大话成像之

数字成像系统 32讲

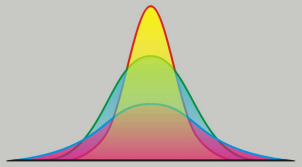
色彩空间 & 色彩重建

Maver Jiang

imaging algorithm specialist

staff image quality engineer

maver.jiang@gmail.com



期中总结：
课程的结构：以理论基础提领应用技术解析

Cmos sensor 基础

光学基础

颜色科学基础

数字信号处理基础

成像系统基础

ISP信号处理系统

- Black level Correction
- Green Imbalance Correction
- Defect Pixel Correction
- Lens Shading Correction
- ……

3A系统

- 自动曝光控制
- 自动白平衡
- 自动对焦
- ISP 统计
- 闪光灯

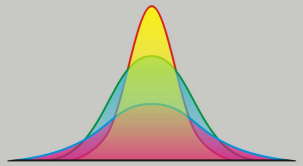
色彩空间与色彩重建

- Color correction
- Color Space conversion
- Gamma Correction

图像质量

- 图像质量评价
- 图像质量调校

Misc



三个概念：

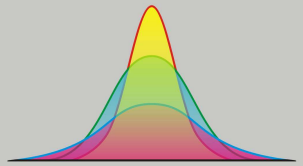
Color model

Color space/color working space

- 设备无关
- 设备相关

Color management：ICC profile

- White point
- Color model
- Color Space
- *profile connection space* (PCS)
- Color Conversion Engine



color model：

RGB

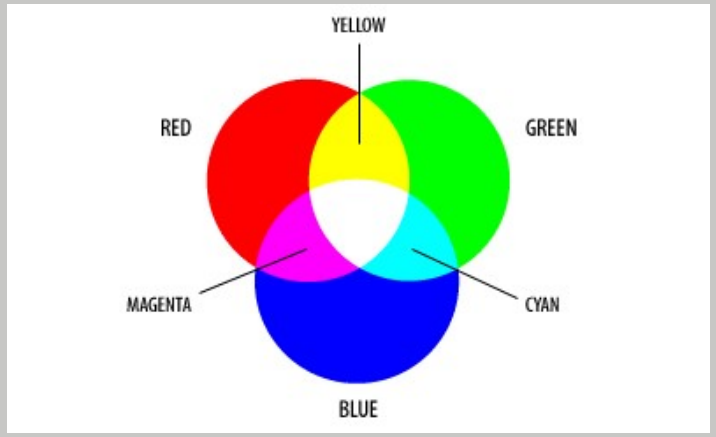
- Additive system加性色彩系统

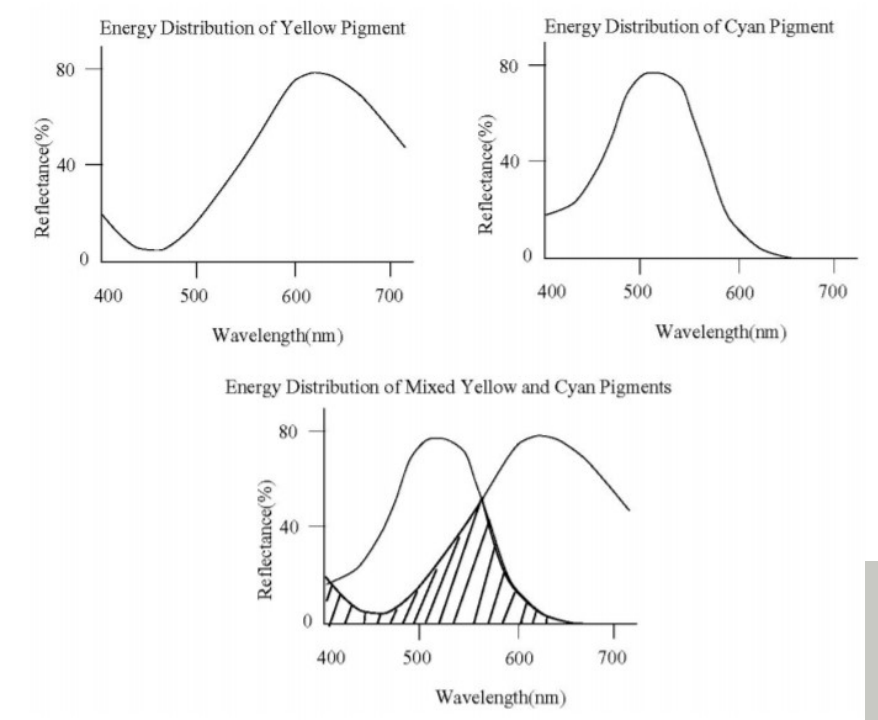
imaging， display， eye

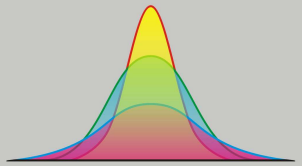
CMYK

- Subtractive system减性色彩系统

dye， paint， print

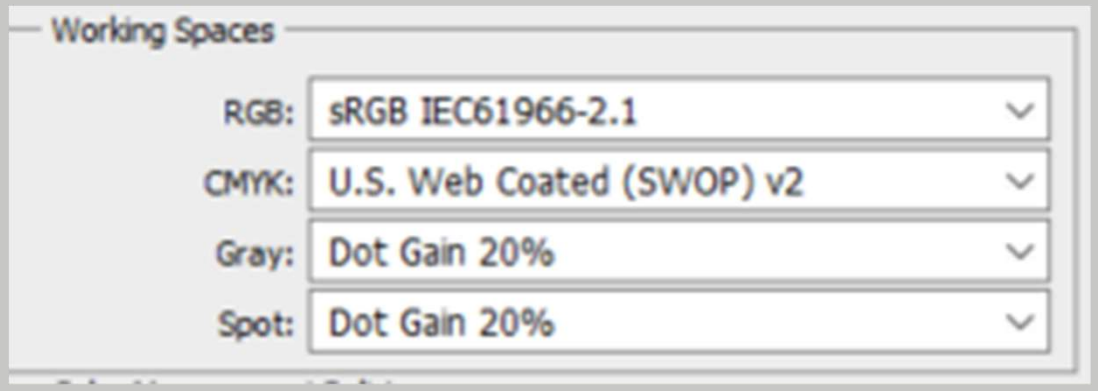


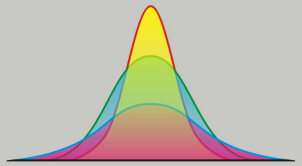




color model：以有限的基本元素表现出颜色，比如rgb， cmyk。是一个广义，非准确定量描述的概念。

所以： 说rgb color model， r,g,b (10,30,50), 没有任何实际意义，无法知道到底是什么颜色
只有在某个色彩空间下，才能按图索骥找到定义的颜色。



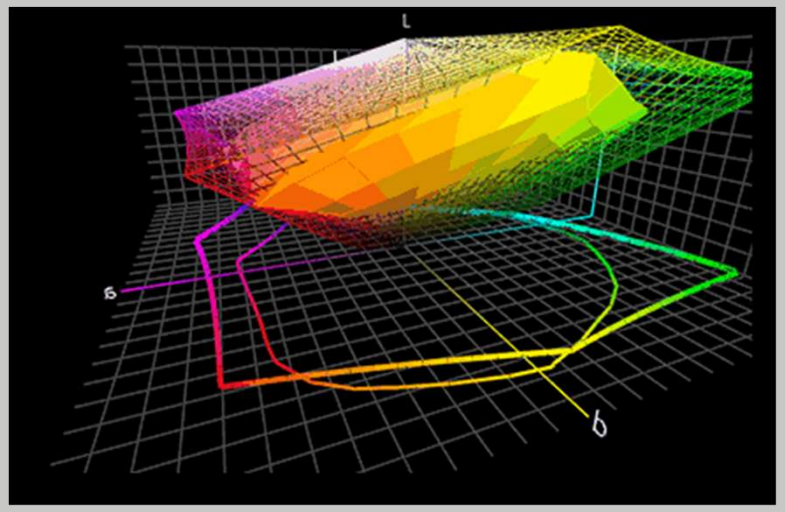


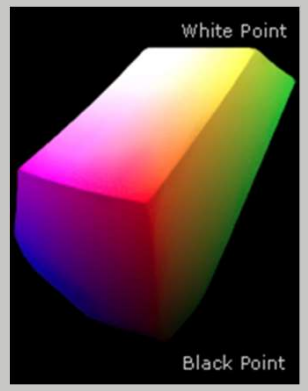
色彩空间定义：

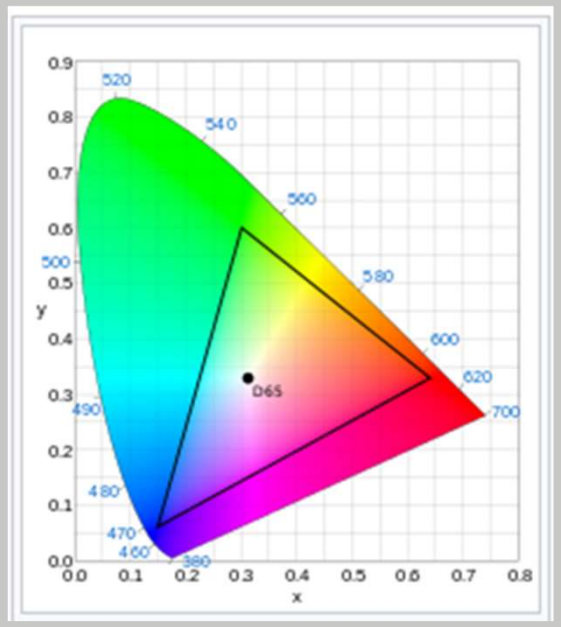
Color space： 也是一个color model，但用准确的量化来描述坐标系，量化范围，白点数据以及非线性转换特性。

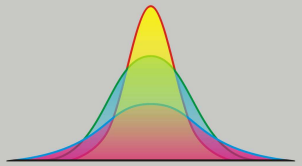
设备无关 ： CIE XYZ, CIE LAB

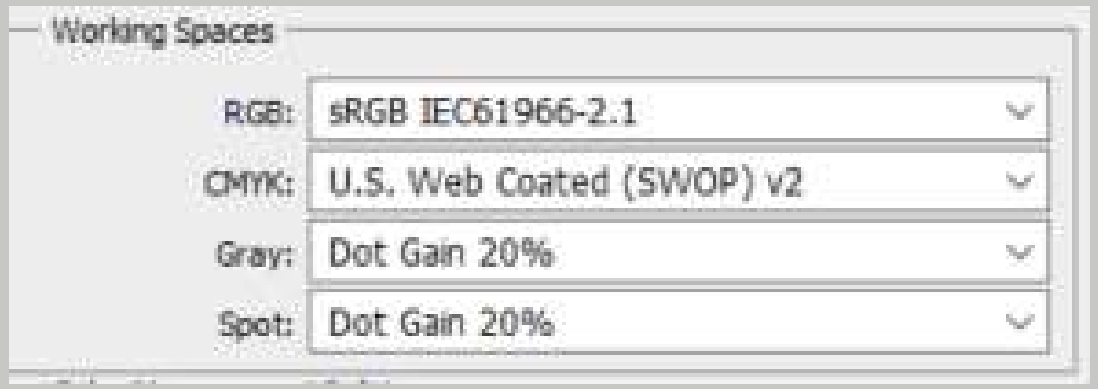
设备相关: sRGB, Adobe RGB





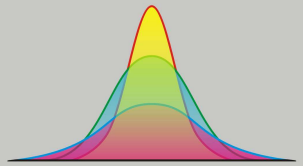






RGB color space parameters for Rec. 601

Color space	White point (D_{65})		Primary color					
	x_W	y_W	x_R	y_R	x_G	y_G	x_B	y_B
625 line	0.3127	0.3290	0.640	0.330	0.290	0.600	0.150	0.060
525 line	0.3127	0.3290	0.630	0.340	0.310	0.595	0.155	0.070



CIE color space 色彩空间

CIE Chromaticity Diagram (1931)

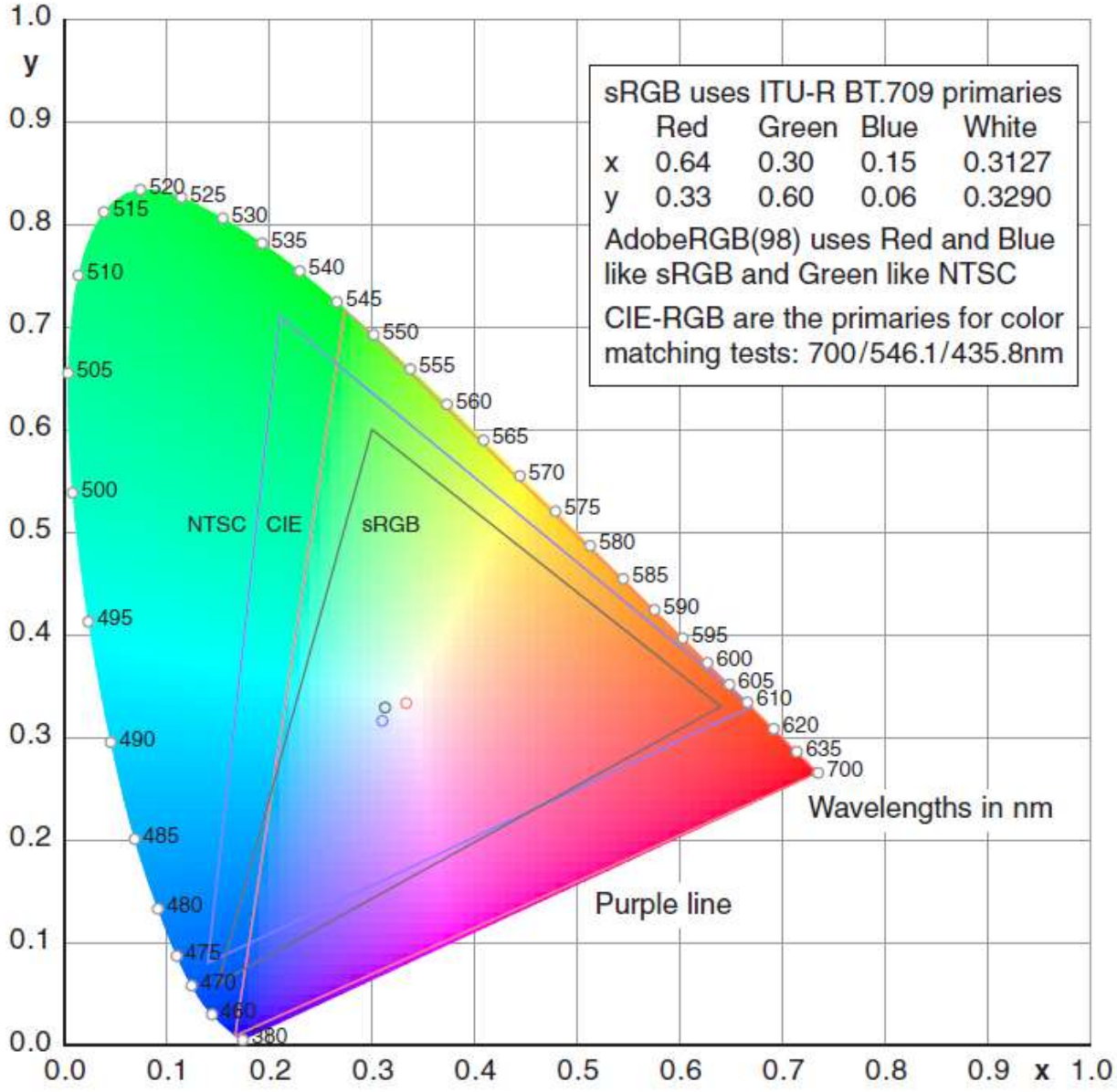
CIE xyY 2D
CIE XYZ 3D

Device independent color space
：CIELAB， CIEXYZ…

Device dependent color space
sRGB, Adobe RGB, etc.

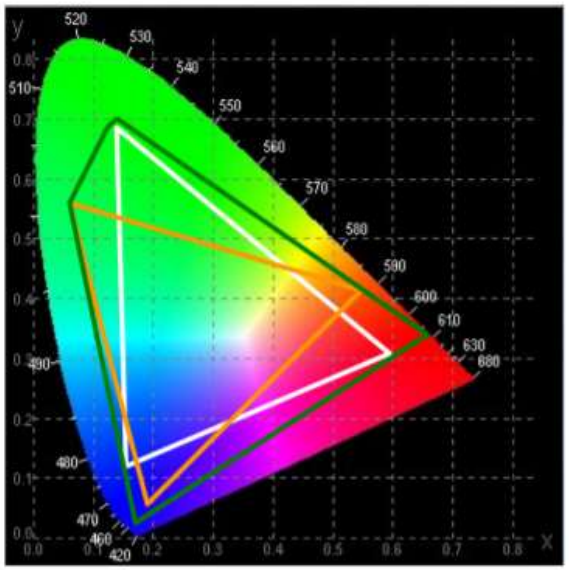
ICC profile:

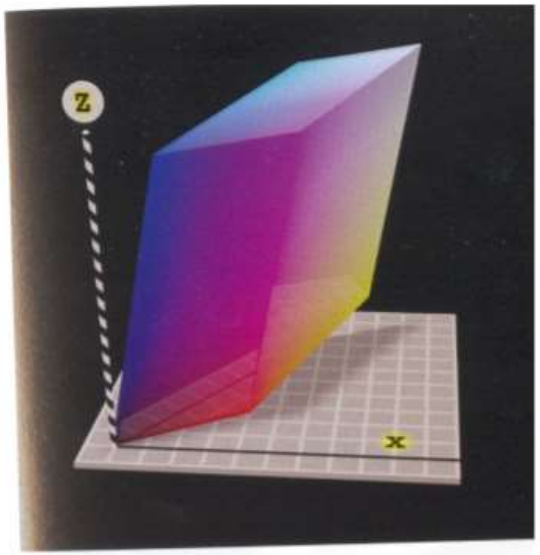
White point
Color model
Color Space
Color Conversion



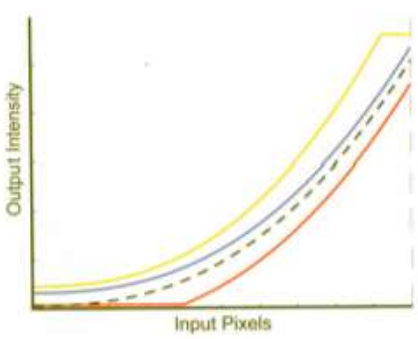
加性色彩重建系统的几个重要概念：

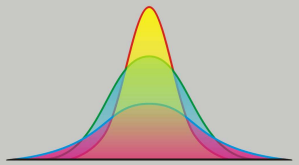
Color Gamut：色域



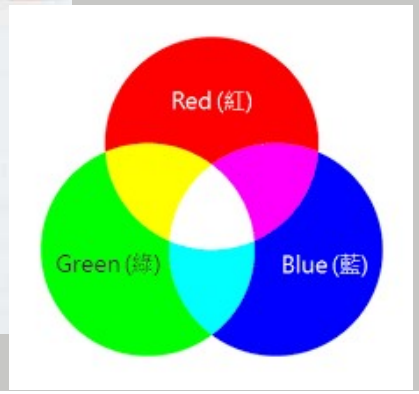


Tone Mapping Function

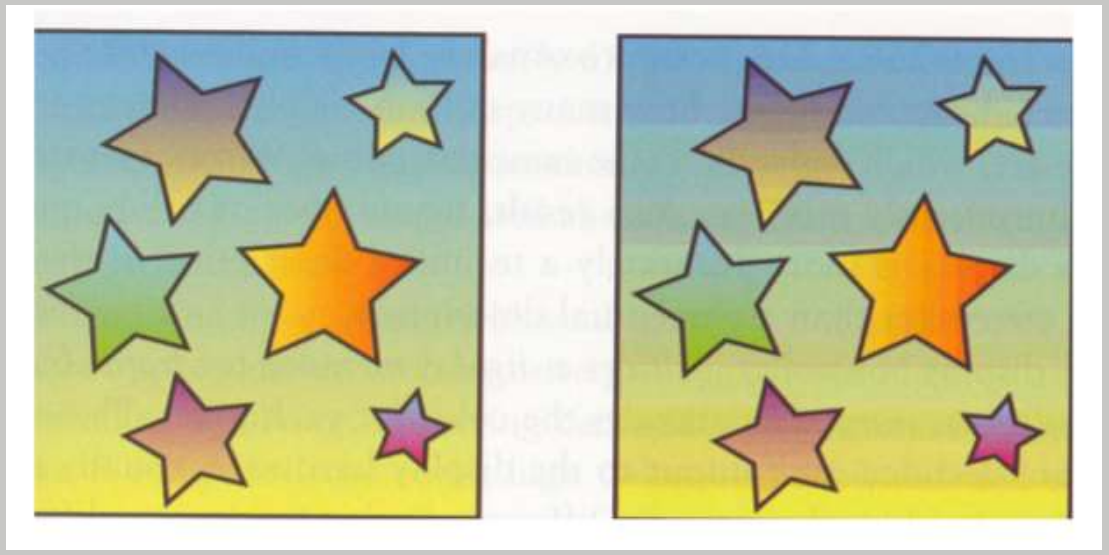


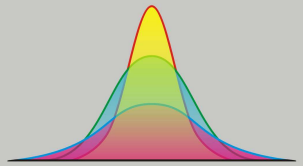


Color Balance



Intensity Resolution





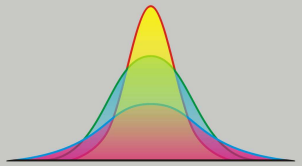
好的色彩重建的基本要求
Basic principles of good color reproduction

Correct mapping of white and neutral colors

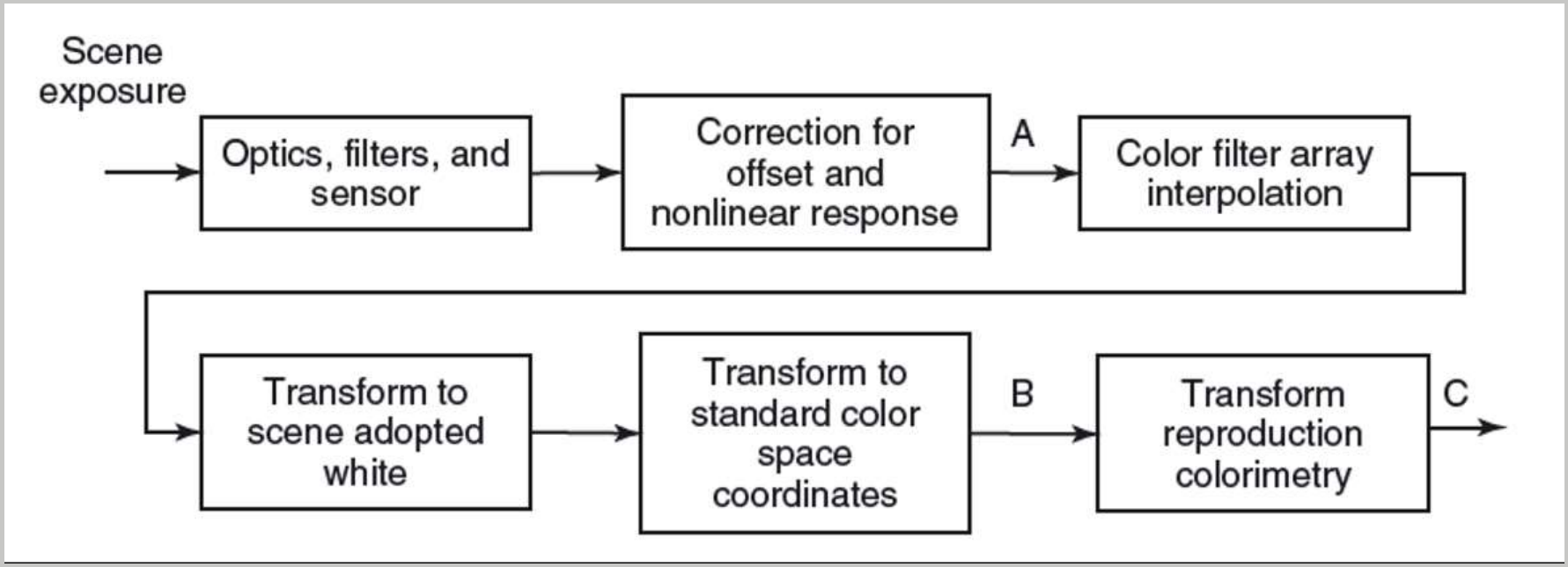
Control of the overall colorfullness

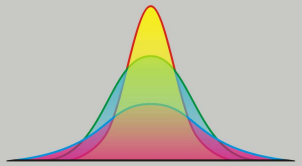
Correct mapping of critical reference colors such as sky, foliage and skin tones

Control of the tone reproduction involves mapping of the overall contrast and brightness



色彩重建的过程


Scene exposure
Optics, filters, and sensor
Correction for offset and nonlinear response
A
Color filter array interpolation
Transform to scene adopted white
Transform to standard color space coordinates
B
Transform reproduction colorimetry
C



色彩重建的数学表达

$$X = \int_{\lambda} \beta(\lambda) S(\lambda) \bar{x}(\lambda) \mathrm{d}\lambda$$

$$Y = \int_{\lambda} \beta(\lambda) S(\lambda) \bar{y}(\lambda) \mathrm{d}\lambda$$

$$Z = \int_{\lambda} \beta(\lambda) S(\lambda) \bar{z}(\lambda) \mathrm{d}\lambda$$

$$\mathbf{s} = \mathbf{B}^{\mathrm{T}}\mathbf{S}\mathbf{r}$$

$$\mathbf{t} = \mathbf{C}^{\mathrm{T}}\mathbf{S}\mathbf{r}$$

$$\mathbf{S} = \begin{bmatrix} s_1 & & 0 \\ & s_2 & \\ & & \ddots \\ 0 & & s_n \end{bmatrix}$$

$$\mathbf{s} = [RGB]^{\mathrm{T}}$$

$$\mathbf{t} = [XYZ]^{\mathrm{T}}$$

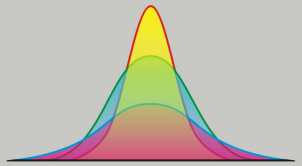
$$\mathbf{r} = [r_1 r_2 \ \dots \ r_n]^{\mathrm{T}}$$

$$\mathbf{B} = \begin{bmatrix} b_{1,1} & b_{1,2} & b_{1,3} \\ b_{2,1} & b_{2,2} & b_{2,3} \\ \vdots & \vdots & \vdots \\ b_{n,1} & b_{n,2} & b_{n,3} \end{bmatrix}$$

$$\mathbf{C} = \begin{bmatrix} \bar{x}_1 & \bar{y}_1 & \bar{z}_1 \\ \bar{x}_2 & \bar{y}_2 & \bar{z}_2 \\ \vdots & \vdots & \vdots \\ \bar{x}_n & \bar{y}_n & \bar{z}_n \end{bmatrix}$$

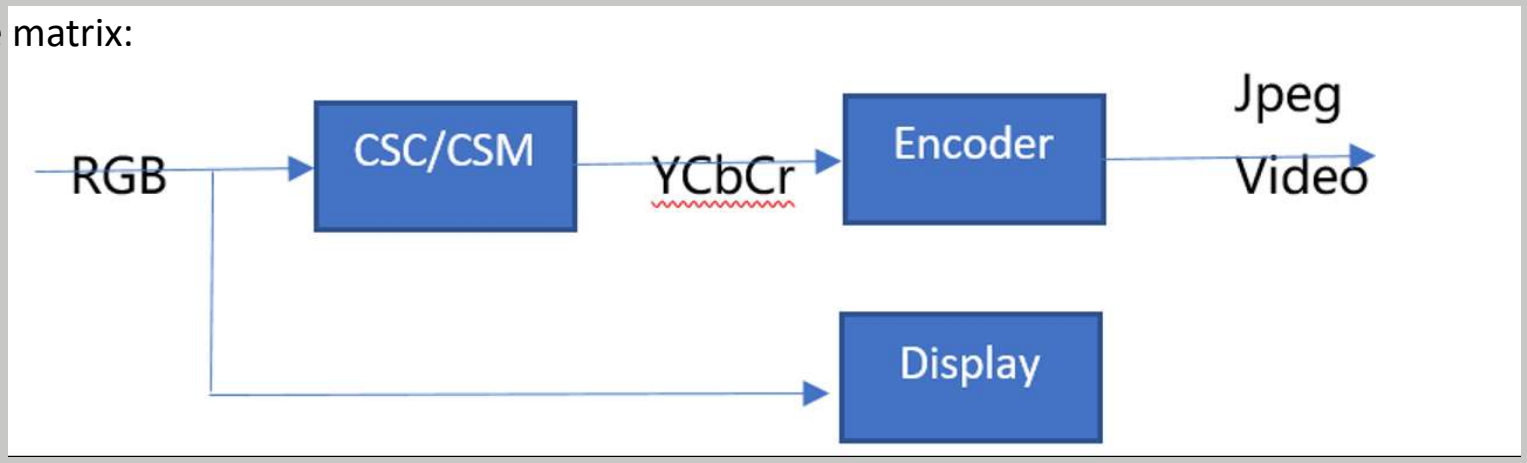
B C 是不一样的，如果要match成一样的，需要两步处理

1. Measure OETF of each other channel, grey balance signal level.
2. Derive a transformation from balanced R',G',B' to 对应的CIE color 坐标。



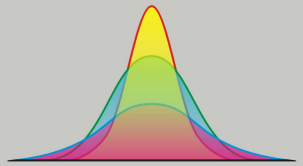
Color space conversion:

Color space matrix:



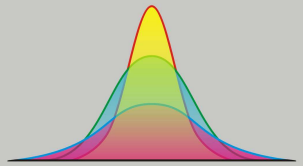
$$\begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix} = \begin{bmatrix} 0 \\ 128 \\ 128 \end{bmatrix} + \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ -0.169 & -0.331 & 0.500 \\ 0.500 & -0.419 & -0.081 \end{bmatrix} \cdot \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

Ranges:
R/G/B [0 ... 255]
Y/Cb/Cr [0 ... 255]



THANKS

本课程由 Maver Jiang提供



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