


Freie Universität  Berlin

Non-Photorealistic Rendering

Maike Buchin
Free University of Berlin


Maike Buchin, Non-Photorealistic Rendering, 14.7.2006 1

Freie Universität  Berlin

Overview

- I. Introduction to NPR
 - Motivation
 - Edge Enhancement
 - Examples
- II. NPR of 3D-Citymodels

Maike Buchin, Non-Photorealistic Rendering, 14.7.2006 2

Freie Universität  Berlin

Computer Graphics

Photorealism

- main goal of CG since its beginnings in the 1960s
- achieved!




Is it always the best form of visualization?

Images


- convey information
- aesthetic

Non-Photorealism

- growing field since 1990s


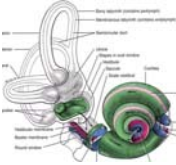

Maike Buchin, Non-Photorealistic Rendering, 14.7.2006 3

Freie Universität  Berlin


Information Visualization

Examples:

- signs, e.g. traffic signs
- sketches, e.g. in instruction manuals and driving directions
- technical drawings, e.g. in medicine, science, architecture



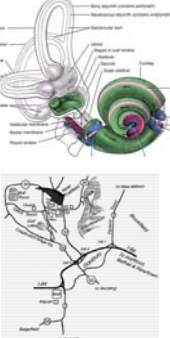
Maike Buchin, Non-Photorealistic Rendering, 14.7.2006 4

Freie Universität  Berlin


Information Visualization

Tools:

- abstraction
- simplification
- emphasis by color, light, lines, perspective
- adding lines that carry information, e.g. edges and motion lines










Maike Buchin, Non-Photorealistic Rendering, 14.7.2006 5

Freie Universität  Berlin

Different Goals - Different Names

- Non-Photorealistic Rendering
- Non-Realistic Rendering
- Comprehensible Rendering
- Interpretive Rendering
- Expressive Rendering
- Illustrative Rendering
- Artistic Rendering
- Stylized Rendering

Sometimes: inspiration or Imitation of hand-drawn

Kalnins et. al., SIGGRAPH 1992

Maike Buchin, Non-Photorealistic Rendering, 14.7.2006 6

Freie Universität Berlin


Overview

- I. Introduction to NPR
 - Motivation
 - Edge Enhancement
 - Examples
- II. NPR of 3D-Citymodels


Malke Buchin, Non-Photorealistic Rendering, 14.7.2006 7

Freie Universität Berlin

Edge Enhancement



A.A. Milne: Winnie the Pooh, Puffin Books, 1992



Rademacher et al., 1999

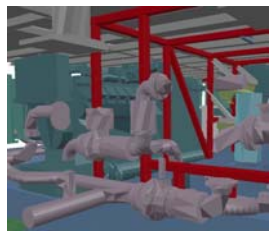
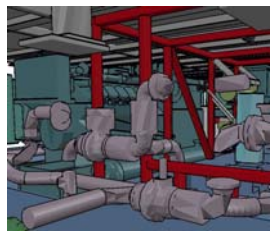
- Traditional drawings
- Cartoons
- Scientific illustrations

Malke Buchin, Non-Photorealistic Rendering, 14.7.2006 8

Freie Universität Berlin

Edge Enhancement

Delimate faces → aid process of perception





Malke Buchin, Non-Photorealistic Rendering, 14.7.2006 9


Freie Universität Berlin

Edge Enhancement


Silhouettes



Boundaries



Discontinuities



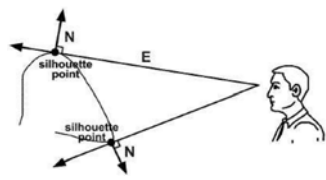
Malke Buchin, Non-Photorealistic Rendering, 14.7.2006 10

Freie Universität Berlin

Edge Enhancement

Silhouettes

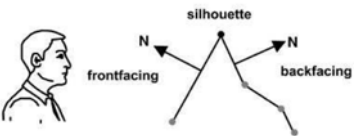
freeform surfaces



silhouette point

silhouette point

polygonal surfaces



silhouette

frontfacing

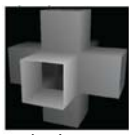
backfacing

Malke Buchin, Non-Photorealistic Rendering, 14.7.2006 11

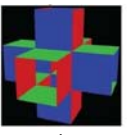
Freie Universität Berlin

Edge Enhancement

Image Space Algorithm: detect discontinuities in

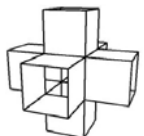


depth map



normal map

and combine



Malke Buchin, Non-Photorealistic Rendering, 14.7.2006 12

Freie Universität Berlin

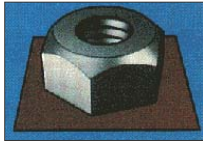
Overview

- I. Introduction to NPR
 - Motivation
 - Edge Enhancement
 - Examples
- II. NPR of 3D-Citymodels


Malke Buchin, Non-Photorealistic Rendering, 14.7.2006 13

Freie Universität Berlin


NPR: Simulating Various Media




Technical Illustration [Saito 90]



Pen & Ink [Winkenbach 94]



Watercolor [Curtis 97]







Paint [Hertzmann 98]

Malke Buchin, Non-Photorealistic Rendering, 14.7.2006 14

Freie Universität Berlin

Painting

Haerberli, SIGGRAPH 1990

Malke Buchin, Non-Photorealistic Rendering, 14.7.2006 15

Freie Universität Berlin

Painting






Litwinowicz, SIGGRAPH 1997

Malke Buchin, Non-Photorealistic Rendering, 14.7.2006 16

Freie Universität Berlin

Hatching


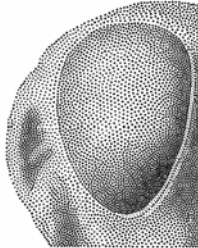



Hertzmann and Zorin, SIGGRAPH 2000

Malke Buchin, Non-Photorealistic Rendering, 14.7.2006 17

Freie Universität Berlin

Stippling

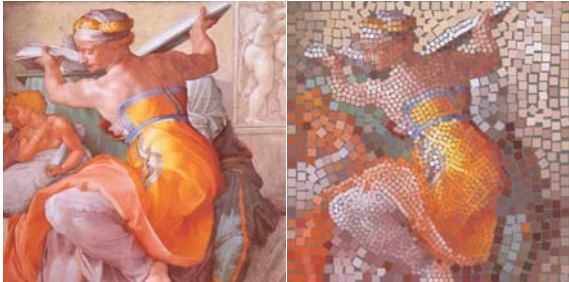



Deussen et al., EuroGraphics 2000

Malke Buchin, Non-Photorealistic Rendering, 14.7.2006 18

Freie Universität Berlin

Tile mosaics



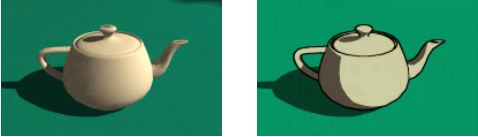
Hausner, SIGGRAPH 2001

Malke Buchin, Non-Photorealistic Rendering, 14.7.2006 19

Freie Universität Berlin

Toon Rendering

- Edge Enhancement
- Toon Shading



Malke Buchin, Non-Photorealistic Rendering, 14.7.2006 20

Freie Universität Berlin

Overview

- I. Introduction to NPR
- II. NPR of 3D-Citymodels
 - 3D City Models
 - Hand-Drawings of Urban Scenes
 - Techniques

Malke Buchin, Non-Photorealistic Rendering, 14.7.2006 21

Freie Universität Berlin

Citymodels

- **static elements of an urban environment:**
buildings, greens, roads, and waterways
- **Applications:**
urban planning, tourism, scientific simulations, games

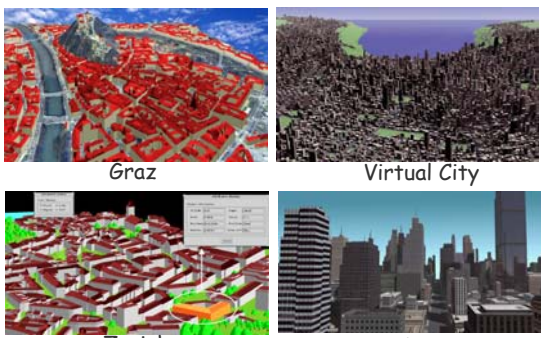


Figure: LandEx

Malke Buchin, Non-Photorealistic Rendering, 14.7.2006 22

Freie Universität Berlin

Examples of 3D-Citymodels



Graz Virtual City Zurich Manhattan

Malke Buchin, Non-Photorealistic Rendering, 14.7.2006 23

Freie Universität Berlin

Overview

- I. Introduction to NPR
- II. NPR of 3D-Citymodels
 - 3D City Models
 - Hand-Drawings of Urban Scenes
 - Techniques

Malke Buchin, Non-Photorealistic Rendering, 14.7.2006 24

Freie Universität Berlin

Hand-Drawings of Urban Scenes

- Cartography
- Architecture
- Art

Malke Buchin, Non-Photorealistic Rendering, 14.7.2006 25

Freie Universität Berlin

Pictorial City Maps

- plain edge enhancement
- very few different colors
- 2 or 3 tone shading
- stylized details (e.g. windows)
- no shadows

Malke Buchin, Non-Photorealistic Rendering, 14.7.2006 26

Freie Universität Berlin

Overview

- I. Introduction to NPR
- II. NPR of 3D-Citymodels
 - 3D City Models
 - Hand-Drawings of Urban Scenes
 - Techniques
 - Building Model
 - Edge Enhancement
 - Tone Shading
 - Windows
 - Shadows
 - Examples

Malke Buchin, Non-Photorealistic Rendering, 14.7.2006 27

Freie Universität Berlin

Buildings

- Classification of buildings by roofstyle

flat hip gable pyramid

Malke Buchin, Non-Photorealistic Rendering, 14.7.2006 28

Freie Universität Berlin

Overview

- I. Introduction to NPR
- II. NPR of 3D-Citymodels
 - 3D City Models
 - Hand-Drawings of Urban Scenes
 - Techniques
 - Building Model
 - Edge Enhancement
 - Tone Shading
 - Windows
 - Shadows
 - Examples

Malke Buchin, Non-Photorealistic Rendering, 14.7.2006 29

Freie Universität Berlin

Edge Enhancement Technique

- truly polygonal objects, i.e. objects with only planar faces
- object based:
 - edges given as part of the model & stored as part of the datastructure
 - Interactive control of edge attributes
- expressiveness through textures

Malke Buchin, Non-Photorealistic Rendering, 14.7.2006 30

Freie Universität Berlin

Edge Enhancement Technique

textured edge billboard

stroke textures

Malke Buchin, Non-Photorealistic Rendering, 14.7.2006 31

Freie Universität Berlin

Interactive Control of Edge Attributes

- Line Style
- Width
- Length
- Color
- Transparency
- Tilt

Malke Buchin, Non-Photorealistic Rendering, 14.7.2006 32

Freie Universität Berlin

Expressing uncertainty

Malke Buchin, Non-Photorealistic Rendering, 14.7.2006 33

Freie Universität Berlin

Overview

- I. Introduction to NPR
- II. NPR of 3D-Citymodels
 - 3D City Models
 - Hand-Drawings of Urban Scenes
 - Techniques
 - Building Model
 - Edge Enhancement
 - Tone Shading
 - Windows
 - Shadows
 - Examples

Malke Buchin, Non-Photorealistic Rendering, 14.7.2006 34

Freie Universität Berlin

2-/3-Tone Shading Technique

greatly reduces the color complexity

two tone

three tone

Malke Buchin, Non-Photorealistic Rendering, 14.7.2006 35

Freie Universität Berlin

Overview

- I. Introduction to NPR
- II. NPR of 3D-Citymodels
 - 3D City Models
 - Hand-Drawings of Urban Scenes
 - Techniques
 - Building Model
 - Edge Enhancement
 - Tone Shading
 - Windows
 - Shadows
 - Examples

Malke Buchin, Non-Photorealistic Rendering, 14.7.2006 36

Freie Universität Berlin

Window Textures

- Characteristic for buildings
- Number of storeys → relative heights
- Mipmapping for different levels of details

Malke Buchin, Non-Photorealistic Rendering, 14.7.2006

37

Freie Universität Berlin

Overview

- I. Introduction to NPR
- II. **NPR of 3D-Citymodels**
 - 3D City Models
 - Hand-Drawings of Urban Scenes
 - **Techniques**
 - Building Model
 - Edge Enhancement
 - Tone Shading
 - Windows
 - **Shadows**
 - Examples

Malke Buchin, Non-Photorealistic Rendering, 14.7.2006

38

Freie Universität Berlin

Shadows

- realism
- orientation in the scene
- relative positions of objects
- light and time of day
- atmosphere

Malke Buchin, Non-Photorealistic Rendering, 14.7.2006

39

Freie Universität Berlin

Types of Shadows

Computer Graphics

- Soft
- Hard

Architecture

- Filled (= hard)
- Hatched

Malke Buchin, Non-Photorealistic Rendering, 14.7.2006

40

Freie Universität Berlin

Shadows on the ground

- determine shadow area on the ground

- texture shadow area using blending

hard (1x1Pixel)

lines (8x1 Pixel)

soft (128x128 Pixel)

Malke Buchin, Non-Photorealistic Rendering, 14.7.2006

41

Freie Universität Berlin

Shadows on the ground

hatched

soft

hard

Malke Buchin, Non-Photorealistic Rendering, 14.7.2006

42

Overview

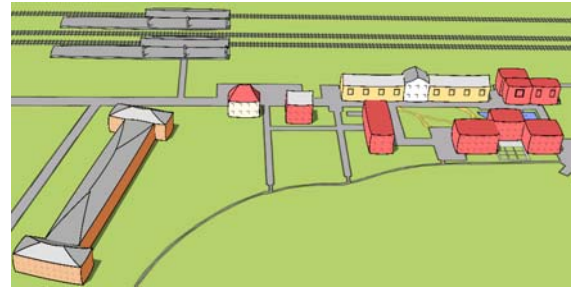
I. Introduction to NPR

II. NPR of 3D-Citymodels

- 3D City Models
- Hand-Drawings of Urban Scenes
- **Techniques**
 - Building Model
 - Edge Enhancement
 - Tone Shading
 - Windows
 - Shadows
- **Examples**



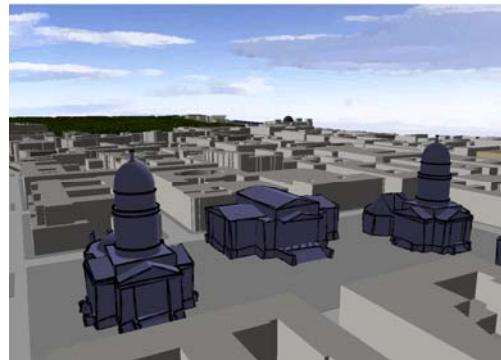
University Complex Griebnitzsee, Potsdam



Citymodel of Frankfurt am Main



Citymodel of Berlin



Literature on NPR

Books:

- **Non-Photorealistic Rendering**, Bruce & Amy Gooch, 2001
- **Non-Photorealistic Computer Graphics**, Thomas Strothotte & Stefan Schlechtweg, 2002



Conferences:

- **SIGGRAPH**: sessions & courses since 1996 & 1999
- **NPAR**: every two years since 2000

THANK YOU! - QUESTIONS?