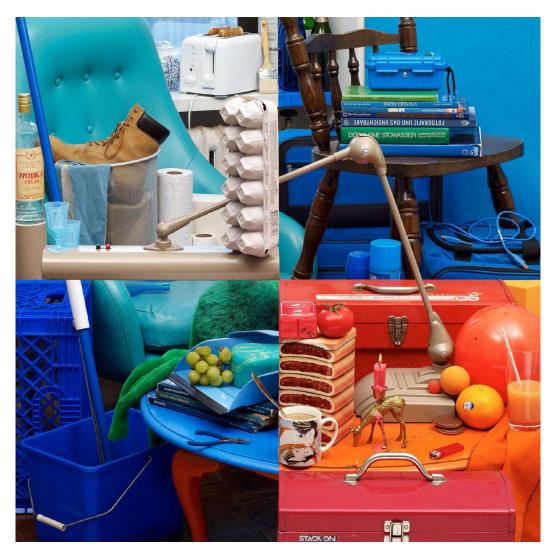
Introduction to Computer Vision

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Colorado School of Mines

Lecture 9

Color

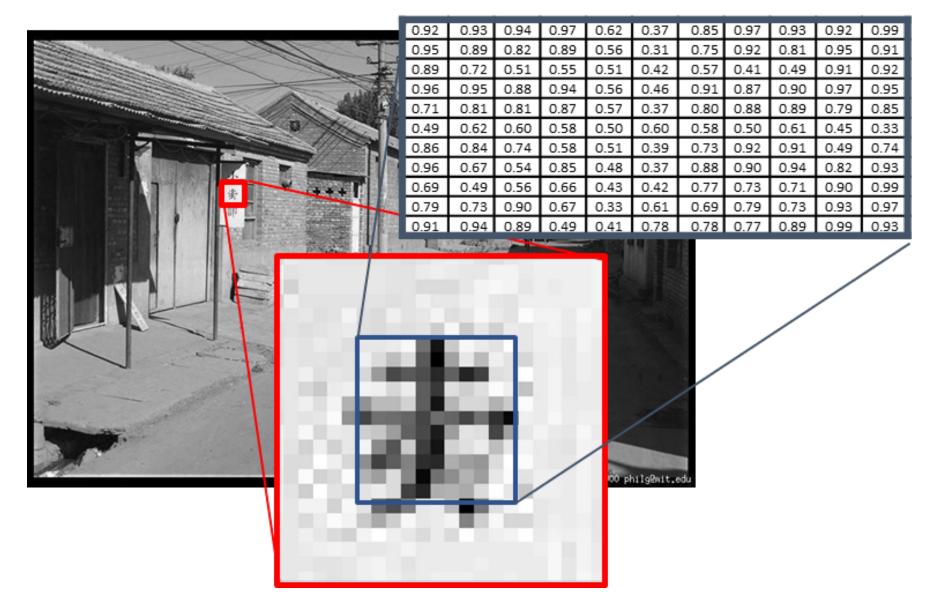


Color

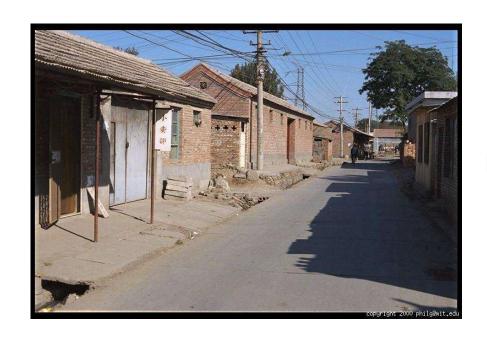
Learning outcomes:

- Frequency Spectrum
- Color Cameras
- Bayer Filter
- Color Spaces

Grayscale intensity



Color





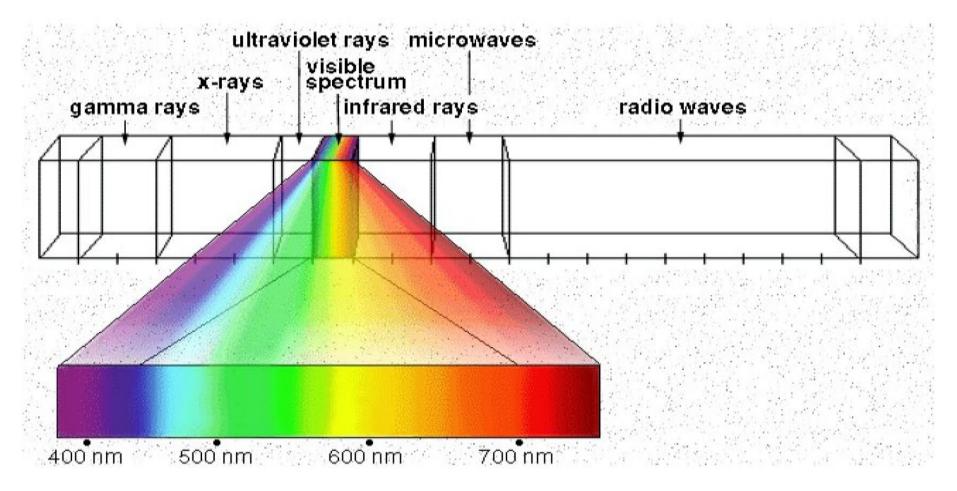


Images in Python (import numpy)

- N x M grayscale image "im"
 - -im[0,0,0] = top-left pixel value, red channel
 - -im[y,x,1] = y pixels down, x pixels to right, green channel
 - -im[N-1,M-1,2] = bottom-right pixel, blue channel

_		Column															
Ro	W	0.92	0.93	0.94	0.97	0.62	0.37	0.85	0.97	0.93	0.92	0.99	IR				
		0.95	0.89	0.82	0.89	0.56	0.31	0.75	0.92	0.81	0.95	0.91					
		0.89	0.72	0.51	0.55	0.51	0.42	0.57	0.41	0.49	0.91	0.92	0.92	0.99	1 G		
		0.96	0.95	0.88	0.94	0.56	0.46	0.91	0.87	0.90	0.97	0.95	0.95	0.91	19		
		0.71	0.81	0.81	0.87	0.57	0.37	0.80	0.88	0.89	0.79	0.85	0.91	0.92			ιB
		0.49	0.62	0.60	0.58	0.50	0.60	0.58	0.50	0.61	0.45	0.33	0.97	0.95	0.92	0.99	D
		0.86	0.84	0.74	0.58	0.51	0.39	0.73	0.92	0.91	0.49	0.74	0.79	0.85	0.95	0.91	
		0.96	0.67	0.54	0.85	0.48	0.37	0.88	0.90	0.94	0.82	0.93	0.45	0.33	0.91	0.92	
		0.69	0.49	0.56	0.66	0.43	0.42	0.77	0.73	0.71	0.90	0.99	0.49	0.74	0.97	0.95	
	.	0.79	0.73	0.90	0.67	0.33	0.61	0.69	0.79	0.73	0.93	0.97	0.82	0.93	0.79	0.85	
¥		0.91	0.94	0.89	0.49	0.41	0.78	0.78	0.77	0.89	0.99	0.93	0.90	0.99	0.45	0.33	
				0.79	0.73	0.90	0.67	0.33	0.61	0.69	0.79	0.73	0.93	0.97	0.49	0.74	
				0.77	0.73	0.89	0.49	0.41	0.78	0.78	0.77	0.73	0.99	0.93	0.82	0.93	
				0.71	0.74	0.07	V. 17	0.41	0.78	0.78	0.77	0.87	0.77	0.73	0.90	0.99	
						0.79	0.73	0.90	0.67	0.33	0.61	0.69	0.79	0.73	0.93	0.97	
						0.91	0.94	0.89	0.49	0.41	0.78	0.78	0.77	0.89	0.99	0.93	

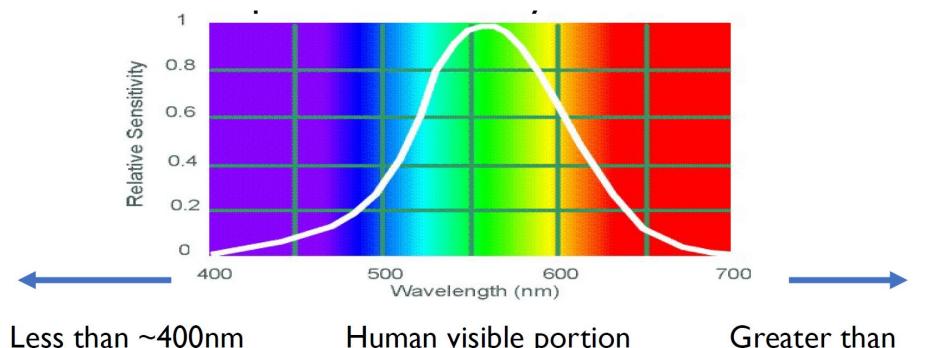
Electromagnetic Spectrum



Wavelength of light and its perceived color

Human Spectral Sensitivity

Approximate human spectral sensitivity

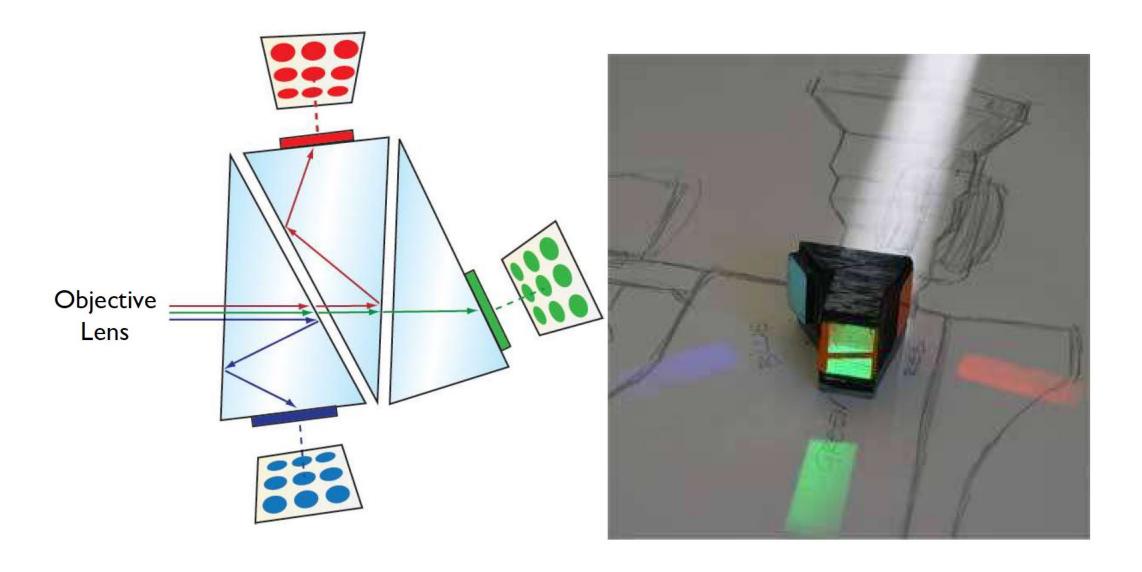


to 10nm = ultraviolet (UV)

Human visible portion of electromagnetic (EM) spectrum

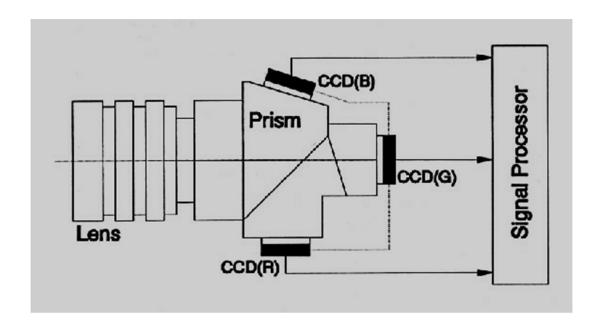
Greater than
~700nm to Imm =
infrared (IR)

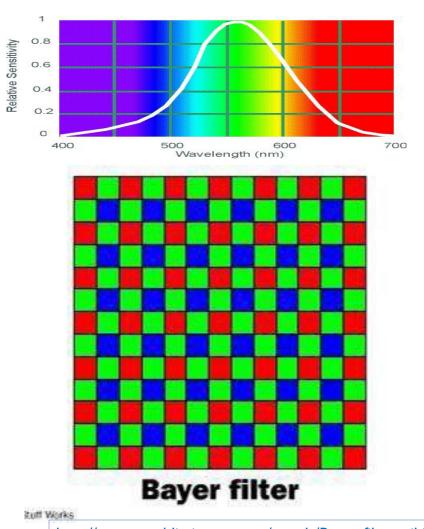
Cameras with 3 Sensors



Color Sensing in Camera (RGB)

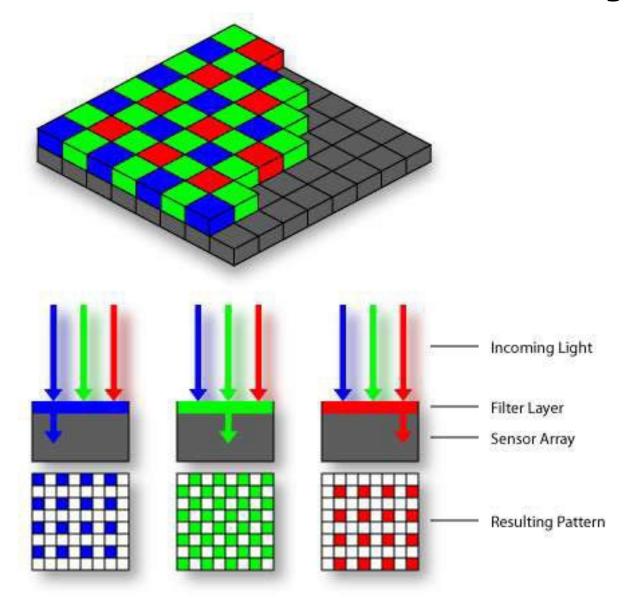
- 3-chip vs. 1-chip: quality vs. cost
- Why more green?
- Why 3 colors?

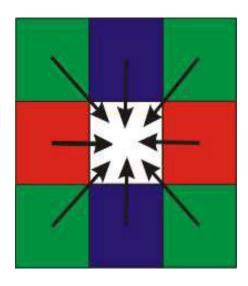




http://www.cooldictionary.com/words/Bayer-filter.wikipedia

Additional Slide: Bayer Grid

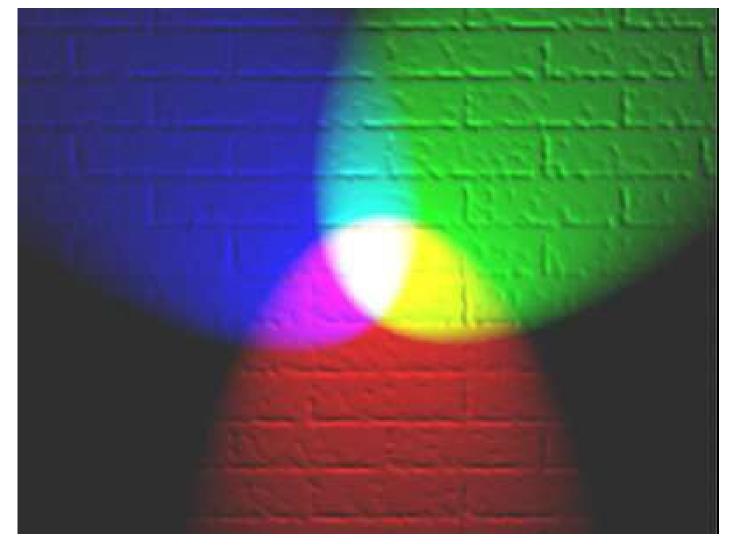




Estimate RGB at 'G' cells from neighboring values

Color spaces

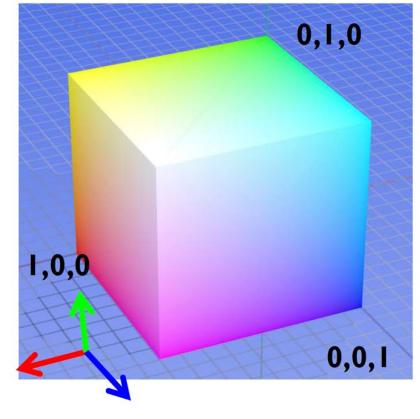
How can we represent color?



Color spaces: RGB

Default color space

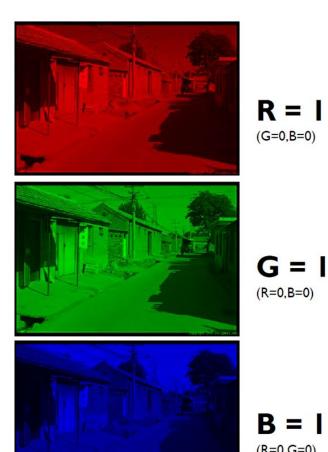




Additive color

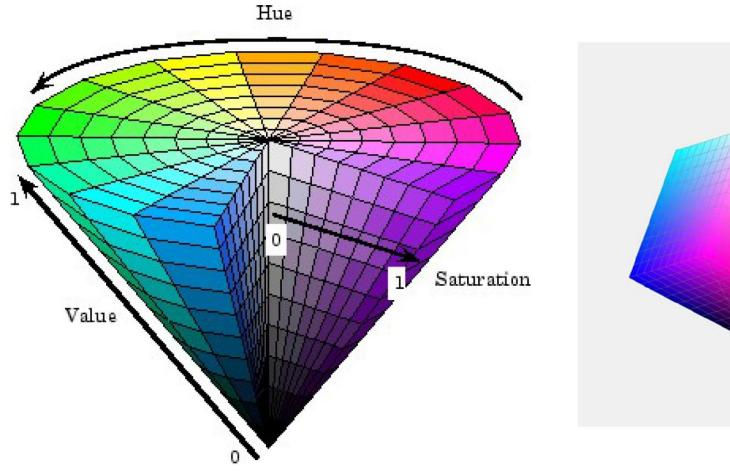
model

Any color = r*R + g*G + b*B

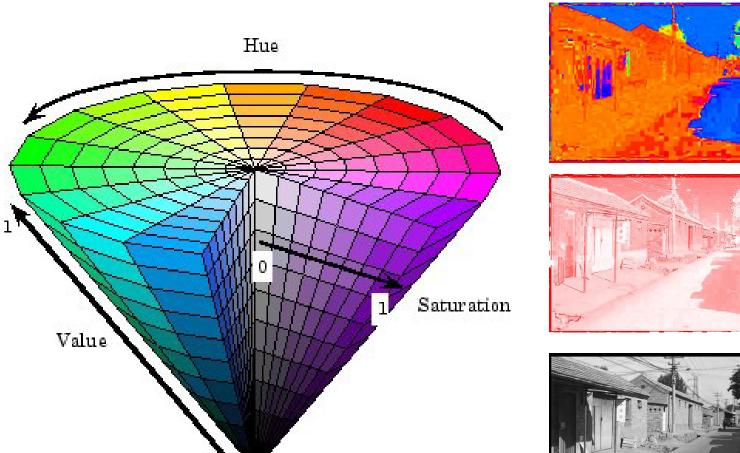


Color spaces: HSV

Intuitive color space



Color spaces: HSV









(H=1,V=1)



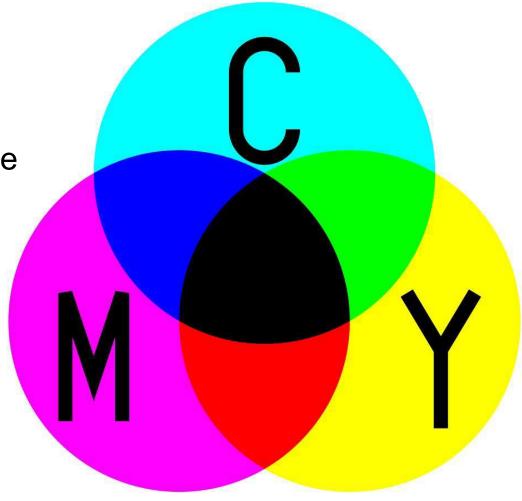
(H=1,S=0)

Color Spaces: CMYK

Subtractive color model

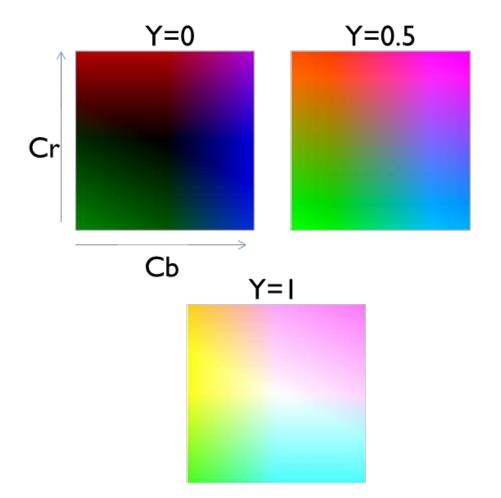
• What if light passes through successive layers of absorbing media?

Printers use this



Color spaces:YCbCr

- YCbCr separates brightness (luma) from color (chroma).
- Y represents luma, Cb and Cr represent blue and red difference
- Fast to compute, good for compression, used by TV













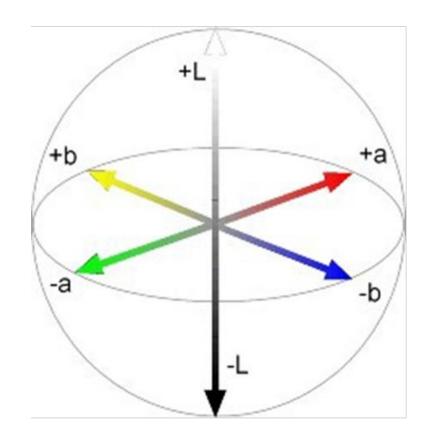




Cr (Y=0.5,Cb=05)

Color spaces: L*a*b*

"Perceptually uniform" color space















b (L=65,a=0)

Application

Colors can be used to segment out & track objects

