Non-Photorealistic Rendering in Context: An Observational Study

Tobias Isenberg
Petra Neumann
Sheelagh Carpendale
Mario Costa Sousa
Joaquim A. Jorge

Department of Computer Science
Faculty of Science
University of Calgary
1. Introduction

Isenberg et al. 2 NPR in Context: An Observational Study
Introduction

- NPR inspired by artistic and illustrative depiction
- Few evaluations of state-of-the-art
- Comparative study of hand-drawn and NPR illustrations
- Restriction to scientific illustrations
- Restriction to pen-and-ink styles
- Qualitative study

Isenberg et al. 3 NPR in Context: An Observational Study
1. Introduction

Related Work

NPR in architecture

Schumann et al. 1996

Influence on gaze direction

Santella and DeCarlo 2004

Space perception

Gooch and Willemsen 2002

Facial illustration

Gooch et al. 2004

Psychology of NPR

Duke et al. & Halper et al. 2003

Medical visualization

Tietjen et al. 2005
2. Study Rationale and Setup

Study Rationale

• viewing/evaluating/understanding illustrations: complex process, difficult to analyze

• exploratory observation:
  – no predetermined hypothesis
  – ethnographic technique: pile sorting
  – criteria & terminology determined by participants
  – important goal: not to bias participants

• observing participants’ actions & opinions

• qualitative results
2. Study Rationale and Setup

Study Setup: Images

- 30 images of 3 “models” generated: archaeological, botanical, and medical model

- 5 professional illustrators and 5 NPR algorithms
Study Setup: Professional Illustrators

- William M. Andrews: hatching or stippling w/ silhouettes
- Davide Brunelli: sketchy hatched outlines
- Humberto Costa Sousa Filho: silhouette, scratchboard w/ hatching
- Andrew E. B. Swift: hatching w/ silhouettes
- Lynda Smith Touart: stippling w/ outlines
2. Study Rationale and Setup

Study Setup: Professional Illustrators

- William M. Andrews: hatchling or stippling w/ silhouettes
- Davide Brunelli: sketchy hatched outlines
- Humberto Costa Sousa Filho: silhouette, scratchboard w/ hatching
- Andrew E. B. Swift: hatching w/ silhouettes
- Lynda Smith Touart: stippling w/ outlines
Study Setup: Professional Illustrators

- William M. Andrews: hatching or stippling w/ silhouettes
- Davide Brunelli: sketchy hatched outlines
- Humberto Costa Sousa Filho: silhouette, scratchboard w/ hatching
- Andrew E. B. Swift: hatching w/ silhouettes
- Lynda Smith Touart: stippling w/ outlines
Study Setup: Professional Illustrators

- William M. Andrews:
  hatching or stippling w/ silhouettes

- Davide Brunelli:
  sketchy hatched outlines

- Humberto Costa Sousa Filho:
  silhouette, scratchboard w/ hatching

- Andrew E. B. Swift:
  hatching w/ silhouettes

- Lynda Smith Touart:
  stippling w/ outlines
Study Setup: Professional Illustrators

- William M. Andrews: hatching or stippling w/ silhouettes
- Davide Brunelli: sketchy hatched outlines
- Humberto Costa Sousa Filho: silhouette, scratchboard w/ hatching
- Andrew E. B. Swift: hatching w/ silhouettes
- Lynda Smith Touart: stippling w/ outlines
Study Setup: NPR Pen-and-Ink Algorithms

- [Secord 2002]: stippling without silhouettes
- [Sousa et al. 2003 & 2004]: precise ink marking
- [Zander et al. 2004]: cross-hatching with silhouettes
- [Schlechtweg et al. 2005]: stippling with silhouettes
- [Schlechtweg et al. 2005]: cross-hatching with silhouettes
2. Study Rationale and Setup

Study Setup: NPR Pen-and-Ink Algorithms

- [Secord 2002]: stippling without silhouettes
- [Sousa et al. 2003 & 2004]: precise ink marking
- [Zander et al. 2004]: cross-hatching with silhouettes
- [Schlechtweg et al. 2005]: stippling with silhouettes
- [Schlechtweg et al. 2005]: cross-hatching with silhouettes
Study Setup: NPR Pen-and-Ink Algorithms

- [Secord 2002]: stippling without silhouettes
- [Sousa et al. 2003 & 2004]: precise ink marking
- [Zander et al. 2004]: cross-hatching with silhouettes
- [Schlechtweg et al. 2005]: stippling with silhouettes
- [Schlechtweg et al. 2005]: cross-hatching with silhouettes
2. Study Rationale and Setup

Study Setup: NPR Pen-and-Ink Algorithms

- [Secord 2002]: stippling without silhouettes
- [Sousa et al. 2003 & 2004]: precise ink marking
- [Zander et al. 2004]: cross-hatching with silhouettes
- [Schlechtweg et al. 2005]: stippling with silhouettes
- [Schlechtweg et al. 2005]: cross-hatching with silhouettes
Study Setup: NPR Pen-and-Ink Algorithms

- [Secord 2002]: stippling without silhouettes
- [Sousa et al. 2003 & 2004]: precise ink marking
- [Zander et al. 2004]: cross-hatching with silhouettes
- [Schlechtweg et al. 2005]: stippling with silhouettes
- [Schlechtweg et al. 2005]: cross-hatching with silhouettes
Study Setup: Participants

- four main groups:
  1. domain experts:
     scientists etc. who know their field
  2. professional illustrators:
     know how to make good illustrations
  3. illustration end users:
     learn with the produced illustrations
  4. NPR researchers:
     develop methods to produce illustrations with computers

- in our study: groups 2–4; mainly graduate students

- 8 participants per group; $\sum 24$ participants
2. Study Rationale and Setup

Study Setup: Procedure

• about 1 hour or less for each session

• three stages

  1. unconstrained pile-sorting: grouping objects, free choice of criteria
  2. semi-structured interview: discussion of the piles and predefined questions
  3. post-session questionnaire: demographics and previous experiences

• data acquisition through video and note taking
3. Pile-Sorting Task: Results and Discussion

Results

• categorization by drawing/rendering style by most people

• less often used criteria: realism/detail, aesthetics, information contents, and orientation

• no significant differences between how the three groups categorized

• cluster graph from correlation table
3. Pile-Sorting Task: Results and Discussion

Results

- categorization by drawing/rendering style by most people
- less often used criteria: realism/detail, aesthetics, information contents, and orientation
- no significant differences between how the three groups categorized
- cluster graph from correlation table

Isenberg et al. 11 NPR in Context: An Observational Study
3. Pile-Sorting Task: Results and Discussion

Results

• categorization by drawing/rendering style by most people

• less often used criteria: realism/detail, aesthetics, information contents, and orientation

• no significant differences between how the three groups categorized

• cluster graph from correlation table
3. Pile-Sorting Task: Results and Discussion

Results

• categorization by drawing/rendering style by most people

• less often used criteria: realism/detail, aesthetics, information contents, and orientation

• no significant differences between how the three groups categorized

• cluster graph from correlation table
3. Pile-Sorting Task: Results and Discussion

**Results**

- categorization by drawing/rendering style by most people
- less often used criteria: realism/detail, aesthetics, information contents, and orientation
- no significant differences between how the three groups categorized
- cluster graph from correlation table
Discussion: pile-sorting to facilitate open discussion
Discussion: categories by style (hatching vs. stippling)
Discussion: amount of detail important (Cluster 3)
Discussion: amount of detail important (Cluster 3)
Discussion: some categorization by artists/algorithms
Discussion: Cluster 1: very distinct style—loose and sketchy
Discussion: Cluster 1: very distinct style—loose and sketchy
Discussion: no clustering w. r. t. model
Possible contexts for images

- science & art textbooks, in classes & museums, other publications, also art displays, comics, games & software

- usage in university textbooks:

- children’s textbooks: more hand-drawn; conflicting opinions
Possible contexts for images

- science & art textbooks, in classes & museums, other publications, also art displays, comics, games & software

- usage in university textbooks:

- children’s textbooks: more hand-drawn; conflicting opinions
Image liking and appeal

• no clear favorites

• least favorites (named by $\geq 58\%$, all others $\leq 25\%$):

• context is essential!
Images looking most CG or hand-drawn

- many hand-drawn images stood out as such—lines:

83% 83%/71% 79% 79% 67% 58%

- hand-drawn images less often named: stippling or mix of stippling with lines
Images looking most CG or hand-drawn

- many hand-drawn images stood out as such—lines:
  - 83%
  - 83%/71%
  - 79%
  - 79%
  - 67%
  - 58%

- hand-drawn images less often named: stippling or mix of stippling with lines
Images looking most CG or hand-drawn

- cg images often named to stand out as such: stippling or high-resolution lines
Images looking most CG or hand-drawn

- cg images often named to stand out as such: stippling or high-resolution lines

88% 79% 79%/58% 54%/42% 46%
Images looking most CG or hand-drawn

- hand-drawn images rarely named to stand out as cg ($\leq 13\%$)

- some cg images frequently thought to be hand-drawn:

- randomness, longer and less dense lines, lower detail
Images looking most CG or hand-drawn

- hand-drawn images rarely named to stand out as cg (≤ 13%)

- some cg images frequently thought to be hand-drawn:

  
  ![Image 1] 67%
  ![Image 2] 63%
  ![Image 3] 46%
  ![Image 4] 29%

- randomness, longer and less dense lines, lower detail
Discussion

• NPR-Turing test not passed, CG images recognized as such (named standing out as hand-drawn by $\leq 29\%$)

• some almost always recognized as CG: detail, 3D shading, exactness

• depending on algorithm AND parameters

• one major exception: RenderBots hatching “sketchy”, “simplified”, “not show shape well”
Discussion

- NPR-Turing test not passed, CG images recognized as such (named standing out as hand-drawn by $\leq 29\%$)

- some almost always recognized as CG: detail, 3D shading, exactness

- depending on algorithm AND parameters

- one major exception: RenderBots hatching “sketchy”, “simplified”, “not show shape well”
Discussion

- NPR-Turing test not passed, CG images recognized as such (named standing out as hand-drawn by ≤ 29%)

- some almost always recognized as CG: detail, 3D shading, exactness

- depending on algorithm AND parameters

- one major exception: RenderBots hatching “sketchy”, “simplified”, “not show shape well”
4. Interview: Results and Discussion

Discussion

• NPR-Turing test not passed, CG images recognized as such (named standing out as hand-drawn by $\leq 29\%$)

• some almost always recognized as CG: detail, 3D shading, exactness

• depending on algorithm AND parameters

• one major exception: RenderBots hatching “sketchy”, “simplified”, “not show shape well”
Impact for NPR Research: Know your goal & audience
5. Conclusion

Impact for NPR Research: Portray materials
Impact for NPR Research: Work with models
Impact for NPR Research: Avoid regularities
Impact for NPR Research: Pay attention to marks
Impact for NPR Research: Pay attention to tools
Main Message:

We can learn much about scientific illustration by observing how people look at illustrations and asking them what they see. The insights gained from evaluating NPR can help to improve our non-photorealistic techniques.
Thanks for your attention!

Special thanks to illustrators William M. Andrews, Davide Brunelli, Humberto Costa Sousa Filho, Andrew E. B. Swift, and Lynda Smith Touart and to Tobias Germer & Adrian Secord!

Also thanks to our funding agencies: