Multiple Perspectives in Computer Graphics: Arguments from Perceptual Grouping and Renaissance Art

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Abstract

In realistic art, multiple perspectives in one image is common and not an exceptional deviation related to specific human perceptions. Perception research shows that perceptual grouping in depth occurs late in vision processing while grouping in the frontal plane occurs early. Therefore, organization is seen in the image plane as well as in depth. Renaissance artists mastered linear perspective in order to depict depth realistically, and also emphasized image plane composition. To do so, they used a collage of carefully rendered object-by-object perspectives, the non-unity of which is imperceptible to viewers. Considering the need for flexible use of perspective, a panel architecture supporting multiple perspectives is presented. To know the limits of tolerable perspective inconsistencies, some experiments are being conducted.

Perceptual Grouping

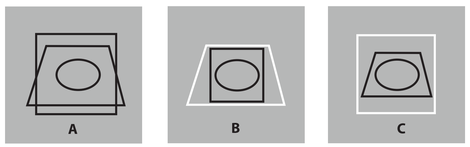
'Perceptual grouping refers to the processes by which the various elements in an image are perceived as "going together" in the same perceptual unit.'

When does perceptual grouping occur in visual processing?

- early (Gestalt, 1930s)
- late (Rock, 1970s)
- early & late (Palmer, 2000s).

The figure below shows that frontal plane grouping occurs before depth perception based on pictorial cues.

Viewers of paintings see organization in the image plane and in depth.



Grouping by proximity, shape and colour affects shape constancy.
(A) Ellipse or circle (B) Ellipse (C) Circle.

Renaissance Art

Renaissance art contains both:

- linear perspective for realism in depth, and
- picture plane geometry for symbolism.

The pluralist approach has many perspectives in a single image, which is a 'collage of different constructions'.

- Renaissance realism was 'object oriented'.
- Photography and computer graphics, are 'space oriented'.

Renaissance artists intuitively treated perceptual grouping as a process occurring both on the image plane and in the depth-interpreted image.

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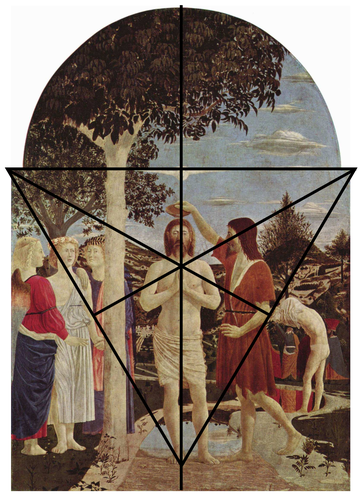
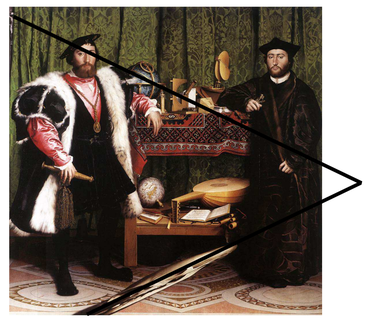
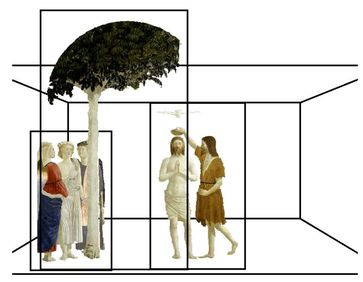


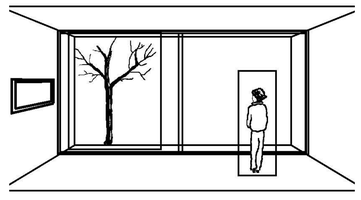


Along with carefully rendered object-by-object perspectives, both paintings contain well-defined image plane composition.

- Left, Baptism of Christ of Piero della Francesca. Main compositional element is an equilateral triangle, symbolizing the Trinity.
- Right, The Ambassadors of Holbein. Anamorphic skull in the foreground indicates a view position from which the illustrated picture plane relationships tell the story of Good Friday.

Proposed Panel Architecture





Three architectural units.

- Panel: containing a bitmap or a picture.
- Scene: perspective box (structured volume) and the panels it contains.
- Picture: 2D projection of a 3D scene.

Comments:

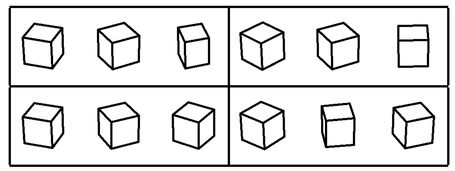
- Panels are rotated, scaled and translated to compose the scene.
- Panels are nested recursively.
- Multiple perspectives, one per picture, are not necessarily consistent.

Preliminary Experiment

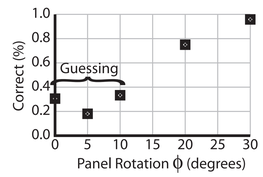
The panel architecture requires investigation of the viewer tolerance for panel rotation. To begin we consider an object with strong perspective lines, to determine by how much its image can be rotated while remaining a satisfactory depiction of the object.

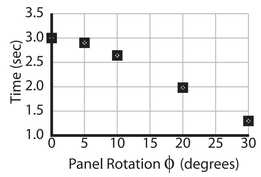
Experiment setup

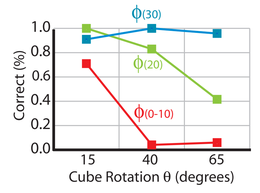
- Problem: how much panel rotation is imperceptible in images of cubes?
- Stimuli: 3 cubes.
  - 2 rotated and projected using linear perspective with $\theta \in (15°, 40°, 65°)$.
  - 1 partially rotated by $\theta' = \theta - \phi$, projected to a panel, which is further rotated by $\phi \in (0°, 5°, 10°, 20°, 30°)$.

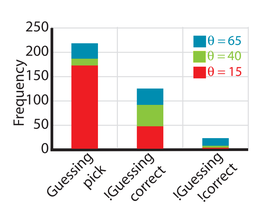


- Goal: find the anomalous cube, or guess.
- 360 trials:
  4 subjects × 5 panel rotations × 3 panel positions × 6 position ordering.









Results

- Small panel rotations ($\phi = 5°, 10°$) indistinguishable from no rotation ($\phi = 0°$, exact projection).
- Faster responses with better performance: no speed-accuracy trade-off.
- Performance depends on cube rotation, θ.
- Exactly projected, $\theta = 15°$cube is likely to be seen as anomalous.

Conclusions

- Small perspective inconsistencies are imperceptible.
- Close to degenerate viewpoints make objects look anomalous.