

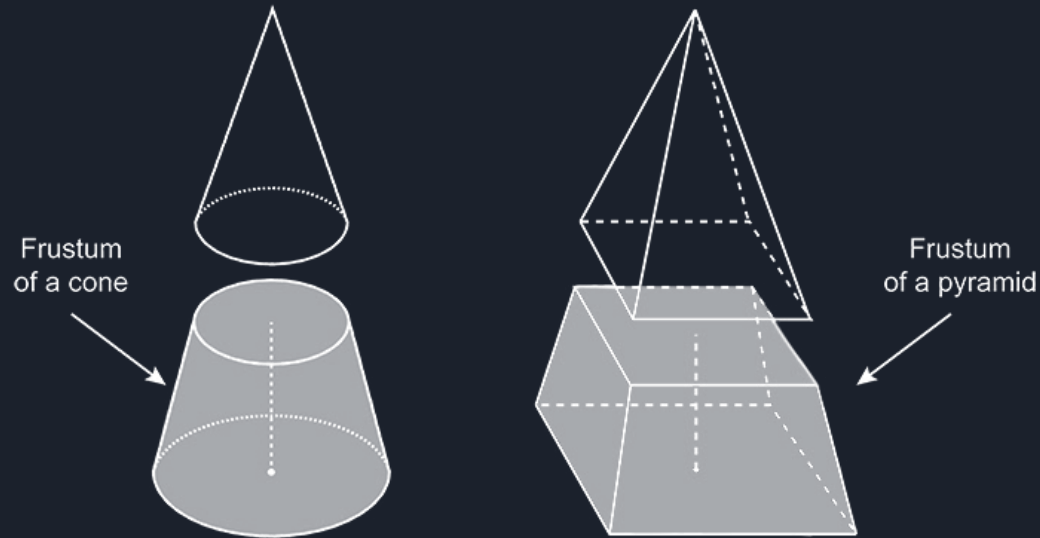



Viewing Frustum & Culling

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What is a Frustum?

- A geometric shape
- Slice cone or pyramid parallel to the base
- For “viewing frustum,” pyramid is the concern



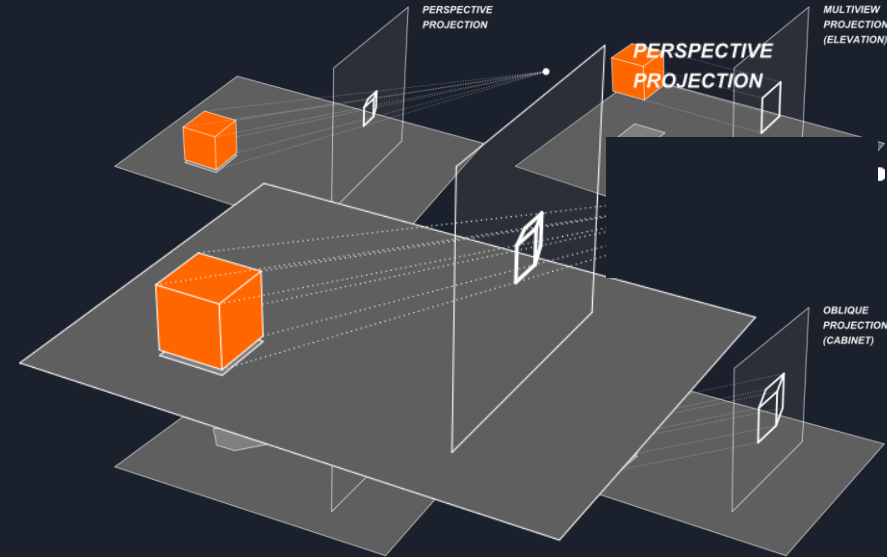


Three Dimension World, 2 Dimension Screen

- While rendering (read: displaying) 3D imagery, PC must convert Lengths/Vertices/Depth -> 2D image
- This is done using projection
- Projection: A method of displaying a 3D Object onto a 2D Surface

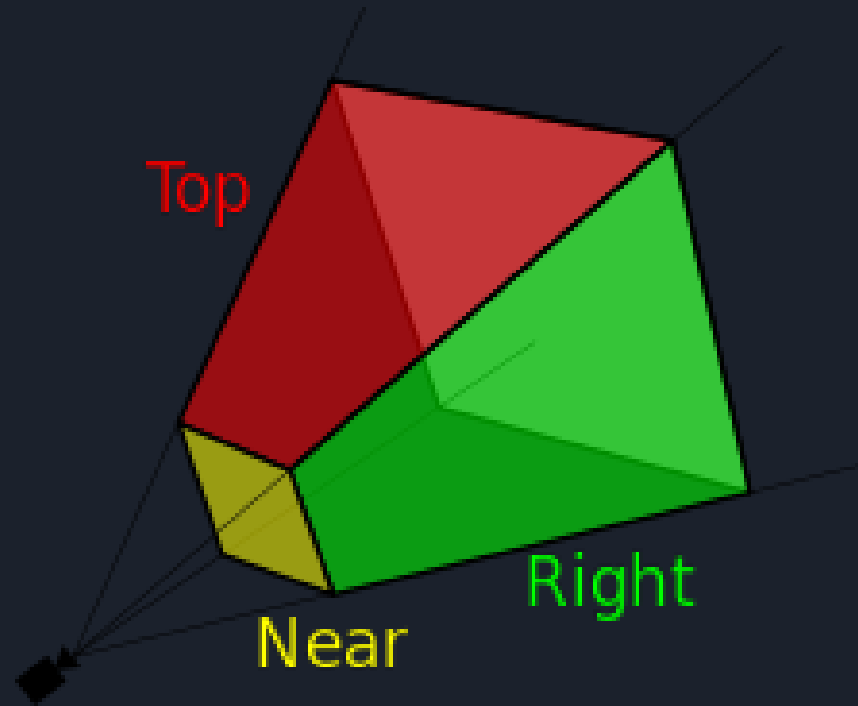
A Visualization:

- Several types of projection methods exist
- Most Relevant is the Perspective Projection
- This is the way eyes and cameras see
- Note: by cutting off the area between the “eye” and the “screen,” we get our frustum shape



Three Dimension World, 2 Dimension Screen

- What you “see” is only between nearplane (monitor) and farplane (arbitrary)
- The area between the physical you (camera) and monitor (nearplane), would be visible if you were actually viewing the world
- Effectively, your monitor acts like a window
- This clipping is so natural most people don’t even notice or think about it, and it lets computers save on resources through:



Here is the final equation to compute the value used to scale the coordinates of the projected point:

$$S = \frac{1}{\tan\left(\frac{fov}{2} * \frac{\pi}{180}\right)}$$

And thus we have the final version of our basic perspective projection matrix:

$$\begin{bmatrix} S & 0 & 0 & 0 \\ 0 & S & 0 & 0 \\ 0 & 0 & -\frac{f}{(f-n)} & -1 \\ 0 & 0 & -\frac{f * n}{(f-n)} & 0 \end{bmatrix}$$



View Frustum Culling

- Math for drawing, rendering, and projecting objects is computationally expensive
- PCs contain a specialized and very monetarily (\$\$\$) expensive component (GPU) which does exactly that
- Using the concept of view frustum helps by letting PC know what the user can see
- Real time and Render time performance benefits
 - Real time: games do this
 - Render time: Big budget animations do this

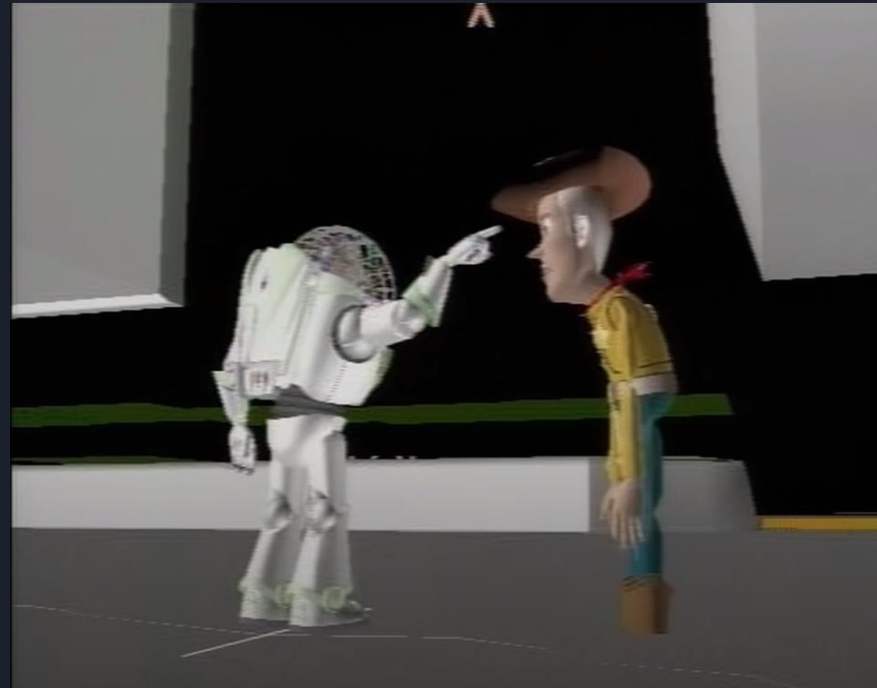
Real Time Performance: Horizon Zero Dawn

- Famous GIF from the game Horizon: Zero Dawn
- Representation of the view frustum lets computer know what can be seen
 - The GPU can skip doing the math on what these parts of the level should look like (still there!)
 - Increases performance due to lowered utilization



Render Time Performance: Toy Story

- Not just games, all 3D renderings make use of Frustum Culling because it's quick, easy, and effective
- Animated cartoons like Toy Story need to individually render out "frames" (still images that make up video) and put them together to make the final video you watch.
- Each frame of Toy Story, in 1995, could take anywhere from an hour to over a day
- Imagine how long it would take if entire scenes had to be rendered rather than slices





Works Cited

- View Frustum Culling <http://www.lighthouse3d.com/tutorials/view-frustum-culling/>
- Why Frustum Culling Matters, and Why It's Not Important <https://gist.github.com/nothings/913056601b56e5719cc987684a16544e>
- The Perspective and Orthographic Projection Matrix <https://www.scratchapixel.com/lessons/3d-basic-rendering/perspective-and-orthographic-projection-matrix/building-basic-perspective-projection-matrix>
- Horizon Zero Dawn Uses All Sorts Of Clever Tricks To Look So Good <https://kotaku.com/horizon-zero-dawn-uses-all-sorts-of-clever-tricks-to-lo-1794385026>