



ISP-CCM (color correction matrix)



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01

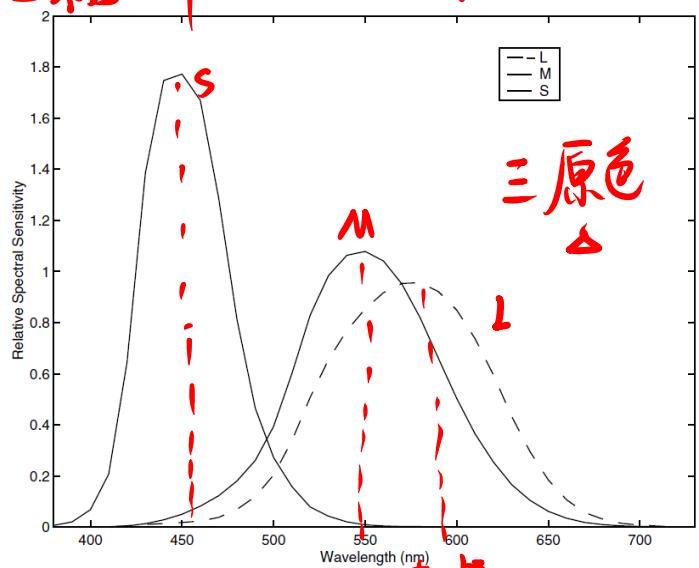
颜色学基础





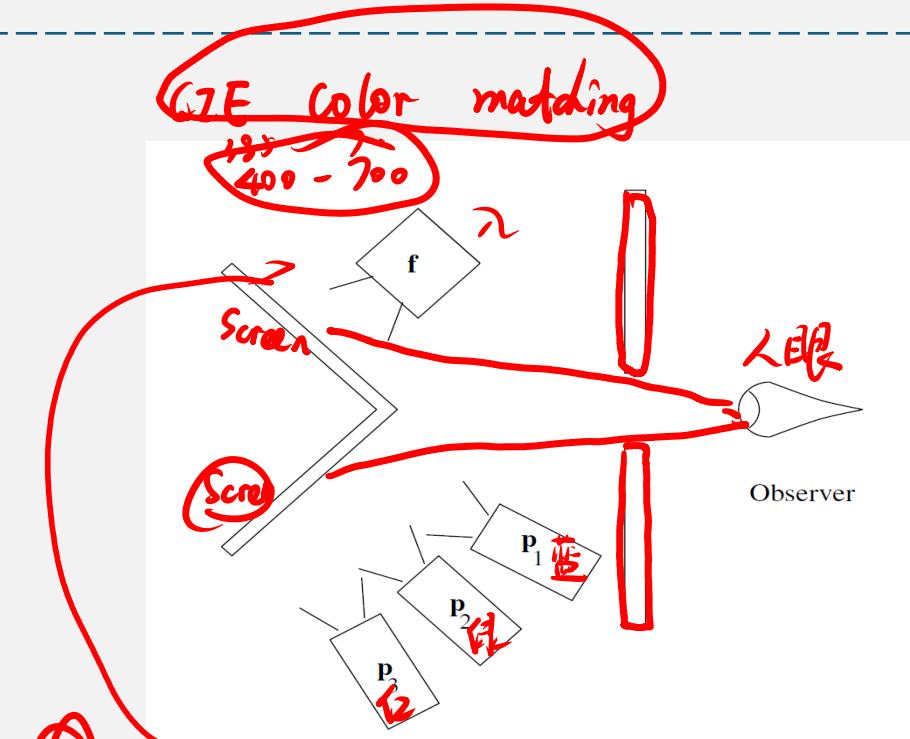
颜色学基础

视锥细胞：色彩
△视杆细胞：亮度



RGB 表达颜色

△ RGB

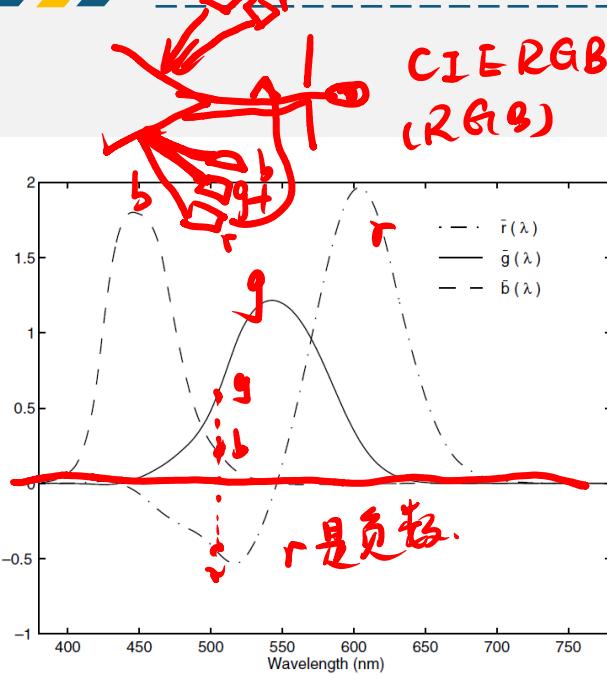


rgb

CIE RGB

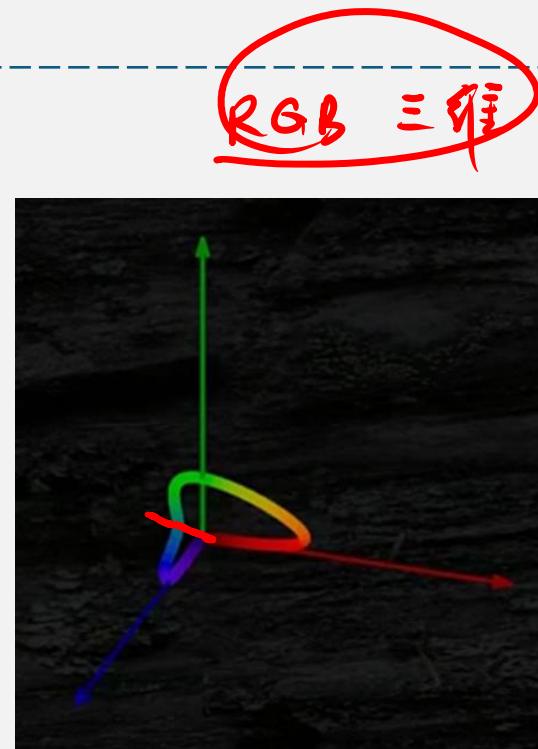


CMOS成像基础



500nm 光色

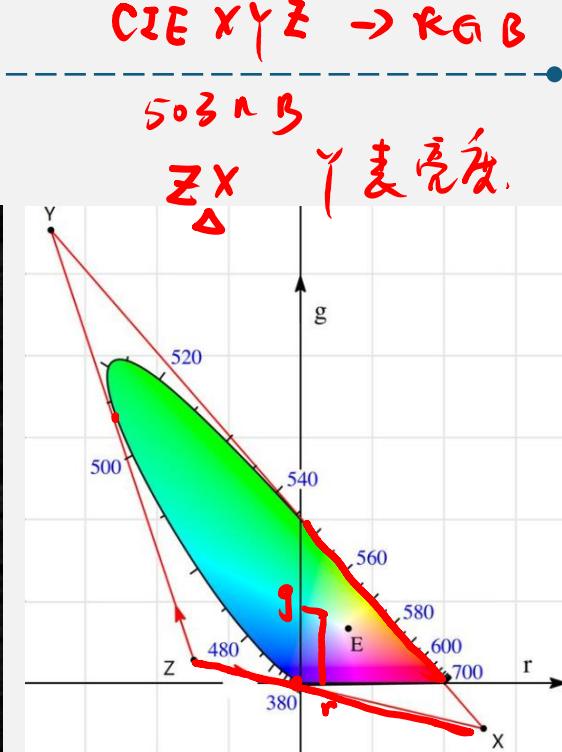
$$0 \cdot g + 0 \cdot r = g + b - r$$



$$G + R + B = 1$$

G, R

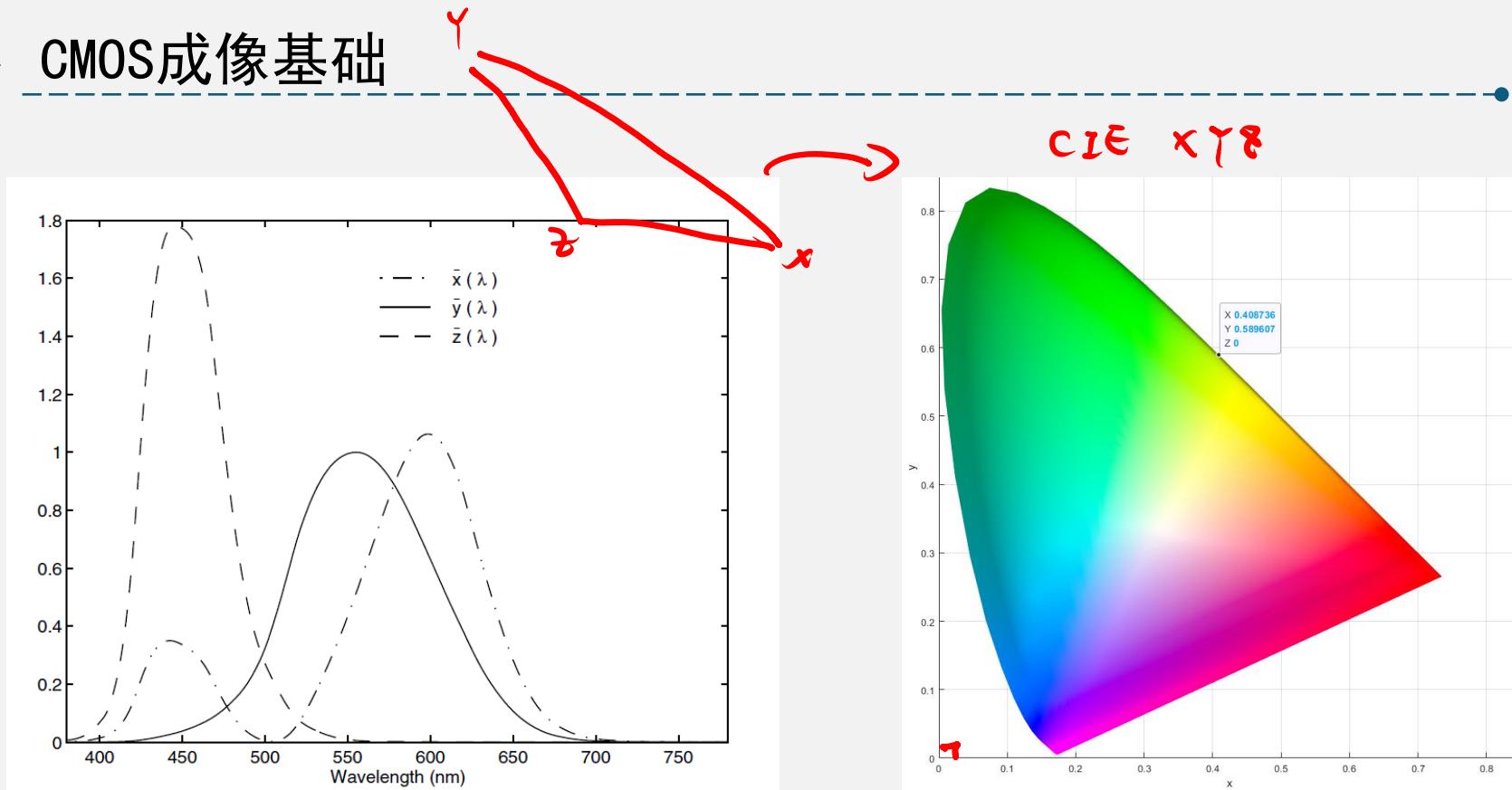
$$B = 1 - G - R$$



b
CIExyz
 $r \cdot g$



CMOS成像基础



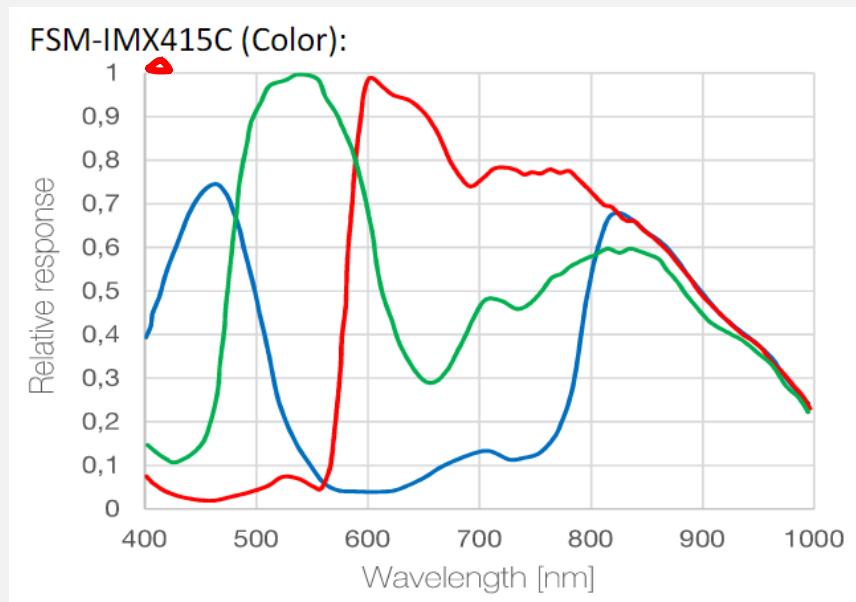
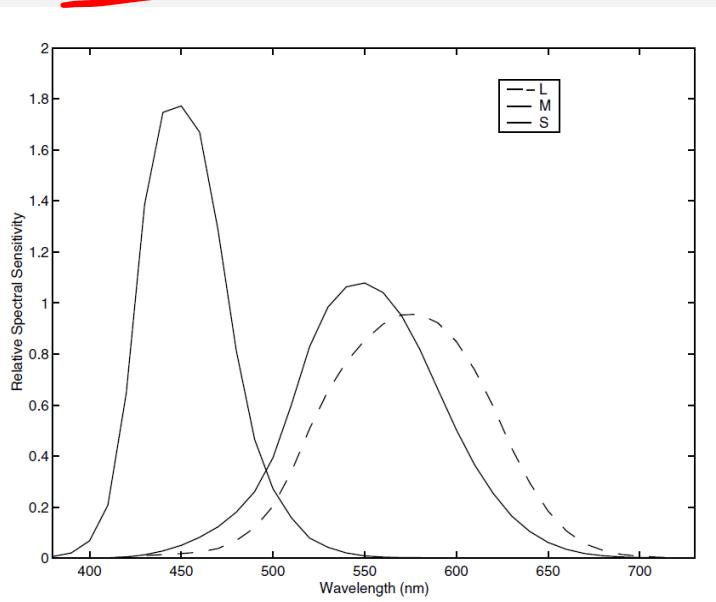
$$R + G + B = 1$$

$$x + y + z = 1$$

02 CCM的原理

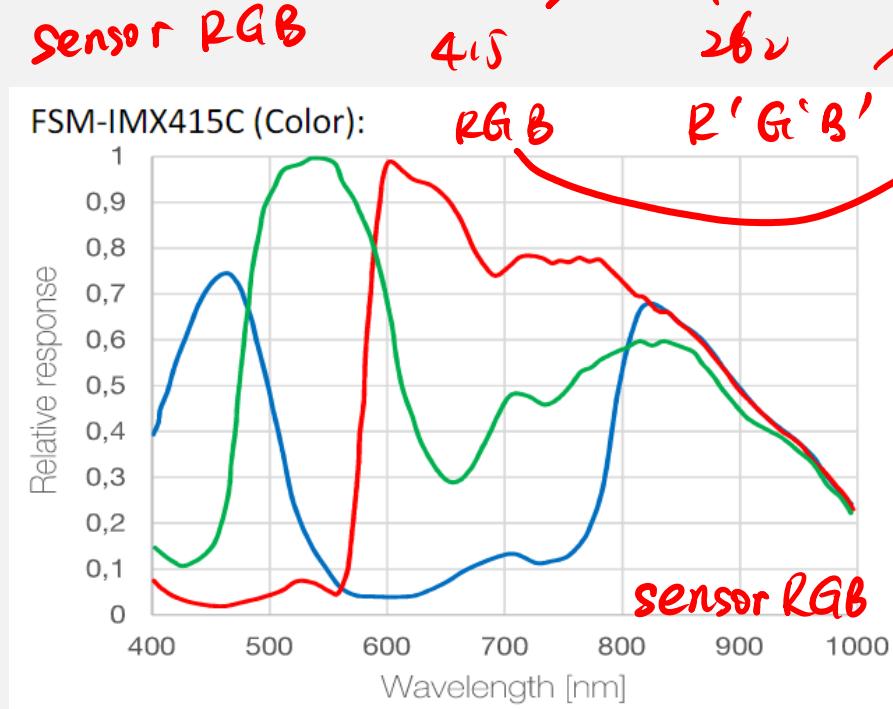


视锥细胞





CCM原理



Sony CMOS



SONY

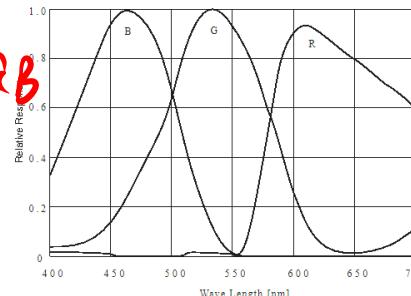
ICX262AQ

Clock Switching Characteristics (Horizontal drive frequency: 18MHz)

Item	Symbol	twh			twl			tr			tf			Remarks
		Min.	Typ.	Max.										
Readout clock	VT	2.63	2.83					0.5			0.5			μs During readout
Vertical transfer clock	V _{q1A} , V _{q1B} , V _{q2} , V _{q3A} , V _{q3B} , V _{q4}										15	250	ns	When using CXD3400N
Horizontal transfer clock	H _{q1}	14	19.5	14	19.5			8.5	14	8.5	14			ns tf ≥ tr - 2ns
	H _{q2}	14	19.5	14	19.5			8.5	14	8.5	14			
Parallel-serial conversion	H _{p1}		6.67					0.01		0.01				μs
	H _{p2}				5.56			0.01		0.01				
Reset gate clock	φRG	7	10		37			4			5			ns
Substrate clock	φSUB	1.7	3.06								0.5		0.5	μs During drain charge

Item	Symbol	two			Unit	Remarks
		Min.	Typ.	Max.		
Horizontal transfer clock H	φ1, H _{q2}	12	19.5	ns		

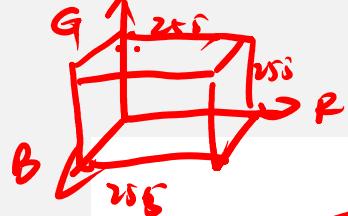
Spectral Sensitivity Characteristics (excludes lens characteristics and light source characteristics)



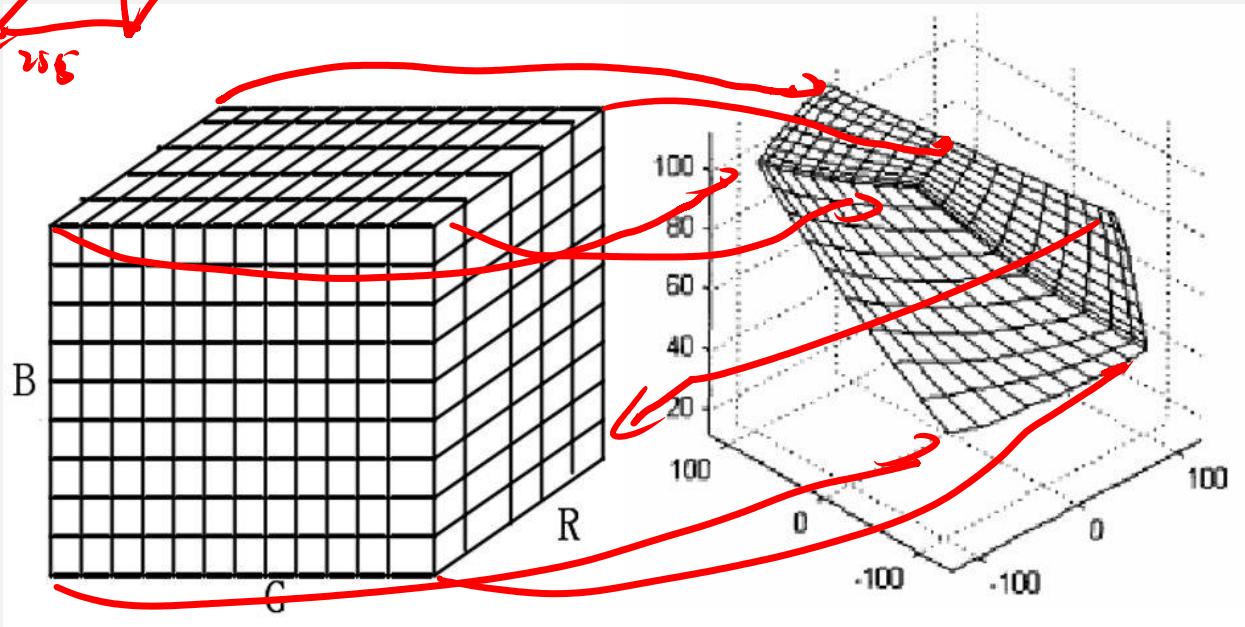


CCM原理-3D-LUT

LUT

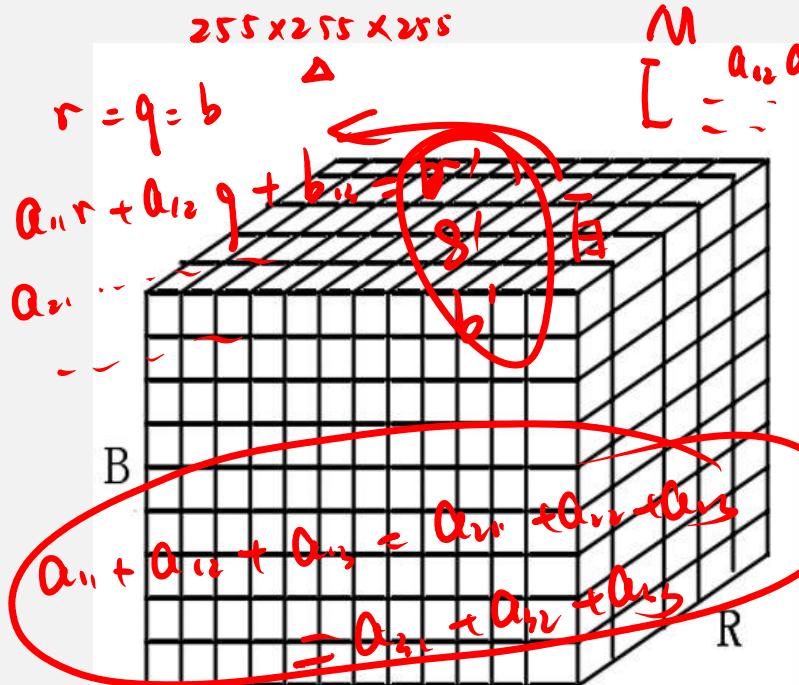


D求E





CCM原理-多项式拟合



CM sensor

$\begin{bmatrix} R_1 & R_2 & \dots & R_M \\ G_1 & G_2 & \dots & G_M \\ B_1 & B_2 & \dots & B_M \end{bmatrix} \xrightarrow{\Delta} M \times 3$

$[M_{rs}] = M \times 3 \xrightarrow{\substack{\text{SRGB} \\ \text{CCM}}} 3 \times 3$

$\begin{bmatrix} r_1 & r_2 & \dots & r_m \\ g_1 & g_2 & \dots & g_m \\ b_1 & b_2 & \dots & b_m \end{bmatrix} \xrightarrow{\Delta} M \times 3$

$C' = [3 \times 3] C_M$ 正线性

3×4

4×3

3×4

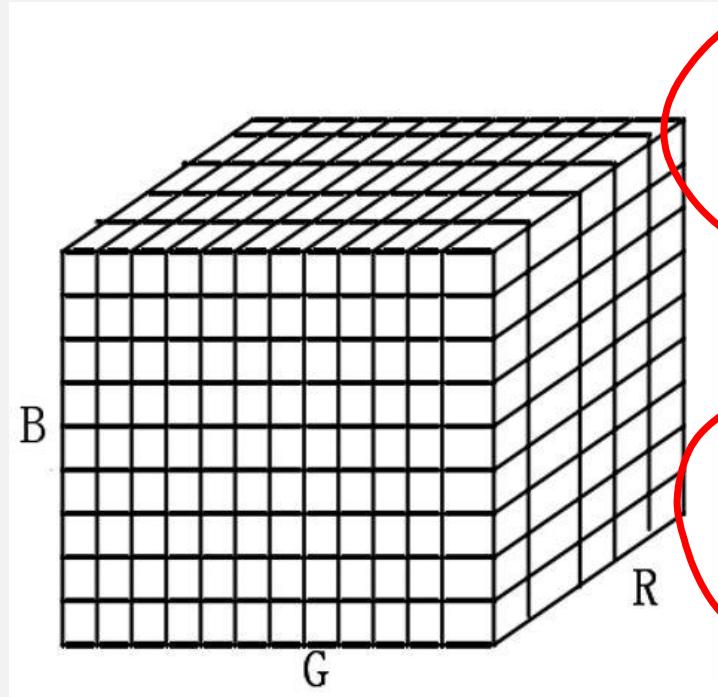
$a_{11} \ a_{12} \ a_{13} \ b_1$

offset

$$r' = a_{11}R_1 + a_{12}G_1 + a_{13}B_1 + b_1$$



CCM原理-多项式拟合



拉格朗日式

$$e = a_{11}r + a_{12}g + a_{13}b + a_{14}\sqrt{rg} + a_{15}\sqrt{rb} + a_{16}\sqrt{gb}$$

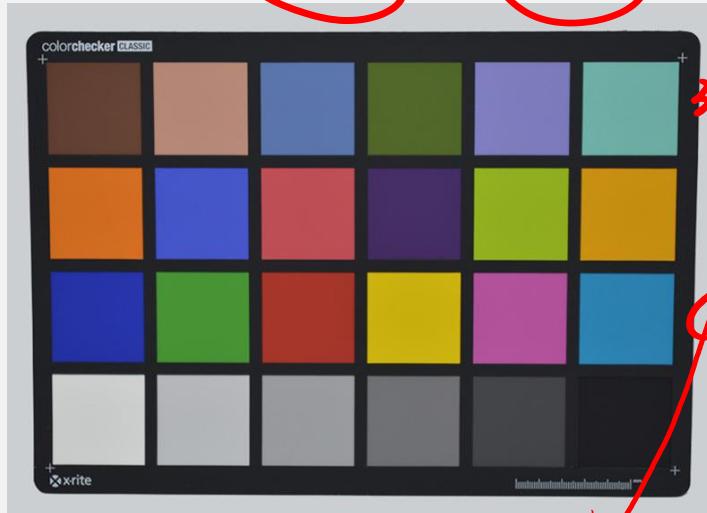
多项式：

$$e = a_{11}r + a_{12}g + a_{13}b + a_{14}rg + a_{15}rb + a_{16}gb + a_{17}r^2 + a_{18}g^2 + a_{19}b^2$$



CCM原理-多项式拟合

线性拟合



target

~~M = 24~~

$$[d\text{elta}E] = \sqrt{L^2 + \Delta A^2 + \Delta B^2}$$

$$3 \times 24 = B \times 1 \quad B \times 24$$

target

delta E

ΔE

$$\begin{matrix} \text{rgb} & 2 \times 3 \\ \text{LAB} & 3 \times 3 \end{matrix}$$

1994

Delta E

ΔE ..

L² Delta E

A = B =

5x3

LAB 3x3

ΔE ..

5x3

ΔE ..

5x3

ΔE ..

5x3

CIE RGB → CIE XYZ A' → A L²
(X · Y · Z) D LAB



CCM原理-神经网络

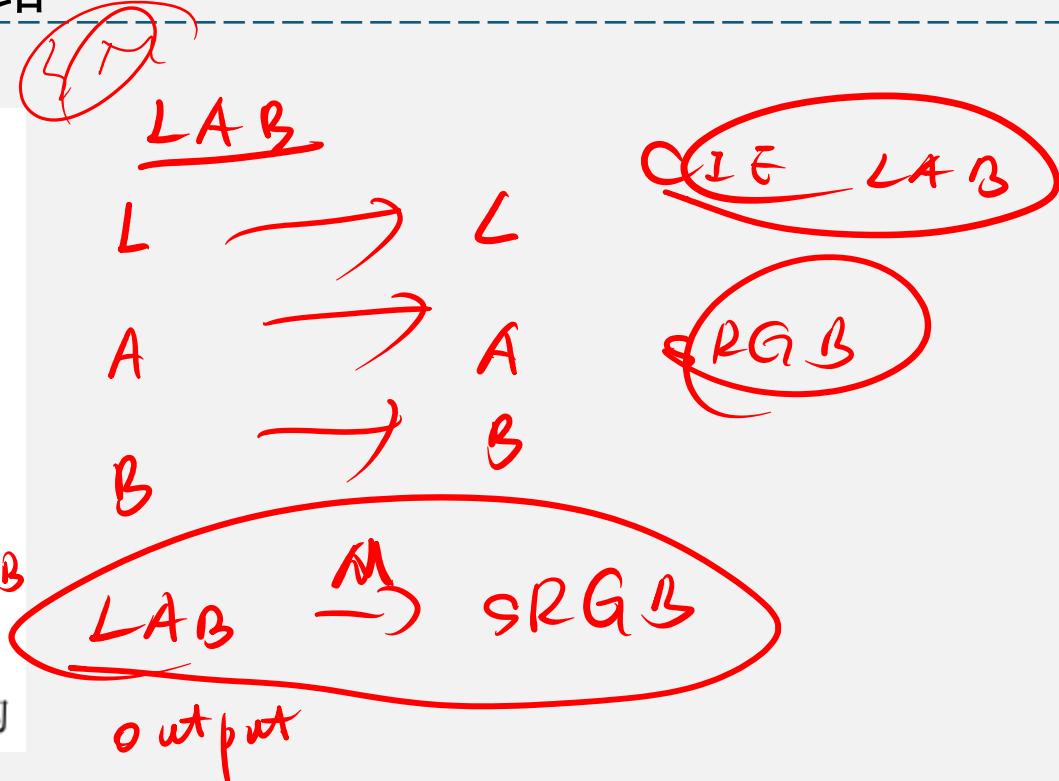
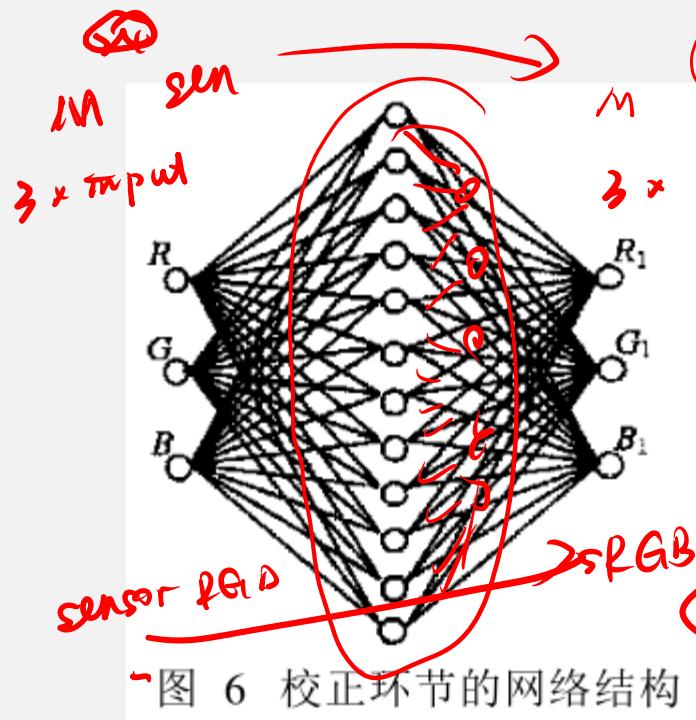


图 6 校正环节的网络结构

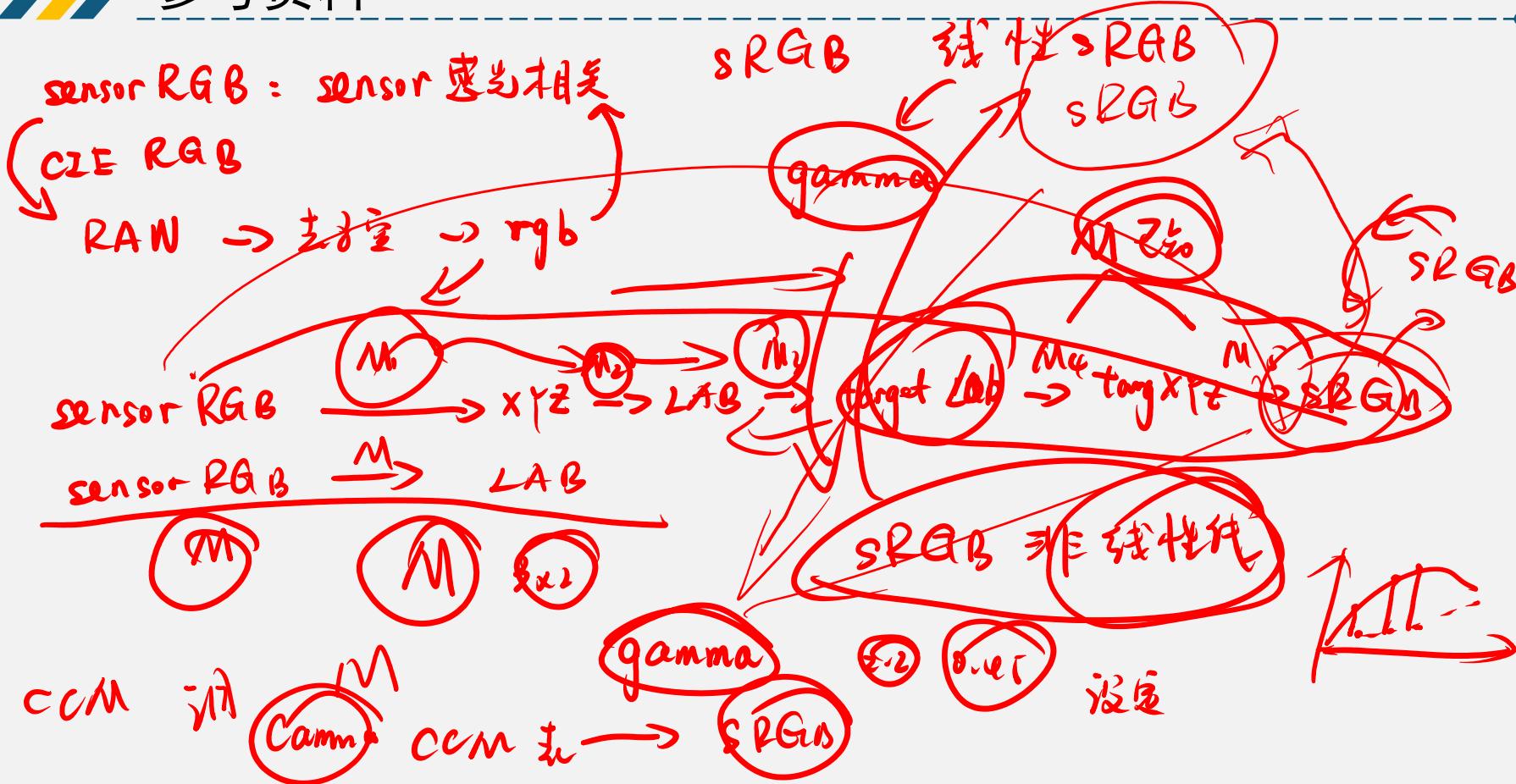


参考资料

- [Color Correction Matrix \(CCM\) | Imatest](#)
- [Plot color reproduction on chromaticity diagram – MATLAB plotChromaticity – MathWorks 中国](#)
- <https://zhuanlan.zhihu.com/p/34562544>
- <https://zhuanlan.zhihu.com/p/462631883>
- <https://zhuanlan.zhihu.com/p/364684230>
- <https://zhuanlan.zhihu.com/p/137639368>



参考资料





参考资料

3x3
m x 3
33
m x 9
3x3
m x 3
3x3
m x 2



03

算法代码实现



See You!



食鱼者



wtzhu13



猪猪爱吃鱼



202206



<https://gitee.com/wtzhu13>



wtzhu__13



食鱼者



该二维码7天内(6月26日前)有效，重新进入将更新



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