Techniques for Video Compression and Analysis (5LSE0), Module 03 - B

MPEG-1 and MPEG-2 standard

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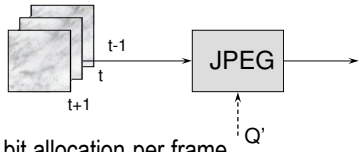
slides version 1.0

5LSE0 - Mod 03 - B
Part 1

Introduction to Motion-Compensated (Interframe Hybrid) DCT Coding

Intraframe Coding

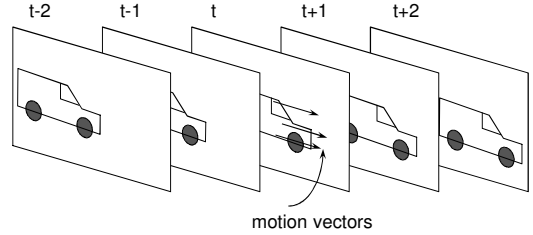
* **Encode frame-by-frame, disregarding all temporal information**
  - Example: Motion-JPEG (AVI compressed)



  - Easy bit allocation per frame
  - Random access is possible
  - Robust to transmission/decompression problems
  - **But** … Moderate compression capabilities

Interframe Coding of temporal differences

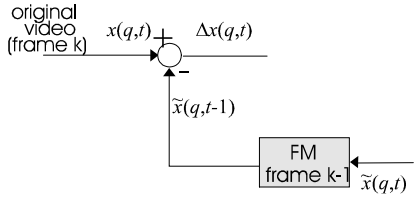
* **Encode differences between frames (temporal DPCM); consider *motion* of parts of the frames**



Complexity is between intra-frame and 3-D coding
  - Can always fall back onto intra-frame coding
  - Moderate delay

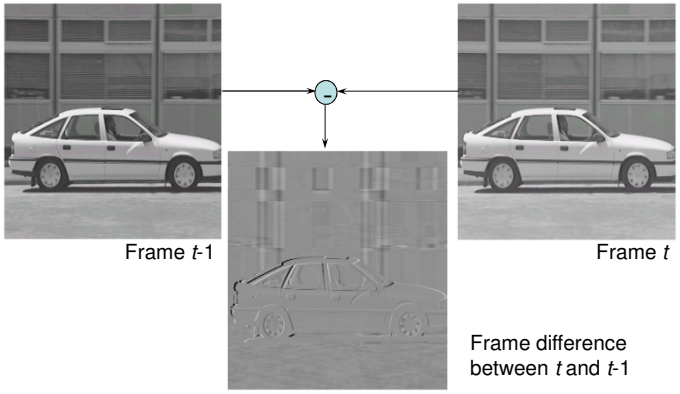
Principles of Hybrid Coding – (1)

* **Basic idea**
  - Predict current frame on basis of (coded) previous one
  - Transmit only quantized prediction differences
  - Usually done on 8x8 blocks



- Prediction difference: $\Delta x(q,t) = x(q,t) - \tilde{x}(q,t-1)$

Example Frame Differences



Temporal Prediction Gain

* **Like normal DPCM, assess the effect of interframe prediction by the prediction gain**

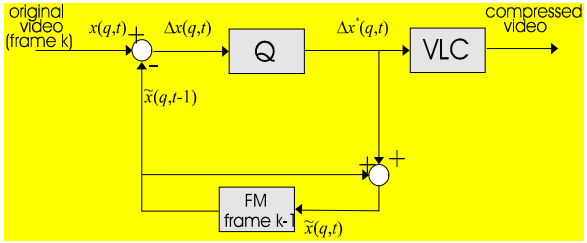
$$G_P = \frac{\text{variance of the original frame}}{\text{variance of the prediction difference}}$$

Frame number	σ_x^2	$\sigma_{\Delta x}^2$	G_P
1	1888.2	282.0	6.7
2	1885.9	225.7	8.4
3	1873.6	265.7	7.1
4	1884.6	329.1	5.7
5	1889.4	342.6	5.5
6	1901.1	368.9	5.2

around 1.2 - 1.5 bit

Principles of Hybrid Coding – (2)

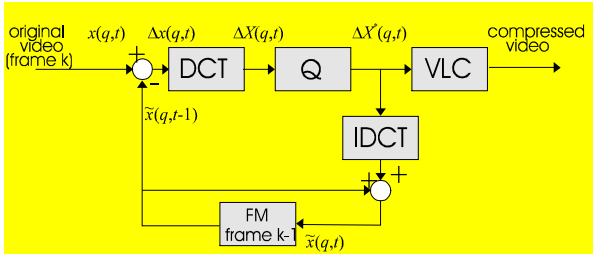
* **Complete temp. DPCM system (1-st ord. predictor, h_1=1)**



* **Quantized prediction difference:** $\Delta x^*(q,t) = Q[\Delta x(q,t)]$
* **Reconstruction:** $\tilde{x}(q,t) = \Delta x^*(q,t) + \tilde{x}(q,t-1)$

Principles of Hybrid Coding – (3)

* **Prediction difference *locally*** still contains a lot of *spatial* correlation and lots of zeroes: **Decorrelate via 8x8 DCT**

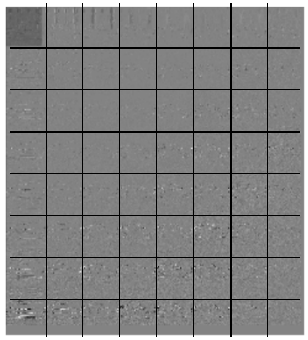


* **Quantization in DCT domain** $\Delta X^*(q,t) = Q[\Delta X(q,t)]$
* **Reconstruction** $\tilde{x}(q,t) = \mathrm{DCT}^{-1}(\Delta X^*(q,t)) + \tilde{x}(q,t-1)$

Example: DCT of differences

Frame difference

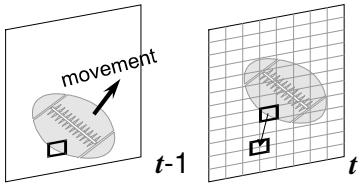
DCT of frame difference in bands



- Higher DCT coefficients contain more variance than lower ones
- Taking frame differences removes spatial low-frequency components

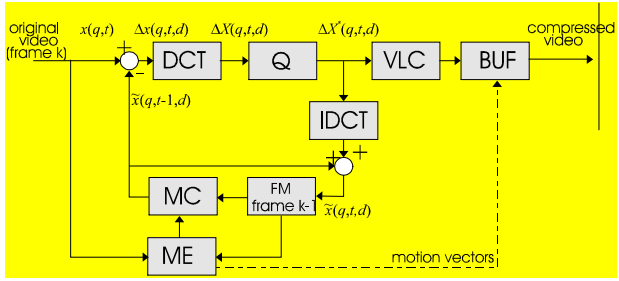
Motion Compensation

* **Part of the spatial correlation is due to unsuccessful temporal prediction**
  - Unpredictable information (occluded regions)
  - Moving spatial information (object movement)
* **Find for each block $x(q,t)$ a corresponding block in encoded frame t-1: *Motion estimation***
  - Difference in positions is called ***motion*** or ***displacement*** vector



Principles of Hybrid Coding – (4)

* **Form difference between $x(q,t)$ and the corresponding block found in encoded frame t-1: *Motion-Comp. Predict.***



  - Motion-compensated prediction difference
  - Overhead: 1 motion v. / block $\Delta x(q,t,d) = x(q,t) - \tilde{x}(q,t-1,d)$

Example – Motion-Compens. Prediction

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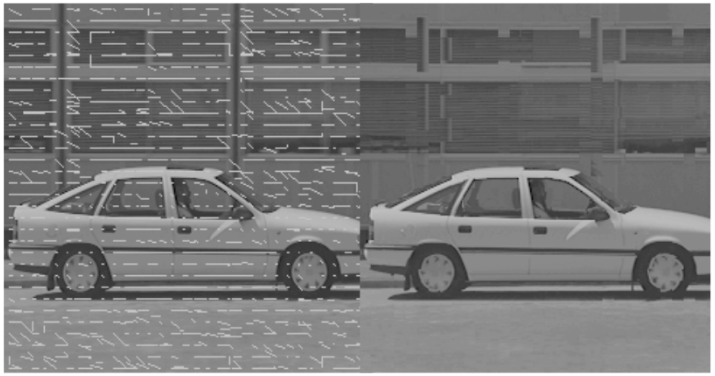

Frame with motion vectors | Motion-compensated prediction

Example Motion-Compens. Predict.

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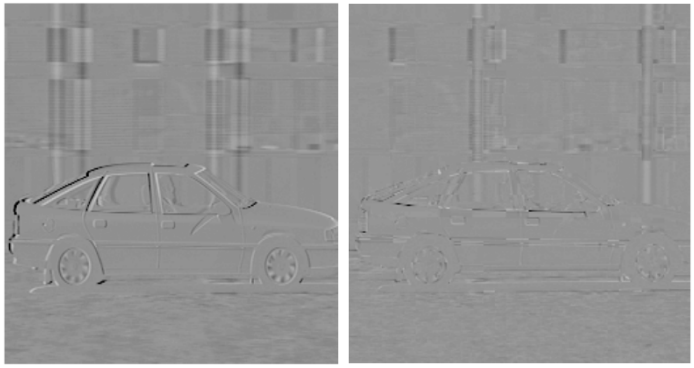

Frame difference | Motion-compensated frame difference

Motion Comp. / Prediction Gain

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		No motion compensation		Motion compensated prediction	
Frame number	σ_x^2	$\sigma_{\Delta x}^2$	G_P	$\sigma_{\Delta x}^2$	G_P
1	1888.2	282.0	6.7	73.5	25.7
2	1885.9	225.7	8.4	86.8	21.7
3	1873.6	265.7	7.1	89.5	20.9
4	1884.6	329.1	5.7	91.9	20.5
5	1889.4	342.6	5.5	96.0	19.7
6	1901.1	368.9	5.2	99.5	19.1

around 0.2 - 0.4 bit

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Part 2

Introduction to MPEG-1/2 System, Coding Concept & Architecture

MPEG System / Standardization

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- **MPEG = Motion Picture Experts Group**
  - joint standardization of ISO and IEC
  - cooperation with CCITT
- **Objective (initial, MPEG-1)**
  - definition of a generic standard for coding of digital video and associated audio and data for digital storage media (DSM)
- **Objective (MPEG-2)**
  - a generic standard for various applications. such as DSM, television broadcasting, and (audiovissual) communication
- **„Generic: wide range of bit rates, variable resolution and quality, flexible for different services**

MPEG System / Milestones – (1)

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- **MPEG-1**
  - Generic coding of moving pictures and associated audio at a throughput rate of up to 1.5 Mbit/s
  - Input is SIF format (half-resolution standard DTV broadcast)
  - Related standard H.261 for audiovisual services at px64 kbit/s
  - Final standard described in ISO-11172
  - Applications areas: CD-i, Video CD, video on PCs
- **MPEG-2**
  - More wide application area than MPEG-1
  - Extensions for interlaced video signals (TV, VCR, DTV, etc.)
  - Bit rates up to 100 Mbit/s (including HDTV, profess. Broadcasting)

MPEG System / Milestones – (2)

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- **MPEG-2 (continued)**
  - final standard described in ISO 11383
  - different descriptions for Audio, Systems
  - draft of standard November 1993, broadly accepted from 1995 ...
- **MPEG-4**
  - advanced extensions of MPEG-2 with respect to block coding
  - New: **model-based** or **object-oriented** coding
  - very low bit rates (e.g. 10 kbit/s ... 100 kbit/s), draft in 1998-99
  - Later extended to MPEG-4 AVC / H.264 for HDTV on Bluray Disk
- **MPEG-7**
  - Archiving video sequences, database management, std. set 2001

MPEG System / Application bit rates

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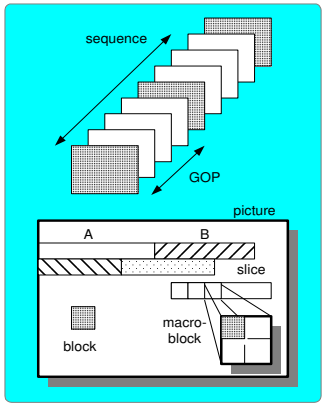
- **MPEG-1 bit rates**
  - Video decoder rates up to 1.856 Mbit/s (telecomm. channel 31 x 64 kbit/s = 1.984 Mbit/s - 0.128 Mbit/s audio
  - CD-i, Video CD have bit rates of 1.2 Mbit/s (audio about 200 kbit/s)
- **MPEG-2 bit rates**
  - 4-5 Mbit/s PAL TV quality
  - 6-9 Mbit/s CCIR-601 component video quality (approach studio quality)
  - 19 Mbit/s ATV standard for HDTV in the USA
  - 20-40 Mbit/s for HDTV contribution (studio to studio)

MPEG System / Structured data –(1)

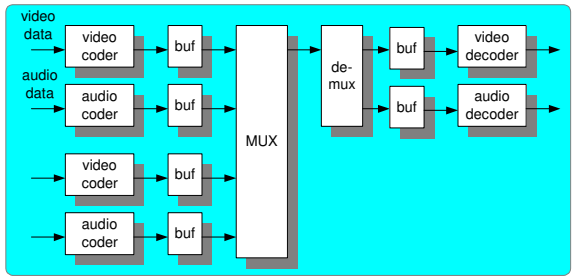
* **Structure of MPEG formatted data, applied codecs**
* **System**
  - Multiplexing, packetizing of multiple compressed data streams
  - Synchronization and timing of individual data contributions
* **Video coding using hybrid compression**
  - Motion compensation in the temporal domain
  - DCT coding in the spatial domain (in the image)
* **Audio coding**
  - Subband coding at 64, 128, or 192 kbit/s
  - Audio subband masking of inaudible components

MPEG System / Structured data –(2)

* **MPEG bit stream Structure**
* Division in layers
  - Sequence layer
  - Group Of Pictures (GOP)
  - Picture layer
  - Slice layer
  - Macroblock layer
  - Block layer



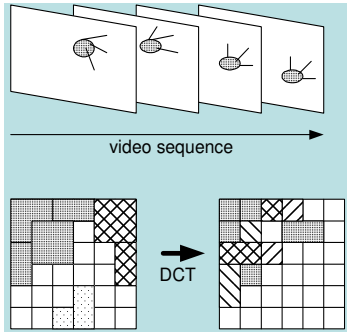
MPEG System / Block diagram



* **MPEG System block diagram (Model has all necessary features)**
  - timing information of synchronous video and audio
  - timing of multiple MPEG-formatted data streams

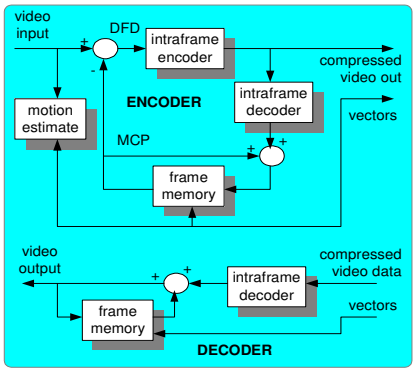
MPEG Video Coding / Principles

* **MPEG video exploits both** spatial **and** temporal **redundancy**
* Temporal **redundancy**
  - Motion estimation
  - Motion compensation
* Spatial **redundancy**
  - Block transformation
  - Variable-length coding



MPEG Video / Hybrid coder architecture

* **MPEG hybrid coding uses**
  - Motion estimation in temporal encoder
  - Intraframe transform coding in spatial encoder/decoder
  - Decoder simpler << than encoder (Mstr.-slave)

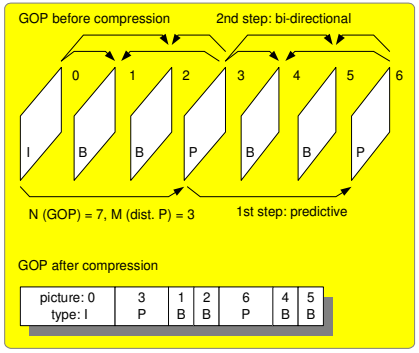


MPEG Video / Picture types: I, P, B

* **Intraframe (I) coded pictures**
  - serve as starting point for a group of pictures
  - modest compression
  - reference picture for other picture types
* **Predictive (P) coded pictures**
  - coded with reference of past pictures (I or P)
  - reference of remaining B-pictures
* **Bi-directional (B) coded pictures**
  - coded with reference of past and future pictures (I,P and P)
  - never used as a reference
  - highest compression
* DC (D) intra-coded pictures (not used, spec. modes)

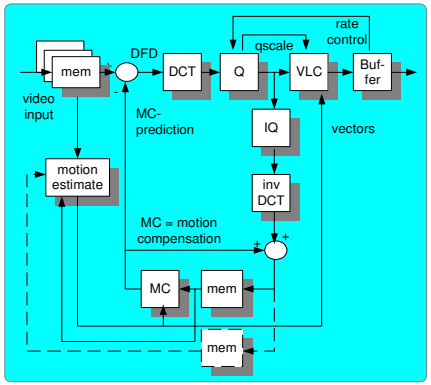
MPEG Video / Group Of Pictures (GOP)

* **GOP in normal order at input**
  - Step 1: code next P picture
  - Step 2: code intermediate B picts.
* **GOP after compression**
  - **Non-chronological** order
  - **Unequal** bit size



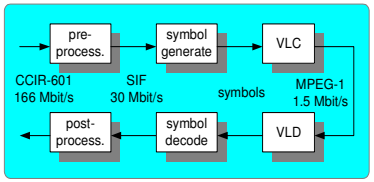
MPEG Video / Predict, Bidirectional

* **MPEG encoder block diagram**
* **ME process requires**
  - Reorder memories
  - ME unit
  - Two-sided extensions
* **VLC at output**
  - Rate-control buffer
  - *qscale* parameter coding



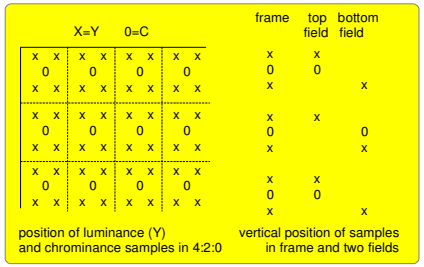
MPEG Video / MPEG-1 sampling – (1)

* **MPEG-1 resampling is required**
  - target 1.5 Mbit/s too low
  - factor of 5 compression by SIF at 30 Mbit/s
* **CCIR-601 (4:2:2 sampling)**
  - Y : 720x576 frame, 2:1 interlace, 50 Hz
  - U,V : 360x576 frame, id.
* **SIF („2:1:0“ sampling)**
  - Y : 352x288 lines
  - U,V: 176x144 lines
  - 25 frame/s
  - 1:1 progressive



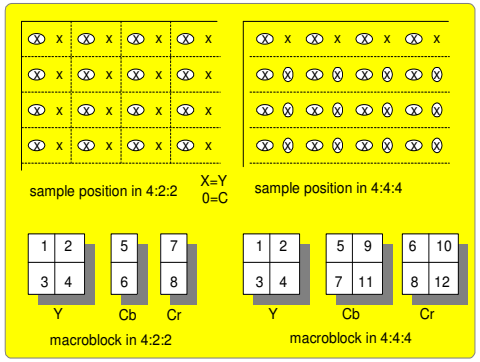
MPEG Video / MPEG-1 sampling – (2)

* **MPEG sampling, mainly on 4:2:0**
  - MPEG-1: line sequential on frame basis
  - MPEG-2: line sequential also with interlaced fields



MPEG Video / MPEG-2 sampling

* **Alternative sampling in MPEG-2**
  - 4:2:2, The CCIR-601 studio standard
  - 4:4:4, for High-quality RGB applications



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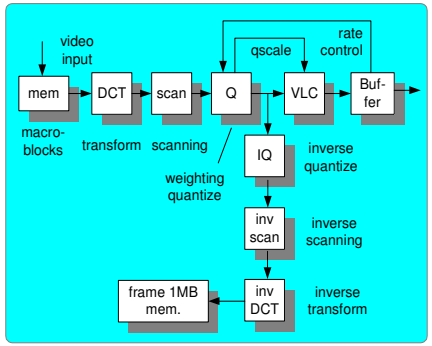
Part 3

Intraframe MPEG-1/2 Video Coding Details

MPEG Video / Intraframe coding part

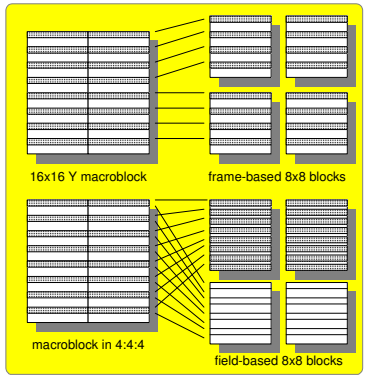
* **MPEG intraframe coder / decoder block diagram**
  - Local encoding
  - Reconstruction for motion compensation
  - Based 8x8 DCT, adapt. Quantization and 2-D VLC
  - Feedback coding with rate buffer control



MPEG-2 Video / 8x8 DCT motion adaptivity

Note: 1 frame = 2 fields (1 odd + 1 even)

* **MPEG-2 accepts interlacing, thus requires motion-adaptive DCT**
  - Keep fixed 8x8 blocks in both modes
  - Static 8x8 **frame-based** and moving 8x8 **field-based** blocks



MPEG Video / Quantization – (1)

MPEG Quantization for inter- / intraframe data

* **DC coefficient**
  - Human eye very sensitive for DC errors, thus **fixed** quantizer
  - MPEG-1: *DC**Q**=DC / 8.0* and inverse *DC = 8.0xDC**Q***
  - MPEG-2: higher DC precision 8-11 bits (*n x DC**Q***)
* **AC coefficients**
  - Weighting $W(u,v)$ according to perception

intra block weighting

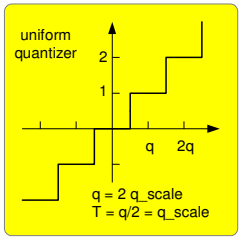
08	16	19	22	26	27	29	34
16	16	22	24	27	29	34	37
19	22	26	27	29	34	34	38
22	22	26	27	29	34	37	40
22	26	27	29	32	35	40	48
26	27	29	32	35	40	48	58
26	27	29	34	38	46	56	69
27	29	35	38	46	56	69	83

inter block weighting

16	16	16	16	16	16	16	16
16	16	16	16	16	16	16	16
16	16	16	16	16	16	16	16
16	16	16	16	16	16	16	16
16	16	16	16	16	16	16	16
16	16	16	16	16	16	16	16
16	16	16	16	16	16	16	16
16	16	16	16	16	16	16	16

MPEG Video / Quantization – (2)

* **AC coefficients (cont.)**
  - **MPEG-1 encoder** formula
    $FQ(u,v) = 16\ F(u,v) / (2\ q\_scale\ W(u,v))$
  - **MPEG-1 decoder** formula
    $F(u,v) = 2\ (FQ(u,v) + k)\ q\_scale\ W(u,v)\ / 16$
  - k = 0 for intrablocks, and $k = sign(FQ(u,v))$ for non-intra blocks
  - **Mismatch control** (value closest to zero): if $F(u,v)$ even, then
    $F(u,v) = F(u,v) - sign(\ F(u,v)\ )$



MPEG Video / Quantization-(3) MPEG-2

- **MPEG-2 has more precise quantization**
- **DC coefficients:** up to 11 bits precision
- **AC coefficients**
  - **MPEG-2 decoder** formula

    $F(u,v) = 2\,(FQ(u,v) + k)\; q\_scale\; W(w,u,v)\;\; / 32$
  - q_scale is mapped onto larger range than 0...31
  - w is defined by intra / non-intra and colour sampling
  - k = 0 for intrablocks, and k = *sign*($FQ(u,v)$) for non-intra blocks
  - special additional mismatch control: $F(7,7) = F(7,7)$ if *SUM* $ac(F(u,v))$ is odd, and $F(7,7) = F(7,7)$ +/- 1 if $F(7,7)$ is even/odd and *SUM* is even.

MPEG Video / Quantization-(4) MPEG-2

MPEG-2 AC coefficients (cont.)

- **Extra adaptivity possibilities**
  - Quantizer matrix $W(w,u,v)$ can be reloaded in frame header, giving **adaptive weighting** on sequence or application
  - q_scale Parameter can be modified on macroblock basis, enables smooth regulation of bit rate locally in the image
  - In any case, MPEG-2 different weighting for Y and C

MPEG Video / Quantization – (5)

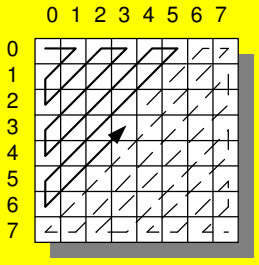
MPEG-2 AC coefficients

- Larger range of q_scale by mapping of transmit code
  - Two characteristics: uniform and non-uniform
  - Non-uniform curve enables different control for low bit-rates

q_scale	quantize type type=0	type=1
0	forbidden	
1	2	1
2	4	2
3	6	3
4	8	4
5	10	5
6	12	6
7	14	7
8	16	8
9	18	10
10	20	12
11	22	14
12	24	16
13	26	18
14	28	20
15	30	22
16	32	24
17	34	28
18	36	32
19	38	36
20	40	40
21	42	44
22	44	48
23	46	52
24	48	56
25	50	64
..	...	...
31	62	112

MPEG Video / VLC Scanning – (1)

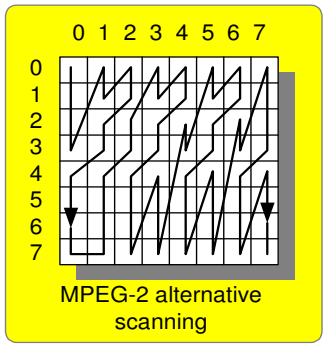
- **Scanning of transform coefficients (MPEG-1/2)**
  - Preprocessing step for variable-length coding
  - Scanning functions reorders coefficients to cluster zeros for runlength coding
  - Start with „low-frequency“ coefficients
  - Fundamental scanning pattern is diagonal



zigzag scanning

MPEG Video / VLC Scanning – (2)

* **MPEG-2 extension of scanning function (interlacing)**
  - Picture header extension: indicate the use of alternative scanning pattern (on picture basis)
  - In case of quantizer matrix download: use always diagonal (zigzag) scanning



MPEG-2 alternative scanning

MPEG Video / Var. Length Coding – (1)

* **Variable-length coding of AC coefficients: algorithm of (runlength, amplitude) coding**
  - STEP 1: (load coefficient), test of coefficient is zero
  - STEP 2: (update runlength), if zero coefficient, increment zero counter, go to STEP 4
  - STEP 3: (jointly code), if non-zero coefficient, then
  - 3a. jointly code [runlength, amplitude] in one codeword
  - 3b. reset runlength counter
  - STEP 4: (do next coefficient), go to STEP 1. If last coefficient, then go to STEP 5.
  - STEP 5: (EOB) Terminate block with EOB-word, ignore runlength value. Codetable is modified Huffman code.

MPEG Video / Var. Length Coding – (2)

* **2-D VLC table of codewords**
  1. Unlikely symbols are coded by [esc. code]+[fixed suffix]
  2. Also VLC coding of macroblock address, motion vectors,...

zero run ↓ / amplitude →	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0	11	2	3	4	4	5	5	5	6	6	6	7	7	7	8	8	8	8	9	9	14
1	12	4	6	7	7	8	9	9	10	10	10	11	11	12	12	12	12	12	12		
2	12	5	7	9	10	10	11	12	12	13											
3	12	6	8	10	12	12	13														
4	12	6	9	11	12																
5	12	7	10	11	12																
6	13	7	10	12																	
7	13	8	12	12																	
8	13	8	12																		
9	13	9	12																		
10	13	9	13																		

EOB = 4

Example of wordlength table

• MPEG-2 has alternative encoding table for intrablocks. For non-intra blocks, always the same table is used.

MPEG Video / Var. Length Coding – (3)

* **2-D. VLC Table of code words**
  - Special code for 1st coeff.
  - Escape code to avoid long code words
  - Appended sign bit

code	runlength	amplitude
10	EOB	
1s (note2)	0	1
11s (note3)	0	1
011s	1	1
0100s	0	2
0101s	2	1
0010 1s	0	3
0011 1s	3	1
0011 0s	4	1
0001 10s	1	2
0001 11s	5	1
0001 01s	6	1
0001 00s	7	1
0000 110s	0	4
0000 100s	2	2
0000 111s	8	1
0000 101s	9	1
0000 01	escape	-

code	runlength	amplitude
0010 0110s	0	5
0010 0001s	0	6
0010 0101s	1	3
0010 0100s	3	2
0010 0111s	10	1
0010 0011s	11	1
0010 0010s	12	1
0010 0000s	13	1
0000 001010s	0	7
0000 001100s	1	4
0000 001011s	2	3
0000 001111s	4	2
0000 001001s	5	2
0000 001110s	14	1
0000 001101s	15	1
0000 001000s	16	1

Note1: s=sign bit, 0=pos/1=neg.
Note 2: code for dct_coeff_first
Note 3: code for dct_coeff_next

MPEG Video / Var. Length Coding – (4)

* **VLC table for motion vectors**
  - Sym-metrical
  - Special code
  - Appended sign bit except 0

VL code	motion code
0000 0011 001	-16
0000 0011 011	-15
0000 0011 101	-14
0000 0011 111	-13
0000 0100 001	-12
0000 0100 011	-11
0000 0100 11	-10
0000 0101 01	-9
0000 0101 11	-8
0000 0111	-7
0000 1001	-6
0000 1011	-5
0000 111	-4
0001 1	-3
0011	-2
011	-1
1	0

VL code	motion code
0000 0011 000	+16
0000 0011 010	+15
0000 0011 100	+14
0000 0011 110	+13
0000 0100 000	+12
0000 0100 010	+11
0000 0100 10	+10
0000 0101 00	+9
0000 0101 10	+8
0000 0110	+7
0000 1000	+6
0000 1010	+5
0000 110	+4
0001 0	+3
0010	+2
010	+1
1	0

5LSE0 - Mod 03 - B
Part 4

Interframe MPEG-1/2
Mot.-Comp. Video Coding

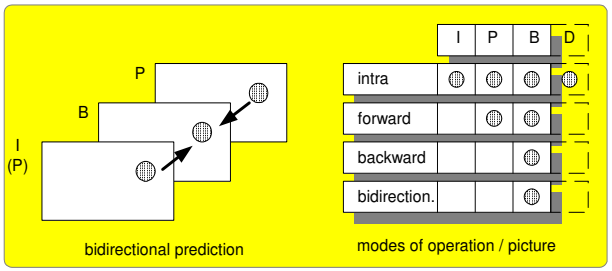
MPEG Video / Temporal Prediction – (1)

Temporal redundancy reduction

* **1. By single-sided prediction**
  - motion compensation should cover large area
  - (due to intermediate B pictures)
  - fallback coding required (for excessive motion or uncovered background)
* **2. Bidirectional motion compensation (interpolation)**
  - assume linear interpolation of surrounding pictures
  - bidirectional prediction is more efficient than single-sided
  - more possibilities with uncovered objects
  - not used as reference for further coding: no error propagation in temporal coding

MPEG Video / Temporal Prediction – (2)

Table of coding modes



MPEG Video / Quantizer inter block – (1)

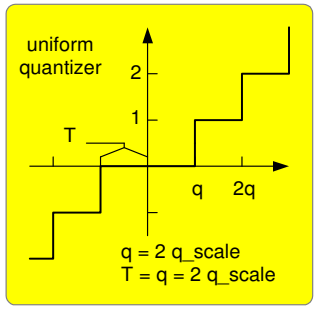
MPEG Quantization interframe data (predictive MBs)

* **DC coefficients**
  - Differential DC coefficients
  - Quantized and coded as AC coefficients
* **AC coefficients**
  - MPEG-1 decoder fomula
  - $F(u,v) = 2\ (QF(u,v)+k)\ q\_scale\ W(u,v)\ /\ 16$
  - $W(u,v) = 16$ default, but new matrix can be loaded
  - $k = sign(QF(u,v))$ for inter-blocks
  - Mismatch control: if $F(u,v)$ even => $F(u,v)=F(u,v)-sign(F(u,v))$ value closest to zero

MPEG Video/ Quantizer inter-blocks – (2)

MPEG Quantization interframe data (predictive MBs)

* AC coefficients (cont.) for MPEG-2
  - MPEG-2 is more precise with normalization factor 32
  - MPEG-2 special mismatch control
  - Quantizer is uniform, but larger dead zone



MPEG Video / Coding modes P&B – (1)

MPEG-1/2 coding modes for inter-coded images (P, B)

Predictive (P)	Bidirectional (B)
Motion, no motion	Forward, from past, Backward, from future, interpolated (from both sides)
Intra (fallback), or non-intra (regular case)	Intra (fallback), or non-intra (regular case)
Coded (regular), or not-coded (skipped block)	Coded (regular), or not-coded (skipped)
Default quantization, new q-scale	Default quantization, new q-scale

MPEG Video / Coding modes P&B – (2)

MPEG-2 extensions for compensated coding modes

* **Frame-based prediction (in both standards)**
  - Equal to MPEG-1 (16x16 compensation blocks)
  - In a frame picture, either frame- or field-based prediction on MB level
* **Field-based prediction (MPEG-2)**
  - Results from interlaced pictures
* **16x8 motion compensation (MPEG-2)**
  - Requires two motion vectors (1 for top- and 1 for bottom field)
  - In B interlaced pictures, even 4 vectors can be used

MPEG Video / Modes for P&B MBs – (3)

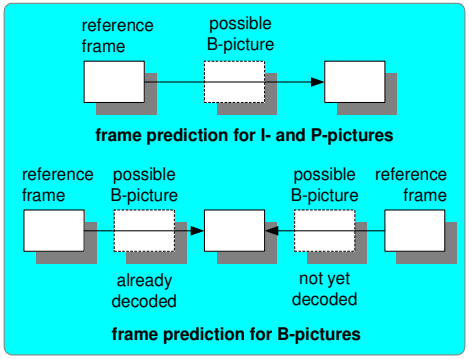
MPEG-2 extensions for compensated coding modes

* **Special: Dual-prime prediction**
  - 1 Motion Vector is coded in full resolution, 1 motion vector is a small differential vector (the dmv)
  - **Field-based prediction**: 2 vectors are derived from this information. The obtained fields are averaged to get the final prediction
  - **Frame-based pictures**: the averaging is done for both fields, yielding 4 field predictions.
  - This mode is only used for P-pictures, without B-pictures in between.

MPEG Video / Modes for P&B MBs – (4)

MPEG-2 extensions for compensated coding modes

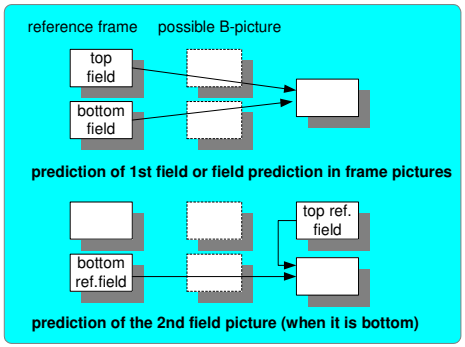
* **Frame-based prediction**
  - 1 mv for P
  - 2 mv for B



MPEG Video / Modes for P&B MBs – (5)

MPEG-2 extensions for compensated coding modes

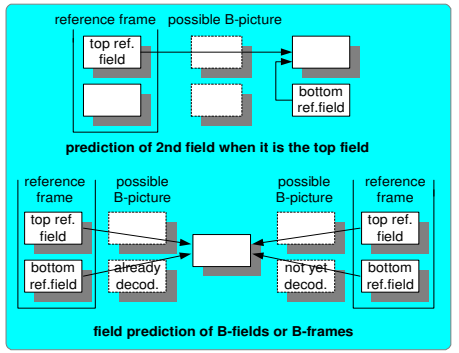
* **Field-based prediction**
  - 2 mv for field to frame for P
  - 2 mv for field to field **for full interlacing P**



MPEG Video / Modes for P&B MBs – (6)

MPEG-2 extensions for compensated coding modes

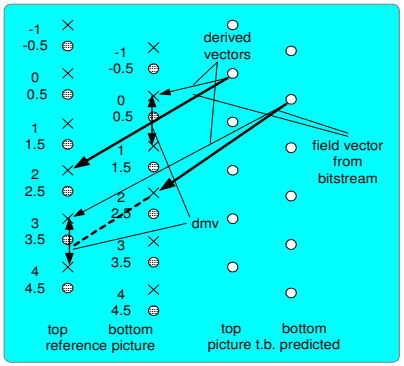
* **Field-based prediction (continued)**
  - 2 mv for P
  - 4 mv for B



MPEG Video / Modes for P&B MBs – (7)

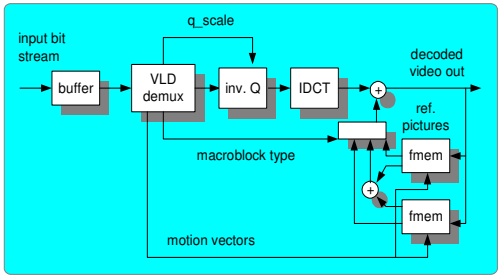
MPEG-2 extensions for MC-coding

* **Special field-based prediction: dual prime**
  - **Main** and **dmv** vector
  - Scaling of vectors for dual prime prediction to field grid
  - Better send one large vector and small one!



MPEG Video / Decoder structure

* **MPEG-2 Video decoder hardware**
  - MPEG strongly asymmetric, follows encoder decisions
  - Decoder has no ME, only MC, saves factor 3-4 in complexity



MPEG Video / MPEG-1 core param'ts

* **MPEG Video core parameters, purpose**
  - guaranteed exchange of MPEG-coded data, which should be decodable on different systems
  - also important: bounding of encoder complexity
* **MPEG-1 Core parameters**
  - Pixels/line <= 720
  - Lines/frame <= 576
  - Frame rate <= 30 Hz
  - Macroblock/picture <= 396
  - Macroblock rate <= 396 x 25 Hz = 330 x 30 Hz = 9,900 Hz
  - Bit rate <= 1.86 Mbit/s
  - Buffer <= 376,832 bits

MPEG / MPEG-2 Profiles & Levels – (1)

* **MPEG-2 Profiles / Levels**
  - Implementation of full specification of MPEG-2 too difficult
  - Profiles serve as limited number of subsets of MPEG-2
  - Bounding of encoder/decoder complexity => help industry!
* **Profile**
  - **Limited subset of** entire bit stream **syntax**
  - Different profiles support different features (applications)
* **Level**
  - **Defined set of constraints** imposed **on the parameters** in the profile bit stream

MPEG / MPEG-2 Profiles & Levels – (2)

* **MPEG-2 profiles / levels**
  - **Example: MP@ML**
* **Main Profile**
  - sampling 720 x 576, 4:2:0 standard
  - DCT based, frame/field DCT, frame/field MC, B frames
* **Simple profile**
  - no B pictures are used
* **Next profile**
  - scalability
  - 4:2:0 or 4:2:2 sampling

MPEG Video / MPEG-2 Profile Table

	Profile				
syntactic element	**Simple**	**Main**	**SNR**	**Spatial**	**High**
chroma format	4:2:0	4:2:0	4:2:0	4:2:0	4:2:0, 4:2:2
frame rate extens. n	0	0	0	0	0
frame rate extens. d	0	0	0	0	0
picture coding type	I, P	I, P, B	I, P, B	I, P, B	I, P, B
repeat first field	constrained	constrained	no constr.	no constr.	no constr.
sequence table extens.	No	No	Yes	Yes	Yes
scalable mode	-	-	SNR	SNR, spatial	SNR, spatial
spatial scalable extens.	No	No	No	Yes	Yes
intra dc precision	8,9,10	8,9,10	8,9,10	8,9,10	8,9,10,11
slice structure	restricted	restricted	restricted	restricted	restricted

MPEG Video / MPEG-2 Level Table

	Level			
syntactic element	**Low**	**Main**	**High-1440**	**High**
horizontal vector range	-512, +511.5	-1024, +1023.5	-2048, +2047.5	-2048, +2047.5
vertical vector rang (fra.)	-64, +63.5	-128,+127.5	-128,+127.5	-128,+127.5
vertical range (field)	-32, +31.5	-64, +63.5	-64, +63.5	-64, +63.5
max. sample / line	352	720	1440	1920
max. lines / frame	288	576	1152	1152
max. frame / second	30	30	60	60
Y sample rate (Msam/s)	3.041	10.368	47.002	62.669
max. bit rate (Mbit/s)	4	15	60	80
VBV buffer size (Mbit)	0.475	1.835	7.340	9.781