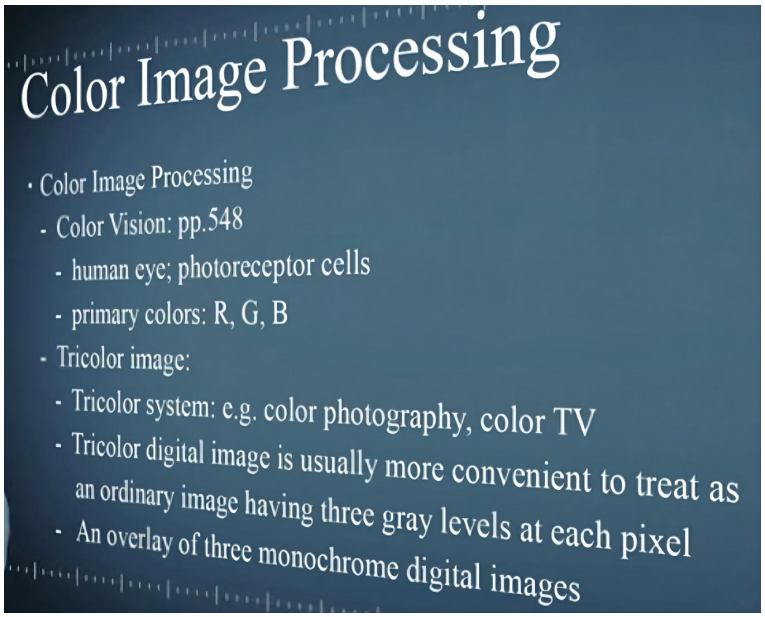
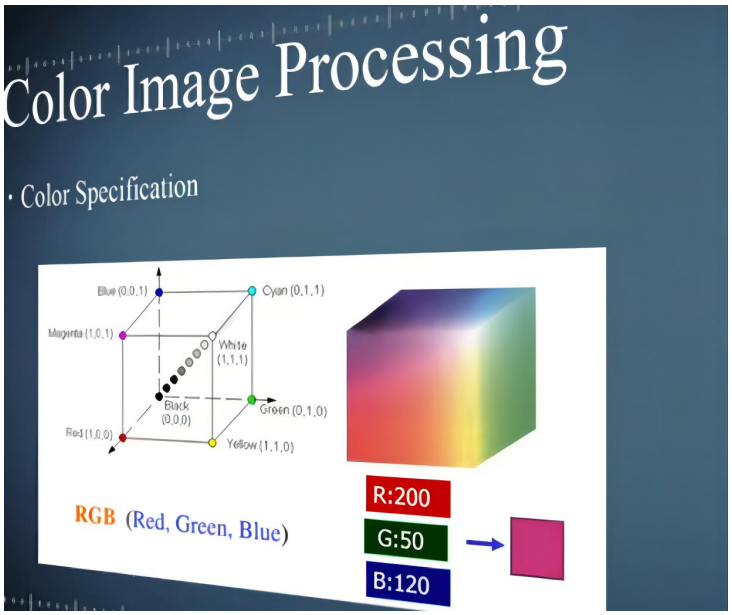
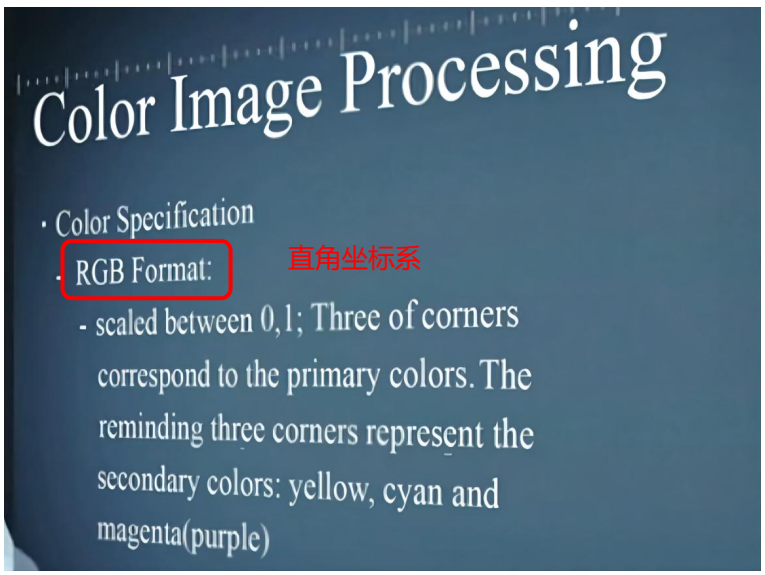
5 第五周 彩色图像和三维图像

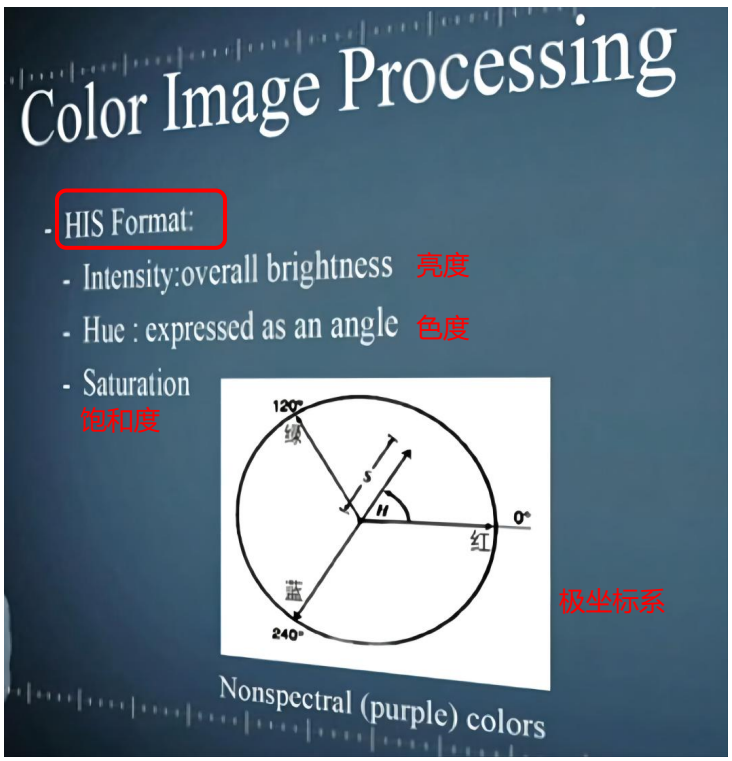
5.1 彩色图像

5.1.1 视觉系统基础 (Visual System)









总结:

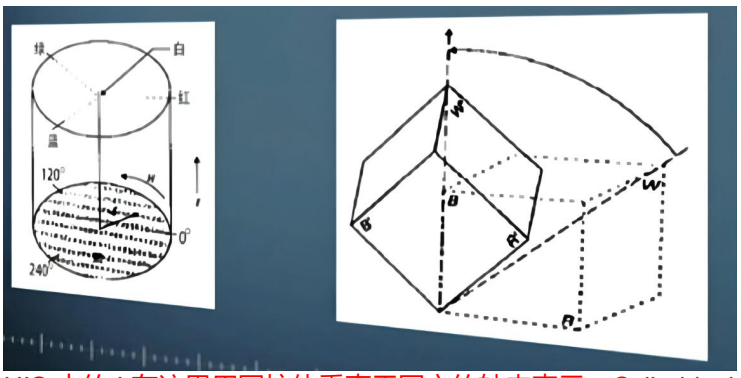
Color Image Processing

- Color Coordinate Conversion:
  - RGB to HIS:
    - Establishing an (x,y,z) coordinate system in which the RGB cube is rotated so that its diagonal lies along the z-axis and its R-axis lies in the xz-plane.

$$x=\frac{1}{\sqrt{6}}[2R-B-G] \quad y=\frac{1}{\sqrt{2}}[G-B]$$

$$z=\frac{1}{\sqrt{3}}[R+G+B]$$

$$\rho=\sqrt{x^2+y^2} \quad \phi=ang(x,y)$$

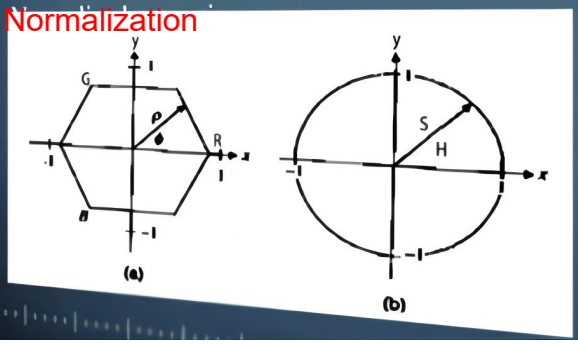


HIS 中的 I 在这里用圆柱体垂直于圆心的轴来表示。Cylindrical coordinates）以黑色像素点和白色像素点的连线为转轴来旋转正方体，旋转360°，它就描述了整个极坐标系。

Color Image Processing

- Color Coordinate Conversion:
  - RGB to HIS:
    - Cylindrical coordinates (θ,ρ,z) corresponds to (H,S,I)
    - Normalization

六边形需要经过normalization，才能形成圆。
对饱和度 S 进行。



Color Image Processing

$$S=\frac{\rho}{\rho_{max}}=1-\frac{3\min(R,G,B)}{R+G+B}=1-\frac{\sqrt{3}}{I}\min(R,G,B)$$

$$\theta=\cos^{-1}\left[\frac{\frac{1}{2}[(R-G)+(R-B)}{(R-G)^2+(R-B)(G-B)}\right]$$

$$H=\begin{cases}\theta & G\geq B\\ 2\pi-\theta & G\leq B\end{cases}$$

Color Image Processing

- Color Coordinate Conversion:
  - HIS to RGB :
    - Converting formulas are different depending on the H:

Color Image Processing

$0^0\leq H\leq 120^0$

$$R=\frac{1}{\sqrt{3}}\left[1+\frac{S\cos(H)}{\cos(60^\circ-H)}\right] \quad B=\frac{1}{\sqrt{3}}(1-S) \quad G=\sqrt{3}I-R-B$$

$120^0\leq H\leq 240^0$

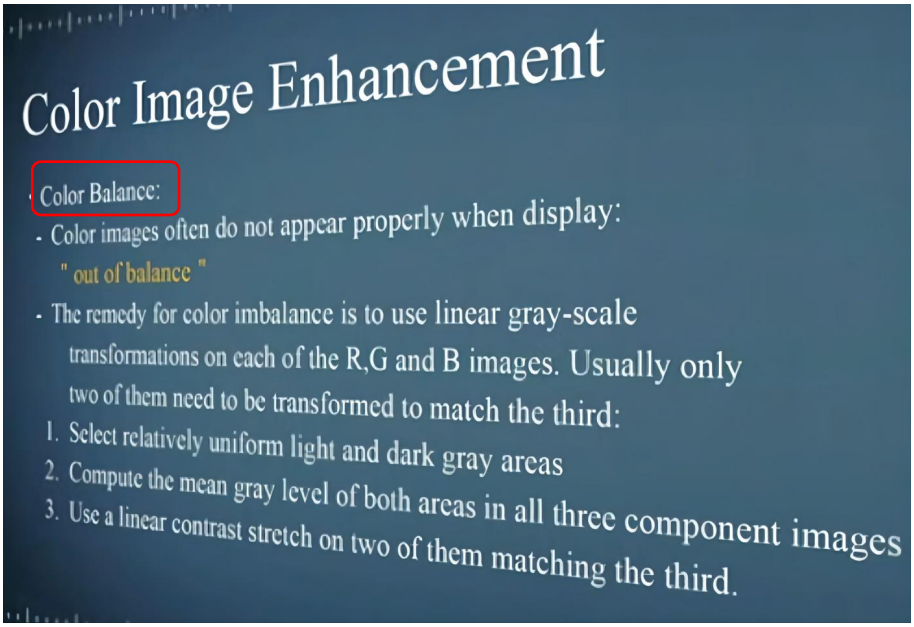
$$G=\frac{1}{\sqrt{3}}\left[1+\frac{S\cos(H-120^\circ)}{\cos(180^\circ-H)}\right] \quad R=\frac{1}{\sqrt{3}}(1-S) \quad B=\sqrt{3}I-R-G$$

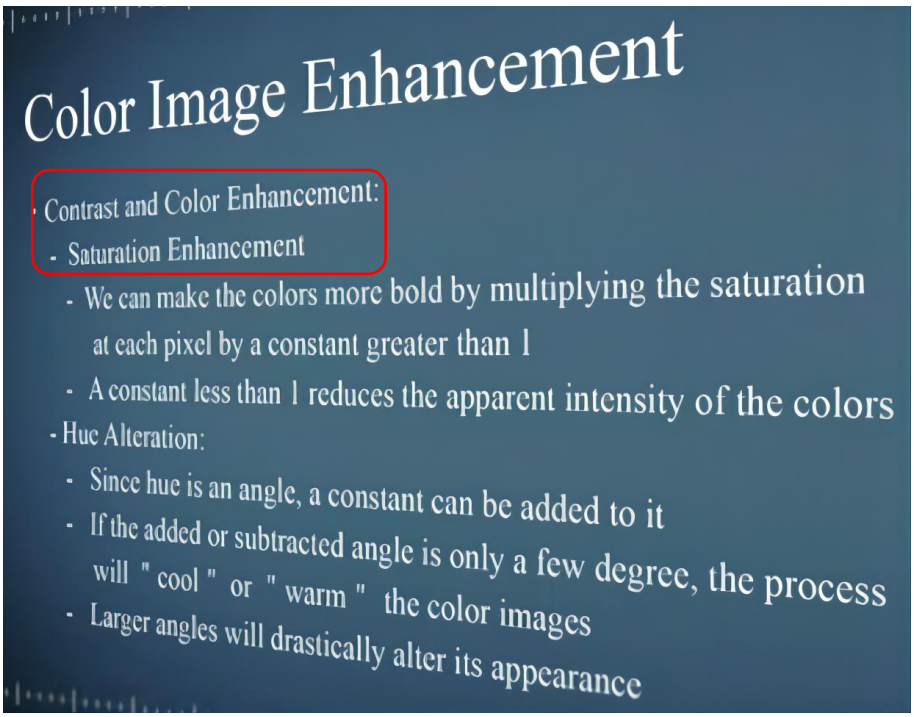
$240^0\leq H\leq 360^0$

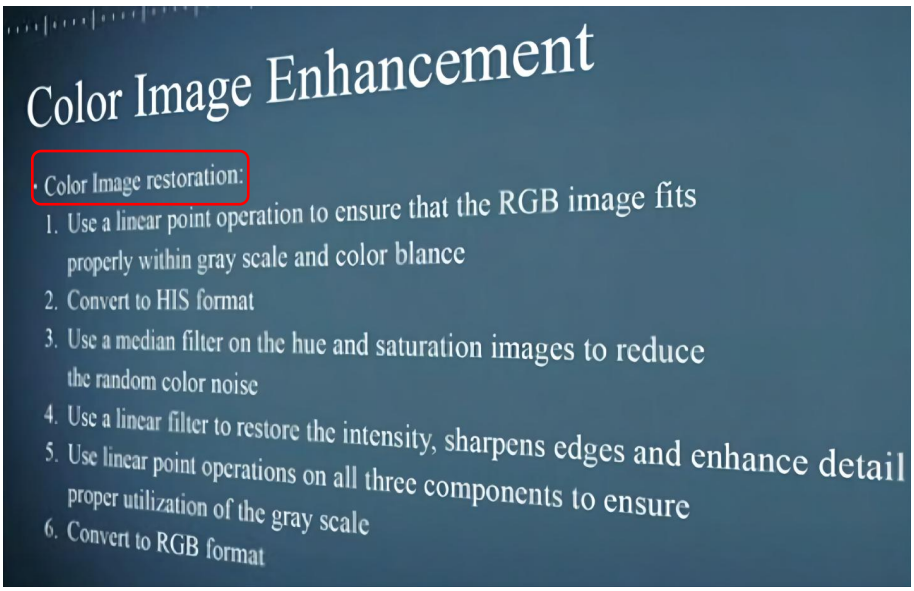
$$B=\frac{1}{\sqrt{3}}\left[1+\frac{S\cos(H-240^\circ)}{\cos(300^\circ-H)}\right] \quad G=\frac{1}{\sqrt{3}}(1-S) \quad R=\sqrt{3}I-G-B$$

总结：

5.1.2 彩色图像的表示方法 (Color Image Formats)



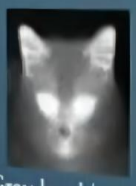




总结:

Color Image Enhancement

- Pseudocolor
  - This term refers to generating a color image from a monochrome image by mapping each of the gray levels to a point in color space.
    - Lookup table



Gray level image

Pseudocolor color image

Color Image Analysis

- Color Image Analysis
  - Color Compensation
    - Color spread: since color image digitizers have broad and overlapping sensitivity spectra, one seldom obtains complete isolated objects in three component images.

- Color spread can be modeled as a linear transformation.
  Matrix C specify how the colors are spread among the three channels. Cij is the proportion of brightness of point j that appears in channel i. X be the 3 by 1 vector of actual brightness at a particular pixel:

$$Y = Cx + b \qquad b: \text{black-level offset}$$

And

$$x = C^{-1}[y-b]$$

- Color Image Analysis
  - Color Compensation
    - Let E specify the relative exposure time set in each channel,

$$y = ECx + b$$

And

$$x = C^{-1}E^{-1}[y-b]$$

- $C^{-1}E^{-1}$: modified color compensation matrix.
- A simple way to modify the color compensation matrix to account for variation in exposure time.

Color Image Segmentation

- Color Image Segmentation:
  - Segmenting a color image by thresholding becomes a process of partitioning color space
  - Different objects often fall into separate clusters of points in a 3D histogram defined in RGB or HIS space.
  - The intensity is seriously effected by illumination and viewing angle
  - It's more productive to segment the image in the hue-saturation plane than that in 3D color space.

彩色图像的分割相对来说容易一些，因为我们可以利用它的彩色信息在不同的 channel 里的表达方式的差异。另外，我们经常也可以将RGB格式的彩色图像转换成HIS格式的，在HIS的 channel 里进行分割也时候也会得到意想不到的效果。

Color Image Measure

- Color Image Measure:
  - Measurements of size and shape are the same as a monochrome image
  - New aspect of color:
    - Average hue
    - Average saturation
    - Average intensity

完成了彩色图像的分割之后，彩色图像中还有一个重要的概念，就是如何去表达彩色图像的特征。这个被成为 Measure。

总结：

5.2 三维图像

5.2.1 三维图像的由来与表示 (Origin and Representation of 3D Image)

Background

二维图像实际上是三维图像投影的结果。

- Spatially three dimensional image:
  - Images have gray levels are a function of three spatial variables
  - For example, Ocean water temperature as a function of x,y and depth etc.
- Two-dimensional (2D) images have been derived from the three-dimensional (3D) world by camera systems that employ a perspective projection to reduce the dimensionality from three to two.

3D Imaging

- Optical Sectioning 切片
  - Serial sectioning: slice the specimen to produce a series of thin sections that may be studied individually to develop an understanding of the 3D structure of the specimen.
  - Two major disadvantage:
    1. Loss of registration that occurs when the sections become separated after slicing
    2. Unavoidable geometric distortion including stretching, curling, folding, and tearing of the thin section.

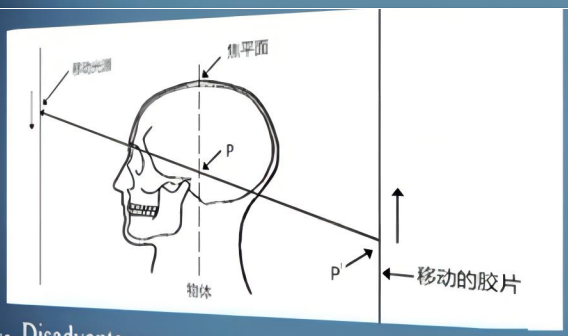
Computer Tomography

- X-ray
  - Human body is opaque to light in visible spectrum, except in very thin sections, however it does transmit X rays.
  - Some structures of body (e.g. bones) absorb X ray more heavily than the other structures.
  - Conventional radiography produces an image in which the 3D structures are projected on to a plane and superimposed shadows on the film.
  - Radiologists frequently use multiple views (X rays taken at different angles) to resolve ambiguities

Computer Tomography

计算机立体成像学 CT

- Tomography
  - Tomography employs a source and film that move during the exposure.
  - The technique is useful where image detail is required in deeply imbedded structures

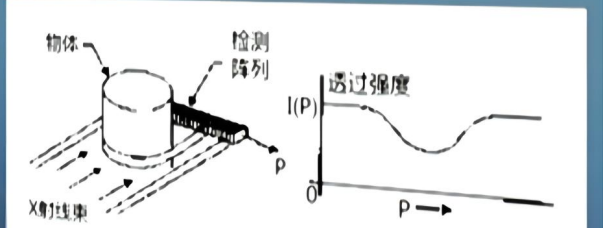


- Disadvantage:
  - Require higher X-ray dosage than in normal radiography.

Computer Tomography

- Axial Tomography
  - Computerized axial tomography (CAT or CT)
    - A technique that incorporates digital image processing to obtain 3D images.
    - The devices involved, commonly called CAT (CT) scanners, reconstruct the 3D image of the X-ray-absorbing object.
    - A planar X-ray beam penetrates the object, and the transmitted beam intensity is measured by a linear array of X-ray detectors.

- Axial Tomography
  - A serials of intensity functions is recorded as the apparatus rotates about the object through a small angle between each exposure whichcover 180 degree of rotation in steps of 2 to 6 degrees.



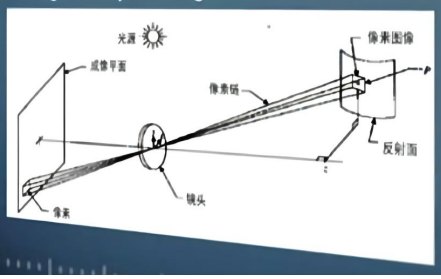
经常听到多少排的CT是指在一次旋转过程中，我们的传感器可以采集多少个层面，比如又64排、180排等等，这样成像的速度更快，或者成像更精细。

总结:

5.2.2 三维图像的处理 (3D Image Processing)

Stereometry 立体成像素

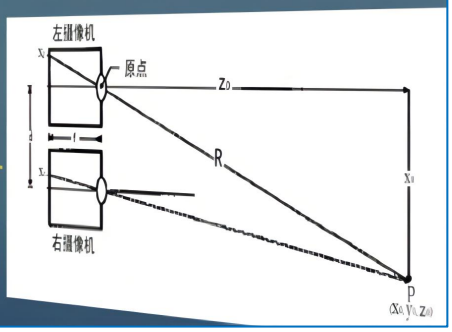
- Stereometry:
  - a technique by which one can deduce the three-dimensional shape of an object from a stereoscopic image pair.
- Model the geometry of image formation.



Stereometry

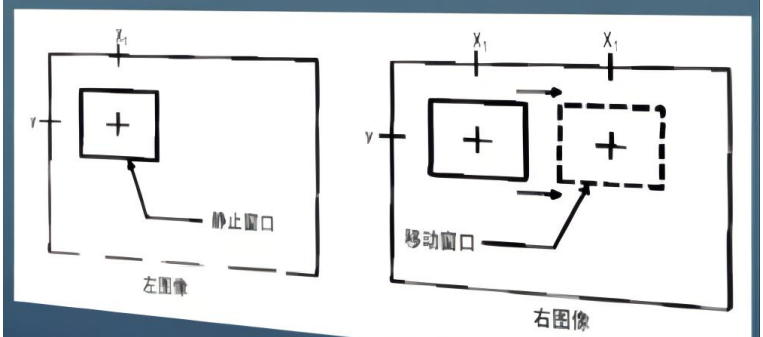
- Stereoscopic Imaging:
  - Dual camera configuration suitable for stereoscopic imaging
  - Range Equations:

$$R = \frac{d\sqrt{f^2 + x_l^2 + y_l^2}}{x_r - x_l}$$



Stereometry

- Stereo Matching:
  - A technique that can be used to locate the right image pixel position that corresponds to a particular left image pixel
  - To obtain accurate range information, one have to do this with sub-pixel accuracy



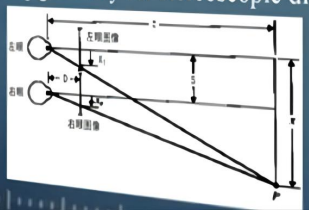
Stereometry

- Stereo Matching procedure:
  1. Fit imaginary windows around a pixel having the same coordinates in another image
  2. Compute a measure of the agreement (cross-correlation, a sum of squared difference etc.) between the images inside the two windows

- Stereo Matching procedure:
  3. Repeat the process as the window in the right image moves toward the right. At some point, the moving window will contain essentially the same details as the fixed window in the left image. When this happens, the image content in the two windows is approximately the same, and the measure of image agreement is maximized

Stereometry

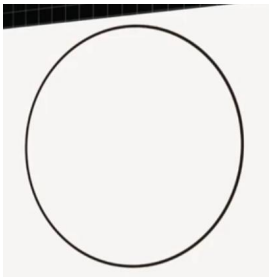
- Stereoscopic Image Display:
  - A 3D scene can be re-created for a viewer through stereoscopic display techniques. This is the basis of the "3D" movie and stereoscopic photography
  - Display Geometry:
    - viewing geometry for stereoscopic display

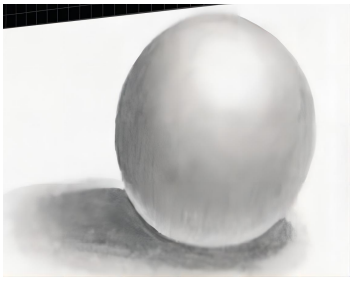


总结:

Shaded Surface Display

- Shaded Surface Display :
  - A technique used to generate an image of a 3D object that exists only as a mathematical description.
  - This technique requires modeling of three things:
    1. The spatial description of the surface
    2. The light-reflecting phenomenon at the surface
    3. The geometry of the light sources and the imaging projection.





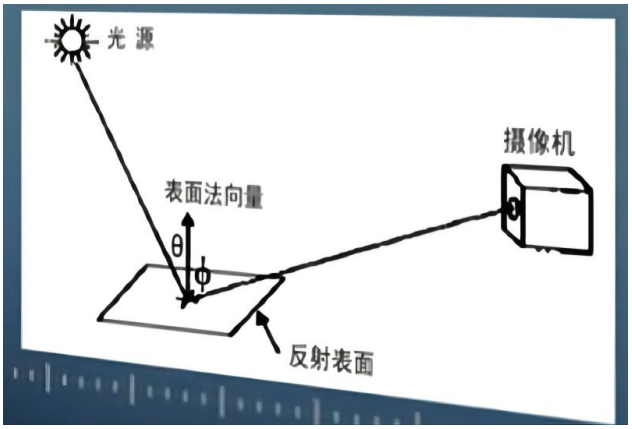
Shaded Surface Display

- Surface Reflection Phenomenon
  - Two important types of reflection:
    - Diffuse scattering: characteristic of matte or chalky
    - specular reflection: characteristic of shiny or metallic surface
  - Reflected intensity

$$I = A\frac{\cos(\theta)}{r^2}\frac{1}{\cos(\phi)}\{B\cos(\phi)+(1-B)[\cos(\theta+\phi)]^n\}$$

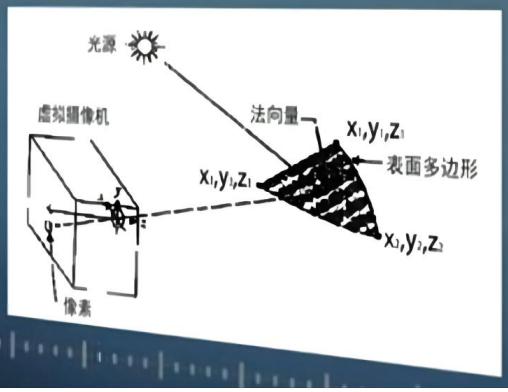
B and n: reflectance parameters
A: constant of proportionality

r: light distance from surface
$0 \leqslant B \leqslant 1$



Shaded Surface Display

- Image Geometry:
  - The model for computing the image of the object's surface
  - If the normal vector to the surface of the polygon is known, the gray level of the pixel can be computed



总结：