The Art and Science of Depiction

Gaze Movement and Focal Points

Fredo Durand
MIT-Lab for Computer Science

Summary

• Visual field, highest precision in the fovea (~2°)
• Contrast processing
• Different pathways
• Computational theory of vision
• Invariants

Need for exploration

• We need to align the fovea with relevant features

Plan

• Different eye movements
• Visual exploration
• Saliency
• Focal points, composition

Eye movements

• Physiological nystagmus (involuntary)
• Saccade (scan visual field)
• Smooth pursuit (track moving objects)
• Vergence (depth adjustment)
• Vestibular (compensate head movement)
• Optokinetic (in moving environment)

Physiological nystagmus

• Involuntary movement
• All the time
• Avoid stabilized images
  – Because they disappear!
**Saccade**
- Scan the visual field
- Can be controlled
- The most important for us
- Ballistic movement: 30 ms and up to 900°/s
- Fixation ~300ms
- Saccadic suppression
  - No blur is experienced during movement

**Smooth Pursuit**
- Track moving objects
- Smooth
- Constant feedback and readjustment
- Slower than saccades (max 100°/s)
- Acuity
  - The image of the tracked object remains sharp

**Vergence**
- Depends on object distance (depth cue)
- Less than 10°/s

**Other movements**
- Vestibular
  - compensate head movement
- Optokinetic
  - in moving environment

**Saccadic exploration**
- Reading: Javal, 1878
- Images: Yarbus, 1965
- Path
- Fixation time

**David Hockney’s collages**
- 1 photo = 1 gaze
- Distorted perspective because saliency
David Hockney’s collages

- Temporal too

Gaze movement & cubism

- Picasso
  - Portrait of Kahnweiler

Gaze movement & cubism

- George Braque
  - Le Portugais
  - 1911-1912

Gaze attraction

- Bottom-up (stimulus-driven)
  - Contrast
  - Color
  - Patterns
- Top-bottom (High-level driven, potentially conscious)
  - Semantic information, familiarity
  - Human beings, eyes
  - Task
  - Personal context

Computational model

- Itti et al. (Caltech)
- Bottom-up only
- Different channels (colors, edges)
- Multi-resolution
- Lateral inhibition

Focal point

- Contrast
- Amount of details
- Image dynamics (lines)
- Semantics
Creating focus: edge burning

Focus via “spotlight”

Focus via contrast

Focus via contrast

Focus via contrast

Focus

Focus via contrast

Tofoli

Arthus-Bertrand

Focus via contrast
Focus through contrast

- Rembrandt

Focus through perspective

- Raphael, The School of Athens

Foveal zone

- Eugene Delacroix
  Study for a portrait of Chopin

Focus through make up

- Make-up: Aucoin

Focus using detail and color

- A. M. Cassandrd, 1925

Focus on human

- Trevor Chamberlain
  Railway viaduct
- Human being
- Highlighted by closure
**Gaze and image cognition**

- Similar to scientific method
  - Make hypothesis
    (mental model of the scene)
  - Perform experiments
    (gaze)

**Depends on task**

- painting by Repin
- B: free
- C: economic level
- D: ages
- E: what were they doing
- F: remember cloth

**Depends on task?**

- Rembrandt, *The Anatomy Lesson*
- Different tasks:
  - A: Aesthetic
  - B: Semantic
- Very similar paths

**Diversive vs. specific**

- Different strategies (Berlyne 1971)
- Diversive exploration
  - Hunt for new stimulation
  - Dispersed
  - Shorter fixation (<300ms)
- Specific exploration
  - Seeks specific information
  - Longer fixation (>400ms)

**Effect of training**

- Compare naïve beholders with specialists
  - Radiologists
  - Art students, art historians
- Specialists more specific
- Naïve more diversive

**Fixation time & style**

- Depends on style “complexity”
- Shorter fixation for more complex style
**Gaze & balance**

- Altered painting
- Inverses strategy of naïve and specialists

**Number of focal point**

- Dynamic of the image
- 1 region: imitates foveation, striking
- Many regions: the gaze is transported, dynamism
- Path

**Focus: Color contrast**

- Arthus-Bertrand

**Focus through contrast**

- Rembrandt

**Two focal zones**

- Robert Mapplethorpe
  *Self-portrait*, 1988

**Focus through perspective**

- Raphael, *The School of Athens*
**Focus: saliency + semantics**

Turner’s Loire journey

- The gaze follows the journey

**Turner’s Loire journey**

- The gaze follows the journey

**Triple focus and subject gaze**

- Robert Doisneau
  - Les Gosses de la place
  - Hebert

**Focal point and dynamics**

- Abbas, 1978
- Pop-out leads to uniform
- Perspective leads to top

**Focal point conflict**

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

**Focal point conflict**

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

**Advertisement and focal points**

- Evolution of saliency
The End…

• Of part I