ECE 8873

Data Compression and Modeling

Lecture 11: Video Coding

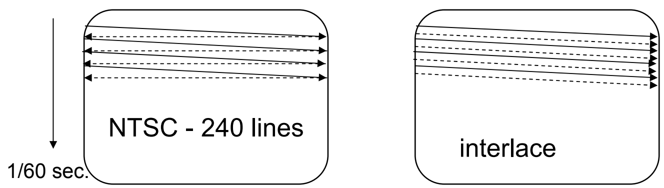
School of Electrical and Computer Engineering
Georgia Institute of Technology
Spring, 2004

NTSC Video Representation

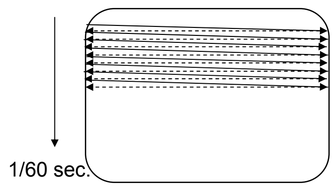
- 525 scan lines per frame, 30 frames per second (actually 29.97 fps, 33.37 ms/frame) on CRT
- Interlaced, each frame divided into 2 fields, 262.5 lines/field
- 20 lines reserved for control information at the beginning of each field
- maximum visible data of 485 lines
- Laserdisc and S-VHS have resolution ~420 lines; ordinary TV ~320 lines
- Each line takes 63.5 microseconds to scan. Horizontal retrace takes 10 microseconds (with 5 microseconds horizontal synch pulse embedded); active line carrying video is 53.5 microseconds

Video Signal Representation

CRT (Cathode Ray Tube) for display of video images



HDTV-ready TVs, or LCD display



Color Video

- **Component video** – each primary color (e.g., R,G,B) is sent as a separate video signal
  - Best color reproduction but requires more bandwidth and good synchronization of the three components
- **Composite video** – color (chrominance) and luminance signals are mixed into a single carrier wave (see next slide)
- **S-Video** (Separated video) – Transformation of RGB into separate luminance and chrominance signals (e.g., YIQ, YUV)
  - a compromise between component analog video and the composite video. It uses two separate “channels,” one for luminance and the other for composite chrominance signal
- **Digital component video** – luminance and color difference video) Y = .299*R + .587*G + .114*B just as in NTSC and Cr = R-Y, Cb = B-Y, 8 bits/sample.

Composite Video

- Seven elements:
  - horizontal line sync pulse
  - color reference burst: 3.58 MHz 0-phase sine wave, 8 to 9 cycles before the picture information on each scan line
  - reference black level
  - picture luminance information
  - color saturation information
  - color hue information
  - vertical sync pulse
- Composite video signals between equipment are connected with a single 75 ohm coax cable, usually with RCA connectors. Composite video signals can also be modulated onto an RF carrier for TV broadcast, or transmitted on coax cable in cable TV distribution systems.

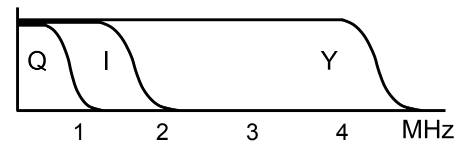
Luminance & Composite Chrominance

Y (luminance)
I & Q (color difference)

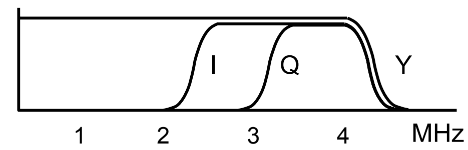
$$\begin{bmatrix} Y \\ I \\ Q \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ 0.596 & -0.274 & -0.322 \\ 0.212 & -0.523 & 0.311 \end{bmatrix} \begin{bmatrix} R' \\ G' \\ B' \end{bmatrix}$$

$\begin{bmatrix} R' & G' & B' \end{bmatrix}$ Gamma corrected RGB

Cr = R'-Y, Cb = B'-Y



NTSC Composite Video Spectrum



ATSC (HDTV) Video Format

Video Format

The video scanning formats supported by the ATSC Digital Television Standard are shown in the following table.

Vertical Lines	Horizontal Pixels	Aspect Ratio	Picture Rate
1080	1920	16:9	60I 30P 24P
720	1280	16:9	60P 30P 24P
480	704	16:9 & 4:3	60I 60P 30P 24P
480	640	4:3	60I 60P 30P 24P

Predictive & Differential Coding in Video

- Simple choice: Consider each frame as an image – perform 2-D prediction within each image and code the residual
- Better choice: take inter-frame dependency into account; code only the inter-frame differences (the "delta" frame)
  - As with other predictive coding schemes, errors due to imperfect transmission or storage may propagate to later frames
  - Difficulty in supporting random access to any portion of the video sequence
  - Need to consider periodic "refreshment" – thus key frames

Key Frames

- Regularly paced: code independently once every n frames, differentially in-between frames
- Synchronized with scene change, but still other structural change to consider before coding the difference frames sequentially:
  - Objects moving
  - Panning
  - Zooming

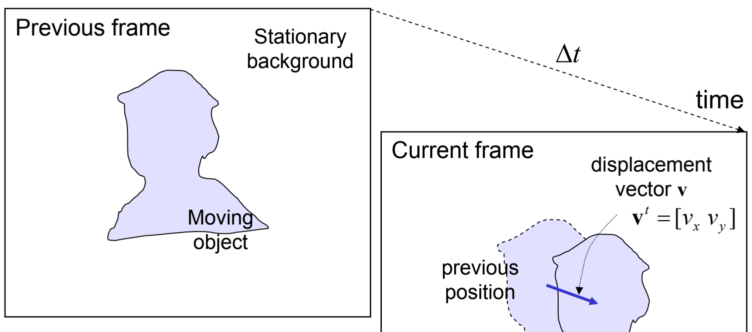
→ Motion prediction/compensation first.

Encoder with MCP

Encoder:
- Identify corresponding moving parts between consecutive frames
- Divide the frame into blocks according to these parts
- Assign a motion vector to each block
- Use the previous frame and the motion vectors to form a predicted version of the current frame
- Send the motion blocks and difference (residual)

Decoder
- Use the previous frame and the motion vectors as a predicted version of the current frame
- Decode and add back the residual

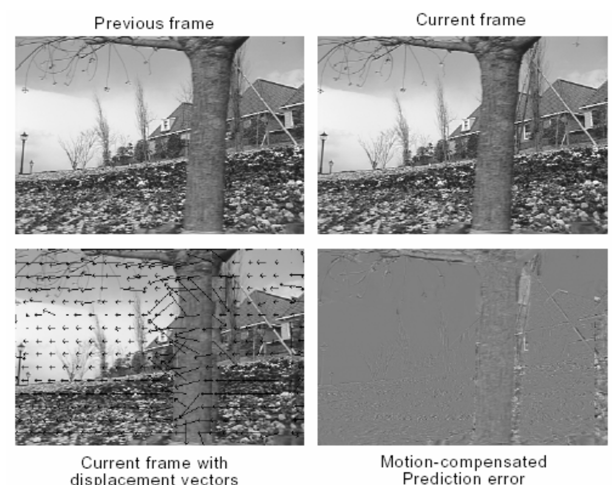
Motion Compensated Prediction



Prediction for luminance signal within the object:

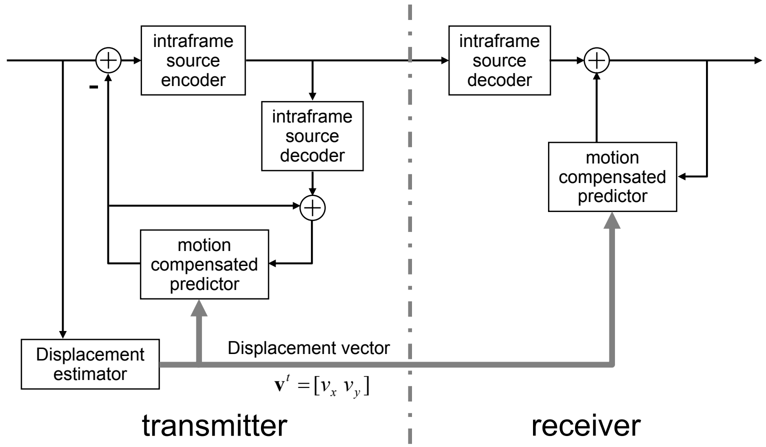
$$\hat{U}(x,y,t) = \kappa U(x - v_x, y - v_y, t - \Delta t)$$

MCP - Example



from Bernd Girod

Motion-Compensated Prediction



MPEG Video Coding