Strategies for better (and reduced bit rate) digital video for multimedia

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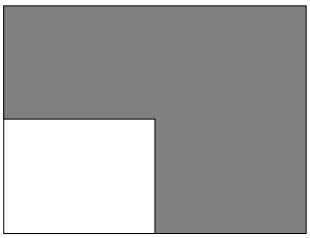
Steps for reducing the bitrate

- Image resolution
- Pixel aspect ratio
- Reframing
- Bits per pixel
- Images per second
- Compression, intraframe, interframe
- Audio
- Related topics
  - Safe area
  - Aspect Ratio revisited
  - MPEG1 for square pixels

Image resolution

- Proportional reduction of resolution
  - Can generate enormous savings
  - Reducing ½ in X means reducing ¼ in X*Y
  - Cons: details are less visible, affects readability
    - Details can be lost, unrecoverable
  - MPEG1 (VCD&CD-I) = ~¼ MPG2 (DVD compliant)

    352*288 versus 720*576

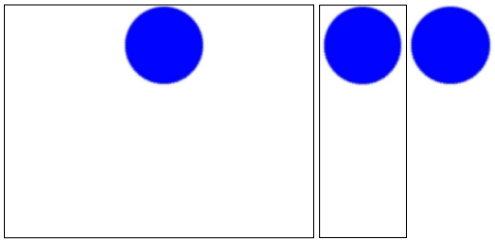


Pixel aspect ratio

- Reducing the dot/pixel count along a line
  - Contributes to reduce the bandwidth (bit rate)
    - Not all pixels are created equal (squares vs rectangles)
  - Cons: less details along a line; image space sync
  - A 768*576 pixels frame is RA=4:3 with square dots
  - MPEG2 (DVD compliant) is 720*576 pixels
    - Pixels have RAp = 4/3 / 1.25 = 1.06(6)
  - MPEG1 (VCD compliant) is 352*288 pixels
    - Pixels have RAp = 4/3 / 1.2(2) = 1.09(09)

(Re)Framing

- Framing for the used image space area
  - Motion empty areas are eliminated, not wasted
    - Not all frames are created equal with RAt = 4:3, 5:3, 16:9
  - Ex: vertically bouncing ball (ideal ground impact)
    - Occupies only a limited area, its width along the motion
    - Standard frames can waste image space/size



Three examples:
Framed, 4:3
Width for the motion
Not Framed (better integration)

Bits per pixel (bpp)

- Using only enough bpp, less color waste
  - Not all videos need all the color
  - Red, Green, Blue (RGB)

bpp	total Colors (C)	Bytes per pixel
48	2^48 = 281474976710656 = 256 TC	6
24	2^24 = 16777216 = 16 MC	3
16	2^16 = 65536 = 64 KC	2
8	2^8 = 256 C	1

  - Lum(in)a(nce), Chroma(inance) (YUV, Y'CbCr)
    - Human eyes: rodes (~120 million) & cones (~6 million)
      - » More bits for B&W than Color

Images per second

- Chosen for the motions content
  - Slow motions need less fps
  - 25 ips: video standard (Europe), 30 ips for NA
  - 24 ips: cinema standard
  - 48 ips: High Frame Rate (market, debate, attract)
  - 10 ips: theoretical threshold to loose single frames
  - 12 ips: (previously) common value (for AVI files)
  - Cons: natural motion appears jerky
    - Humans are very good detecting non natural motion
      - » Walking (in films as *Terminator 2*, *Avatar*, *Titanic*)

Compression

- Reducing the RAW coding
  - Intraframe, Compress the image
    - » RLE and others
    - » DCT coding, JPEG, MJPEG, I frames in MPEG
  - Interframe, Compress the differences
    - » PB frames in MPEG
  - CODECs: DV (Digital Video); Cinepak, not the best but universal; Indeo Video, Intel; DIVx, MPEG4 for AVI; TSCC (TechSmith Screen Capture Codec); …
  - Best results: IPB sequences (or equivalent), Double pass coding, VBR (Variable Bit Rate)

Audio

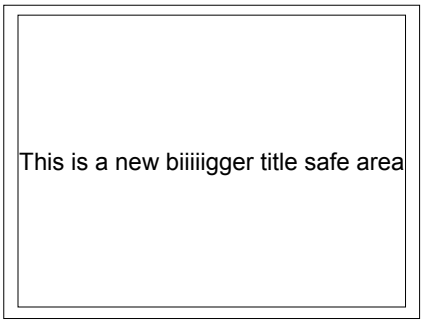
- Sampling freq., bps, mono/stereo, coding
  - 192, 96, 48, 44.1, 32, 22.05, 16 or 8 kHz?
  - 32, 16 or 8 bits per sample (bps)?
  - Stereo or mono?
  - PCM is not compressed, CDA has 74 min, stereo
  - Do some math: audio can use a large bandwidth
  - Good compromise for multimedia: ADPCM
    - Do some real tests
  - Don't forget to process audio for video

Related topics

- Safe area
- Aspect Ratio revisited
- MPEG1 for square dots
- Coding comparisons, all 25 ips

Safe area

- Video in multimedia can use the full image
  - The 10% Image safe area is viewable, *not lost*
  - More Text safe area, can be 10%, instead of 20%
  - Cons: (seen) peripheral recorded phantom details



Aspect Ratio revisited

- Portuguese: Relação de Aspecto (RA)
- Ratio between X and Y, dimensionless
  - Tells you the image geometry regardless of resolution
- Different image examples

pixels	ratio	RA
768*576	768/576 = 1.3(3)	4:3
384*288	384/288 = 1.3(3)	4:3
1280*768	1280/768 = 1.6(6)	5:3 (or 15:9)
1920*1080	1920/1080 = 1.7(7)	16:9
200*400	200/400 = 0.5	1:2

  RA = 1, square; RA > 1 or < 1, *down* or *up* rectangle

- This is true for square pixels, RAp = 1

Aspect Ratio, non square pixels

- We have to consider the RA of the pixel
  - RAp=1, square 
  - RAp>1, *down* rectangle pixel 
  - The total RAt of the final image is

    RAt = RAi * RAp (RAtotal = RAimage * RApixel)
  - Examples, for RAt = 4:3 = 1.3(3)
    - DV SD and MPEG2 DVD compliant, 720*576 pixels

      4/3 = (720/576) * 1.06(6)
    - MPEG1, VCD and CD-I compliant, 352*288 pixels

      4/3 = (352/288) * 1.09(09)

MPEG1 for square dots

- MPEG1 (VCD compliant) is 352*288 pixels
  - Pixels have RAp = 4/3 / 1.2(2) = 1.09(09)
    - Software should adapt rendering for RAp != 1
      - Not adapting: image space distortion
  - How to impose there is no distortion
    - Force adjust view area for RAt = 4/3 (anti distort)
      - By specification (HTML) or manual adjustment (PPT)
    - Use square dots, (re)code MPEG1 for RAp = 1
      - RAt = RAi*RAp ; 4/3 = (X/288) * 1 ; X = 384 pixels
      - Final resolution: 384*288 pixels

Coding comparisons, all 25 ips

- One hour of video in 720*576 pixels resolution
  - RAW RGB, 24 bpp, no sound (1) ~100 GB
  - DV, Luma-Chroma, 5:1 compress (1) ~13 GB
    (with sound: PCM, stereo, 48 KHz, 16 bps)
  - MPEG2, double pass, VBR coding (2) ~4 GB
    (with compressed sound: stereo, 48 KHz, 16 bps)
- Compare to MPEG1 VCD compliant
  - 352*288, 70 min on CD ~630 MB, 1 hour: ~540 MB
    (with compressed sound: stereo, 44.1 KHz, 16 bps)

(1) Independent of the content (2) dependent on the content (slower video -> more duration)