So far….

- Chapter 4 – Color spaces
- Chapter 3 – image representations
  - Bitmap
  - grayscale

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

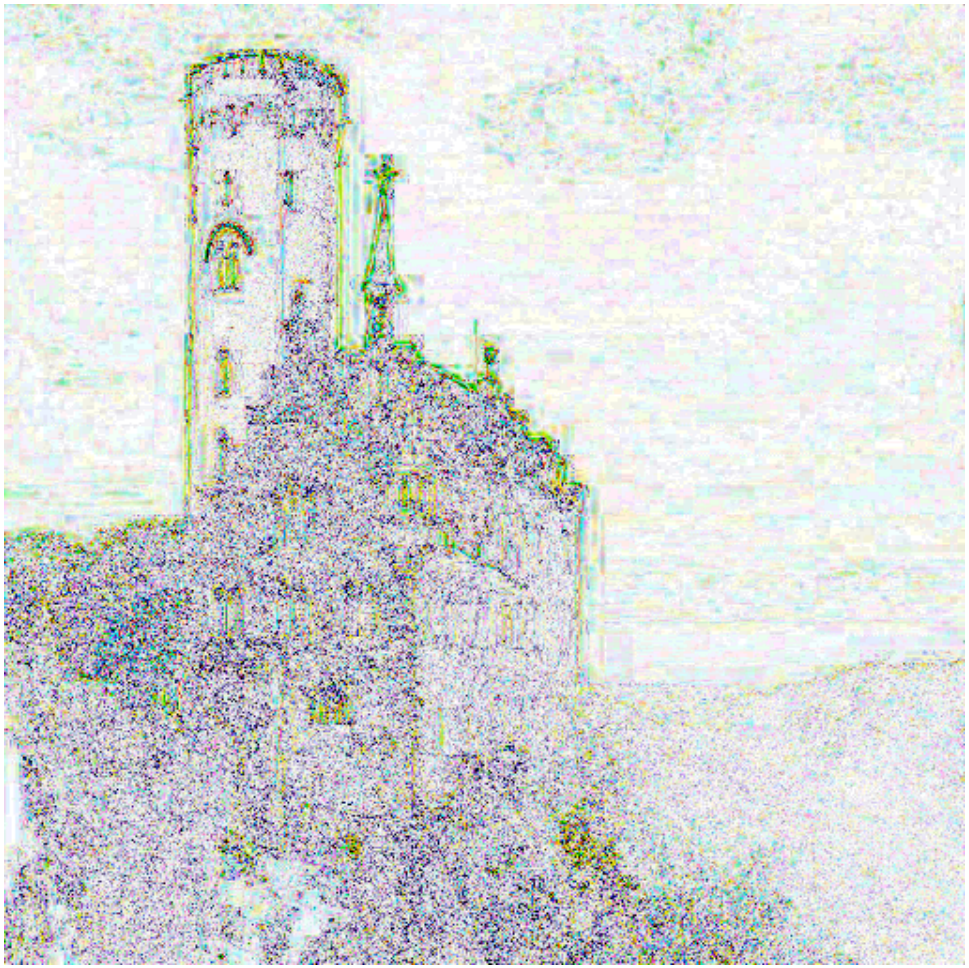
- Lossy compression of TrueColor Image (24 bit)
  - Human eye cannot see high frequency
    - Transform from spatial to frequency domain using discrete cosine transformation (DCT) (fast fourier approximation)
    - In frequency domain, use quantization table to drop high frequency components. The Q-table 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

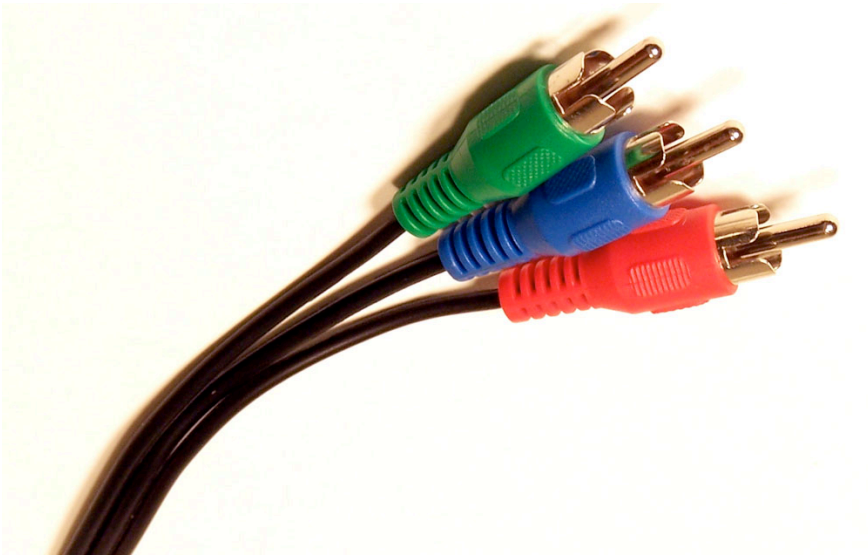
- PNG
- TIFF
  - Container for JPEG or other compression
- JPEG is a compression technique, JFIF is the file format. A JPEG file is really JFIF file. TIFF is a file format.
- Postscript is a vector graphics language
  - Encapsulated PS adds some header info such as bounding box
- PDF is a container for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

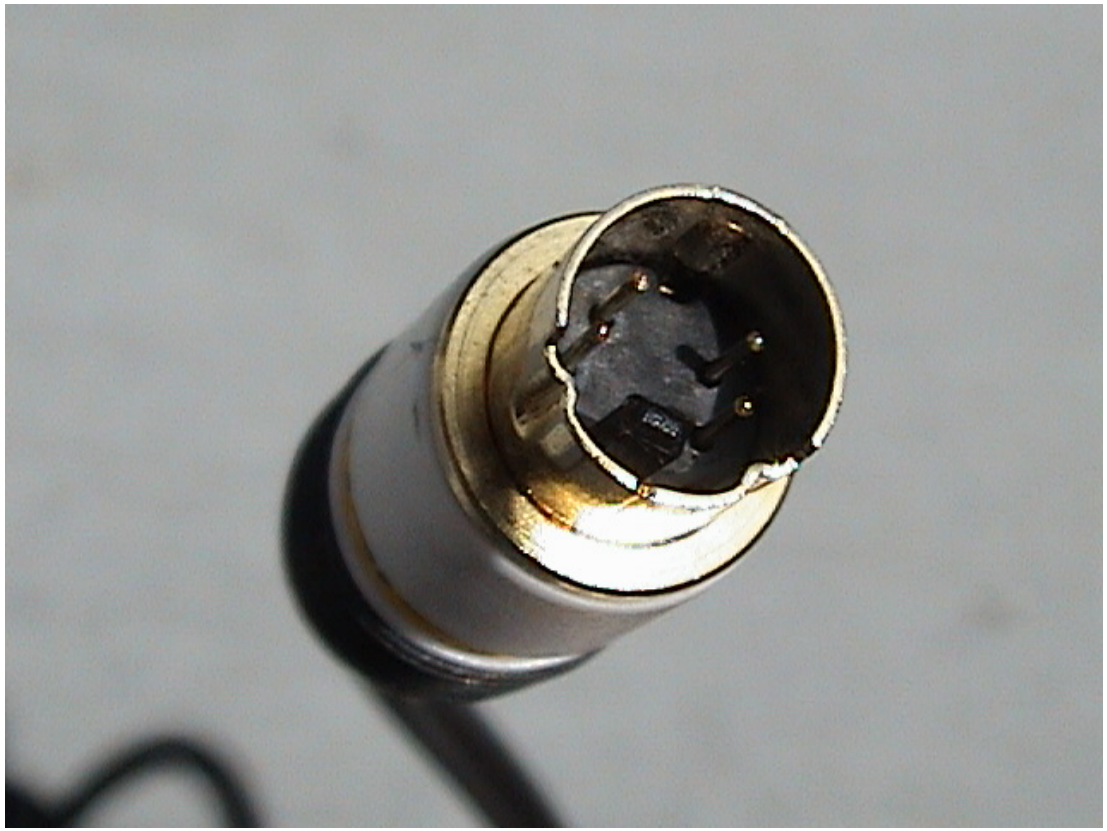
Chapter 5: Video

- Types of video signals
  - Component video
    - Three separate cables carry the RGB or YCbCr signals (Analog)
    - Best form of analog video



Pictures from Wikipedia

- S-Video
  - One wire for luminance
  - One wire for both chroma component



- Composite video
  - Single RCA cable carries luminance and chroma component
  - Signals interfere
- For even cheaper connections, VCRs have a connector that broadcasts signals in Channel 3/4. Signals are modulated and demodulated, losing fidelity

Digital connections

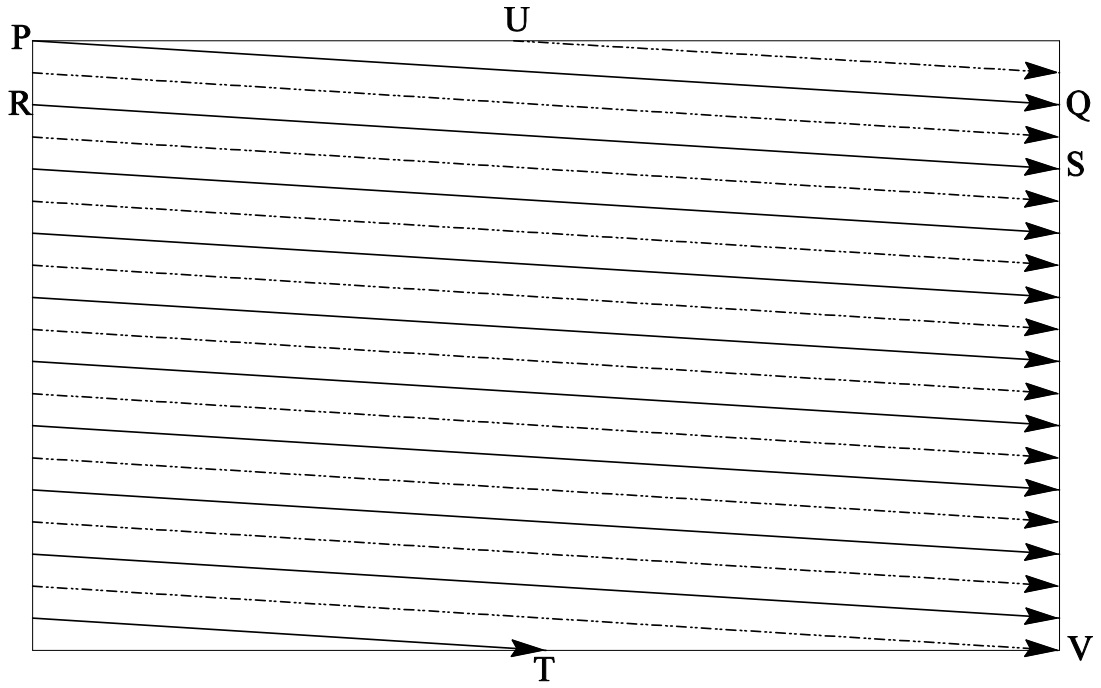
- DVI
  - Example display modes (single link):
    - HDTV (1920 × 1080) @ 60 Hz
    - UXGA (1600 × 1200) @ 60 Hz
    - WUXGA (1920 × 1200) @ 60 Hz
    - SXGA (1280 × 1024) @ 85 Hz
  - Example display modes (dual link):
    - QXGA (2048 × 1536) @ 75 Hz
    - HDTV (1920 × 1080) @ 85 Hz
    - WQXGA (2560 × 1600) pixels (30" LCD)
    - WQUXGA (3840 × 2400) @ 41 Hz

- HDMI
  - High definition Multimedia Interface
    - uncompressed, all-digital audio/video interface
    - High-Bandwidth Digital Content Protection (HDCP) DRM
    - Without HDCP HD-DVD & Bluray can restrict quality to DVD
    - Supports 30-bit, 36-bit, and 48-bit (RGB or YCbCr)
    - Supports output of Dolby TrueHD and DTS-HD Master Audio streams for external decoding by AV receivers

Analog video

- Interlaced Raster Scan
  - Way to increase refresh frequencies by alternating odd and even scan lines in separate refresh
  - NTSC has a notion of blacker than black signal that triggers a beginning of line
  - 525 scan lines at 29.97 frames per second
  - VHS: 240 samples per line, S-VHS: 400-425, Hi-8: 425, miniDV: 480x720)
  - PAL and SECAM: 625 scan lines, 25 frames per second
    - NTSC: 6 MHz, PAL&SECAM: 8 MHz

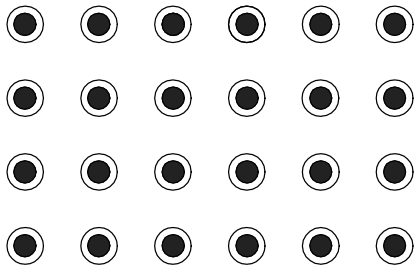
Interlacing



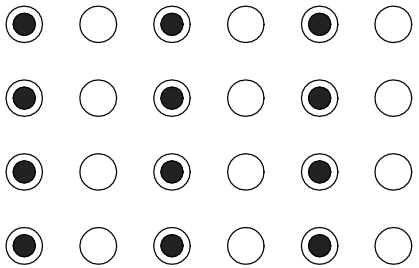
Digital video - Chroma subsampling

- 4:4:4, 4 pixels of Y, Cb and Cr each
- 4:2:2 : Cb and Cr are half
  - NTSC uses this subsampling
- 4:1:1 : Cb and Cr are factor of four
  - DV uses this subsampling
- 4:2:0 : Cb and Cr are subsampled, effectively 4:1:1
  - Used in JPEG, MPEG and HDV

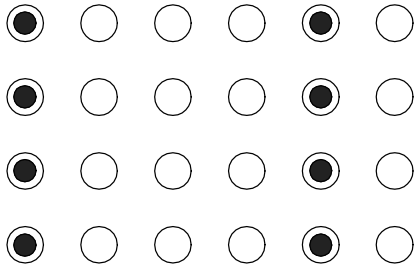
Chroma sub-sampling



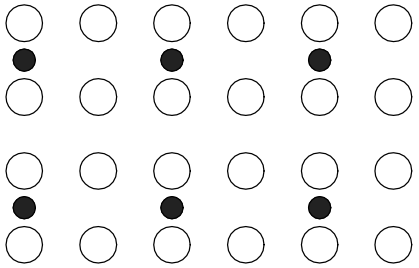
4:4:4



4:2:2



4:1:1



4:2:0

Pixel with only Y value

Pixel with only Cr and Cb values

Pixel with Y, Cr, and Cb values

Digital video standards

- **CCIR Standards for Digital Video**
- CIF stands for Common Intermediate Format specified by the CCITT.
  - (a) The idea of CIF is to specify a format for lower bitrate.
  - (b) CIF is about the same as VHS quality. It uses a progressive (non-interlaced) scan.
  - (c) QCIF stands for “Quarter-CIF”. All the CIF/QCIF resolutions are evenly divisible by 8, and all except 88 are divisible by 16; this provides convenience for block-based video coding in H.261 and H.263

Digital video specifications

	CCIR 601 525/60 NTSC	CCIR 601 625/50 PAL/ SECAM	CIF	QCIF
Luminance resolution	720 x 480	720 x 576	352 x 288	176 x 144
Chrominance resolution	360 x 480	360 x 576	176 x 144	88 x 72
Colour Subsampling	4:2:2	4:2:2	4:2:0	4:2:0
Fields/sec	60	50	30	30
Interlaced	Yes	Yes	No	No

High Definition TV

- US style:
  - MPEG 2 video, Dolby AC-3 audio
  - 1920x1080i - NBC, CBS ..
  - 1280x720p - ABC, ESPN
  - 1920x1080p - Xbox 360, PSP3
    - 1920x1080p24 – cinematic
- HDV uses rectangular pixels: 1440x1080
- For video, MPEG-2 is chosen as the compression standard. For audio, AC-3 is the standard. It supports the so-called 5.1 channel Dolby surround sound, i.e., five surround channels plus a subwoofer channel.