

UNIVERSITÉ DE GENÈVE

Communication Multimédia

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UNIVERSITÉ DE GENÈVE

Communication Media


DVD family

Communication Media – The DVD Family



- <http://www.unik.no/~robert/hifi/dvd/>
- **Digital Versatile (Universal) Disc of Digital Video Disc**
- Technology developed in 1994 started new generation of Compact Discs
- Intended for replacement of VHS, CD-DA, CD-ROM, ...
- For masses
 - DVD-Video, DVD-ROM 1996 (?)
 - DVD-R 1997 ("dash R" NOT "minus R")
 - DVD-RAM 1998
 - DVD-RW 1999 Japan / 2001 US and rest
 - ? Home-DVD sets 2000
 - DVD+RW 2001
 - DVD+R 2002
 - ? There is a work towards compatibility between DVD-R(W) and DVD+R(W)

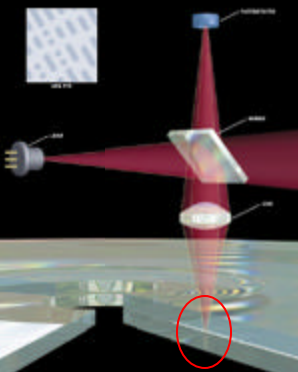
Communication Media – The DVD Family



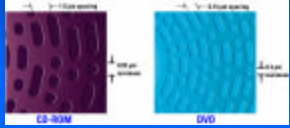
- **Digital Versatile (Universal) Disc of Digital Video Disc**
- High density format designed for storage of digital video, serving as a memory of high capacity or as support for a next generation video games
- 4 types
 - 4.7 GB Simple face/Simple density (135mn video - 8.5h audio)
 - 8.5 GB Simple face/Double density
 - 9.4 GB Double face/Simple density
 - 17 GB Double face/Double Density – 8h video

Communication Media – The DVD Family

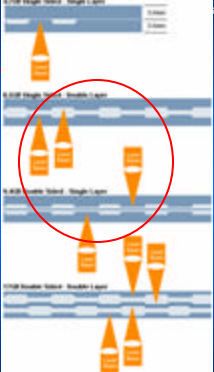
- two layers of data paths
- As the disk rotates, holes/no holes cause variations in the amount of light the disk reflects
- Photodetector translates this into the 0's and 1's
- Adjusting the position of the lens permits the player to read information from either the upper or lower information layer of a DVD.
- The light passing through the hologram in the center of the lens focuses to a second spot, suitable for reading existing CDs (one layer of data paths)



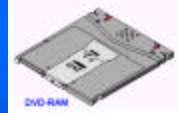
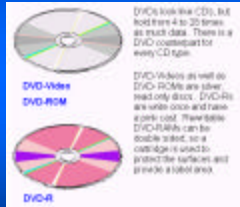
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- Layers – refocused laser beam reads different layers
- DVD ~11km of data
- CD ~ 5km of data
- Write ~700°C / Erase ~200 °C



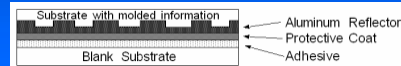
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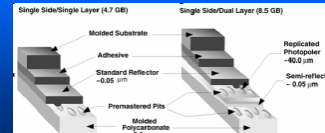
Numbered sectors to interact with data quicker

Communication Media – The DVD Family

Physical characteristics of DVD



Each of the variations consists of two 0.6mm substrates which are bonded together



Communication Media – DVD & CD ROM

8b user \leq 17 written

8b user \leq 16 written

Increase in capacity

Factors	CD	DVD
Channel bit code	8/14(+3 bits) EFM	8/16 EFM
Larger surface area utilization	86.0 cm ²	87.6 cm ²
Decrease in RS(error correction) code	25% channel	13% channel
Track pit	1.6 μ m	0.74 μ m
Minimum pit length	0.972 μ m	0.4 μ m
Reduction in packet overhead	2048/2352 bytes	2048/2060 bytes
Gain		
Area increase in channel bits	5.254	(1.6*0.972)/(0.74*0.40)
Packet overhead reduction	1.1142	(2352/2060)
Tighter FEC (Error correction)	1.16	(0.87/0.75)
Increase in usable area of disc	1.019	(87.6/86)
Tighter channel code	1.0625	(17/16)
Overall Gain	7.35	4.7 / 0.65 GBytes

DVD / CD

Communication Media – The DVD family

- Errors in data by: dust, scratches, corrosion
- DVD has strong error correction and control techniques (ECC)
- Additional bits stored along with users-data taking ~ 13% of the overall disc capacity (& 30% in CD)
- Possibility to correct error burst up to 2000 Bytes (~4m length scratch)

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DVD-ROM

- Direction of the reader
 - Data written in spiral shape from internal \leq external border of a disc
- Double density reader
 - Parallel paths – the same direction for direction 2 layers

DVD-Video

- Direction of the reader
 - Data written in spiral shape: internal \leq external border of a disc
- Double density reader
 - Opposite direction of layers – at the end of the first layer, the second is read inversely – from external to internal border

Communication Media – The DVD Family

DVD - Some characteristics

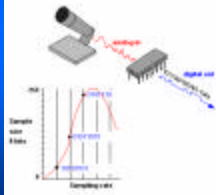
video

- MPEG-2 or NTSC-PAL
- 16:9 (HDTV) - 4:3 (standard TV) proportions of screen
- 2 – 8 h capacity \leq depending on movie's motion-level
- sub-titles
- multiple angles of the same scene
- multiple audio tracks (languages)
- etc...

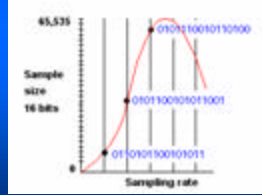
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- Sound in DVD-video - Some characteristics
- Recall sound sampling



8 bits / sample



16 bits / sample

Communication Media – The DVD Family

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- DVD Sound in DVD-video – until 8 streams audio, each stream can be:
 - PCM (Pulse Code Modulation, 1 to 8 canals)
 - SDDS (Sony Dynamic Digital Sound) (can 5.1 or 7.1)
 - Dolby Digital (1 to 5.1 canals)
 - MPEG-2 audio (1 to 7.1 canals)
 - DTS (Digital Theatre Sound) (1 to 5.1 canals)

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- DVD Sound - until 8 streams audio, each stream can be
 - PCM (Pulse Code Modulation, 1 to 8 canals)
 - non-compressed samples (inefficient!)
 - sampling rate (48 or 98Khz)
 - and
 - sample size (16, 20, 24 bits)
 - larger than in case of CD (44kHz, 16bits)

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- DVD Sound - until 8 streams audio, each stream can be
 - SDDS (Sony Dynamic Digital Sound) (can 5.1 or 7.1)
 - Compression with loss based on PCM at 48khz
 - compression technique of as mini-disc (ATRAC) – coding only tones recognizable by human's ear
 - Problem with support by the current DVD readers

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- DVD Sound - until 8 streams audio, each stream can be
 - Dolby Digital (1 to 5.1 canals)
 - 6 canals PCM (48khz, 24bits/sample) in entry (left, right, centre, surround left and right, base sound)
 - lossy compression - AC-3 (Active-Coding 3, perceptual coding)
 - 5.2 - known as Dolby Digital Surround EX
 - Adds one canal representing the centre-back of the listener.
 - Compatible with reader 5.1 but needs decoder for this additional canal

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- DVD Sound - until 8 streams audio, each stream can be
 - MPEG-2 audio (1 to 7.1 canals)
 - Compression with loss - PCM at 48khz / 16 bits
 - additional centre-left and right canal
 - DTS (Digital Theatre Sound) (1 to 5.1 canals)
 - firstly demonstrated in movie "Jurassic Park"
 - Compression with loss- PCM at 48khz / 20 bits
 - Less compression than Dolby Digital, but for certain purposes better quality
 - DTS 5.2 (DTS *Digital Surround ES*) = Dolby Digital 5.2

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⚡ DVD – Protection & « we - have - seen – that » on CD

	CDs	DVDs
Discs first go on sale	1982	1996
Hard drive capable of holding entire disk is standard on new PCs	1995	1997
MPEG compression software leaked onto the Internet makes it feasible to download entire albums and movies	1997	1999
Pirated programs traded widely via Napster/Grutella, newsgroups or FTP sites	1998	2000

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⚡ DVD - Protection

⚡ zone

- ⚡ **Code** is assigned to each region and DVDs and readers bought in one region have one code. It is not possible to read a disc from one region with the reader from other region
 - ? for interoperability reasons they should be one "code"

⚡ Macrovision (Analogue Protection System)

- ⚡ Works on the analogue signal
- ⚡ Modification of the signal in zone signalling the start of new image/scene – responsibility of video recorder

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⚡ DVD – Protection (protect ⚡ crack ⚡ fix ⚡ protect ⚡ ...)

⚡ Content Scrambling System (CSS) broken in 1999 by teenager (Norway)

- ⚡ Content is encrypted with a key, decryption key can be found on disc, this key is itself decrypted!
- ⚡ All readers have the access key
- ⚡ Reading with a dedicated (standalone) reader
 - ⚡ Reader accesses the key decrypted in disc with use of his access key
 - ⚡ The content can be decrypted after having a key
- ⚡ Reading with a reader connected to PC
 - ⚡ Additional step is required for avoiding of an unprotected transfer of decrypted key over the bus PC
 - ⚡ There is a secure canal for exchange of this key

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⚡ DVD – Protection (protect ⚡ crack ⚡ fix ⚡ protect ⚡ ...)

⚡ July 2004 – AACS – advanced access content system

⚡ Goal: protect unauthorized copying + allow multiple DVD devices

⚡ Conflict :

- ⚡ entertainment makers ⚡ want 2 copies of movie so buy two !
- ⚡ electronics firms ⚡ you have unrestricted copyrights for YOU then you buy more equipment to play it at different devices in home network

⚡ data encrypted on disc

- ⚡ 2 keys: one on disc + one in a player (128 bits)
- ⚡ Key on disc is decrypted by the one which player has
- ⚡ But maybe each player has unique key ?

- ⚡ Idea of the new method is to keep protecting data even after it has been cracked ⚡ when cracked – make key obsolete + you cannot play DVD anymore

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⚡ DVD-Audio

- ⚡ Goal: dedicated DVD for audio ⚡ to have a possibility for better quality of the sound, than the one in DVD-video

⚡ Multiple sampling levels and number of bits per sample possible

- ⚡ High fidelity: 2 canals, 192 khz, 24 bits (DVD -video: 48khz, 24 bits and CD: 44khz, 16 bits)
- ⚡ max 6 canals audio-surround 48 khz, 24 bits (like DVD -video)
- ⚡ Also possible to have fixed images, some video and visual menu

Communication Media – The DVD Family - comparison

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	DVD-ROM	DVD-R	DVD-RAM	DVD-RW	DVD+RW
Capacity	4.7 / 9.4	3.95 / 7.9	2.6 / 5.2 / 9.4	4.7	3.0
Shape	disk	disk	cartridge	disk	disk
Mark Formation	pit	Thermal deformation	Phase change	Phase Change	Phase change
Materials		Organic dye	GeSbTe	AgInSbTe	AgInSbTe
Laser wavelength	650/635	650/635	650	638/650	650
NA	0.6	0.6	0.6	0.6	0.65
Mark length	0.27	0.293	0.41-0.43	0.267	
Track pitch	0.74	0.8	0.74 L/G	0.74 G	0.74 G
Cyclability	–	–	10 ³	10 ² -10 ⁴	10 ² -10 ⁴



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- **DVD readable / rewritable (DVD-R < DVD-RW)**
- **DVD-R**
 - compatible with reader DVD -Video, DVD -Rom
 - non-rewritable
 - 4.7 GB (2 h of 5 Mbits/s - the same quality as DVD-Video)
 - Survival time - 100 years
- **DVD-RW**
 - Not 100% compatible with all readers <
 - 1000x rewritable
 - 4.7 GB
 - Variable data stream supported
 - reorganisation of paths supported

Communication Media – The DVD Family



- **DVD-Ram**
 - Promise compatibility with current readers
 - 100 000 x rewritable
 - 7 GB
 - Variable data stream supported
- DVD-RW and -RAM < new generation of readers <
- **DVD+RW**
 - Promise compatibility with current readers
 - rewritable
 - 4.7 GB
 - Not a wish of DVD-Forum

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- **DVD next steps**
- **Blue-Ray DVD** - standard announced by 9 companies members of DVD forum
- Disc of highest capacity - 27 GB
 - Laser blue-violet capable of reading smaller "holes" than red laser nowadays
 - Rewritable
 - reading impossible in readers used now
 - When widely used ?

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Blue-Ray DVD & others

	CD	DVD	Blu-ray
NA	0.45	0.6	0.85
λ (nm)	780	650	405
Capacity (GBytes)	0.65	4.7	27
Bit rate (Mbit/s)	1.2	11.2	35
	Killer app	Music	Video
			HDTV

Laser beam parameters

28" High Definition TV monitor





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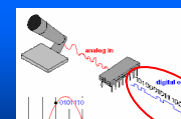
Video Compression Techniques

Basics on compression

What is compression ?

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- In digital systems
- The process of data manipulation to reduce the amount of data needed to represent something
- Still image
- Audio
- Text
- Video



Example Audio

squeeze it
to less
number of
bits!

Where needed ?

- More data in less space
- Multiple channels on 1 channel
- Audio editing
- Video editing
- Audio, video, text exchange over Internet
- Etc.

To compress we use algorithms

- Algorithm
 - mathematical process that performs the compression and the decompression required to restore the compressed signal to its original form
- 2 modes of compression
 - Fixed mode – always the same math used, independent on the content
 - Adaptive mode – math used depends on the content to be compressed – e.g. compress differently parts of frames with and without movement. Parts with movement have higher resolution !

To compress we use algorithms

- Note – compression of video
- Converting video into digital produces large amount of data
- Flow of data is measured by bit rate
 - Example HDTV:
 $2048 \times 2048 \text{ pixels} \times 24 \text{ bits} \times 60 \text{ frames/sec}$
 $= 6\,039\,797\,760 \text{ bits/sec} \sim 6 \text{ Gbits / sec !}$
- Uncompressed video bit rate is too much and must be reduced!

Compression types

- 2 compression techniques: lossless and lossy
 - Lossless
 - ? Works like e.g. WinZip
 - ? Low compression factor
 - ? Non-destructive for data
 - ? Looks for redundant info from frame to frame
 - Why store the same background each time ?
 - ? Less info to send/store
 - ? Best works for
 - Static images with not much detail...

Lossless Compression

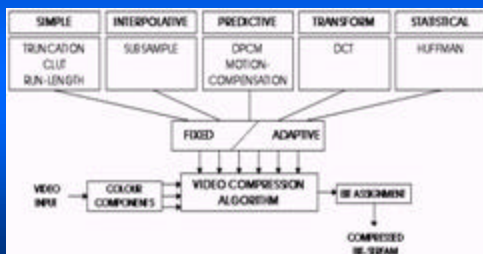
- Run-over-length-data encoding
 - Pre-arranged code
 - String of ones
 - String of zeros
- Statistical - Huffman or entropy coding
 - Compute probability that certain data will occur
 - Assign short codes to probable sequences

Lossy Compression

- May be applied for images/video with
 - Little redundancy
 - Much movement
 - Fine details
- It is destructive (can't regain info!)
- How does it work ?
 - eliminates the details that eye is not able to recognize
 - Re-quantizes details more and more – recursive process
 - Until the bit rate matches the required (e.g. 1Mbps)

Video compression techniques

CLUT = color lookup table



Compression by Truncation

Bit rate reduction

- Drop one (/more) of the least significant bits in stream
- If fixed mode (always the same math) you will not determine what represented by dropped bits
- If adaptive mode – you drop these bits that won't affect the detail (you analyze the content)
- Bit stream is fed into the buffer where the dropped bits can be recovered
- Problem starts when buffer becomes full (much detail or motion)

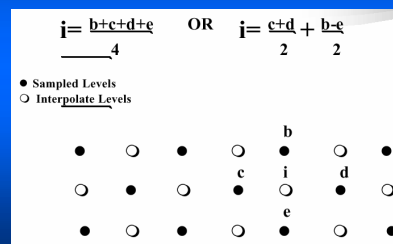
Compression by sub-sampling and interpolation

Used with samples BEFORE digitizing them

- Sampling frequency is reduced by $\frac{1}{2}$ (sub-sampling)
- Samples on adjacent lines (neighbors) are offset by $\frac{1}{2}$ the sampling interval
- Values of dropped samples are interpolated from the adjacent horizontal & vertical samples

Compression by sub-sampling and interpolation

Example: interpolated sample i based on b, c, d, e



Compression by prediction

- You want to code ALL pixels but assume difference in signal levels between adjacent pixels as small (usually)
- So we can have smaller number of bits per word :
 - 4 bits instead of 8 bits
- Which is called *Differential Pulse Code Modulation* (DPCM) – techniques NOT used by itself, but with combination with other techniques
- Occasionally there is a large difference between adjacent pixels at sharp edges – this is called Slope Overload and results in blurry, not sharp edges

Compression by transformation

- Transform the values of a group of pixels into another set
 - This can be transmitted using less data
 - After transmission inverse transformation
 - Recover original values
- Example:
 - values A,B,C,D are transformed to W, X, Y, Z via formulas:
 - ? $W=A, X=B-A, Y=C-A, Z=D-A$
 - inverse transformation
 - ? $A=W, B=W+X, C=W+Y, D=W+Z$

Compression basis – what is wavelet?

- Wavelets
 - Mathematical filters
 - Split image into series of frequency bands
 - Most visually important for eye is low frequency
 - More bits for low frequency
 - Less bits for higher frequency
- Wavelets can decide
 - How many frequency bands
 - How detailed and
 - How much error protection is in image representation

Compression basis – what is fractal?

- Recreate image by selecting pattern from set
- Resize, rotate and fit to make a new image
- Pick patterns
- Send only info on how to put them together
- Can have very high compression factor
- Not for use in video (!)

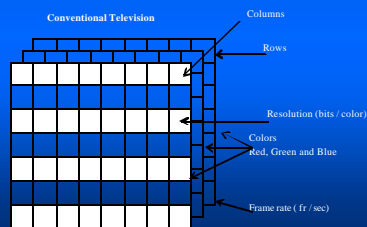


Compression basis – what is Discrete Cosine Transform?

- DCT - Used mostly in video
- Uses intra- and inter-frame compression
- Basis for: JPEG, MPEG, DV, H.xx videoconferencing
- Assume: Eye more sensitive to some frequencies
- Divides picture into blocks
 - Generally 8x8 pixels - each color (RGB) into separate block
 - transforms to different values - into a pattern of spatial frequency (f) values
 - f-values, by reverse transform reproduces original pixel brightness samples
- Will have large number of near-zero values, which we round to zero

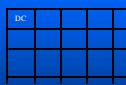
Discrete Cosine Transform – step 1

- Complex algorithm to convert 8x8-pixels \rightarrow f-values
- vast computing power is required



Discrete Cosine Transform – step 2

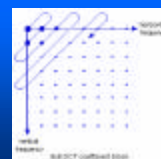
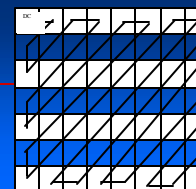
- DC value represents overall background brightness of the block
- slight computing errors of DC value may result into image distortion
- Theoretically the transformation is lossless, no distortion of images
 - but in real electronic systems, computation is imperfect, approximate values will be produced



Mathematical Cosine Transform into 64 general Harmonic Frequencies

Discrete Cosine Transform – step 3

- Zigzag scanning of 64 frequency values
- lowest frequency first, toward highest
- i.e., group low frequency coefficients in top of vector

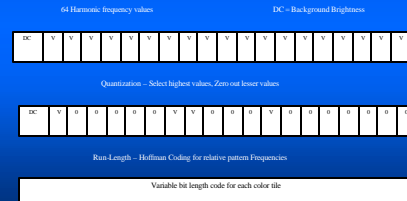


Discrete Cosine Transform – step 4

- ✦ So far, no compression is accomplished
- ✦ Next is the quantization threshold is applied on the desired compression ratio
 - ✦ removal of all values under threshold value
 - ? ie., bits are truncated to low bits like
 - ✦ 10110 = 45 (6 bits) to
 - ✦ 1011 = 11 (4 bits) to
 - ✦ 101 = 5 (3 bits)
 - ? Lowering the image quality

Discrete Cosine Transform – step 5 and final

- ✦ Finally, the 64 processed frequency values are encoded for transmission



After Discrete Cosine Transform – statistical techniques

- ✦ Take image: do Discrete Cosine Transform ✦ Read image in zig-zag ✦ quantize ✦ code images in video stream using Huffman (statistics)
- ✦ Huffman coding
 - ✦ Some image values occur less frequently
 - ✦ Shorter words used to define frequent values
 - ✦ Requires transmitting a code-table
- ✦ Cascaded compression
 - ✦ Combine multiple techniques
 - ✦ In successive steps work over the video stream

JPEG and MPEG standards

- ✦ JPEG – Joint Photographic Expert Group
 - ✦ Still image compression
- ✦ MPEG – Motion Picture Expert Group
 - ✦ Goal: Motion compression + description of MM data
 - ? MPEG-1 1.2 Mbps, video CDs,
 - ? MPEG-2 1.2-15Mbps, DVD, Digital TV, DCT-based compression,
 - ? MPEG-4 to describe MM in objects (not compression)
 - ? MPEG-7 meta – data to describe/manage MM (not compression)
 - ? MPEG-21 how to deliver MM content, components (not compression)
 - ? MPEG-3 + others-not implemented and already obsolete!

JPEG compression

- ✦ Single standard – variety of algorithms
- ✦ Supports both lossless and lossy compression
- ✦ Uses configurable parameters
- ✦ Trade off: compression & quality
- ✦ Basis for MPEG motion compression
- ✦ Also motion JPEG
 - ✦ For lower compression rates

JPEG compression

- ✦ 4 modes of operation
 - ✦ Sequential (lossy)
 - ? Encode in the order you scan images
 - ✦ Progressive (lossy)
 - ? Multiple passes over sequence of images
 - ? Raw fast image encoding + each next pass gives higher resolution
 - ✦ Lossless
 - ? Exact reproduction guaranteed
 - ✦ Hierarchical (lossy)
 - ? Multiple passes + each image encoded in multiple resolutions

JPEG Performance

- bpp – (average) bits /per pixel
- Before compression : 24 bpp (!)
- After JPEG compression:
 - 0,15 - 0,5 bpp : Moderate to good quality
 - 0,5 - 0,75 bpp : Good to very good quality
 - 0,75 - 1,5 bpp : Excellent quality
 - 1,5 - 2,0 bpp : Undistinguishable from the original

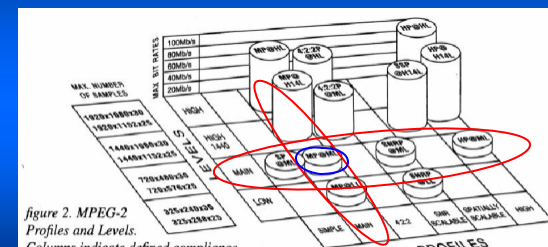
MPEG standard

- <http://www.cselt.stet.it/mpeg/>
- <http://www.am.hhi.de/mpeg-video>
- Basic notions of the MPEG compression
 - Uses both: inter- & intra- compression techniques
 - **Inter-Frame** : Motion Compensated Prediction
 - Reduction of temporal redundancies between frames
 - ? based on the estimation of motion between video frames
 - ? Only difference between original images and motion compensated prediction images is coded
 - ? Motion vector for blocks of pixels
 - **Intra-Frame** : Transform Domain Coding
 - ? Discrete Cosine Transform as in JPEG

MPEG standard

- Not sharply defined, not fully implemented
- Defines bit stream & how streams are recognized by decoders & changed back into AV and other info
 - Goal: Motion compression + description of MM data
 - ? MPEG-1 1.2 Mbps, video CDs
 - ? MPEG-2 1.2-15Mbps, DVD, Digital TV, DCT-based compression
 - ? MPEG-4 to describe MM in objects (not compression)
 - ? MPEG-7 meta - data to describe/manage MM (not compression)
 - ? MPEG-21 how to deliver MM content, components (not compression)
 - ? MPEG-3 + others -not implemented and already obsolete!
- MPEG-2 defines different standards compression tools

MPEG-2: 6 profiles x 4 levels – 24 combinations



MPEG 4:2:2 is called studio MPEG – variation of MPEG-4 for professional use, high quality

MPEG-2 - Levels and Profiles

- **Profile** defines set of new algorithms (additional to lower profiles)
- **Level** defines range of parameters supported (image size / frames and bits/sec)
- MPEG-2 implementations converge towards **MAIN Profile @ MAIN Level** to support broadcast TV: 720 pixels / 576 lines / 30 frames/sec
- Table: Upper bounds of parameters at each level of a profile

	Level	Parameters
HDTV	HIGH	1920 samples/line - 1152 lines/frame - 60 frames - 80Mbps
HDTV	HIGH 1440	1440 samples/line - 1152 lines/frame - 60 frames - 60Mbps
TV	MAIN	720 samples/line - 576 lines/frame - 30 frames - 15 Mbps
CIF, VHS	LOW	352 samples/line - 288 lines/frame - 30 frames - 4 Mbps

CIF = Common Intermediate Format VHS = Video Home System HDTV = High definition TV

MPEG-2 - Levels and Profiles (for curious)

- Algorithms and functionalities supported with each profile

Profile	Algorithms
HIGH	Supports all functionality provided by the Spatial Scalable Profile plus the provision to support 3 layers with the SNR and Spatial scalable coding modes 4:2:2 YUV4-representation for improved quality requirements
SPATIAL Scalable	Supports all functionality provided by the SNR Scalable Profile plus an algorithm for Spatial scalable coding (2 layers allowed) 4:0:0 YUV4-representation
SNR Scalable	Supports all functionality provided by the MAIN Profile plus an algorithm for SNR scalable coding (2 layers allowed) 4:2:0 YUV4-representation
MAIN	Non-scalable coding algorithm supporting functionality for coding interlaced video / random access / B-picture prediction modes 4:2:0 YUV4-representation
SIMPLE	Includes all functionality provided by the MAIN Profile but does not support B-picture prediction modes 4:2:0 YUV4-representation

MPEG Audio Layers

<http://www.cseit.stet.it/mpeg/faq/faq-audio.htm>

- Each layer adds more efficient coding
- Higher layer decoders can decode lower layer streams
 - Layer I : Lowest complexity - suitable for applications where the encoder complexity plays an important role (ex. slow machines)
 - Layer II : more complex encoder - slightly more complex decoder - directed towards 'one to many' applications, i.e. one encoder serves many decoders able to remove more of the signal redundancy and to apply the psychoacoustic threshold more efficiently, but costly!

MPEG Audio Layers

<http://www.cseit.stet.it/mpeg/faq/faq-audio.htm>

- Each layer adds more efficient coding.
- Higher layer decoders can decode lower layer streams
 - Layer III : MP3 - more complex - directed towards lower bit rate applications (additional redundancy and irrelevancy extraction from enhanced frequency resolution in its filter bank)
 - MP3 - lives it's own life
 - Forward compatibility layers III < I

So: MPEG & other video compression techniques

- Lossy compression
 - Common: MPEG-2, Wavelets and Fractal
 - Preferable compression method for huge MM data files
 - Example: teleconferencing, HDTV, satellite communication, movie storages etc
 - Some details are eliminated permanently
 - Low quality image
- Lossless Compression
 - all info completely restored when uncompressed
- Motion compression is part of MPEG standards

MPEG-2 – motion compression

- Parts of frame that has changed from previous frame are called – residuals
- Find them in every frame !
- Next frame adds residuals to prediction-based on previous frame
- This is called adaptive prediction

Architecture of MPEG-2 & motion compression

- The bit-stream is based on a sequence of images
- There are four kinds of images (frames)
- I pictures : Intracoded pictures (independent of any other)
An I picture must exist in the start of the video stream and at any random access entry point
- P pictures : Predicted pictures using motion compensation from a previous I or P picture
- B pictures : Bidirectional prediction pictures coded by interpolating between a previous + future I or P
- D pictures : Special form used for implementing fast search modes (so: not for use of motion compression)

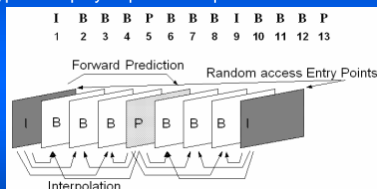
Architecture of MPEG-2 & motion compression

- I pictures require most of the data
like JPEG image (8x8 structure, DCT coded + statistically encoded)
- P pictures require 1/3 data of the I picture data
- B pictures take 1/2 to 1/5 data of a P picture
- Best compression is achieved by using as many B pictures as possible
problem: the future P or I picture must be transmitted in advance < more buffering needed (for P's and I's) and longer delays

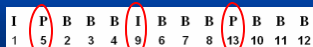
Architecture of MPEG-2 & motion compression

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- A Typical displayed picture sequence would be of the form



- Transmission/encoding sequence



MPEG-2 – motion compression

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- Errors will be perpetuated to the next frame ✗
- To correct it there are I frames often
- Example: 3 corrections/sec ✗ every 10 frames
- Limited editing use of this technique



MPEG – summary on motion compression

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- MPEG-1
 - Up to 1.5 Mbps
 - ? Designed for Single speed of CD-ROM
 - ? T-1 data line
 - ? Similar to VHS quality
- MPEG-2
 - Multiple "tool-kits" – profiles and levels
 - Uses Group-Of-Pictures : I, P, B frames
 - ? GOP is always started by a new I frame
 - Up to 15 Mbps
 - ? Higher quality, including HDTV

MPEG-4 – NOT compression BUT coding of AVOs

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- <http://www.cseit.stet.it/mpeg/standards/mpeg-4.htm>
- AVO – Audio Video object
- Coding of audio objects ✗ to enable interactivity
- Scenes = sum of media objects, organized hierarchically – easy and fast access to these objects

MPEG-4 - Coding of AVOs

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- Coding of audio objects - enabling interactivity*
- Natural sounds : 2 to 64 kbps
- Synthesized sound
 - Text to speech standardization
 - Speech synthesis, Facial animation, international language support, support for specifying age, gender dialect of speaker etc.
 - Score Driven Synthesis
 - SAOL - *Structured Audio Orchestra Language* (defines instruments)
- Effects of mixers, chorus, etc.

MPEG-4 - Coding of AVOs

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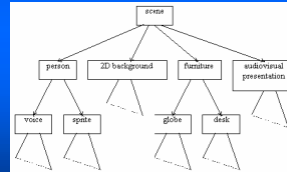
- Coding of Visual Objects - enabling interactivity
- Natural Textures, Images and Video
 - efficient compression of images and video
 - efficient compression of textures on 2D and 3D meshes
 - efficient compression of time-varying geometry streams that animate mesh
 - efficient random access to all types of visual objects
 - extended manipulation functionality for images and video sequences
 - content-based coding of images and video

MPEG-4 - Coding of AVOs

- Synthetic Objects
 - synthetic description of human face and body
 - animation streams of the face and body
- Natural video
 - Very Low Bit-rate Video (VLBV) 5...64 kbps
 - Higher bit-rates up to 4Mbps
 - Arbitrary video shapes
 - Scalable coding of video objects

MPEG-4 - Coding of AVOs

- Robustness in Error Prone Environments (e.g. wireless transmission)
 - Resynchronization - Data Recovery from Error (copy blocks from previous scene)
- Scene description – based on Virtual Reality Modelling Language (VRML)
 - allow interaction / scenes change; composition of set of objects into a scene



- Content-related protection against illegal copying: *Intellectual Property Identification (IP)* data set inside the multimedia stream

Besides JPEG and MPEG – Other coding and audio/video compression standards

- H.320 : The framework standard for narrowband video-phone, videoconference etc.
goal: interoperability
 - H.221 : Framing protocol (frame 80 Bytes: audio/video/other)
 - H.230 , H.231 H.242 : control, multiplexing, set-up
 - H.233 : encryption
 - H.261 : video compression (idea- similar to JPEG)
 - G.711, G.722 and G.728 : audio compression

	Bandwidth	Bit-rate
G.711	3.4 KHz	64 kbps
G.721	3.4 KHz	32 kbps
G.722	7 KHz	48,56,64 kbps
G/728	3.4 KHz	16 kbps

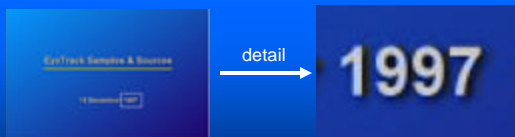


Besides JPEG and MPEG – Other coding and audio/video compression standards

- H.324 : Extension of H.320 for less than 64kbps
- Developed for telephone lines (use of modems)
 - H.263 : video compression – based on H.261
 - H.223 : multiplexing
 - H.245 : control
 - G.723 : audio compression
Bandwidth 3.4 KHz, data rate 24 kbps
 - intention was to develop standard for future phones – 176 x 132 pixels @ 4 to 12 frames/sec
(FYI: TV : 30 frames/s and on mobile devices: 5-15 frames/s)

Compression & Artifacts

- Mosquito noise (blurry)
 - Results from high-frequency data loss in the compression/decompression process



Compression & Artifacts

- Quilting (no straight line)
 - Shows up as discontinuities between adjacent DCT blocks in an image, most noticeable in Digital Video standard – straight diagonal lines slightly tilted from the horizontal and vertical



Compression & Artifacts

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- ⚡ Motion blocking
 - ⚡ Detail diminishes in areas of fast motion
 - ⚡ I Couldn't find an example ⚡

In conclusion - what is compression ?

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- ⚡ Compression = more data + less space
- ⚡ Algorithm = math used to process this data:
compress/decompress
 - ⚡ Fixed mode: always same math, content independent
 - ⚡ Adaptive mode: change math depending on content
 - ⚡ 5 compression techniques
 - ? Truncation, sub-sampling and interpolation,
prediction, transformation, statistics
- ⚡ JPEG for still images and MPEG + H.xx for motion
compression