the gamedesigninitiative at cornell university

Lecture 15

Perspective in 2D Games

Graphics Lectures

- Drawing Images
  - SpriteBatch interface
  - Coordinates and Transforms

bare minimum to draw graphics

- **Drawing Perspective**
  - Camera
  - Projections

side-scroller vs. top down

- Drawing Primitives
  - Color and Textures
  - Polygons

necessary for lighting & shadows

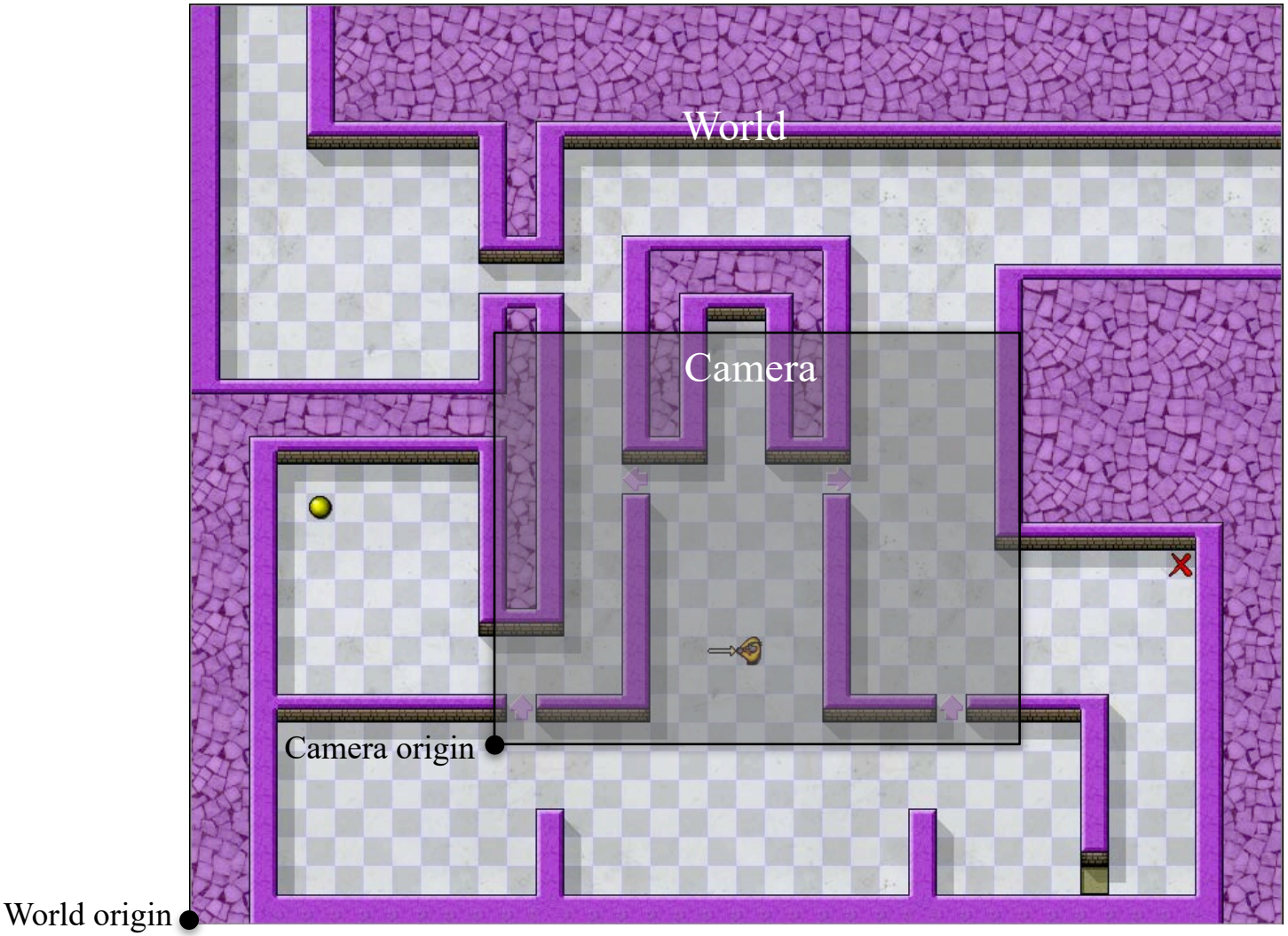
Take Away for Today

- What is the game "camera"?
  - How does it relate to screen space? Object space?
  - How does the camera work in a 2D game? 3D?
- How do we give 2D games depth?
  - Advantages, disadvantages of *orthographic view*
  - Advantages, disadvantages of *axonometric view*
- How does "tileability" affect art in games?

The Game Camera

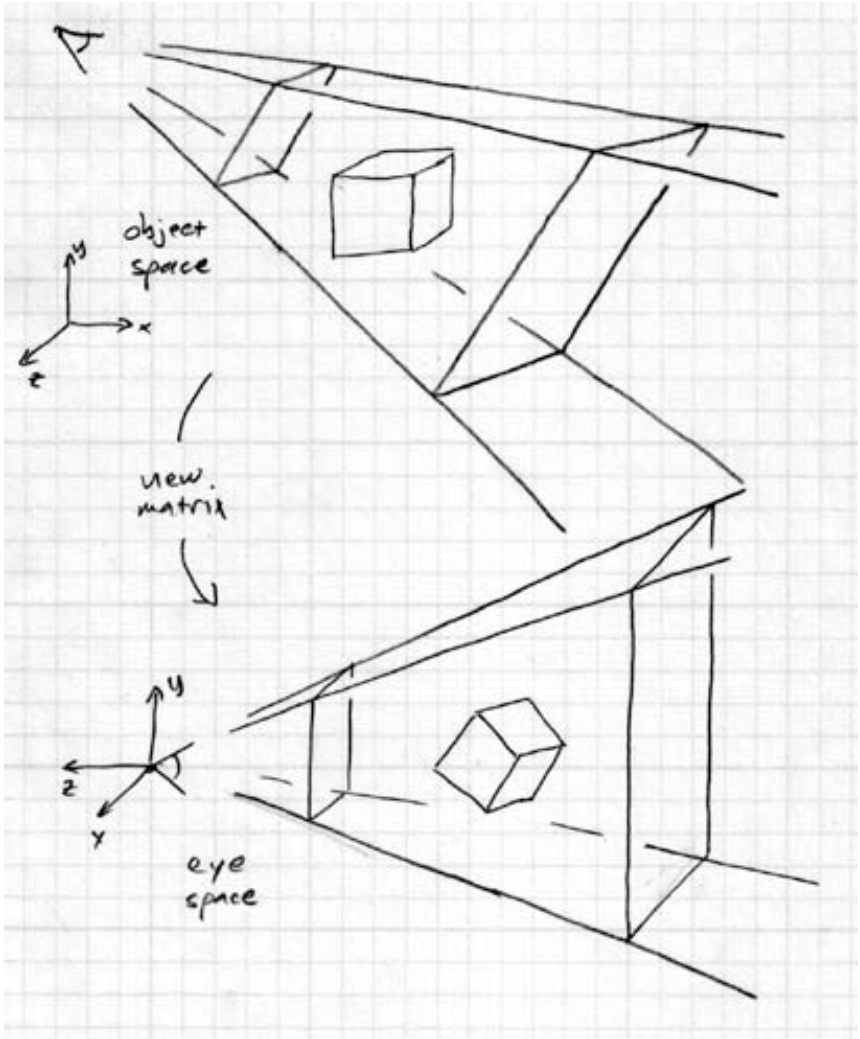
- What makes a game 3-D?
  - Everything is shown on a 2-D screen (mostly)
- 3D game have a **user controlled** "camera"
  - Position camera to look at art from all sides
  - 3-D art has enough information to allow this
- CS/INFO 3152 limits you to a 2-D game
  - The game camera has a *fixed perspective*
  - You render all art to one visible side

Camera in 2D Games



Specifying the Camera

- Camera is a **coord space**
  - Called "eye space"
  - Eye position at origin
- How to move camera?
  - Transforms again!
- **Inverse** of scrolling
  - Scrolling: move obj to eye
  - Camera: move eye to obj
  - Two matrices are *inverses*



Cameras in LibGDX

- LibGDX has a `Camera` class
  - Stores camera type, and eye location
  - We typically use `OrthographicCamera`
  - Define as size of screen, with origin at bottom
- Apply to SpriteBatch with `setProjection()`
  - Convert camera into a Matrix4 object
  - Use the `combined` field, **not** `projection`
  - See `GameCanvas.java` in *Lab 2*

Cameras in LibGDX

```
SpriteBatch batch = new SpriteBatch();

// Create a camera for the game window

Camera camera = new OrthogonalCamera(width,height);

// Set the camera in the SpriteBatch

Matrix4 matrix = camera.combined;

batch.setProjectionMatrix(matrix);

// Ready to use SpriteBatch

batch.begin();

...
```

Convert Camera to transform to use

Cameras in LibGDX

OrthogonalCamera

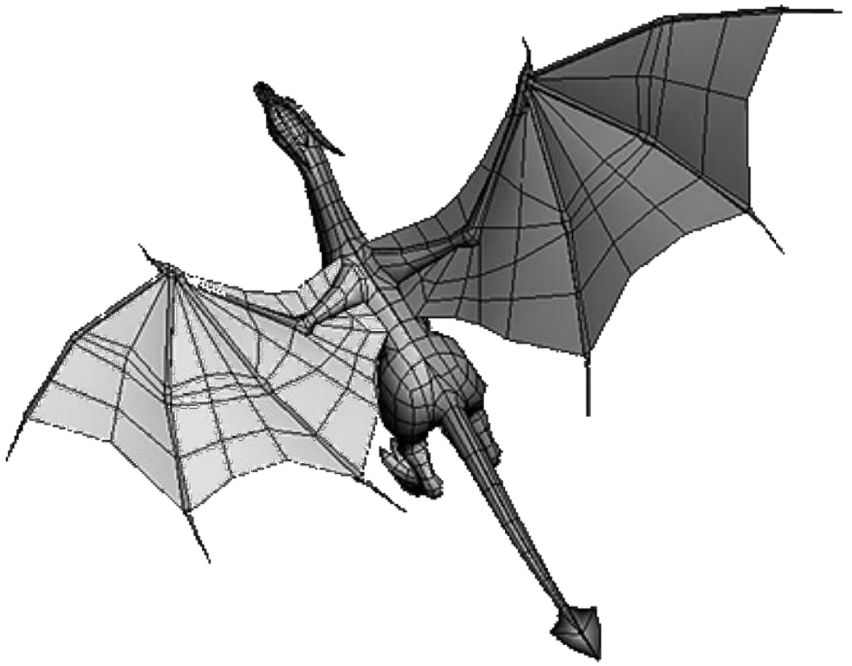
- Used for all 2D games
  - Objects have 2d positions
  - Draws back-to-front
- Specify the *viewport*
  - The window size
  - The window origin
  - Move origin to scroll

PerspectiveCamera

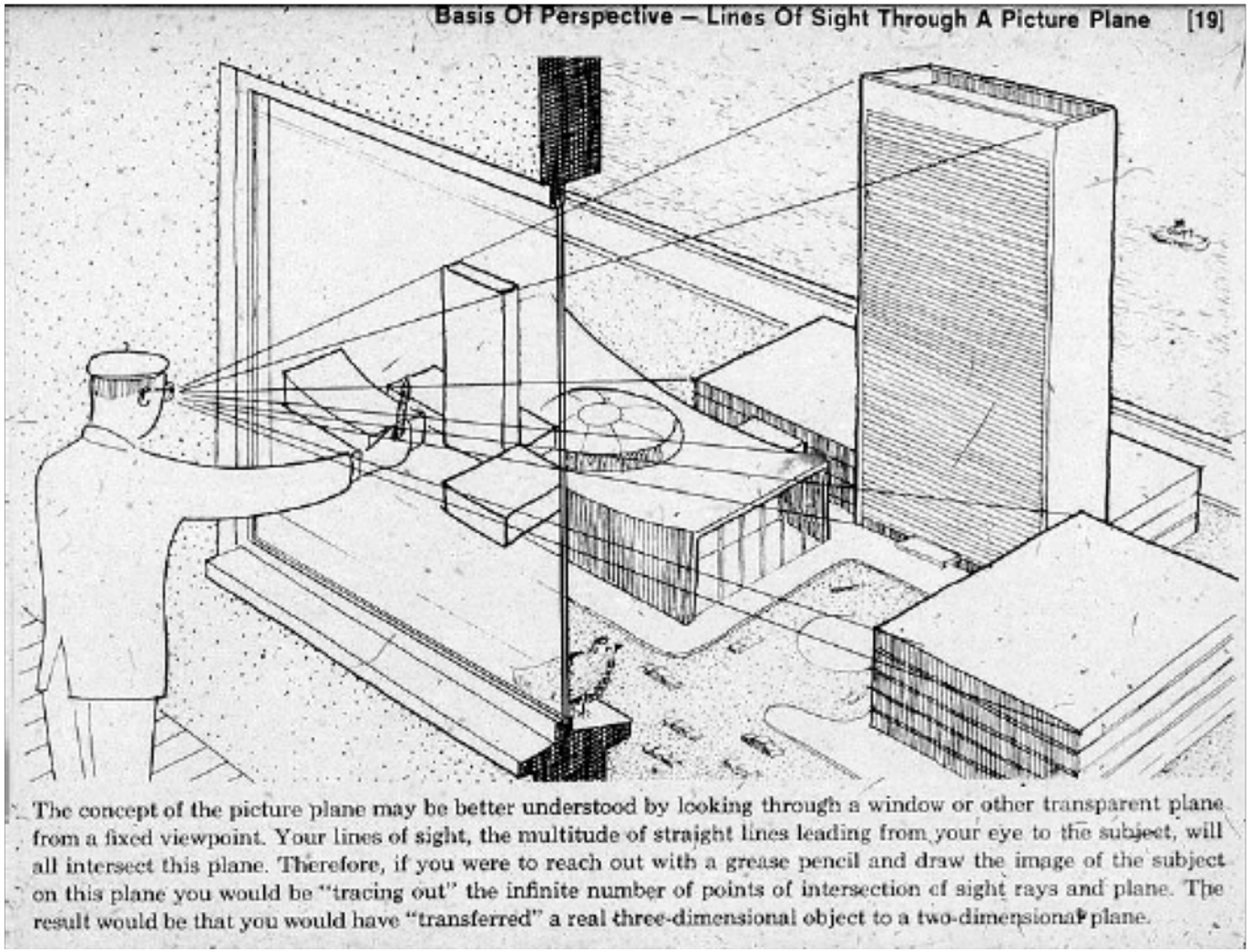
- Used for all 3D games
  - Objects have 3d positions
  - Draws a picture plane
- Specify *eye coordinates*
  - Eye origin
  - Looking direction
  - Up direction

Drawing for a Perspective

- 3D Models make it easy
  - Rotate model to position
  - Flatten to jpeg, tiff, etc…
- But 3D modeling is hard
  - Very technical programs
  - Cannot draw "by hand"
- How to draw perspective?
  - Artist "captures" camera
- **Realism creates problems**

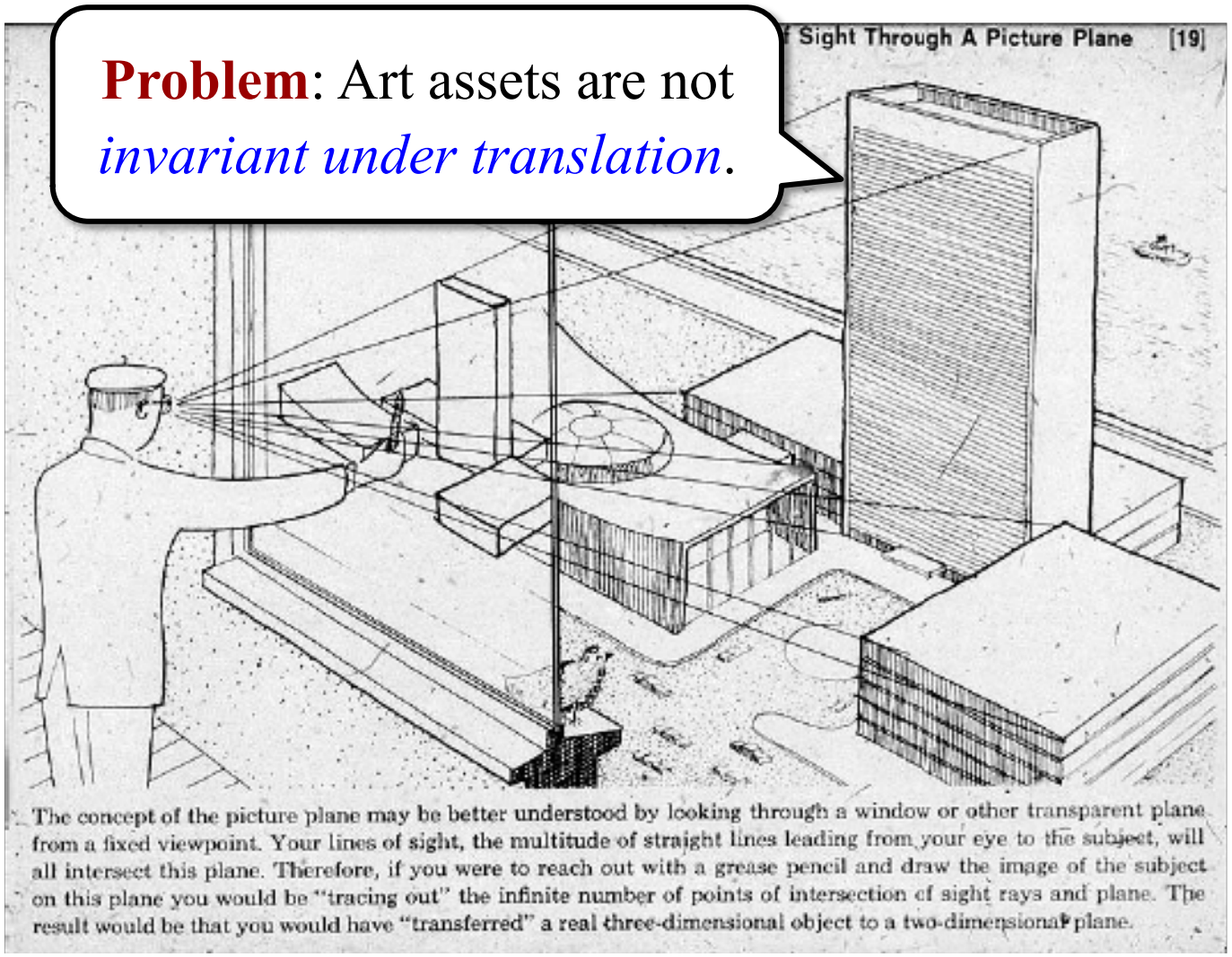


Plane Projection in Drawing

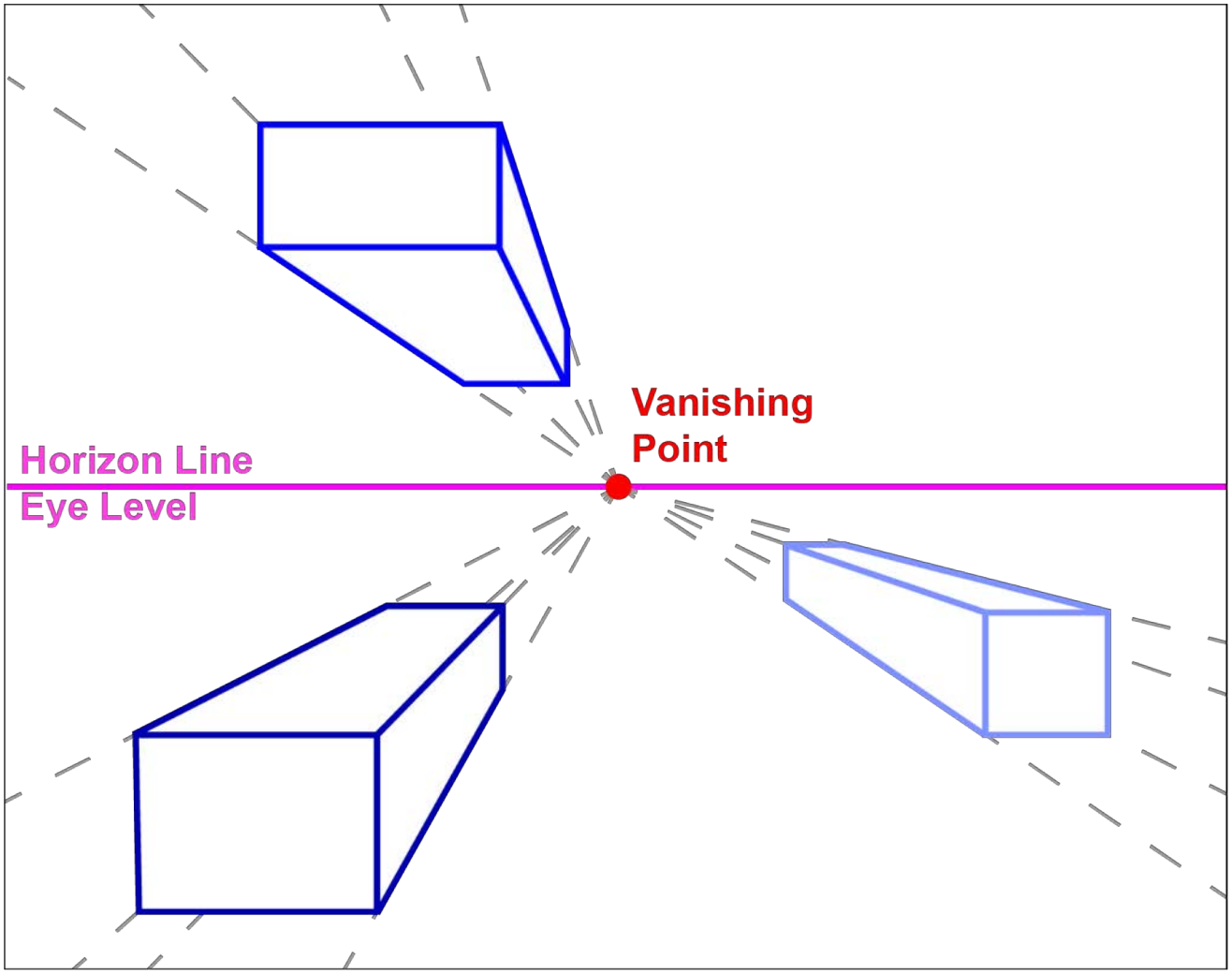


Plane Projection in Drawing

Problem: Art assets are not *invariant under translation*.



Vanishing Points are **Not** Our Friend



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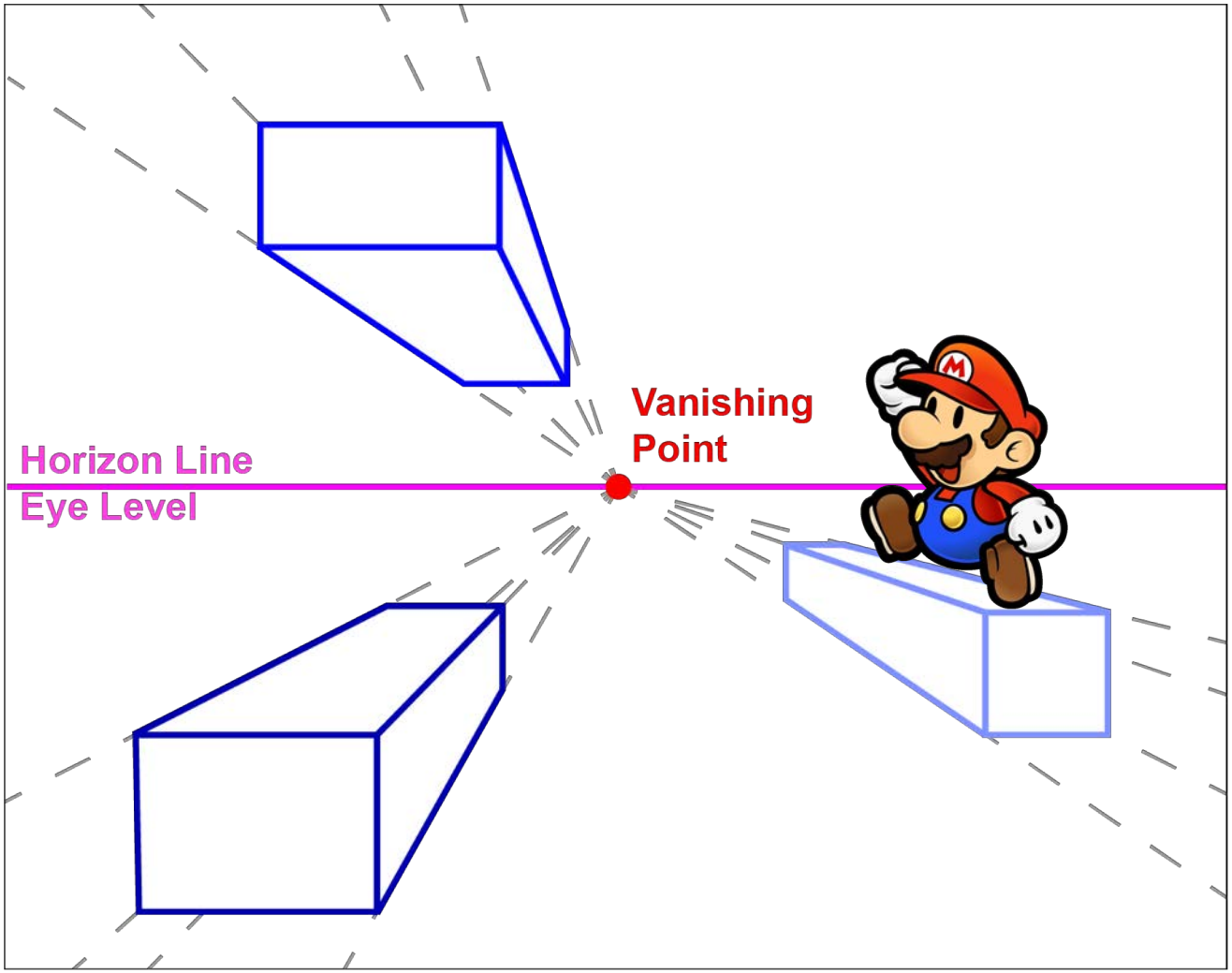

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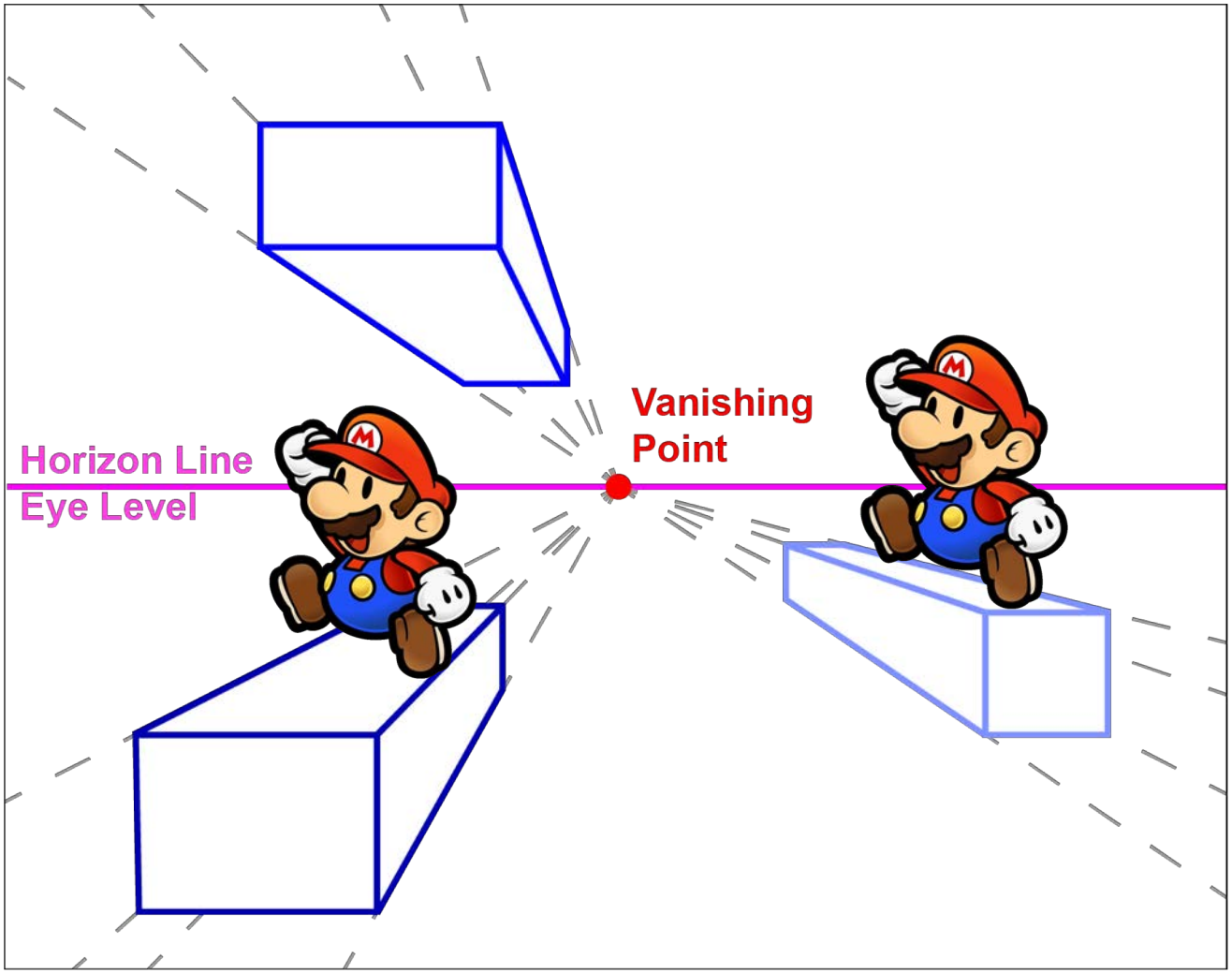

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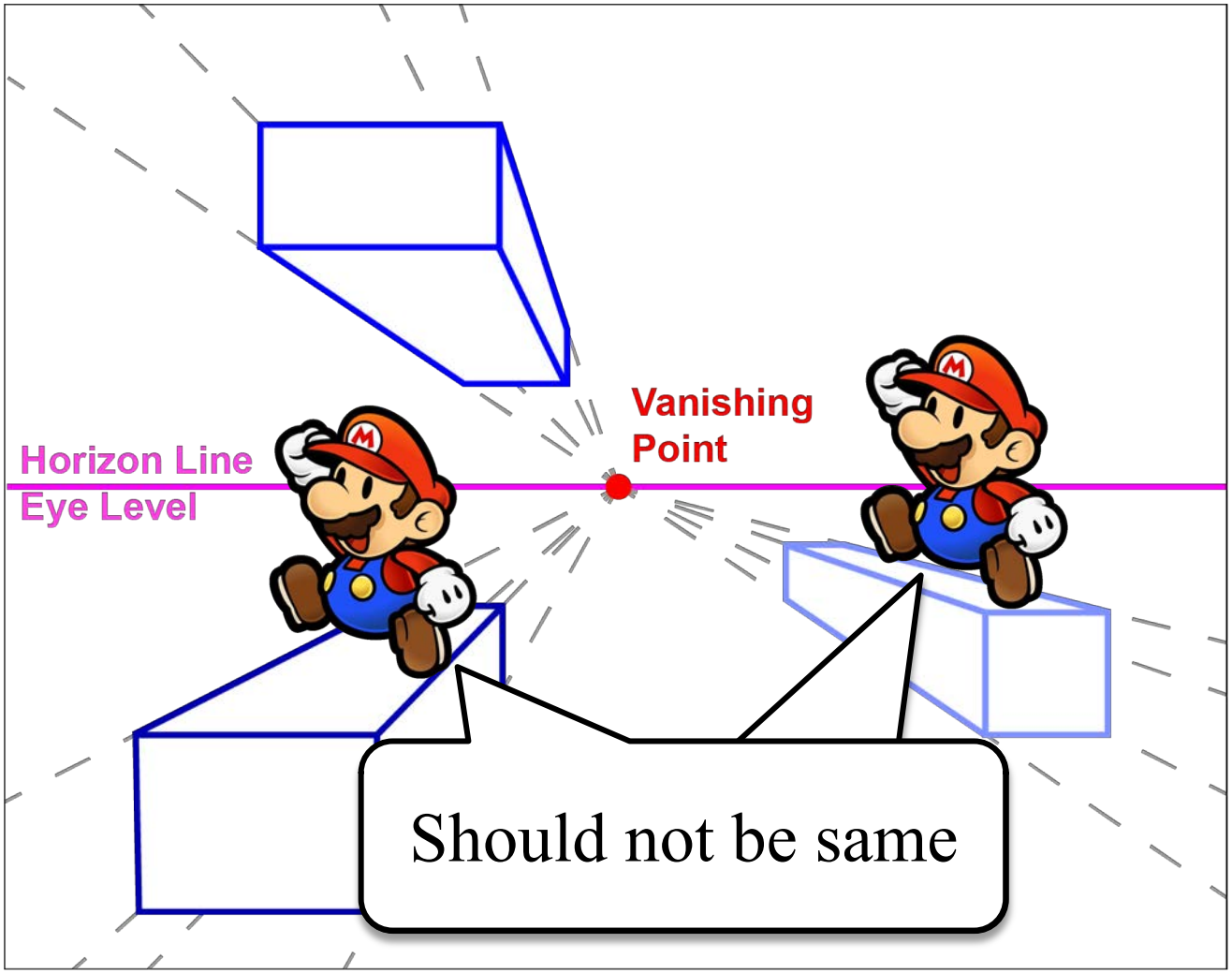

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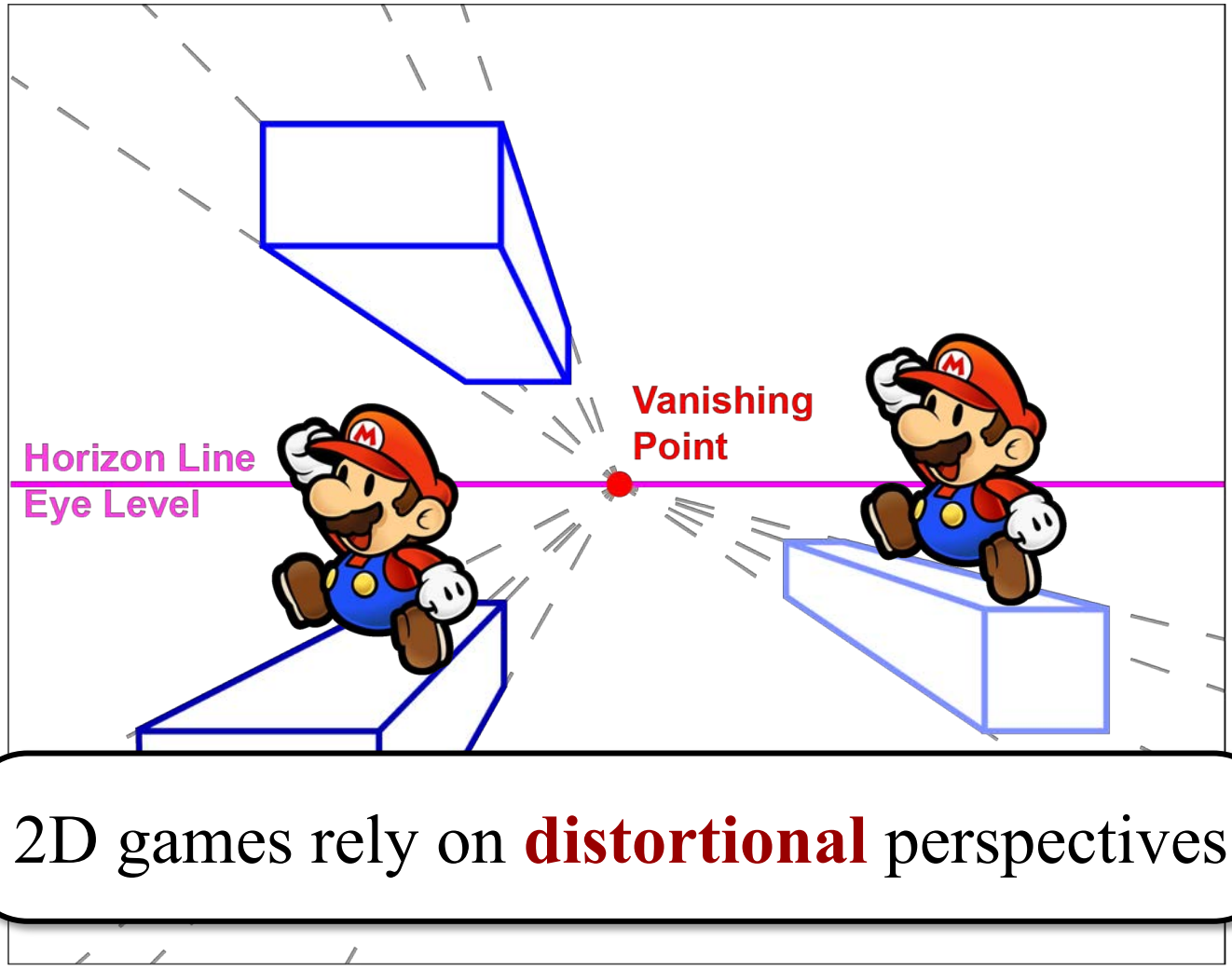
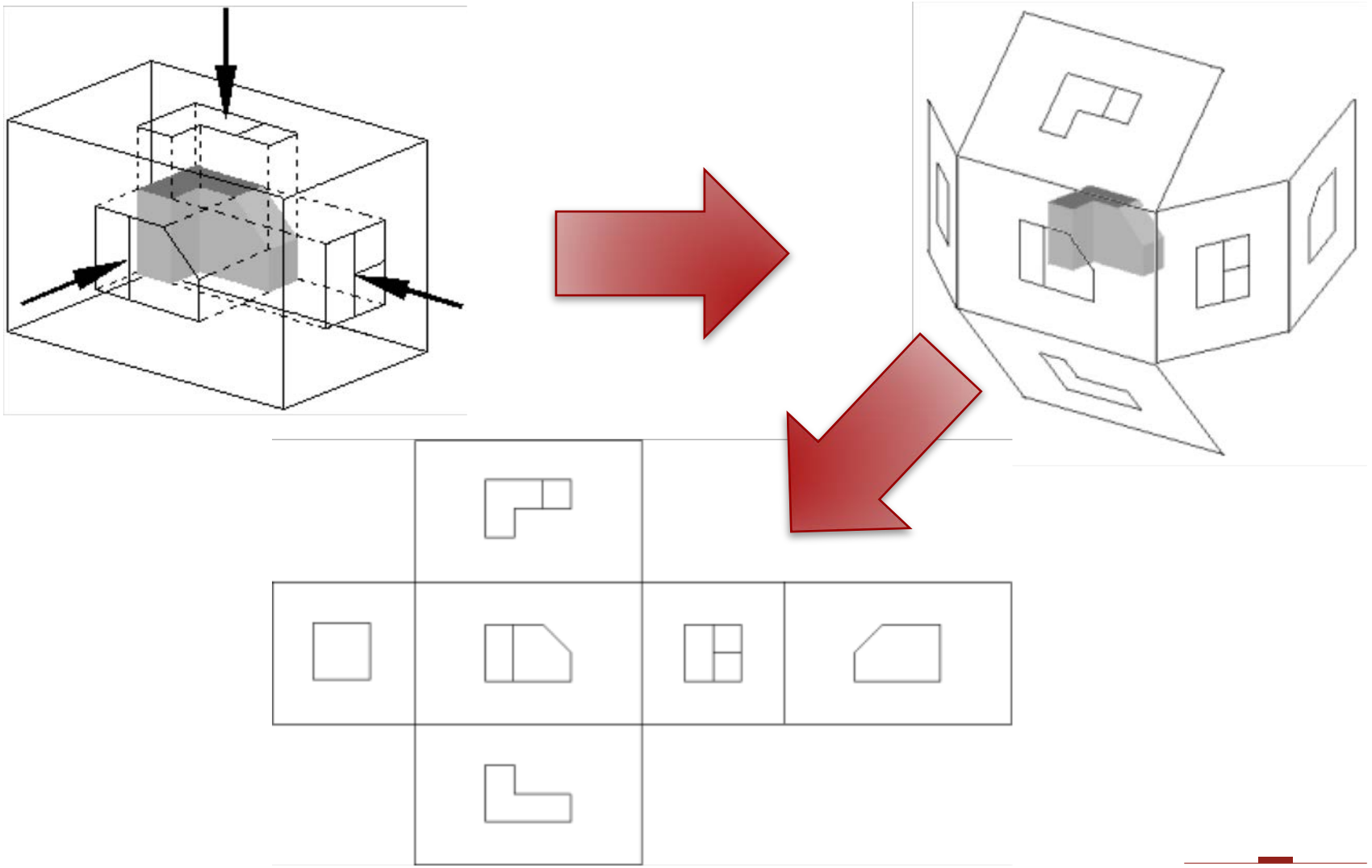


2D games rely on **distortional** perspectives

Orthographic Projection

- *Project perpendicular* to an axis
  - **Top-down**: perpendicular to z-axis
  - **Side scrolling**: perpendicular to y-axis
- Very easy to do artistically
  - Art objects are flat tiles
  - Layer tiles via compositing
- But enforces *2-D gameplay*
  - 3rd dimension lost; cannot be seen
  - **Distorted**: All rays to eye are parallel

Orthographic Projection



Side-View: *Braid*

Top-Down: *Hotline Miami*

Top-Down: *Gauntlet*

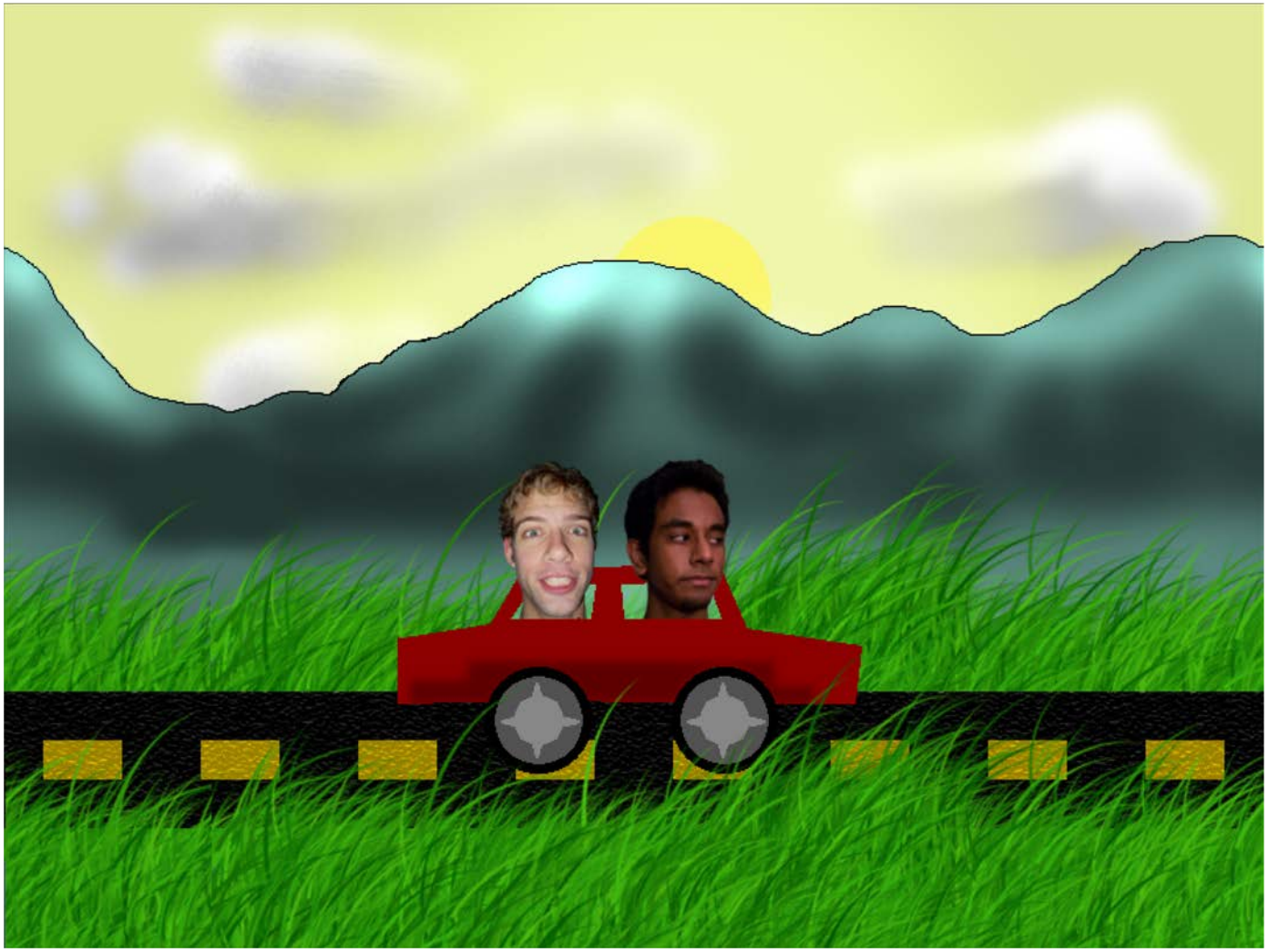
Drawbacks of Orthographic Projection

- **Top-down** is extremely limiting
  - Can only see the top of the avatar
  - Hard to make interesting characters
  - Typically limited to platformers
- There little **no depth** to gameplay
  - At best can create gameplay *layers*
  - 3rd dimension is very discrete (2.5D)
  - Represent 3rd dimension with *parallax*

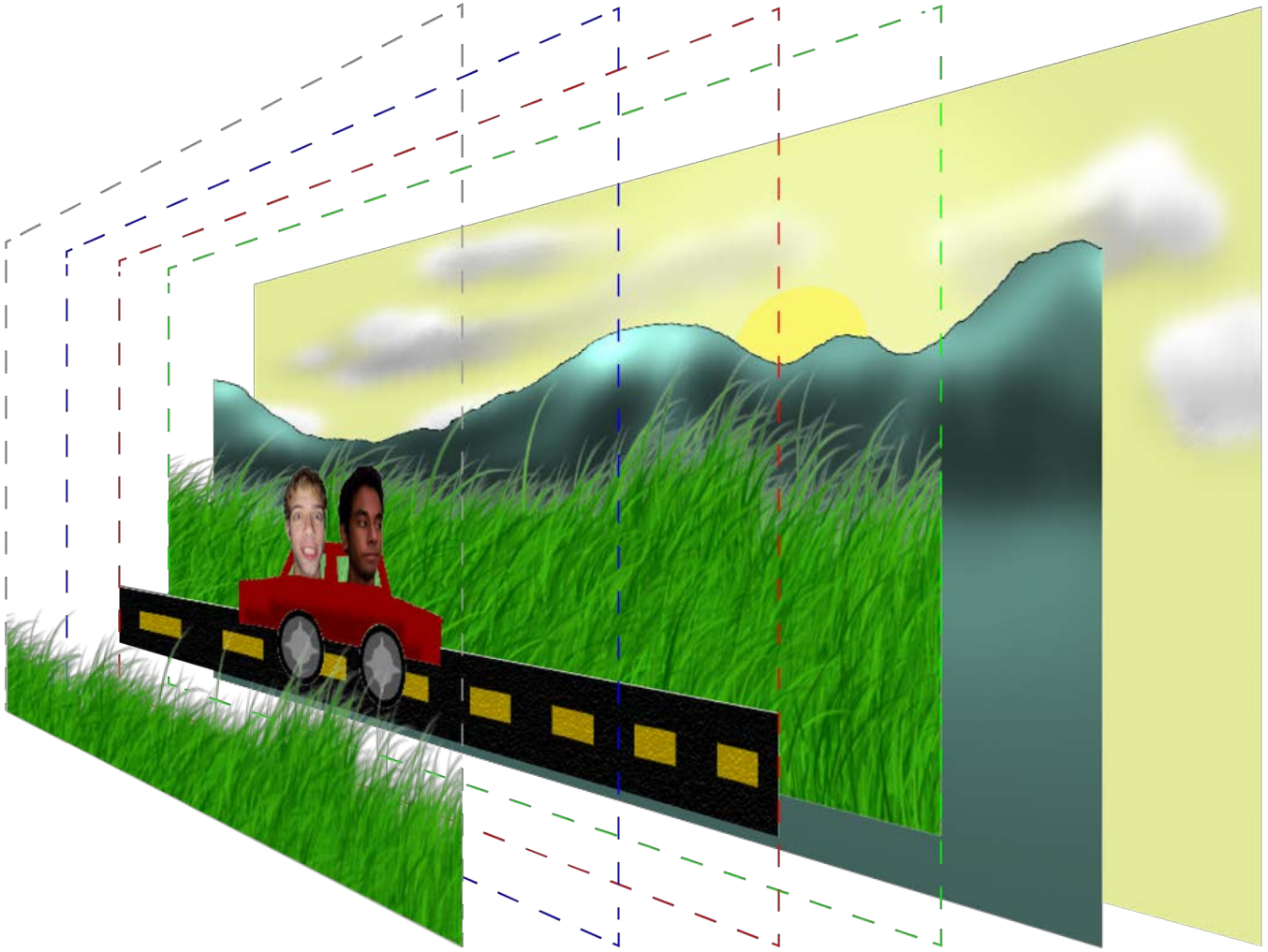
Parallax Scrolling

- Gives depth to orthographic projection
  - Objects in background have distance
  - Rate of scrolling depends on distance
- Implement with multiple background layers
  - Each layer scrolls at a different rate
  - See course website for sample code
- Often requires some degree of **transparency**
  - *Composite* front layers with back layers

Parallax Scrolling

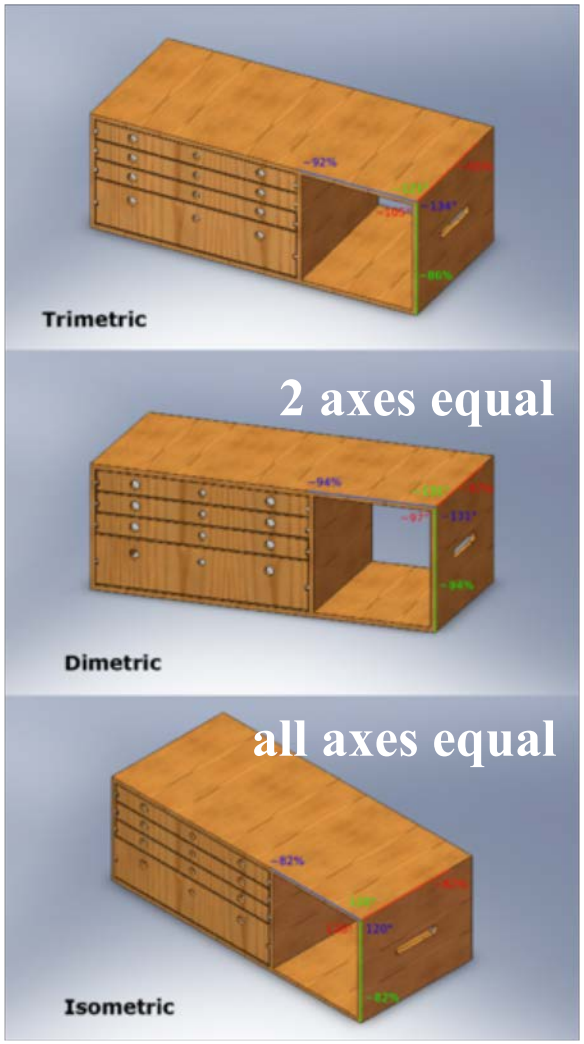


Parallax Scrolling



Axonometric Projection

- Off axis view of object
  - View along all 3-axes
- Once again: **distorted**
  - Not a true projection
  - No *vanishing point*
  - Axes are "foreshortened"
- Allows 3-D gameplay
  - "Cliffs" are visible
  - May also **hide objects**!

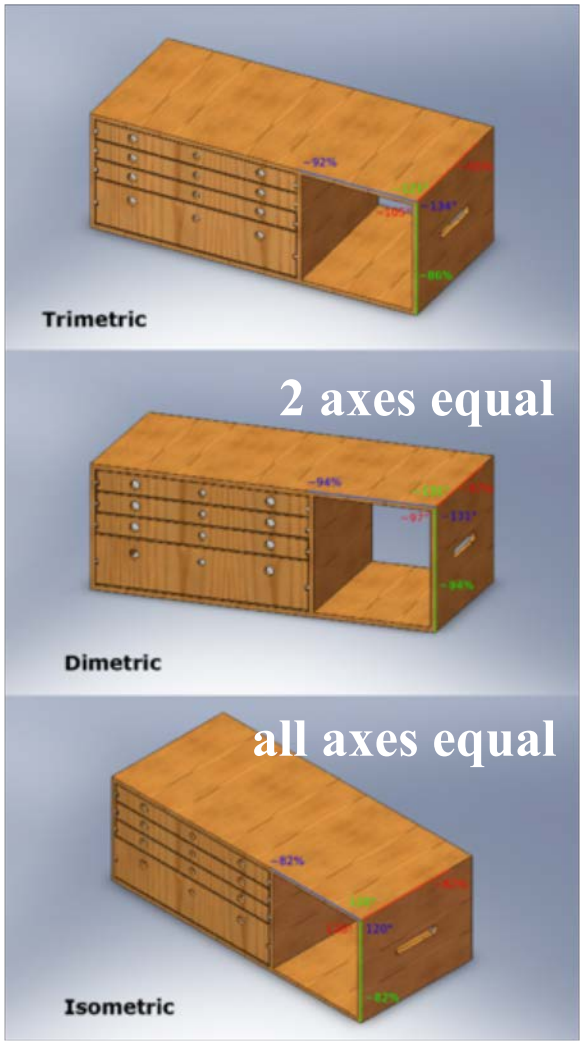


Axonometric Projection

Axonometric Projection

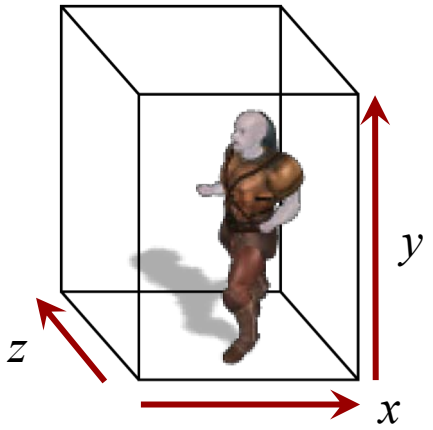
Projection Types

- **Isometric**
  - All axes are equal
  - If need all dimensions
  - Used in classic RPGs
- **Dimetric**
  - *z*-axis is very short
  - *x*, *y* axes are equal
  - Orthographic+depth
  - For aesthetic reasons only



Projection Geometry

- Axes relative to screen
  - z goes "into" the screen
  - x, y are in screen plane
- Axonometric coodinates
  - May not be "true" coords
  - "Meaning" of x, y, z?
- Orthographic substitutes
  - **Side-scroller**: y is height
  - **Top-down**: z is height



Isometric

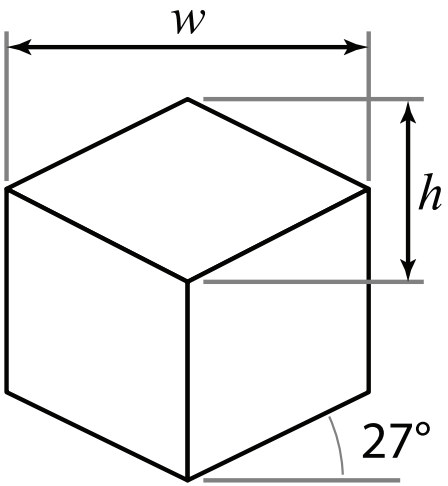
z is "artificial" dimension

Isometric View

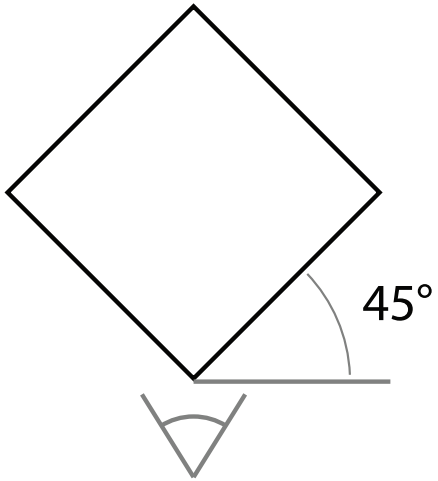
- x, y, z = Axonometric Coords
- x', y' = Screen Coordinates

$$x' = x - z$$

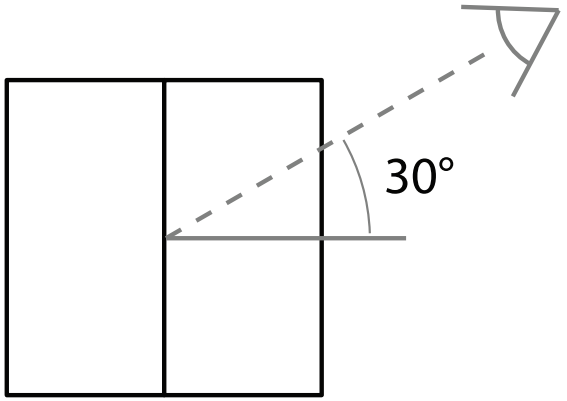
$$y' = y + \tfrac{1}{2}(x+z)$$



Game View



Top View



Side View

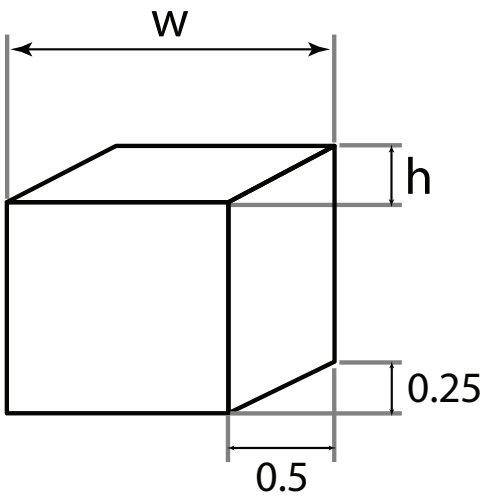
Isometric View: *Zaxxon*

Dimetric View (Side-Depth)

- x, y, z = Axonometric Coords
- x', y' = Screen Coordinates

$$x' = x + \tfrac{1}{2}(z)$$

$$y' = y + \tfrac{1}{4}(z)$$



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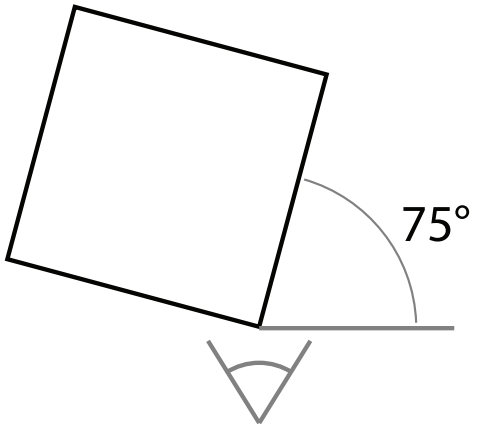
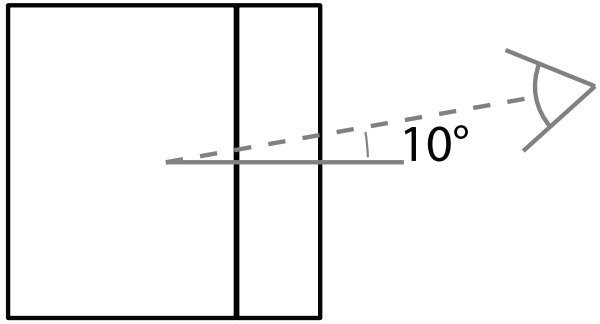


Top View



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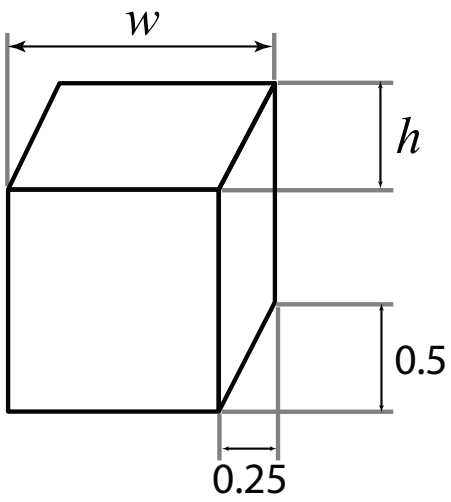
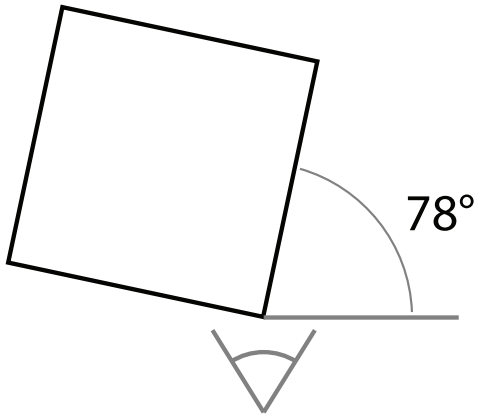
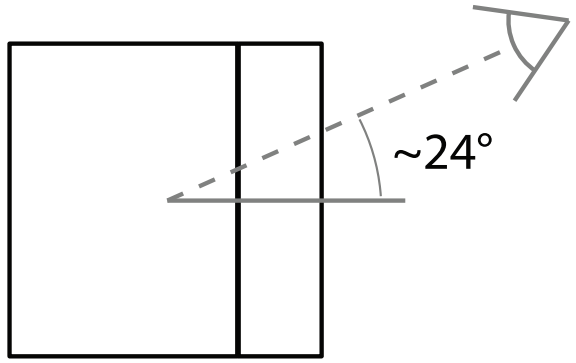


Game View



Top View

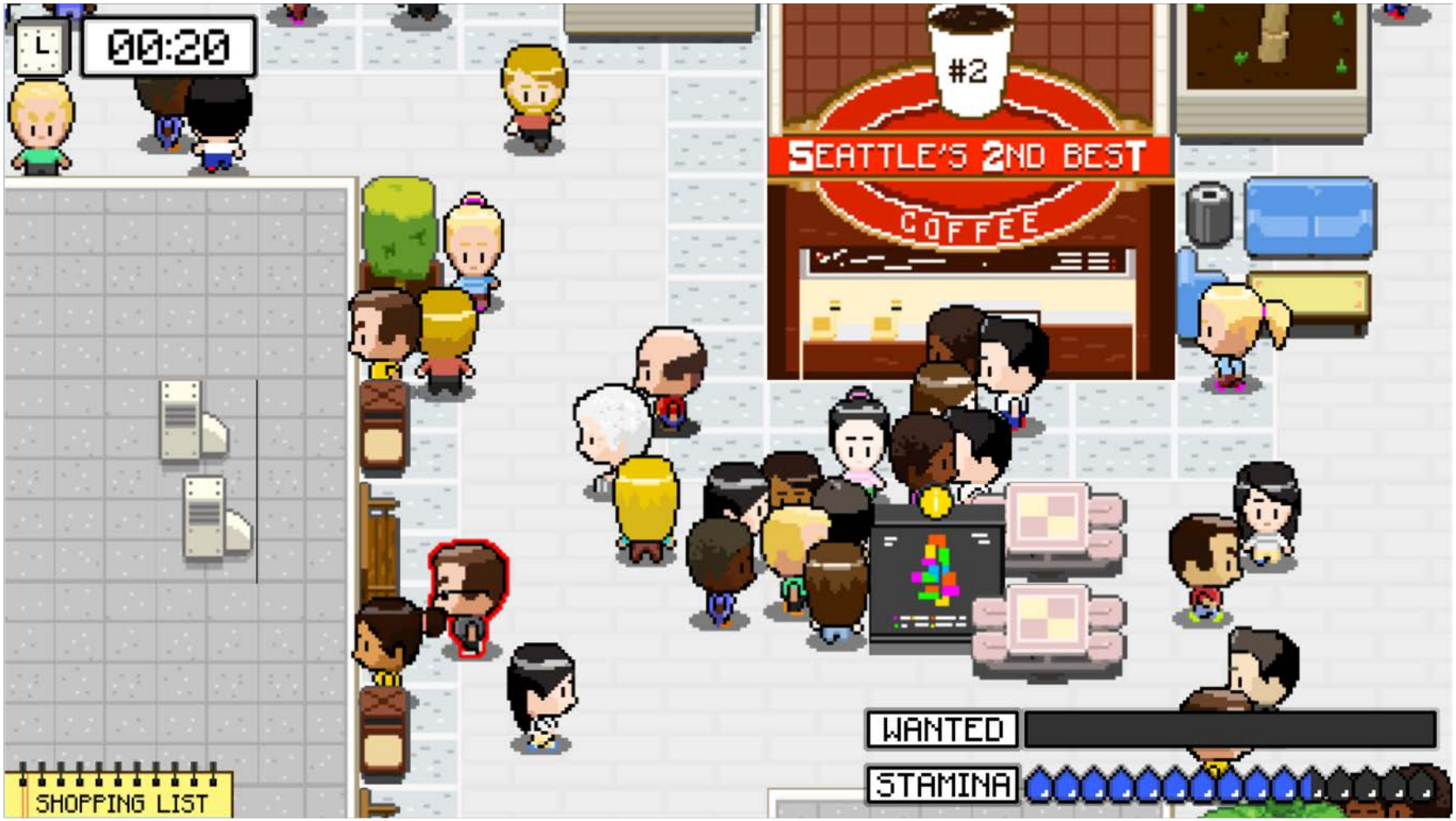


Side View

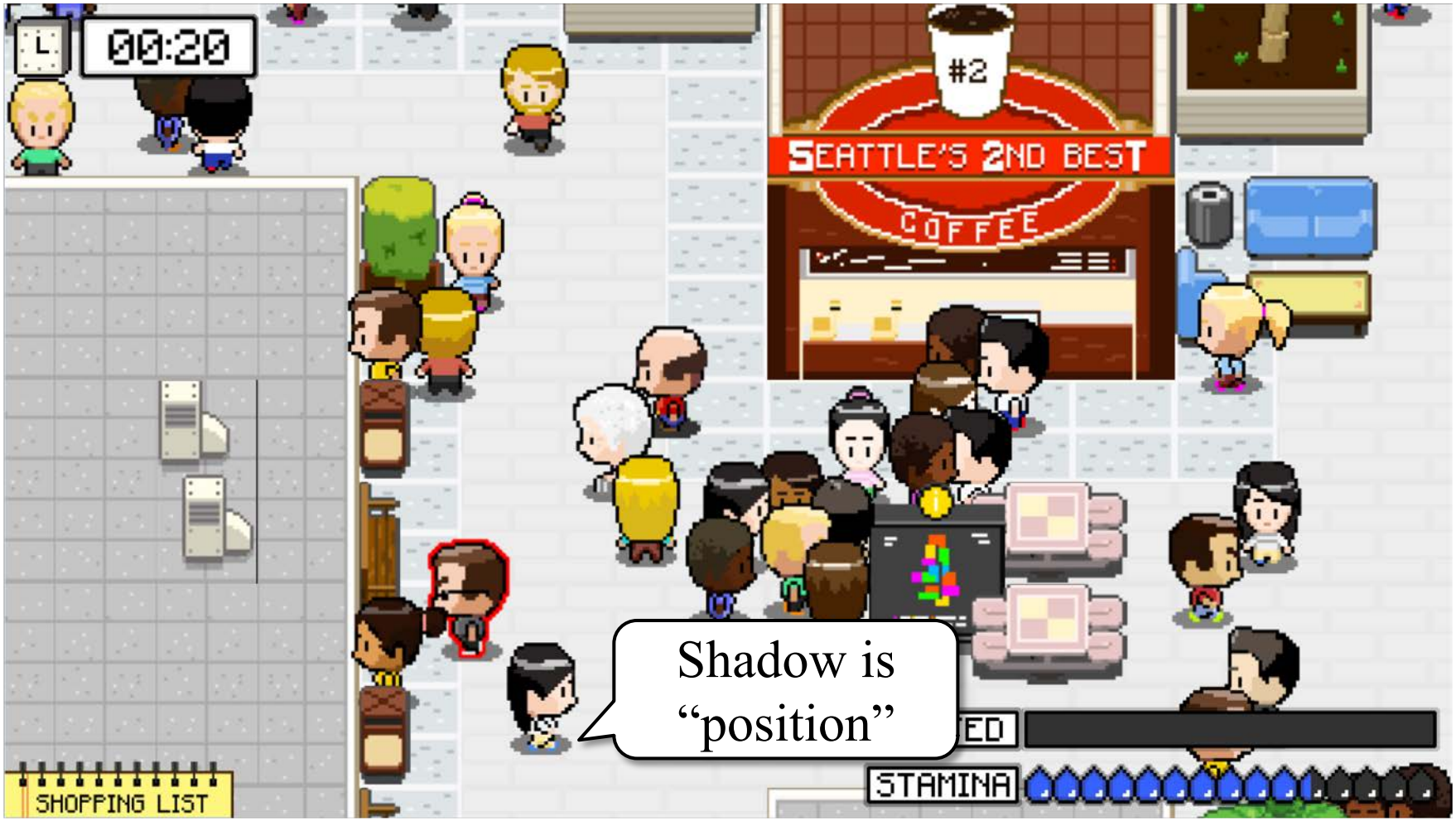
But **Gameplay** is Still Orthographic

But **Gameplay** is Still Orthographic

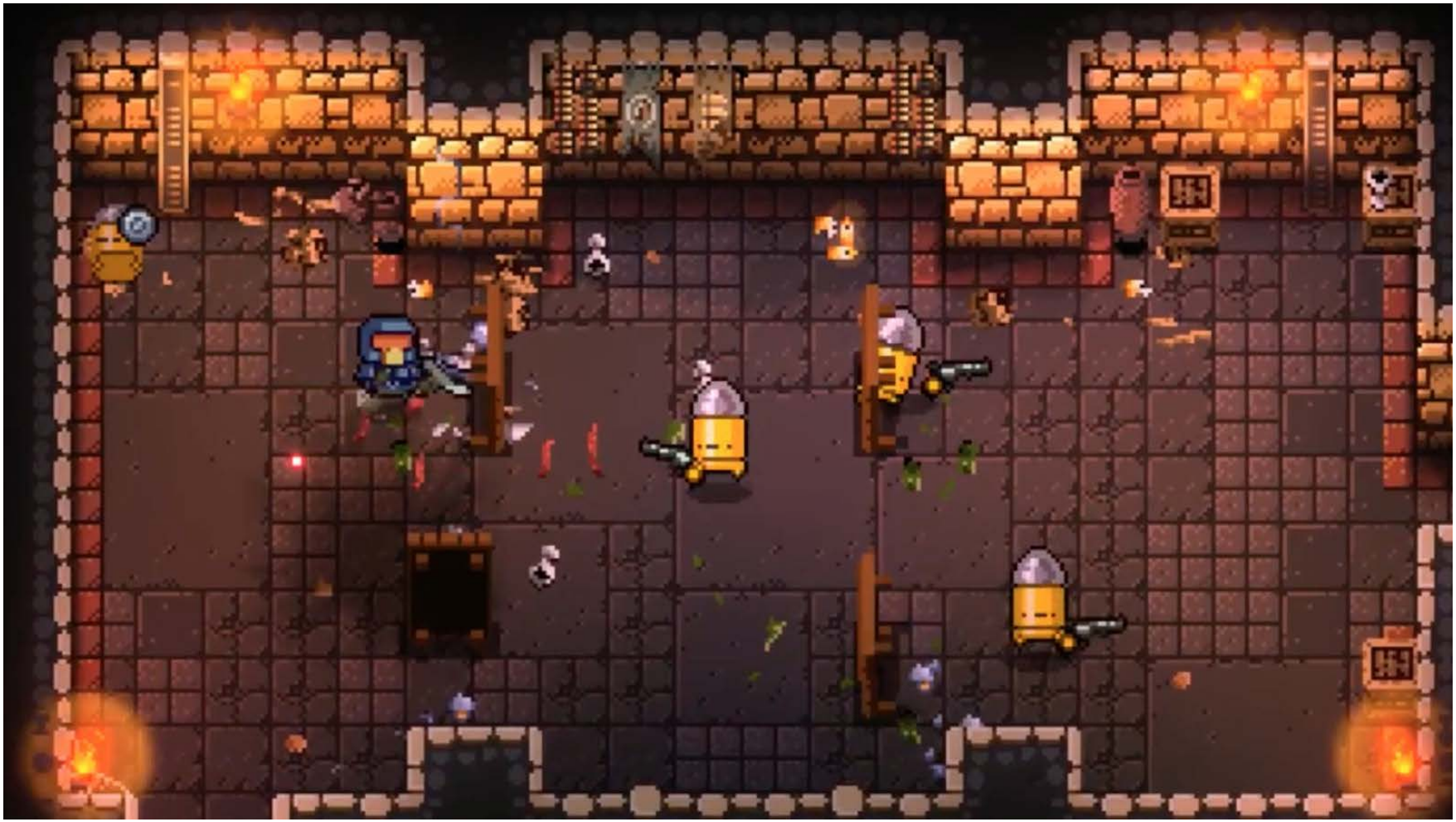
Dimetric: *Black Friday*



Dimetric: *Black Friday*



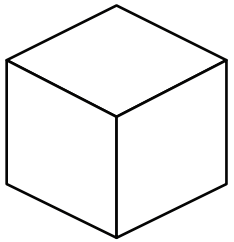
Dimetric: *Enter the Gungeon*

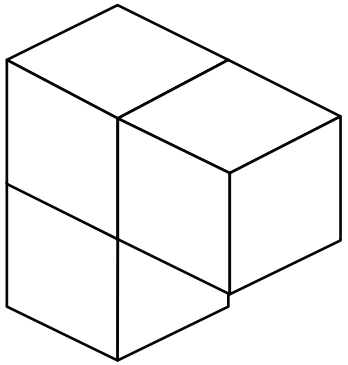


Dimetric: *Enter the Gungeon*

Drawing for Axonometric View

- Use boxes shown on slide
  - Tiling boxes is easy
  - Draw shape inside box
- Complex, large shapes?
  - Glue together boxes
  - Draw inside box group
- Objects need many angles
  - Transparency is tricky
  - Standard: 8 compass points
- **Example**: LakeHills.ai





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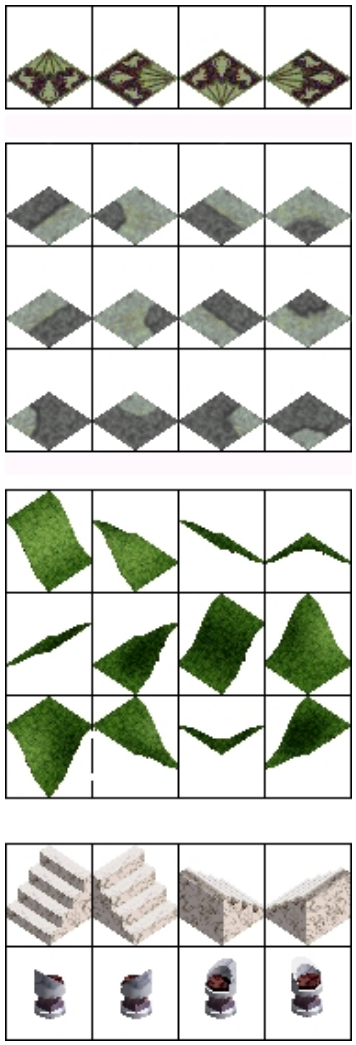
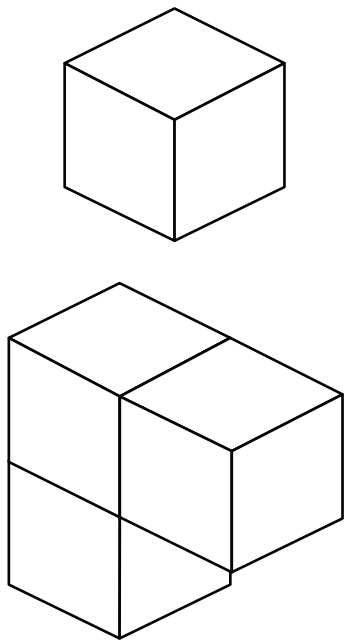
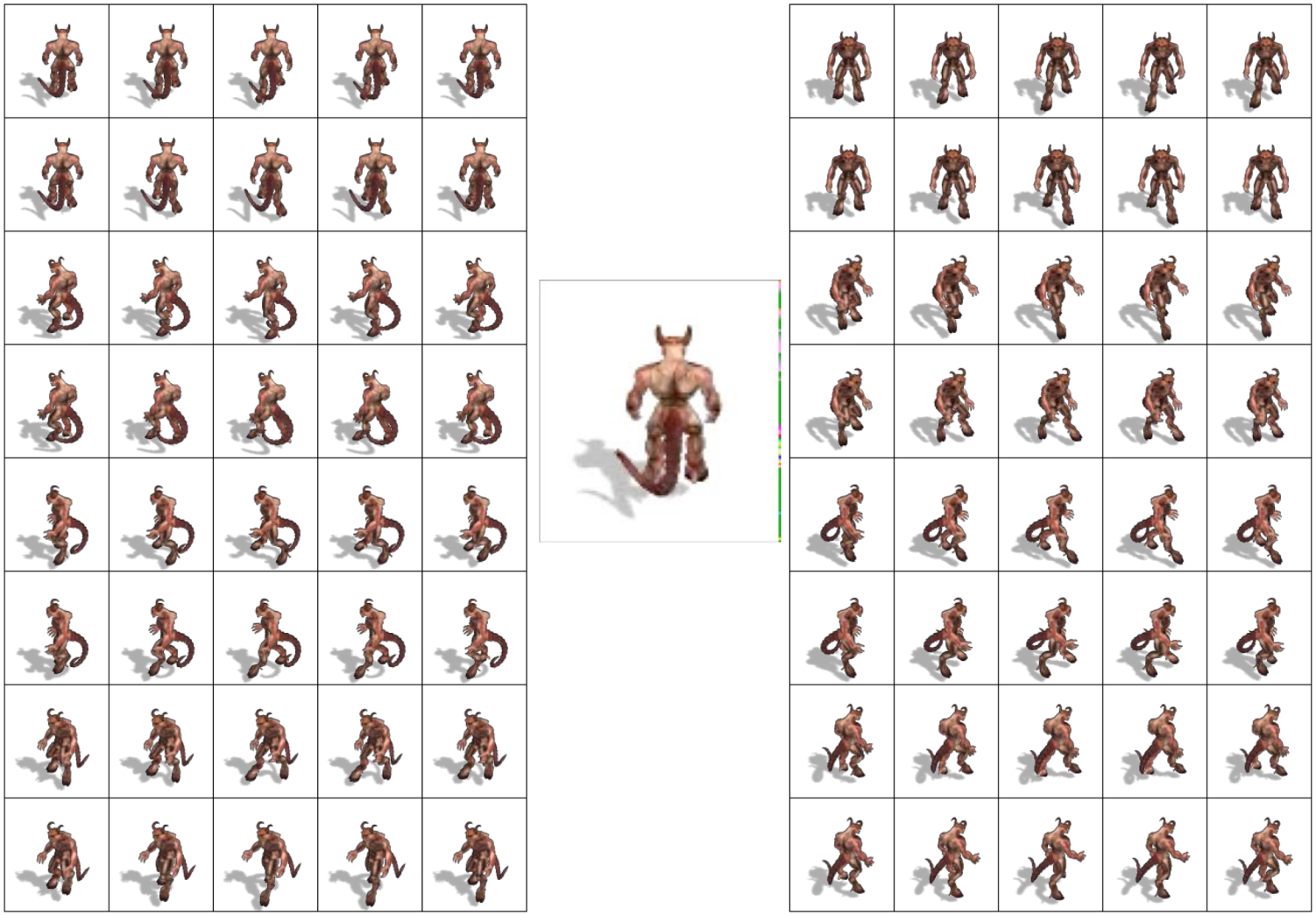




Isometric Walking Animation



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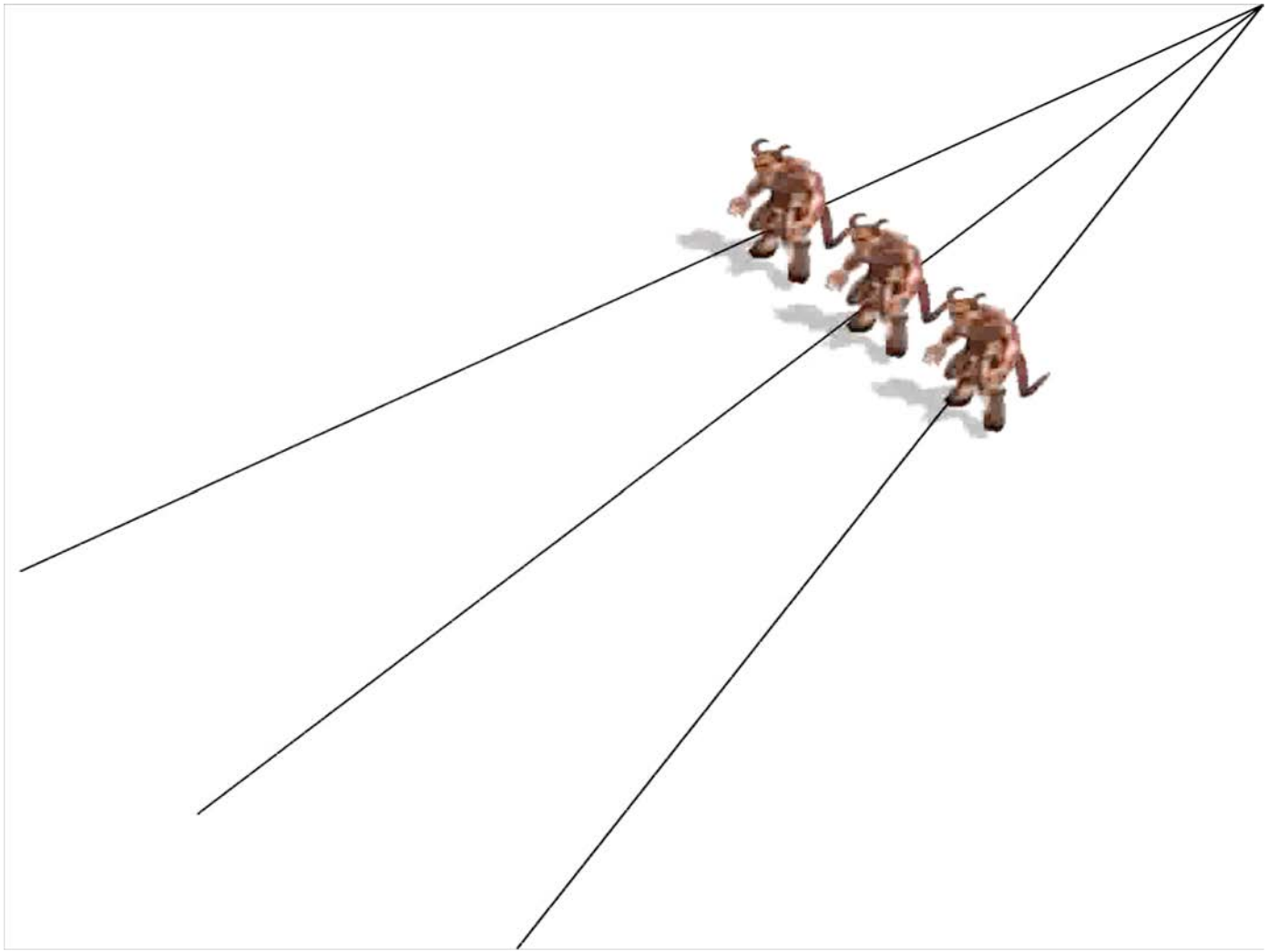


Which Style to Use?

Orthographic

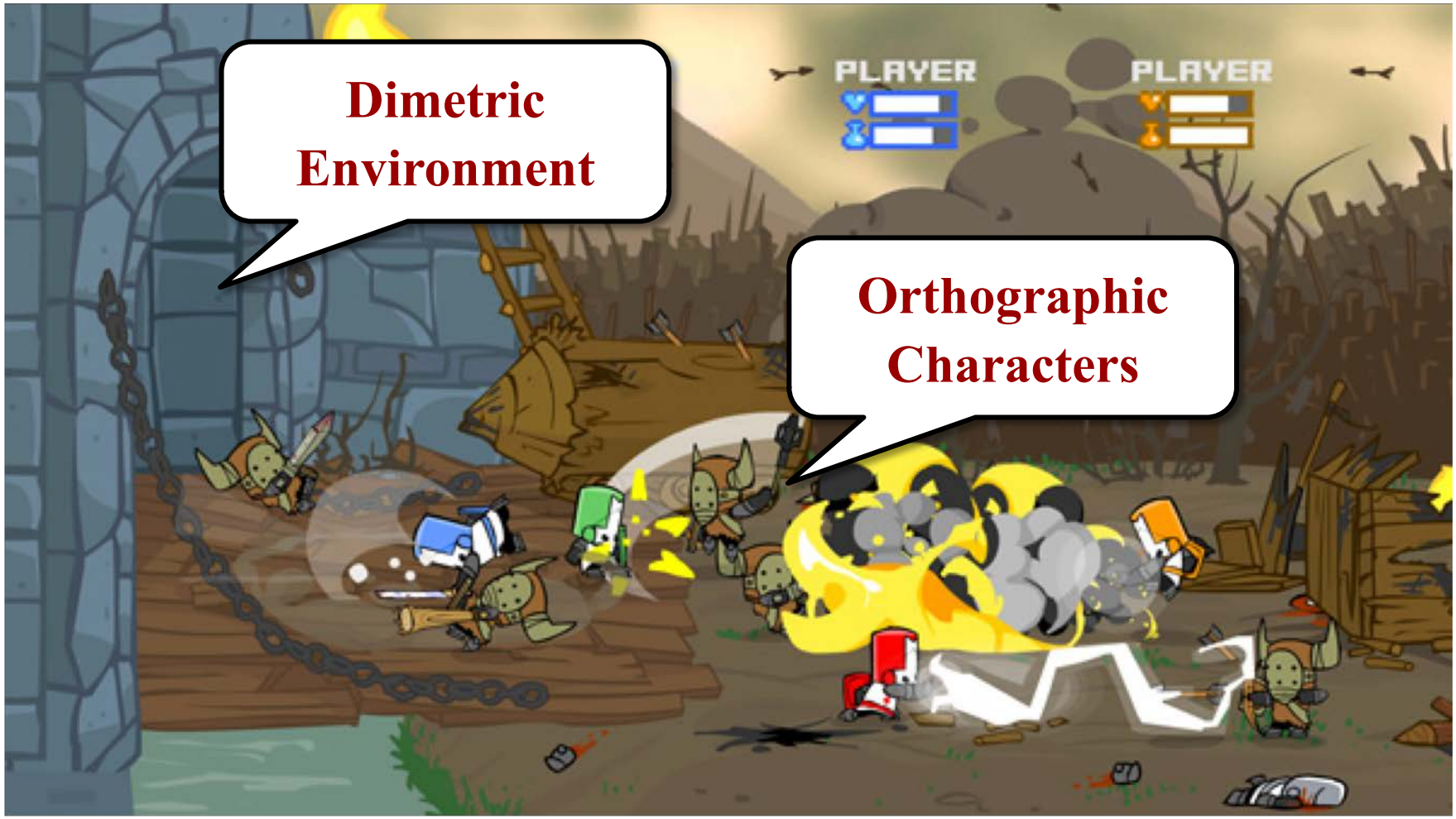
- **Advantages**
  - Easy to make tiles
  - Easy to composite
- **Disadvantages**
  - Movement is 2D
  - Game feels flat
- Common in this class

Axonometric

- **Advantages**
  - Sort of easy to tile
  - Some 3-D movement
- **Disadvantages**
  - Harder to composite
  - Objects may be hidden
- Lot of work for artist

Combining the Perspectives

Combining the Perspectives



Summary

- Camera represents "eye space" coordinates
  - 3D games have arbitrary camera movement
  - 2D games are limited to scrolling movement
- 2-D art requires you chose a projection
  - **Orthographic** is easy, but limits gameplay
  - **Axonometric** has better gameplay, but harder to draw
- Axonmetric type depends on style of game
  - Isometric common to classic RPGs
  - Dimetric gives depth to traditional orthographic