

Image acquisition and representation. Color spaces.

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Electromagnetic Spectrum

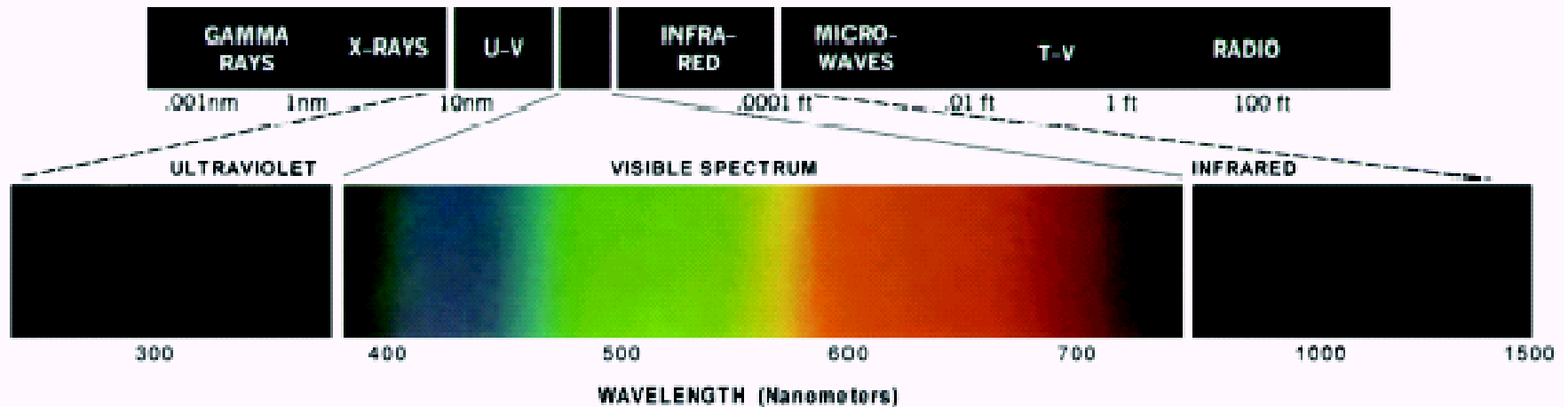
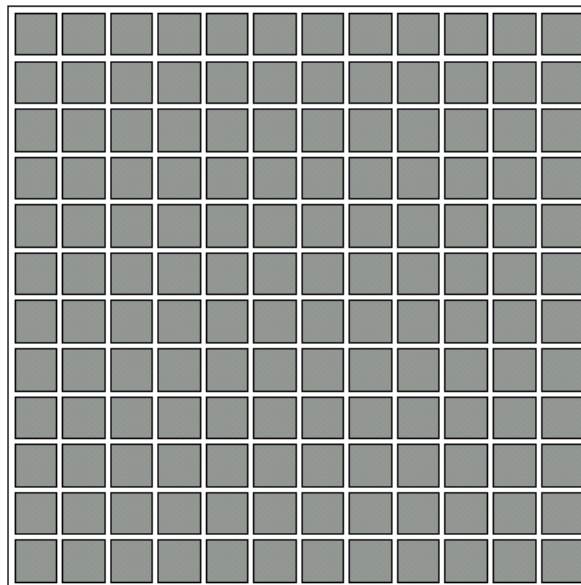
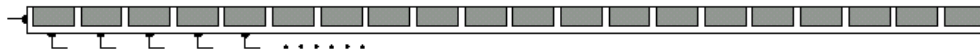
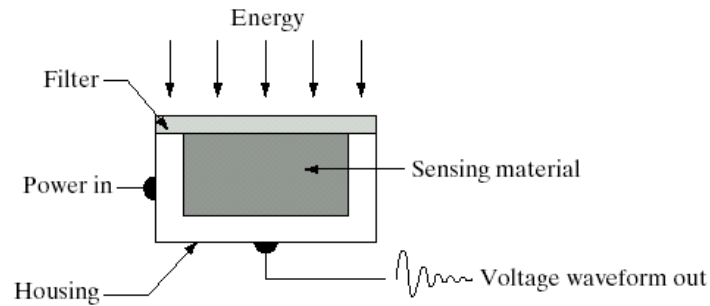


Image Formation

- Depends on type of EM radiation
- Depends on sensors
- Visible light: reflection
- X-ray: absorption, not reflection
- Synthetic aperture radar (SAR): reflection at spaced intervals

Sensors



- Charge coupled device (CCD)
- Complementary Metal Oxide Semiconductor (CMOS)
- Photodiode array
- etc.

Image Formation: visible light

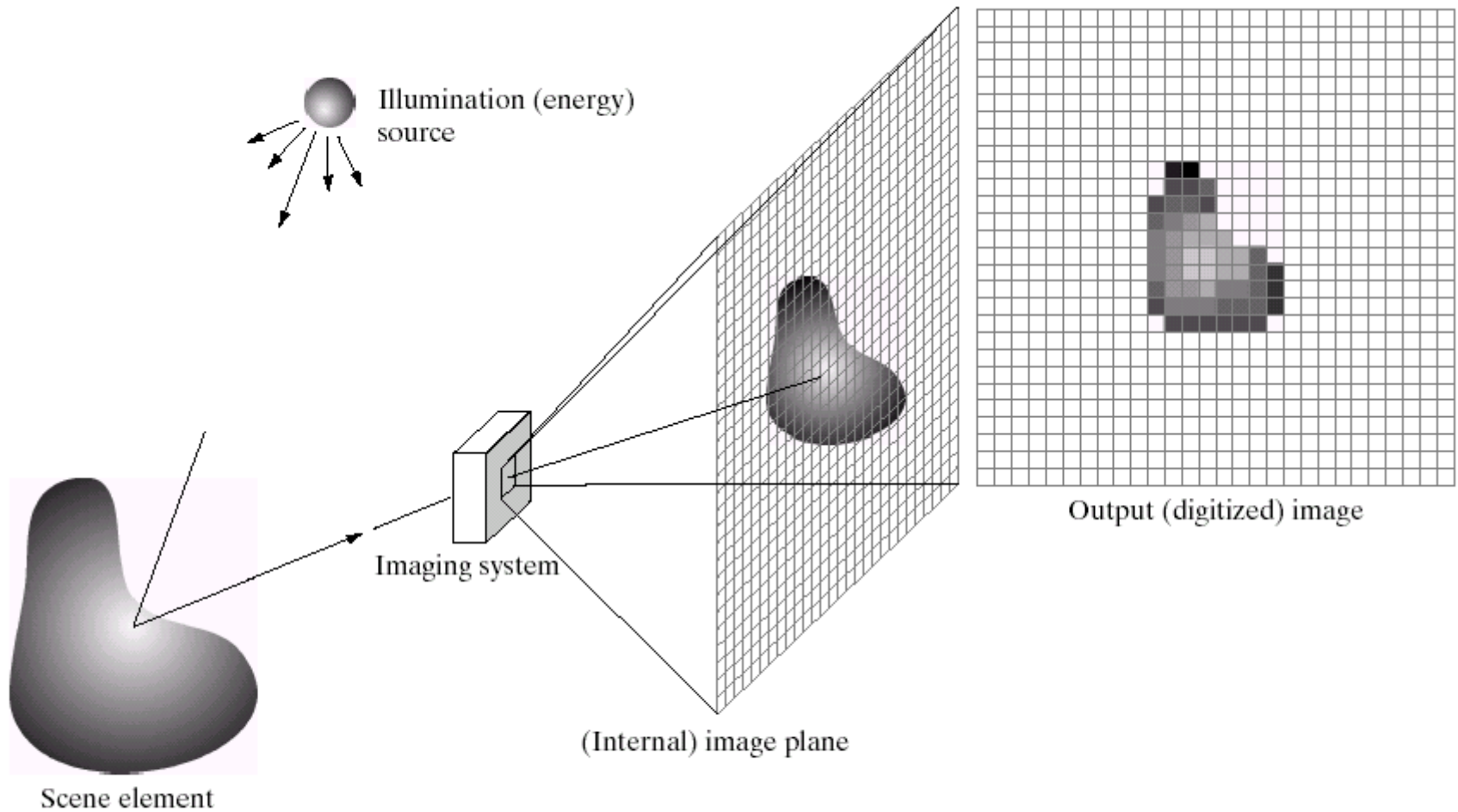
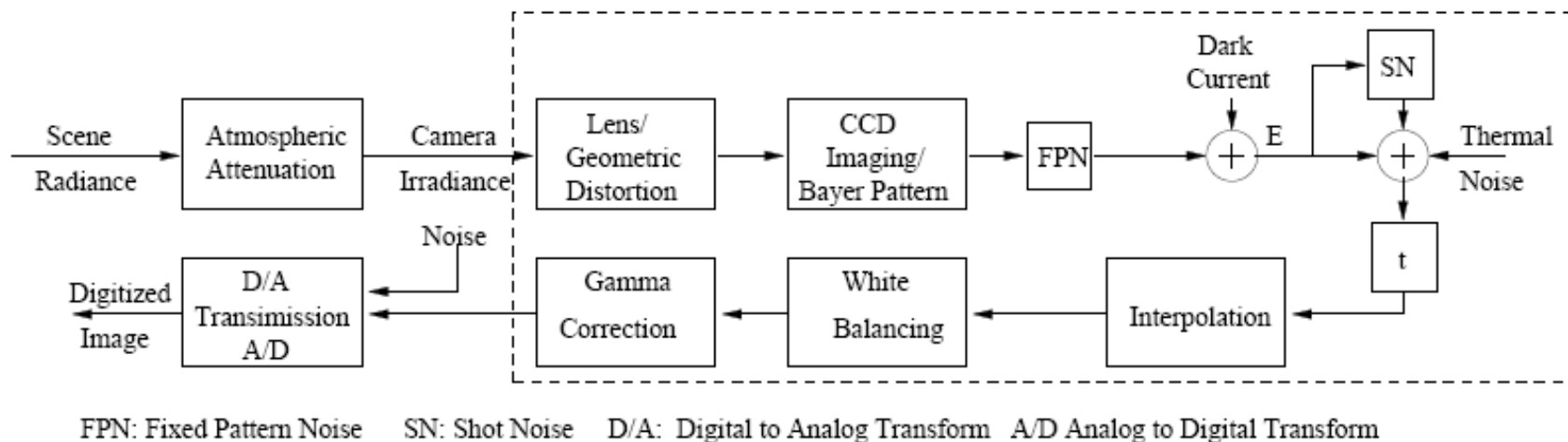
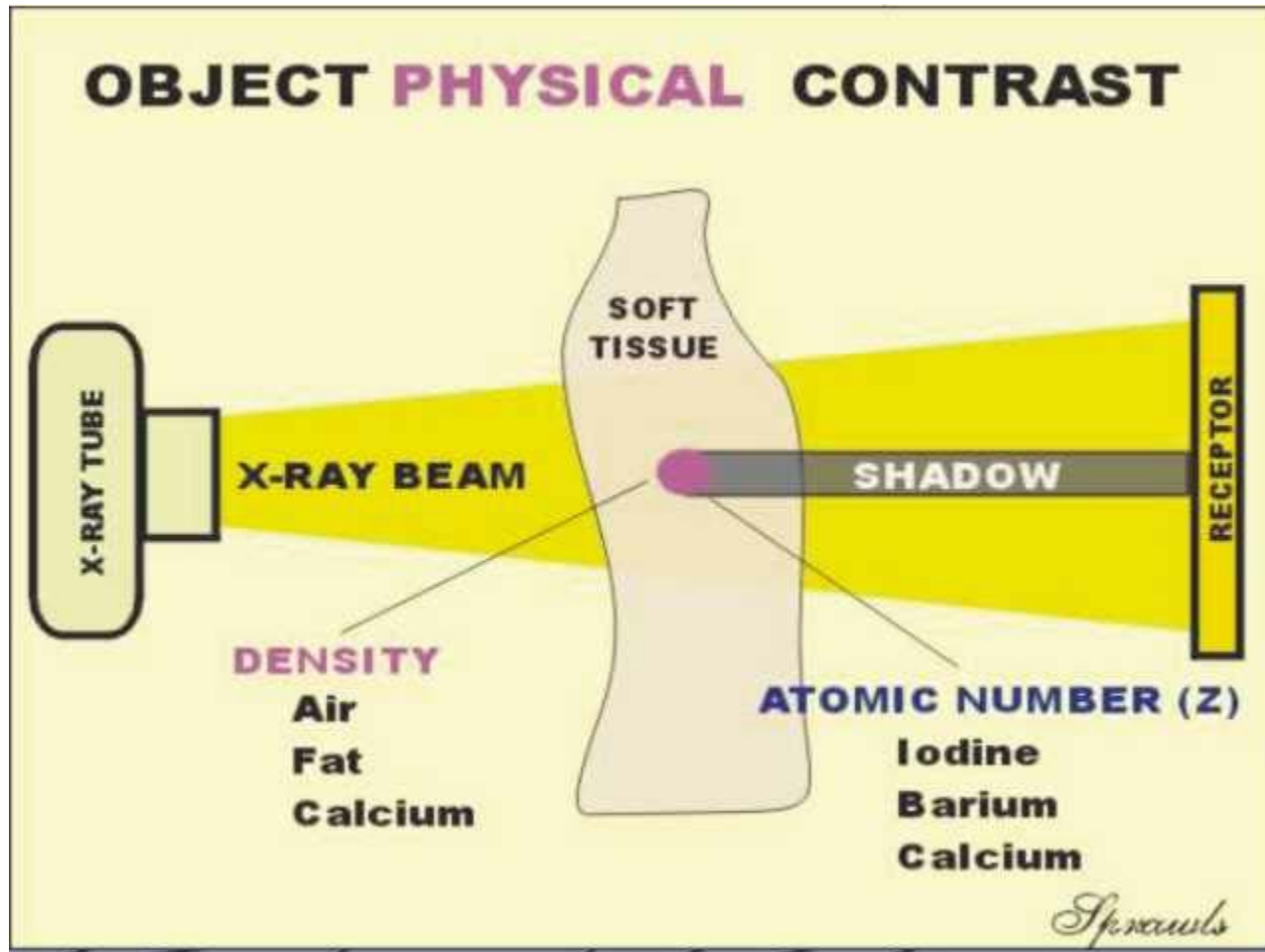


Image Formation (detail)



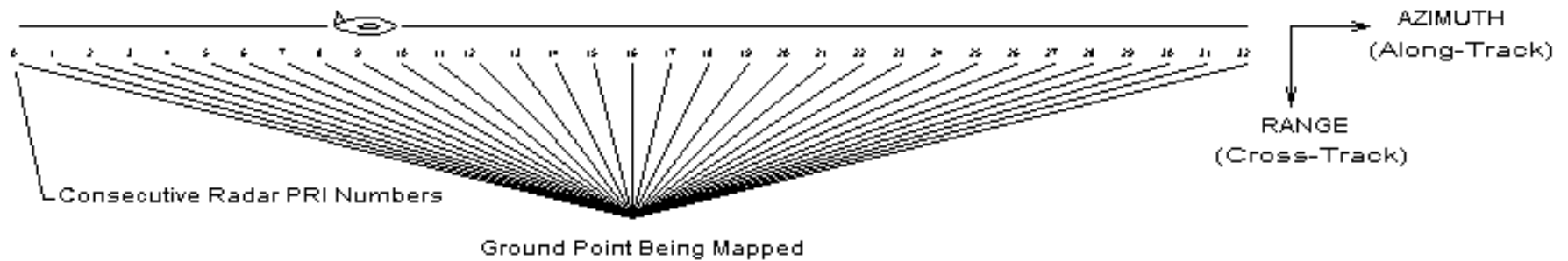
From: Statistical Calibration of CCD Imaging Process
Yanghai Tsin, Visvanathan Ramesh, Takeo Kanade
ICCV 2001

Image Formation: X-ray



<http://www.sprawls.org/visuals/XRAYCON/objcon.jpg>

Image Formation: SAR



http://www.skylondaworks.com/sc_sar0.gif

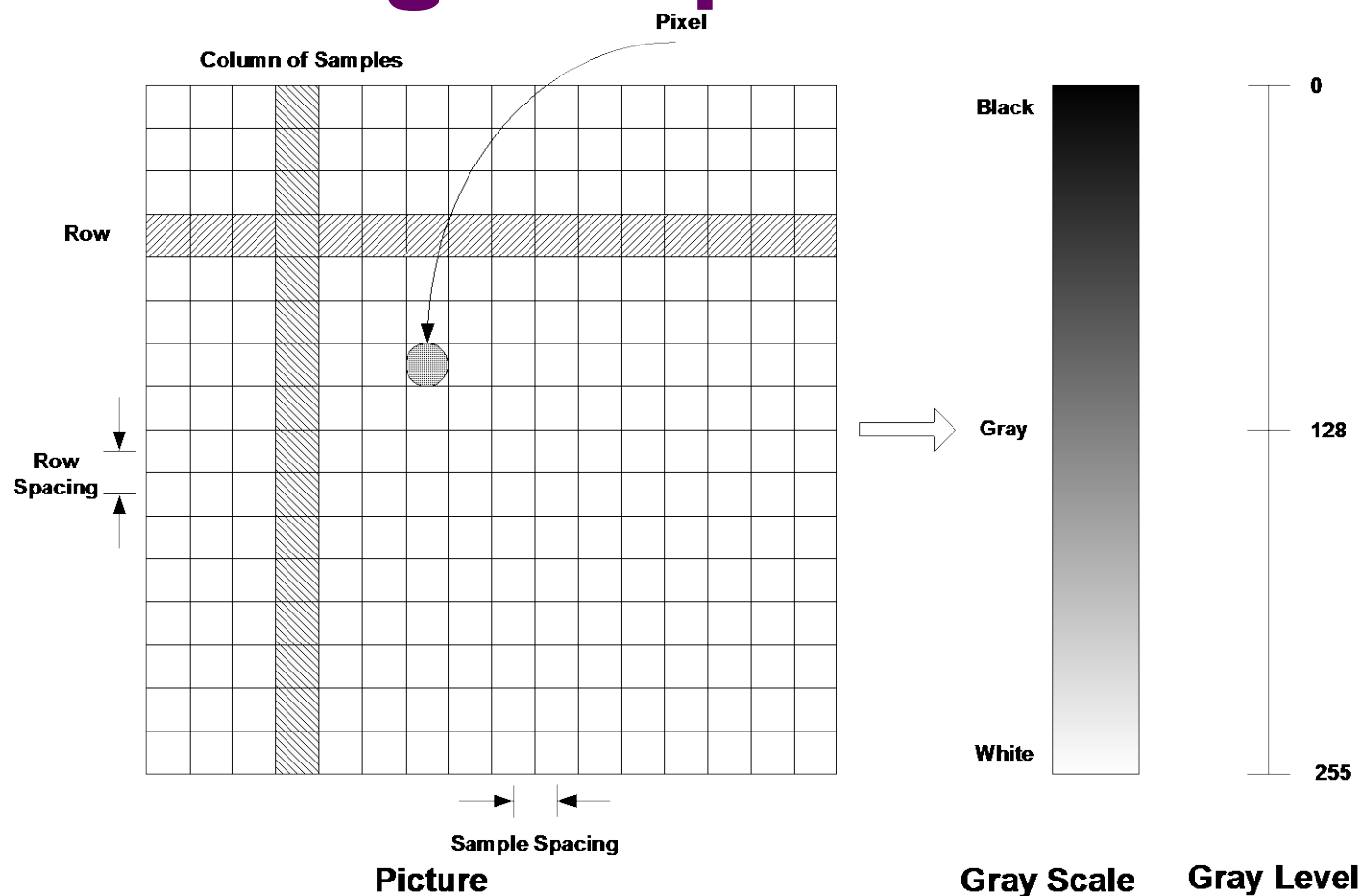
How important?

- Many of the processing techniques we will study work equally well
 - Regardless of types of images
 - Regardless of sensors used
- But sometimes, knowledge of the image formation helps in the solution of the problem.
 - e.g. In x-ray images, brighter pixels → more opaque objects → metals?

Summary

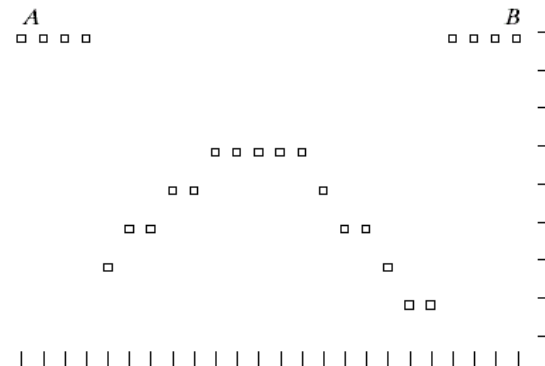
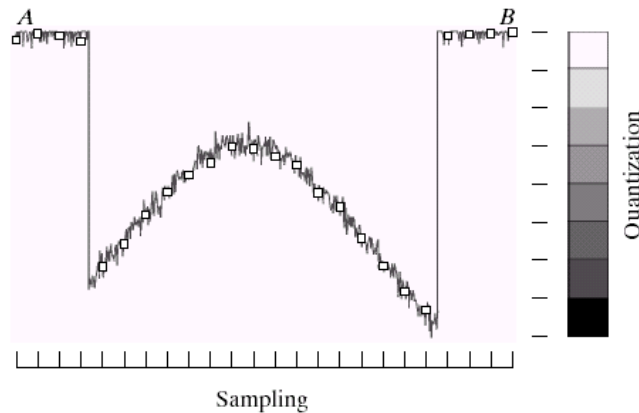
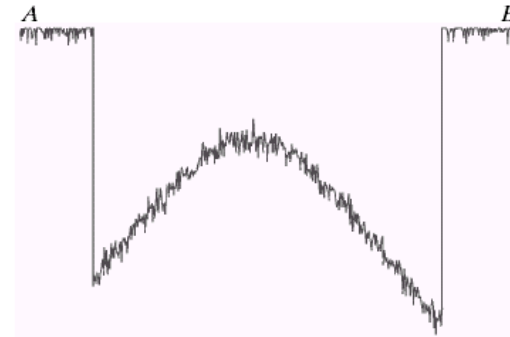
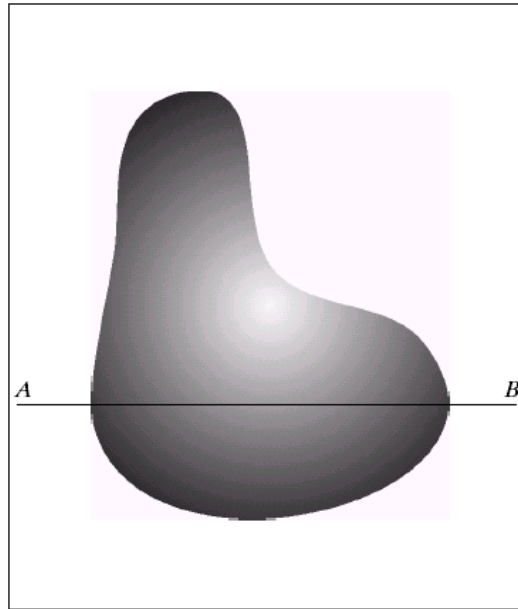
- Image acquisition is the first step in image processing.
- Knowledge of the acquisition process and the type of EM radiation is sometimes useful.
- Digital sensors are increasingly more prevalent.

Image Representation

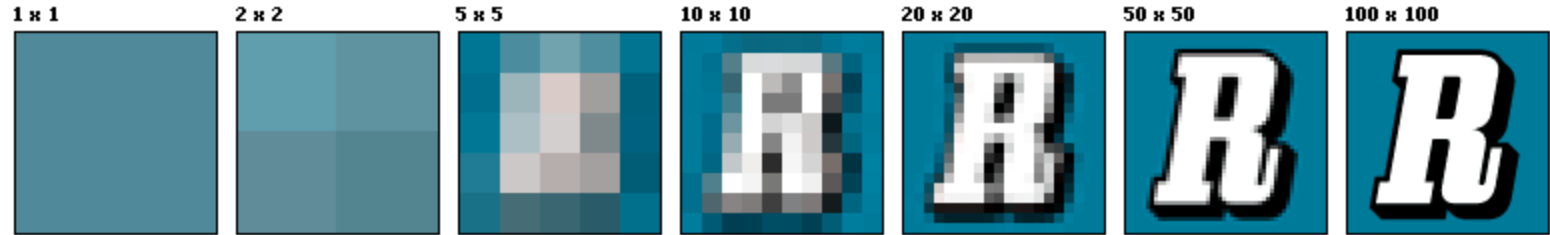


Sampling refers to spatial resolution.
Quantization refers to pixel-value resolution.

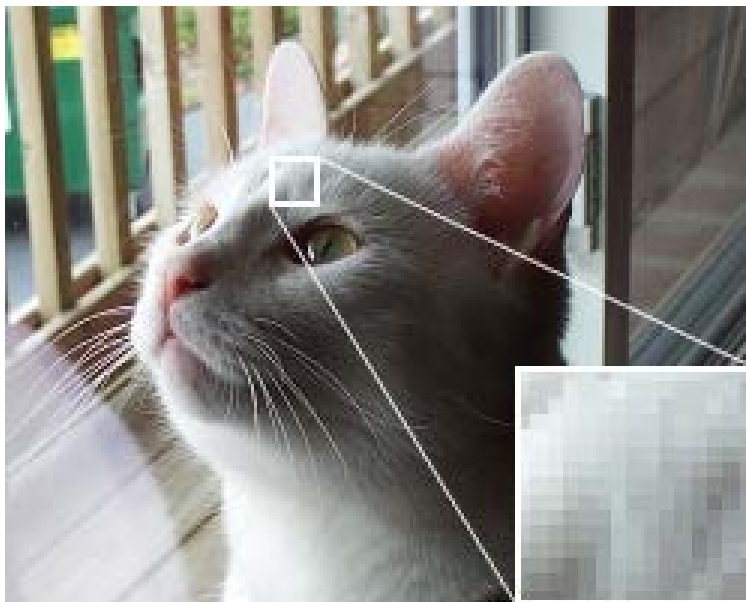
Sampling, Quantization



Sampling, Quantization

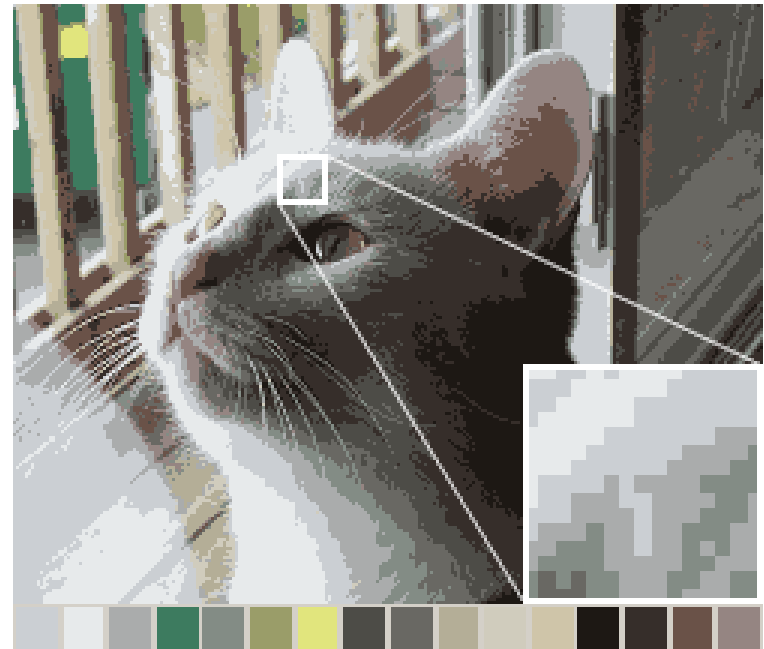


http://en.wikipedia.org/wiki/Image_resolution



RGB 24-bit image
(16 million colors)

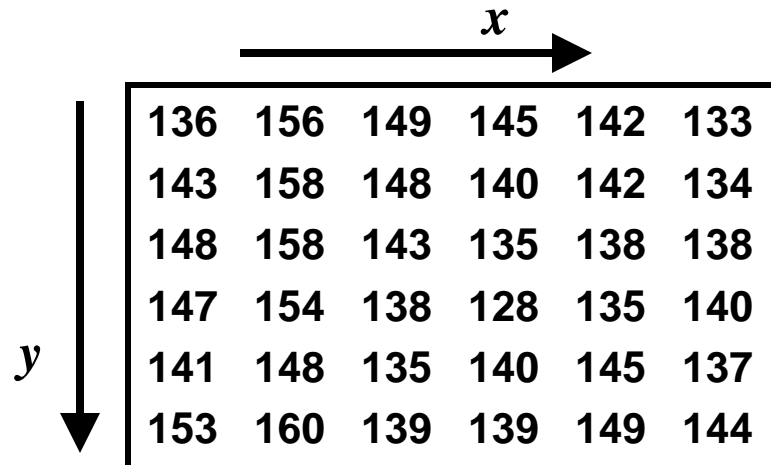
http://en.wikipedia.org/wiki/Color_quantization



RGB
(16 colors)

Grayscale Images

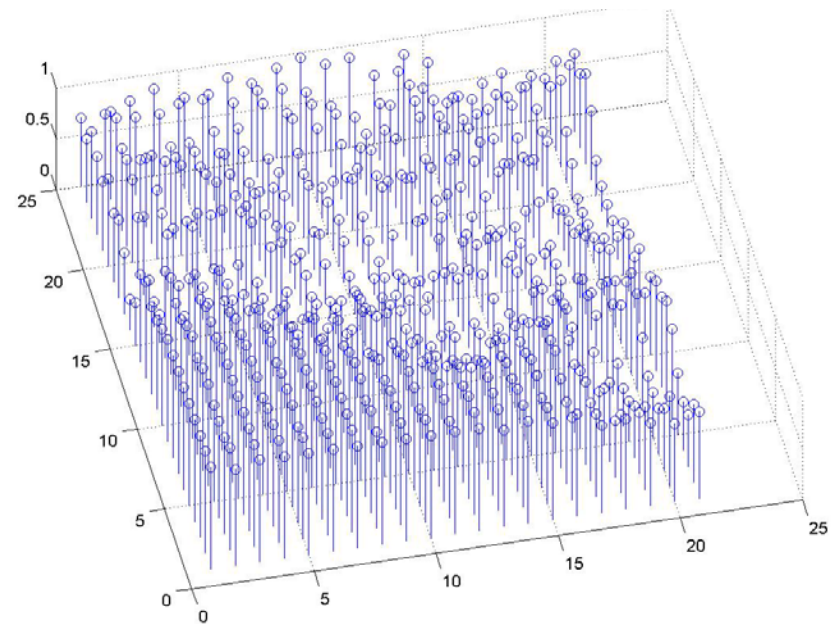
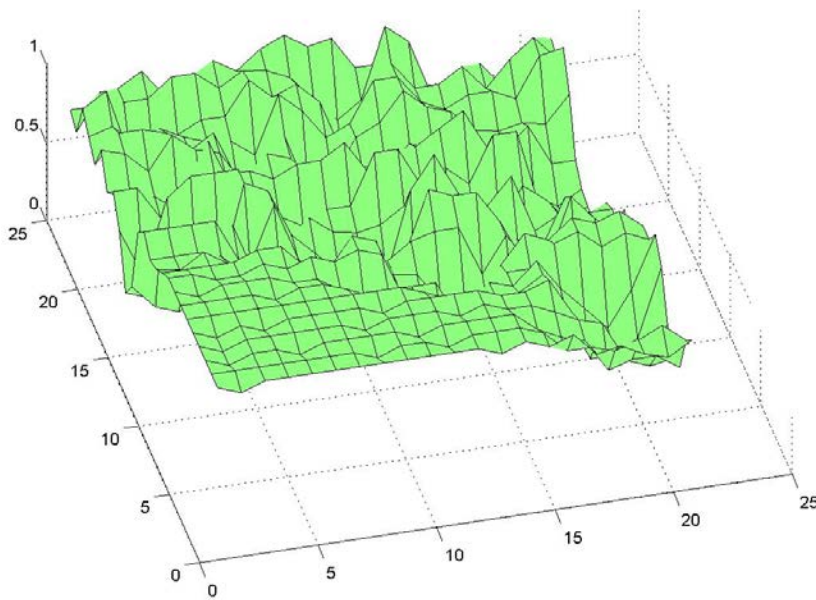
- We will begin with grayscale (intensity) images.
 - Deal with color later
- Typically represented as 2D array of pixel values between 0 (black) and 255 (white).
- Coordinate system varies with software used.



136	156	149	145	142	133
143	158	148	140	142	134
148	158	143	135	138	138
147	154	138	128	135	140
141	148	135	140	145	137
153	160	139	139	149	144

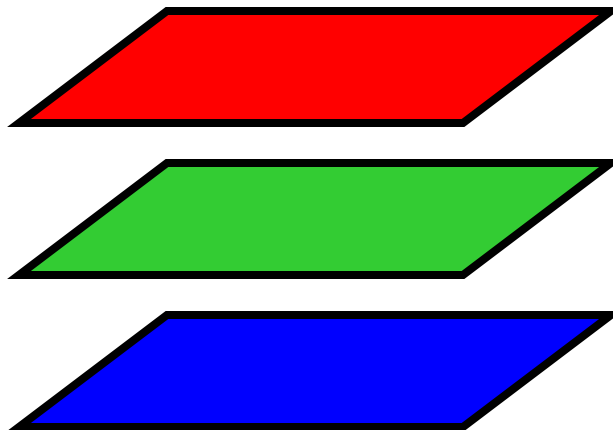
Grayscale Images

- Surface over x-y plane



Color Images

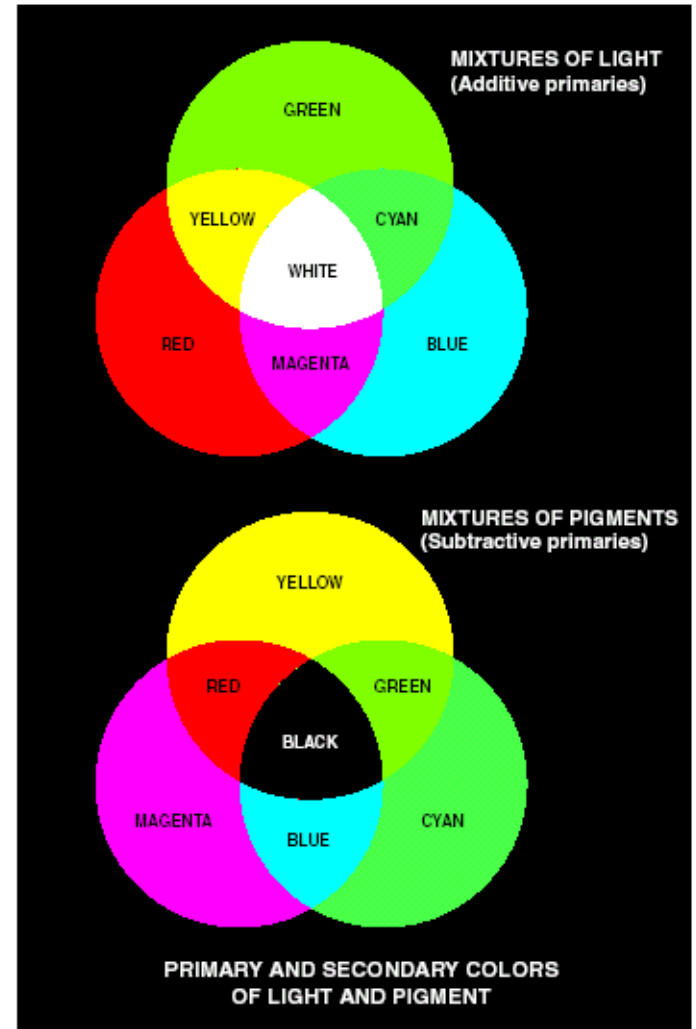
- Typically represented as 3x 2D arrays of Red, Green, Blue (RGB) pixel values.
- Each color channel between 0 to 255
 - (or 0 to 1)
- Total = 16 million colors



Color Spaces

- Primary colors:
 - Red, Green, Blue
 - Additive
- Secondary colors:
 - Cyan, Magenta, Yellow
 - Subtractive

$$\begin{bmatrix} C \\ M \\ Y \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} - \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$



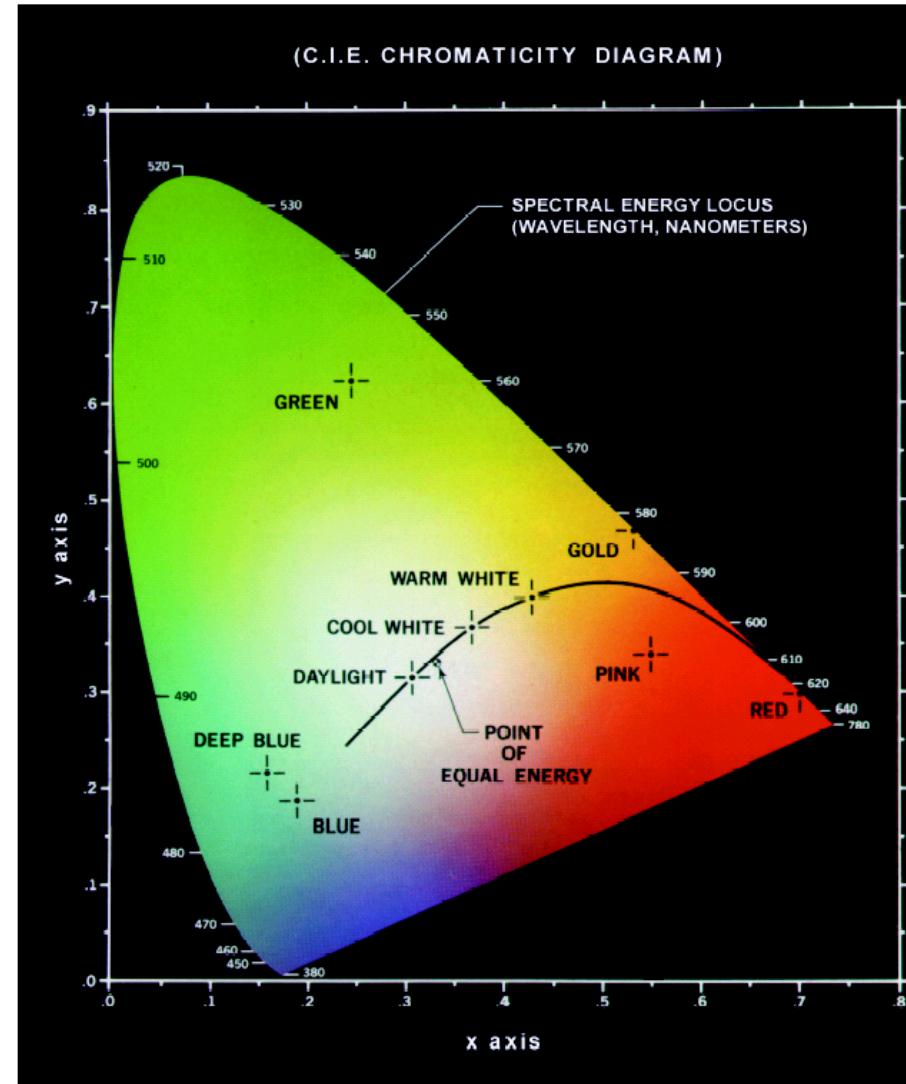
More Color Spaces

- X,Y,Z represent R,G,B

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

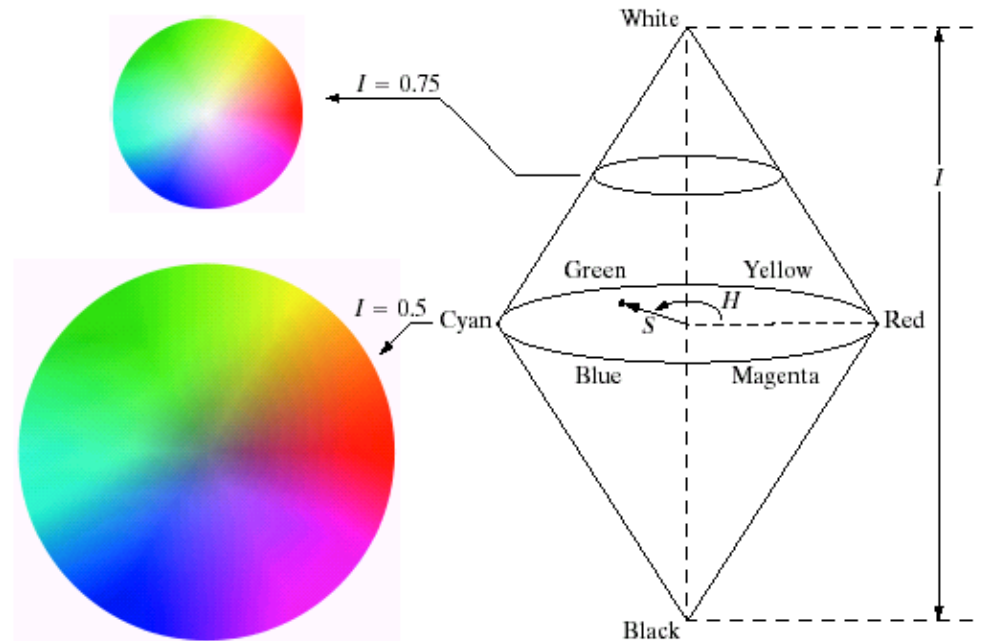
$$y = \frac{Y}{X + Y + Z}$$

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



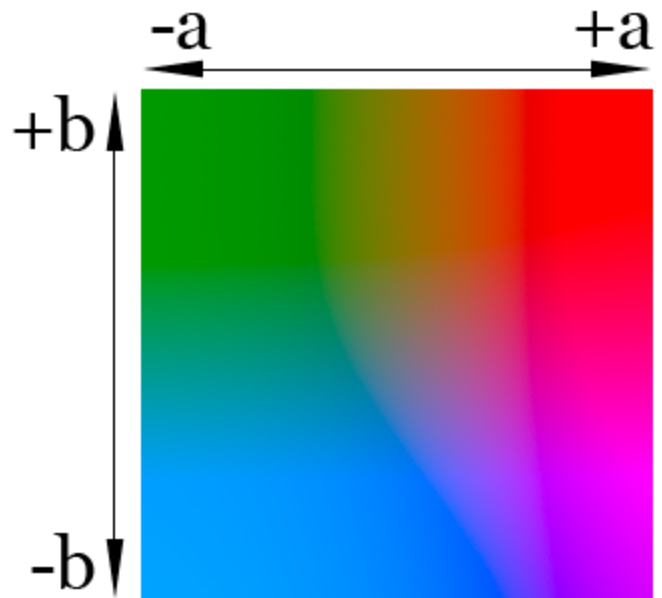
Yet Another Color Space

- HSI (Hue, Saturation, Intensity)
 - HSV slightly different
- Good for color manipulation
- Hue: angle from red
- Saturation: radius
- Intensity: height



Still More Color Spaces

- CIE $L^*a^*b^*$
- Perceptually linear
 - Similar to human perception
- L^* : lightness (black-white)
- a^* : green-magenta
- b^* : yellow-blue



Much More Color Spaces

- YUV, YIQ, YCbCr
- Used in TV broadcast (NTSC, PAL)
 - Y: luminance
 - UV, CbCr: chrominance
- Human eye more sensitive to luminance than to chrominance
 - YUV 4:2:2 format

$$\begin{bmatrix} Y \\ U \\ V \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ -0.147 & -0.289 & 0.436 \\ 0.615 & -0.515 & -0.100 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

So Which to Use?

- Depends on the problem.
- RGB: for viewing on monitor
- CMY(K): for printers
- HSI or HSV: good for separating intensity/color
- CIE $L^*a^*b^*$: to mimic human perception
- YUV, YCbCr: for TV signals

Image File Formats

- Many in existence
 - Common ones: JPEG, BMP, TIFF, PNG, GIF, TGA, RAW, PGM, PPM, PCX
- There are tools to read/write them, so don't sweat it.
 - Matlab: `imread`, `imwrite`
- Digital cameras also tag on EXIF data

Shooting Information:	
Item Name	Value
File Name	IMG_3799.JPG
Camera Model Name	Canon PowerShot S2 IS
Shooting Date/Time	8/11/2005 9:52:27 AM
Shooting Mode	Program AE
Photo Effect	Custom Effect
Tv (Shutter Speed)	1/60
Av (Aperture Value)	2.7
Light Metering	Evaluative
Exposure Compens...	-2/3
ISO Speed	50
Lens	6.0 - 72.0 mm
Focal Length	6.0 mm
Digital Zoom	None
IS Mode	Shoot Only
Image Size	2592x1944
Image Quality	Superfine
Flash	On
Flash Type	Built-In Flash
Flash Exposure Co...	-1 1/3

Summary

- Grayscale images are typically represented as 2D array.
- Color images: 3x 2D arrays
- There is a choice of color space
 - Which to use depends on the problem
- There are many image file formats.
 - Details not important as there are many tools to manipulate these formats.