The Art and Science of Depiction

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From CG and geometry...

Array indexed by the polygons

Visual event $ev$

Arc of the skeleton

Search tree

... to make-up and swimming-suits
Overview of the talk

- No computer-graphics research
- Preliminary and not-so-preliminary reflections about images
- 1st part:
  - Context and goals
    (Raising expectations)
- 2nd part:
  - Overview of the class
    *The Art and science of depiction*
  - (Failing the expectations)

Motivations: Post-PhD blues…

- Why do our image lack aesthetic?
- What’s our goal?
- *Where Do We Come From? What Are We? Where Are We Going?*
**Motivations**

- What is “Realism”? What is “Photorealism”?
- Are photographs realistic?
- Are photographs photorealistic?
- What is Non-Photorealistic Rendering?

**Non-Photorealistic Rendering**

- A variety of awesome techniques and solutions
- But what are the issues?
- Difficulty of classification
- Each paper deals with several problems
- Lack of inter-operability
Why make images?

- Educational
- Tell story
- Simulation
- Design
- Sign
- Guide task
- Visualization
- Search
- Analysis

- Create shape
- Expression
- Beauty
- Shock
- Medical
- Humor
- Faith
- Prevention
- Etc.

- Not one single class of images
- Thus, there may be many ways to make images
- CG focuses too much on one of them

Non-realism vs. realism

- Non-realism is MORE than degraded realism
  - E.g. clarity, selection, abstraction, etc.
**Realism vs. realism**

- A realistic image can be MORE than realistic
- E.g. dodging and burning
  - During the print
  - Locally darken or lighten using a mask

**Dodging and Burning**

- Ansel Adams
- *Clearing Winter Storm*
Generic pictorial issues

- A lot of issues are universal
- E.g. oil painting / photograph

Contrast is reinforced at the occlusion silhouette
- Tone modification / haze
Computer Graphics Imagery

- Rendering is efficient
- Hardware is fast
- 3D content creation becomes the bottleneck
- Most CG images are still not very compelling

The one-way pipeline

- Rendering pipeline, rendering equation
- From 3D model to image
- No feedback

3D geometry
Material attributes
Light sources
Viewpoint

Light simulation
Projection
Rasterization, etc.

Image
Feedback and Darwinian selection

- Picture production is a trial and error process
- The artist tries pictorial techniques, constantly judges the current state of the picture and reacts accordingly

The Bull by Picasso

What can we do?

- Simulate the feedback
  - Optimization approaches
  - Perception/artistic-based “metric”
  - What are the goals?
- Bypass the feedback
  - What are the pictorial issues?
  - What are the pictorial techniques?
  - Hopefully inverse the feedback
- Try to understand what is going on and what we’re trying to do!
What and whom for?

- Trained image makers
  - Understand what they need
  - Provide more relevant tool
- Image-dummies
  - Automatic and semi-automatic
  - E.g. “gorgeous image” for CAD
  - E.g. “digital photo beautifier”
- Computers (100% automatic)
  - E.g. can we transfer the art and craft of cinema into games?

Can artists tell us?

- Well, a lot of translation is necessary
- Their feedback loop is extremely good
- But it is often an inaccessible black box
Can art historians tell us?

- Well, a lot of translation is necessary
- They know what is good in an image
- Their language is descriptive, not generative
- Often limited to 14th-19th century Western art
- But recent art history works with general images

Can perception scientists tell us?

- Well, a lot of translation is necessary
- Experimental results
  - E.g. colors, perspective perception
- Provide framework to pictorial techniques
  - Corresponding human visual mechanisms
  - Unfortunately, often no quantitative prediction
  - Suggests relevant “dimensions” or issues
- Unfortunately complex images are… too complex
**Can perception & art history tell us?**

- Well, some translation is necessary
- But very fruitful
- That is the topic of this talk!

**Can we tell them something?**

- Well, a lot of translation is necessary
- Raise interesting questions
- Generative approach to pictures
- Systematic validation
  - We cannot omit anything (you get what you ask for)
  - Parallel: computer-vision showed the complexity of human vision
Towards picture sciences?

- Perception
- Art History
- Visual Arts
- Computational Vision
- Computer Graphics

- A paradigm: Language sciences

The Art and Science of Depiction

- Graduate class at MIT (but undergrads as well)
- Multidisciplinary
- Students from Architecture, Computer Science, Cognitive Sciences, Media Art & Science
Other goals

- Multidisciplinary, make connections
- Different viewpoint on picture
- Correct scientific errors in art books
- Excuse to talk about cool stuff
- Excuse to look at cool pictures

Disclaimer & epistemology

- What will be described are connections, correlations, NOT truths, causalities, explanations
- Moreover, they are often hypothesis not yet verified
- But we hope they offer insights
Plan

- Visual system and art
- Limitations of medium: compensation and accentuation
- Representation system

Beware of the El-Greco Fallacy

- El-Greco, elongated characters
- Were supposed due to astigmatism
- However, pictures and real people would have been stretched equally
- Almost as fallacious as assuming painting should be inverted because our eyes invert what we see
Vision as information processing

- Input: retinal image
- Output: 3D layout, object recognition, etc.

![Visualization of vision processing stages](image)

Computational theory of vision

- Marr’s stages (extended by Palmer et al.)
- Human and Computer Vision
- Classification of different kinds of processes
- Has proved fruitful in art studies

![Comparison of view-centered and object-centered processing](image)
**Retinal image**

- Intensity

**Image-based (primary sketch)**

- Contrast, edge detection
**Surface-based**

- Visible surfaces, organization
- Distance, orientation

**Object-based**

- 3D properties, structure
- Nature of the description highly discussed
**Category-based**

- Recognition, category, function

**Feedback**

- Bottom-up and top-bottom
**Evolution of children’s drawings**

- First draw what they know (object-based)
- Then what they see (towards retinal)
- Asked to draw a table

![Child’s view of a table](image)

<table>
<thead>
<tr>
<th>Class of drawing &amp; average age</th>
<th>7.4</th>
<th>9.7</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.6</td>
<td>14.3</td>
<td>13.7</td>
</tr>
</tbody>
</table>

**3D and 2D attributes**

- Show a dice to children (~6-7)
- They usually draw a rectangle
- The rectangle could stand for one face
**3D and 2D attributes**

- Show coloured or numbered dice to children (6-7)
- The still draw a rectangle
- But different colours or many points

The rectangle stands for the whole dice. The notion of 3D object with corners is translated as a 2D object with corners.
Relation to pictures

• Different classes of pictures for different stages
• Not a strict classification, not a cultural judgment

Relation to pictures

• Chinese painting refuse extrinsic, only essential
• No shadow
Retinal image

- Impressionism
- Photography

Retinal image

- Impressionism
- Not so simply classified
**Image-based**

- Line Drawing

**Intermediate**

- View-based
- Cues for surface-based feature extraction are enhanced
  - Depth cues
  - Orientation cues
- No subjective feature (e.g. lighting)
**Higher level**

- Primitive art
- Cubism
- Schema
- “What I know”
**Expressionism**

- “What I feel”

![The Scream by Edvard Munch](image)

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**Gaze movement**

- We need to align the fovea with relevant features
Gaze movement

- We need to align the fovea with relevant features
- Saccadic exploration
  - Path
  - Fixation time

Gaze attraction & focal zone

- E.g. Through contrast
One focal zone

- Arthus-Bertrand
- Striking but…

Two focal zones

- Robert Mapplethorpe
  \textit{Self-portrait, 1988}
- More dynamic
**Triple focus and subject gaze**

- Robert Doisneau
  - Les Gosses de la place
  - Hebert
- More lively

**Turner’s Loire journey**

- The gaze follows the journey
**Focal point conflict**

- Bottom-up is different from top down
- Makes image dynamic

**Fixation time & style**

- Depends on style “complexity”
- Shorter fixation for more complex style
Advertisement and focal points

• Evolution of saliency

Plan

• Visual system and art

• Limitations of medium: compensation and accentuation

• Representation system
**Limitations of the medium**

- Flatness
- Finite size, frame
- Unique viewpoint
- Static
- Contrast and gamut

- Can be eliminated
- Can be compensated
- Can be accentuated

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**Eliminating flatness**

- Stereo display
Enhancing depth through contrast

Accentuating flatness

- Monet
- Occlusion boundaries are barely visible
- Retinal stage rather than surface
**Accentuating – dissonance**

- Magritte
- Occlusions are reversed

**The contrast is limited**

- Real world: $10^{-6}$ to $10^6$
- Picture: 1 to 50, 1 to 300 at best

High dynamic range

Low contrast
Low contrast is also an advantage

- W. Eugene Smith photo of Albert Schweitzer
- 5 days to print!
- Things can be related because the intensity is more similar
- Balance, composition

The image is static – Motion Blur
Multiple Snapshots

- Marcel Duchamp
  *Nude Descending a Staircase*
  1912

Static image & composition

- Tak Kwong Chan
  *The Horse – Away He Goes*
  1980
- Both static and dynamic qualities:
  the limitation is a richness
Plan

- Visual system and art

- Limitations of medium: compensation and accentuation

- Representation system
**Representation systems: goals**

- Coarse-grain description of style
- Independent systems, independent decisions
- Description and comparison
- Potentially generative (for NPR)

**A paradigm: Cartography**

- A map is a depiction of a reality
- Can be more efficient than photo
- There is no perfect universal solution
- The systems are usually explicit!
Map making

- Which information will be represented
- Projection
- Which kind of symbols will be used
- Colour codes

Projection
**Projection: Topological**

- Beck’s map of London underground, 1931

**Projection: Topographical**

- London underground
“Metaphoric” Projection

Error: Columbus's map
Error/choice/distortion

- Descelier, 1546

E.g. huge elephant
**Denotation (Primitive & Dimensions)**

**LE RÉSEAU TGV**

Les lignes sont en pointillé et les gares en couleur. Les gares principales sont indiquées par des flèches.

**Légende**

- SNCF
- Montparnasse
- Gare de Lyon

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**Les régions viticoles**

Les vins produits dans chacune des régions principales régions viticoles possèdent leur propre personnalité, liée aux terroirs, aux cépages ou aux traditions. L’appellation contrôlée, régie par la loi garantis leur origine et leur typicité.

**Légende**

- Bourgogne
- Champagne
- Alsace
- Loire
- AOC Provence
- IGP et vin doux
- Sud-Ouest
- Languedoc-Roussillon
- AOC Rhône
**Colour system**

- E.g. elevation

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**Representation system**

- Drawing

- Denotation

- Tone & color
Final conclusions and future work

- What the hell can we do with all this?

To Be Continued…
**Representation systems**

- Drawing and projection
- Denotation
- Tone & colour

- The two first systems are classical
- Because painting was the only recognized art form

**Drawing system**

- Linear perspective
- Orthographic
- Topological
- Other
**Denotation system**

- Silhouette: 2D (regions)
- Line Drawing: 1D (lines)
- Optical: 0D (points)

**Tone & colour system**

- Extrinsic (outgoing light)
- Intrinsic (reflectance properties)
- Other, e.g. symbolic
**Marks vs. primitive**

- Mosaic
- Primitives = lines
- Marks = points (or small regions)
Style

• Coarse-grain style
  – Different categories of drawing, denotation, tone

• Finer-grain

• Local style

• Parameterization

• Capture
  – Automatically deduce style from 3D renderings
  – (semi)-Automatically capture style from image(s)

Shading and highlighting
Corrective Make Up

- Depending on the shape of the face

Corrective lighting
An example

Is it fair?
Touch-up: too dark face

Touch-up: silhouette
**Touch-up: undesirable lines**

[Image of a person with a 'touch-up' on the body.]

**Touch-up: stretch and arm**

[Image of a person with a 'touch-up' on the arm and head.]
**Deforming lens**

- Deform one part of the frame
- Stretched arm and legs

**Perspective distortion**

- The sphere is projected as an ellipse
**Perspective distortion**

- The sphere is projected as an ellipse

**Leonardo & contradictions**

- Wide angle vision
Leonardo & contradictions

- Wide angle vision
- Lateral recession

Perspective distortion

- Portrait: distortion with wide angle

Wide angle
Standard
Telephoto