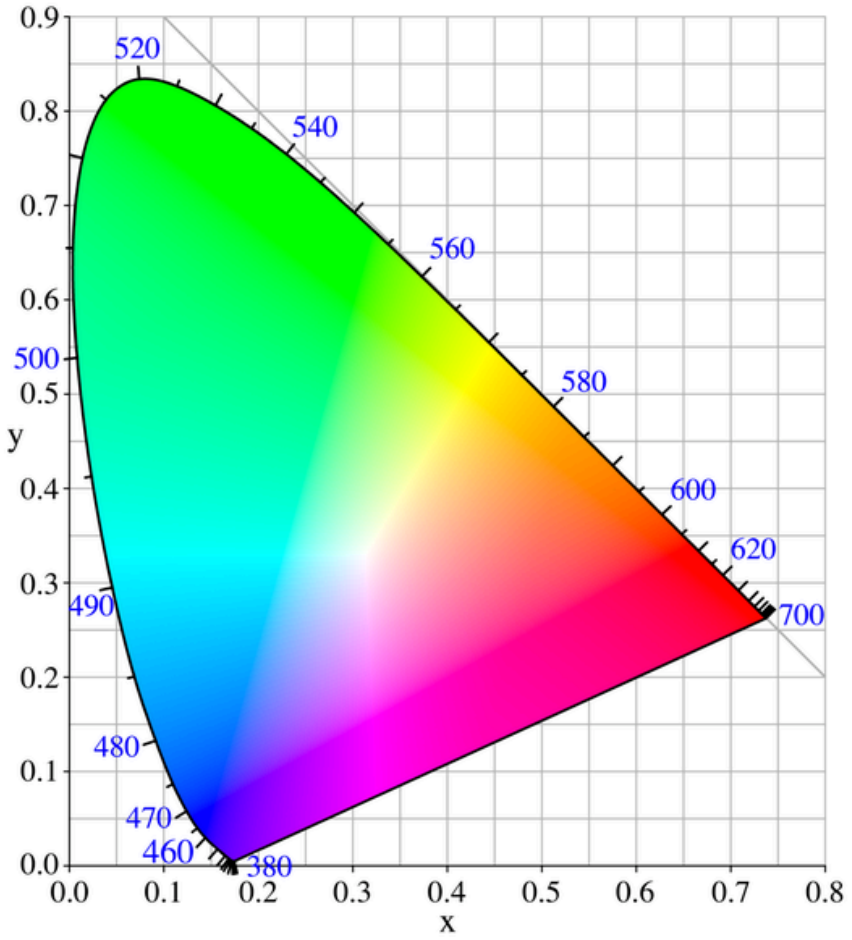
4.2 Color Models in Images

- Colors models and spaces used for stored, displayed, and printed images.
- **RGB Color Model for CRT Displays**
  - We expect to be able to use 8 bits per color channel for color that is accurate enough.
  - However, in fact we have to use about 12 bits per channel to avoid an aliasing effect in dark image areas — contour bands that result from gamma correction.
  - For images produced from computer graphics, we store integers proportional to intensity in the frame buffer. So should have a gamma correction LUT between the frame buffer and the CRT.

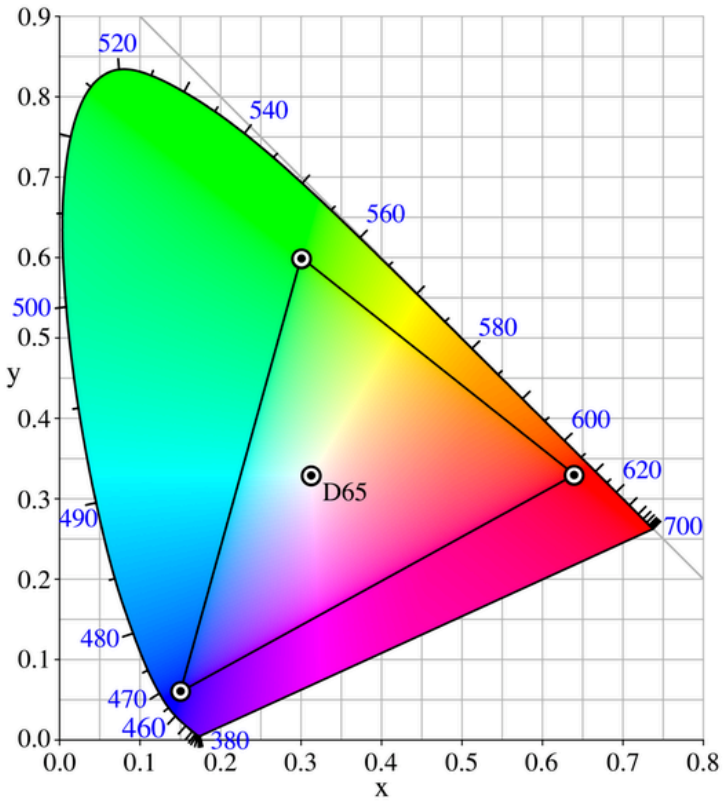
Color matching

- How can we compare colors so that the content creators and consumers know what they are seeing?
- Many different ways including CIE chromacity diagram



sRGB color space

- Extremetities of the triangle define the primaries and lines describe the boundaries of what the display can show. D65 is a “white” point
- Each display different
- Out-of-gamut colors outside triangle



- Table 4.1: Chromaticities and White Points of Monitor Specifications

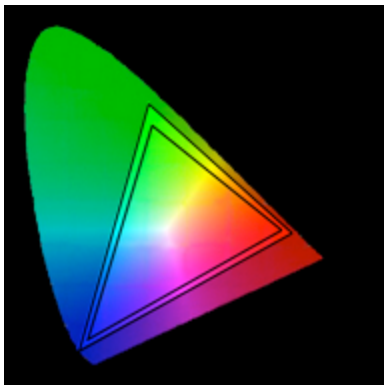
	Red		Green		Blue		White Point	
System	xr	yr	xg	yg	xb	yb	xW	yW
NTSC	0.67	0.33	0.21	0.71	0.14	0.08	0.3101	0.3162
SMPTE	0.630	0.340	0.310	0.595	0.155	0.070	0.3127	0.3291
EBU	0.64	0.33	0.29	0.60	0.15	0.06	0.3127	0.3291

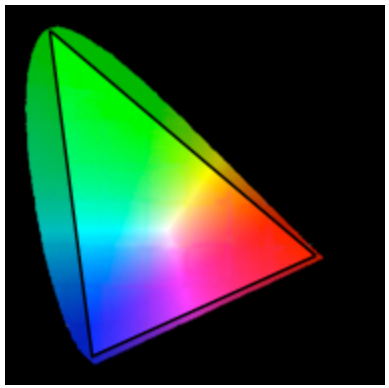
Monitor vs Film

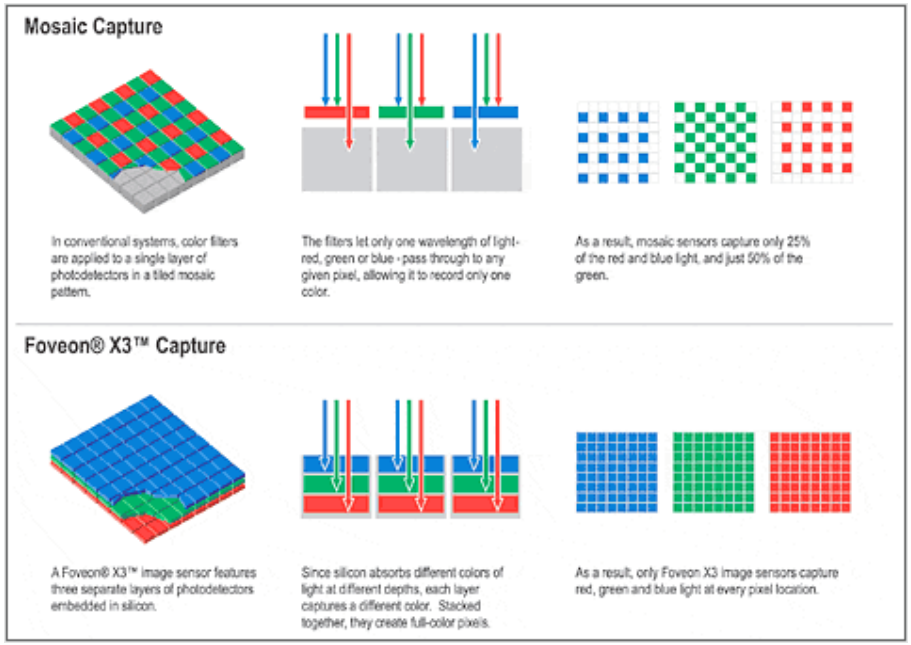
- Monitor vs Film
- Digital cameras use monochromatic pixels and extrapolate
- Twice as much green pixels as eye is sensitive to green

GRGR

BGBG







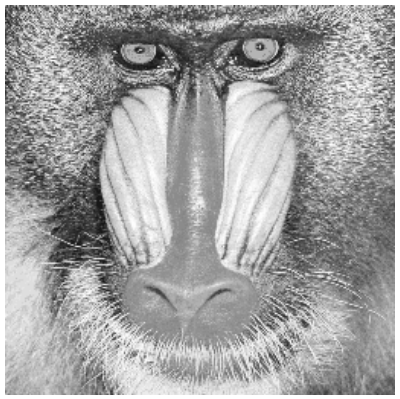
http://www.cirquedigital.com/howto/color_tutorial.html

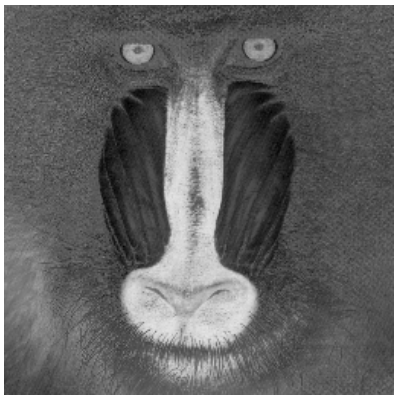
4.3 Color Models in Video

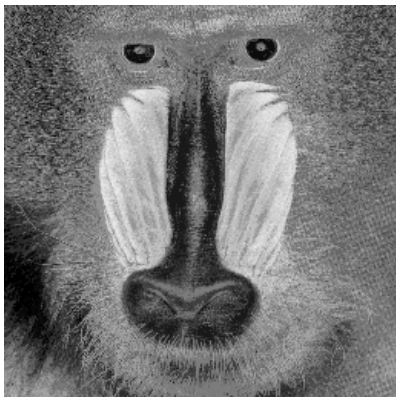
Video Color Transforms

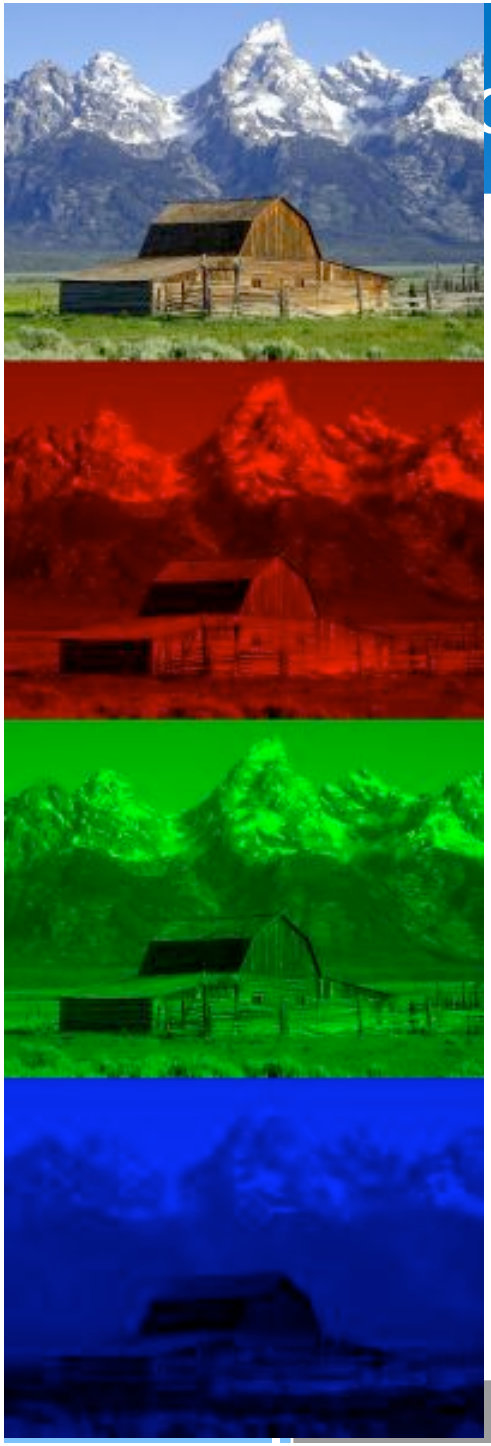
- Largely derived from older analog methods of coding color for TV. Luminance is separated from color information.
- YIQ is used to transmit TV signals in North America and Japan.This coding also makes its way into VHS video tape coding in these countries since video tape technologies also use YIQ.
- In Europe, video tape uses the PAL or SECAM codings, which are based on TV that uses a matrix transform called YUV.
- Finally, digital video mostly uses a matrix transform called YCbCr that is closely related to YUV

YUV (related to YCbCr)



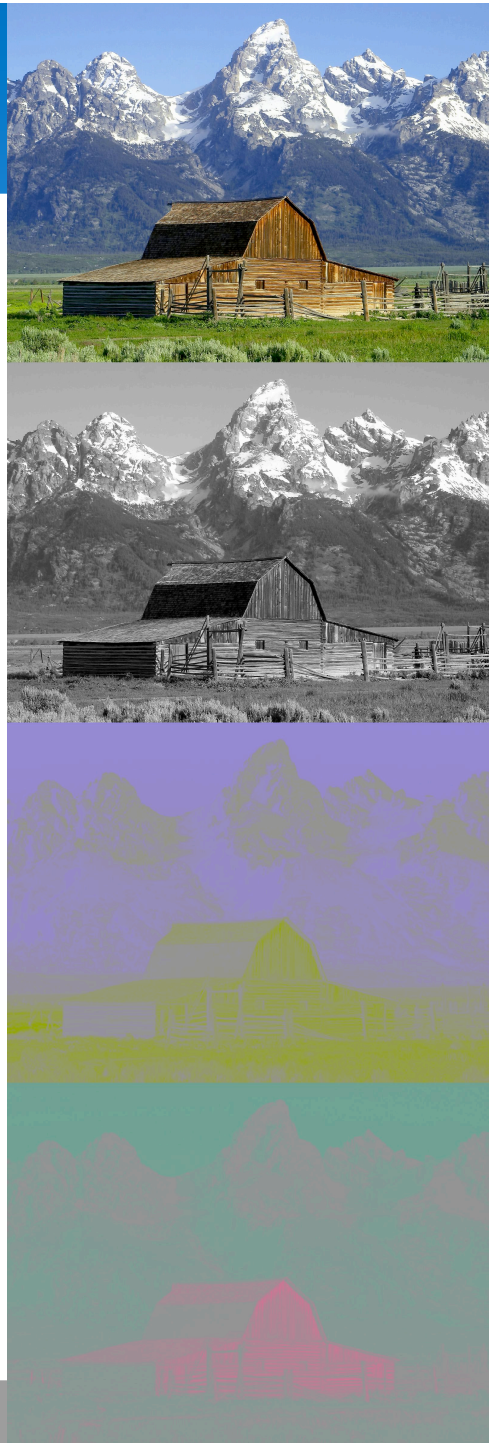






or spaces

- RGB - 8 bits per color
- YCbCr - Y is the luminance component and Cb and Cr are Chroma components
- Human eye is not sensitive to color



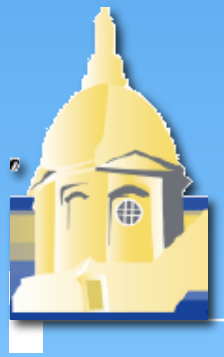
Graphics/Image Data Representations

- 1 Bit Image (bitmaps) - use 1 bit per pixels

- 8 bit gray-level image

Images

- Bitmap: The two-dimensional array of pixel values that represents the graphics/image data.
- Image resolution refers to the number of pixels in a digital image (higher resolution always yields better quality)
  - Fairly high resolution for such an image might be 1600 x 1200, whereas lower resolution might be 640 x 480
- **dithering** is used to print: which trades intensity resolution for spatial resolution to provide ability to print multi-level images on 2-level (1-bit) printers
- TrueColor (24 bit image)



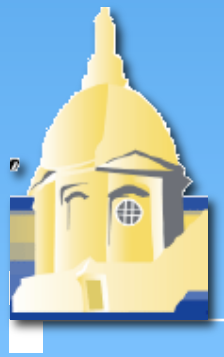
(a) *(b)* *(c)*

Fig. 3.4: Dithering of grayscale images.

(a): 8-bit grey image “lenagray.bmp”. (b): Dithered version of the image. (c): Detail of dithered version.

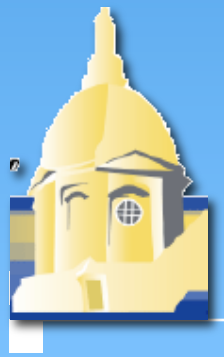
8-bit color image

- Can show up to 256 colors
- Use color lookup table to map 256 of the 24-bit color (rather than choosing 256 colors equally spaced)
  - Back in the days, displays could only show 256 colors. If you use a LUT for all applications, then display looked uniformly bad. You can choose a table per application in which case application switch involved CLUT switch and so you can’t see windows from other applications at all



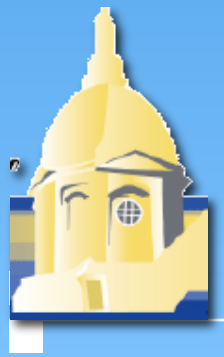
24-bit Color Images

- In a color 24-bit image, each pixel is represented by three bytes, usually representing RGB.
  - - This format supports 256 x 256 x 256 possible combined colors, or a total of 16,777,216 possible colors.
  - - However such flexibility does result in a storage penalty: A 640 x 480 24-bit color image would require 921.6 kB of storage without any compression.
- An important point: many 24-bit color images are actually stored as 32-bit images, with the extra byte of data for each pixel used to store an alpha value representing special effect information (e.g., transparency)



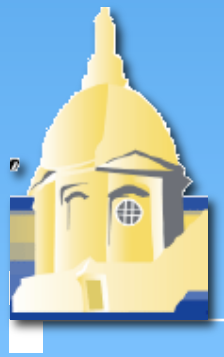
Popular Image Formats

- GIF
  - Lossless compression
  - 8 bit images
  - Can use standard LUT or custom LUT
  - LZW compression



JPEG

- Lossy compression of TrueColor Image (24 bit)
  - Human eye cannot see high frequency
    - Transform from spatial to frequency domain using discrete cosine transformation (DCT) (fast fourier approximation)
    - In frequency domain, use quantization table to drop high frequency components. The Q-table is scaled and divided image blocks. Choice of Q-table is an art. Based on lots of user studies. (lossy)
    - Use entropy encoding - Huffman encoding on Quantized bits (lossless)
    - Reverse DCT to get original object
  - Human eye cannot discern chroma information
    - Aggresively drop chroma components. Convert image from RGB to YCbCr. Drop Chroma using 4:2:0 subsampling

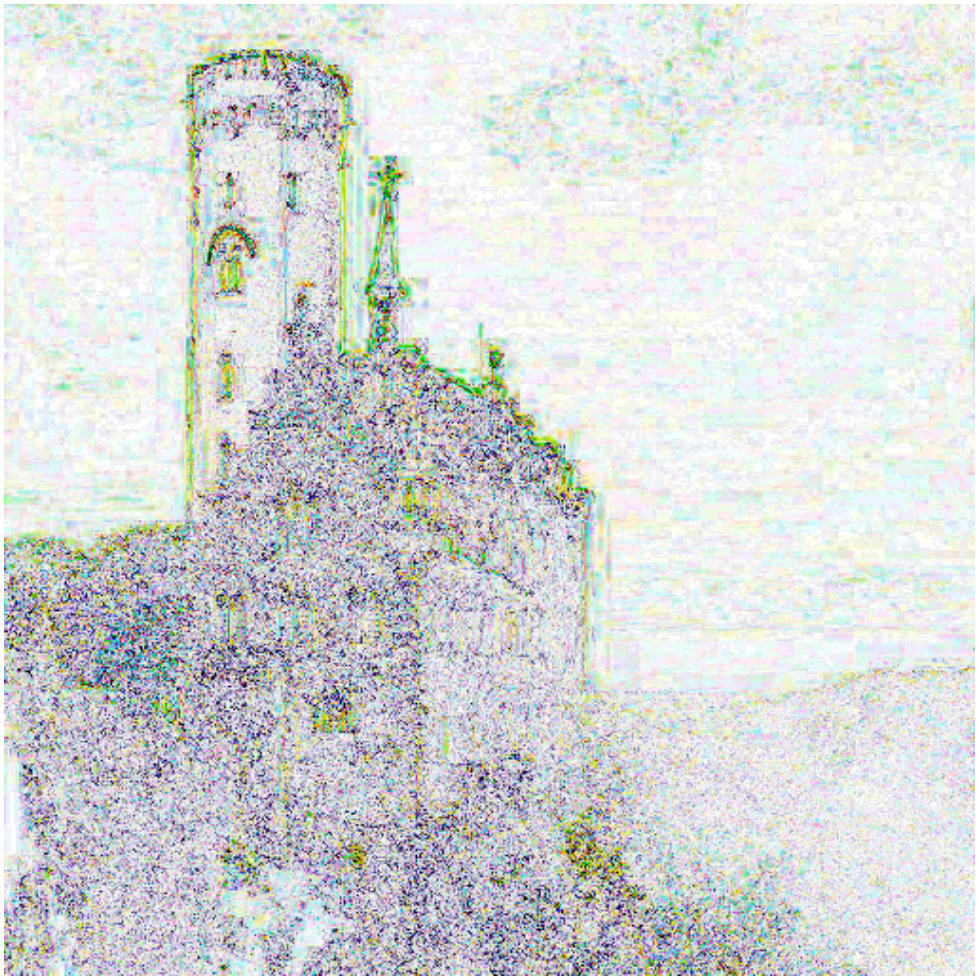


JPEG artifacts (from Wikipedia)

- Original

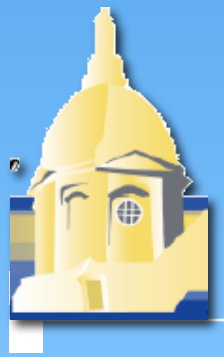
JPEG artifacts (Q=50)

- Differences (darker means more changes)



Other formats

- PNG
- TIFF
  - Container for JPEG or other compression
- JPEG is a compression technique, JFIF is the file format. A JPEG file is really JFIF file. TIFF is a file format.
- Postscript is a vector graphics language
  - Encapsulated PS adds some header info such as bounding box
- PDF is a container for PS, compression and other goodies



Summary

- Multimedia technologies use the limitations of human vision and devices in order to achieve good compression
- What does this mean for surveillance applications? Are the assumptions made by JPEG still true for applications that are analyzing images for other purposes