Subdivision for Line Drawings

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Overview

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Introduction

• Subdivision surfaces
  – general surfaces representation
Introduction

- Subdivision surfaces
  - general surfaces representation

- Non-photorealistic rendering
  - here: line drawings
Introduction

- Subdivision surfaces
  - general surfaces representation

- Non-photorealistic rendering
  - here: line drawings

- no explicit connection yet
Subdivision

- Geometry representation
Subdivision

- Geometry representation
- Interpolating or approximating
Subdivision

- Geometry representation
- Interpolating or approximating
- Arbitrary mesh
Subdivision: Modified Butterfly

-1/16 1/8 -1/16

1/2

-1/16 1/8 -1/16

1/2
Subdivision: Modified Butterfly

\[ \begin{array}{ccc}
-1/16 & 1/8 & -1/16 \\
\bullet & 1/2 & 1/2 \\
-1/16 & 1/8 & -1/16 \\
\end{array} \]
**Subdivision:** Control mesh
Subdivision: Subdivided once
Subdivision: Subdivided twice
Subdivision: Subdivided three times
Subdivision: Line drawings

- Silhouettes
  - border from a specific viewpoint
  - adjacent to front-facing and back-facing polygon
Subdivision: Line drawings

- Silhouettes
  - border from a specific viewpoint
  - adjacent to front-facing and back-facing polygon

- Creases
  - sharp features on surface
  - inherent to subdivision model
Subdivision: Level 0
Subdivision: Level 1
Subdivision: Level 2
Subdivision: Level 3
Subdivision: Line drawings

Problem: triangle count quadruples in each refinement step

- Rapid determination of silhouettes
- Fast drawing of silhouettes and creases
Silhouette Propagation

- New method for determining silhouettes
Silhouette Propagation

- New method for determining silhouettes
- Idea: propagate silhouettes while refining the mesh
Silhouette Propagation: silhouette triangles
Silhouette Propagation: triangles refined
Silhouette Propagation: refined again
Silhouette Propagation

- New method for determining silhouettes
- Idea: propagate silhouettes while refining the mesh
Silhouette Propagation

- New method for determining silhouettes
- Idea: propagate silhouettes while refining the mesh
  - silhouette band
Silhouette Propagation

- New method for determining silhouettes
- Idea: propagate silhouettes while refining the mesh
  - silhouette band
  - update while subdividing
Silhouette Propagation: before subdivision
Silhouette Propagation: subdivided
Silhouette Propagation: new silhouette
Silhouette Propagation

• New method for determining silhouettes
• Idea: propagate silhouettes while refining the mesh
  – silhouette band
  – update while subdividing
Silhouette Propagation

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- Problem: subdivision itself is expensive
Silhouette Propagation

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  - update while subdividing
- Problem: subdivision itself is expensive
- Applications:
  - dynamic subdivision
  - off-line rendering
Drawing by Subdivision

- New method for accelerating drawing
- Idea: subdivide in 2D instead of 3D
Drawing by Subdivision: Mesh
Drawing by Subdivision: One 2D subdivision
Drawing by Subdivision: No 2D subdivision
Drawing by Subdivision: Three 2D subdivisions
Drawing by Subdivision

- New method for accelerating drawing
- Idea: subdivide in 2D instead of 3D
Drawing by Subdivision

• New method for accelerating drawing
• Idea: subdivide in 2D instead of 3D
  – collect edges
Drawing by Subdivision

- New method for accelerating drawing
- Idea: subdivide in 2D instead of 3D
  - collect edges
  - make chains
Drawing by Subdivision

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- Problem: accuracy
Drawing by Subdivision

• New method for accelerating drawing
• Idea: subdivide in 2D instead of 3D
  – collect edges
  – make chains
  – subdivide chains

• Problem: accuracy
• Solution: perform a few 3D refinement steps first
Drawing by Subdivision: No 3D subdivision
Drawing by Subdivision: One 3D subdivision
Drawing by Subdivision: Two 3D subdivisions
Results

- Implemented in Squeak
Results

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  - open source Smalltalk system
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  - omni-platform, multi-media
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- factor 2–4 speedup for silhouette propagation over brute-force
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- factor 2–4 speedup for silhouette propagation over brute-force
- factor 10 speedup for 2D over 3D subdivision
Results
Results
Conclusion

• Subdivision is good for NPR
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• Exploit features of surface representations
  ⇒ silhouette propagation
Conclusion

- Subdivision is good for NPR
- Exploit features of surface representations
  ⇒ silhouette propagation
- Simplify where possible
  ⇒ 2D subdivision for drawing
Extensions

- hidden line removal
  ⇒ visibility propagation
Extensions

• hidden line removal
  ⇒ visibility propagation

• overshooting when drawing
  ⇒ chordal parametrization of curves
Questions?