Computer-Generated Pen & Ink Illustration

G. Winkenbach and D.H. Salesin

Presented By: Michael Imbrogno

Motivation

- Communication of visual information often benefits from abstraction
- Example: architectural illustrations

Illustration of Frank Lloyd Wright's "Robie House"

Why Pen & Ink?

- Combines well with text
  - Same pen and paper
- Economy of expression
  - Tone and texture conveyed with strokes
  - Not necessary to draw **all** strokes

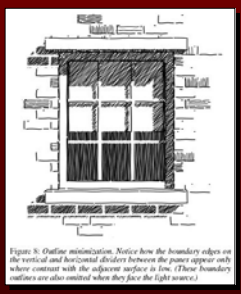

Figure 8: Outline minimization. Notice how the boundary edges on the vertical and horizontal dividers between the panes appear only where contrast with the adjacent surface is low. (These boundary outlines are also omitted when they face the light source.)

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Goals

- Enhance communication of 3D architectural models using pen & ink techniques
- Survey traditional pen & ink techniques
- Incorporate these techniques into automatic rendering system

Overview

- Traditional Pen & Ink
- Computer-Generated Pen & Ink
- Related Work
- Conclusions

Overview

- **Traditional Pen & Ink**
  - Strokes
  - Tone and texture
  - Silhouettes and creases
- Computer-Generated Pen & Ink
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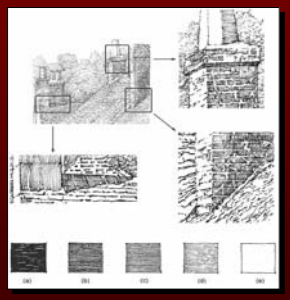
Strokes

- Thickness:
  - Too thin → washed-out
  - Too thick → detracts from detail
- Evenly-weighted lines look lifeless; vary thickness along stroke

Coventry Cathedral Ruins (A.E.E. Jones)

Tone

- Tones created from lines of roughly equal weight and spacing



Modified by A.E.E. Jones, Original by D.A. Gregg (1910)

Texture

- Crisp, straight lines → glass
- Absence of detail → glare
- Materials:
  - Sketchy lines → old
  - Stippling → new

Frank Lloyd Wright-Style House (A.E.E. Jones)

Silhouettes & Creases (Outlining)

- Crisp lines → hard objects
- Thick lines → shadow or contrast

External Entrance Doorway, Coventry Cathedral Ruins (A.E.E. Jones)

Overview

- Traditional Pen & Ink
- **Computer-Generated Pen & Ink**
  - Rendering Pipeline
  - Strokes
  - Prioritized stroke textures
  - Silhouettes and Creases
- Related Work
- Conclusions

Rendering Pipeline

- Approach: Modify 3D pipeline
- Differences from traditional 3D pipeline:
  - Dual nature of strokes
    - Lighting and texture no longer separate
  - Need to combine 2D and 3D info.
    - Need 2D images to compute proper tone
    - Need 2D adjacency info. for proper outlining

Rendering Pipeline (cont.)

- Input: 3D model, textures, lighting model, visible surface algorithm, shadow algorithm
- Render strokes, not polygons
- Maintain two 2D spatial subdivisions:
  - Planar map (for outlining)
  - 2D BSP tree (for clipping)

Strokes

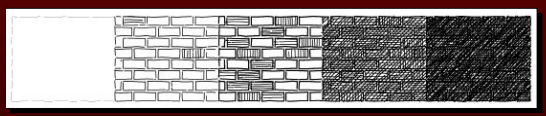
- Stroke definition:
  - A parametric path
  - A *nib* model as a function of pressure
  - A pressure function
  - A waviness function

Strokes (cont.)

- Stroke rendering:
  - Scan convert path after waviness added
  - Stamping copy of nib, scaled by pressure function

Prioritized Stroke Textures

- Collection of strokes that produce a particular texture and tone
- Each stroke assigned a priority
  - Strokes drawn in decreasing priority
  - Draw strokes until desired tone achieved



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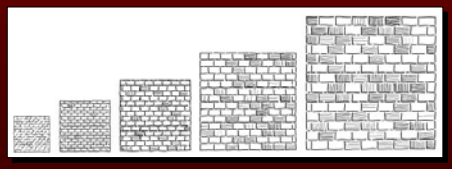
Prioritized Stroke Textures (cont.)

- Desired tone computed using reference image (i.e. G-buffer)
- Current tone computed as ratio of ink to polygon area

Stroke Texture Advantages

- Resolution dependence: Fewer strokes needed for low resolution devices
- Scale invariant: Maintain same tone at different scales



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Stroke Texture Indication

- Use Beier and Neely control line approach

Silhouettes & Creases: Overview

- Expression of texture
- *Indication*
- *Accent* (thickening) for shadow
- View dependency

Expressing Outline Texture

- Stroke textures have associated *boundary outline texture*

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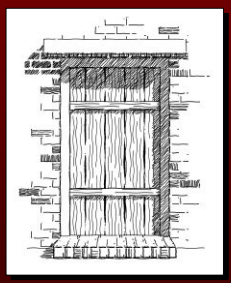
Outline Indication

- No texture → Draw outline
- Texture → Draw outline of edge E when two adjacent faces to E have similar tone
  - Choose outline texture of closer face



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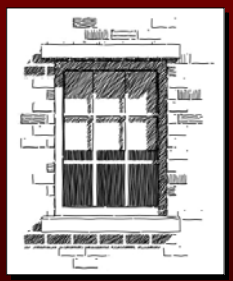
Outline Accents

- Light direction determines accents
  - Edges that cast shadows are thickened
  - Illuminated edges not drawn at all



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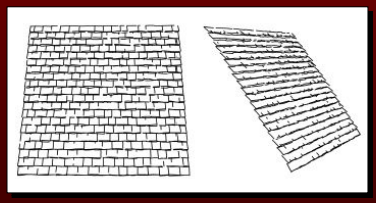
Outline View Dependence

- Stroke textures given an anisotropic bidirectional reflectance distribution function (BRDF)



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Overview

- Traditional Pen & Ink
- Computer-Generated Pen & Ink
- **Related Work**
  - Interactivity
  - Parametric surfaces
  - Image representation
  - Orientable textures
- Conclusions

Interactivity

- M.P. Salisbury et al. "Interactive Pen-and-Ink Illustration." In Proc. *ACM SIGGRAPH 94*, pp. 101-108, July 1994.

Parametric Surfaces

- G. Winkenbach and D.H. Salesin. "Rendering Parametric Surfaces in Pen and Ink." In *Proc. ACM SIGGRAPH 96*, pp. 469-476, October 1996.

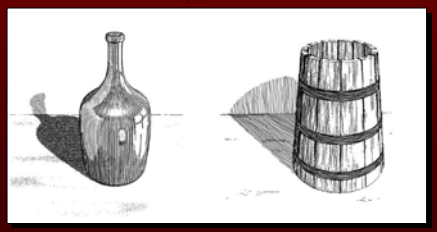
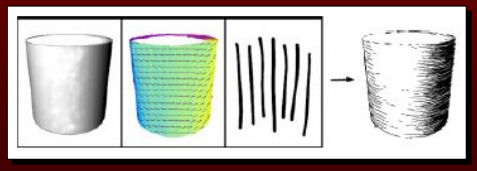


Image Representation

- M. Salisbury et al. "Scale-Dependent Reproduction of Pen-and-Ink Illustrations." In Proc. *ACM SIGGRAPH 96*, pp. 461-468, October 1996.

Orientable Textures

- M.P. Salisbury. "Orientable Textures for Image-Based Pen-and-Ink Illustration." In Proc. *ACM SIGGRAPH 97*, pp. 401-406, October 1997.



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Summary

- Surveyed traditional principles of pen & ink illustration
- Described an automated 3D pen & ink rendering system
- Introduced the prioritized stroke texture
  - Resolution/scale dependent rendering

Criticisms

- Creating new stroke textures an involved process
  - Tone, outline, BRDFs, etc.
  - Programming required
  - Impossible for artist

Questions?

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