



浙江大学计算机学院
数字媒体与网络技术

Digital Asset Management

数字媒体资源管理

2. Introduction to Digital Media Format

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基于Python的教学

- 推荐使用的工具链：
 - ipython
 - ipython notebook
 - ImageMagick
 - Flask ...

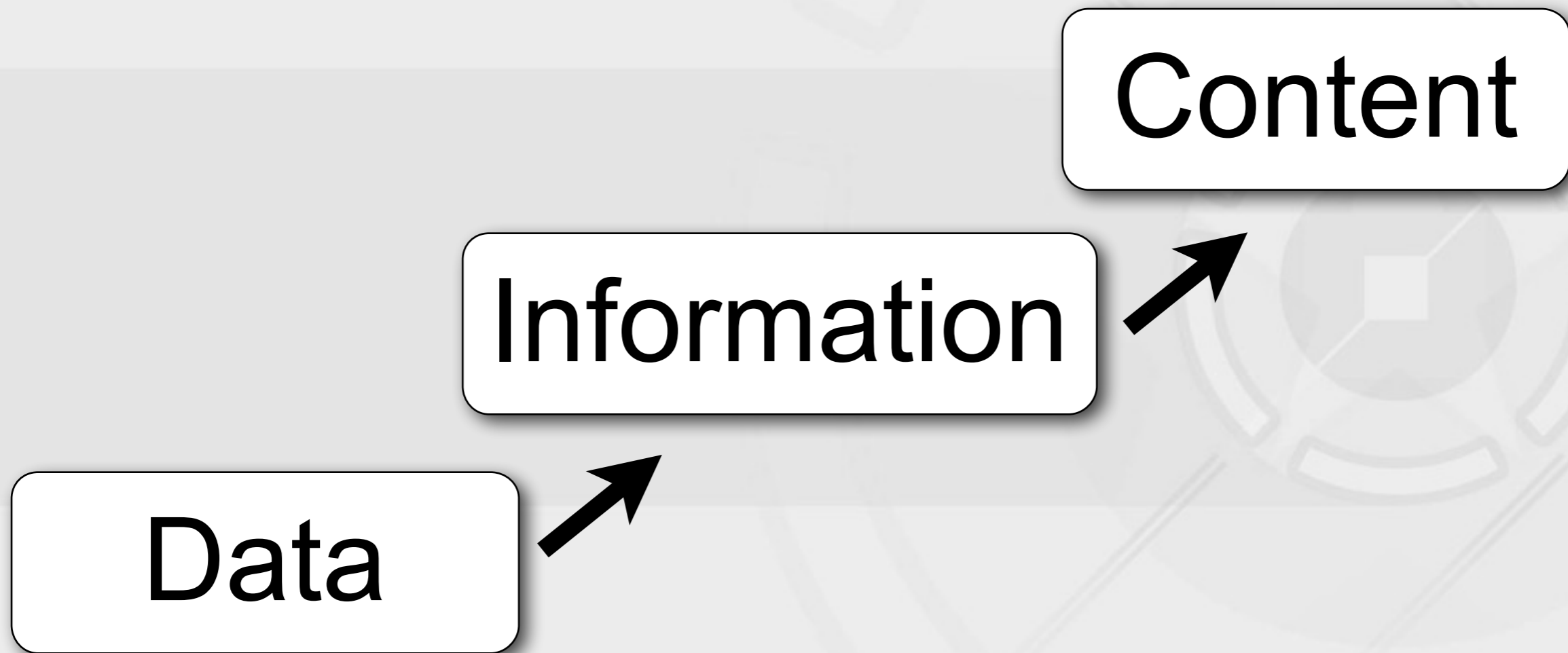




Review



Content



What is Digital Asset Management?

- Tools for organizing, storing and retrieving content in digital format
- downloading, renaming, backing up, rating, grouping, archiving, optimizing, maintaining, thinning, and exporting ...
- Includes:
 - text, video, images, movies, sound, and 3D content



Content

content = essence + metadata
内容 = 素材 + 元数据



Digital media data types

Table. File format used in Macromedia Director

File import					File export		Native
Image	Palette	Sound	Video	Animation	Image	Video	
BMP	PAL	AIFF	AVI	DIR	BMP	AVI	DIR
GIF	ACT	AU	MOV	FLA		MOV	DXR
JPG		MP3		FLC			EXE
PICT		WAV		FLI			
PNG				GIF			
PNT				PPT			
PSD							
TGA							
TIFF							
WMF							



Outline

- Image format and coding methods
- Audio format and coding methods
- Video format and coding methods
- Introduction to HTML and XML
- Graphics format and coding methods



Key points

- To grasp features of different types of digital media
- To understand principles of coding different types of digital media





2.1 Image format and coding methods



Common image formats

- General types:

- GIF
- JPEG
- PNG
- TIFF
- TGA

- Raw data:

- RAW
- DNG

- Platform spec.:

- ➔BMP (Win)
- ➔PAINT&PICT (Mac)
- ➔PPM (X-Win)

- Vector data:

- ➔WMF (Win)
- ➔PS and PDF



Common image formats

- Key points of storage
 - Color space
 - Coding methods
 - Byte order: hardware dependent
 - MSB/LSB (most/least significant byte)
 - MSB - Power PC CPU
 - LSB - Intel X86 CPU





2.1.1 Color spaces



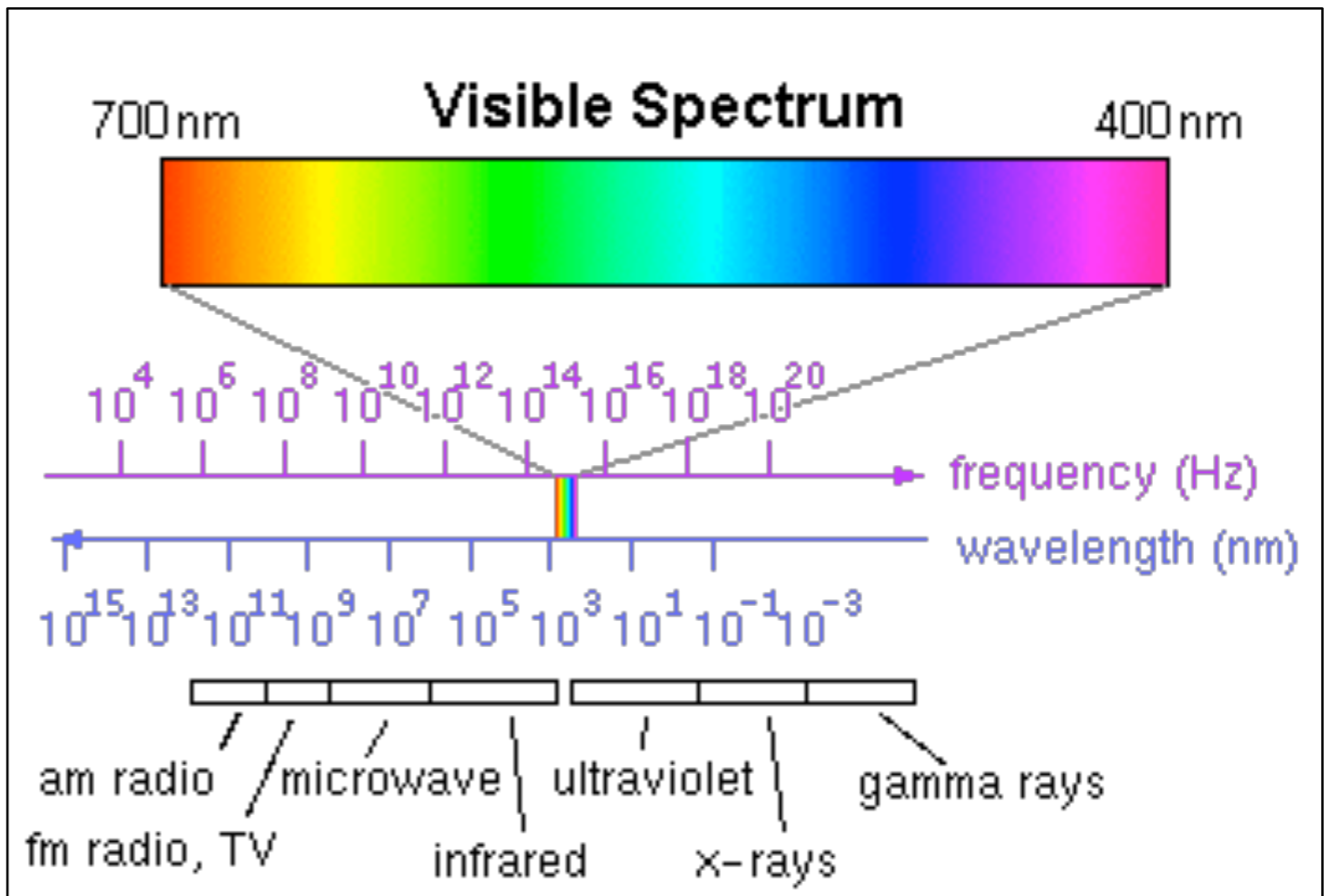
Color systems and color models

- Common systems
 - RGB
 - XYZ
 - Lab
 - YUV
 - HSV

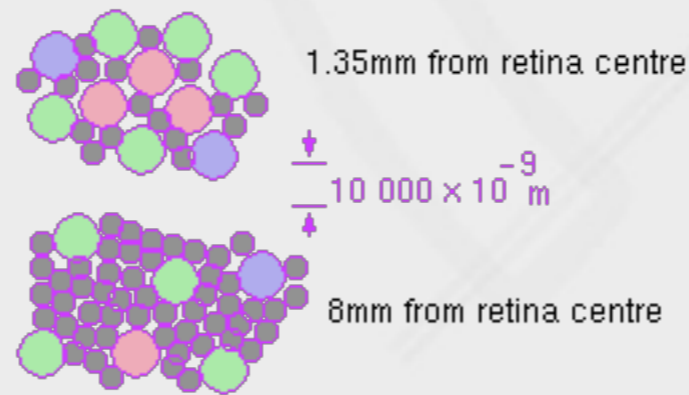
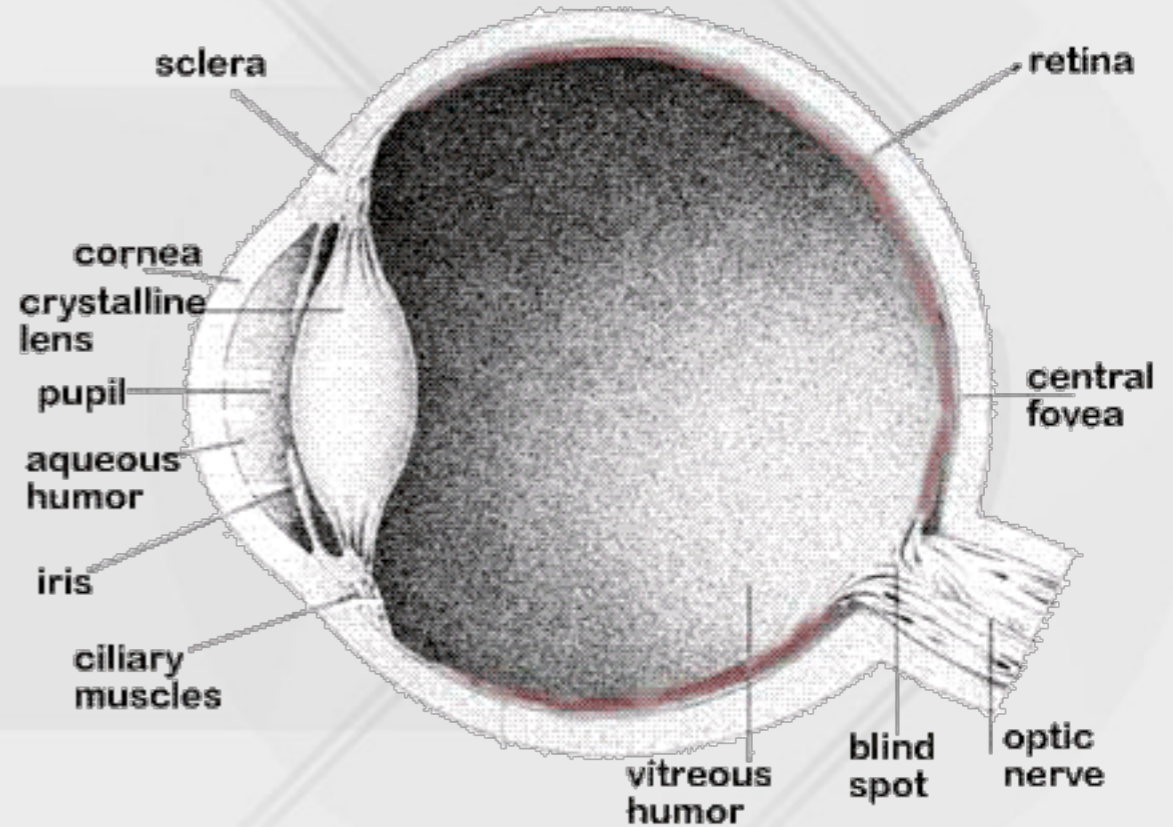
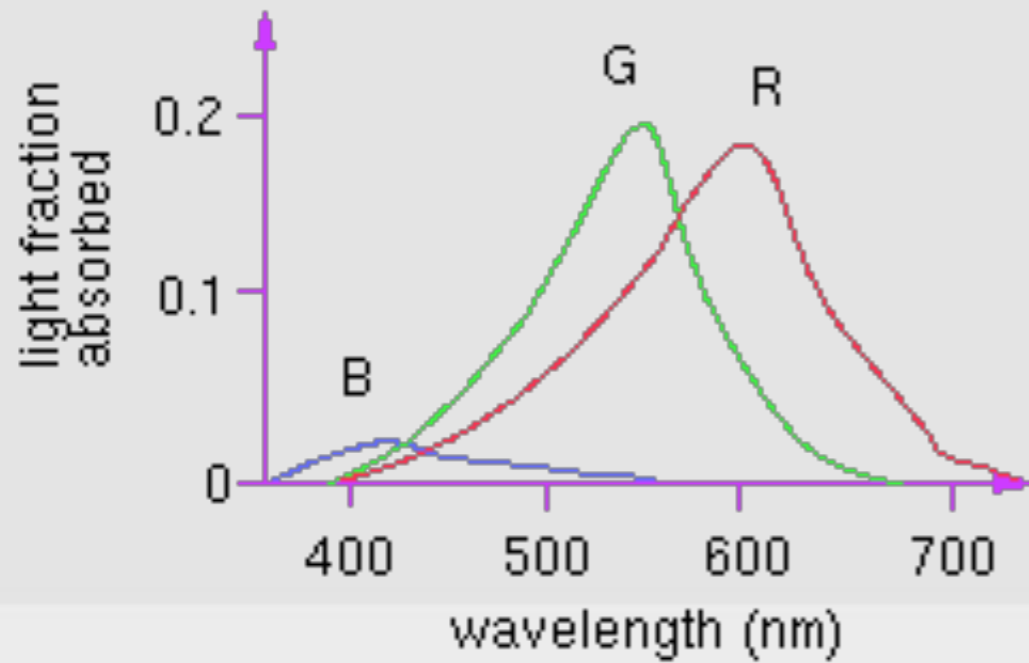


Color systems and color models

- Common systems
 - RGB
 - XYZ
 - Lab
 - YUV
 - HSV



Color Model



Color perception

- Three types of cones:

S

M

L

Blue

Green

Red

roughly approximate

430nm

560nm

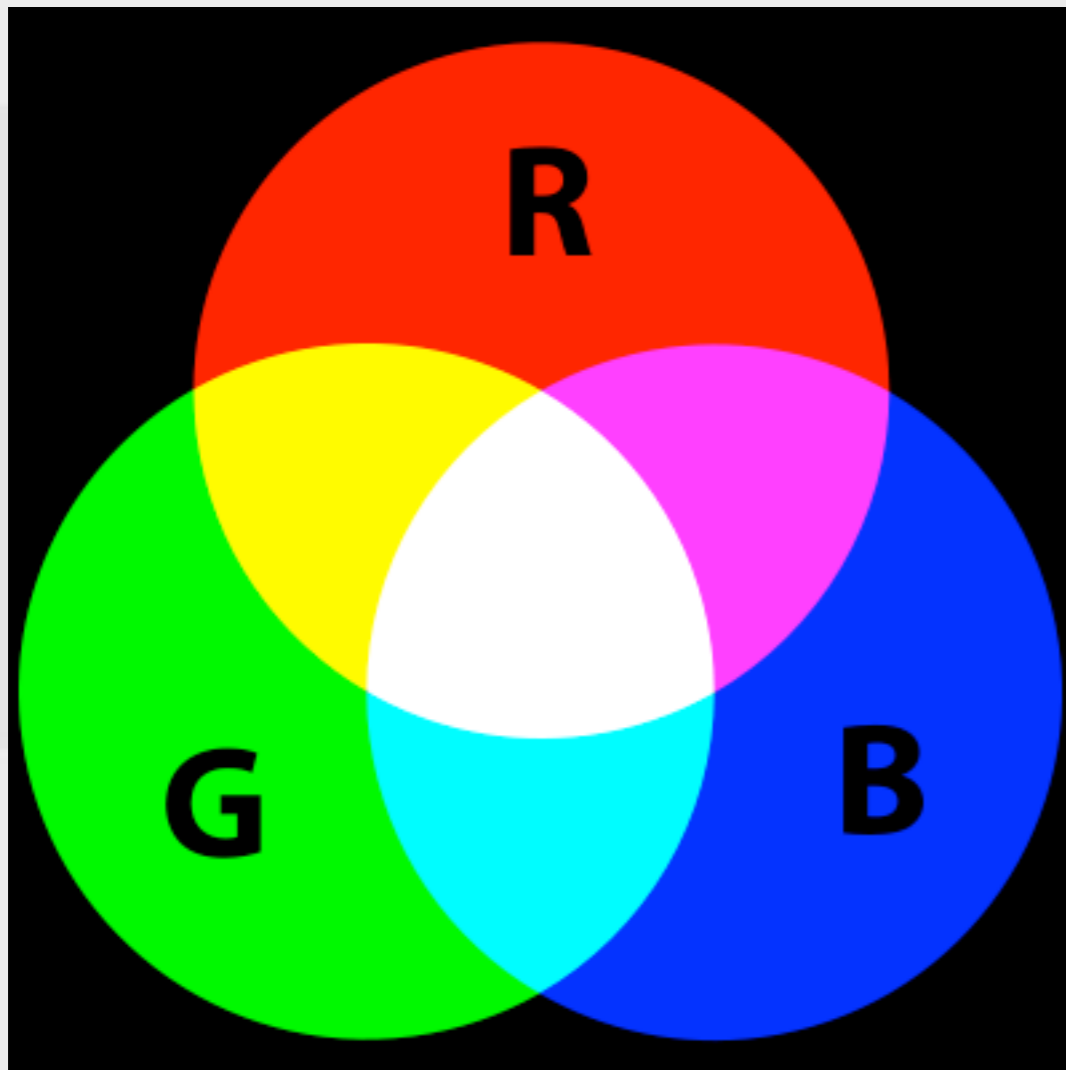
610nm

peak sensitivities

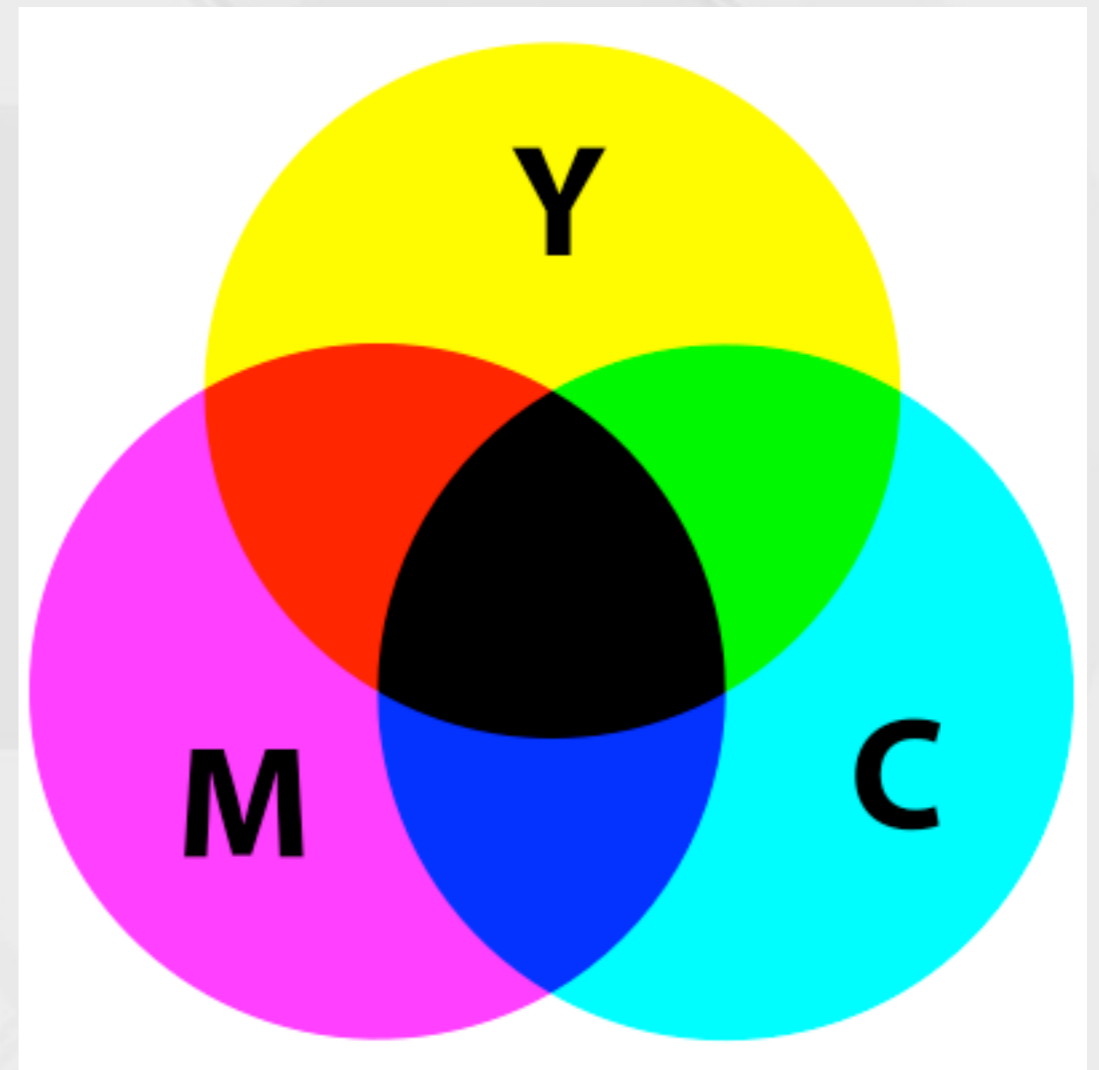
- Colorblindness results from a deficiency of one cone type.



RGB & CMYK



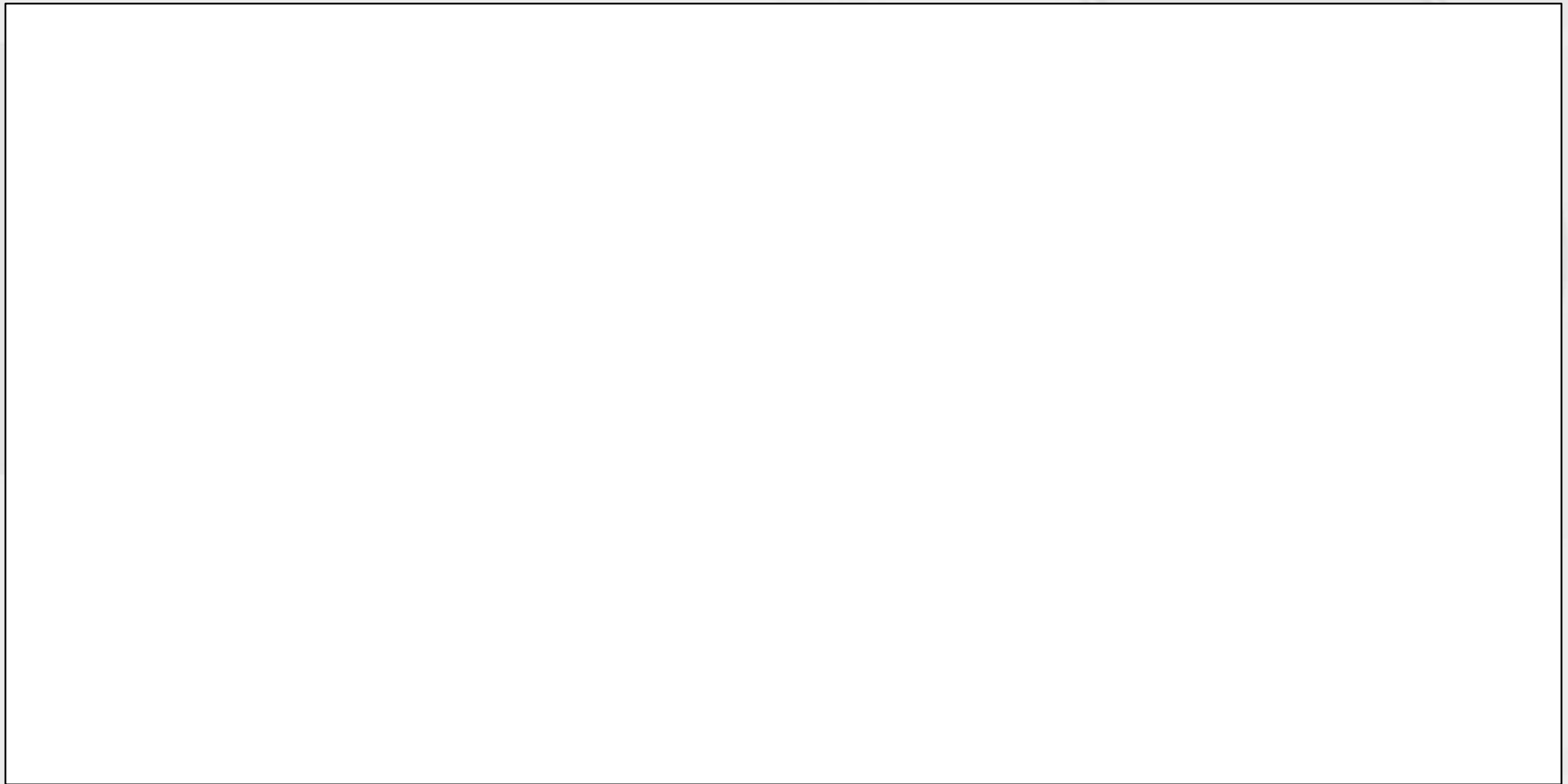
Additive color mixing



Subtractive color mixing



CMYK \Rightarrow RGB



CMYK \Rightarrow RGB

$t_{\text{CMYK}} = C, M, Y, K$



CMYK => RGB

$$t_{\text{CMYK}} = C, M, Y, K$$

$$t_{\text{CMY}} = C', M', Y'$$

$$= C(1 - K) + K, M(1 - K) + K, Y(1 - K) + K$$



CMYK \Rightarrow RGB

$$t_{\text{CMYK}} = C, M, Y, K$$

$$t_{\text{CMY}} = C', M', Y'$$

$$= C(1 - K) + K, M(1 - K) + K, Y(1 - K) + K$$

$$t_{\text{RGB}} = R, G, B$$

$$= 1 - C', 1 - M', 1 - Y'$$



CMYK \Rightarrow RGB

$$t_{\text{CMYK}} = C, M, Y, K$$

$$\begin{aligned} t_{\text{CMY}} &= C', M', Y' \\ &= C(1 - K) + K, M(1 - K) + K, Y(1 - K) + K \end{aligned}$$

$$\begin{aligned} t_{\text{RGB}} &= R, G, B \\ &= 1 - C', 1 - M', 1 - Y' \end{aligned}$$

$$\begin{aligned} t_{\text{RGB}} &= \{1 - (C(1 - K) + K), 1 - (M(1 - K) + K), 1 - (Y(1 - K) + K)\} \\ &= \{1 - C(1 - K) - K, 1 - M(1 - K) - K, 1 - Y(1 - K) - K\} \end{aligned}$$



CMYK => RGB

$$t_{\text{CMYK}} = C, M, Y, K$$

RGB => CMYK?

$$t_{\text{CMY}} = C', M', Y'$$

$$= C(1 - K) + K, M(1 - K) + K, Y(1 - K) + K$$

$$t_{\text{RGB}} = R, G, B$$

$$= 1 - C', 1 - M', 1 - Y'$$

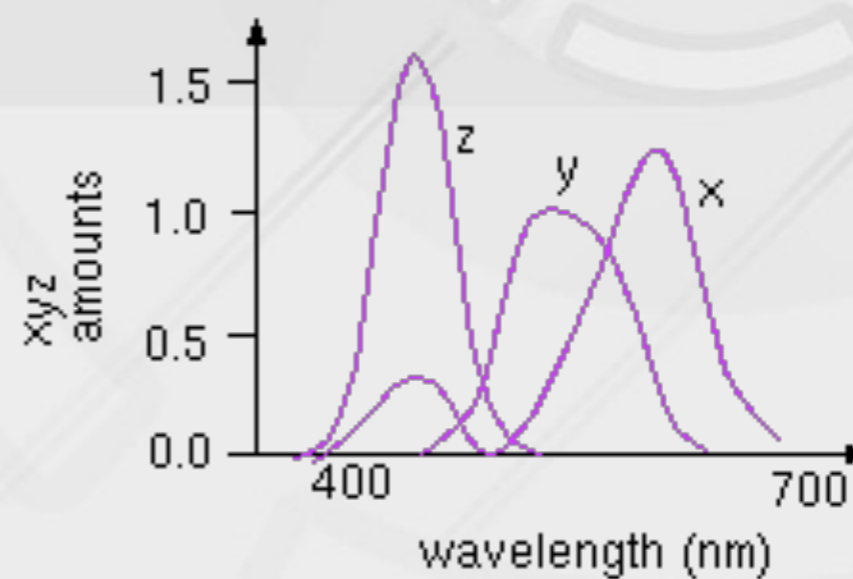
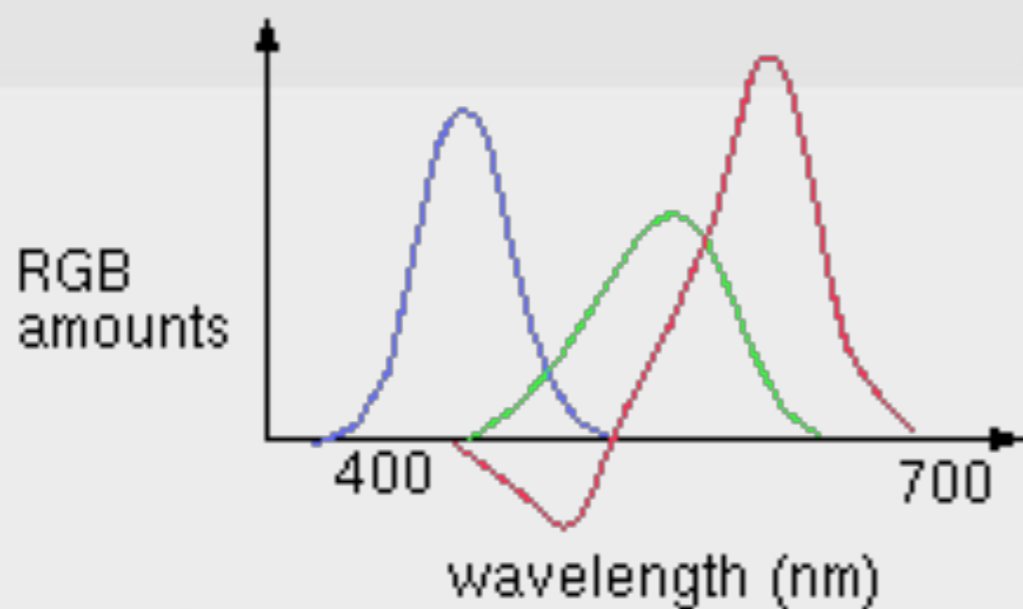
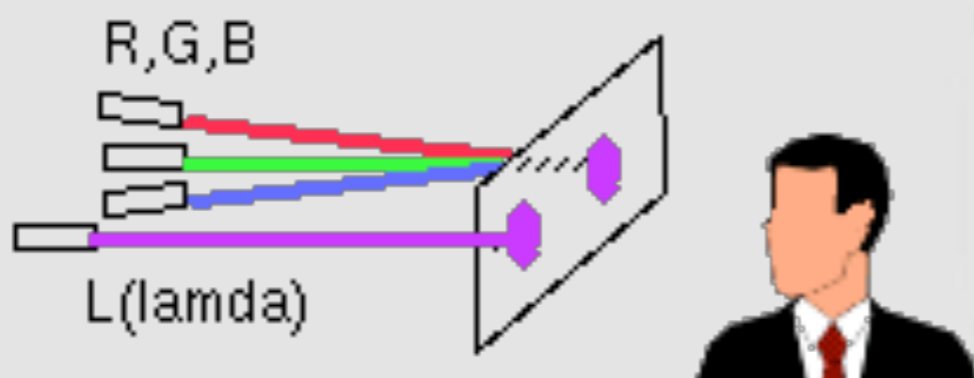
$$t_{\text{RGB}} = \{1 - (C(1 - K) + K), 1 - (M(1 - K) + K), 1 - (Y(1 - K) + K)\}$$

$$= \{1 - C(1 - K) - K, 1 - M(1 - K) - K, 1 - Y(1 - K) - K\}$$



CIE XYZ space

- CIE: Commission Internationale d'Eclairage"



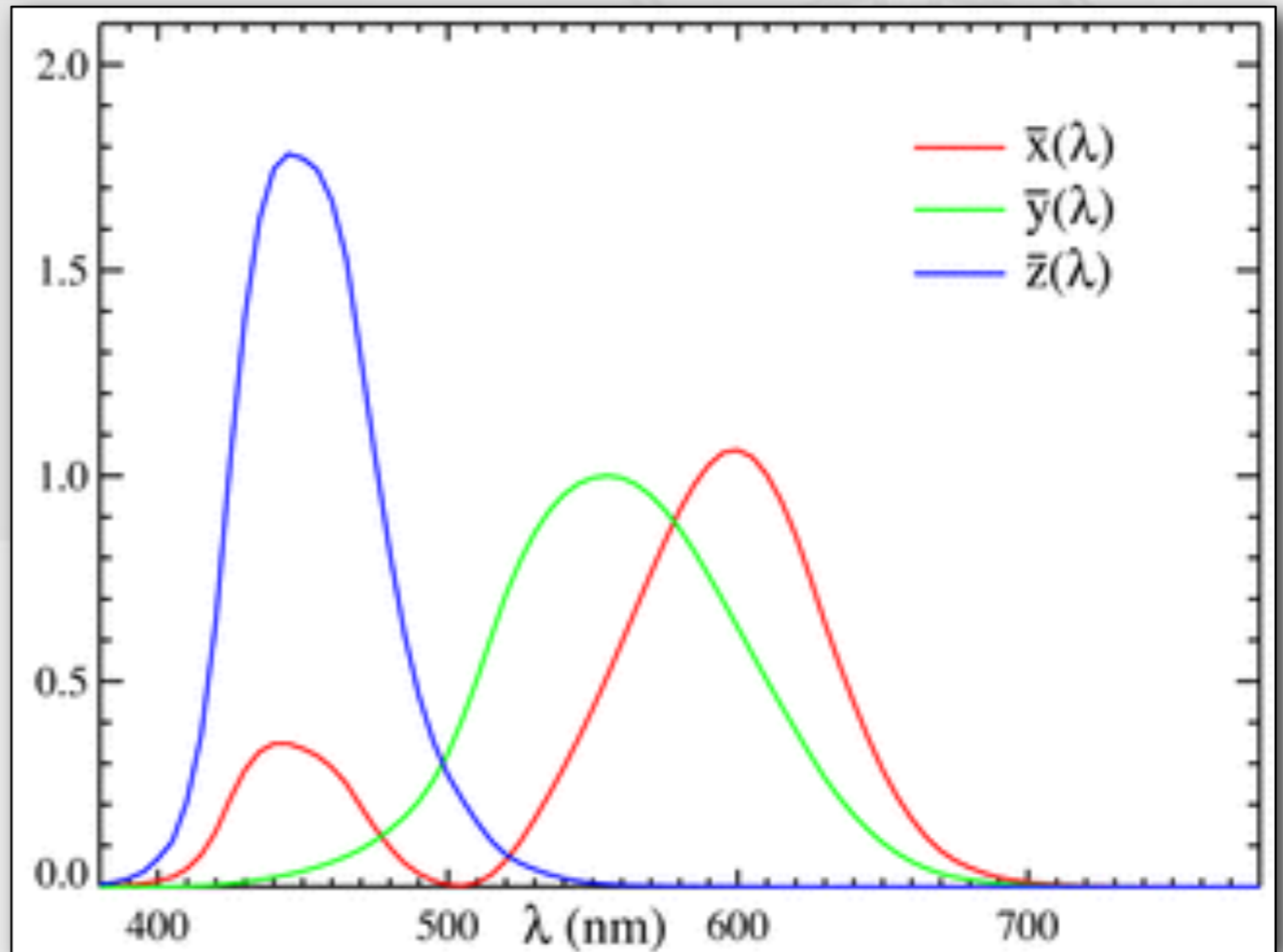
CIE XYZ space

- Color matching function

$$X = \int_0^{\infty} I(\lambda) \bar{x}(\lambda) d\lambda$$

$$Y = \int_0^{\infty} I(\lambda) \bar{y}(\lambda) d\lambda$$

$$Z = \int_0^{\infty} I(\lambda) \bar{z}(\lambda) d\lambda$$

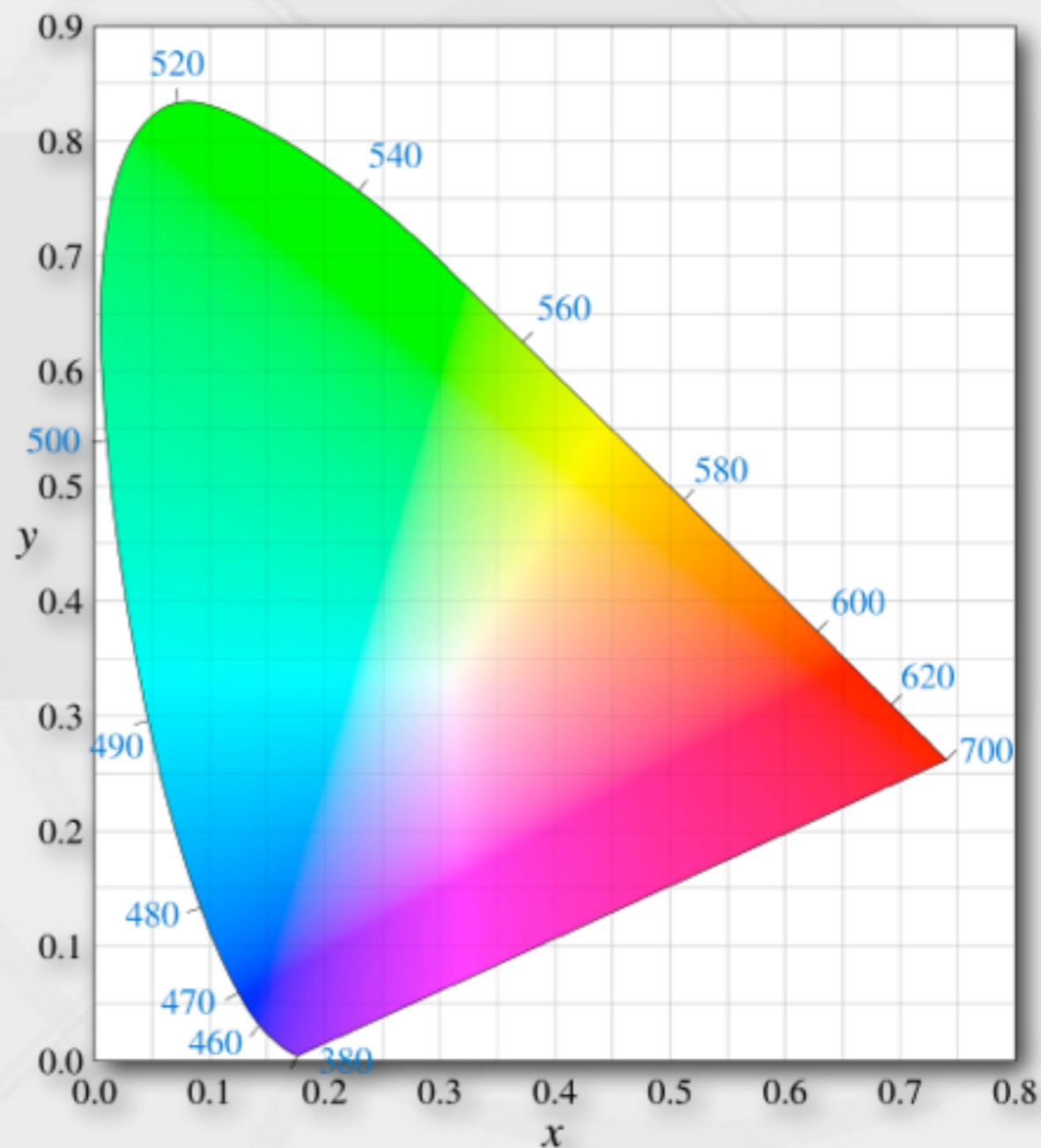


CIE XYZ space

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

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

$$z = \frac{Z}{X + Y + Z} = 1 - x - y$$



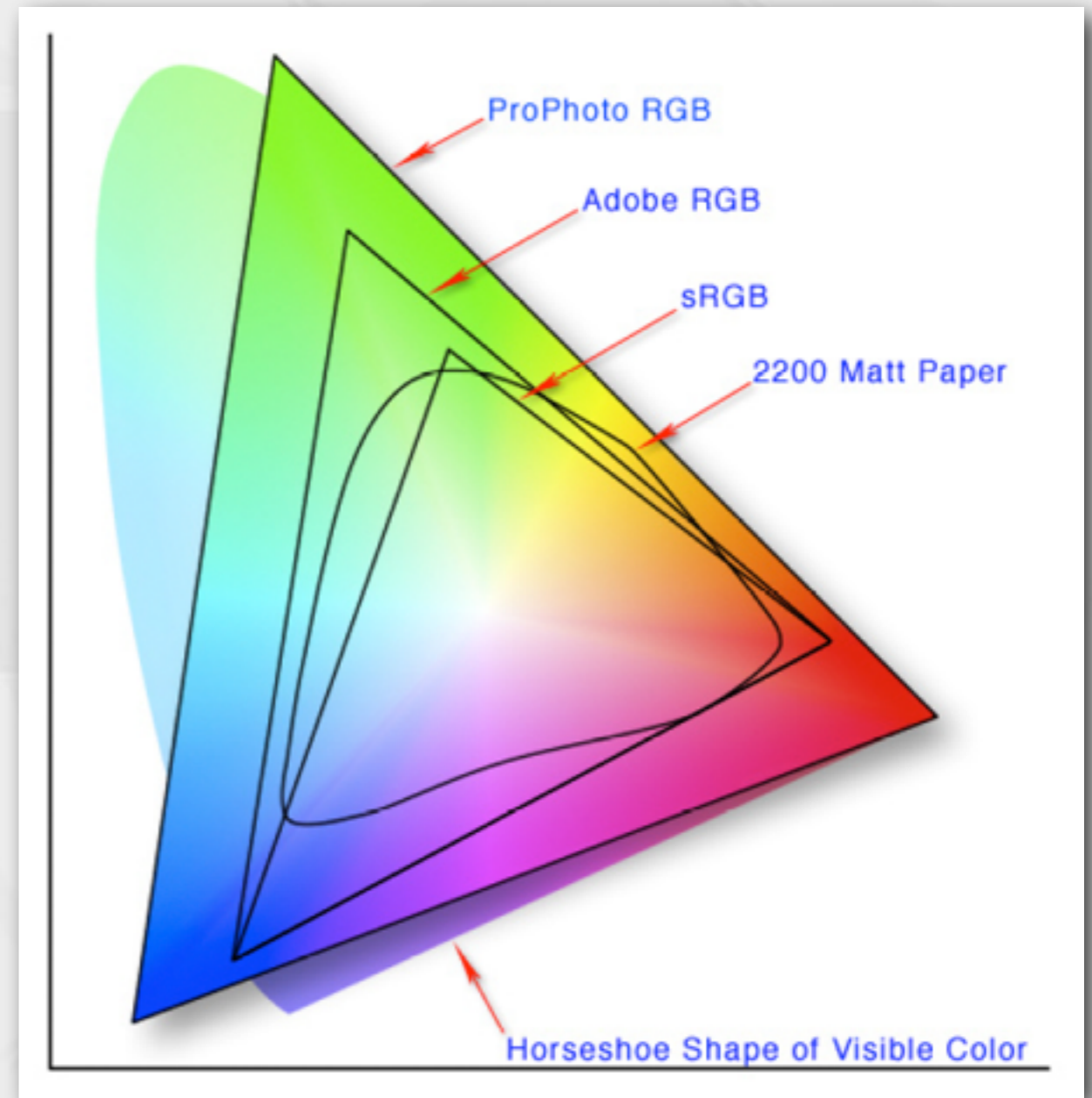
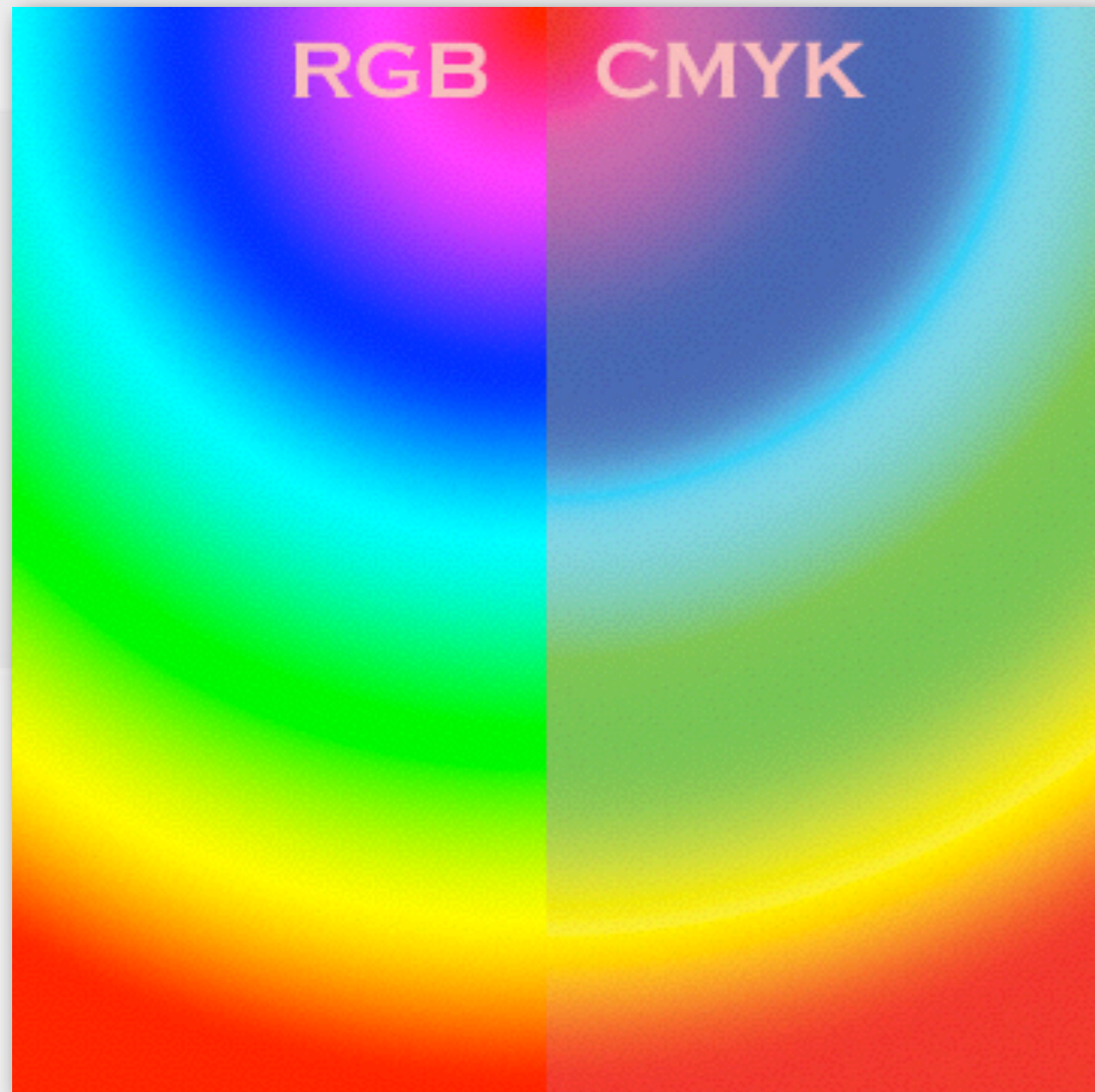
RGB vs. XYZ

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \frac{1}{b_{21}} \begin{bmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} = \frac{1}{0.17697} \begin{bmatrix} 0.49 & 0.31 & 0.20 \\ 0.17697 & 0.81240 & 0.01063 \\ 0.00 & 0.01 & 0.99 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

Since 1931



RGB :: CMYK :: XYZ color spaces



YUV color spaces

Image



Y



U



V

- used in most video capture system
- PAL television system



YUV color spaces

Image



- used in most video capture system
- PAL television system

Y



U



V



$$\begin{bmatrix} Y' \\ U \\ V \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ -0.14713 & -0.28886 & 0.436 \\ 0.615 & -0.51499 & -0.10001 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$



Color spaces: reference

- http://en.wikipedia.org/wiki/Color_space
- <http://www.cs.unc.edu/~mcmillan/comp136/Lecture4/Color.html>





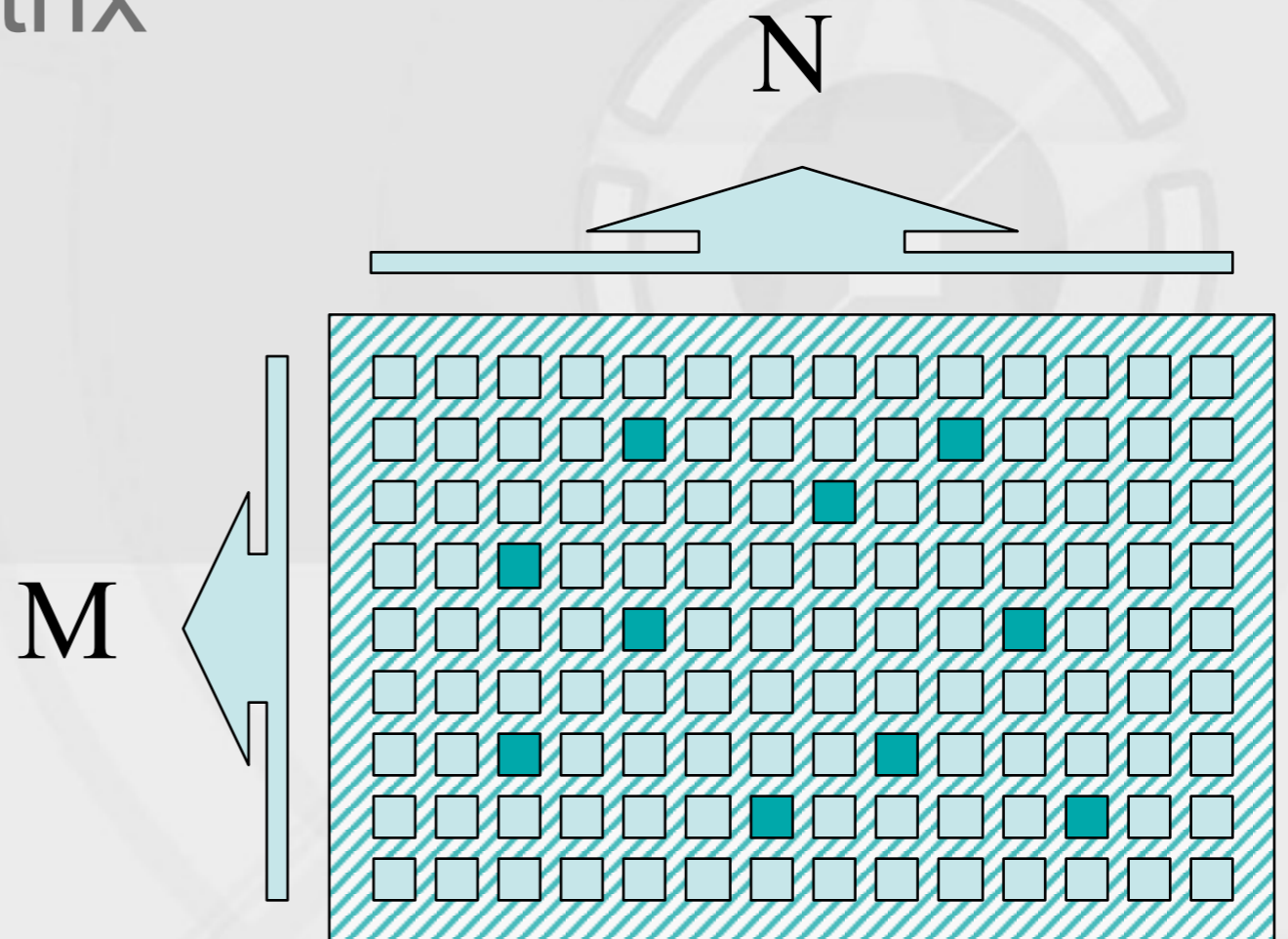
2.1.2

Image representations

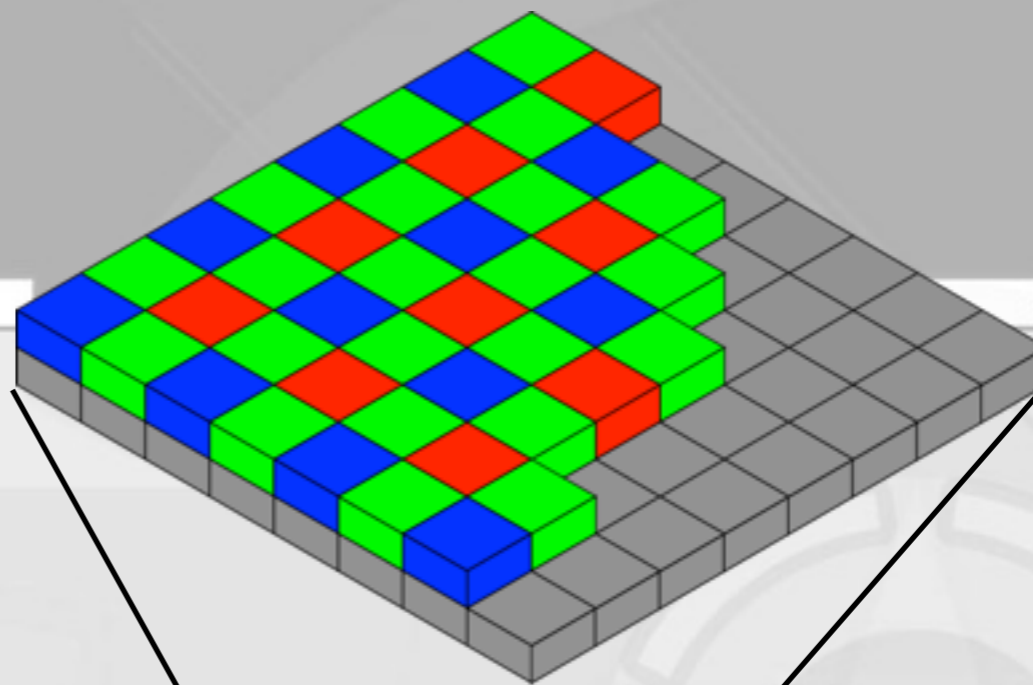


Representation of digital images

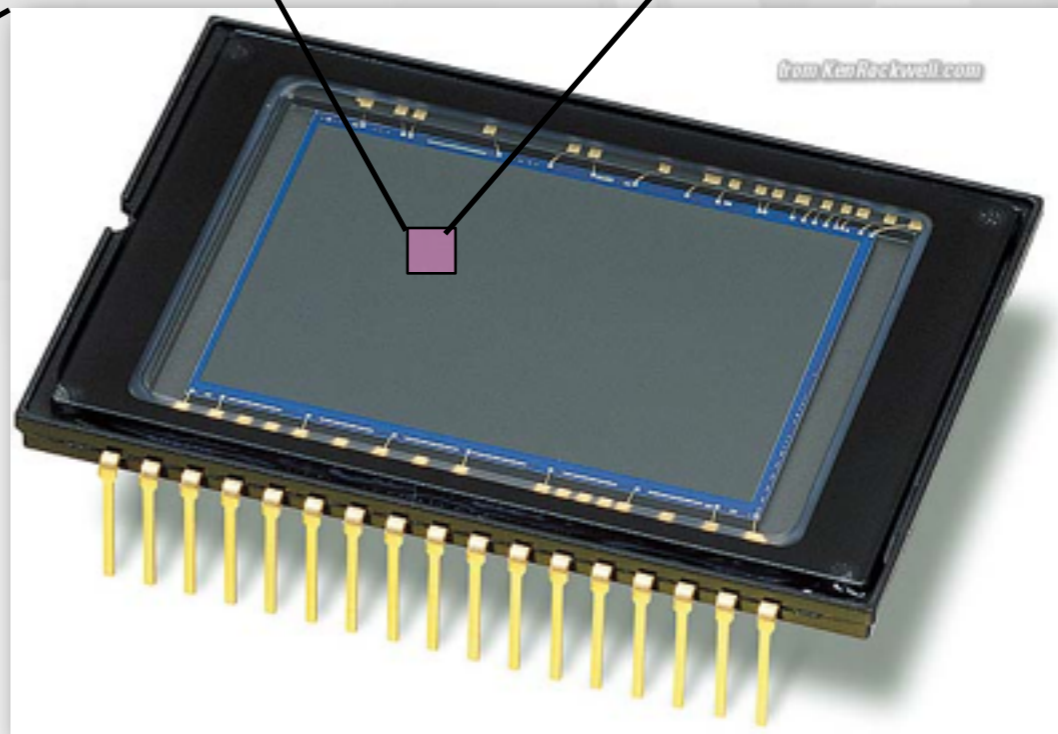
- An image can be viewed as a $N \times M$ vector matrix
- Grayscale image
- Color image
- Palette



CCD sensors



Nikon D40



CCD sensor

© sensorcleaning.com

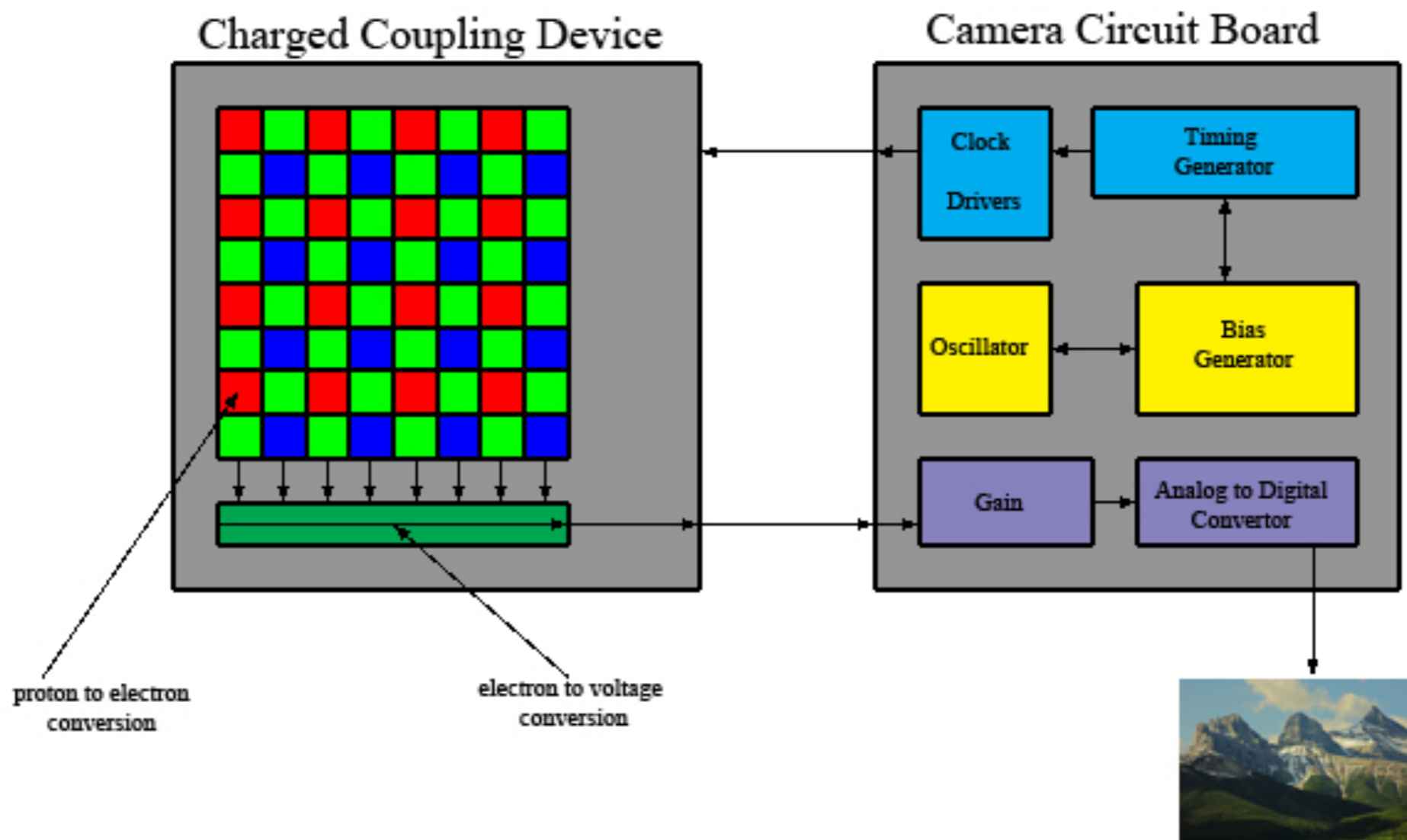


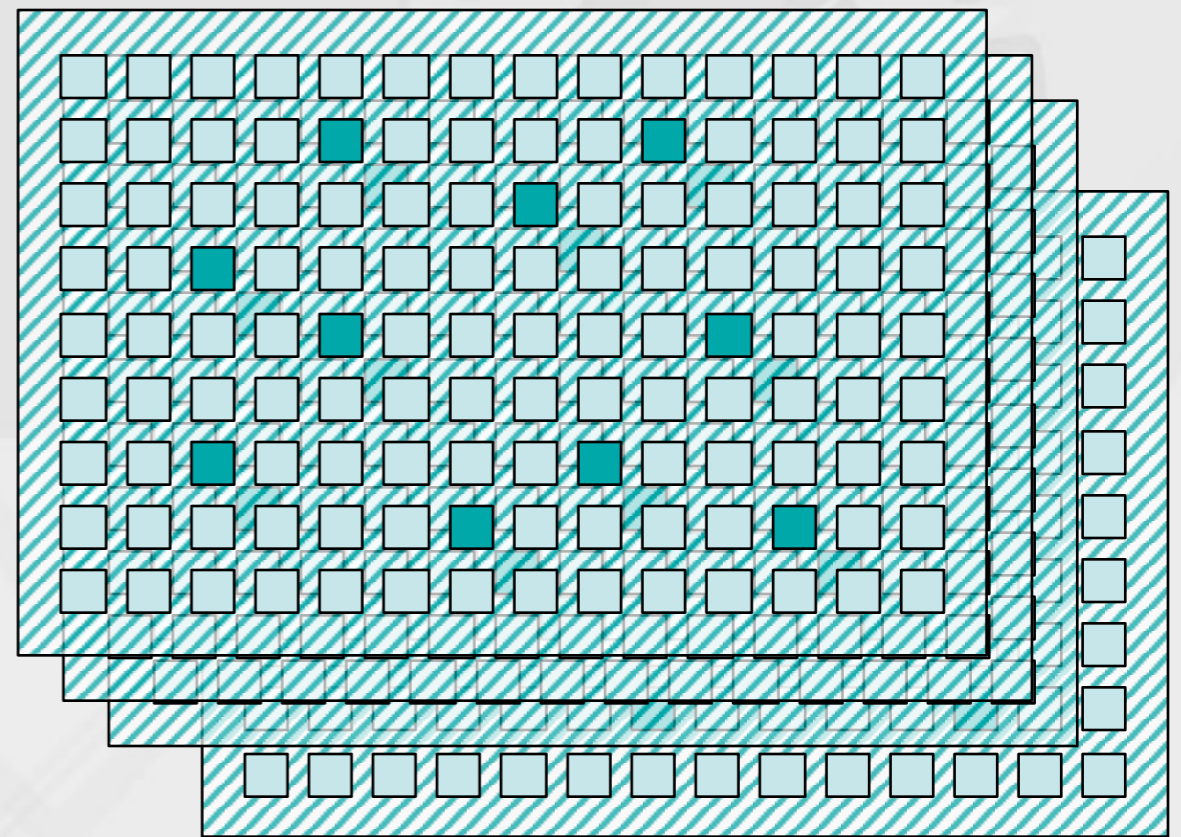
Image resolutions

Dimensions	MEGA pixels	Name	Comments
640x480	0.3	VGA	
720x576	0.4	CCIR 601 DV PAL	PAL DV, and PAL DVDs
768x576	0.4	CCIR 601 PAL full	PAL with square sampling grid ratio
800x600	0.4	SVGA	
1024x768	0.8	XGA	
1280x960	1.2		
1600x1200	2.1	UXGA	
1920x1080	2.1	1080 HDTV	high resolution digital TV format
2048x1536	3.1	2K	Typically used for digital effects in feature films.
4096x3072	12.4	4K (!!!)	



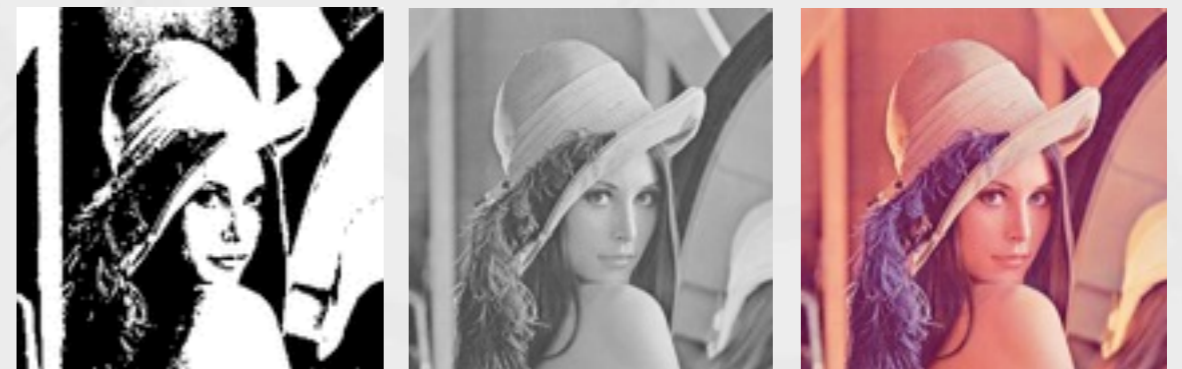
Rep of Images

- Binary image
 - 1 bit = Boolean value
 - One bit-planes
- Common Grayscale image:
 - 8 bits = 256 degrees of grayscale
 - Eight bit-planes



Rep of Images

- Most used color images
 - 24bit RGB
 - Red/Green/Blue each channel has 256 degrees of grayscale
 - Can represent $2^{24} = 16,777,216$ types of color



Rep of image – Palette

- Some systems and applications can only use 8-bit color images
 - Solution: Palette (Color look-up table)



High dynamic range image



HDRI example: a New York City nighttime cityscape



High dynamic range image

- HDR pixels:
 - 16-bit or 32-bit **floating point** numbers
 - 10–12 bits **luminance** (亮度)
 - 8 bits **chrominance** (色度)
 - 10^{-4} to 10^8 : the range of visible luminance values
- CMOS image sensors: up to 110dB
- Tone mapping:
 - Typical computer monitors, prints, and other methods of displaying images only have a limited dynamic range





An example of a High Dynamic Range (HDR) photography,
made of three different exposures



2.1.3 Image encoding



Image compression methods

- lossless compression
- lossy compression

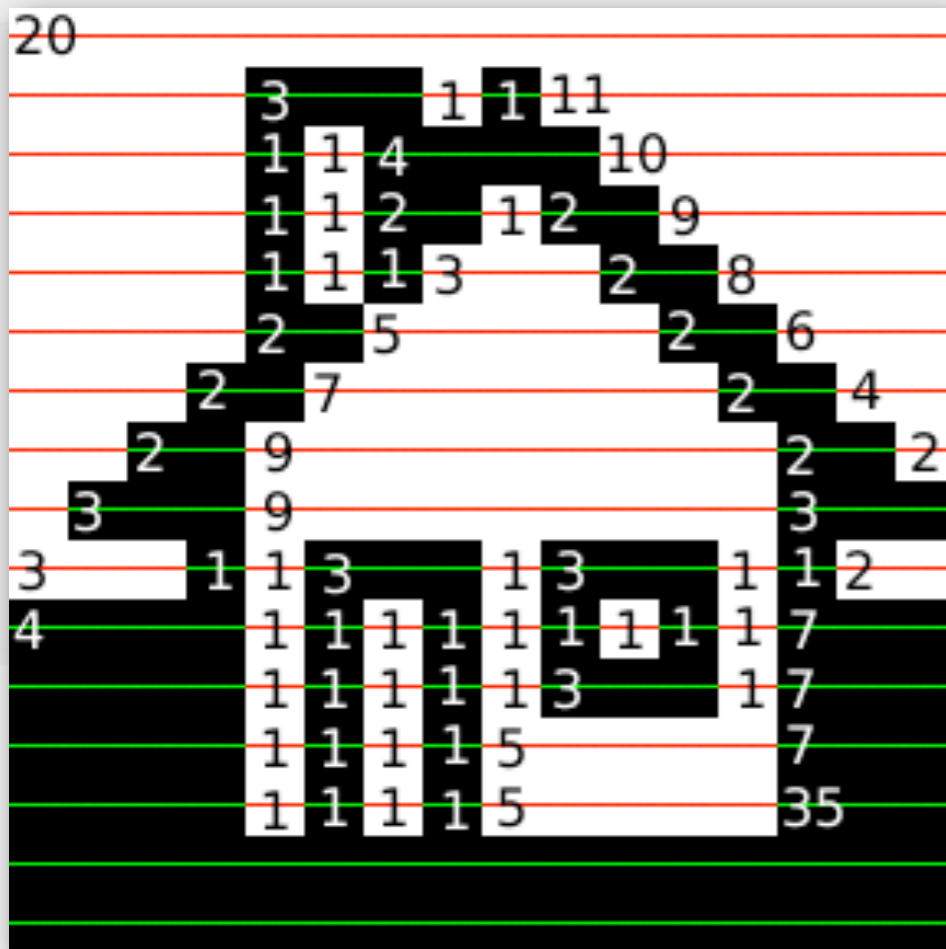


Lossless image compression methods

- Based on information theory
- General encoding methods
 - RLC (Run-Length Coding)
 - VLC (Variable-Length Coding)
 - Dictionary Coding
 - Arithmetic Coding



Run-Length Encoding



Flag	Run Count	Run Value
------	-----------	-----------

Encoded line with the following runs:

- 28 pixels of value 53
- 13 pixels of value 212
- 1 pixel of value 37
- 1 pixel of value 53
- 1 pixel of value 12
- 1 pixel of value 12
- 4 pixels of value 113

Flag = 255

Flag	Count	Value	Flag	Count	Value	Value	Value	Value
255	27	53	255	12	212	37	53	12

Value	Flag	Count	Value
12	255	4	113

LZW : Lempel-Ziv-Welsh

- Universal lossless data compression algorithm
 - by Abraham Lempel, Jacob Ziv, and Terry Welsh
- The compressor algorithm builds a string translation table from the text being compressed



LZW - Compressor

```
w = NIL;
add all possible char codes to the dictionary
for (every character c in the uncompressed data) do
  if ((w + c) exists in the dictionary) then
    w = w + c;
  else
    add (w + c) to the dictionary;
    add the dictionary code for w to output;
    w = c;
  endif
done
add the dictionary code for w to output;
display output;
```



● 原输入数据为:

● A B A B A B A B B B A B A B A A C D A C D A D C A B A A B A B ...

● 初始标号集为:

● 编码过程:

● 编码结果:

● 原输入数据为:

● A B A B A B B B A B A B A A C D A C D A D C A B A A A B A B ...

● 初始标号集为:

0	1	2	3	4	5
A	B	C	D	Clear	End

● 编码过程:

● 编码结果:

● 原输入数据为:

● A B A B A B A B B B A B A B A A C D A C D A D C A B A A A B A B ...

● 初始标号集为:

0	1	2	3	4	5
A	B	C	D	Clear	End

● 编码过程:

步骤	前缀	后缀	Entry	认识(Y/N)	输出	标号
1		A	(, A)			
2	A	B	(A,B)	N	A	6
3	B	A	(B,A)	N	B	7
4	A	B	(A,B)	Y		
5	6	A	(6,A)	N	6	8
6	A	B	(A,B)	Y		
7	6	A	(6,A)	Y		
8	8	B	(8,B)	N	8	9
9	B	B	(B,B)	N	B	10
10	B	B	(B,B)	Y		
11	10	A	(10,A)	N	10	11
12	A	B	(A,B)	Y		

● 编码结果:

● 原输入数据为:

● A B A B A B A B B B A B A B A A C D A C D A D C A B A A B A B ...

● 初始标号集为:

0	1	2	3	4	5
A	B	C	D	Clear	End

● 编码过程:

步骤	前缀	后缀	Entry	认识(Y/N)	输出	标号
1		A	(, A)			
2	A	B	(A,B)	N	A	6
3	B	A	(B,A)	N	B	7
4	A	B	(A,B)	Y		
5	6	A	(6,A)	N	6	8
6	A	B	(A,B)	Y		
7	6	A	(6,A)	Y		
8	8	B	(8,B)	N	8	9
9	B	B	(B,B)	N	B	10
10	B	B	(B,B)	Y		
11	10	A	(10,A)	N	10	11
12	A	B	(A,B)	Y		

● 编码结果:

0	1	2	3	4	5	6	7	8	9	10	11
A	B	C	D	Clear	End	AB	BA	6A	8B	BB	10A

LZW - Decompressor

```
read a char k;  
output k;  
w = k;  
while (read a char k) do  
    if (index k exists in dictionary) then  
        entry = dictionary entry for k;  
    else if (k == currSizeDict)  
        entry = w + w[0];  
    else  
        signal invalid code;  
    endif  
    output entry;  
    add w+entry[0] to the dictionary;  
    w = entry;  
done
```



Deflate

- a lossless data compression algorithm:
 - LZ77 algorithm + Huffman coding.
 - originally defined by Phil Katz for version 2 of his PKZIP archiving tool,
 - later specified in RFC 1951.
 - used by gzip, modern versions of zip and as part of the compression process of PNG, PPP, HTTP, SSH



Lossless image compression methods (cont.)

- Other lossless image compression methods
 - Image different encoding (差分)
 - Lossless JPEG (JPEG 2000)
 - discrete wavelet transform



Lossy image compression methods

- Quantization
- Transform coding
 - Discrete Cosine Transform
 - Discrete Wavelet Transform
 - Karhune-Loeve Transform (Principle component analysis)



Image compression standards

- JPEG
 - Joint picture encoding group
 - Discrete Cosine Transform
- JPEG 2000
 - newer standard
 - Discrete Wavelet Transform



JPEG compression: main idea

<http://zh.wikipedia.org/zh-cn/JPEG>

52	55	61	66	70	61	64	73
63	59	55	90	109	85	69	72
62	59	68	113	144	104	66	73
63	58	71	122	154	106	70	69
67	61	68	104	126	88	68	70
79	65	60	70	77	68	58	75
85	71	64	59	55	61	65	83
87	79	69	68	65	76	78	94

16	11	10	16	24	40	51	61
12	12	14	19	26	58	60	55
14	13	16	24	40	57	69	56
14	17	22	29	51	87	80	62
18	22	37	56	68	109	103	77
24	35	55	64	81	104	113	92
49	64	78	87	103	121	120	101
72	92	95	98	112	100	103	99

-26	-3	-6	2	2	-1	0	0
0	-2	-4	1	1	0	0	0
-3	1	5	-1	-1	0	0	0
-4	1	2	-1	0	0	0	0
1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

RGB Image

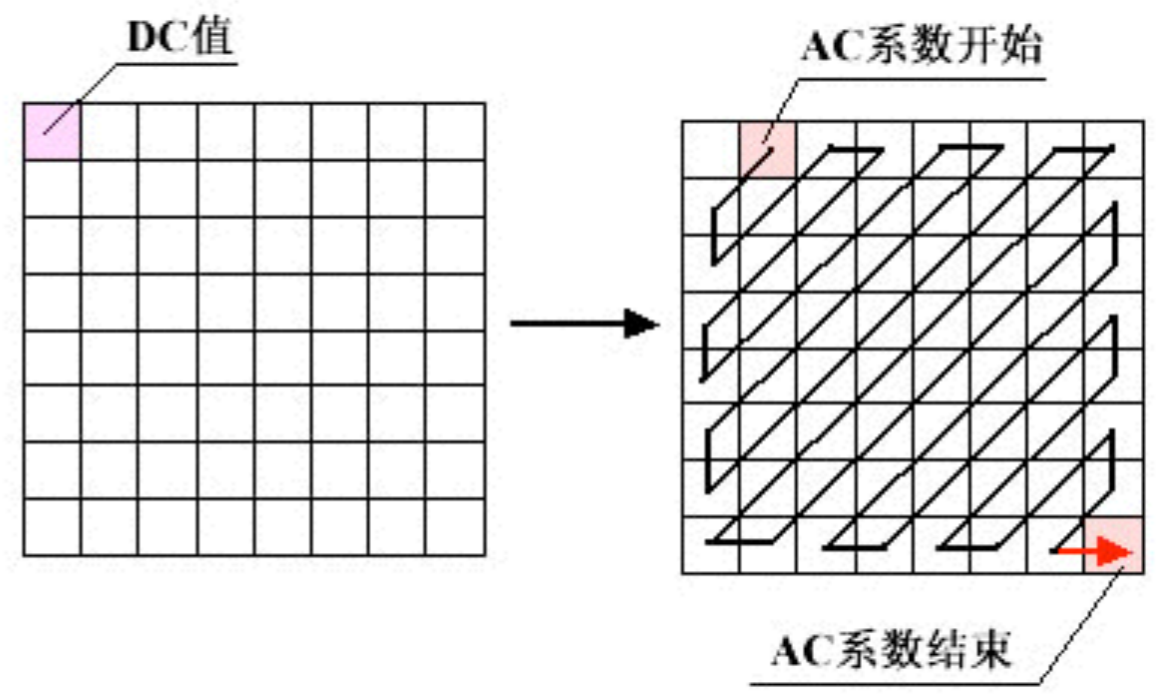
YCbCr Color Model

8x8 image blocks

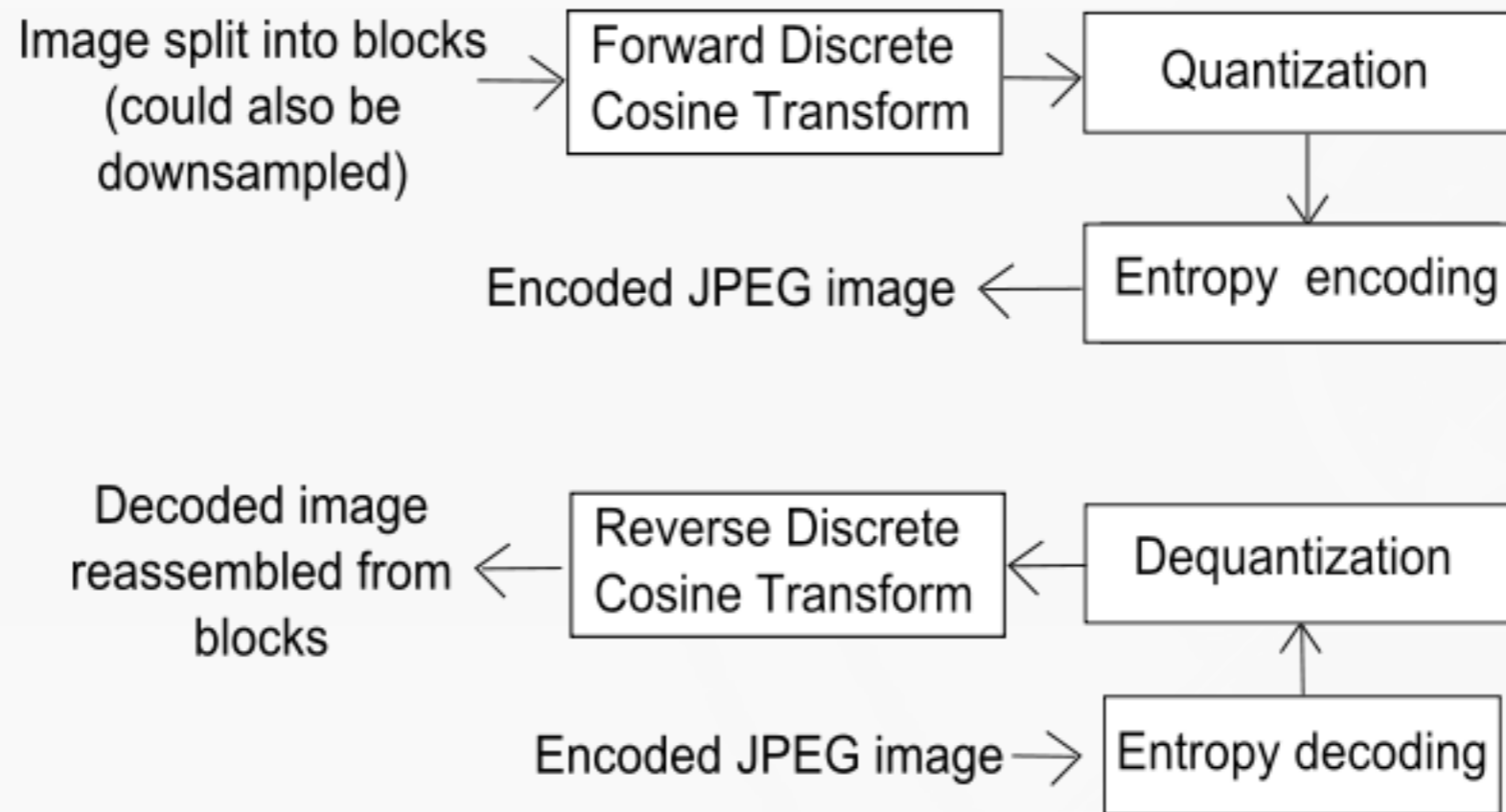
DCT

Quantization

frequency-domain representation



JPEG compression: implementation



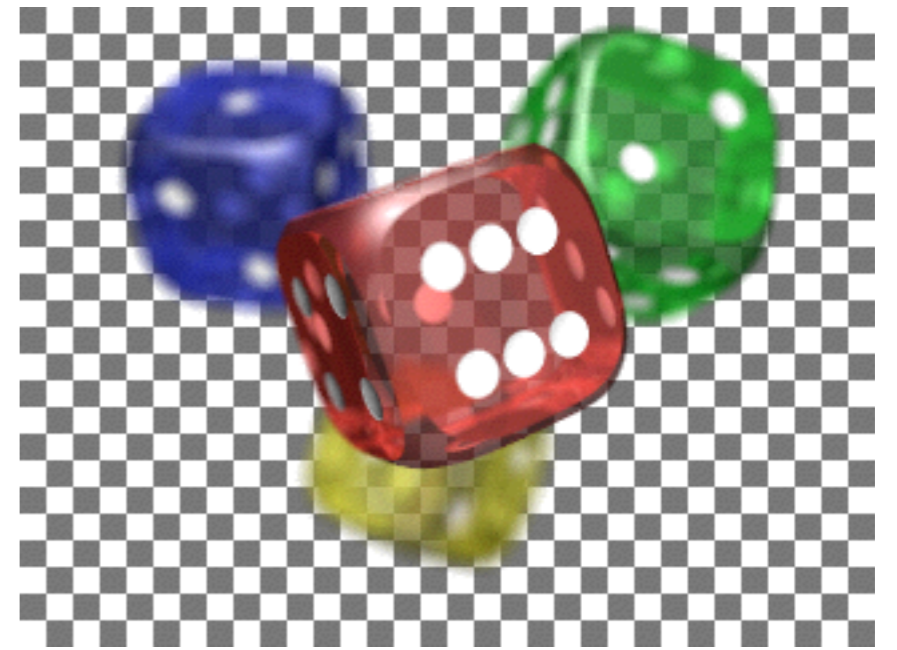
Common image formats - GIF

- Graphics Interchange Format
 - UNISYS Corporation and CompuServe
 - Lempel-Ziv-Welch compression method
 - GIF87 / GIF89a
 - Features
 - Only support 8-bit (256) color image
 - Support several animation effects
 - Support interlaced image coding



Common image formats - PNG

- Portable Network Graphics
 - motivation: CompuServe owns the LZW coding patent for GIF images
 - open source
 - Transparent
 - PNG64



Common image formats - JPEG

- Lossy to lossless editing



Common image formats - TIFF (6.0)

- Tagged Image File Format
 - flexible and adaptable
 - handling images and data within a single file
 - header tags: size, definition, image-data arrangement, applied image compression
 - defining the image's geometry.



Common image formats - TIFF (6.0)

- a TIFF can be a container file
 - compressed JPEG and RLE
 - lossless compression
- include a vector-based Clipping path (outlines, cropping, image frames)



DNG: Digital Negative (数字负片)



- a royalty free **RAW** image format
- design by Adobe
- based on TIFF/EP
- mandates use of metadata



Summary – Essential factors of image storage

- Resolution
- Compression rate
 - 1bpp, 2bpp, ...
 - Compression methods
- Color representation
 - RGB, YUV, Lab ...



Image converting tools

- ACDSEE
- imagemagik (Linux)
- XnView
 - <http://perso.orange.fr/pierre.g/>

