Texture Mapping

texture → mapping → model

Cem Yuksel, John Keyser, and Donald H. House, "Mesh Colors," ACM Transactions on Graphics (TOG), 29(2) 2010
Texture Mapping
Texture Mapping

Parameterization
Texture Mapping

1. Parameterization
2. Filtering

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Texture Mapping

1. Parameterization
2. Filtering

[Lefebvre et al. 2005]
Texture Mapping

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Texture Mapping

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Texture Mapping

1. Parameterization

2. Filtering

[Lefebvre et al. 2005]
Texture Mapping

1 Parameterization

2 Filtering

[Lefebvre et al. 2005]
Texture Mapping

• Displacement Maps
  – Inconsistencies at seams cause cracks!
Texture Mapping

• 2D Textures
  – **Automatic planar parameterization**
  – **Guaranteed one-to-one mapping**
    [Hormann and Greiner 1999; Sheffer and de Sturler 2000; Sander et al. 2001; Floater 2003]
  – **User defined constraints**
    [Lévy 2001; Desbrun et al. 2002; Kraevoy et al. 2003]
  – **Higher resolution for detailed areas**
    [Sloan et al. 1998; Balmelli et al. 2002; Sander et al. 2002; Carr and Hart 2004; Igarashi and Cosgrove 2001]
Texture Mapping

• 2D Textures
  – Seams: Interpolation artifacts
  – Duplicated color values
  – Problems with MIP-map filtering
  – No local texture detail adjustment
  – Very sensitive to model topology
Texture Mapping

• 3D Textures
  – Octree Textures
    [Benson and Davis 2002; DeBry et. al. 2002]
  – Hash Textures
    [Lefebvre and Hoppe 2006]
Texture Mapping

• Other Methods

  – Polycube maps
    [Tarini et. al. 2004]

  – Tile trees
    [Lefebvre and Dachsbacher 2007]

  – Ptex (per-face textures)
    [Burley and Lacewell 2008]
Texture Mapping

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Mesh Colors

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Mesh Colors

• Properties:
  – No mapping
  – No discontinuities (no seams)
  – Guaranteed one-to-one correspondence
  – Correct MIP-map filtering
  – Local resolution adjustment
  – Permits model editing and subdivision
  – Compatible with current graphics pipeline
Mesh Colors
Mesh Colors

• $R = 1$
• Vertex colors
Mesh Colors

• $R = 2$
• Edge colors
Mesh Colors

- \( R = 2 \)
- Edge colors
Mesh Colors

- $R = 4$
- Face colors
Mesh Colors

• $R = 4$

• Face colors
Mesh Colors

• $R = 8$
• Color positions from indices
Mesh Colors

• Colors are shared along edges
  – Guaranteed continuity
Mesh Colors & Modeling

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Mesh Colors

• Non-uniform face resolutions
Mesh Colors

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Mesh Colors

• Non-triangular Meshes
  — Quadrilaterals
    • Triangle pair
    • Quadrilateral positioning
  — NURBS
  — Subdivision surfaces
    • Dividing faces only
Filtering
Mesh Colors
Filtering Mesh Colors

• Nearest Filtering
Filtering Mesh Colors

• Linear Filtering
Filtering Mesh Colors

• MIP-map Filtering
  – Level 3
Filtering Mesh Colors

• MIP-map Filtering
  – Level 2
Filtering Mesh Colors

• MIP-map Filtering
  – Level 1
Filtering Mesh Colors

• MIP-map Filtering
  – Level 0
Filtering Mesh Colors

- MIP-map Filtering

Level 3  Level 2  Level 1  Level 0
Implementation
Mesh Colors
Mesh Colors

- Separating mesh and color data
Implementation

• All faces must know
  – 1 x Face color index
  – 3 x Edge color indices
  – 3 x Vertex color indices
  – Face resolution

Send to the shader
Analysis
Mesh Colors
Mesh Colors

• Unified content creation
• Memory efficient
• Fast
• Correct filtering
Content Creation with Mesh Colors

Mesh colors are on the low-res mesh.
Content Creation with Mesh Colors

Mesh colors are on the low-res mesh.

- No UV layouts
- On the fly resolution adjustment
- Modeling & Painting together
Mesh Colors

✓ Unified content creation

• Memory efficient
• Fast
• Correct filtering
Similar Memory Use

2D Texture
3 MB

Mesh Colors
(converted from 2D texture)
2.4 MB
Mesh Colors

- Unified content creation
- Memory efficient
  - Fast
  - Correct filtering
Real-time Rendering

<table>
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<th>Hardware</th>
<th>2D texture</th>
<th>Nearest</th>
<th>Linear</th>
<th>MIP-map</th>
<th>Anisotropic</th>
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<td>109 fps</td>
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</tr>
</tbody>
</table>

Texture filtering on hardware is ~20x faster!
Real-time Rendering

• For high performance
  – Mesh Colors for content creation
  – Convert to 2D texture for rendering

• Hardware support for Mesh Colors?
  – 2D textures produce incorrect filtering!
  – Mesh Colors produce correct filtering
Tiled 2D texture

zoom: 4x
Offline Rendering

• Mesh Colors are ready!
Mesh Colors

- Unified content creation
- Memory efficient
- Fast
- Correct filtering
Summary
Mesh Colors
No Mapping!

texture

model
No Discontinuities
Guaranteed 1-1 Correspondence
Correct MIP-map Filtering

Unwrapped 2D texture  Mesh Colors

zoom: 4x  zoom: 4x
Local Resolution Adjustment

• Non-uniform face resolutions
Modeling with Painting

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Compatible with Current Pipeline

• Separating mesh and color data
Mesh Colors

• Easy to use (for end user)
  – No mapping
  – High flexibility

• Easy to implement (for programmer)
  – Colors have well-defined positions on the surface

• High quality

• High performance
Mesh Colors

• Mesh Colors are ideally suited for
  – 3D painting
  – Storing precomputed data
    • Ambient occlusion
    • Radiosity
  – Displacement

• Mesh Colors provide a solution to the *fundamental* problems of texture mapping.
Acknowledgements

• Murat Afsar
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Mesh Colors

Questions?