Perceptual and Artistic Principles for Effective Computer Depiction

Computational Vision and Picture

Fredo Durand
MIT- Lab for Computer Science

Distal vs. proximal stimulus

• Distal stimulus: reality
• Proximal stimulus: retinal image

Vision as an inverse problem

• The distal stimulus is projected into a proximal stimulus
**Vision as an inverse problem**
- The distal stimulus is projected into a proximal stimulus
- How can we inverse this projection?

**Unconscious inference (Helmholtz)**
- Our vision system solves a problem
- Under-constrained problem
  - A visible point A’ can correspond to an infinity of 3D points (A1, A2, A, A3…)

**How assumptions help**
- **Ames chair**
  - 3 different scenes
  - Same projection
  - We assume it is a chair
  - Resolves ambiguity
  - Can be wrong

**The Ames room**
- Invalid assumption
  - Walls perpendicular
- Wrong conclusions
  - Men have different sizes

**Positive and hollow face**
- Both seen convex because hollow faces are rare!

**Constancy & architecture**
- Palazzo Spada in Rome (by Boromini)
  - Short corridor
  - Column size decreases
  - Appears longer
The paradox of vision

• Available information: proximal stimulus
• Conscious information: distal stimulus

Brightness vs. lightness

• Brightness: subjective amount of light
• Lightness: how “white”

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Pictures and the inverse problem

• Pictures can
  – Simplify the analysis
  – Be a puzzle, a riddle

Plan

• Vision as a cognitive process
• Computational theory of vision
• Complex mapping
Vision as information processing

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

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

Retinal image

- Intensity: hard to comprehend

Image-based (primary sketch)

- Contrast, edge detection
- Not so easy

Surface-based

- Visible surfaces, organization
- Distance, orientation

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- 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

Scope of the theory

- Computer Vision
- Human Vision
- No direct correspondence in the brain
- Has proved fruitful conceptual tool

Relation to children drawing

- First children draw what they know
  - Object-centered
- Then, what they see
  - View-centered

Evolution of children’s drawings

- Asked to draw a table
- First, what they know
- Later, what they see

Child’s view

Class of drawing & average age

Age 5
Age 9 (gifted!)
**What about adults?**

- Reproduce two drawing with similar angles
- Wheel:
  - Accuracy ~5°
- Street:
  - Error: 32°
- Because in the first case, they focus on the 3D (distal) interpretation

**Drawing reproduction**

- Drawing on the right side of the brain, Edwards
- Advises to reproduce drawings upside down
- Distal interpretation does not impede
- Forgers often reproduce paintings upside-down

**Relation to pictures**

- Different classes of pictures for different stages
- Not a strict classification

**Relation to pictures**

- Chinese painting refuse extrinsic, only essential
- No shadow

**Retinal image**

- Turner
  - “My business is to paint not what I know, but what I see”
**Retinal image**
- Impressionism
- Photography

**Image-based**
- Line Drawing
- Rivera

**Intrinsic vs. Extrinsic**
- Visual angle vs. true size
- Caravaggio:
  Wrong geometrically but looks good

**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”
Higher level

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

Expressionism

- “What I feel”

Relation with 2D/3D emphasis

- Almost the opposite!
- 3D impression corresponds to retinal image
- 2D quality arises from higher-level pictures
- Because of vision paradox
  - Distal is seen when proximal is shown

Relation with 2D/3D qualities

- 3D impression but Retinal image

Relation with 2D/3D qualities

- 2D emphasis but Higher level
Making pictures: inverse of inverse

- Previsualization (Adams)
- Solving the direct problem is a good start, but...

Plan

- Vision as an cognitive process
- Computational theory of vision
- Complex mapping

3D and 2D attributes

- [Willats 97]
- Show coloured or numbered die 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

Projection: Topographical

- London underground
- Metric properties are used

Projection: Topological

- Beck’s map of London underground, 1931
- Only the connectedness and organization are preserved
- [Agrawala, in this volume]

Mapping of curvature

- Convex: positive curvature
  - 3D example: Egg
  - 2D: Convex contour
- Concave: negative curvature
  - 3D example: Interior of cup
  - 2D: Nothing, hidden contour
- Saddle: mix of positive and negative curvature
  - 3D example: Saddle (surprising!)
  - 2D: Concave contour
Mapping of curvature

• But some artists map 3D concave objects to 2D concave outlines
• This maps the property of concavity
• The left view of the plate is more “correct” but does not convey the notion of concavity

“projective” plate
“mapped” plate

Mapping of curvature

• Small plate under the cup

Mapping of curvature

• Complex denotation
• See [Durand, page 15]

Further reading

• Calvin & Hobbes by Watterson!