Vizilu:
A Visual Illusion Picture Frame

Prof. George Wolberg
Dept. of Computer Science
City College of New York

Background

- Picture frames have been used for centuries as protective and decorative edging for visual art.
  - The earliest frame was found in an Egyptian tomb dating back to CE 50-70
  - The decorative role of frames became prominent in the 12th century with the rise of hand-carved wooden frames to adorn church décor
  - Although styles have changed, the frame remains a vessel in which to showcase art/photos.

Goal

- Reimagine the picture frame as a platform in which to enhance photos by imbuing them with an illusion of motion.
  - Reach beyond the traditional use of frames as vessels to display 2D photos
  - Extend frames into serving as portals for 3D interaction
  - No 3D glasses necessary to experience the illusion of motion.
  - Experience your photos as kinetic art

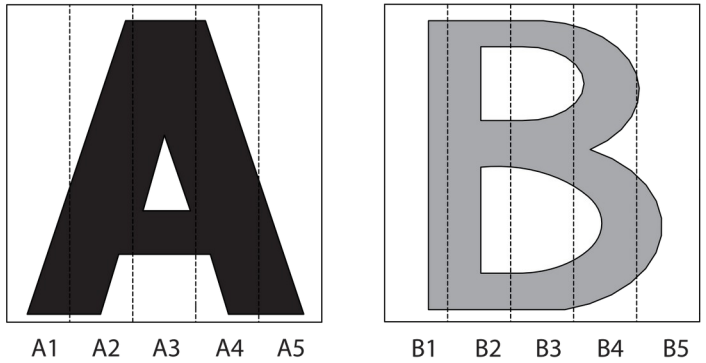
Proposed Work

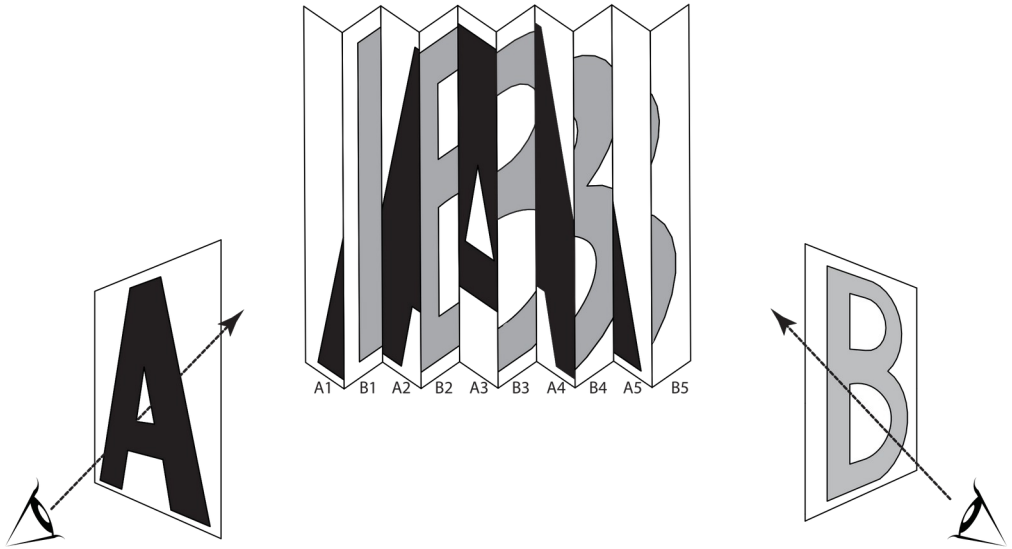
- The proposed work places photos into a scene that appears to move in response to the viewer’s position.
- This establishes an interactive viewing experience that facilitates deeper engagement as the viewer explores the scene across varying distances and angles.
- The presence of motion in art can be traced to the root of the kinetic art movement in the 1920s.
- In this work, we let the art remain static and require the viewer to move to imbue the art with a stunning and vivid illusion of motion.

Previous Work: Agamograph

- A simple variation of kinetic art that follows this approach was introduced in the 1950's by Israeli artist, Yaacov Agam.
- He popularized the Agamograph, a lenticular artform in which paintings/pictures are applied on a pleated surface.
- It affords the viewer two different images depending on the viewing direction in relation to the art.
- As the viewer moves laterally, their view changes from one image to a second image.
- Popular for use in roadside billboards.

Agamograph Concept





Previous Work: Reverspective

- Introduced in the 1960’s by British artist, Patrick Hughes.

Reverspective Concept

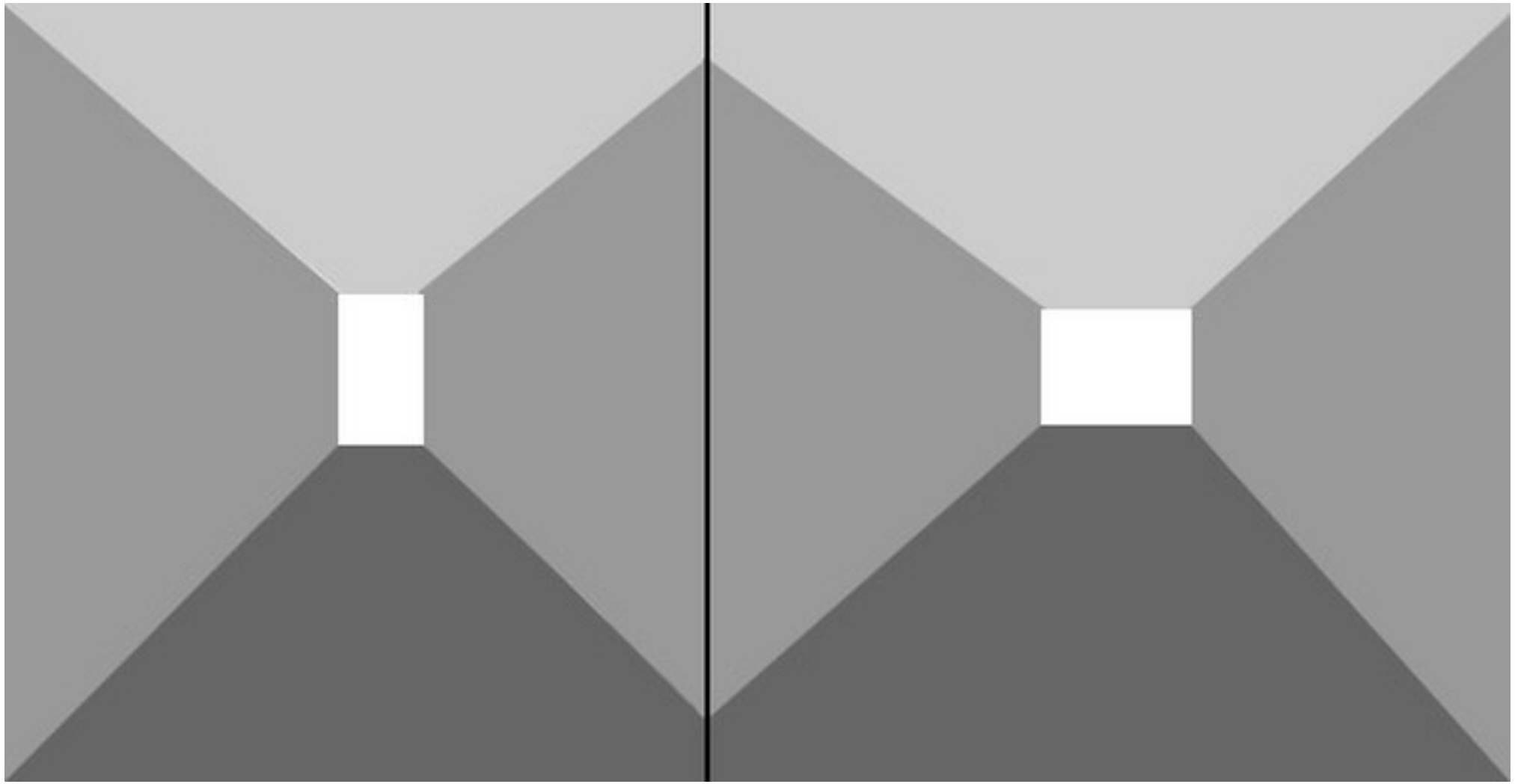
- An illusion of motion is achieved by presenting the viewer with contradictory sensory cues.
- On flat artwork, vanishing points are embedded deep into the scene, well in *front* of the viewer, where distant objects appear smaller.
- In reverspective, the artwork surface is not flat.
- This enables its 3D geometry and rendered artwork to be transformed such that the vanishing points are moved *behind* the viewer.

Reverspective Surface

- The surface protrudes towards the viewer.
- Nearby surface areas are made to appear as if they are further away.
- This technique contradicts the established norms of linear perspective.
- It tricks the brain to form an alternate understanding of the scene, which we perceive to be the illusion of motion.

Reverspective Example

Reverspective Example



Reverspective Example

Reverspective Properties

- Reverspective is elevated into the domain of kinetic art, which depends on motion for its effect.
- Although motors typically drive kinetic art, the apparent motion of this artwork is attributed solely to the movement of the viewer around the stationary imagery affixed to the 3D surface.
- The surface consists of tilted planar facets draped in imagery that conforms to reverse perspective geometry.
- Historically, the graphics that spans the surface of reverse perspective art has been limited to hand-painted or printed artwork that presented no opportunity for the consumer to alter.

Reverse Perspective in Byzantine Art

The throne and footstool show reverse perspective, with lines converging towards the viewer.

Vizilu

- Vizilu introduces a customizable variant to this fascinating artform.
- We apply background imagery that blends seamlessly with user-supplied photographs.
- This hybrid is possible by utilizing background themes such as photo galleries that include regions in which user photos can be inserted to offer a satisfying level of customization.
- Vizilu introduces an opportunity to leverage photos as the centerpiece of a mesmerizing visual illusion in an artform that has resisted customization.

Multi-Faceted Vizilu Frame

Illusion of Motion

- The illusion of motion in the Vizilu frame is achieved by:
  - applying a reverse perspective transformation to user photos
  - installing those warped images onto a multi-faceted 3D surface
  - the surface juts out toward the viewer with vanishing points behind the viewer
- A spectacular illusion of vivid motion appears as the viewer moves from side to side in front of the framed imagery.
- Spectators now become active participants in an engaging visual dance that matches their movements with novel viewpoints into the scene.

Linear Perspective Background

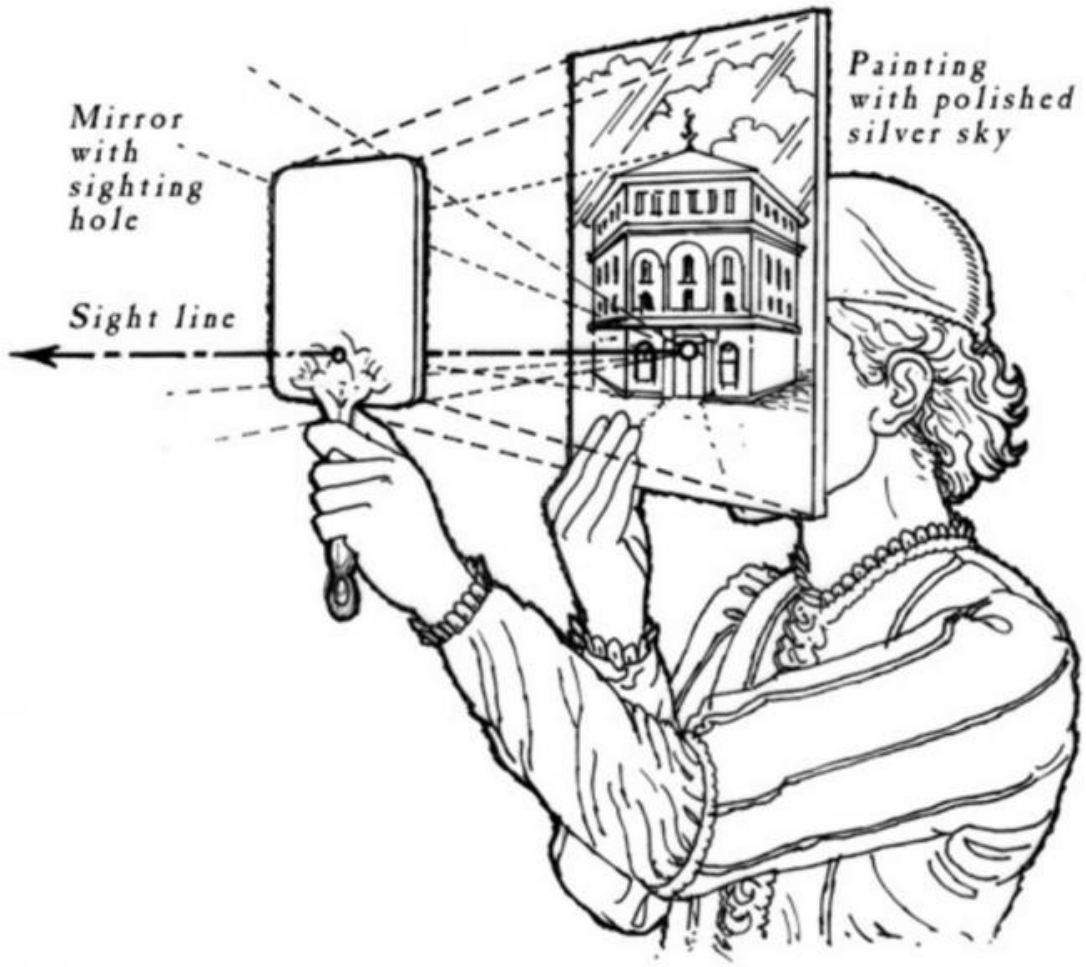
- Visual realism in art was greatly advanced by the advent of linear perspective, which is a system of creating an illusion of depth of 3D scenes on a flat 2D surface.
- It was devised by the Italian Renaissance architect Filippo Bruneleschi (1377-1446) in around 1415
- Facilitates the well-known observations:
  - distant objects appear foreshortened
  - parallel lines and planes converge to infinitely distant vanishing points as they recede in space from the viewer.

The Duomo Cathedral of Florence

More than 500 years after it was built, **Filippo Brunelleschi's** dome of the Duomo (aka Santa Maria del Fiore) in Florence, Italy, remains the largest masonry dome ever built.

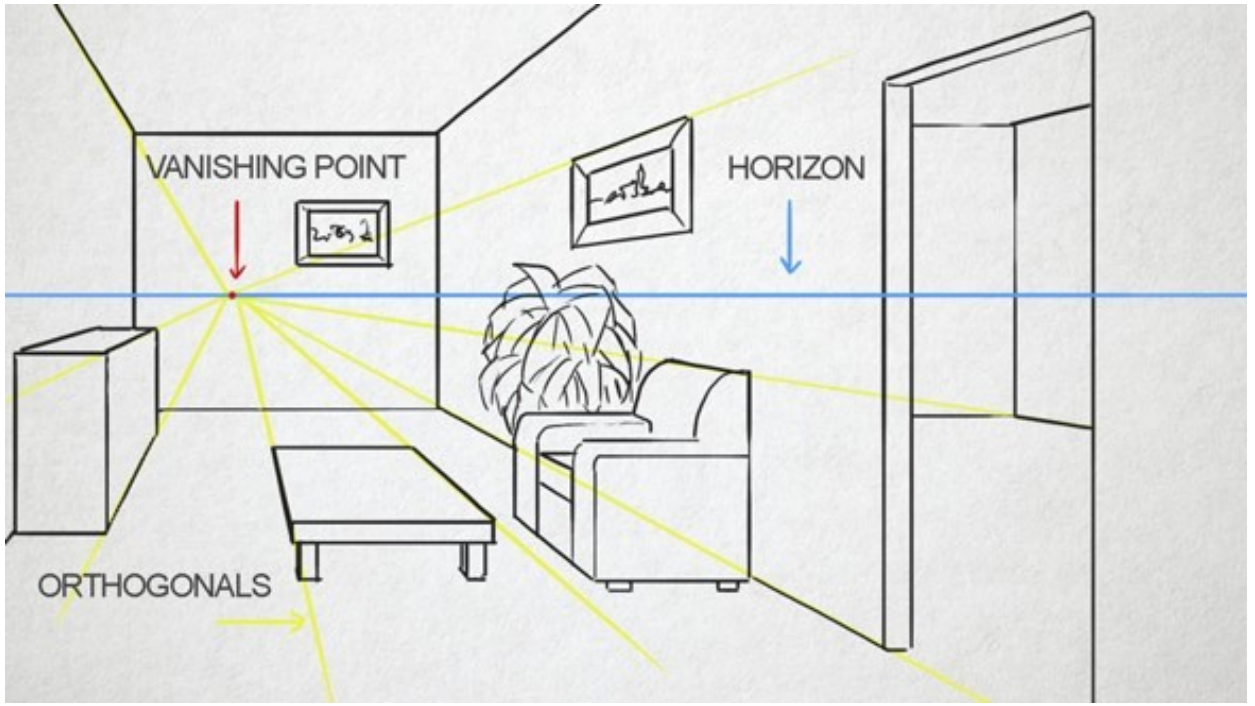
Brunelleschi Experiment

Florence Baptistry

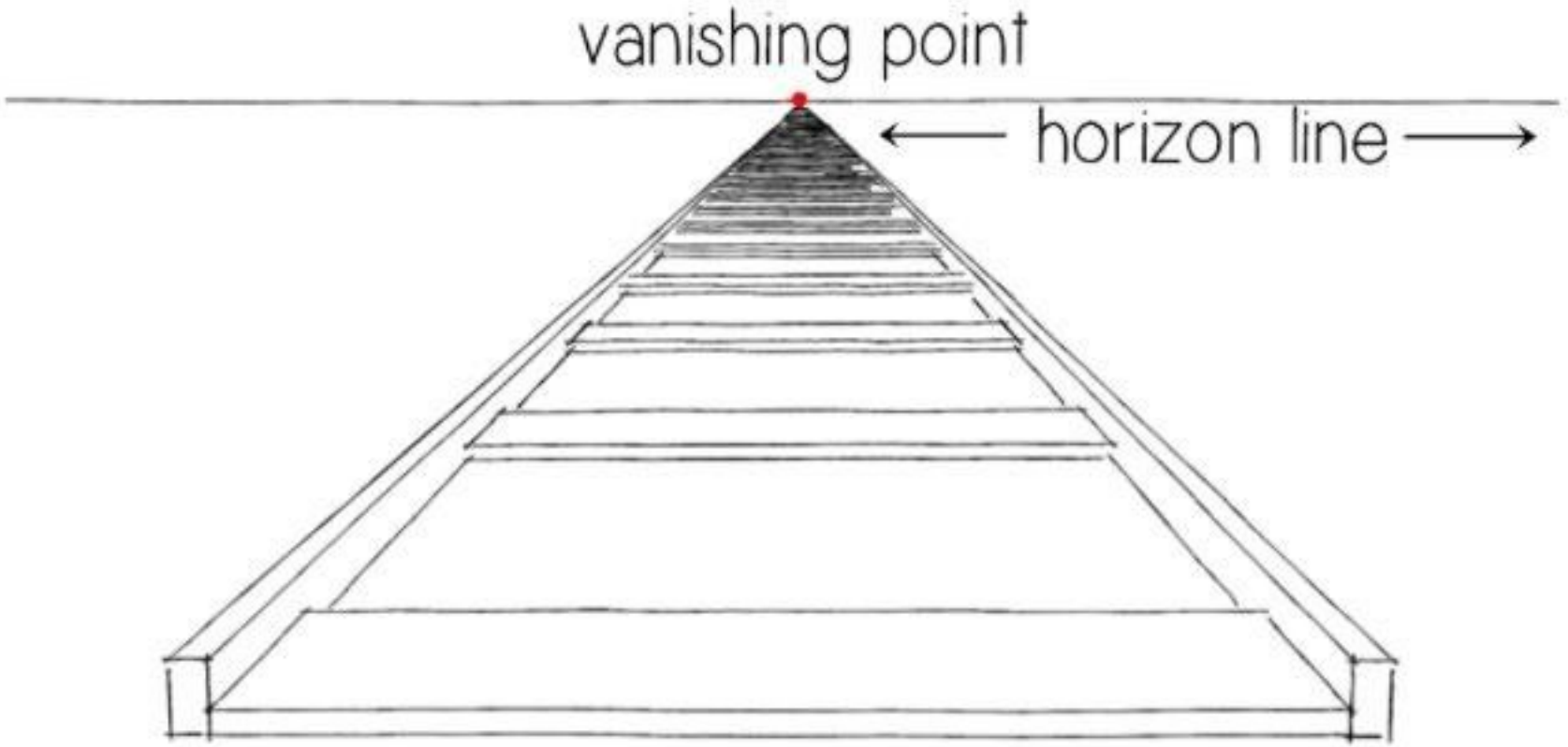


Linear Perspective Components

- Linear perspective uses three essential components:
  - Orthogonals (parallel lines that recede in the distance)
  - Horizon line
  - Vanishing point along the horizon line

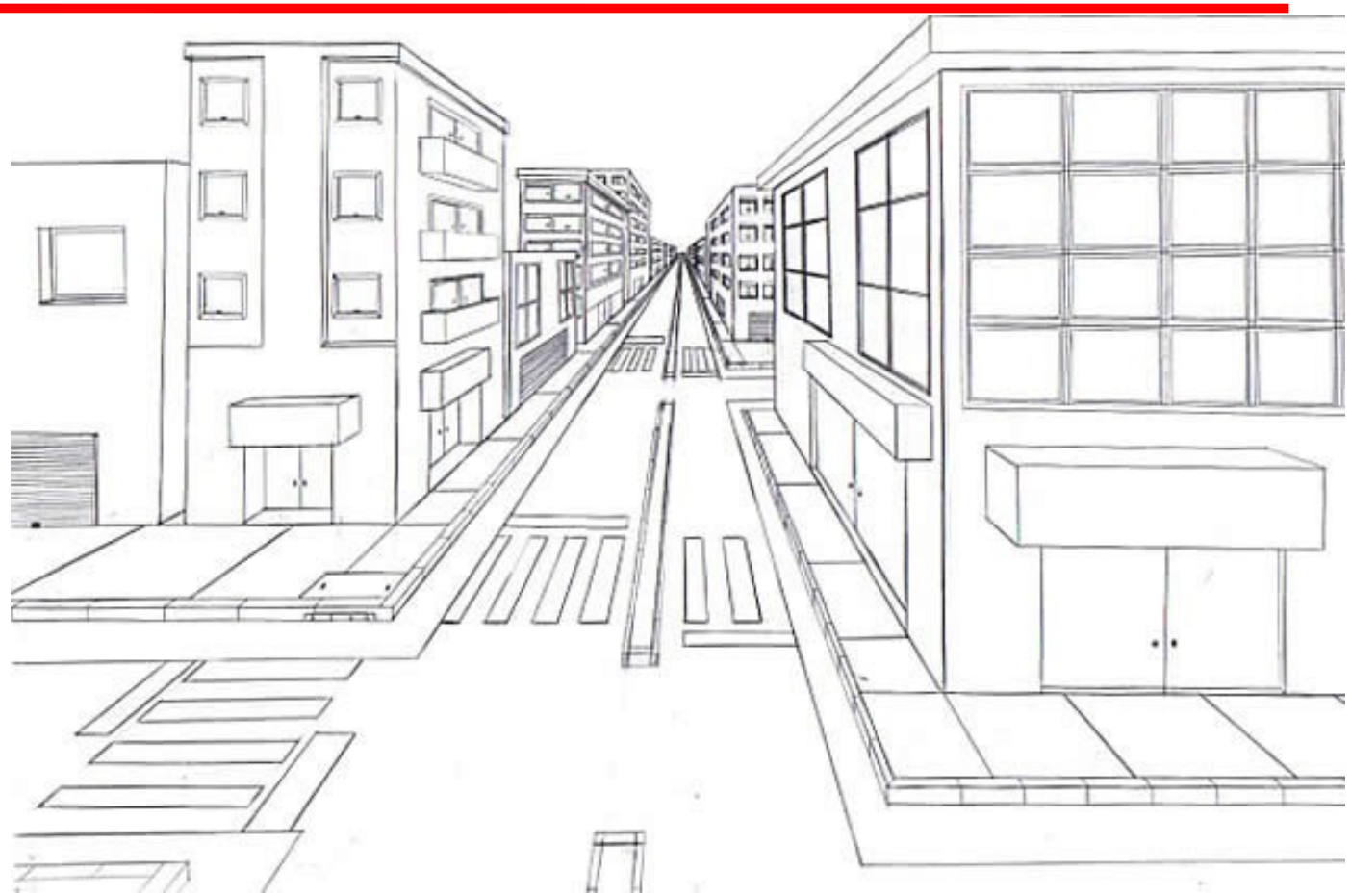


One-Point Perspective (1)



A vanishing point is where any set of parallel lines appears to meet on the horizon line.

One-Point Perspective (2)

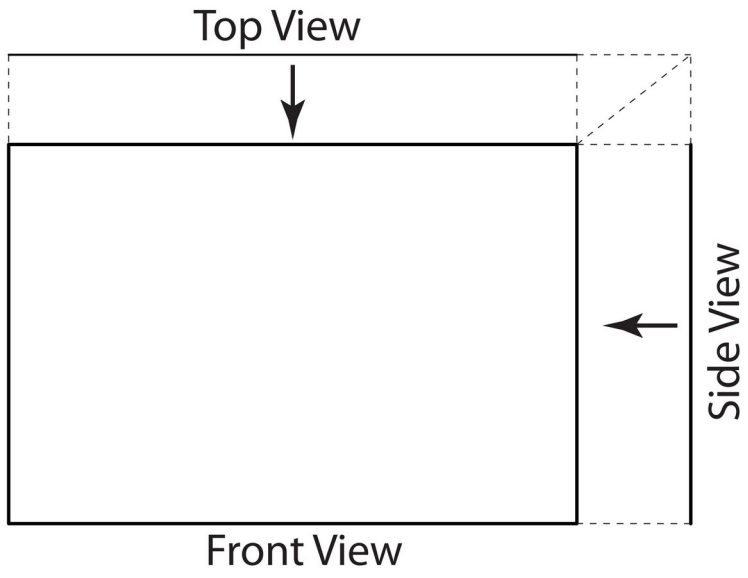


Vanishing points are embedded deep within the scene.

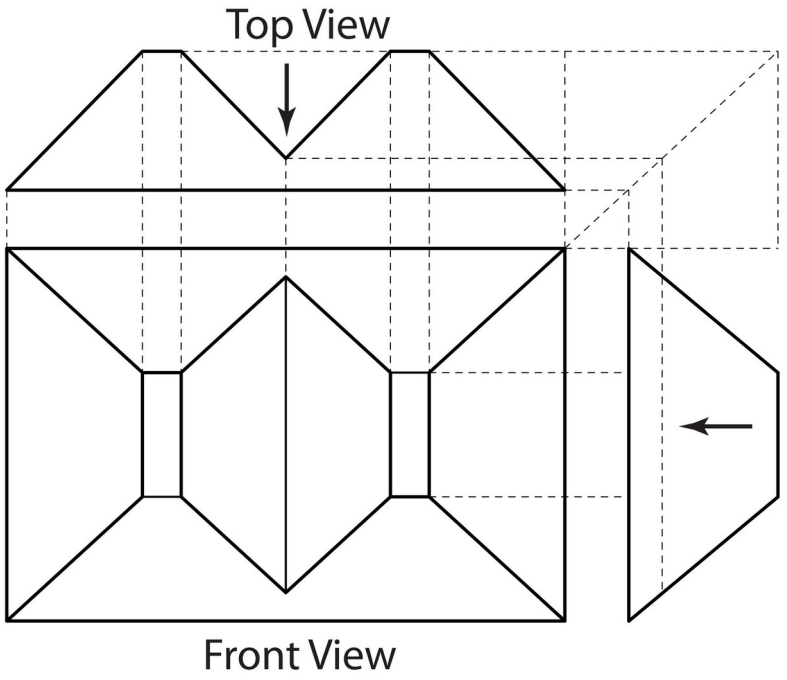
Linear Perspective Uses

- Most prevalent use is on flat surface: known as *flat perspective*
  - Conventional approach devised by Brunelleschi
  - Vivid depth created from depth cues such as perspective foreshortening and convergence of parallel lines towards one or more vanishing points
- Another use has been applied for theatre staging: *forced perspective*
  - Paint directly on a 3D surface whose depth is congruent with painting
  - Near/distant points on painting lie on near/distant points on surface
- Novel use introduced by Patrick Hughes: *reverse perspective*
  - Reversed depths suggested by the painting
  - Near/distant points on painting lie on distant/near points on surface

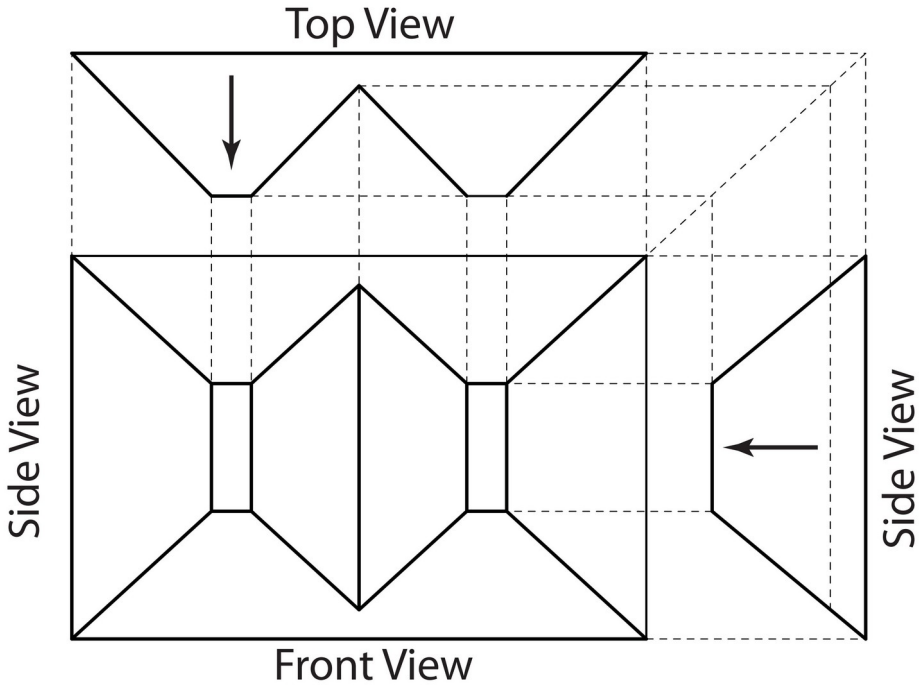
Schematic Representation



Flat perspective

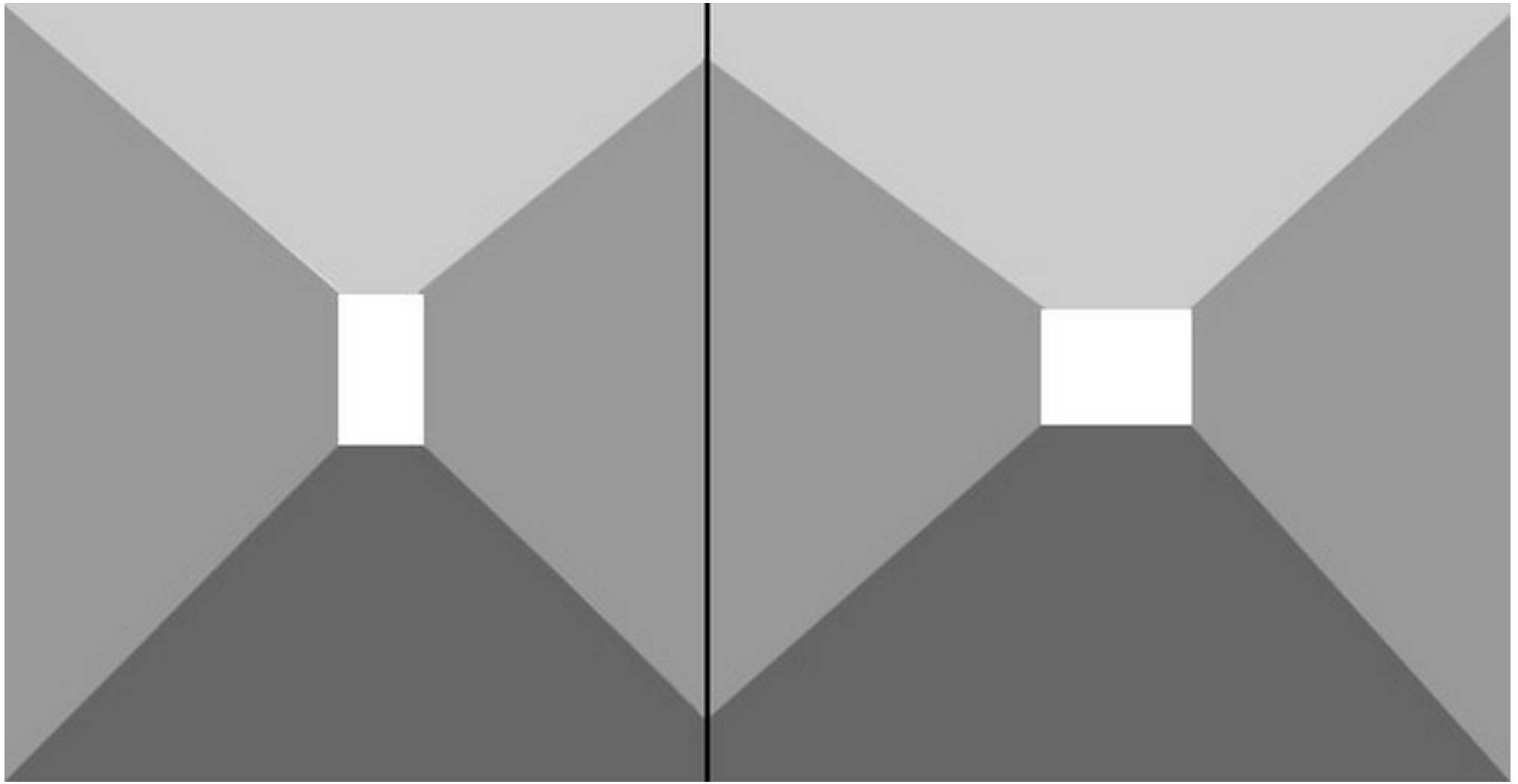


Forced perspective



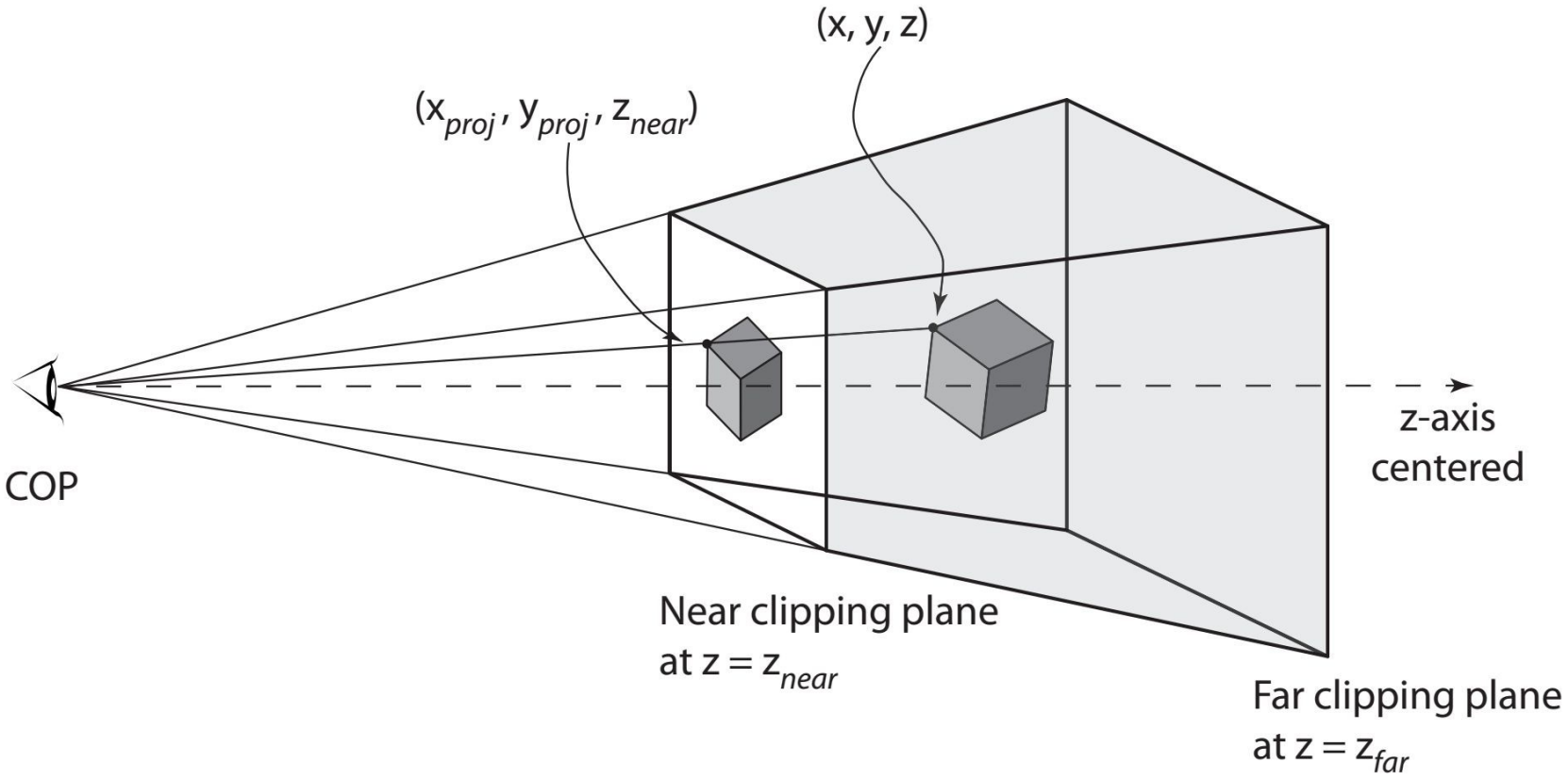
Reverse perspective

Reverse Perspective Surface

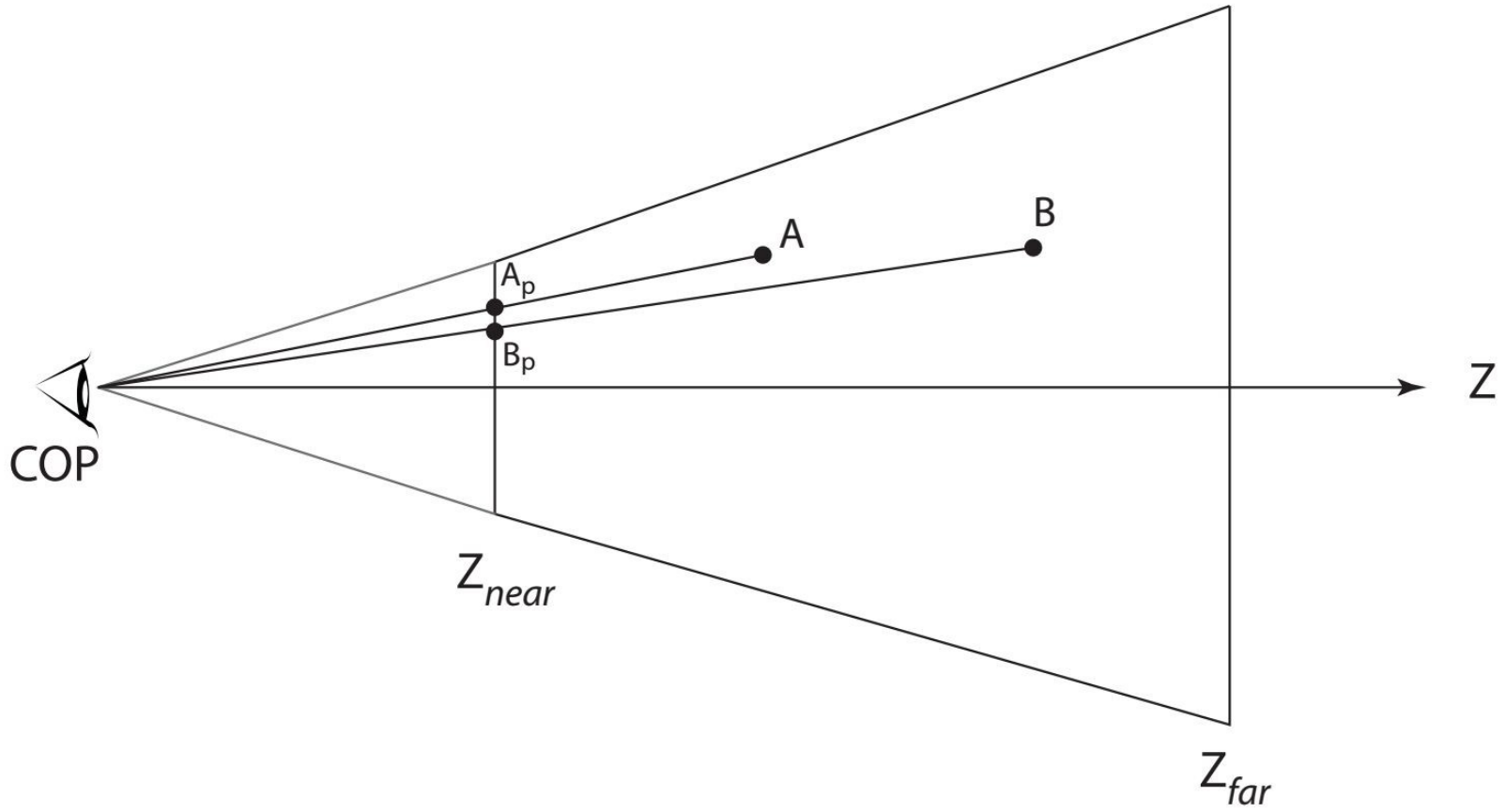


Reverse Perspective Painting

Perspective View Volume



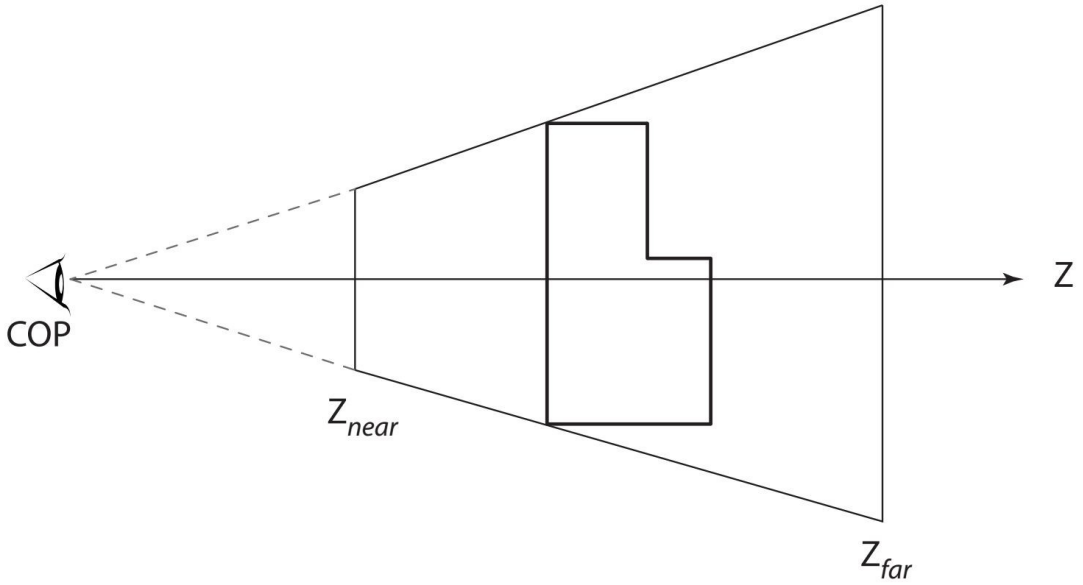
Perspective Foreshortening



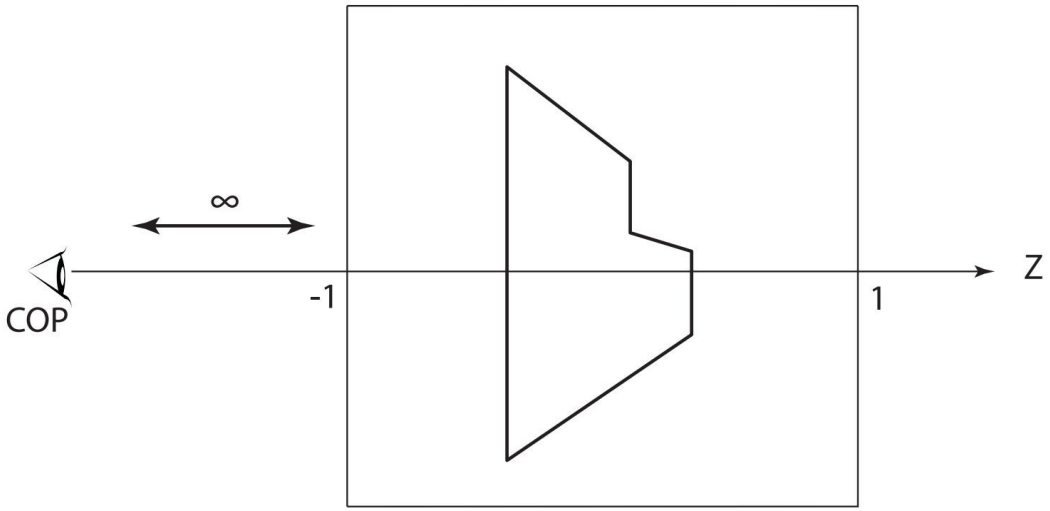
Distant points appear foreshortened as they project to the view plane at Znear

Canonical View Volume Transformation

Frustum is transformed into canonical view volume (cube) to simplify clipping against the frustum

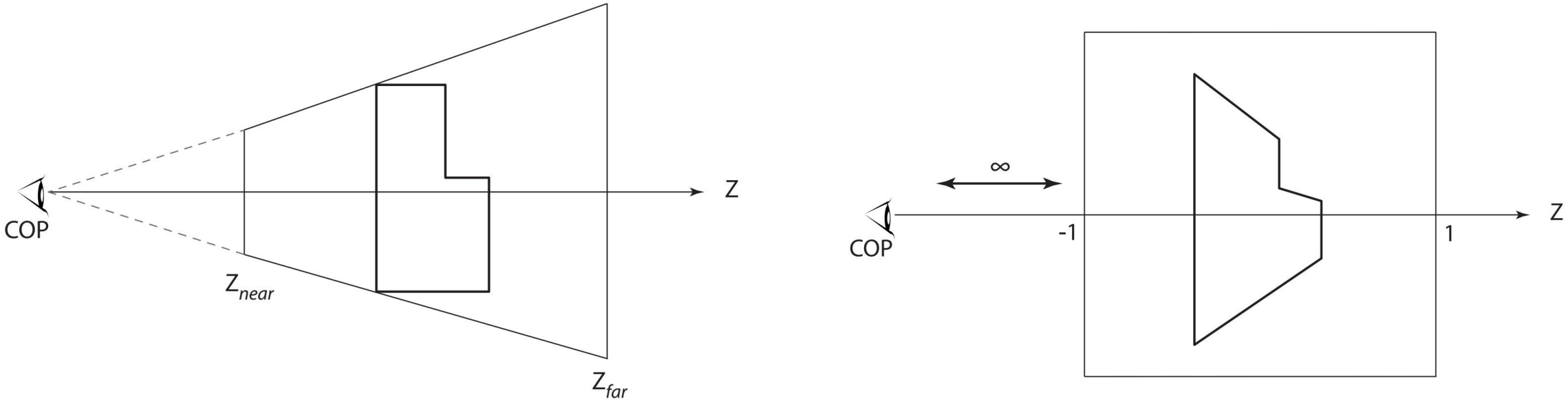


An object embedded in a view frustum



Object warped after transformation of frustum into the canonical view volume (cube).

Canonical View Volume Transformation

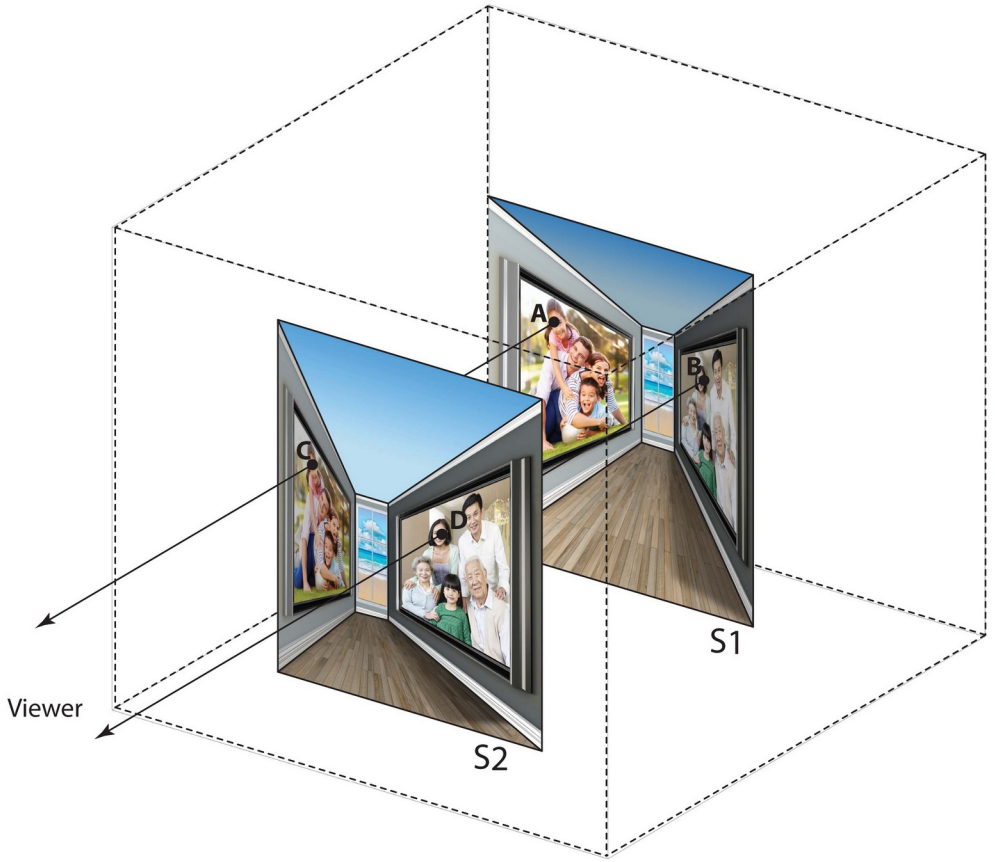


This also replaces perspective projection with orthographic projection, whereby the *x* and *y* coordinates remain the same, while the *z* coordinate (depth) is simply dropped to form the 2D points on the view plane.

Orthographic Projection

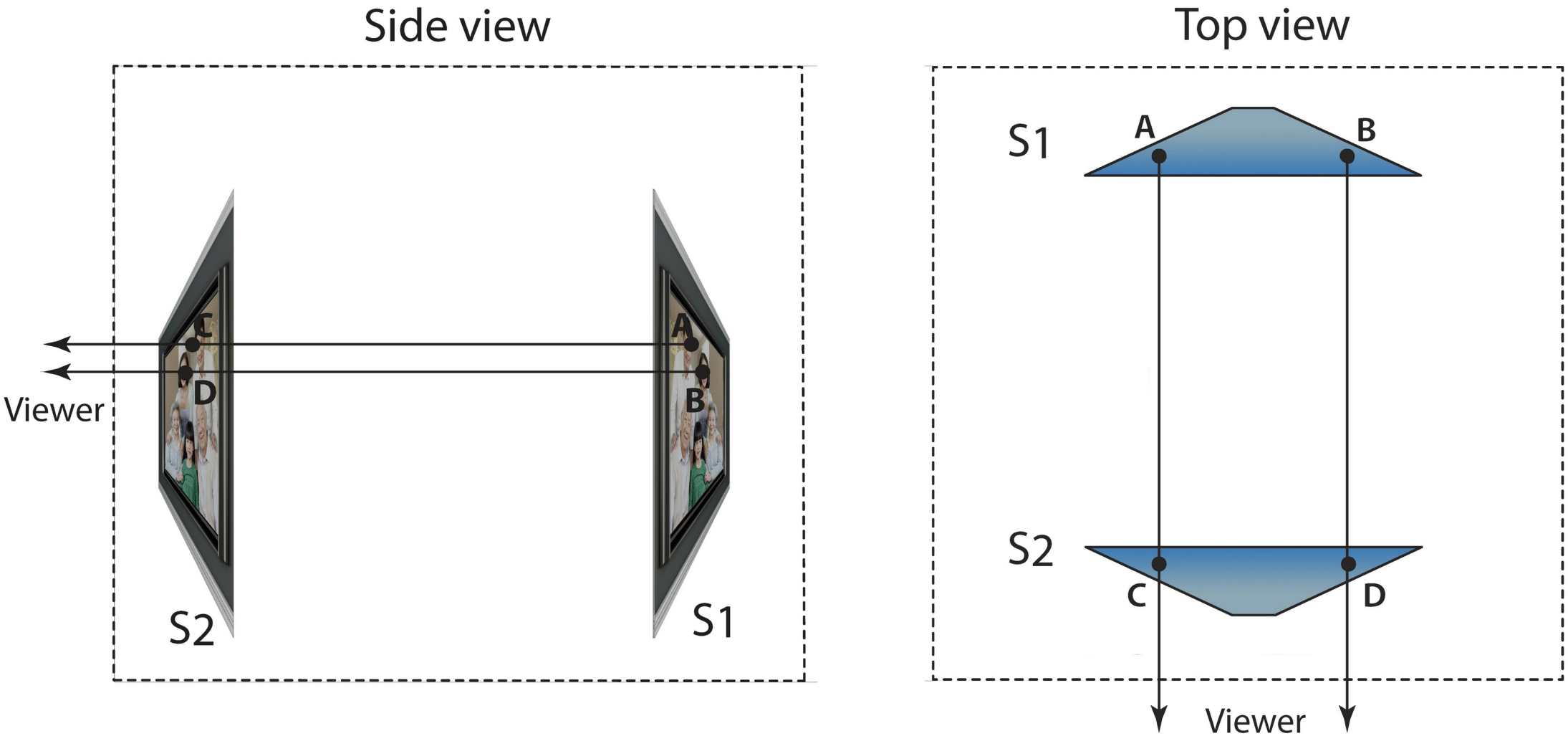
- Since the *(x,y)* coordinates of a 3D point in a cube remains unchanged after orthographic projection, the depth *z* of that point no longer matters.

View plane image



Oblique view of orthographic projection in cube

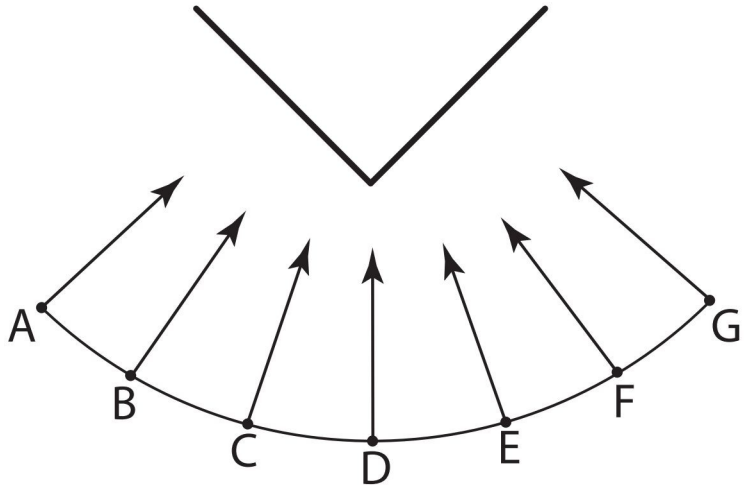
Two Candidate Surfaces

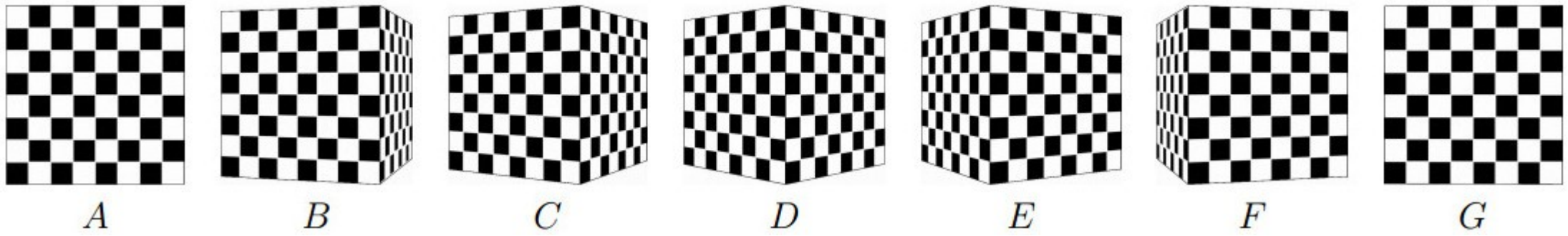


Orthographic Projection Properties

- The parallel set of rays that are orthographically projected from S1 may pierce any set of surfaces as they make their way to the viewplane.
- One such surface includes the reverse geometry in S2, in which the depth cues suggested by the image are inconsistent with the depth.
- An image painted on surfaces S1 and S2 appears identical after orthographic projection.
- The viewer sees the same projected image as long as they remain directly in front of the surface embedded in the cube.
- The impact of the surface geometry lies only when producing new renderings of the painted scene from novel view directions.

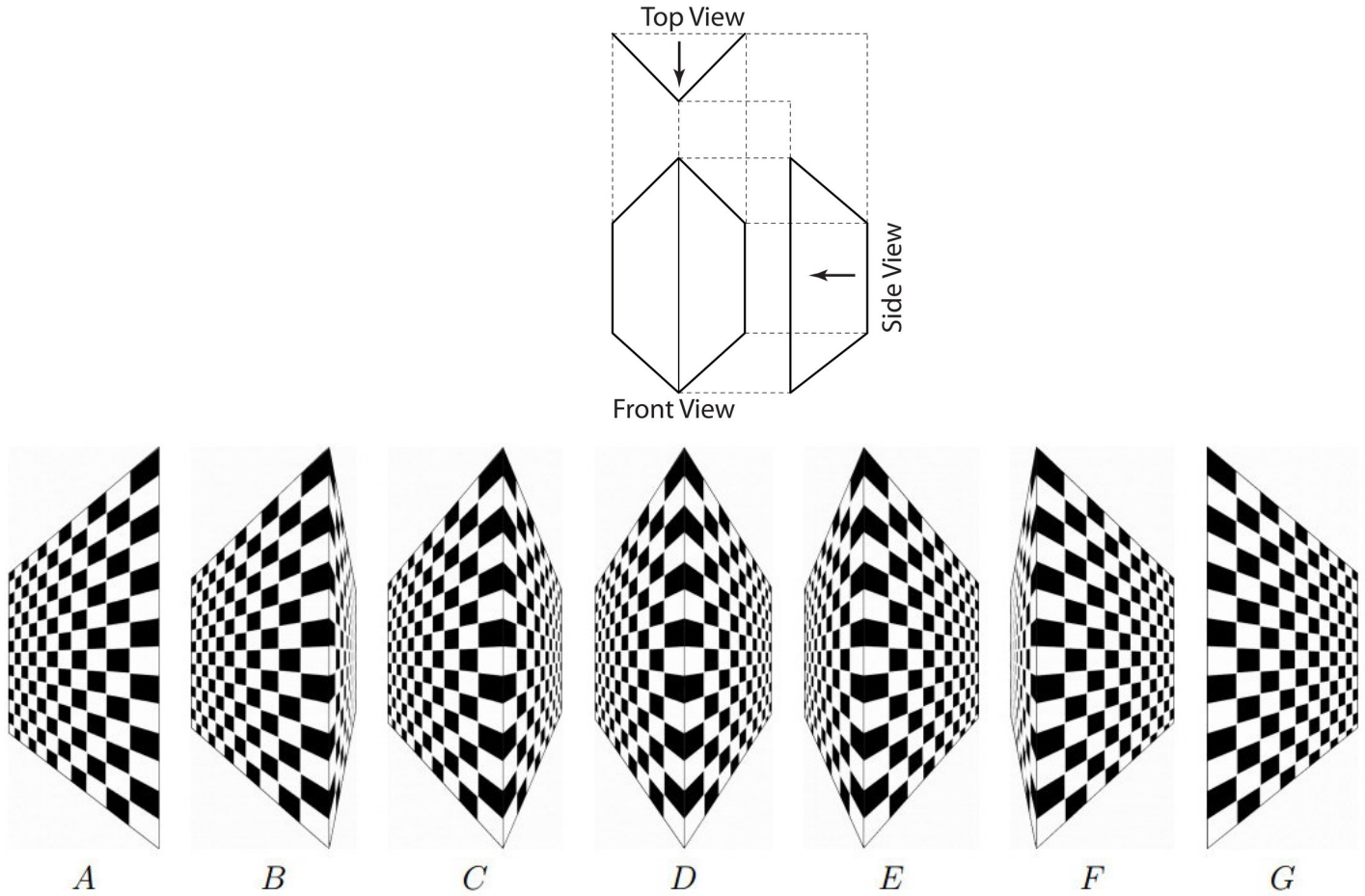
Forced Perspective Views





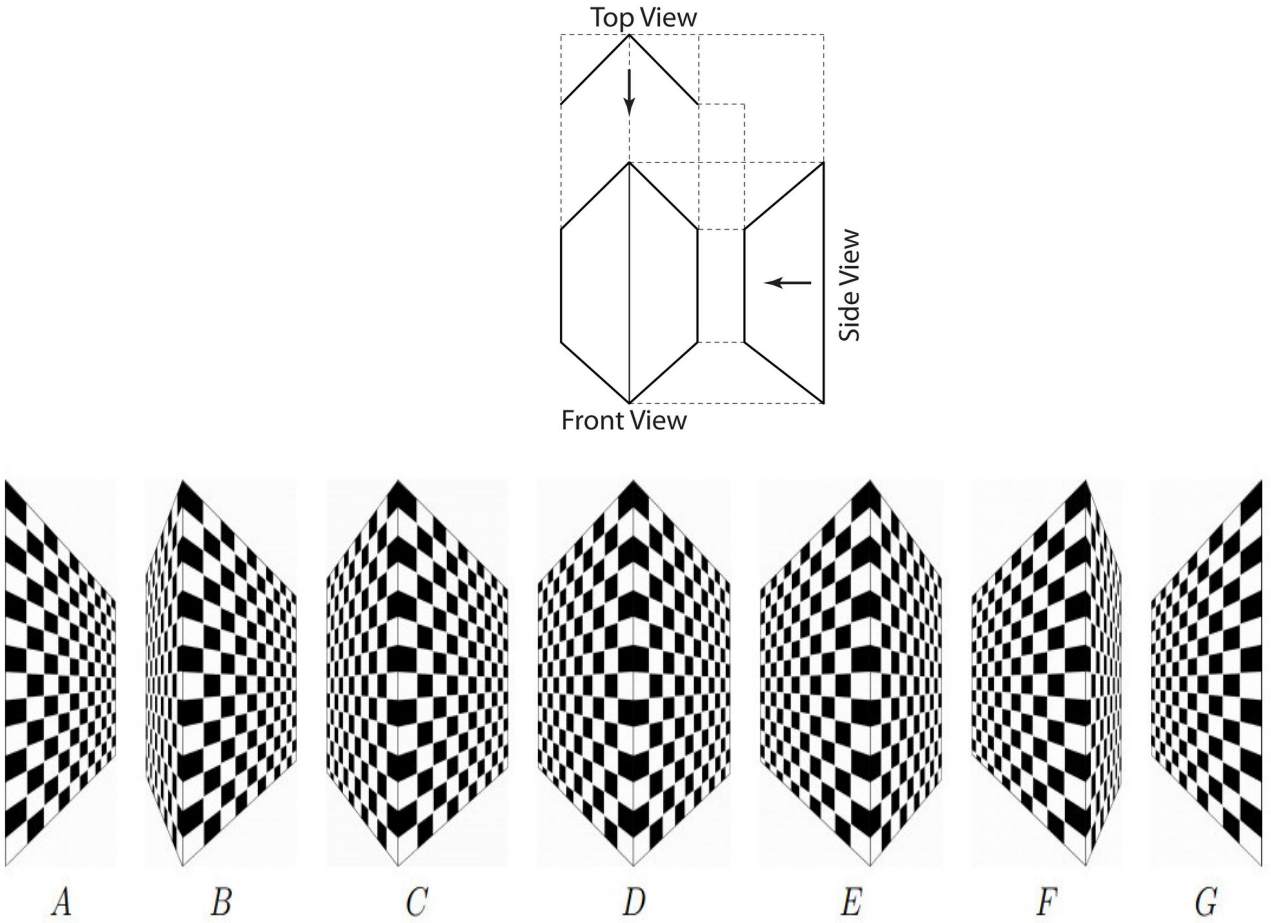
Consistent with a stationary viewer watching a cube spin in the clockwise direction about a vertical axis

Forced Perspective Views



Consistent with a stationary viewer watching facets spin in the clockwise direction about a vertical axis

Reverse Perspective Views

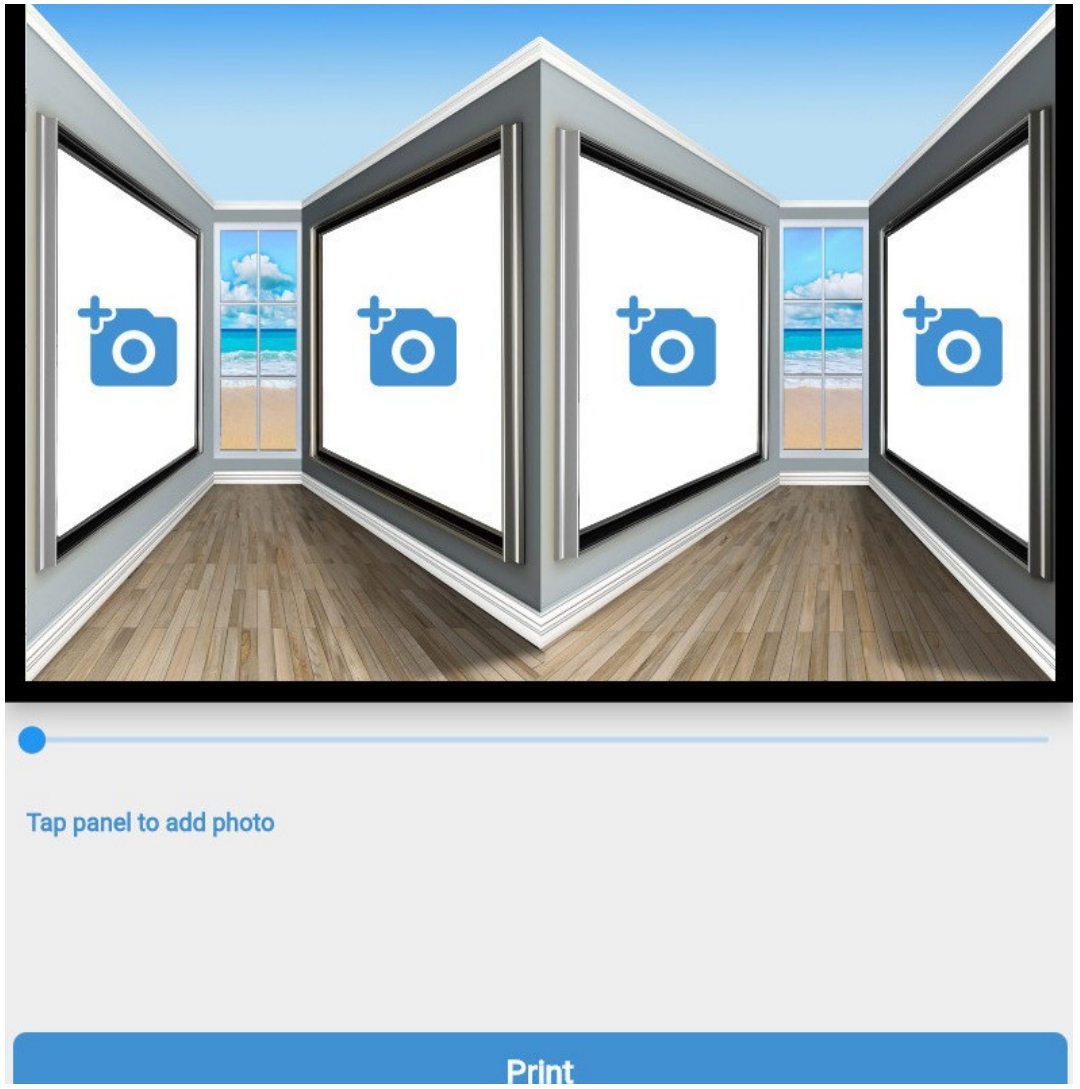


Consistent with a stationary viewer watching facets spin in the counter-clockwise direction about a vertical axis

Software

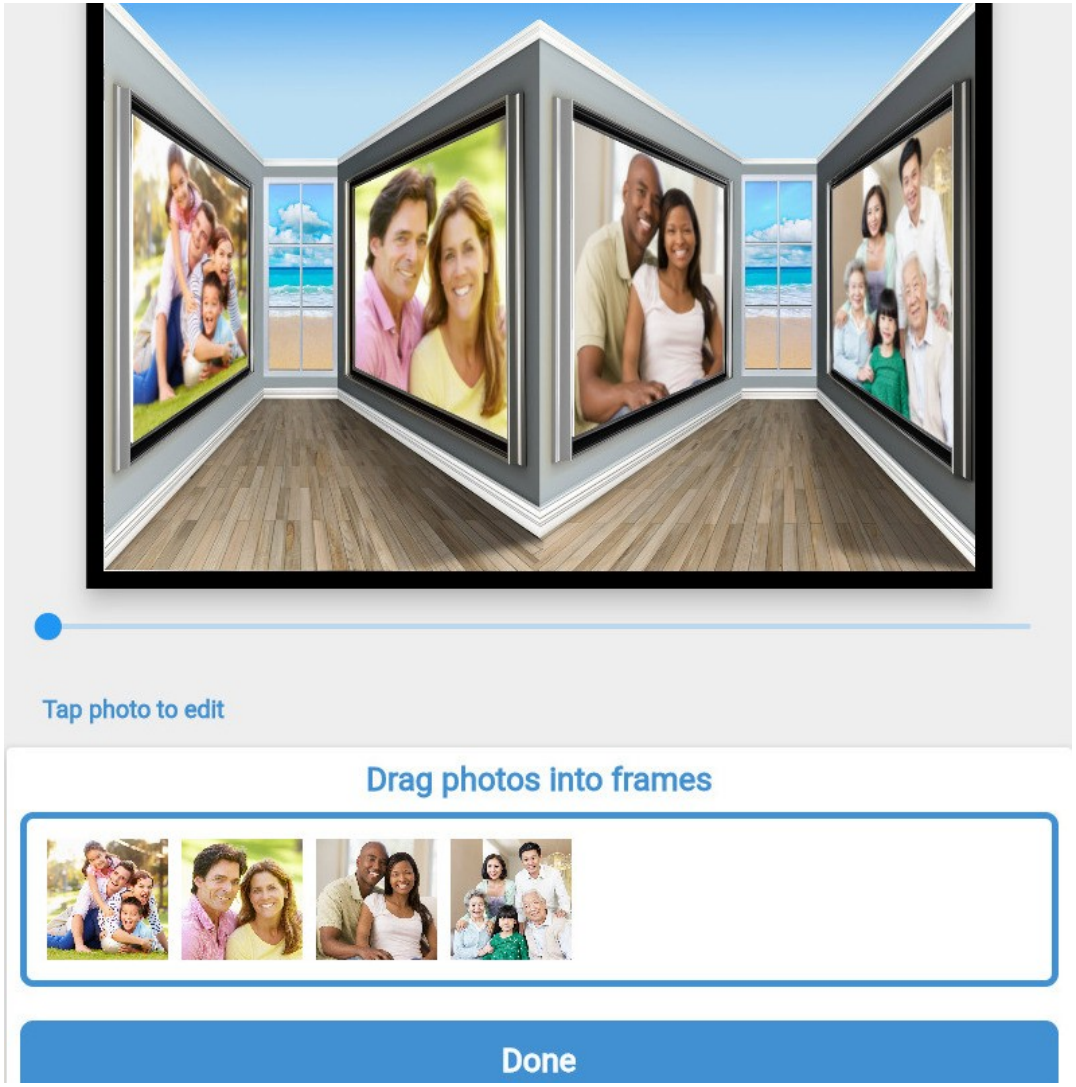
- The Vizilu frame is supplemented with software to perform a reverse perspective transformation upon the selected photos.
- This makes the photos conform to the 3D surface geometry of the frame using vanishing points that lie behind the viewer to trigger the illusion of motion.
- The software enables the customer to crop/scale the photos, arrange them in a multi-photo layout, and visualize the result.
- Flutter/Dart were used to create the Vizilu app for the iOS/Android/web platforms.

User Interface



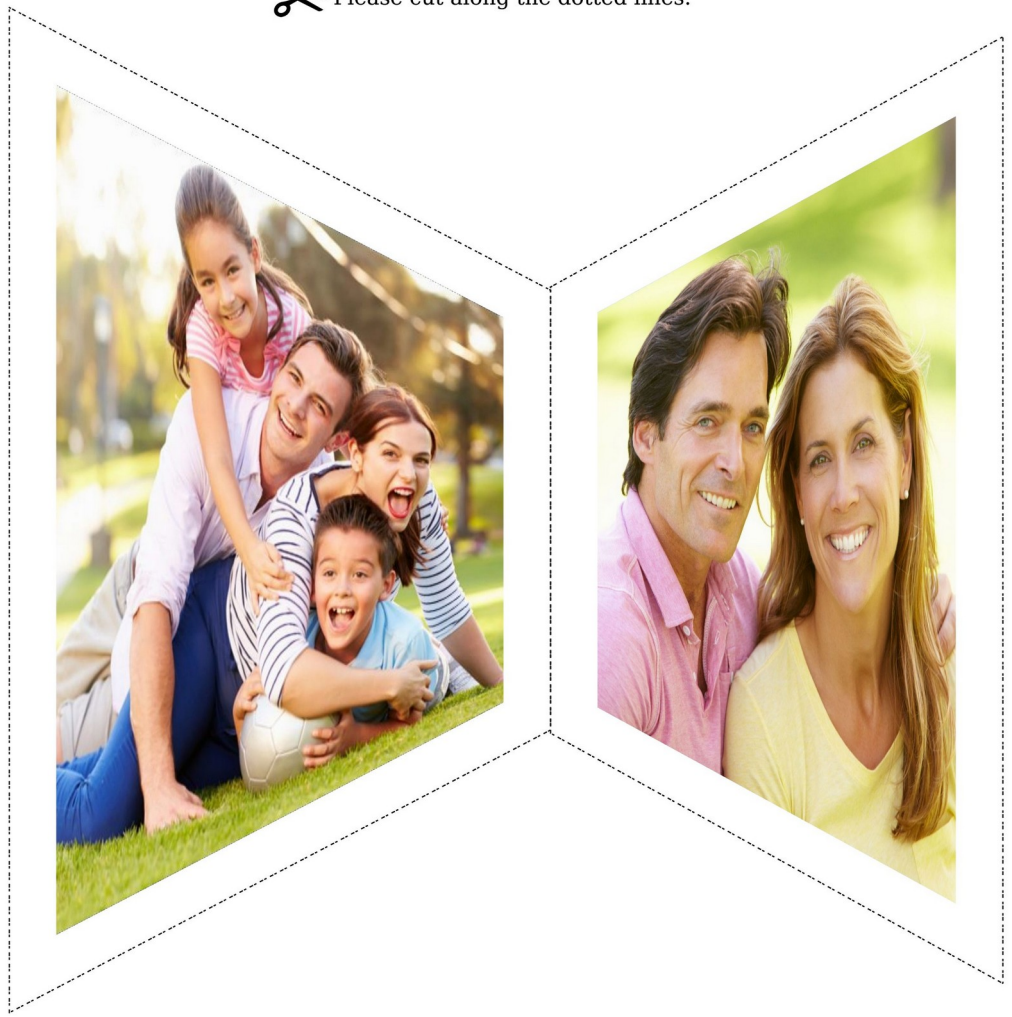
Edit Photos

Rearrange Photos



Print Warped Photos

Please cut along the dotted lines.



Install Photos

Vizilu Frame

Sway to See Illusion

U.S. Patent

System and Methods for Providing a Picture Frame with an Interactive Experience,
George Wolberg, Jeffrey Wolberg, and Siavash Zokai,
U.S. Patent No. 12,008,726.
Issue Date: June 11, 2024.