Physical and Synthetic Images

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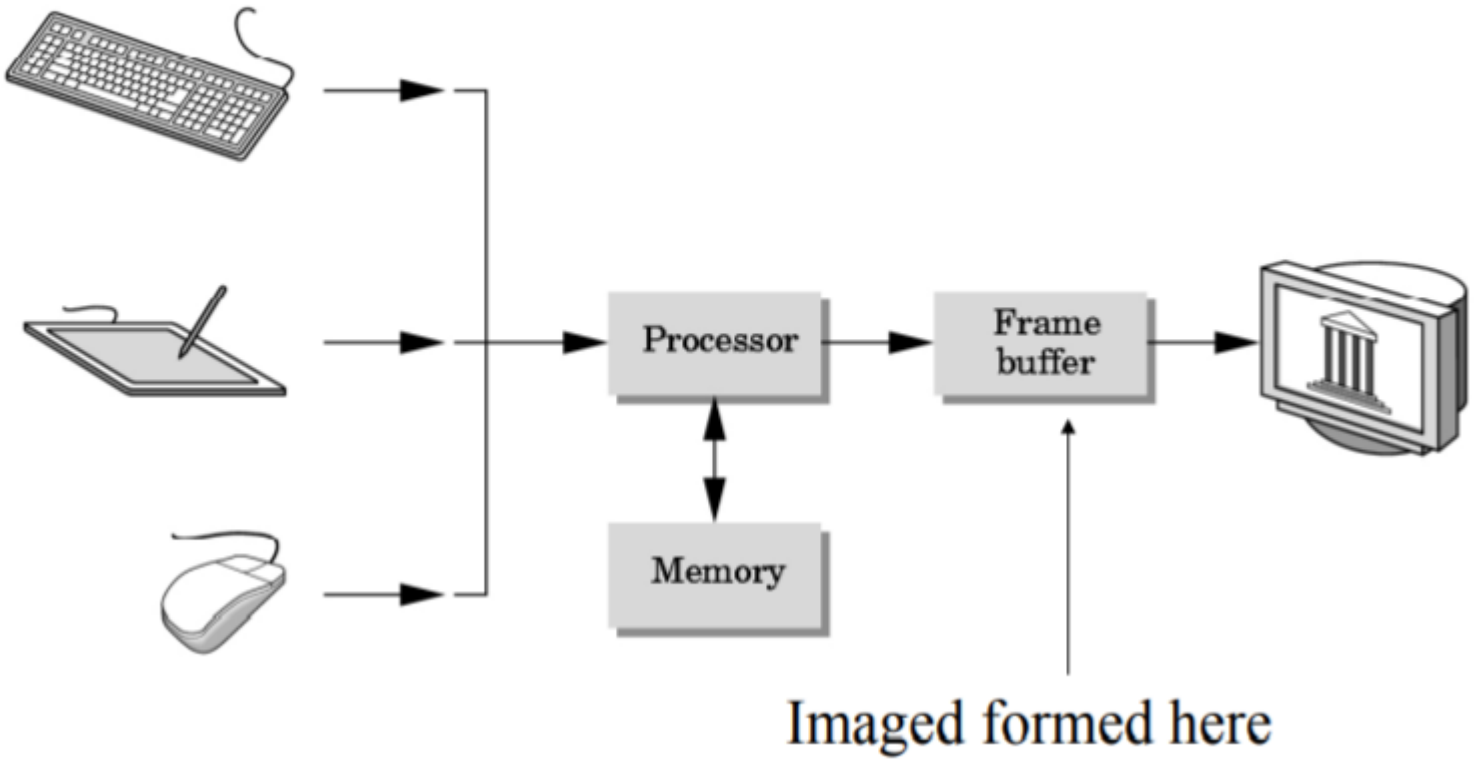
SCOPE, VIT-AP

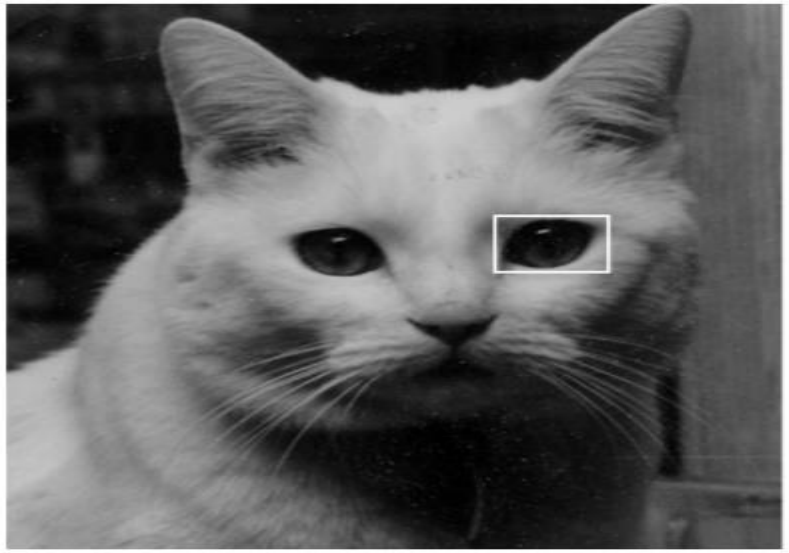
A Typical Graphics System



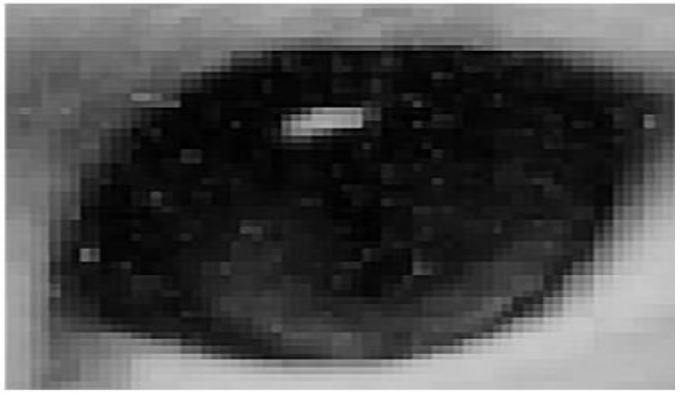
Pixels and the Frame Buffer

- All graphics systems are raster-based.
- A picture is produced as an array – the raster – of picture elements, pixels.
- Each pixel corresponds to a small area of the image

Pixels are stored in a part of memory called the **frame buffer**.



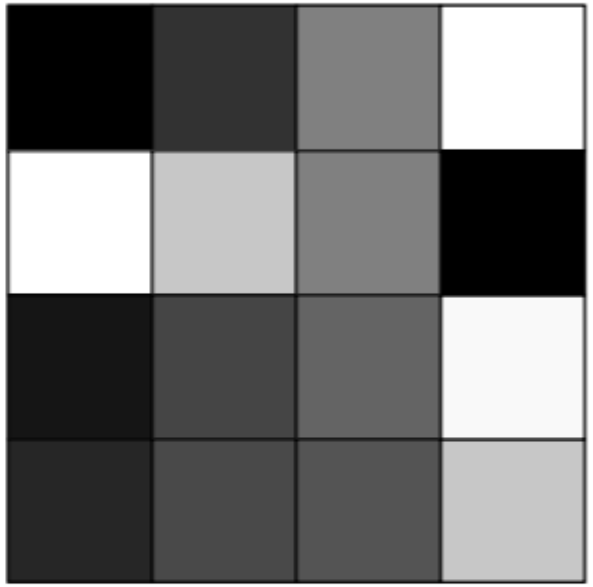
A) Image of Yeti the cat.



B) Detail of area around one eye showing individual pixels.

A sample Image in Pixel_Gray_Map (PGM) Format

```
P2
# test
4 4
255
0     50    127   255
255   200   127   0
10    60    100   250
20    70    80    200
```



This is a 4_by_4 8 bit image, i.e., 255 represents white and 0 represents black, other numbers are used for different shades of gray.

Pixels and the Frame Buffer

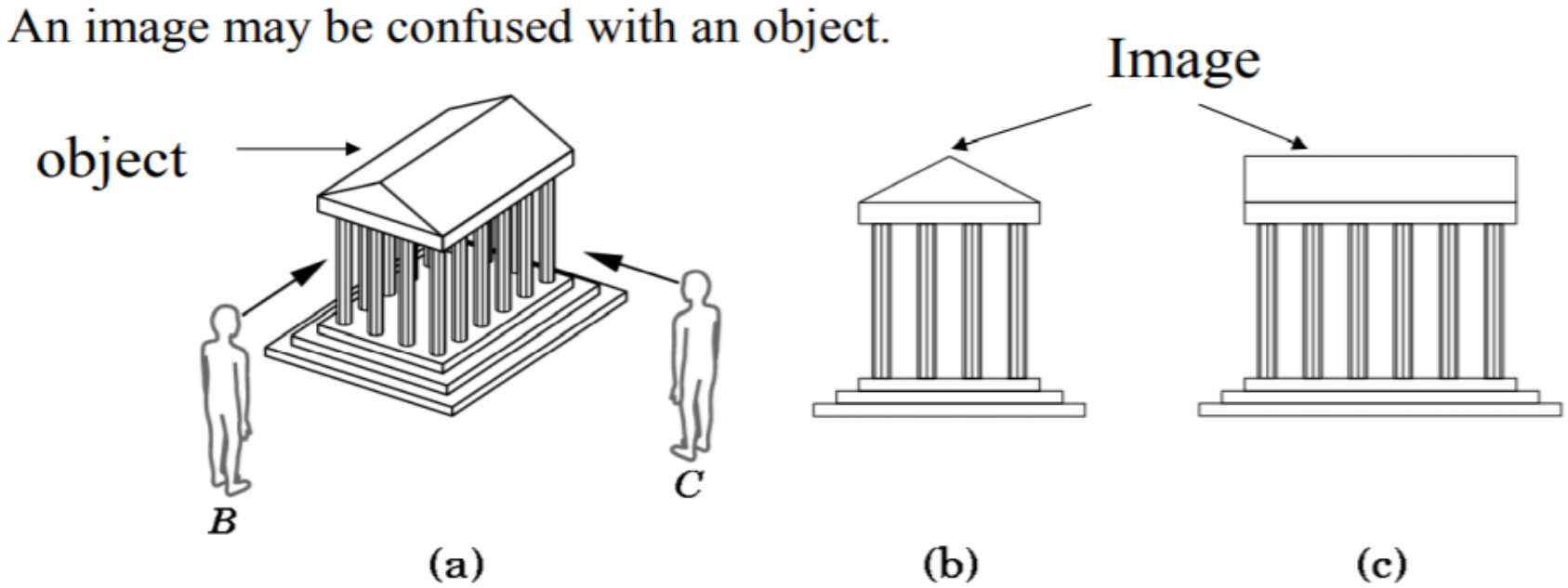
- The depth of the frame buffer, defines the number of bits that are used for each pixel and defines the number of colors.
- The resolution is the number of pixels in the frame buffer and determines the detail that you can see in the image.
- The conversion of geometric entities to pixel assignments in the frame buffer is known as rasterization, or scan conversion.

Physical and Synthetic Images

- A computer generated image is a synthetic or artificial,
- In the sense that the object being imaged does not exist physically.
- In order to understand how synthetic images are generated, we first look into the ways traditional imaging systems such as cameras form images.

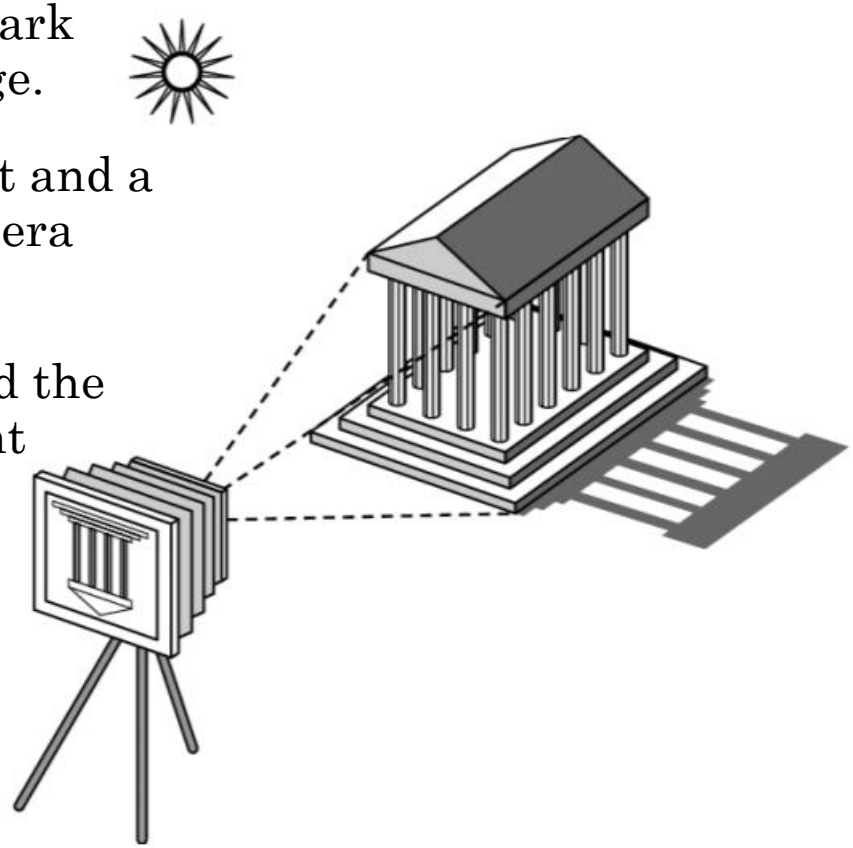
Physical imaging systems

- To form an image, we must have someone, or something, that is viewing our objects, be it a human, a camera, or a digitizer.
- It is the viewer that forms the image of our objects.
- In human visual system, the image is formed on the back of the eye, on the retina. In a camera, the image is formed on the film plane.

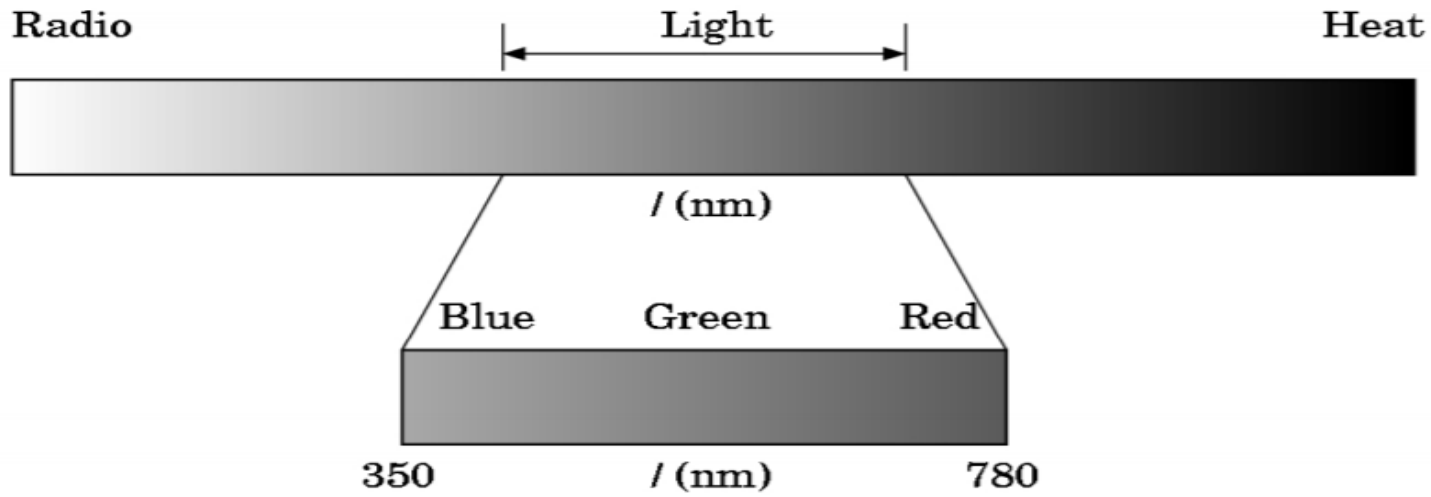


Light and Images

- If there is no light source, an object would be dark and there won't be anything visible of the image.
- Light usually strikes various parts of the object and a portion of the reflected light will enter the camera through the lens.
- The details of the interaction between light and the surfaces of the object determine how much light enters the camera.
- Light is formed of electromagnetic radiation characterized by its wavelength or frequency.



- The electromagnetic spectrum includes radio waves, infrared (heat), and a portion that causes a response in our visual systems, visible light spectrum.

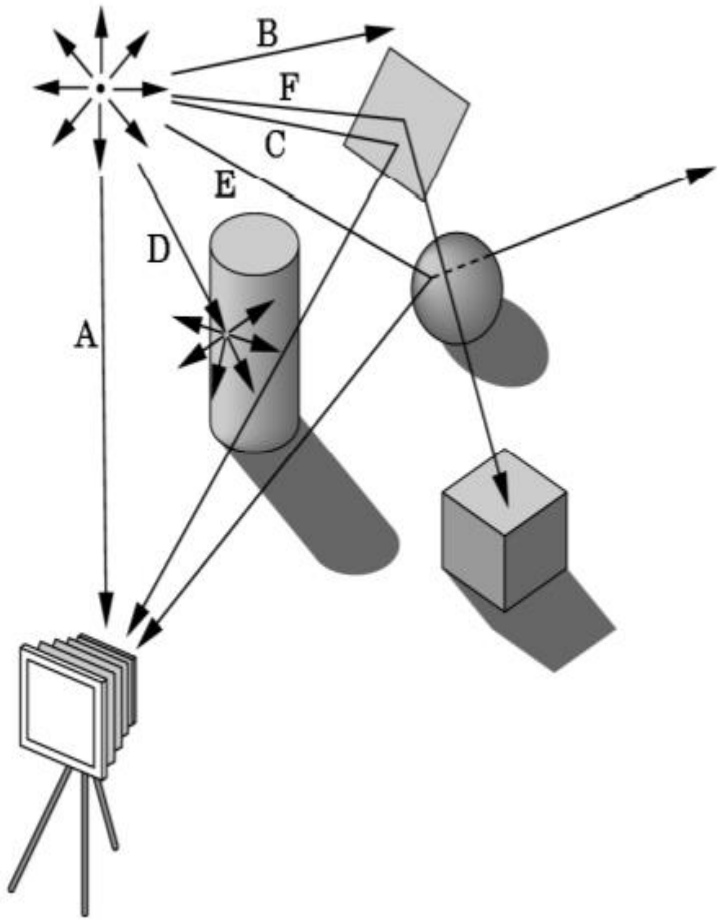


The color of light source is determined by the energy that it emits at various wavelengths.

In graphics, we use the geometric optics which models light sources as emitters of light energy that have a fixed rate or intensity

Ray tracing

- We can model an image by following light from a source. The light that reaches the viewer, will determine the image-formation.
- Ray tracing is an image-formation technique used as the basis for producing computer-generated images.
- A ray is a semi-infinite line that emanates from a point and travels to infinity in a particular direction.
- Light travels in straight line, thus only a portion the light will get to the viewer.
- The light from the light source can interact with the surface of the object differently, depending on the orientation and the luminosity of the surface.



The Human Visual System

Lights enters the eye through Cornea and Lens.

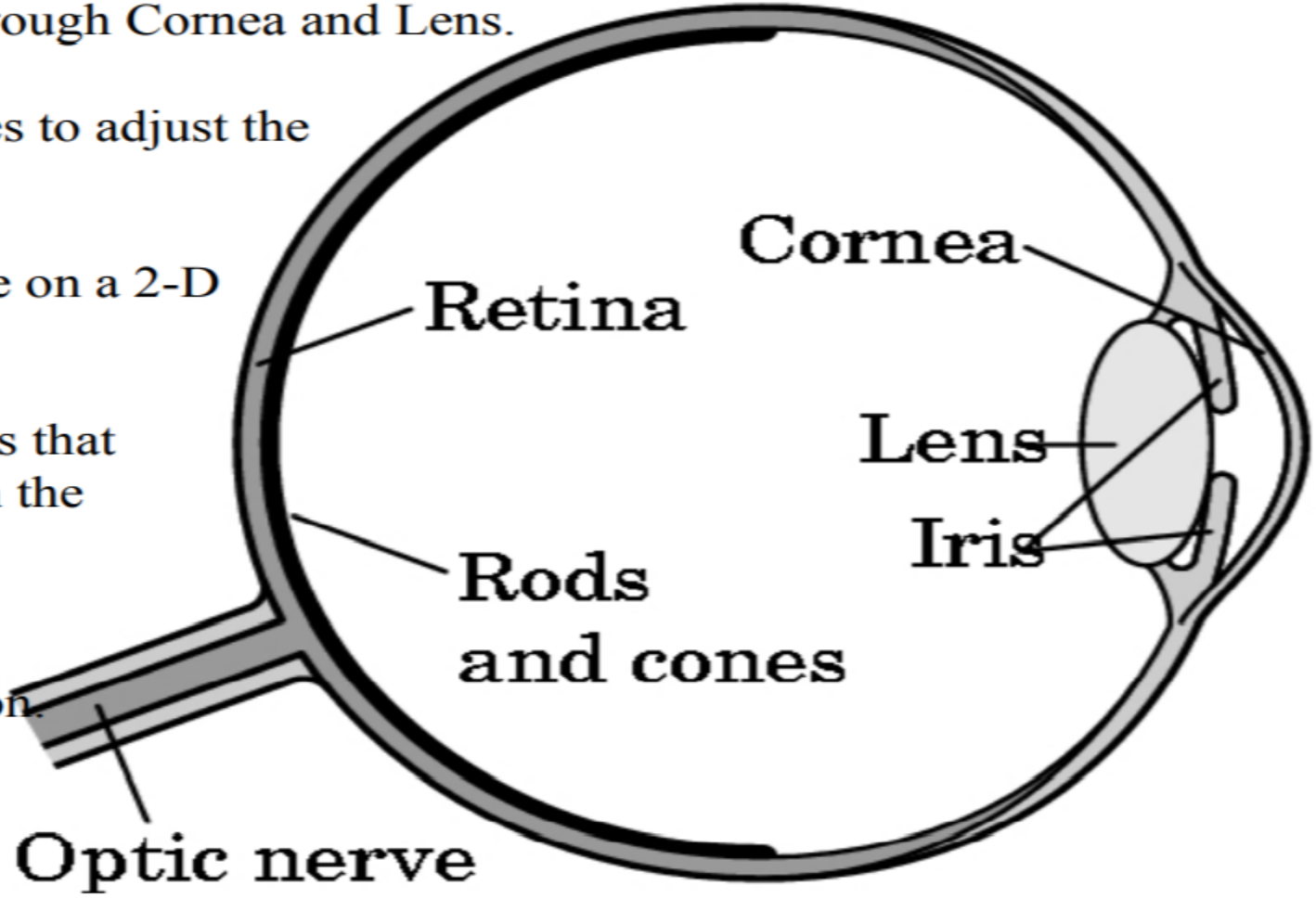
The Iris opens and closes to adjust the amount of light.

The lens forms an image on a 2-D structure called Retina.

There are rods and cones that Act like light sensors on the Retina.

Rods are low-level light sensors, night vision.

Cones are responsible for our day vision.

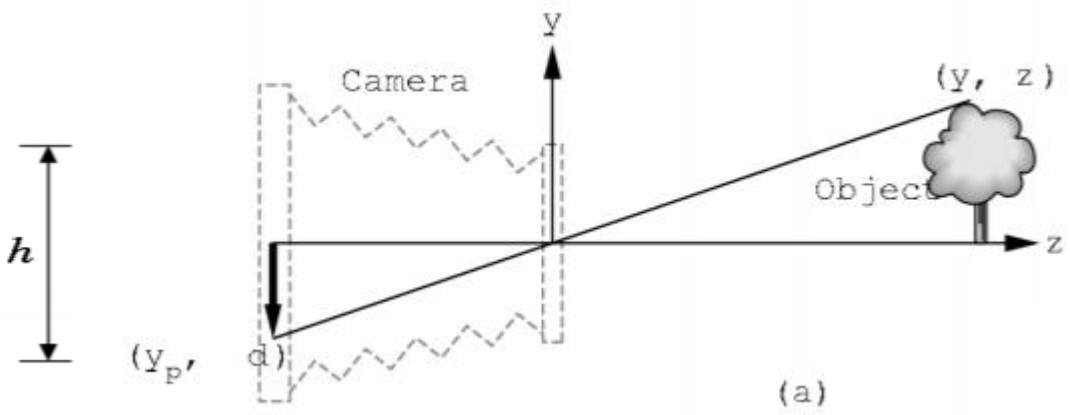


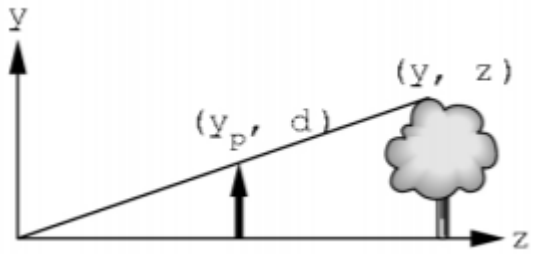
Synthetic Imaging

- Synthetic images are computer-generated image that are similar to forming an image using an optical system.
- This paradigm is known as synthetic-camera model.
- The image is formed on the back of the camera, so we can emulate this process to create artificial images
- We can compute the image using simple trigonometric calculations.

$$\tan(\theta) = \frac{h/2}{d}$$

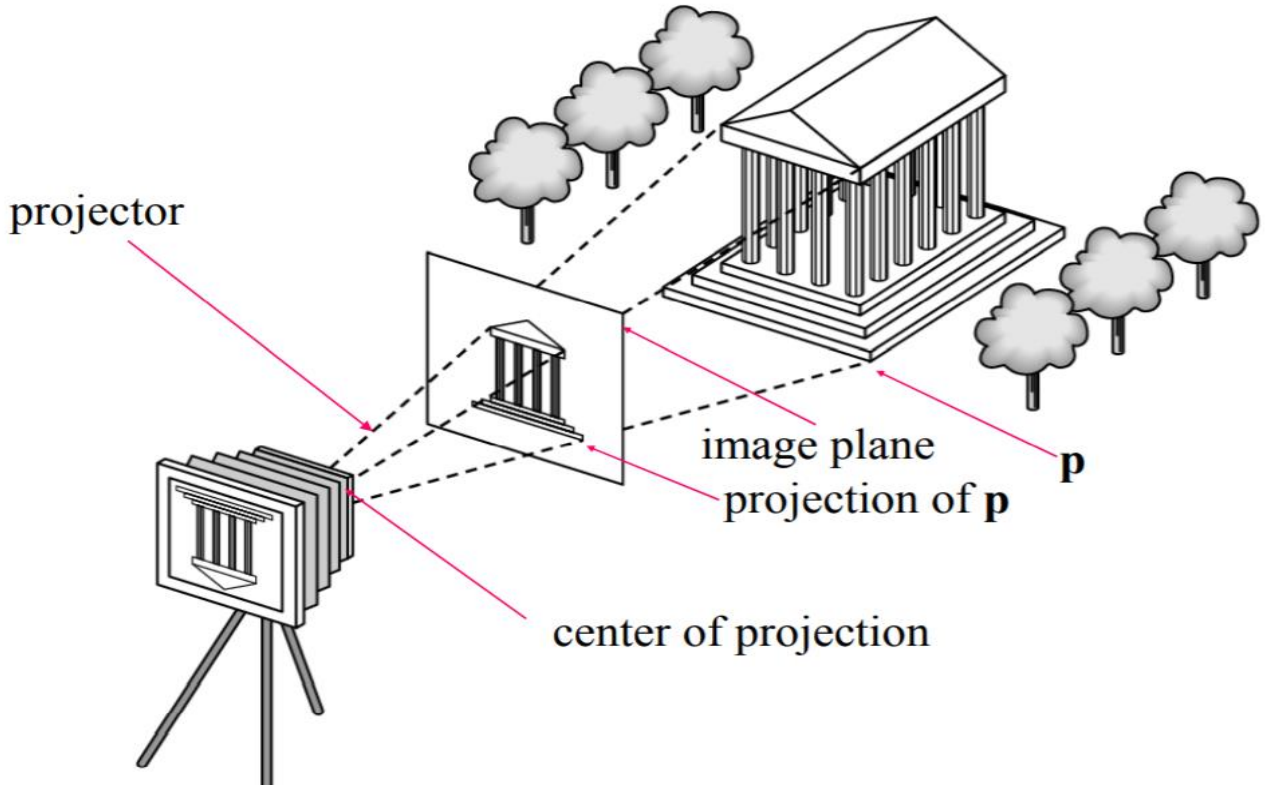
$$\theta = 2\tan^{-1}\frac{h}{2d}$$





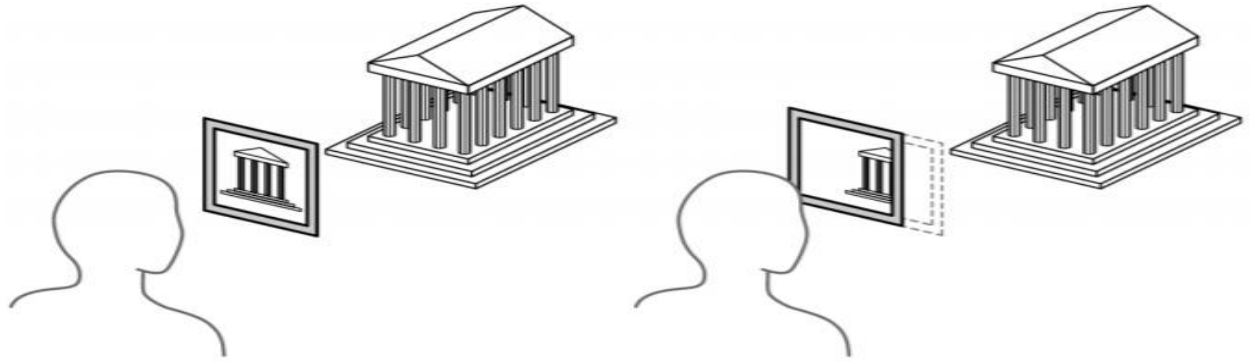
Synthetic Imaging

- We find the image of a point on the object by drawing a line, projector, from the point to the center of the lens, or the center of projection. In our synthetic camera, the film plane is moved in front of the lens and is called Projection plane.



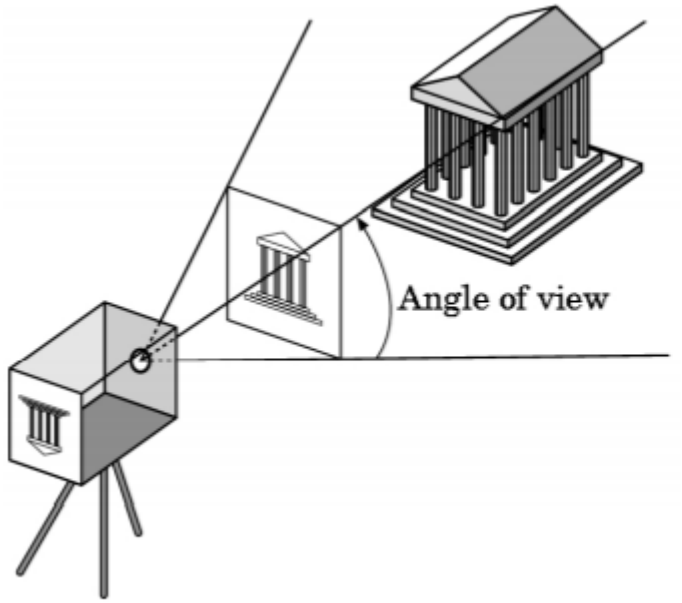
Synthetic Imaging

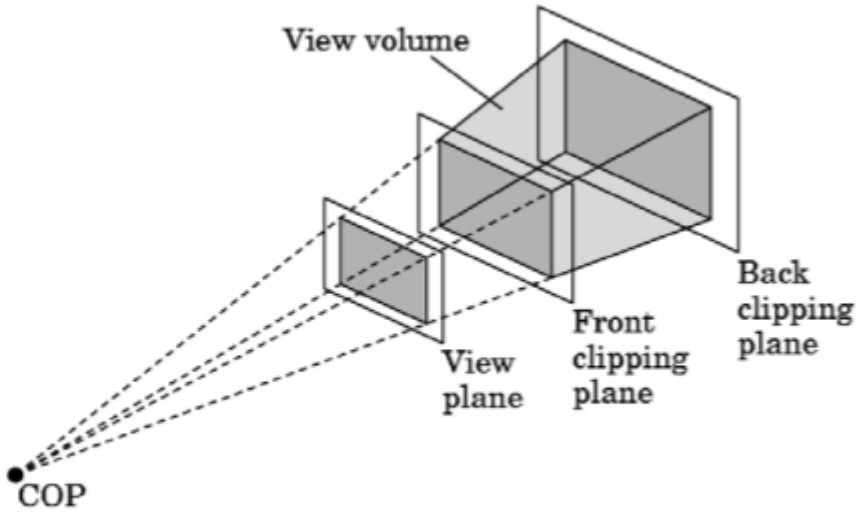
- We must consider the limited size of the image. Not all objects can be imaged onto the camera film plane. The angle of view expresses this limitation.
- In our synthetic camera, we place this limitation by placing a clipping rectangle or clipping window in the projection plane.



(a) (b)

Given the location of the center of the projection, the location and orientation of the projection plane, and the size of the clipping rectangle, we can determine which objects will appear in the image.


Angle of view


View volume
Back clipping plane
Front clipping plane
View plane
COP