for real-time mesh segmentation [22] | EMC          |
| Bottom-up aggregation         | Hierarchical aggregation for efficient shape extraction [23]            | HAE          |
| Graph-cut                     | Interactive part selection for mesh and point models using hierarchical graph-cut partitioning [5] | GCS          |
| Harmonic field based          | Sketching mesh segmentation based on feature preserving harmonic field [19]  
Mesh decomposition with cross-boundary brushes [25] | HFM          |
2. Foreground Sketches

[Fan et al., Eurographics 2011]
Foreground Sketches

I want to cut out the head part from the bunny model...
Live Demo
Basic Idea

- Learn the part property from the input sketches
- Surface metric
Part-aware Surface Metric

• Shape diameter function (SDF) [Shapira et al. 2008]
  – Rely on volume information
  – Insensitive to noise
  – Insensitive to pose variation
Build SDF Models

GMM Estimation

\[ p_f(\hat{d}) \]

\[ p_b(\hat{d}) \]

Foreground

Background
Probability Model

- Compute the probability of one point in the region of foreground/background

\[
L_f^v = -\ln\left( p_f M(v) + \varepsilon \right)
\]

\[
L_b^v = -\ln\left( p_b M(v) + \varepsilon \right)
\]

Foreground

Background
Graph Cuts
Results

- Independent on specific brushes
Results

• Insensitive to pose variation
Results

- Insensitive to noise
Progressive Sketches
Flowchart

Original Model → Initial Global Optimization → Progressive Local Optimization → Final Global Optimization
Results

• Running time

<table>
<thead>
<tr>
<th>Model</th>
<th># Vertex</th>
<th>T₁ (ms)</th>
<th>T₂ (ms)</th>
<th>T₃ (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dino</td>
<td>28,150</td>
<td>53</td>
<td>10</td>
<td>178</td>
</tr>
<tr>
<td>Woman</td>
<td>5,691</td>
<td>8</td>
<td>6</td>
<td>27</td>
</tr>
<tr>
<td>Airplane</td>
<td>6,797</td>
<td>12</td>
<td>5</td>
<td>24</td>
</tr>
<tr>
<td>Armadillo</td>
<td>25,193</td>
<td>36</td>
<td>10</td>
<td>120</td>
</tr>
<tr>
<td>Bunny</td>
<td>34,835</td>
<td>54</td>
<td>11</td>
<td>248</td>
</tr>
</tbody>
</table>

* T₁, T₂, T₃ denote the computation time of the three steps in our algorithm, i.e., the initial global optimization, averaged local optimization, and the final global optimization, respectively.
Results
Motif

“What you paint is what you get.”
3. Cross-Boundary Sketches

[Zhang and Tai, Eurographics 2010]
Cross-boundary Sketches

I want to cut out the head part from the bunny model...
Live Demo
Basic Idea

• An iso-line of a harmonic field
Multiple Sketches
4. On-Boundary Sketches

[Meng et al., CASA 2011]
On-boundary Sketches

I want to cut out the head part from the bunny model...
Live Demo
iCutter: Intelligent Cutter

- The user does not care much about how to draw the sketches
Basic Idea

- Averaged multiple harmonic fields
- Isoline selection
Insensitive to Poses
Cut Out Local Parts
Multiple Sketches
Comparison and Evaluation
Sketch-based User Interfaces

• Boundary based
  – Cross-boundary sketch (CBS)
  – iCutter: On-boundary sketch (OBS)

• Region based
  – Foreground/background sketch (FBS)
  – Foreground sketch (FS)
Sketch-based User Interfaces

CBS

OBS

FBS

FS
# Methodologies

<table>
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<th>Method</th>
<th>UI</th>
<th>Region/boundary based</th>
<th>Main algorithm</th>
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<td>Easy mesh cutting</td>
<td>Foreground/background brush</td>
<td>Region</td>
<td>Region growing</td>
</tr>
<tr>
<td>Paint mesh cutting</td>
<td>Foreground brush</td>
<td>Region</td>
<td>SDF + Graph cut</td>
</tr>
<tr>
<td>Cross boundary</td>
<td>Cross boundary brush</td>
<td>Boundary</td>
<td>Harmonic field</td>
</tr>
<tr>
<td>iCutter</td>
<td>Boundary brush</td>
<td>Boundary</td>
<td>Scalar field</td>
</tr>
</tbody>
</table>
Sketch-based User Interfaces

• People always use sketches to express ideas and communicate
• Easy to use
• Intuitive
• More applications
  – Sketching shape retrieval
  – Modeling and editing
  – ...

User Interaction

• In many practical applications, fully automatic algorithms are not necessary
  – Hard and slow
• A little user interaction
  – Easier
  – Faster
  – More precise
• But, no interaction is allowed in the others.
Questions?