The Art and Science of Depiction

Denotation system

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Invention of linear perspective

• Why so late?
  – Different goal
  – Different background
  – Advent of measurement
  – Mathematic analytical skills
  – Single viewpoint assumption
Accidental/generic

- From the objective geometric point of view
- From the subjective analysis point of view
  - Assume viewpoint is generic
  - Thus, the alignment cannot be accidental
Prototypes

• Solso
Maximum size

• Kosslyn
• Imagine a horse in the distance
• Imagine it moves continuously towards you
• When does it “overflows” your visual field?
Maximum size

- Kosslyn
- Imagine a horse in the distance
- Imagine it moves continuously towards you
- When does it “overflows” your visual field?
- 20° for strict overflow
- 40-60 ° for lax overflow
Maximum size

• Kosslyn
• Imagine a horse in the distance
• Imagine it moves continuously towards you
• When does it “overflows” your visual field?
• 20º for strict overflow (equivalent 100mm)
• 40-60 º for lax overflow (30-50mm)
Denotation system

• Silhouette:
  – 2D (regions)
  – Picasso, *Rite of Spring*

• Line Drawing
  – 1D (lines)

• Optical
  – 0D (points)
Denotation system

- Silhouette:
  - 2D (regions)

- Line Drawing
  - 1D (lines)
  - Picasso, Portrait of Stravinsky

- Optical
  - 0D (points)
Denotation system

- Silhouette:
  - 2D (regions)
- Line Drawing
  - 1D (lines)
- Optical
  - 0D (points)
  - Picasso, *Paul as Arlequin*
A fourth denotation system

• Sculpture
  – 3D (volume)
    Picasso, *Head of a Woman (Fernande)*, 1909

• Silhouette:
  – 2D (regions)

• Line Drawing
  – 1D (lines)

• Optical
  – 0D (points)
Introduction to denotation systems

- Difference between drawing and paintings
- The multiple role of e.g. lines
- What denotes what in the picture?

Fig. 1.12. Drawing of a Man by a five-year-old boy.
Plan

• Introducing denotation systems
• Line drawing
• A catalogue of primitives
Denotation system

- Scene
- Scene primitive
- Picture primitive
- Marks
Denotation system

• Scene
  – Objects, parts
• Scene primitive
  – Volumes, surfaces, lines and points of the scene.
• Picture primitive
  – Regions, lines and point in the picture
• Marks
  – Physical marks on the canvas
Denotation system

- Scene
- Scene primitive
- Picture primitive
- Marks
- Dimensions
- Extendedness
- Mapping
Stages of vision

• Bottom-up and top-bottom

Cup

Retinal Image → Image-based Processing → Surface-based Processing → Object-based Processing → Category-based Processing
Marks vs. primitive

• The mark is only the physical realization of the primitive
• They can have different dimensionality
Marks vs. primitive

- Mosaic
- Primitives = lines
- Marks = points
  (or small regions)
Marks vs. primitive

- Seurat, La Grande Jatte (detail)
Marks vs. primitive

- Paul Siemsen
- Picasso

When the name Picasso falls upon the eye, a portrait of a legend comes to mind. It’s the legend in the world of art which surrounds a man who possessed and expressed many of the highest ideals of mankind. The popular legend is of the outward attributes: seduction and gregariousness; wealth and love; abundance of works and extraordinary versatility in all facets of his field. It has been estimated that he has created over fifty thousand works of art. Pablo Ruiz Picasso was born into a family of art, so he naturally had a very early beginning in his creation. His life was long, ninety-one years, but when we do the arithmetic we still find that he averaged throughout his creative years almost two pieces of art per day. Considering the physical size and the conceptual scope of many of his works, these numbers bespeak a remarkable feat. How is it that a man could be so productive and inventive that he would become, as one author describes him, “the most prolific artist of all times.” Picasso’s words may reveal the answer: “Painting is stronger than I am; it makes me do what it wants.” Another of the components of the popular legend is that of his departure from tradition. Picasso is known by many as having been instrumental in founding and energizing two new movements in art, cubism and surrealism; and to have inspired other movements including abstract art and pop art. His departure from cubism, which has become perhaps his best known realm, was met with much resistance and controversy, but the general attitude of those who saw this new trend was at best, curious, at worst, to condemn them to condemnation. A very few had any awareness that in Picasso’s painting was giving birth to truly significant modes of seeing and expression. These few, and Picasso himself, might have argued that the seemingly radical forms were logical outgrowths. Or versions of the tradition of painting that had lasted least of the spirit and superior ways of seeing was, in this case, an unconscious reinvention of forms of innocence and openness that had to be looked through the lens of the soul. His own cubist movement became intellectually structured and dogmatic; he set his own rules and kept himself in the main consecutively stream of art itself, which adheres to principles of a more general and intercommunicable nature. Picasso was thus free to explore within the principles of cubism and surrealism the same processions of order and movement that he observed in his own work. He was one of the first to recognize that expression through art is not the application of a canon of beauty, but what the artist renounced, and the brain could construct independently of that canon. When you pose a woman you don’t take instruments to measure her body, you love her with your dreams. His ability to create independently of the numerous canons of beauty that have been set down by Germaine Greco, one of Picasso’s earliest portraits, who said “He alone among the rest of his time, that all the world can see, but the truth which only he can see. This is true for him and he has been a poet of expression truth. Picasso painted his well-known portrait of Germaine Greco, for without something of an inner vision his expression is on the portrait would seem absurd. At any rate, the portraits he made. Show at any time for the portrait and then he wiped off her face and substituted a face with imaginary features. There were criticisms which he dismissed with “Everybody thinks that the portrait is not like her, but never mind, in the end she will look like the portrait.” Such a statement might seem impertinent, but his art and his life were born of desire and in deep concentration. Every work was an impulse, a breathing, a vision in line. his spirit, then also his imagination. He seldom signed his works and no one knew what he would do. He customarily refused to explain them. It is perceived that such acts may have put too definitive boundaries on the pieces, limiting the potential that is in them. A father gives his child his own autonomy, never acknowledging the moment he becomes adult and never saying him this is the kind of person you are. That is the kind of influence you have, because the child may become much more or much less, or may be seen to be much more or much less. For similar reasons, not hesitates to the legions of the legend of Pablo Picasso on the floor, so for fear of severely limiting, or limiting the child. Yet, even as the legend itself is found within the depths of the viewer’s consciousness, so are the words found lying out of a piece of paper.
Marks vs. primitive

Denotation system
Marks vs. primitive

- Giuseppe Arcimboldo
  *Summer*, 1563
Marks vs. primitive

- Victor Ostromoukhov, Artistic halftoning
Marks vs. primitive

- Chuck Close *Stanley* 1980-81
**Denotation**

- Example of a cylinder and a disc
Denotation: optical

- Example of a cylinder and a disc
- Picture point denote scene point
- 0 (dot) => 0 (visible point)
Denotation: optical

- Charles Bell *Chicago* 1980
Denotation: line drawing

- Example of a cylinder and a disc
- Picture line denotes scene line
- 1 (line) => 1 (scene occluding contour and edge)
Denotation: outline drawing

- Example of a cylinder and a disc
- Picture line denotes scene line
- 1 (line) => 1 (scene occluding contour)
- No internal edge
Denotation: silhouette

- Example of a cylinder and a disc
- Picture region denotes scene visible region
- $2_{10}$ (region) $\Rightarrow$ $2_{10}$ (visible region)
- Edge becomes more fuzzy and less salient
Silhouette vs. outline
Silhouette vs. outline
Silhouette vs. outline
Silhouette vs. outline

Denotation system
Silhouette vs. outline
Thanks to science, your hair will look as good as everyone in your chat room thinks it does.
Denotation: volume

• Example of a cylinder and a disc
• Picture region denotes scene volume
• $2_{10}$ (extended region) $=>$ $3_{100}$ (extended volume)
• $2_{11}$ (circular region) $=>$ $3_{110}$ (disc)
Denotation: volume

- Example of a cylinder and a disc
- Picture region denotes scene volume
- 1 (line) $\Rightarrow 3_{100}$ (extended volume)
Denotation: volume

- 1 (line) => $3_{100}$ (extended volume)
Denotation: volume

- $1 \ (\text{line}) \Rightarrow 3_{100} \ (\text{extended volume})$
- Related to the structural skeleton
Denotation: volume

Les devises Shadok

EN ESSAYANT CONTINUELLEMENT ON FINIT PAR RÉUSSIR. DONC:
PLUS ÇA RATE, PLUS ON A DE CHANCES QUE ÇA MARCHE.
3D and 2D attributes

- Show colored or numbered dice to children (6-7)
- The still draw a rectangle
- But different colors 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
**Denotation: volume**

Fig. 4.4. A child’s attempts to draw the mold mark on a ball. (a) The child’s drawing of the ball. (b) An adult drawing, including the mold mark. (c) “I can’t draw it here because it’s not outside the ball.” (d) “I can’t draw it here because it’s not inside the ball.” (e) “And I can’t draw it here because it won’t show up. So I can’t do it.” From Willats (1985), courtesy of Cambridge University Press.
Denotation analysis

Denotation system
Denotation analysis

3

- $3_{111}$ volumes (head)
- $3_{110}$ volumes (shields)
- $3_{100}$ volumes (arms, legs, clubs)

2

- $2_{11}$ regions
- $2_{10}$ regions
Denotation: special case

- Alexander Calder, *Cow*, 1926
Lineal/pictorial

- Heinrich Wölfflin, 1916
- Renaissance vs. Baroque
- The line and drawing vs. the brush stroke
Lineal/pictorial

- E.g. Michelangelo vs. Rembrandt
Plan

- Introducing denotation systems
- Line drawing
- A catalogue of primitives
Line drawing polyhedral objects

- [Clowes 71, Huffman 71, Waltz 75]
- Computer vision
- Analyze line drawing
- Label regions, analyze occlusions
- Classify edges and vertices of the line drawing
Labeling edges

• Convex +

• Concave -

• Occluding -> (object on the right)
Labeling corners
Labeling corners

Fig. 5.3. Complete listing of possible pictures of corners in drawings of rectangular objects. From Huffman (1971), courtesy of Edinburgh University Press.
Labeling junctions

- The arrow is always in the same direction (because of occlusion)
Labeling
Ambiguous/impossible

Fig. 5.6. Labelings for (a) unambiguous, (b) ambiguous, and (c) impossible drawings of rectangular objects. The “impossible” labeling is marked with an asterisk.
Ambiguous/impossible
Ambiguous/impossible

Denotation system
Extension to shadowed scenes

- Waltz 1975
Line drawing of smooth objects
Line drawing of smooth objects

- Only one kind of edge
  - occluding contour
- Two types of vertices
  - T-junction
    (a.k.a. T-vertex)
  - End-junction
    (a.k.a. cusp)
Line drawing of a torus
Line drawing of a torus

cusp

t-vertex

fold
Line drawing of a torus

cusp
t-vertex
fold
Drawing of smooth objects

- Walt Disney sketch for Mickey's Parrot 1938
Drawing of imaginary smooth object

- Paul Klee
- “As the figure grows little by little before our eyes an association of ideas may easily tempt us into objective interpretation. For with a bit of imagination every complex structure lends itself to a comparison with familiar forms in nature”
Fig. 5.8. Labelings for (a) unambiguous, (b) ambiguous, and (c) impossible drawings of smooth objects. The “impossible” labeling is marked with an asterisk.
Ambiguous/impossible

- Klee
  Little Baroque Basket 1939
Ambiguous/impossible

- Pratt Institute
  Gresh Mc Ginn
Ambiguous/impossible

- Pratt Institute
- Gresh Mc Ginn
Just for fun

- Theory of singularity
- Evolution of the drawing when the viewpoint moves
- Structure changes at visual events
Convex/concave/saddle

- **Convex**: positive curvature
  - Egg

- **Concave**: negative curvature
  - Interior of cup

- **Saddle**: mix of positive and negative curvature
  - Saddle (surprising, isn’t it?)
Convex/concave/saddle

- **Convex**: positive curvature
  - Egg
  - Convex contour
- **Concave**: negative curvature
  - Interior of cup
  - Hidden contour
- **Saddle**: mix of positive and negative curvature
  - Saddle (surprising, isn’t it?)
  - Concave contour
Drawing of smooth objects

- Klee, *Naked on the Bed*, 1939
Drawing of smooth objects

• Klee, *Naked on the Bed*, 1939
Drawing of smooth objects

- Picasso, *Portrait of Stravinsky*
Drawing of smooth objects

- Katsuka Shunsho, Japanese, 1782
A second look

- Cup
- Table
Plan

• Introducing denotation systems
• Line drawing
• A catalogue of primitives
Picture primitive

- Points
- Lines
- Regions
Scene primitive

- View independent vs. view dependent

- 3D
- 2D
- 1D
- 0D
3D and 2D scene primitives

- 3D
  - Volume
  - Extendedness (sphere, disc, lump)
- 2D
  - Surface
1D scene primitives

• View independent
  – Very thin objects (string, etc.)
  – Edge
  – Reflectance edge
  – Shadow edge
  – Transparency edge
  – Surface contours

• View dependent
  – Occluding contour
  – Silhouette
1D scene primitives

- View independent
  - Very thin objects (string, etc.)
  - Edge
  - Reflectance edge
  - Shadow edge
  - Transparency edge
  - Surface contours

- View dependent
  - Occluding contour
  - Silhouette
1D scene primitives

• View independent
  – Very thin objects (string, etc.)
  – Edge
  – Reflectance edge
  – Shadow edge
  – Transparency edge
  – Surface contours

• View dependent
  – Occluding contour
  – Silhouette
1D scene primitives

- View independent
  - Very thin objects (string, etc.)
  - Edge
  - Reflectance edge
  - Shadow edge
  - Transparency edge
  - Surface contours

- View dependent
  - Occluding contour
  - Silhouette
1D scene primitives

- View independent
  - Very thin objects (string, etc.)
  - Edge
  - Reflectance edge
  - Shadow edge
  - Transparency edge
  - Surface contours

- View dependent
  - Occluding contour
  - Silhouette
1D scene primitives

• View independent
  – Very thin objects (string, etc.)
  – Edge
  – Reflectance edge
  – Shadow edge
  – Transparency edge
  – Surface contours

• View dependent
  – Occluding contour
  – Silhouette
Transparency

• Lissitzky
**1D scene primitives**

- **View independent**
  - Very thin objects (string, etc.)
  - Edge
  - Reflectance edge
  - Shadow edge
  - Transparency edge
  - Surface contours
- **View dependent**
  - Occluding contour
  - Silhouette
Surface contours
Surface contours
Surface contours
1D scene primitives

• View independent
  – Very thin objects (string, etc.)
  – Edge
  – Reflectance edge
  – Shadow edge
  – Transparency edge
  – Surface contours

• View dependent
  – Occluding contour
  – Silhouette
Edge detection
Edge detection

• Contour film
Edge detection

- Matisse, *Loulou*
Edge detection

- Matisse, *Loulou*
0D scene primitives

- Generic visible point
- View independent
  - Corner
  - X-junction for shadow
- View dependent
  - T-junction
  - Cusp
  - X-junction for transparency
A complex example
A complex example

• Tom Purvis 1935

EAST COAST by LNER
A complex example

- E Mc Knight Kauffer 1947

The enemy wants to know what you know...

Keep it under your STETSON
A complex example

- Ingres
A complex example

- Klee, *Oh But Oh!*, 1937
A complex example

- Klee, *Oh But Oh!*, 1937
Backlighting

• Line drawing...
Complex system

- Henry Wolf
  
  *Nude*
Drawing

- Dürer, *Head of a Man*
Drawing

- Raphael
Drawing

• Georges Seurat *Sous la Lampe* 1882-83
Simplification

- Picasso *The Bull* 1945