

# Video Compression

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## What is Compression?

- Compression is a process of converting data into a form requiring less **space** to store or less **time** to transmit, which permits the original data to be reconstructed with acceptable precision at a later time.

## Orange Juice Analogy!

- Freshly squeezed orange juice (uncompressed)
- Remove water (redundancy), convert it to concentrate (encoding)
- Shipped, stored, and sold.
- Add water to concentrate (decoding), tastes like freshly squeezed!!!

## Why is compression necessary?

- Storage space limitations
- Transmission bandwidth limitations.

## Resolution

- QCIF: 180 x 144
- MPEG: 352 x 288
- VGA: 640 x 480
- NTSC 720x486
- Workstation 1280x1024
- HDTV: 1920 x 1080
- 35mm slide: 3072 x 2048

## Floppy Disk

- Floppy disk capacity = 1.44 MB
- A single 1280x1024x24 image= 3.9 MB
- A single 640x480x24=922kB
- Floppy disk holds only one VGA image!

## CD-ROM

- Capacity=600 MB
- A 1280x1024x24 @30 fps=118MB/s
- CD-ROM would hold only about 5 sec of video!
- A 160x120x16 image @30fps=1.15MB/sec
- CD-ROM now holds 8.7 minutes of video

## Bandwidth

- $160 \times 120 = 1.15 \text{ MB/sec}$
- Quad-speed CD-ROM drive delivers 600 KB/sec (half of the required speed)
- “T1” line delivers 1.54 Mb/sec (192KB/sec)
- Ethernet delivers 10Mb/sec (1.25 MB/sec) (barely fast enough, will use up entire bandwidth, 2-way video not possible)

## Digital TV

- Networks started broadcasting limited DTV programs in Nov 98.
- All commercial stations are supposed to switch to DTV by 2002
- All stations are supposed to switch to DTV by 2003
- Govt wants broadcasters’ NTS channel returned by 2006 for auctioning!

## Digital TV

- CBS carried few NFL games last year
- CBS and ABC plans
  - evening news
  - movies
  - rest of the day upconvert standard TV
- NBC
  - no broadcast yet
  - plans for “Tonight Show” this fall!

## Digital TV

- CBS and NBC use 1080i (1920X1080), which is 995Mb/s at 30 fps
- ABC and Fox use 720p (1280X720), which is 424Mb/s at 30 fps
- 6 MHz channel assigned to each network can carry 19.4Mb/s
- Need 50:1 compression ratio!

## Why is compression acceptable?

- Limitations of visual perception
  - Number of shades (colors, gray levels) we can perceive
  - Degrees of arc we can resolve
  - Reduced sensitivity to noise in high-frequencies (e.g. edges of objects)
  - Reduced sensitivity to noise in brighter areas
- Ability of visual perception
  - Ability of the eye to integrate spatially
  - Ability of the mind to interpolate temporally

## Why is compression acceptable?

- Some type of visual information is less important than others
- Goal is to throw away bits in psychovisually lossless manner
- We have been conditioned to accept imperfect reproduction
- Limitations of intended output devices

## Why is compression possible?

- Some sample values (gray levels, colors) are more likely to occur at a particular pixel than others.
  - Remove spatial and temporal redundancy that exist in natural video
    - Correlation itself can be removed in a lossless fashion
    - Important to medical applications
    - Only realizes about 2:1 compression

## Why is compression possible?

- No single algorithm can compress all possible data
- Random data cannot be compressed



## Lossless Compression

- Needed when loss is unacceptable or highly undesirable
- Fixed compression ratio is hard to achieve
- Compression/decompression time varies with image

## Lossy Compression

- Used when loss is acceptable or inevitable
- Permits fixed compression ratios
- Better suited for fixed time decompression

## Compression Techniques

- Subsampling
- Quantization
- Error Diffusion
- Delta Coding
- Prediction
- Color space conversion
- Huffman coding
- Run-length encoding
- De-correlation
- Motion Compensation
- Model-based compression

## Other Techniques

- Fractals
- Wavelets
- Vector Quantization
- K-L Transform
- ...

## Compression using original source

- For best compression, get the original source material and try to *understand* its properties.
  - Email messages are far smaller than fax, voice mail or video mail.
  - A musical score is far more compact than a digitized recording

## Compression of Synthesized Image or Video

- For synthesized image or video clip it is far more efficient to transmit original source material and re-synthesized the image or clip at the receiver than to transmit the compressed image or video clip.

## How to Select Compression Scheme?

- High quality reproduction?
- Very high compression ratio?
- Fixed compression ratio?
- Real-time compression?
- Real-time decompression?
- Limited de-compression computer power?