

Image Formation

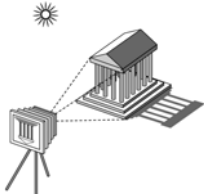
Objectives :

- Fundamental imaging notions
- Physical basis for image formation
 - Light
 - Color
 - Perception
- Synthetic camera model
- Other models

Image Formation

- In computer graphics, we form images which are generally two dimensional using a process analogous to how images are formed by physical imaging systems
 - Cameras
 - Microscopes
 - Telescopes
 - Human visual system

Elements of Image Formation

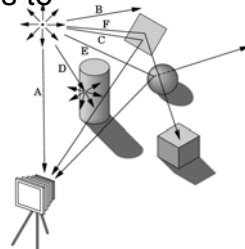
- Objects
 - Viewer
 - Light source(s)
- 
- Attributes that govern how light interacts with the materials in the scene
 - Note the independence of the objects, the viewer, and the light source(s)

Light

- *Light* is the part of the electromagnetic spectrum that causes a reaction in our visual systems
- Generally these are wavelengths in the range of about 350-750 nm (nanometers)
- Long wavelengths appear as reds and short wavelengths as blues

Ray Tracing and Geometric Optics

One way to form an image is to follow rays of light from a point source finding which rays enter the lens of the camera. However, each ray of light may have multiple interactions with objects before being absorbed or going to infinity.



Angel: Interactive Computer Graphics 4E © Addison-Wesley 2005

KENT STATE 5

Luminance and Color Images

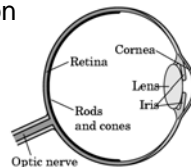
- Luminance Image
 - Monochromatic
 - Values are gray levels
 - Analogous to working with black and white film or television
- Color Image
 - Has perceptual attributes of hue, saturation, and lightness
 - Do we have to match every frequency in visible spectrum? No!

Angel: Interactive Computer Graphics 4E © Addison-Wesley 2005

KENT STATE 6

Three-Color Theory

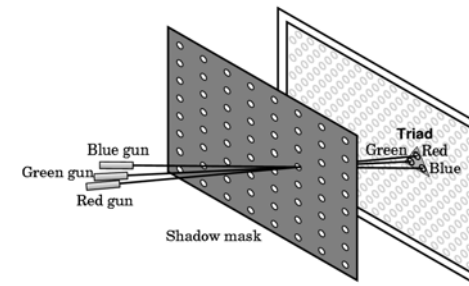
- Human visual system has two types of sensors
 - Rods: monochromatic, night vision
 - Cones
 - Color sensitive
 - Three types of cones
 - Only three values (the *tristimulus* values) are sent to the brain
- Need only match these three values
 - Need only three *primary* colors



Angel: Interactive Computer Graphics 4E © Addison-Wesley 2005

KENT STATE 7

Shadow Mask CRT



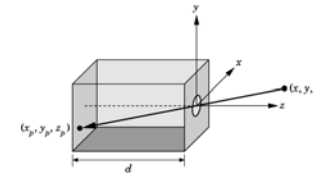
Angel: Interactive Computer Graphics 4E © Addison-Wesley 2005

KENT STATE 8

Additive and Subtractive Color

- Additive color
 - Form a color by adding amounts of three primaries
 - CRTs, projection systems, positive film
 - Primaries are Red (R), Green (G), Blue (B)
- Subtractive color
 - Form a color by filtering white light with cyan (C), Magenta (M), and Yellow (Y) filters
 - Light-material interactions
 - Printing
 - Negative film

Pinhole Camera

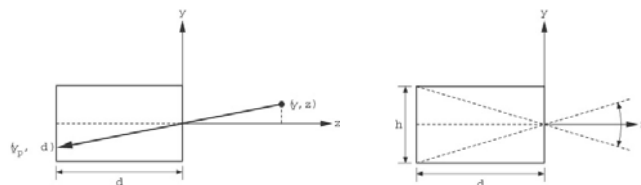


Use trigonometry to find projection of point at (x, y, z)

$$x_p = -x/z/d \quad y_p = -y/z/d \quad z_p = d$$

These are equations of simple perspective

Pinhole Camera



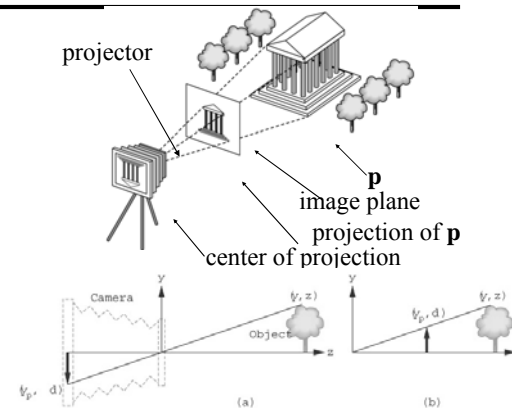
$$x_p = -x/z/d$$

$$y_p = -y/z/d$$

$$z_p = d$$

Angle of View
 $\theta = 2 \tan^{-1} h/2d$

Synthetic Camera Model

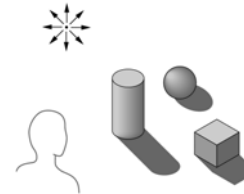


Advantages

- Separation of objects, viewer, light sources
- Two-dimensional graphics is a special case of three-dimensional graphics
- Leads to simple software API
 - Specify objects, lights, camera, attributes
 - Let implementation determine image
- Leads to fast hardware implementation

Global vs Local Lighting

- Cannot compute color or shade of each object independently
 - Some objects are blocked from light
 - Light can reflect from object to object
 - Some objects might be translucent



Why not ray tracing?

- Ray tracing seems more physically based so why don't we use it to design a graphics system?
- Possible and is actually simple for simple objects such as polygons and quadrics with simple point sources
- In principle, can produce global lighting effects such as shadows and multiple reflections but ray tracing is slow and not well-suited for interactive applications