江西理工大學 信息工程学院

JIANGXI UNIVERSITY OF SCIENCE AND TECHNOLOGY SCHOOL OF INFORMATION ENGINEERING

Digital Image Processing
数字图像处理

Lecture 07:

Digital image Fundamentals_B

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江西理工大學信息工程学院
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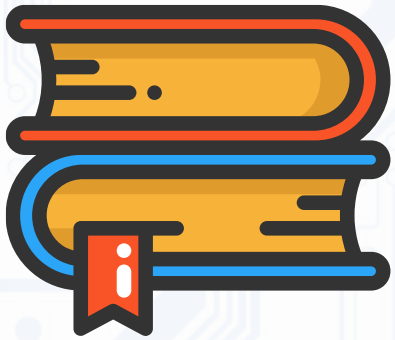
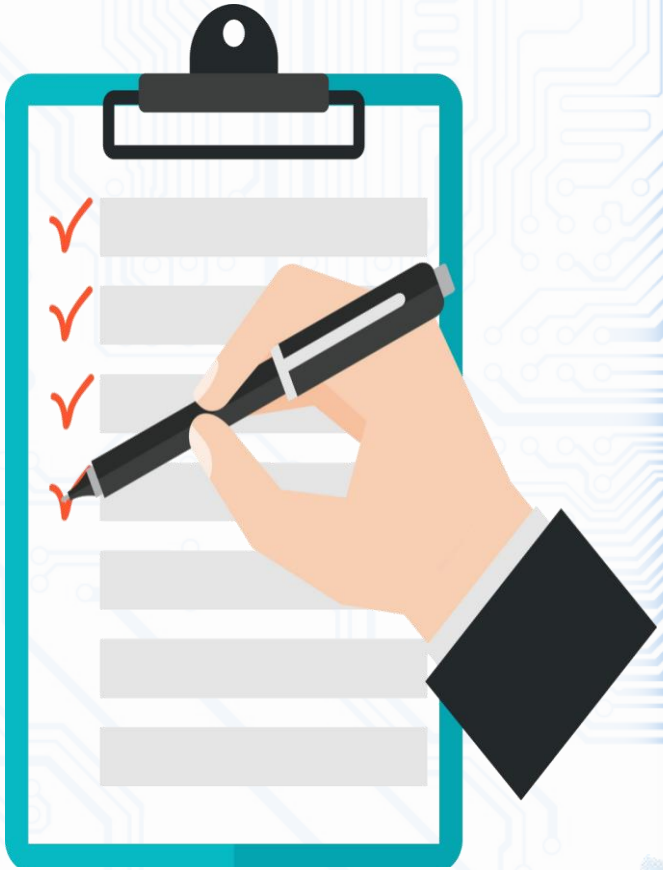


Digital Image Processing

LECTURE 07: Digital image fundamentals_B

Review some Definition

Agenda



Definition 1: Image File Formats **图像文件格式**

Definition 2: Colour Fundamentals (cont…)

Definition 3: Color Models

Definition 4: Saturation & Noise **饱和度和噪音**

Definition 5: Dithering **抖色，混色**

Definition 1: Image File Formats

- Hundreds of image file formats. Examples
  - Tagged Image File Format (TIFF)
  - Graphics Interchange Format (GIF)
  - Portable Network Graphics (PNG)
  - JPEG, BMP, Portable Bitmap Format (PBM), etc
- Image pixel values can be
  - **Grayscale:** 0 - 255 range
  - **Binary:** 0 or 1
  - **Color:** RGB colors in 0-255 range (or other Color model)
  - **Application specific** (e.g. floating point values in astronomy)

标记图像文件格式 (TIFF)；
图形交换格式（GIF）；
便携式网络图形 (PNG)；
JPEG、BMP、可移植位图格式（PBM）等；

灰度：0 - 255 范围；
二进制：0 或 1；
颜色：0-255范围内的RGB颜色（或其他颜色模型）；
特定于应用程序（例如天文学中的浮点值）；

How many Bits Per Image Element?

Grayscale (Intensity Images)

灰度（强度图像）
Huī dù (qiángdù túxiàng)

Chan.	Bits/Pix.	Range	Use
1	1	0.. .1	Binary image: document, illustration, fax
1	8	0.. .255	Universal: photo, scan, print
1	12	0.. .4095	High quality: photo, scan, print
1	14	0...16383	Professional: photo, scan, print
1	16	0.. .65535	Highest quality: medicine, astronomy

Color Images

彩色图像
Cǎisè túxiàng

Chan.	Bits/Pix.	Range	Use
3	24	$[0. ,.255]^3$	RGB, universal: photo, scan, print
3	36	$[0. . .4095]^3$	RGB, high quality: photo, scan, print
3	42	$[0. ..16383]^3$	RGB, professional: photo, scan, print
4	32	$[0.. .255]^4$	CMYK, digital prepress

Special Images

特殊图像 Tèshū túxiàng

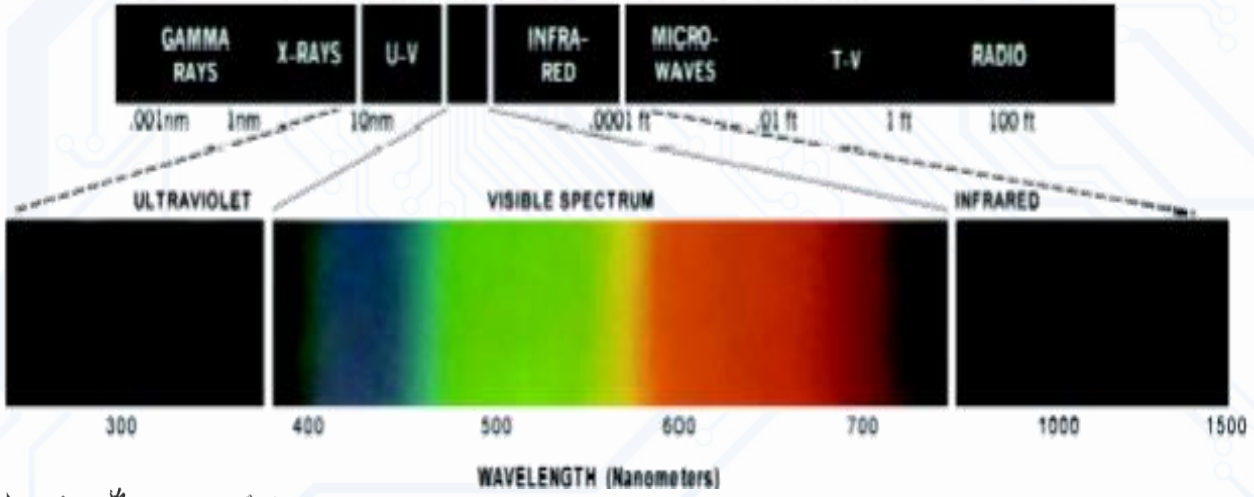
Chan.	Bits/Pix.	Range	Use
1	16	-32768.. .32767	Whole numbers pos./neg., increased range
1	32	±3.4 • 1038	Floating point: medicine, astronomy
1	64	±1.8 • 10308	Floating point: internal processing

Definition 2: Colour Fundamentals (cont…)

色彩基础 Sècǎi jīchǔ

- Chromatic light spans the electromagnetic spectrum from approximately 400 to 700 nm
- As we mentioned before human colour vision is achieved through 6 to 7 million cones in each eye

色光的电磁波谱跨度约为400到700纳米
正如我们之前提到的，人类的颜色视觉是通过每只眼睛六七百万视锥细胞实现的



Definition 2: Colour Fundamentals (cont…)

- Achromatic light - Black and White (and their shades, gray shades).

无色差光-黑色和白色(及其阴影，灰色阴影)。

- Chromatic light - Colors (and their shades).

彩色光-颜色(及其阴影)

- Three basic quantities are used to describe the quality of a chromatic light source: radiance, luminance, and brightness.

辐射是从光源流出的总能量，通常以瓦特 (W) 为单位。

- **Radiance** is the total amount of energy that flows from the light source, and it is usually measured in watts (W).

亮度，以流明 (lm) 为单位，衡量观察者从光源感知到的能量。

- **Luminance**, measured in lumens (lm), gives a measure of the amount of energy an observer perceives from a light source.

亮度是一个主观描述，实际上无法测量。

- **Brightness** is a subjective descriptor that is practically impossible to measure.

Definition 2: Colour Fundamentals (cont…)

- Cones are the sensors in the eye responsible for color vision.

  视锥细胞是眼睛中负责颜色视觉的传感器。

  - Approximately 65% of all cones are sensitive to red light,
  - 33% are sensitive to green light,
  - and only about 2% are sensitive to blue.

- Due to these absorption characteristics of the human eye, colors arc seen as variable combinations of the so-called primary colors red (R), green (G), and blue (B).

  由于人眼的这些吸收特性，颜色被看作是所谓的原色红(R)、绿(G)和蓝(B)的可变组合。

Definition 2: Colour Fundamentals (cont…)

- The characteristics generally used to distinguish one color from another are brightness, hue, and saturation.

亮度;

  - **Brightness** embodies the chromatic notion of intensity.
  - **Hue** is an attribute associated with the dominant wavelength in a mixture of light waves.

饱和;

  - **Saturation** refers to the relative purity or the amount of white light mixed with a hue.

色相和饱和度;

  - Hue and saturation taken together are called **Chromaticity**.

色度。

Definition 2: Colour Fundamentals (cont…)

- 通常用来区分一种颜色与另一种颜色的特征是亮度、色调和饱和度。
  - 亮度体现了强度的色彩概念。
  - 色相是一种在混合光波中占主导波长的属性。
  - 饱和度是指相对纯度或白光与色相混合的量。
  - 色相和饱和度合在一起称为色度。

Definition 2: Colour Fundamentals (cont…)

- The amounts of red, green, and blue needed to form any particular color are called the **tristimulus** values and are denoted, X, Y, and Z, respectively. 三刺激

形成任何特定颜色所需的红色、绿色和蓝色的数量称为三刺激值，分别表示为X、Y和Z。

$$x = \frac{X}{X+Y+Z}$$

$$y = \frac{Y}{X+Y+Z}$$

- A color is then specified by its trichromatic coefficients, defined as

然后，颜色由其三色系数指定，定义为

$$z = \frac{Z}{X+Y+Z}.$$

Definition 2: Colour Fundamentals (cont…)

- 形成任何特定颜色所需的红色、绿色和蓝色的数量称为三刺激值，分别表示为X、Y和Z。

$$x = \frac{X}{X+Y+Z}$$

$$y = \frac{Y}{X+Y+Z}$$

- 然后，颜色由其三色系数指定，定义为

$$z = \frac{Z}{X+Y+Z}$$

Definition 3: Color Models

- A color model (also called color space or color system) is a specification of a coordinate system and a subspace within that system where each color is represented by a single point.

颜色模型(也称为颜色空间或颜色系统)是一个坐标系统和该系统中的子空间的规范，在该子空间中，每种颜色由单个点表示。

RGB 颜色模型 RGB yánsè móxíng

- **The RGB color model:** In the RGB model, each color appears in its primary spectral components of red, green, and blue. This model is based on a **Cartesian coordinate system**.

笛卡尔坐标系。 Dí kǎ'ěr zuòbiāo xì.

RGB颜色模型:在RGB模型中，每种颜色以其主要光谱成分红、绿、蓝出现。这个模型基于笛卡尔坐标系。

Definition 3: Color Models The RGB color model

The *color subspace* is the **cube** in which RGB values are at three corners; cyan, magenta, and yellow are at three other corners; black is at the origin; and white is at the corner farthest from the origin.

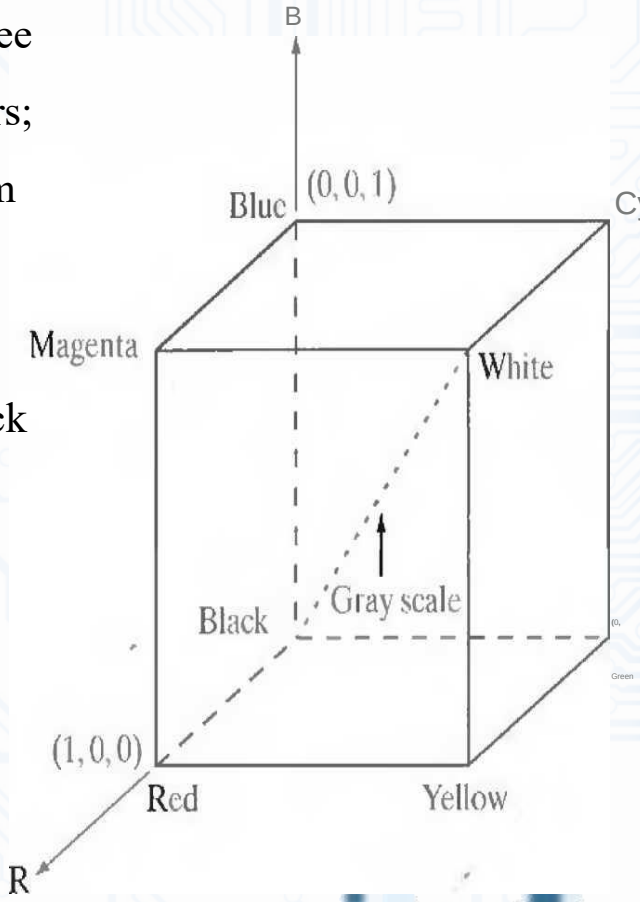
灰度 Huī dù

The **gray scale** (points of equal RGB values) extends from black to white along the diagonal line joining these two points.

颜色 Yánsè

The different **colors** are points on or inside the cube, and are defined by vectors extending from the origin.

All values of R, G. and B are assumed to be in the range [0, 1].



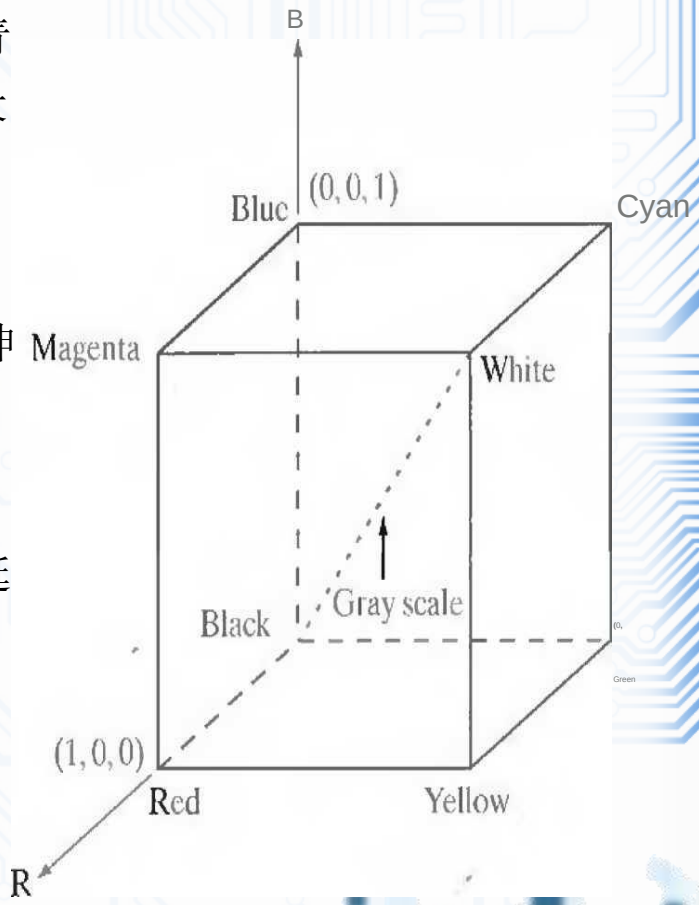
Definition 3: Color Models The RGB color model

颜色子空间是RGB值在三个角处的立方体; 另外三个角是青色、品红和黄色; 黑色是原点; 白色在离原点最远的角落。

灰度(RGB值相等的点)沿着连接这两点的对角线从黑色延伸到白色。

T不同颜色的点是立方体上或里面的点，它们是由从原点延伸出来的向量定义的。

假设R、g、B的所有值都在[0,1]范围内。



Definition 3: Color Models The RGB color model

RGB颜色模型的优点： RGB yánsè móxíng de yōudiǎn:

- **Merits of RGB color model:**

  (i) Well suited for hardware implementations

  (ii) Matches nicely with the fact that the human eye is strongly perceptive to red, green, and blue primary colors .

- **Demerits of RGB color model:** Not well suited for describing colors in terms that are practical for human interpretation.

- **The HSI color model:** A color perceived by a human eye is described by its Hue, Saturation and Intensity.
- **HSI** (Hue, Saturation and Intensity) color model thus decouples the intensity component from the color-carrying information (hue and saturation).

Definition 3: Color Models The RGB color model

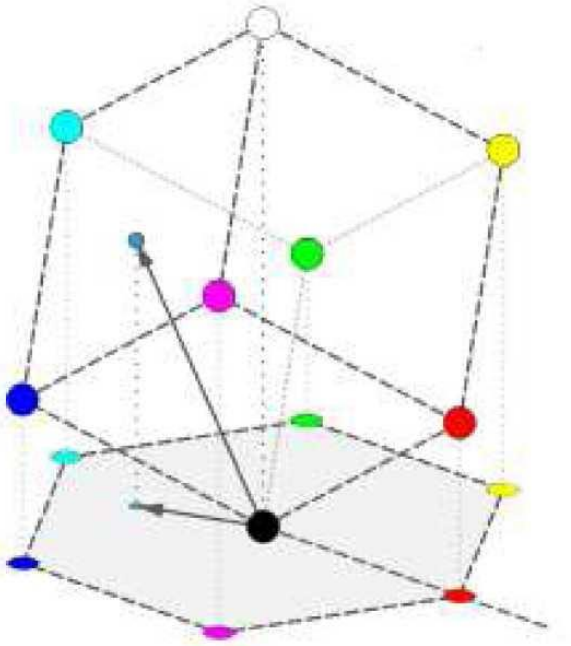
RGB颜色模型的优点： RGB yánsè móxíng de yōudiǎn:

- **RGB颜色模型的优点:**
  - (i)非常适合硬件实现
  - (ii)与人类的眼睛对红、绿、蓝三原色有强烈的感知能力这一事实非常吻合。
- RGB颜色模型的缺点:不太适合用人类可以实际解释的术语来描述颜色。
- HSI颜色模型:人眼感知的颜色由色相、饱和度和强度来描述。

Definition 3: Color Models The RGB color model

- The HSI coordinate system and corresponding color subspace is obtained as follows:

- **The RGB color cube rotated such that the cube is standing on its black vertex with the white vertex directly above and the cyan, blue, green, red, yellow and magenta vertices forming a hexagon as shown**



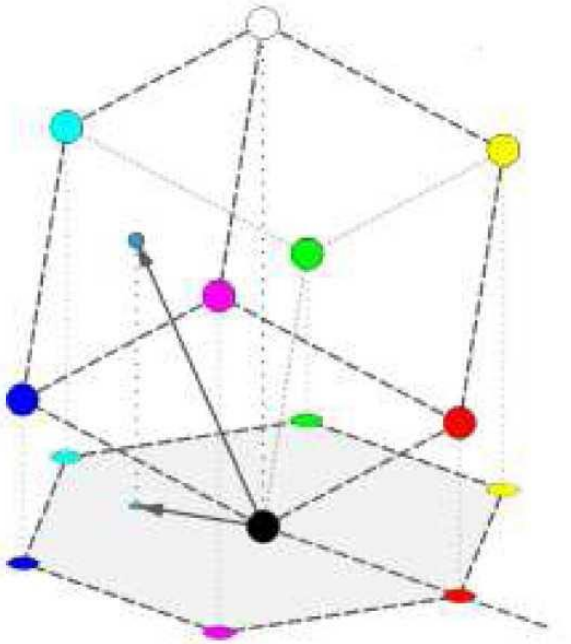
Forming the HSI color model from the RGB color model

The dot is an arbitrary color point. The angle from the red axis gives the hue, and the length of the vector is the saturation. The intensity of all colors in any of these planes is given by the position of the plane on the vertical intensity axis.

Definition 3: Color Models The RGB color model

- 得到HSI坐标系及对应的颜色子空间如下:

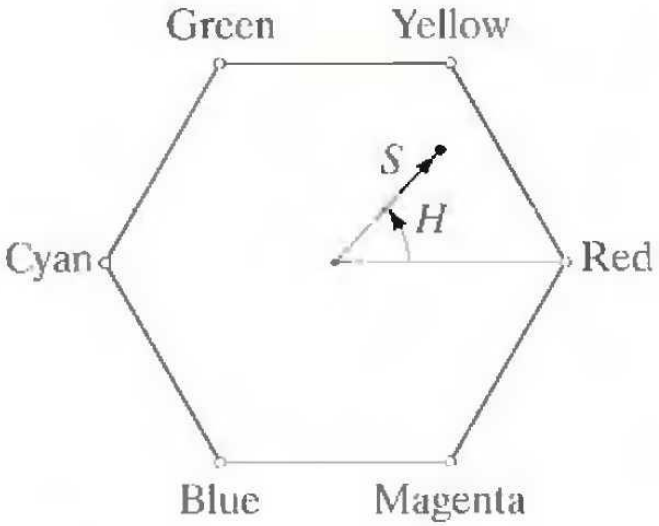
- **RGB颜色立方体旋转，使立方体站在黑色顶点上，白色顶点正上方，青色、蓝色、绿色、红色、黄色和品红色顶点形成一个六边形，如图所示**



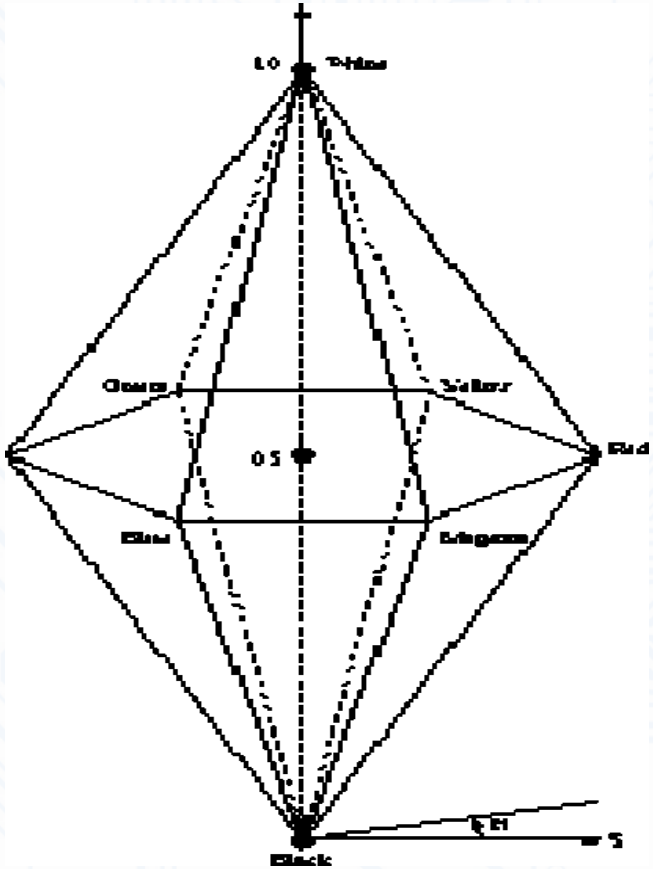
Forming the HSI color model from the RGB color model

这个点是一个任意的颜色点。 红色轴的角度表示色调，向量的长度表示饱和度。 这些平面中所有颜色的强度由平面在垂直强度轴上的位置给出。

Color Models
The HSI color model



The HSI color model

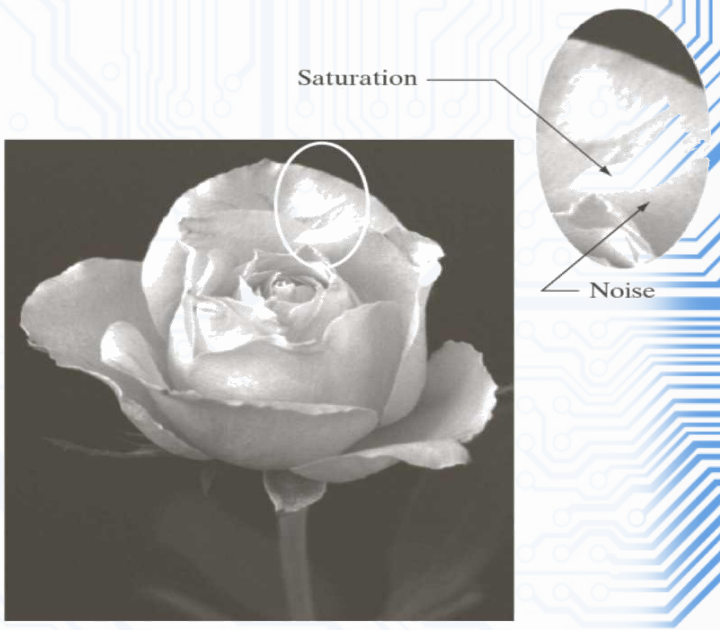


Cm

Definition 4: Saturation & Noise

饱和度和噪音 Bǎohé dù hé zàoyīn

- Saturation: highest intensity value above which Color is washed out
- Noise: grainy texture pattern



- 饱和度:最高的强度值，超过这个值颜色就会被洗掉
- 噪声:颗粒状纹理图案

Intensity Level Resolution

强度水平分辨率 Qiángdù shuǐpíng fēnbiàn lǜ

- *Intensity level resolution:* number of intensity levels used to represent the image
- The more intensity levels used, the finer the level of detail discernible in an image
- Intensity level resolution usually given in terms of number of bits used to store each intensity level
- 强度级分辨率:用于表示图像的强度级的数目
- 使用的强度级别越多，图像中可识别的细节级别就越精细
- 强度级分辨率通常以存储每个强度级所用的比特数来表示

Number of Bits	Number of Intensity Levels	Examples
1	2	0, 1
2	4	00, 01, 10, 11
4	16	0000, 0101, 1111
8	256	00110011, 01010101
16	65,536	1010101010101010

Resolution: How Much Is Enough?

- The big question with resolution is always *how much is enough*?
- Depends on what is in the image *(details)* and what you would like to do with it *(applications)*
  - Key questions:
    - Does image look aesthetically pleasing?
    - Can you see what you need to see in image?

Example: Picture on right okay for counting number of cars, but not for reading the number plate

Resolution: How Much Is Enough?

- 分辨率的最大问题总是多少才算足够?
- 取决于图片中的内容(细节)以及你想用它做什么(应用程序)
- 关键问题:
  - 图像看起来美观吗?
  - 你能看到你需要看到的图像吗?

例子:右边的图片可以用来数汽车的数量，但不能用来读车牌

Intensity Level Resolution

Low Detail

Medium Detail

Definition 5: Dithering

抖动 Dǒudòng

抖动 Dǒudòng

Dithering is a technique to simulate the display of intensities/colors that are not available in the current grayscale/Color palette of the display device.

Generally a full set of intensities/colors is usually represented with a reduced number of intensities/colors.

This is accomplished by arranging adjacent pixels of different intensities/colors into a pattern which simulates intensities/colors that are not available.

抖动是一种模拟显示强度/颜色的技术，这些强度/颜色在显示设备的当前灰度/调色板中不可用。
一般来说，一套完整的强度/颜色通常用减少的强度/颜色来表示。
这是通过将不同强度/颜色的相邻像素排列到一个模式中来实现的，该模式模拟了不可用的强度/颜色。

Definition 5: Dithering

- Dithering becomes possible because human eyes only average over an area, a property known as the **spatial integration**.

空间整合 Kōngjiān zhěnghé

- Dithering methods:
  - **Thresholding, classical half-toning,**
  - **Random Dither, Patterning, Ordered Dither and Error Diffusion.**

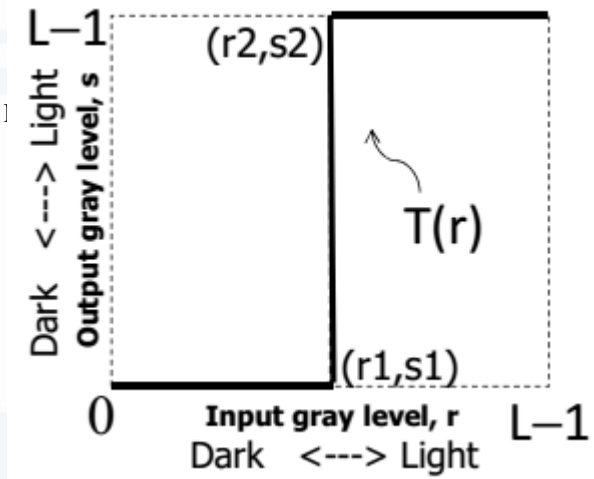
阈值，经典半色调，；
随机抖动、图案化、有序抖动和误差扩散。

Dithering - Thresholding

阈值 Yùzhí

Thresholding: The threshold is chosen to be in the middle of the grey scale of the source image. The pixels in the source image darker than this threshold value are replaced with black and those lighter than it with white.

阈值:阈值选择在源图像灰度的中间。 源图像中比这个阈值暗的像素用黑色代替，比它亮的像素用白色代替。



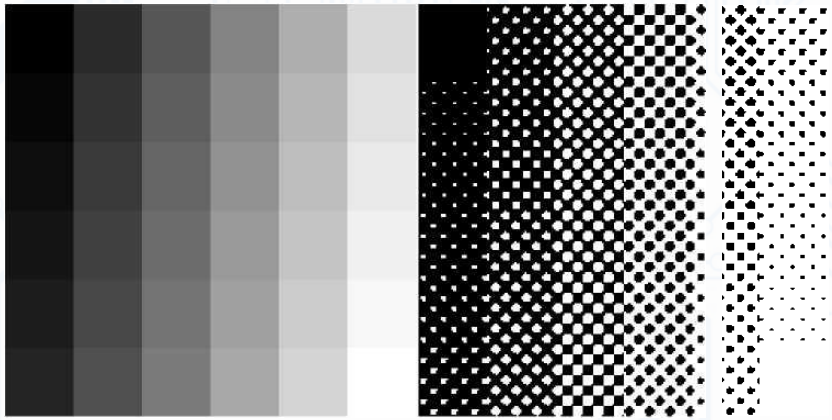
Thresholding: Function & Example

Dithering - Classical Half-toning

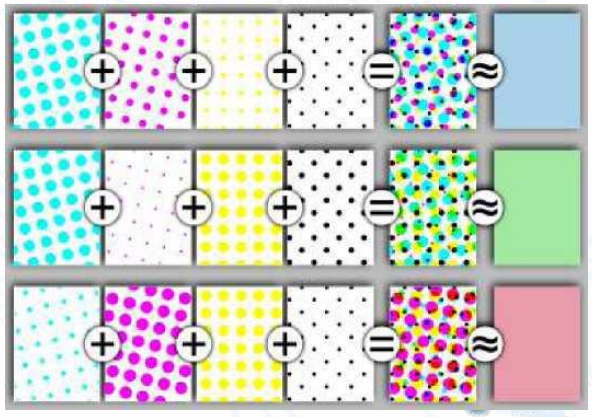
古典半色调 Gǔdiǎn bàn sèdiào

- **Classical Half-toning:** Different intensities or grey levels are represented by dots of varying sizes and patterns.
- Half-toning is also used for printing Color pictures. 半色调也用于印刷彩色图片。
- The general idea is the same, by varying the density of the four secondary printing colors, cyan, magenta, yellow and black (abbreviation CMYK), any particular shade can be reproduced.

经典半色调:不同强度或灰度级由不同大小和图案的点表示。
总的思路是一样的，通过改变四种二次印刷颜色(青色、品红、黄色和黑色(简称CMYK))的密度，可以复制任何特定的色度。



Grayscale Half-toning



Color Half-toning

Dithering

随机抖动： Suíjī dǒudòng:

- **Random dither:** A random amount of noise is added to source image and threshold is applied. 图案： Tú'àn:
- **Patterning:** For each possible pixel (or group of pixels) in source image, a pattern of pixels that approximates that value is created and displayed. Remembering the concept of spatial integration, if appropriate patterns are chosen the appearance of various intensity levels can be simulated.

有序抖动： Yǒu xù dǒudòng:

- **Ordered dither:** In ordered dither, patterning is achieved with one-to-one mapping between pixels in source image and pattern pixels. This eliminates spatial distortion due to spatial enlargement and subsequent loss of spatial resolution in patterning technique.

Dithering

随机抖动： Suíjī dǒudòng:

- 随机抖动:一个随机数量的噪声被添加到源图像阈值是应用的。

图案： Tú'àn:

- 图案:对于源中的每个可能的像素(或像素组)图像中，近似该值的像素模式创建并显示。 记住空间的概念集成，如果选择适当的模式外观可以模拟各种强度水平。

有序抖动： Yǒu xù dǒudòng:

- 有序抖动:在有序抖动中，模式是用一源图像像素和模式像素之间的到一映射。这消除了由于空间扩大和图型技术中空间分辨率的随后损失。

Dithering

误差扩散： Wùchā kuòsàn:

- **Error diffusion:** For each possible pixel in source image, a closest available intensity/Color is identified and the difference between the source image pixel value and the closest available intensity/Color is calculated.
- This error is then distributed to some neighbours of this pixel before their closest available intensities/colors are identified.

Original (8 bits)

Threshold (1 bit)

Random dither (1 bit)

Ordered dither (1 bit)

Error diffusion(1 bit)

Dithering

误差扩散： Wùchā kuòsàn:

- 误差扩散:对源图像中的每个可能像素，识别最接近的可用强度/颜色，并计算源图像像素值与最接近的可用强度/颜色之间的差值。
- 然后，在识别出最接近的可用强度/颜色之前，这个错误被分配到这个像素的一些邻居。

Original (8 bits)

Threshold (1 bit)

Random dither (1 bit)

Ordered dither (1 bit)

Error diffusion(1 bit)

MAY-BRITT MOSER
Nobel Prize in Physiology or Medicine 2014

"I learned at an early age that work makes you happy."

Student Task_3: DIP

- 请帮我翻译部分的朋友鼓掌
- Qǐng bāng wǒ fānyì bùfèn de péngyǒu gǔzhǎng

Solve the Question shared in mooc

解决mooc分享的问题

Send for Next lecture

发送下一个讲座

江西理工大学
Jiangxi University of Science and Technology
信息工程学院
School of information engineering

Digital Image Processing

THANK YOU

"BE HUMBLE. BE HUNGRY.
AND ALWAYS BE THE
HARDEST WORKER
IN THE ROOM."