Manifold Dual Contouring

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Implicit Modeling

\[ f(x) = 0 \]
Dual Contouring

[Ju et al 2002]
Dual Contouring

[Ju et al 2002]
Dual Contouring

[Ju et al 2002]
Sharp Features

[Garland, Heckbert 1998]
Adaptive Surface Extraction
Problems with Dual Contouring

Non-Manifold Geometry

Conservative Topology Test
Previous Work

- **DC with multiple surface components**

- **Vertex Clustering**

- **Topology-Preserving Contour Simplification**
  - [Cohen et al 1996], [Ju et al 2002], [Lewiner et al 2004]
Manifold Assumption

Original Data

MC

DC

DMC
Vertex Clustering
Vertex Clustering

Not sufficient to prevent non-manifold geometry!
Topological Safety
Topological Safety
Topological Safety

$C_2$
Topological Safety

- A surface is a 2-manifold, if for every vertex
  - The number of intersections of $S_v$ with the edges of each face of $C_v$ is either 0 or 2
  - $S_v$ is equivalent to a disk with a single, connected boundary
Topological Safety

- A surface is a 2-manifold, if for every vertex
  - The number of intersections of $S_v$ with the edges of each face of $C_v$ is either 0 or 2
  - $\chi(S_v) = V(S_v) - E(S_v) + F(S_v) = 1$
Topological Safety

- A surface is a 2-manifold, if for every vertex
  - The number of intersections of $S_v$ with the edges of each face of $C_v$ is either 0 or 2
  - $\chi(S_v) = V(S_v) - E(S_v) + F(S_v) = 1$
Recursive Safety Computation

\[ \chi(S_v) = \sum_k \chi(S_{vk}) - \frac{e(S_{vk})}{4} \]

\[ \sum_k \chi(S_{vk}) = 0 \]
\[ \sum_k e(S_{vk}) = 0 \]
Recursive Safety Computation

\[ \chi(S_v) = \sum_k \chi(S_{v_k}) - \frac{e(S_{v_k})}{4} \]

\[ \sum_k \chi(S_{v_k}) = 2 \]
\[ \sum_k e(S_{v_k}) = 5 \]
Recursive Safety Computation

\[ \chi(S_v) = \sum_k \chi(S_{vk}) - \frac{e(S_{vk})}{4} \]

\[ \sum_k \chi(S_{vk}) = 4 \]
\[ \sum_k e(S_{vk}) = 10 \]
Recursive Safety Computation

\[ \chi(S_v) = \sum_k \chi(S_{vk}) - \frac{e(S_{vk})}{4} \]

\[ \sum_k \chi(S_{vk}) = 5 \]

\[ \sum_k e(S_{vk}) = 14 \]
Recursive Safety Computation

\[ \chi(S_v) = \sum_k \chi(S_{vk}) - \frac{e(S_{vk})}{4} \]

\[
\sum_k \chi(S_{vk}) = 6 \\
\sum_k e(S_{vk}) = 18
\]
Recursive Safety Computation

\[ \chi(S_v) = \sum_k \chi(S_{v_k}) - \frac{e(S_{v_k})}{4} \]

\[ \sum_k \chi(S_{v_k}) = 7 \]

\[ \sum_k e(S_{v_k}) = 24 \]
Recursive Safety Computation

\[ \chi(S_v) = \sum_k \chi(S_{vk}) - \frac{e(S_{vk})}{4} \]

\[ \sum_k \chi(S_{vk}) = 8 \]

\[ \sum_k e(S_{vk}) = 30 \]
Recursive Safety Computation

\[ \chi(S_v) = \sum_k \chi(S_{v_k}) - \frac{e(S_{v_k})}{4} \]

\[ \sum_k \chi(S_{v_k}) = 9 \]
\[ \sum_k e(S_{v_k}) = 33 \]
Recursive Safety Computation

\[ \chi(S_v) = \sum_k \chi(S_{v_k}) - \frac{e(S_{v_k})}{4} \]

\[ \sum_k \chi(S_{v_k}) = 10 \]
\[ \sum_k e(S_{v_k}) = 36 \]
Results

Uncollapsed

Only Vertex Clustering

Manifold Safety Test
Results

476184  142570  62134  14335  2738  78
Comparison

Original Shape

Dual Contouring

Our Method
Comparison

Original Shape  Dual Contouring  Extended Dual Contouring  Our Method
## Performance

<table>
<thead>
<tr>
<th>Octree Depth</th>
<th>Base Polys</th>
<th>Clustering w/o Manifold Test</th>
<th>Clustering w/ Manifold Test</th>
<th>Poly Generation</th>
<th>Simplified Polys</th>
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</thead>
<tbody>
<tr>
<td><strong>Spring</strong></td>
<td>6</td>
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</tbody>
</table>
Conclusions

- Vertex clustering algorithm that allows multiple components per cell in DC
- Simple, recursive test for vertex clustering that guarantees manifold geometry