

# WYSIWYG NPR:

Drawing Strokes Directly on 3D Models  
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Eric Blais

## "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

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## Related Work

- Temporal coherence
  - Allows smooth exploration of a world



B. Meier (1996)



Deussen & Strothotte (2000)

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## Related Work

- Painting on 3D models



Hanrahan & Haerberli (1990)

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## Related Work

- 3D NPR modeling



SKETCH (1996)



Teddy (1999)

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## WYSIWYG NPR

- Flexible, intuitive system to quickly create NPR worlds from 3D models



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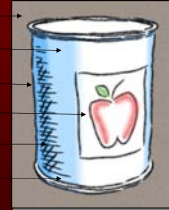
## Outline

- Introduction
- ➔ Overview
- Rendering
- Decals, creases, and silhouettes
- Hatching
- Results/Conclusion

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## Overview

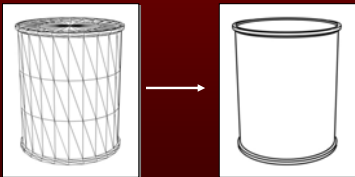
- Artist controls 6 aspects:
  - Background
  - Base coat
  - Silhouette style
  - Decals
  - Hatchings
  - Crease style



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## Overview

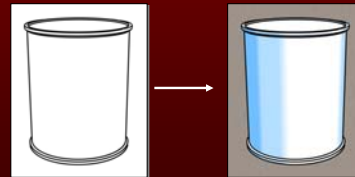
- Example: Creating an NPR can of fruits
- Start with the 3D model of a can:



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## Overview

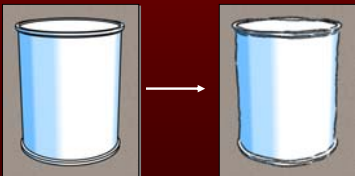
- Step 1: Add the base coat to the model and the background



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## Overview

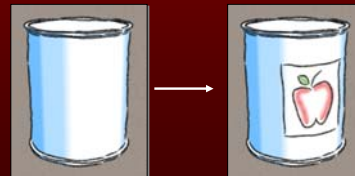
- Step 2: Set the silhouette and crease styles



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## Overview

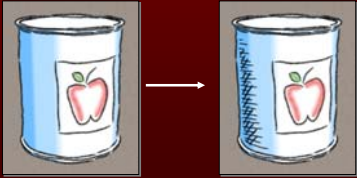
- Step 3: Draw the decals directly on the 3D model



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## 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



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## 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



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## Rendering - Stroke Shaders

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

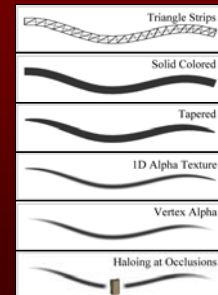


Northrup & Markosian (2000)

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## Rendering - Strokes

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



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## 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



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## 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



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## Creases

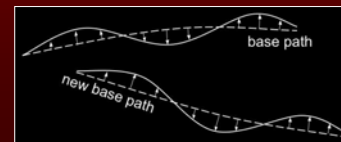
- Complex models can have 1000s of creases
  - Too time consuming to draw them one by one
  - Want a way to assign a desired style to many creases at once
  - Can't look too mechanical
- Use: Synthesis by example



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## Synthesis by example

- Artist sketches over a crease
- Offset from the crease path is recorded
- Similar offset patterns applied over other crease paths



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## Silhouettes

- View dependent
  - Number, length, size of silhouette edges are all variable
  - Want inter-frame coherence
- Use: Rubber-stamping



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## 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



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## Hatching

- Structured hatching
  - Roughly parallel strokes
  - Evenly spaced
- Free hatching
  - User-defined form



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## Structured Hatching

- Constant stroke density always maintained by:
  - Adding new strokes when viewpoint becomes closer
  - Modifying the stroke width for small changes



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## Free Hatching

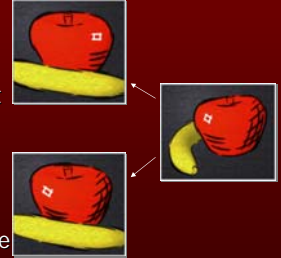
- User draws the hatching for specific levels of detail
- Density consistency maintained by blending between the user-defined levels



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## 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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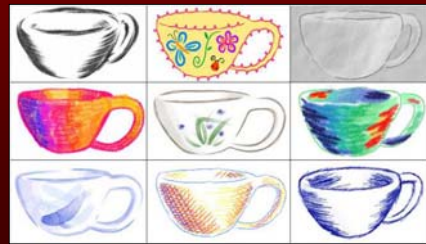
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## Results

- Very flexible system



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## Results

- High-quality images



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## Results

- Can generate complex scenes quickly



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## Results

- Allows interactive exploration of the scene
- Supports animated geometries



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## Limitations

- Many styles not yet supported



David Small

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## 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)



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## 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

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