Electronic Publishing

Size Does Matter
ECEN 1200
Telecommunications 1

Electronic Newspaper

- How can document be converted and published?
  - Options: Scan, edit directly in HTML, word processor, or page layout program.
- How much storage is needed?
  - Per day, week, month, year?
- How long does it take to download/view a page?
  - Depends on connection: Telephone (28.8 kb/s), Cable (0.2..1 Mb/s), Ethernet (10 or 100 Mb/s), etc.

Scanner Resolution

- Suppose each page is simply scanned.
- What resolution in dpi (dots per inch) is needed?
- Page size is 10”x14”=140 sq.in. Thus:

<table>
<thead>
<tr>
<th>dpi</th>
<th>Total size in pixels</th>
<th>Total size in bytes uncompressed (24 b/pix)</th>
<th>Compressed jpeg (approx)</th>
<th>Download time (modem, 28.8 kbps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>10x10x140 = 14,000</td>
<td>42,000 = 42 kB</td>
<td>4.2 kB</td>
<td>1.2 sec</td>
</tr>
<tr>
<td>100</td>
<td>100x100x140 = 1,400,000</td>
<td>4,200,000 = 4.2 MB</td>
<td>420 kB</td>
<td>117 sec</td>
</tr>
<tr>
<td>500</td>
<td>500x500x140 = 12,600,000</td>
<td>37,800,000 = 37.8 MB</td>
<td>3.78 MB</td>
<td>1050 sec (17.5 min)</td>
</tr>
<tr>
<td>1000</td>
<td>1000x1000x140 = 140,000,000</td>
<td>420,000,000 = 420 MB</td>
<td>42 MB</td>
<td>11667 sec (3.2 hrs)</td>
</tr>
</tbody>
</table>

- 200 dpi
- 300 dpi

Scanning the Newspaper

- If the newspaper is scanned at 200 dpi, 200x200x10x14x3 = 16.8 Mbytes are needed per page. After compression (by about 10) this is still 1.68 Mbytes (>1 floppy).
- Download via telephone line (28.8kb/s) takes 1680x8/28.8 = 466.7 sec (7.8 min)
- This is much too slow! Clearly, another approach is needed.
Distinguish and process separately:
- Yellow: Images
- Gray: Text

Resolution of Photo

- Counting dots in enlarged portion of image gives about 15 dots per 1/8 in. => approx 120 dpi.

Encoding of Photo

- Resolution: 100 dpi
  => 100 x 100 = 10,000 pixels/sq.in.
- Photo area is
  8” x 4.5” = 36 sq.in.
- Truecolor: 24 bits/pixel (=3 bytes/pixel)
  => 36x10000x3 = 1.08 MB for photo

Resolution for Masthead and Graphics

- Using GIF files at 50 dpi looks quite reasonable:
Encoding of Masthead and Graphics

- Resolution: 50 dpi (dots/in)
  => 50x50 = 2500 pixels/sq.in.
- Graphics area is
  - Masthead: 8x5 = 40 sq.in.
  - Weather: 2x2 = 4 sq.in.
- At 4 bits/pixel (=0.5 bytes/pixel)
  => 44x2500x0.5 = 55 kB per page

Encoding of Text

- 20 chars/in, 8 lines/in.
  => 8x20 = 160 chars/sq.in.
- Total area minus image area is
  140 – 40 – 36 - 4 = 60 sq.in.
  => 160x60 = 9600 chars on page
  => approx 10 kB per page using ASCII
- Note: This is much less than images!

Total for Frontpage

- Assume compression by 10 (JPEG) for photo and compression by 2.5 (GIF) for masthead and graphic. Then
  - Photo: 108 kB
  - Masthead/graphic: 22 kB
  - Text: 10 kB
  - **Total: 140 kB per page**
  => 140x8/28.8=39 sec download via phone line

Reduction of Photo Resolution

- A browser typically uses an area of about 800x600 pixels. Thus, using a resolution of about 75 dpi is enough. In this way the photo uses only 36x75x75x3/10=60,750 bytes. Now the newspaper frontpage uses about **93 kB**.
- This downloads in 26 sec, which is quite close to being usable.

Art Book on CD-ROM

Each double page contains a work of art on one page and a description on the opposite page.

- Resolution: 300 dpi
  => 300 x 300 = 90,000 pixels/sq.in.
- Image area is
  9” x 12” = 108 sq.in.
- Truecolor: 24 bits/pixel (=3 bytes/pixel)
  => 108x90000x3 = 29.16 MB per image
- JPEG (compress by 10): **2.9 MB/image**

Encoding of Art Image

- Resolution: 300 dpi
  => 300 x 300 = 90,000 pixels/sq.in.
- Image area is
  9” x 12” = 108 sq.in.
- Truecolor: 24 bits/pixel (=3 bytes/pixel)
  => 108x90000x3 = 29.16 MB per image
- JPEG (compress by 10): **2.9 MB/image**
Encoding of Text

- 15 chars/in, 6 lines/in.
  => 6x15 = 90 chars/sq.in.
- Text area is
  9” x 12” = 108 sq.in.
  => 90x108 = 9720 chars on page
  => approx 10 kB per page using ASCII
- Again: This is much less than image!

Total per Double Page

- Assume compression by 10 (JPEG) for art image. Then
  Art image: 2916 kB
  Text: 10 kB
  Total: 2926 kB per page
  => 700/2.93 = 239 double pages fit on CD-ROM
- Thus, an art book fits quite well onto a single CD-ROM.

Video/Audio Productions

- Here is an example of a 3 min movie clip with 320x224 image resolution

fps: Frames per Second

- To perceive a sequence of images as continuous motion at least 16 images or frames/sec are needed.
- Movies use 24 fps (or 23.976)
- NTSC (National Television System Committee) TV uses 30 fps (or 29.79)
- European TV uses 25 fps

Typical Image Resolutions

- VCD (video CD, using MPEG1), VCR quality
  • 352 x 240 (22:15 aspect ratio)
- SVCD (super VCD, using MPEG2), high quality
  • 480 x 480 (16:9 anamorphic, using non-square pixels)
- NTSC studio quality
  • 720 x 540 (4:3 aspect ratio)
- DVD (digital versatile disc, MPEG2) Movie
  • 720 x 576 (5:4 aspect ratio)
- DV (digital video) Camcorder (NTSC)
  • 720 x 480 (3:2 aspect ratio)

Bits per Pixel

- TV uses the (Y,Cb,Cr) model, with luminance Y and chrominance Cb,Cr as
  • Y = 0.3*R + 0.59*G + 0.11*B,
  • Cb = B-Y, Cr = R-Y
- Consumer devices: 8-bit sampling for Y, 8/4 bits for Cb and Cr => 12 bits/pixel
- Professional devices: 8-bit sampling for Y, 8/2 bits for Cb and Cr => 16 bits/pixel
- Note: YUV and Y,Cb,Cr models are very similar and YUV can be used instead of Y,Cb,Cr
Uncompressed Video Rates

- **VCD** (video CD, using MPEG1), VCR quality
  - $352 \times 240 \times 30 \times 12 = 30,412,800 \text{ bps}$
- **SVCD** (super VCD), high quality
  - $480 \times 480 \times 30 \times 12 = 82,944,000 \text{ bps}$
- **NTSC studio quality**
  - $720 \times 540 \times 29.97 \times 12 = 186,437,376 \text{ bps}$
- **DVD** (digital versatile disc, MPEG2) Movie
  - $720 \times 576 \times 24 \times 12 = 119,439,360 \text{ bps}$
- **DV** (digital video) Camcorder (NTSC)
  - $720 \times 480 \times 29.97 \times 12 = 124,291,584 \text{ bps}$

Uncompressed Audio Rates

- **Low quality, mono** (e.g., VCD)
  - $1 \times 32000 \times 16 = 512,000 \text{ bps}$
- **High quality, stereo** (e.g., CD)
  - $2 \times 44100 \times 16 = 1,411,200 \text{ bps}$
- **High quality, multi-channel** (e.g., DVD)
  - $5 \times 48000 \times 16 = 3,840,000 \text{ bps}$
- **High quality, stereo PCM** (e.g., DV)
  - $2 \times 48000 \times 16 = 1,536,000 \text{ bps}$

Compression

- The raw video (and audio) rates, even for low quality parameters are very high.
- VCD quality requires about 31 Mbps for video and sound without compression.
- MPEG1 was developed to record movies on CD with bitrate 1.5 Mbps.
- This requires (fixed rate) video compression by 20..30 and audio compression by 2..4.

Typical Media Speeds (Video and Sound)

- **Video CD** (MPEG1, layer-2 audio)
  - Up to 1.5 Mbps (700 MB: approx 60 min)
- **SVCD** (MPEG2, layer-2 audio)
  - Up to 2.9 Mbps (750 MB: approx 35 min)
- **DVD** (digital versatile disc, MPEG2, layer-2)
  - Up to 9.8 Mbps (4.4 GB: 2 hrs @ 4.9 Mbps)
- **DV** (digital video)
  - 25 Mbps fixed
- **DSL** (digital subscriber line, MPEG4)
  - 0.5 ... 2.0 Mbps (depends on phone line)

Typical Compression Ratios

- VCD using 352x240 resolution at 30 fps with stereo sound, encoded with MPEG1
  - Video compression: approx $30$
  - Audio compression: approx $3$
  - $\Rightarrow 1.48 \text{ Mbps (video + audio)}$
  - 700 MB CD-ROM stores approx 1 hr video
- The VCD format is quite popular in Asia.

Typical Compression Ratios

- DVD using 720x576 resolution at 24 fps, 5-channel sound, encoded with MPEG2
  - Video compression: approx $27$ (typ. 20..35)
  - Audio compression: approx $8$ (typ. 2..10)
  - $\Rightarrow 4.9 \text{ Mbps (video + audio)}$
  - Single layer, single side DVD has 4.4 GB
  - 4.4 GB DVD stores approx 2 hr video
Typical Compression Ratios

- DV using 720x480 resolution at 29.97 fps, stereo sound, encoded with DV codec
  - Video compression: approx 5.3
  - Audio compression: 1 (PCM, uncompressed)
  - => 25 Mbps (video + audio)
  - Requires **11.25 GB** storage space per hour

Video/Audio Productions

- This 3 min movie clip has 320x224 image resolution
- What are the compression ratios for video and audio?
- How much storage space and download time does it take?

Video/audio Info from Virtual Dub Program

- **Video**
  - 320x224 pixels/frame, 12 bits/pixel
  - 5500 frames => 183.33 sec
  - Uncompressed size:
    - \(320 \times 224 \times 12 \times 5500 / 8 = 591.36\) Mbytes
  - Compressed size:
    - Average bitrate: 279 Kbps
    - \(279 \times 183.33 / 8 = 6.39\) Mbytes
    - Thus \(x = 591.36 / 6.39 = 92.5\)
    - Compression ratio is **92.5:1**

- **Audio**
  - 44100 samples/sec, 16 bits/sample
  - Stereo, 183.33 sec
  - Uncompressed size:
    - \(44100 \times 16 \times 2 \times 183.33 / 8 = 32339.4\) kBytes
  - Compressed size: 2149 kBytes
  - Thus \(x = 32.34 / 2.15 = 15.04\)
  - Compression ratio is **15:1**

Total Size and Download Time

- **Total size (compressed):**
  - Video: 6394 kBytes, audio: 2149 kBytes
  - Total: 6394 + 2149 = **8543** kBytes
- **Download time:**
  - Telephone modem (28.8 kbps)
    - \(8543 \times 8 / 28.8 = 2373\) sec (= 39.6 min)
  - Ethernet LAN (100 Mbps)
    - \(8543 \times 8 / 100000 = 0.68\) sec