Chapter 7.2:  
Layer 6:  Compression

CS/ECPE 5516: Comm. Network  
Prof. Abrams, Spring 2000  
Based in part on material from Scott F. Midkiff

Multimedia Systems

- Interactive versus non-interactive

![Diagram of server-client relationship with Video Archive and Stored Live]

Example Multimedia Applications

- Multimedia-on-demand  
  - Video-on-demand  
  - Audio-on-demand  
- Live video  
  - Meetings  
  - Collaboration  
  - News  
- Remote sensing and imaging

Need for Video Compression

- Video characteristics  
  - Demanding with respect to storage and/or data rate  
  - (640x480 pixels/f)(24 b/pixel)(30 f/s) = 221 Mbps  
  - Highly redundant -- duplicated information  
  - Compression ratios of 200:1 or even 2000:1 are possible  
- Compression is needed to enable  
  - Storage  
  - Transmission

Compression Example (JPEG)

<table>
<thead>
<tr>
<th>Quality</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>100%</td>
<td>57459</td>
</tr>
<tr>
<td>90%</td>
<td>20525</td>
</tr>
<tr>
<td>60%</td>
<td>8293</td>
</tr>
<tr>
<td>25%</td>
<td>4984</td>
</tr>
<tr>
<td>10%</td>
<td>3338</td>
</tr>
<tr>
<td>5%</td>
<td>2551</td>
</tr>
</tbody>
</table>

JPEG = Joint Picture Experts Group

Compression Techniques

- Information may be lost (but not missed)  
  - **Lossy** compression -- information is lost  
  - **Lossless** compression -- no loss  
- Lossy techniques: drop info not important to human perception.  
  **Examples:**  
  - Images: changes in high frequency brightness changes as you move across image  
  - Audio: low frequency sounds in woman’s voice
Lossless Compression Algorithms (1)

- Run Length Encoding
  "AAABB" \(\Rightarrow\) “3A2B”
  Can actually increase file size
  Can be applied to images by comparing adjacent pixels
- Differential Pulse Code Modulation
  “AAABBCC” \(\Rightarrow\) “A00112” since B is 1 away from A, …
- Delta encoding
  “AAABBCC” \(\Rightarrow\) “A00101” since C is 1 away from B, …

Lossless Compression Algorithms (2)

- Dictionary-based methods
  - Build table of variable length strings
    “to be or not to be is Shakespeare’s line – is it not?”
    Dictionary:
    0="to be"
    1="not"
    2="is"
    \(\Rightarrow\) “0 or 1 0 2 Shakespeare’s line – 2 it 1?”
  - Cost: must send dictionary before file
  - Examples: Lempel-Ziv (Unix compress)

Lossy Compression – Images (1)

- GIF
  - Given 24-bit pixels, pick the 256 most used colors.
    Map each 24-bit pixel into 1-of-256.
  - Achieves 3x compression.
  - Then run Lempel-Ziv, maybe achieving 10x compression.

Lossy Compression – Images (2)

- JPEG
  - DCT Phase:
    - Divide image into 8x8 pixel blocks.
    - If you move across x-axis, you see pixels vary with some frequency.
    - Compute something like Fourier transform, called Discrete Cosine Transform (DCT) – maps intensity to frequency domain with 64 intensities.

JPEG

- DCT Phase
- Quantization Phase
  - Use table of coefficients; divide step 1 values by coefficients.
    Maps many frequencies to zero.
- Encoding phase
  - Huffman code: use few bits for most popular numbers
  - Use delta encoding for subsequent array values
- Color: repeat 3 times (RGB)

Video Compression Techniques

- Scope of compression
  - Intraframe -- eliminate or reduce redundancy within a single frame
  - Interframe -- eliminate or reduce redundancy between consecutive frames
  - Prediction, interpolation – predict frame based on previous/subsequent values
  - Sample to take advantage of human perception
MPEG Overview (1)

- Features
  - Can achieve compression ratios of 200:1
  - Would reduce data rate to around 1.2 Mbps for a 640x480 image
  - MPEG-1 compresses 320x240 images and requires at least 1.5 Mbps
  - Also includes audio compression with compression ratios of 5:1 to 10:1

MPEG Overview (2)

- Compression techniques
  - Uses DCT for intraframe compression
  - Uses interframe compression by storing differences between successive frames
  - There are three frame types
    - Intraframes (I frames) are encoded using intraframe compression
    - Predicted frames (P frames) are predicted from previous I frames
    - Bidirectional frames (B frames) are interpolated from previous and future frames

MPEG Overview (3)

- Repeated pattern of frames (pictures) is a group of pictures (GOP)
  - Example: IBBBPBBB
  - Forward prediction
  - Bidirectional prediction

Transmission of MPEG

- If stored video, send IBBBPBBBI as IPBBBBBBI
- Might use Differentiated Services, with I’s and P’s as high priority
- Can change quantization matrix during video

Some Video Compression Standards

- MPEG-1, MPEG-2, MPEG-3, and MPEG-4
- ITU-T (CCITT) standards
  - H.320 (H.261) — ISDN (64 Kbps increments)
  - H.323 — LAN
  - H.324 — POTS
- MJPEG (Motion JPEG)