Perceptual and Artistic Principles for Effective Computer Depiction

Computational Vision and Picture

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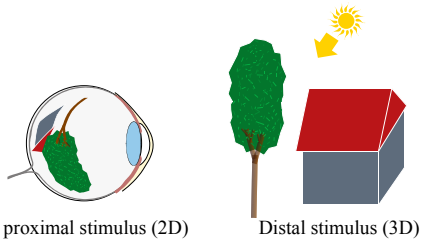
Plan

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

Distal vs. proximal stimulus

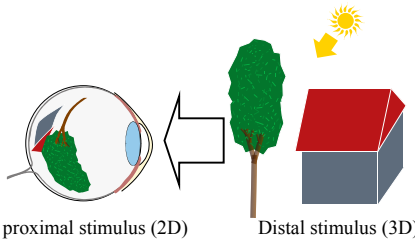
- Distal stimulus: reality
- Proximal stimulus: retinal image



proximal stimulus (2D) Distal stimulus (3D)

Vision as an inverse problem

- The distal stimulus is projected into a proximal stimulus



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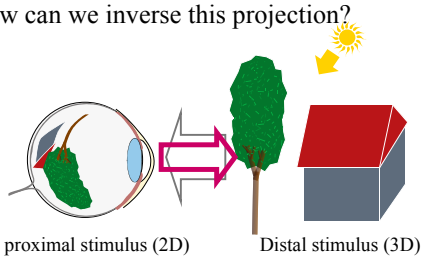
Vision as an inverse problem

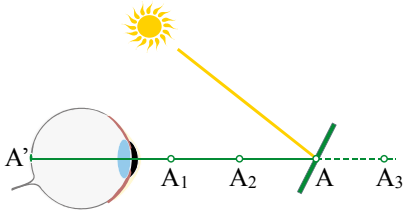
- The distal stimulus is projected into a proximal stimulus
- How can we inverse this projection?



proximal stimulus (2D) Distal stimulus (3D)

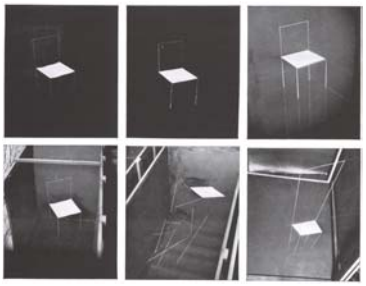
Unconscious inference (Helmholtz)

- 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…)



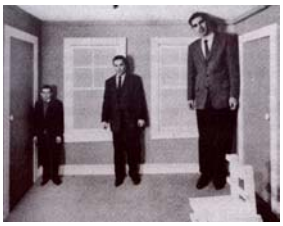
How assumptions help

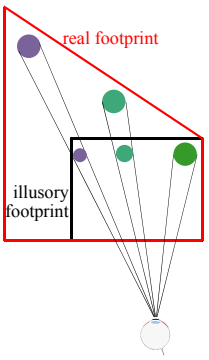
- Ames chair
  - 3 different scenes
  - Same projection
  - We assume it is a chair
  - Resolves ambiguity
  - Can be wrong



The Ames room

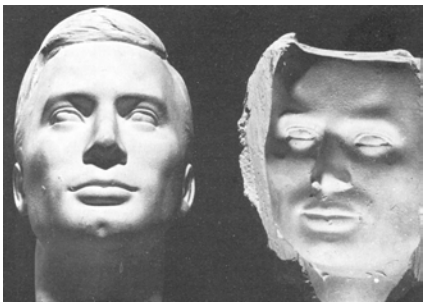
- Invalid assumption
  - Walls perpendicular
- Wrong conclusions
  - Men have different sizes





Positive and hollow face

- Both seen convex because hollow faces are rare!

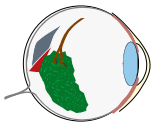


Constancy & architecture

- 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



proximal stimulus (2D)

Distal stimulus (3D)

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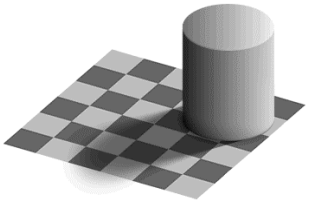
Brightness vs. lightness

- Brightness: subjective amount of light
- Lightness: how "white"



The white cells in shadow are as dark as the black illuminated cells

Illusion by Ted Adelson

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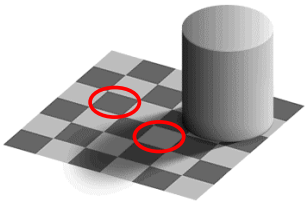

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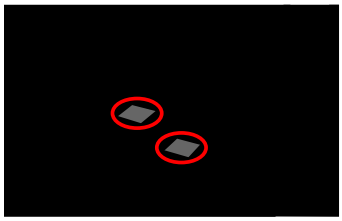

The white cells in shadow are as dark as the black illuminated cells

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Pictures and the inverse problem

- Pictures can
  - Simplify the analysis
  - Be a puzzle, a riddle

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Plan

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- Computational theory of vision
- Complex mapping

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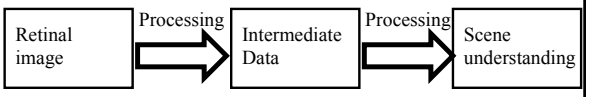
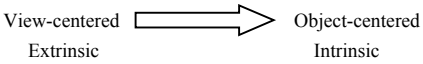
Vision as information processing

- 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

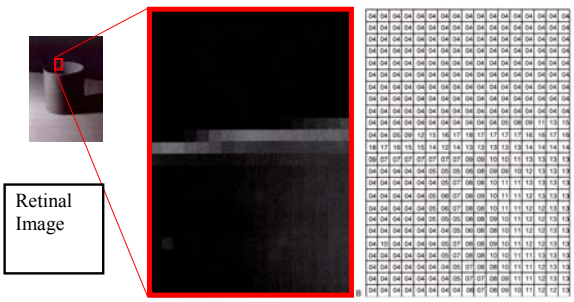
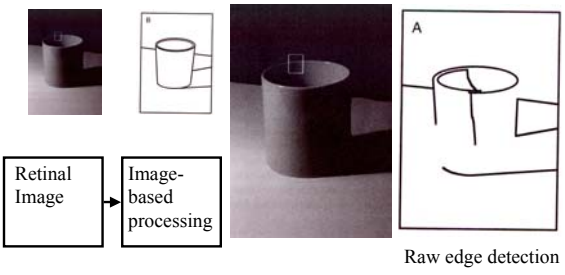


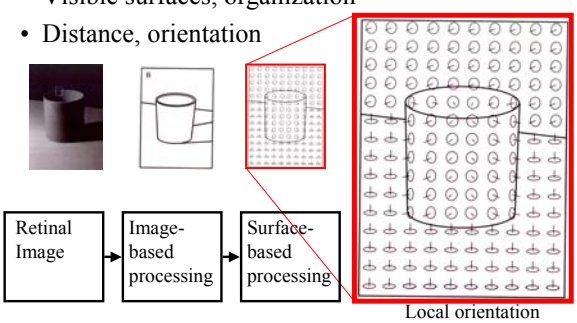
Image-based (primary sketch)

- Contrast, edge detection
- Not so easy



Surface-based

- Visible surfaces, organization
- Distance, orientation



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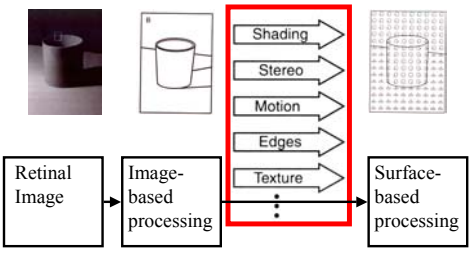
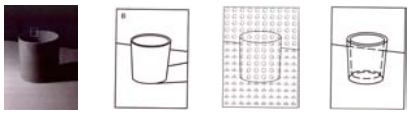
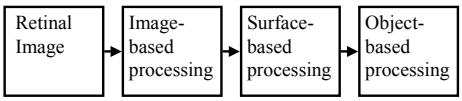


Object-based

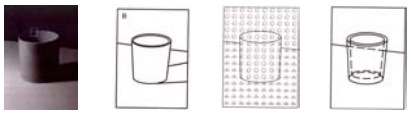
- 3D properties, structure
- Nature of the description highly discussed



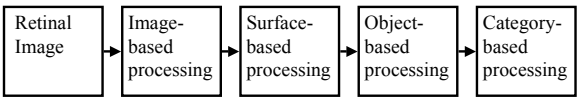


Category-based

- Recognition, category, function

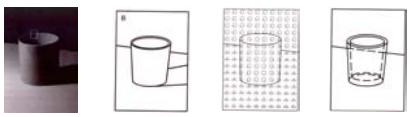


Cup



Feedback

- Bottom-up and top-bottom



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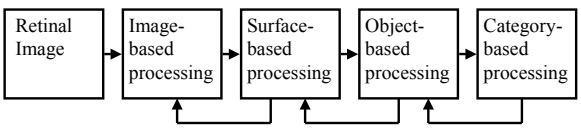
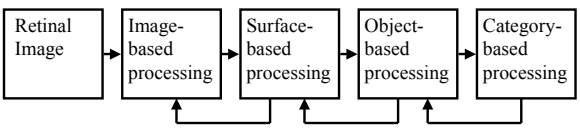


Scope of the theory

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



Relation to children drawing

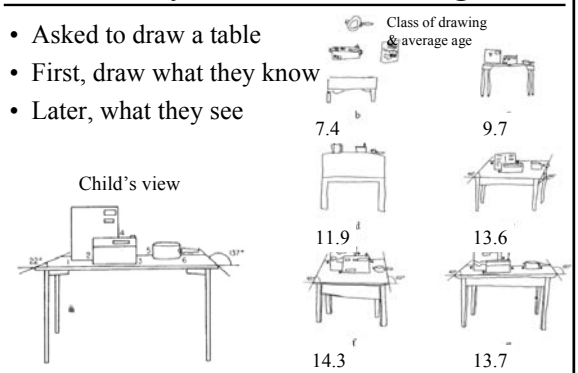
- First children draw what they know
  - Object-centered
- Then, what they see
  - View-centered

Age 5

Age 9 (gifted!)

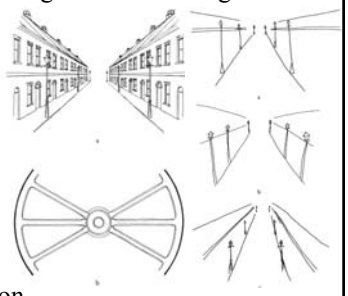
Evolution of children's drawings

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



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

Original Picasso drawing | Reproduction | Reproduction upside-down

Relation to pictures

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

View-centered Extrinsic → Object-centered Intrinsic

Relation to pictures

- Chinese painting refuse extrinsic, only essential
- No shadow

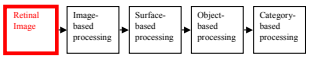
View-centered Extrinsic → Object-centered Intrinsic

Retinal image

- Turner
- "My business is to paint not what I know, but what I see"

Retinal image

- Impressionism



Retinal image

- Impressionism
- Photography

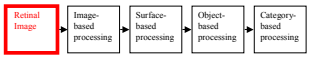
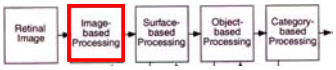


Image-based

- Line Drawing
- Rivera



Intrinsic vs. Extrinsic

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

Intrinsic vs. Extrinsic

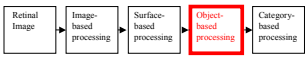
- Visual angle vs. true size
- Vermeer:
  too accurate to be true!

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"



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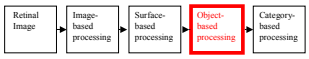

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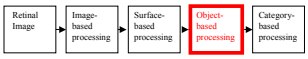
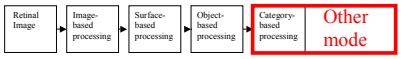


Expressionism

- "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

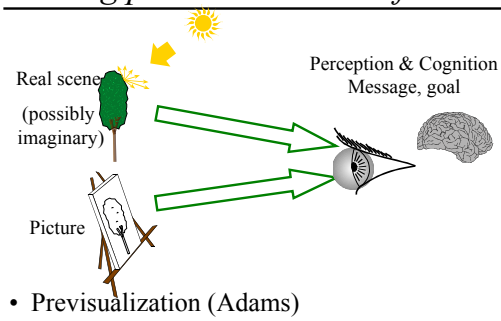
Relation with 2D/3D qualities

- 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

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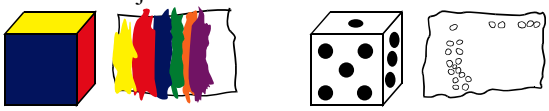
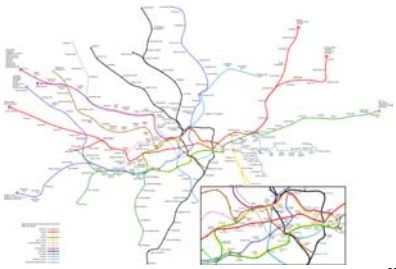
3D and 2D attributes

- [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

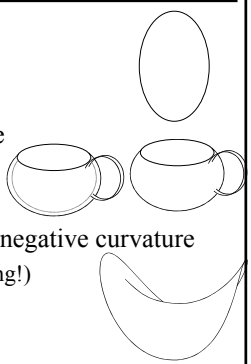


Projection: Topological

- 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



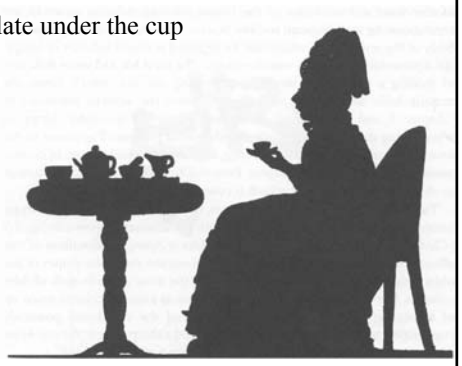
Mapping of curvature

- 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

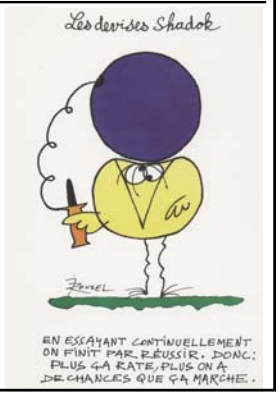
Mapping of curvature

- Small plate under the cup



Mapping of curvature

- Complex denotation
- See [Durand, page 15]



Further reading

Further reading

- Calvin & Hobbes by Watterson !