WYSIWYG NPR:
Drawing Strokes Directly on 3D Models
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“The Grand Challenge for NPR”
- Create stylized worlds from scratch
  - Aesthetic look fully under the artist’s control
  - World can be explored with style remaining consistent
- Let artists do what they do best
- Let computers do what they do best

Related Work
- Temporal coherence
  - Allows smooth exploration of a world
  

Related Work
- Painting on 3D models
  
  Hanrahan & Haeberli (1990)

Related Work
- 3D NPR modeling
  

Related Work
- WYSIWYG NPR
  - Flexible, intuitive system to quickly create NPR worlds from 3D models
Outline
- Introduction
- Overview
- Rendering
- Decals, creases, and silhouettes
- Hatching
- Results/Conclusion

Overview
- Artist controls 6 aspects:
  - Background
  - Base coat
  - Silhouette style
  - Decals
  - Hatchings
  - Crease style

Example: Creating an NPR can of fruits
- Start with the 3D model of a can:

Step 1: Add the base coat to the model and the background

Step 2: Set the silhouette and crease styles

Step 3: Draw the decals directly on the 3D model
Overview

- Step 4: Add the hatching for the shadow
- We’re done!

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Rendering

- Two different categories of shaders:
  - Fill shaders
    - Background
    - Base coat
  - Stroke shaders
    - Silhouettes
    - Creases
    - Decals
    - Hatching

Rendering - Fill Shaders

- Background shader
  - One per scene
  - Fills space outside all objects
- Base coat shaders
  - One per object
  - Fills visible triangle of the objects

Rendering - Stroke Shaders

- Stroke rendering based on the model of Northrup and Markosian (2000)

Rendering - Strokes

- Strokes are rendered on a separate triangle strip over the 3D model
- Strokes have:
  - Variable width (taper)
  - Variable alpha
  - Haloing
Rendering - Media Simulation

- Paper effects can be applied to any stroke
- Same approach as Curtis et al. (1997)
  - Paper height encoded at each pixel
  - High points easily catch pigments

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Decals

- Drawn directly over the 3D model
- Creates a stroke path over the model's surface

Creases

- Creases are identified in the model by:
  - Explicit tag on certain edges
  - Automatic discovery based on dihedral angle sharpness
- Want to allow artist to customize the stroke style for all creases

Complex models can have 1000s of creases
- Too time consuming to draw them one by one
- Want a way to assign a desired style to many creases at once
- Can't look too mechanical
- Use: Synthesis by example

Synthesis by example

- Artist sketches over a crease
- Offset from the crease path is recorded
- Similar offset patterns applied over other crease paths
Silhouettes
- View dependent
  - Number, length, size of silhouette edges are all variable
  - Want inter-frame coherence
- Use: Rubber-stamping

Rubber-stamping
- Artist provides a stroke prototype
- Stroke is copied along the silhouette of the object

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Hatching
- Provides texture, tone value
- Simulates shadows or highlights
- Provides automatic LOD control

Structured Hatching
- Constant stroke density always maintained by:
  - Adding new strokes when viewpoint becomes closer
  - Modifying the stroke width for small changes
Free Hatching
- User draws the hatching for specific levels of detail
- Density consistency maintained by blending between the user-defined levels

Stationary vs. Mobile Hatching
- **Stationary Hatching**
  - Remains fixed on the model
  - Simulates a fixed light source
- **Mobile Hatching**
  - Moves on the model
  - Simulates a view-dependent light source

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Results
- Very flexible system

Results
- High-quality images

Results
- Can generate complex scenes quickly
Results
- Allows interactive exploration of the scene
- Supports animated geometries

Limitations
- Many styles not yet supported

Limitations
- Only 1 silhouette stroke style per object supported
- Silhouettes still not perfectly coherent from frame to frame
- Issues addressed in “Coherent Silhouette Styles” (Siggraph 2003)

Conclusion
- Good progress on “The Grand Challenge”
  - Artist has much control over the aesthetic look of the final result
  - Style coherence is maintained during exploration
  - Software does much of the dirty work
- More work left to do
  - Not even close to allowing same amount of aesthetic flexibility currently available on paper
  - Frame-to-frame coherence of silhouettes can still be improved
  - Hatching still requires much user input