# JPEG and MPEG-2: a brief overview

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January 3, 2011

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# Introduction

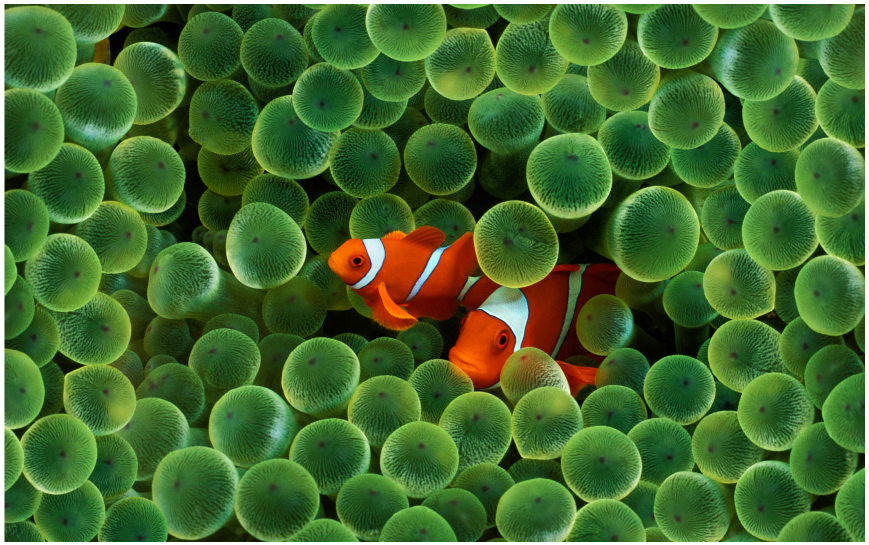
# Motivations - compression standards for still pictures

## Motivations

Still color picture 800x300 pixels, 24 bits/pixel: 6.3 Mbits/image
(modem 56k $\rightarrow$ 3min 39s !!).

Tremendous progress made in a number of adavanced technologies leading to powerful computers and computations. Pictures, widely utilized in our daily lifes.
Possibility to compress data infomation due to the statistical redundancy of information and to the psychovisual redundancy.

**Resolution 2560 $\times$ 1600**



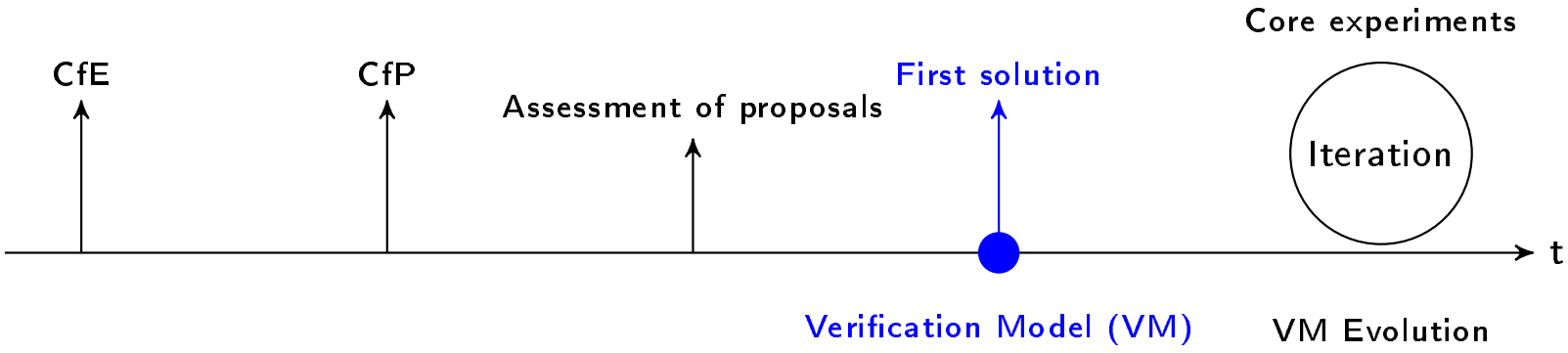
# What is the goal of a compression standard?

**Definition (Standard)**

A format that has been approved by a recognized standards organization or is accepted as a de facto standard by the industry.

For the compression standards, there are two organizations: ITU-T-VCEG and ISO MPEG. A standard only specifies bitstream syntax and decoding process.

The goal is to create the best video compression standards for targeted applications.




CfE: Call for Evidence; CfP: Call for Proposal.

For example: H264, CfP (1998), standard 2003.

# Image Compression standards

- JPEG (Joint Photographic Experts Group), ISO/IEC 10918-1, ITU-T Recommendation T.81, (1992);
- JPEG2000 (Joint Photographic Experts Group) ISO/IEC 15444-1, (2004);
- GIF (Graphics Interchange Format) two standards GIF87a and GIF89a (LZW algo);
- JBIG (Joint Bi-level Image experts Group)is a format for bi-level (black/white) image compression. International Standard, IS 14492 (1999) ISO/IEC 1359, (1999);

# JPEG

# Presentation

## JPEG: Joint Photographic Experts Group

ISO/IEC JTC1/SC29/WG10

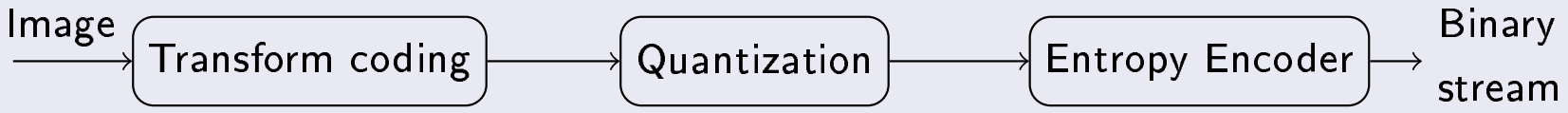
ISO: International Organization for Standardization
IEC: International Electrotechnical Commission
JTC: Joint ISO/IEC Technical Committee
SC29: Subcommittee 29 (Coding of Audio, Picture...) WG10: Working Group 10.

- Work commenced in 1986 and finished in 1992 by the publication of the standard ISO/IEC 10918-1 and CCITT Rec. T.81.
- Widely used for ... a lot of applications.

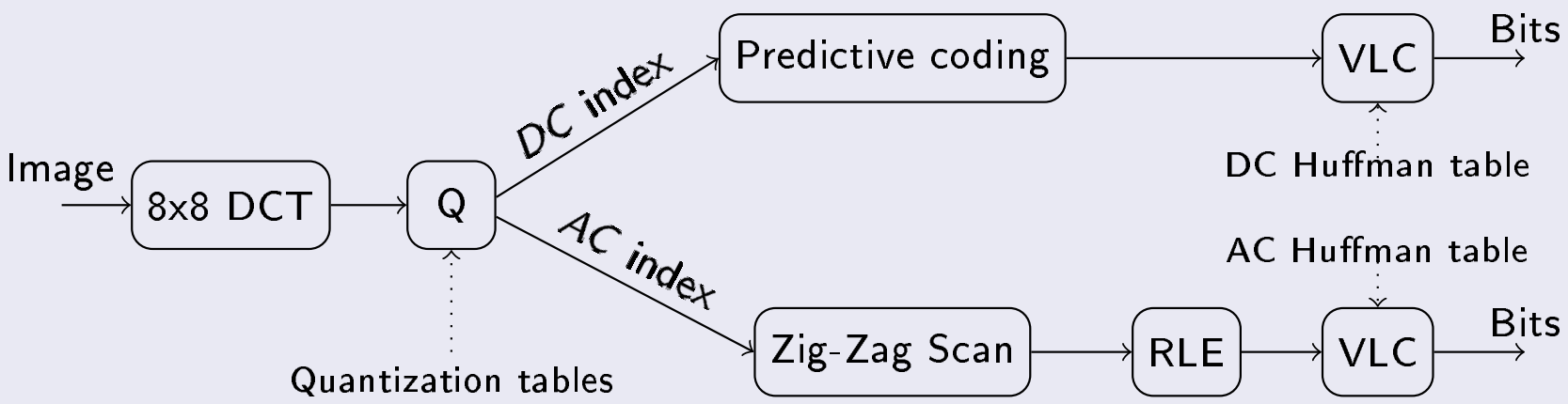
Two profiles: JPEG (Baseline) and JPEG-LS (Lossless).

# General scheme of JPEG (baseline)

## General layout of the coding scheme

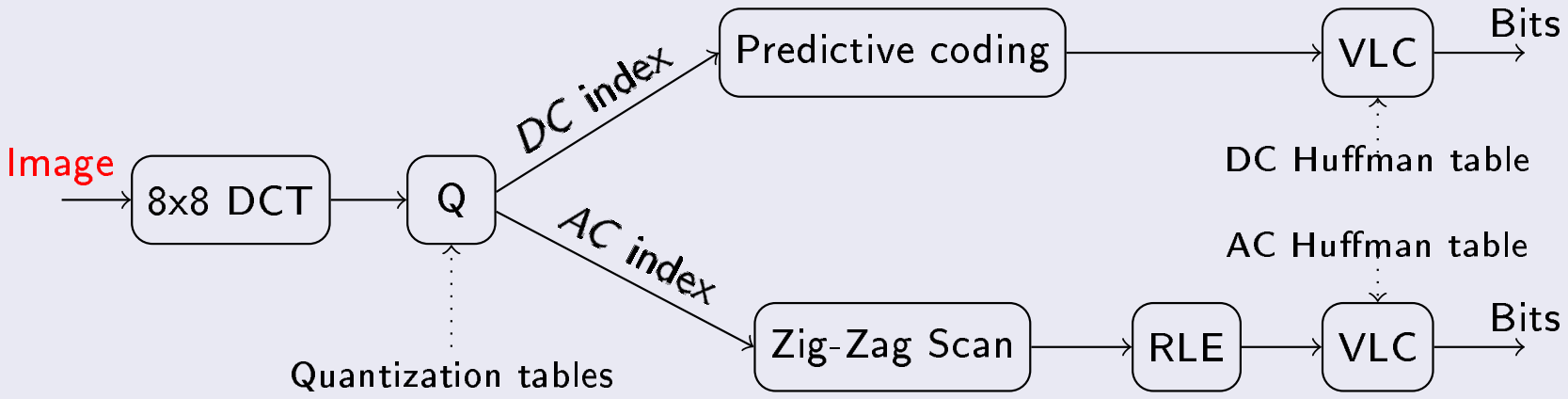



## Block diagram of JPEG Baseline



# Input format

## Block diagram of JPEG Baseline



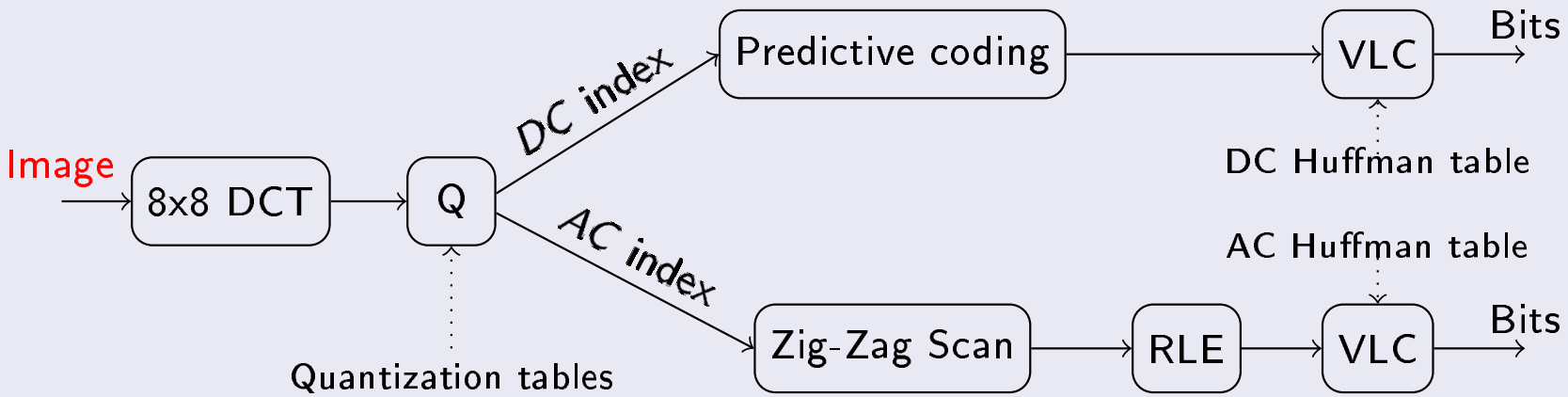

- Color space is *YUV*:

$$\begin{bmatrix} Y \\ U \\ V \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ -0.1687 & -0.3313 & 0.5 \\ 0.5 & -0.4187 & -0.813 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

(a) Source (b) Y (c) U (Blue) (d) V (Red)

# Input format

## Block diagram of JPEG Baseline

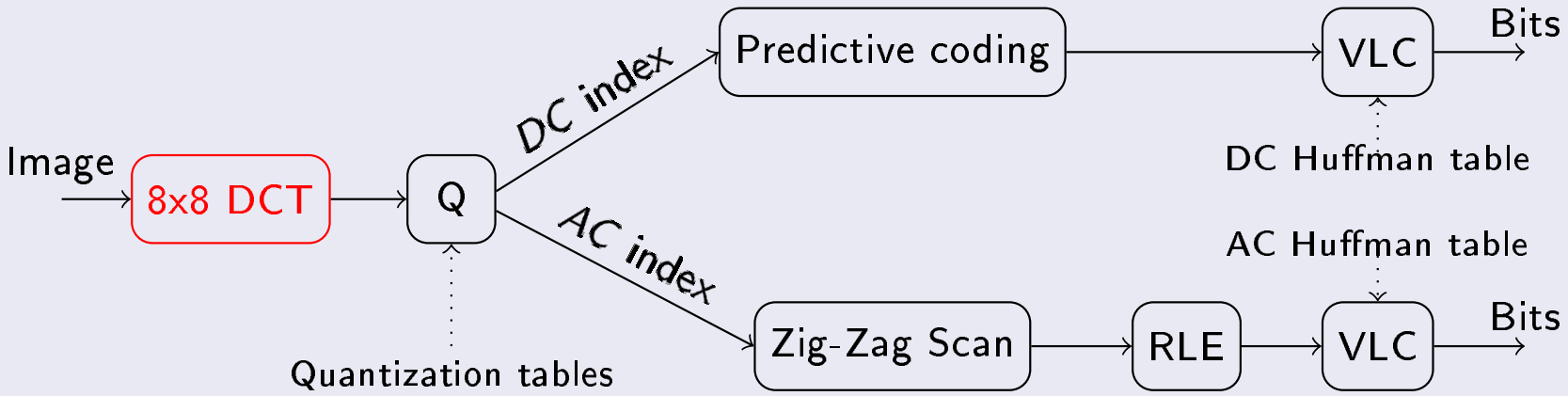



- Format 4:2:0 (Human eyes are less sensitive to the chrominance than to the luminance):

(a) Source (b) Y (c) U (d) V

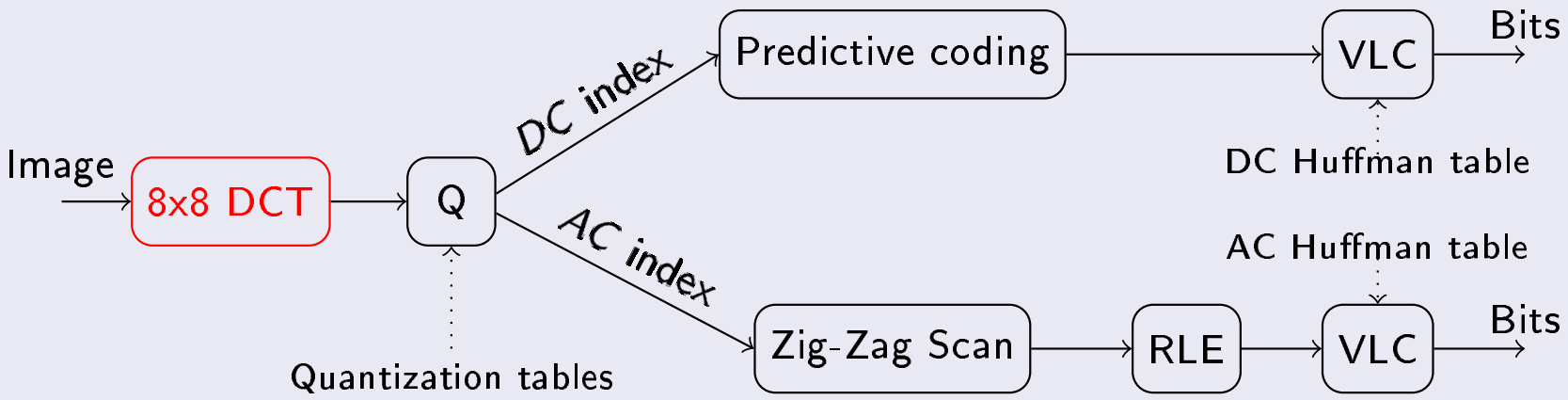
# Block grid

## Block diagram of JPEG Baseline




# DCT

## Block diagram of JPEG Baseline




Reminder: $I = \sum_{m=0}^{M-1} \sum_{n=0}^{N-1} \langle I, \varphi_{n,m} \rangle \varphi_{n,m}$, $\mathcal{B} = \{\varphi_{n,m}\}_{0 \leq n < N, 0 \leq m < M}$ an orthogonal basis.

## DCT 8x8

For a given block $NxN$:

$$\varphi_{n,m}(x,y) = \lambda(n)\lambda(m)\frac{2}{N}\cos\frac{\pi(2x+1)n}{2N}\cos\frac{\pi(2y+1)m}{2N}, \quad \lambda(t) = \begin{cases} \frac{1}{\sqrt{2}} & \text{if } t = 0 \\ 1 & \text{otherwise} \end{cases}$$

# DCT

## DCT and inverse DCT

The DCT of a block $I$ of size $NxN$ is defined by:

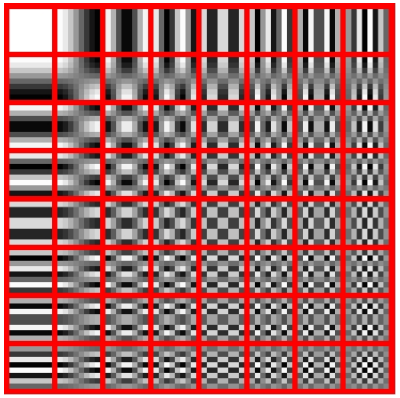
$$DCT(I)(n,m) = \frac{2}{N}\lambda(n)\lambda(m)\sum_{i=0}^{N-1}\sum_{j=0}^{N-1} cos\frac{\pi(2i+1)n}{2N} cos\frac{\pi(2j+1)m}{2N} I(i,j)$$

$$\Leftrightarrow$$

$$\langle \varphi_{n,m}, I \rangle$$

The inverse DCT is defined by:

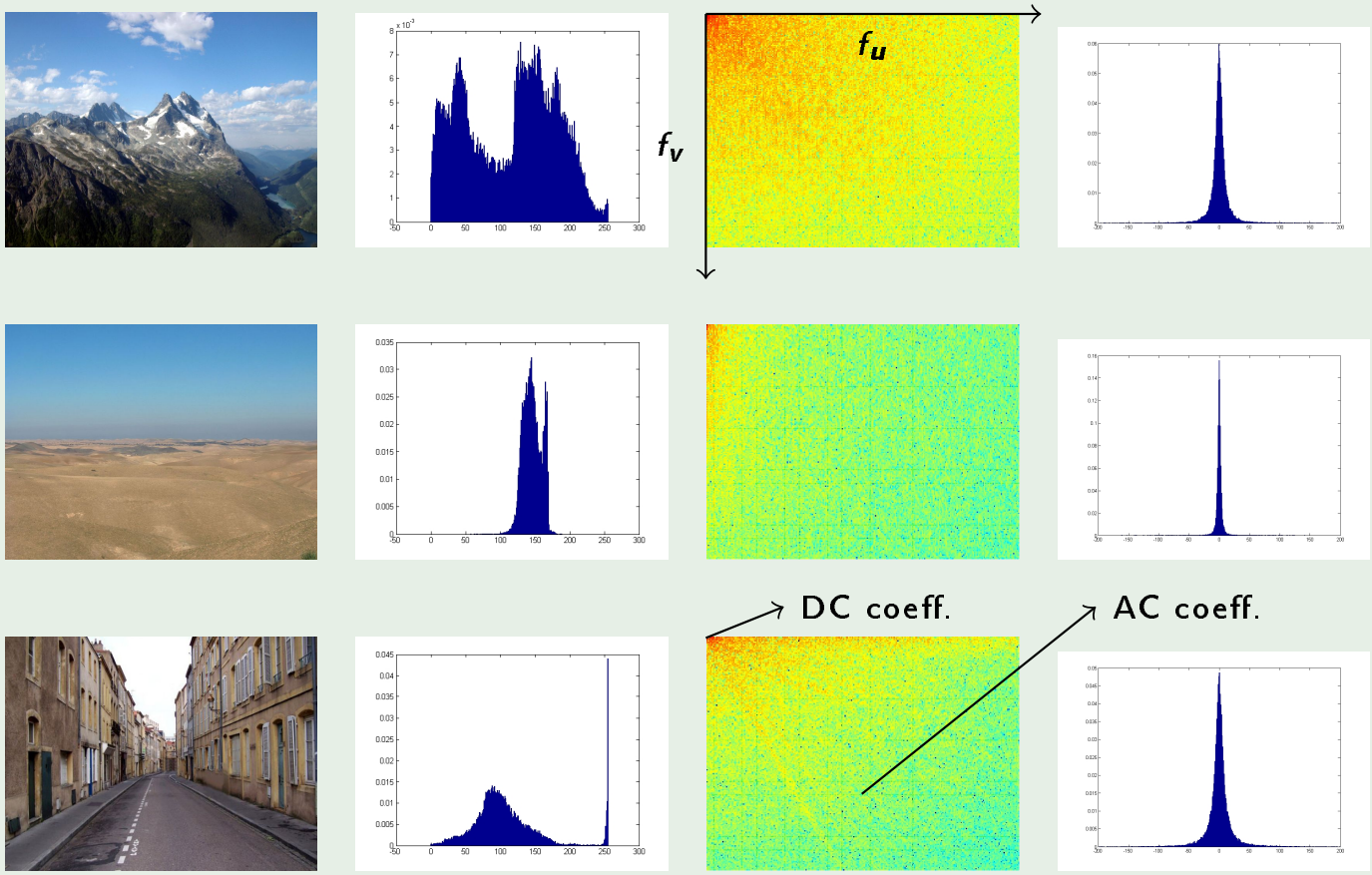
$$I(x,y) = \frac{2}{N}\sum_{m=0}^{N-1}\sum_{n=0}^{N-1} \lambda(n)\lambda(m) cos\frac{\pi(2x+1)n}{2N} cos\frac{\pi(2y+1)m}{2N} DCT(I)(n,m).$$



Two dimensional DCT basis. The source data (8x8) is transformed to a linear combination of these 64 frequency squares.

# DCT

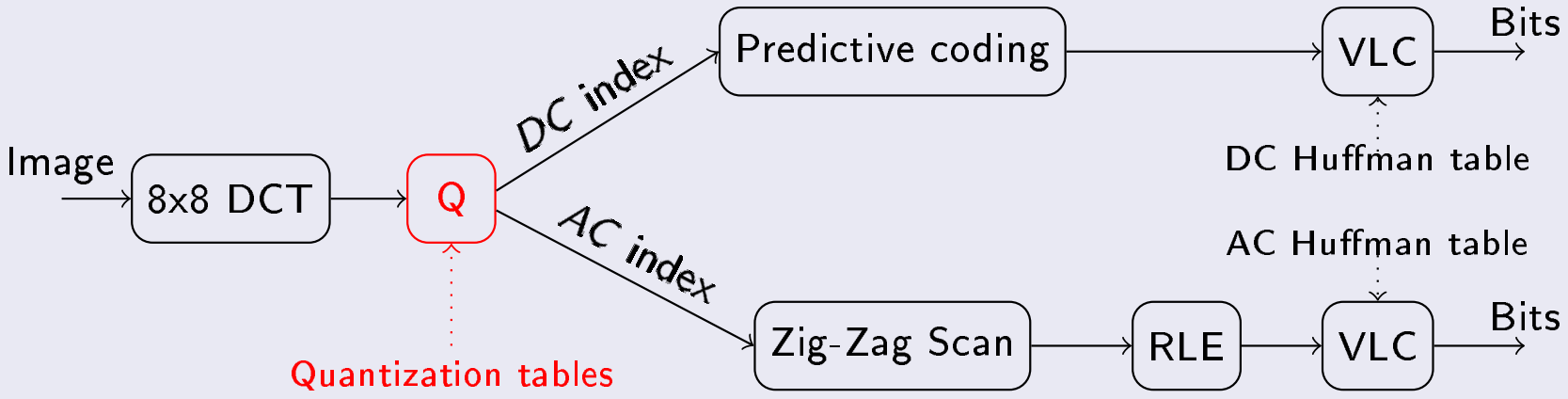
## Example




Original | Normalized histogram | DCT | Dist. DCT coeff.

# Quantization

## Block diagram of JPEG Baseline




## Quantization

$$F_Q(u,v) = \left\lfloor \frac{F(u,v) + \left\lfloor \frac{Q(u,v)}{2} \right\rfloor}{Q(u,v)} \right\rfloor$$

with, $F$ the unquantized DCT coefficients, $\lfloor . \rfloor$ the floor function, $Q$ the typical quantization matrix, as specified in the original JPEG Standard.

# Quantization

## Quantization table $Q$

Luminance Table:

$$Q_L = \begin{bmatrix} 16 & 11 & 10 & 16 & 24 & 40 & 51 & 61 \\ 12 & 12 & 14 & 19 & 26 & 58 & 60 & 55 \\ 14 & 13 & 16 & 24 & 40 & 57 & 69 & 56 \\ 14 & 17 & 22 & 29 & 51 & 87 & 80 & 62 \\ 18 & 22 & 37 & 56 & 68 & 109 & 103 & 77 \\ 24 & 35 & 55 & 64 & 81 & 104 & 113 & 92 \\ 49 & 64 & 78 & 87 & 103 & 121 & 120 & 101 \\ 92 & 92 & 95 & 98 & 112 & 100 & 103 & 99 \end{bmatrix}$$

Chrominance Table:

$$Q_C = \begin{bmatrix} 17 & 18 & 24 & 47 & 99 & 99 & 99 & 99 \\ 18 & 21 & 26 & 66 & 99 & 99 & 99 & 99 \\ 24 & 26 & 56 & 99 & 99 & 99 & 99 & 99 \\ 47 & 66 & 99 & 99 & 99 & 99 & 99 & 99 \\ 99 & 99 & 99 & 99 & 99 & 99 & 99 & 99 \\ 99 & 99 & 99 & 99 & 99 & 99 & 99 & 99 \\ 99 & 99 & 99 & 99 & 99 & 99 & 99 & 99 \\ 99 & 99 & 99 & 99 & 99 & 99 & 99 & 99 \end{bmatrix}$$

Deduced from CSF (Contrast Sensitivity Function). CSF gives the sensitivity of observers to luminance-varying sinusoidal gratings of different spatial frequencies. $CSF = \frac{1}{TH}$, $TH$ minimal amplitude to detect the target.

Notice that we can use a quality factor to scale the quantization (tradeoff between quality and compression ratio).

# Quantization

## Example (Extracted from Digital Images Compression Techniques, Majid Rabbani and Paul W. Jones)

Original block

$$f = \begin{bmatrix} 139 & 144 & 149 & 153 & 155 & 155 & 155 & 155 \\ 144 & 151 & 153 & 156 & 159 & 156 & 156 & 156 \\ 150 & 155 & 160 & 163 & 158 & 156 & 156 & 156 \\ 159 & 161 & 162 & 160 & 160 & 159 & 159 & 159 \\ 159 & 160 & 161 & 162 & 162 & 155 & 155 & 155 \\ 161 & 161 & 161 & 161 & 160 & 157 & 157 & 157 \\ 162 & 162 & 161 & 163 & 162 & 157 & 157 & 157 \\ 162 & 162 & 161 & 161 & 163 & 158 & 158 & 158 \end{bmatrix}$$

Transform block

$$F = \begin{bmatrix} 1260 & -1 & -12 & -5 & 2 & -2 & -3 & 1 \\ -23 & -17 & -6 & -3 & -3 & 0 & 0 & -1 \\ -11 & -9 & -2 & 2 & 0 & -1 & -1 & 0 \\ -7 & -2 & 0 & 1 & 1 & 0 & 0 & 0 \\ -1 & -1 & 1 & 2 & 0 & -1 & 1 & 1 \\ 2 & 0 & 2 & 0 & -1 & 1 & 1 & -1 \\ -1 & 0 & 0 & -1 & 0 & 2 & 1 & -1 \\ -3 & 2 & -4 & -2 & 2 & 1 & -1 & 0 \end{bmatrix}$$

# Quantization

## Example (Extracted from Digital Images Compression Techniques, Majid Rabbani and Paul W. Jones)

Transform block

$$F = \begin{bmatrix} 1260 & -1 & -12 & -5 & 2 & -2 & -3 & 1 \\ -23 & -17 & -6 & -3 & -3 & 0 & 0 & -1 \\ -11 & -9 & -2 & 2 & 0 & -1 & -1 & 0 \\ -7 & -2 & 0 & 1 & 1 & 0 & 0 & 0 \\ -1 & -1 & 1 & 2 & 0 & -1 & 1 & 1 \\ 2 & 0 & 2 & 0 & -1 & 1 & 1 & -1 \\ -1 & 0 & 0 & -1 & 0 & 2 & 1 & -1 \\ -3 & 2 & -4 & -2 & 2 & 1 & -1 & 0 \end{bmatrix}$$

Typical quantization matrix

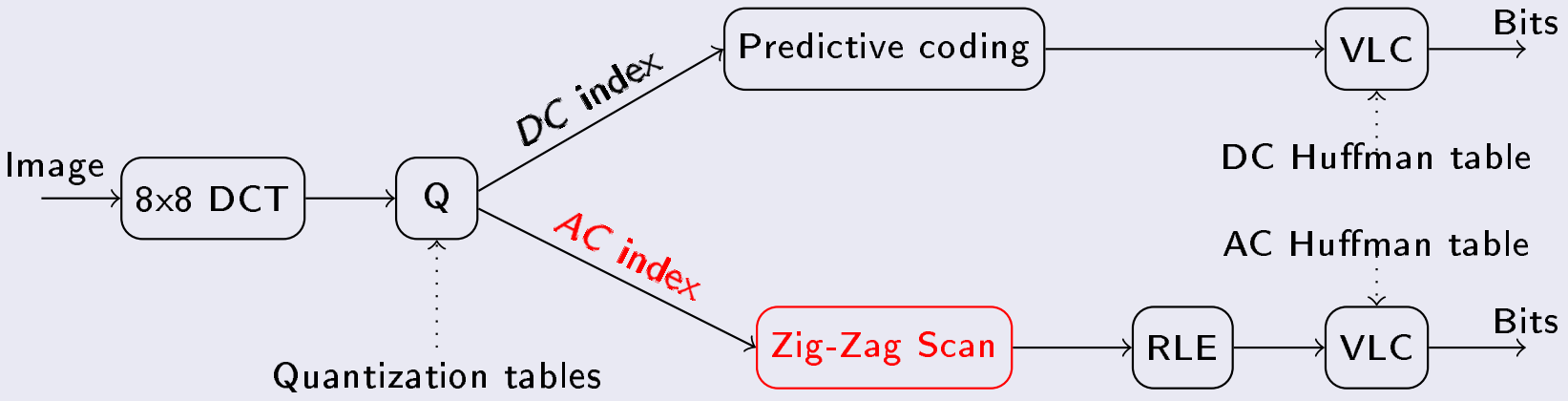
$$Q_L = \begin{bmatrix} 16 & 11 & 10 & 16 & 24 & 40 & 51 & 61 \\ 12 & 12 & 14 & 19 & 26 & 58 & 60 & 55 \\ 14 & 13 & 16 & 24 & 40 & 57 & 69 & 56 \\ 14 & 17 & 22 & 29 & 51 & 87 & 80 & 62 \\ 18 & 22 & 37 & 56 & 68 & 109 & 103 & 77 \\ 24 & 35 & 55 & 64 & 81 & 104 & 113 & 92 \\ 49 & 64 & 78 & 87 & 103 & 121 & 120 & 101 \\ 2 & 92 & 95 & 98 & 112 & 100 & 103 & 99 \end{bmatrix}$$

Transform quantized block

$$F_Q = \begin{bmatrix} 79 & 0 & -1 & 0 & 0 & 0 & 0 & 0 \\ -2 & -1 & 0 & 0 & 0 & 0 & 0 & 0 \\ -1 & -1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

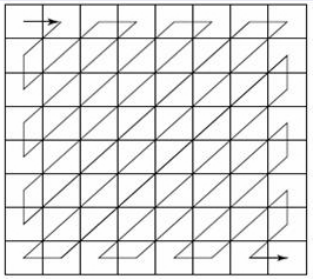
# Coding of the coefficients AC

## Block diagram of JPEG Baseline




## Zig-Zag Scan

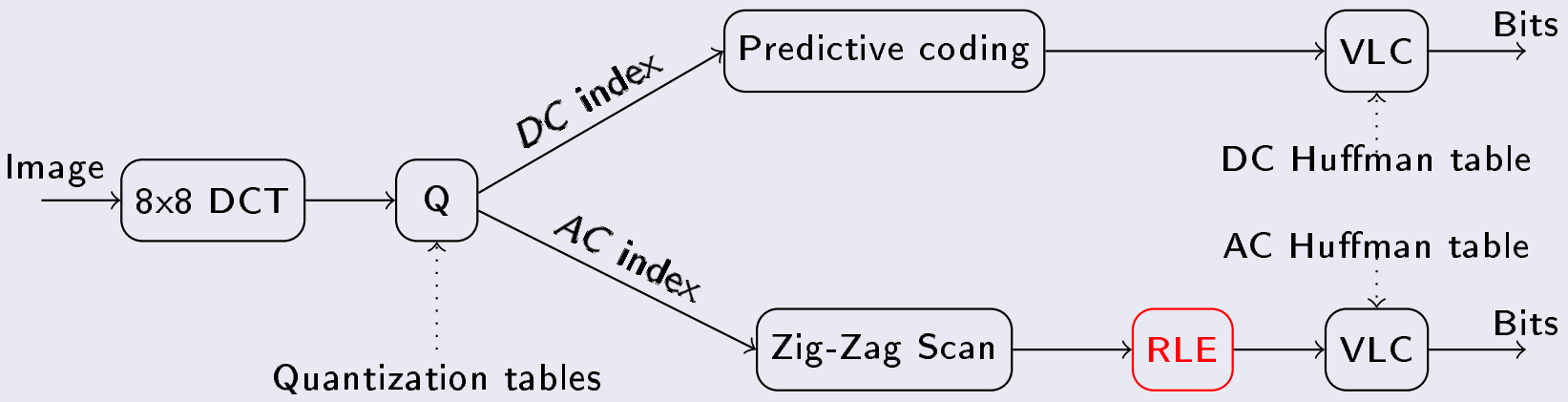
$$F_Q = \begin{bmatrix} XX & 0 & -1 & 0 & 0 & 0 & 0 & 0 \\ -2 & -1 & 0 & 0 & 0 & 0 & 0 & 0 \\ -1 & -1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$



The zig-zag scan gives: 0,-2,-1,-1,-1,0,0,-1,EOB. EOB stands for End Of Block (all subsequent coefficients are zero).

# Coding of the coefficients AC

## Block diagram of JPEG Baseline



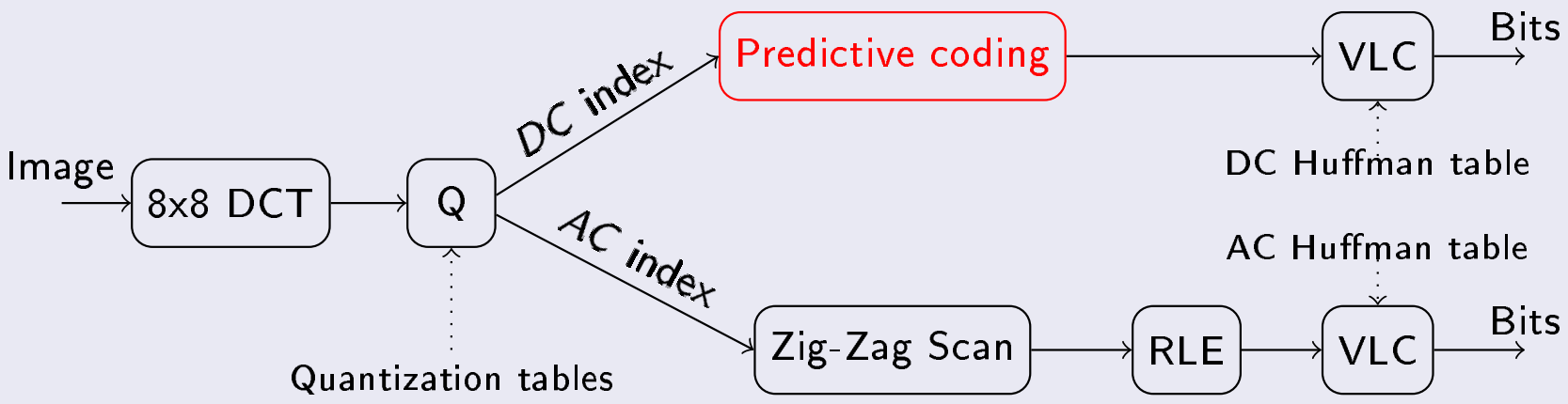

## RLE - Run Length Coding

As many of quantized AC coefficients become zero, they can be very efficientlty encoded by exploiting the run of zeros. The run-length of zeros are identified by the non-zero coefficients. A sequence of identic symbols is called a run. Each run is represented by a single codeword. The sequence 0,-2,-1,-1,-1,0,0,-1,EOB of the previous example is thus encoded:

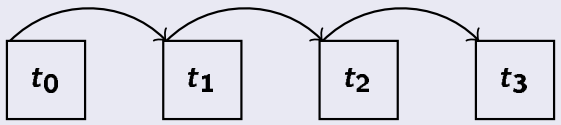
(1,-2);(0,-1);(0,-1);(0,-1);(2,-1);EOB.

# Coding of the coefficients DC (zero frequency)

## Block diagram of JPEG Baseline




## DPCM - predicitve coding




$$DPCM(t_1) = DC_{t_1} - DC_{t_0}$$

To take into account the spatial redundancy of the average luminance.

# Example

## Example (JPEG compression)

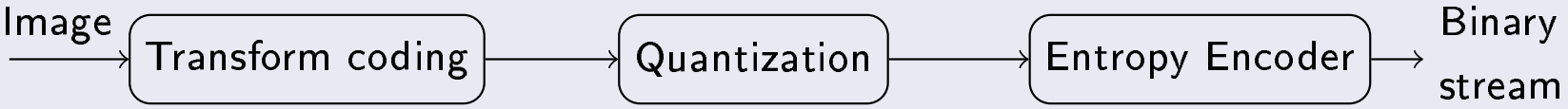

(a) $CR = 2.6 : 1$ (b) $CR = 23 : 1$ (c) $CR = 144 : 1$

$$CR = \text{Compression rate} = \frac{\text{Nb bits of input}}{\text{Nb bits of output}}$$

**Extracted from http://en.wikipedia.org/wiki/JPEG .**

# Summary

## General layout of the JPEG coding scheme




- Still color picture coding;
- RGB to YUV color-space conversion;
- 2D DCT on block 8x8;
- Quantization by table quantization (Quality factor);
- RLE and Huffman code the non-zero quantized DCT coefficients.

# MPEG-2

# Brief history

MPEG = Moving Picture Experts Group
Part of the International Standards Organization (ISO)

## Targeted applications

MPEG-2 is dedicated for digital storage media and broadcast. The targeted bit rate is in the range 1 to 20 Mbps:

- 1 to 6Mbps: digital television broadcastion (SD);
- 5 to 8 Mbps: DVD video;
- 10 to 20Mbps: digital television broadcastion (HD).

The work started in November, 1991 and the standard (MPEG-2 ISO/IEC 13818) has been published in November, 1995.

# Brief history

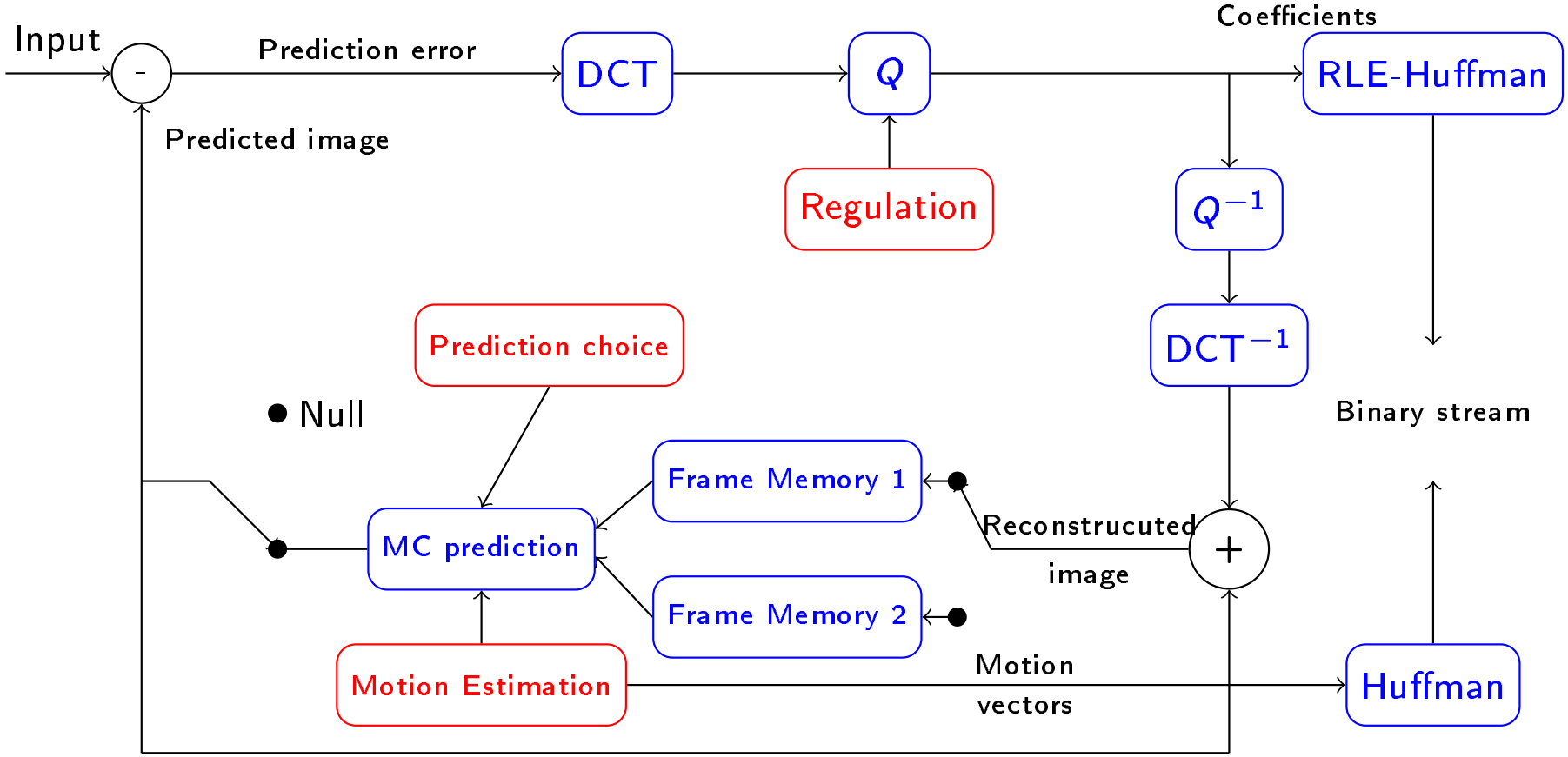
MPEG-2 (ISO/IEC 13818):

- 13818-1: Systems;
- 13818-2: Video;
- 13818-3: Audio;
- 13818-4: Conformance;
- 13818-5: Software;
- 13818-6: Digital Storage Media;
- 13818-7: Non-Backward Compatible Audio;
- ...

MPEG-2 = MPEG-1 (ISO/IEC 11172)
+ Interlace Tools (Field picture, DCT, prediction...)
+ Profiles & Levels

# Motion-compensated hybrid coding scheme

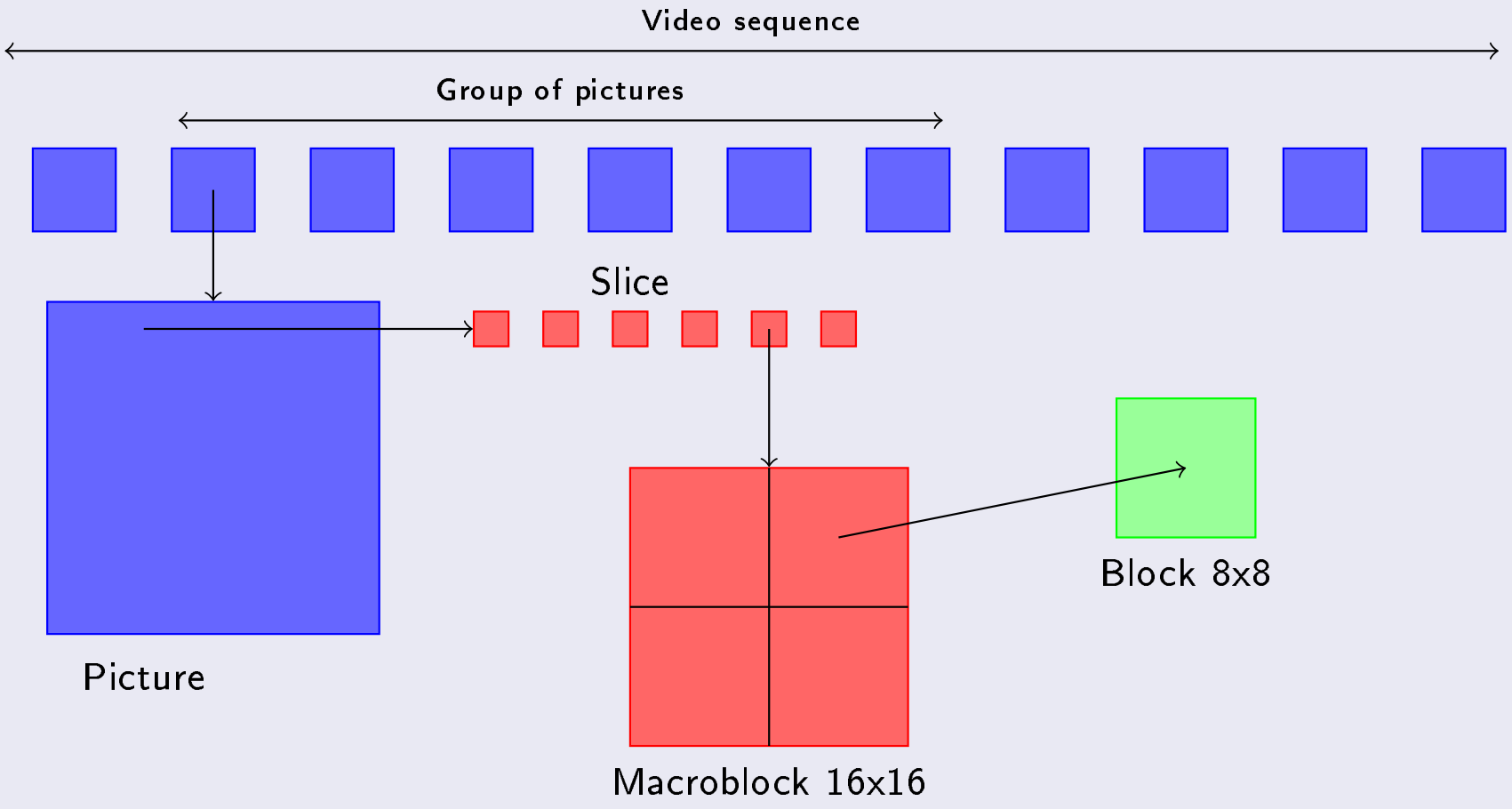
Typical MPEG Encoder Structure




Open to invention and proprietary techniques

# Hierarchical syntax

## MPEG structure



# Slices

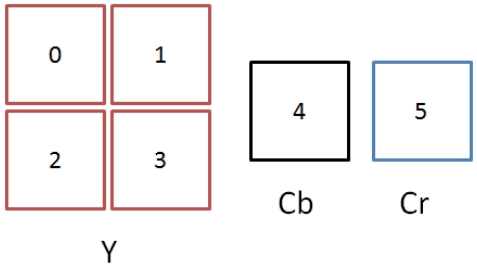
**Definition (Slice)**

A slice is composed of an arbitray number of consecutive macroblocks.

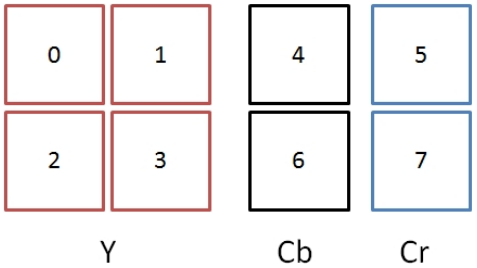
- The first and last macroblocks of a slice shall not be skipped macroblocks;
- Every slice shall contain at least one macroblock;
- Slices shall not overlapp;
- The position of slices may change from picture to picture;
- The first and last macroblock of a slice shall be in the same horizontal row of macroblocks.

# Macroblock

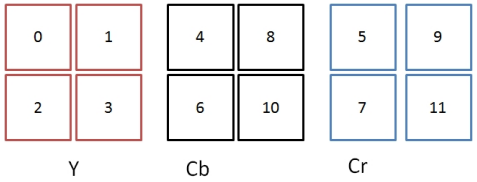
Three macroblock structures:




(a) 420




(b) 422

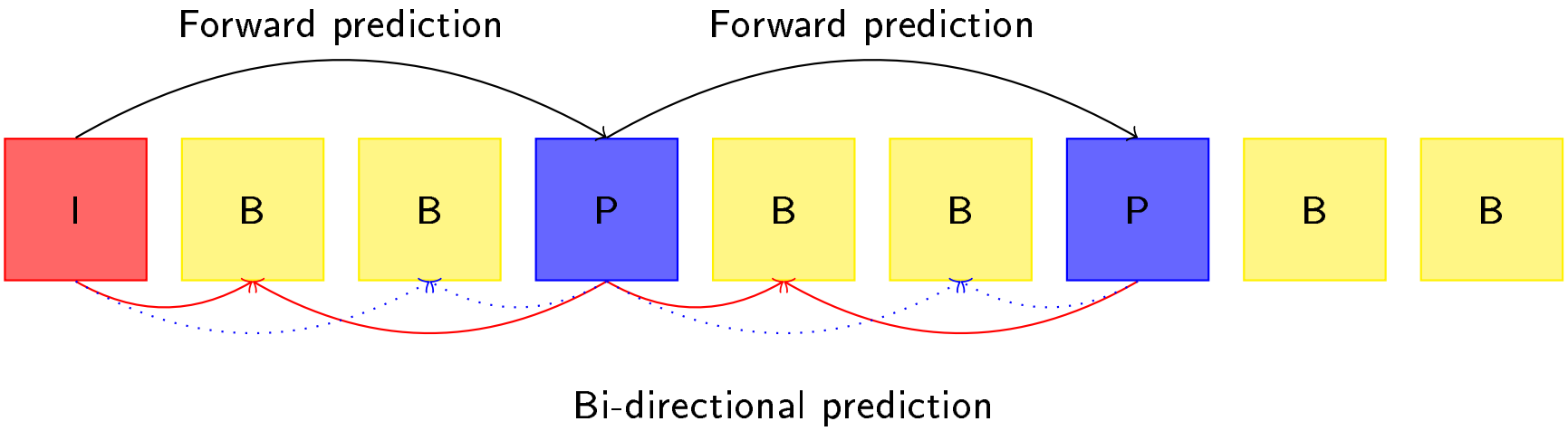



(c) 444

# Types of pictures

## I, P, and B pictures

- Intra picture (I): intra-frame spatial DCT;
- Predicted picture (P): DCT with forward prediction (residual coding);
- Bi-directional picture (B): DCT with bi-directional prediction (residual coding).




These three types of pictures are used to form the GOP (Group of Pictures).

# Group of Pictures

## GOP N-M

N is the I picture interval and M is the anchor picture interval (M-1 B pictures between anchor pictures).

- A GOP must contain a I picture;
- B pictures must be located between anchor pictures (I or P);
- A GOP must start with a I picture in coding order;
- A GOP must start with a I or B picture and must end with an I or P picture in display order.

## Example (GOP in coding order)

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GOP 1-1 | I | I | I | I | I | I | I | I | I | | | |
| GOP 6-2 | I | B | P | B | P | B | I | B | P | | | |
| GOP 12-3 | I | B | B | P | B | B | P | B | B | P | B | B |

# Group of Pictures

## Display and coding order

- Display order: input of the encoder and output of the decoder;
- Coding order: output of the encoder and input of the decoder.

Display order (input encoder)

$B_1$ $B_2$ $I_1$ $B_3$ $B_4$ $P_1$ $B_5$ $B_6$ $P_2$ $B_7$ $B_8$ $P_3$ $B_9$

Coding order (output encoder)

$I_1$ $B_1$ $B_2$ $P_1$ $B_3$ $B_4$ $P_2$ $B_5$ $B_6$ $P_3$ $B_7$ $B_8$

Display order (output decoder)

$B_1$ $B_2$ $I_1$ $B_3$ $B_4$ $P_1$ $B_5$ $B_6$ $P_2$ $B_7$ $B_8$

Time

# Input Format

## YUV 4:2:0

- Color space *YUV* 4:4:4:

$$\begin{bmatrix} Y \\ U \\ V \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ -0.1687 & -0.3313 & 0.5 \\ 0.5 & -0.4187 & -0.813 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

(d) Source (e) Y (f) U (Blue) (g) V (Red)

- Format 4:2:0 (Human eyes are less sensitive to the chrominance than to the luminance):

(a) Source (b) Y (c) U (d) V

# Interlaced format

## Progressive vs Interlaced

- Progressive: one time instant is required to acquire the picture;
- Interlaced: two time instants are required to acquire the picture (Two fields, field period = frame period / 2).

$t$
Frame

$t$
Field 1

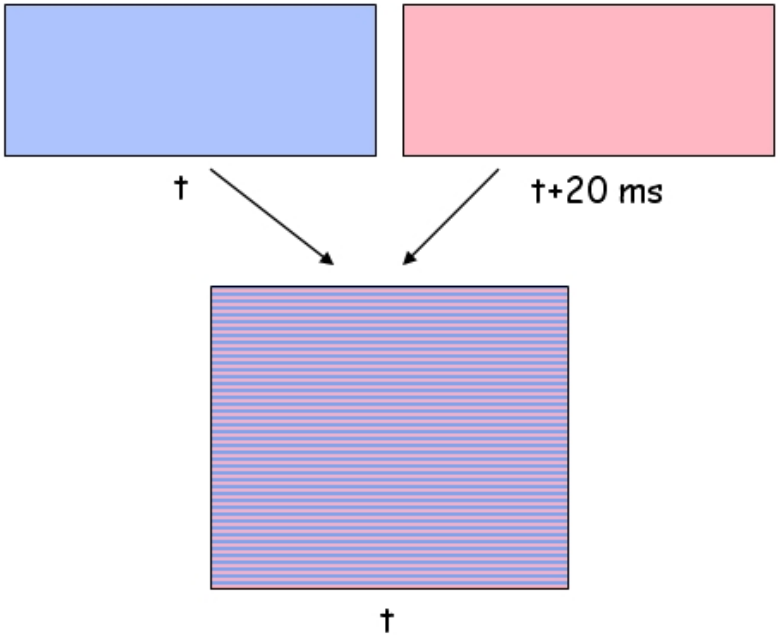
$t + \delta$
Field 2

# Interlaced format

## Progressive vs Interlaced

Interlaced scanning is a way to save bit rate (almost invisible for us due to the vision persistence and our critical flicker frequency).

- Interlaced scanning provides a high vertical resolution for still scenes (similar to progressive format);
- Artifacts for moving areas.




# DCT

## Orthogonal transform of 8x8 pixel block into 8x8 frequency coefficient matrix

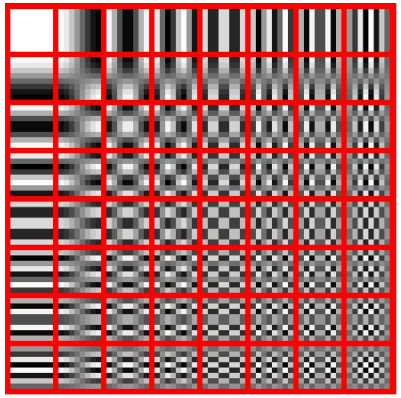
The DCT of a block $I$ of size $NxN$ is defined by:

$$DCT(I)(n,m) = \frac{2}{N}\lambda(n)\lambda(m)\sum_{i=0}^{N-1}\sum_{j=0}^{N-1} cos\frac{\pi(2i+1)n}{2N} cos\frac{\pi(2j+1)m}{2N} I(i,j)$$

The inverse DCT is defined by:

$$I(x,y) = \frac{2}{N}\sum_{m=0}^{N-1}\sum_{n=0}^{N-1} \lambda(n)\lambda(m) cos\frac{\pi(2x+1)n}{2N} cos\frac{\pi(2y+1)m}{2N} DCT(I)(n,m).$$

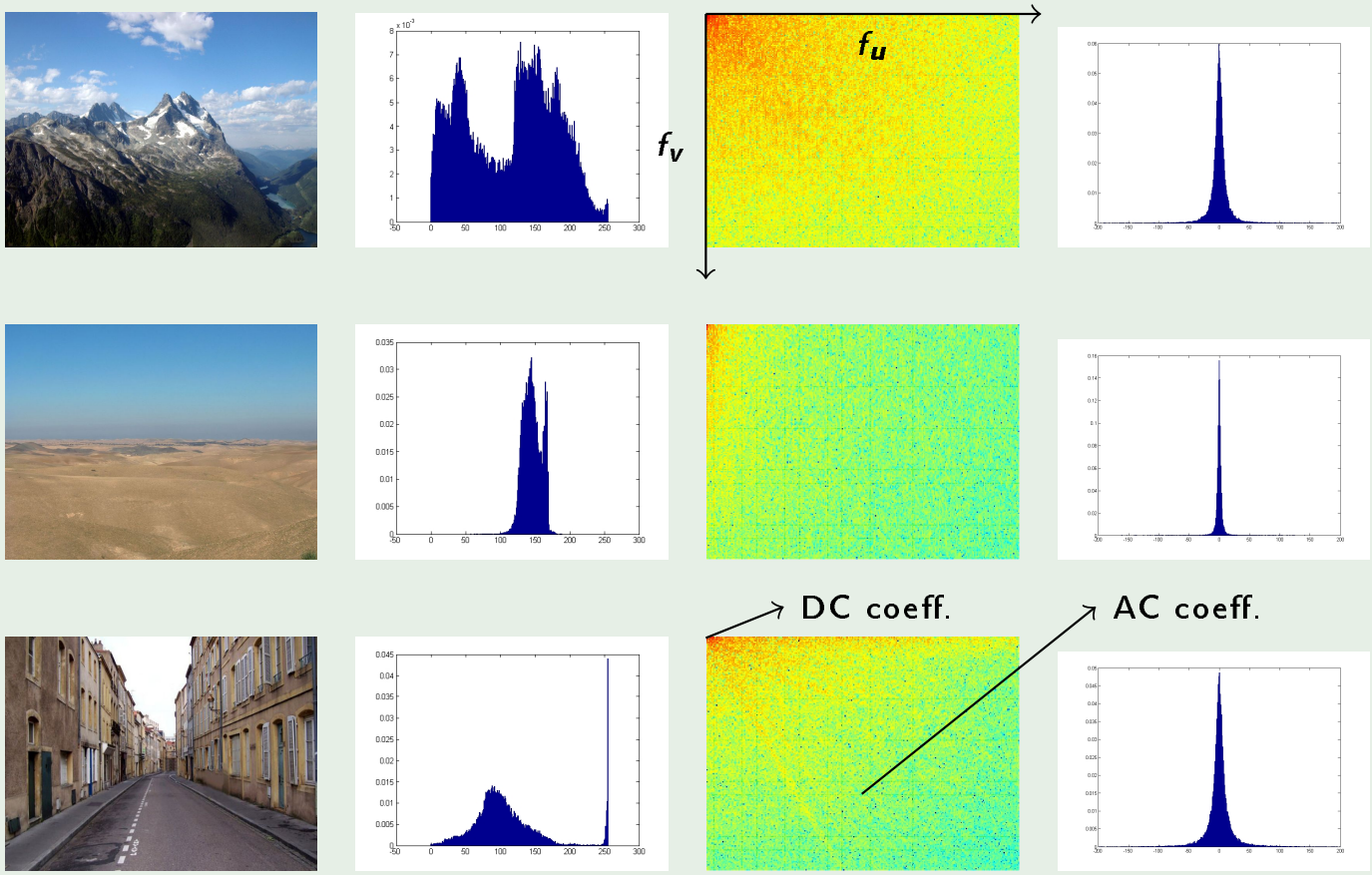
$$\lambda(t) = \begin{cases} \frac{1}{\sqrt{2}} & \text{if } t = 0 \\ 1 & \text{otherwise} \end{cases}$$



Two dimensional DCT basis. The source data (8x8) is transformed to a linear combination of these 64 frequency squares.

# DCT

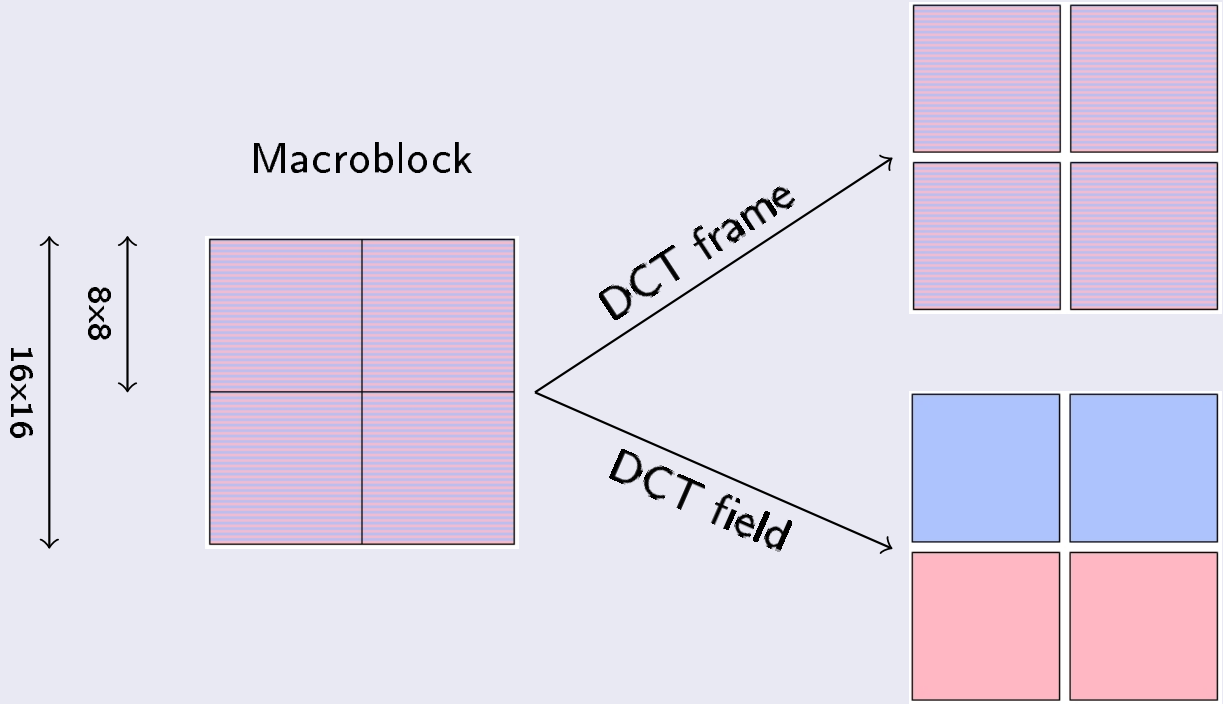
## Example


$f_u$
$f_v$
DC coeff.
AC coeff.
Original
Normalized histogram
DCT
Dist. DCT coeff.

# Field/frame DCT

## Frame or field DCT?

Frame DCT is the tansformation mode used in MPEG-1 as illustrated below. Field DCT is applied on the field (see below):




You have the choice between these two different DCT. What is the general idea to be efficient?

# Quantization


## Definition (Scalar quantization)

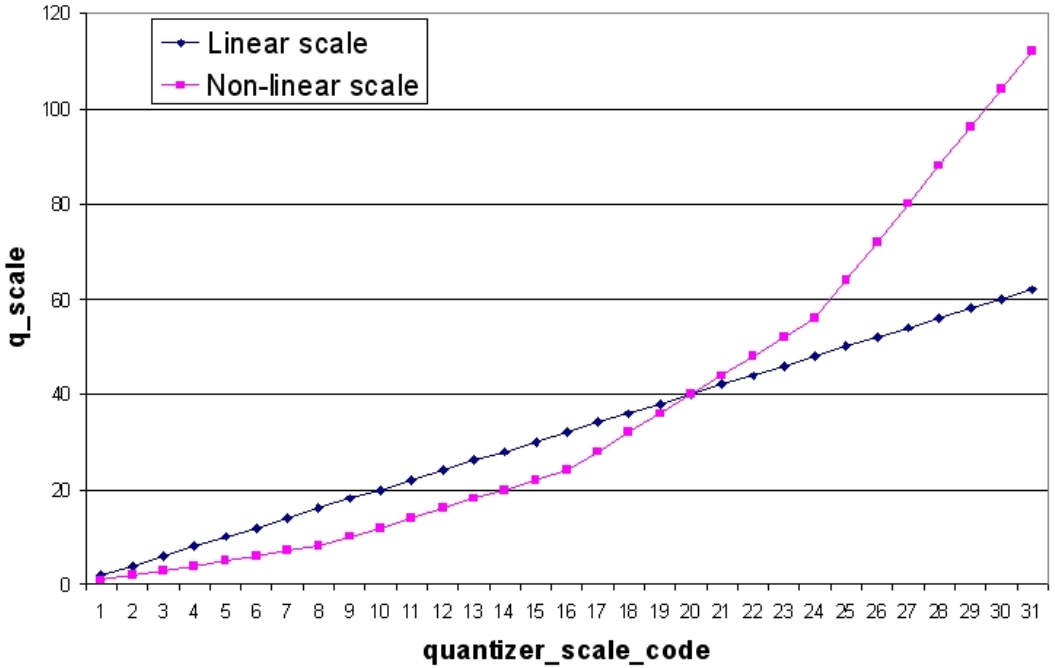
$$\begin{array}{ccc} Q : \mathcal{X} & \longmapsto & \mathcal{C} = \{y_i, i = 1, 2, ...N\} \\ x & & Q(x) = y_i \end{array}$$

- $N$ is the number of quantization level;
- $\mathcal{X}$ discret;
- $\mathcal{C}$ is always discret (codebook,dictionnary);
- $card(\mathcal{X}) > card(\mathcal{C})$;
- As $x \neq Q(x)$, we will lost some information (lossy compression).

# Quantization


## Two different quantizer scale

- Linear quantizer scale (qscaletype=0)
- Non-linear quantizer scale (qscaletype=1)



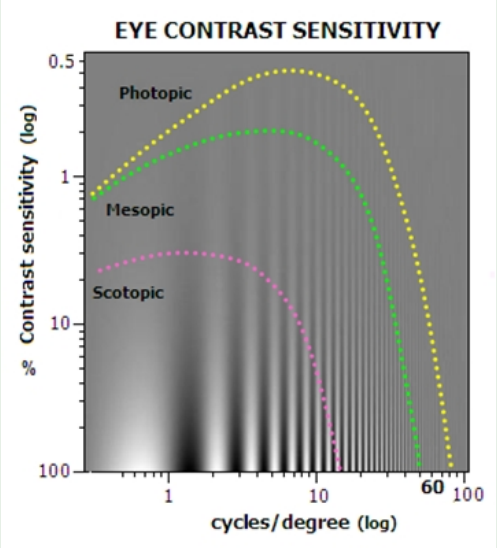
# Quantization

## Quantization matrix

- Possibility to use quantization matrix to weight the quantized coefficients.
- This matrix is based on the Contrast Sensitivity Function (coarser quantization of high spatial frequencies without visual annoyance).
- Default matrices are specified by the standard. Therefore, it is not necessary to send them. Not the case for proprietary matrix.

## Example (Illustration of our visual sensitivity (CSF))

Psychophysic experiments seek to determine whether the subject can detect a stimulus.



# Quantization

## Default quantization matrix

Default matrix for intra coding:

$$Q_I = \begin{bmatrix} 8 & 16 & 19 & 22 & 26 & 27 & 29 & 34 \\ 16 & 16 & 22 & 24 & 27 & 29 & 34 & 37 \\ 19 & 22 & 26 & 27 & 29 & 34 & 34 & 38 \\ 22 & 22 & 26 & 27 & 29 & 34 & 37 & 40 \\ 22 & 26 & 27 & 29 & 32 & 35 & 40 & 48 \\ 26 & 27 & 29 & 32 & 35 & 40 & 48 & 58 \\ 26 & 27 & 29 & 34 & 38 & 46 & 56 & 69 \\ 27 & 29 & 35 & 38 & 46 & 56 & 69 & 83 \end{bmatrix}$$

Non intra matrix:

$$Q_{NI} = \begin{bmatrix} 16 & 16 & 16 & 16 & 16 & 16 & 16 & 16 \\ 16 & 16 & 16 & 16 & 16 & 16 & 16 & 16 \\ 16 & 16 & 16 & 16 & 16 & 16 & 16 & 16 \\ 16 & 16 & 16 & 16 & 16 & 16 & 16 & 16 \\ 16 & 16 & 16 & 16 & 16 & 16 & 16 & 16 \\ 16 & 16 & 16 & 16 & 16 & 16 & 16 & 16 \\ 16 & 16 & 16 & 16 & 16 & 16 & 16 & 16 \\ 16 & 16 & 16 & 16 & 16 & 16 & 16 & 16 \end{bmatrix}$$

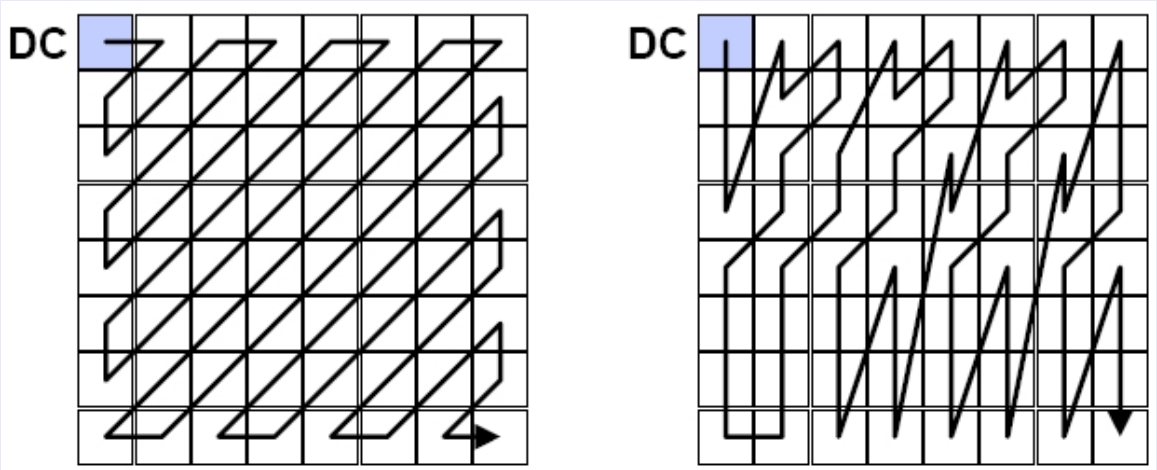
Non-intra quantization Matrix (MPEG-2 Test Model 5)

$$Q_{NI} = \begin{bmatrix} 16 & 17 & 18 & 19 & 20 & 21 & 22 & 23 \\ 17 & 18 & 19 & 20 & 21 & 22 & 23 & 24 \\ 18 & 19 & 20 & 21 & 22 & 23 & 24 & 25 \\ 19 & 20 & 21 & 22 & 23 & 24 & 25 & 27 \\ 20 & 21 & 22 & 23 & 25 & 26 & 27 & 28 \\ 21 & 22 & 23 & 24 & 26 & 27 & 28 & 30 \\ 22 & 23 & 24 & 26 & 27 & 28 & 30 & 31 \\ 23 & 24 & 25 & 27 & 28 & 30 & 31 & 33 \end{bmatrix}$$

# Zig-zag scan

## Two scan patterns are used in MPEG-2

- Normal zig-zag scan as defined in MPEG-1 (below on the left);
- Alternate zig-zag scan. This new scan pattern can be used when the frame DCT is applied on an interlaced video. There are more DCT coefficients for the highest vertical frequencies.



# Macroblock coding

## I pictures

- All macroblocks are encoded in INTRA.

## P pictures

- Macroblocks can be encoded in INTRA;
- Macroblocks can be encoded in INTER (with a forward prediction);

## B pictures

- Macroblocks can be encoded in INTRA (fallback mode);
- Macroblocks can be encoded in INTER:
  - forward prediction;
  - backward prediction;
  - bidir prediction.

# MC Prediction

Motion estimation and Motion compensation (MC).

An image of the sequence is defined by $I(x, y, t)$. $(x, y)$ represents the spatial coordinates whereas $t$ represents the time.

**Fundamental assumption**

The image intensity is conserved along trajectories !!!

$$I(x, y, t) = I(x + \delta_x, y + \delta_y, t + \delta_t)$$

Classification:

- Feature / Region Matching: the motion field is estimated by correlating features (edge, intensity...) from one frame to another (Block Matching, Phase correlation...);
- Gradient-based methods: the motion field is estimated by using spatio-temporal gradients of the image intensity distribution (Pel-recursive method, the Horn-Schunck algorithm...).

# MC Prediction

## Motion models

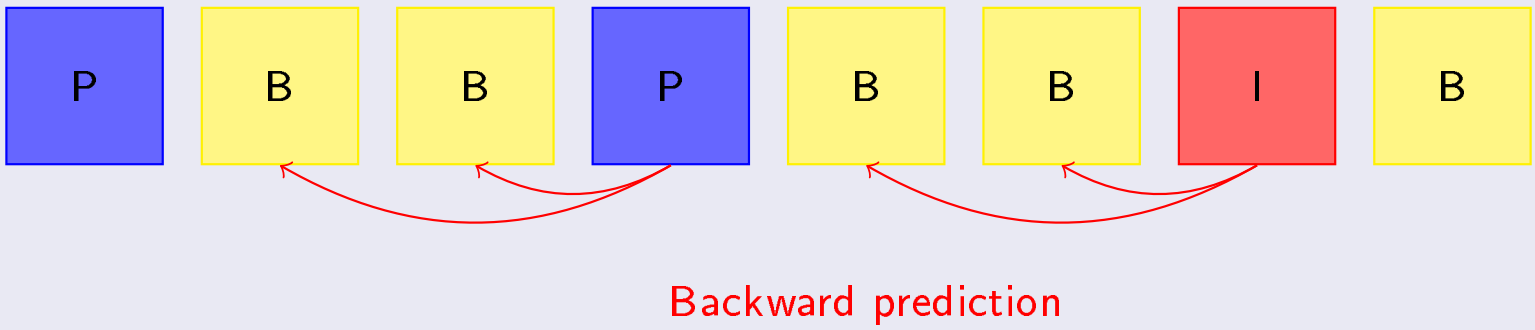
Motion model uses in MPEG-2 is 2D Translation (2 parameters, this model dealing only with the translation is used in video coding (works quite well because motion between concecutive frames is rather small)).

$$\begin{bmatrix} u \\ v \end{bmatrix} = \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} dx \\ dy \end{bmatrix}$$

Rotation, scaling and deformation are not taken into account to evaluate the displacement.

# MC Prediction

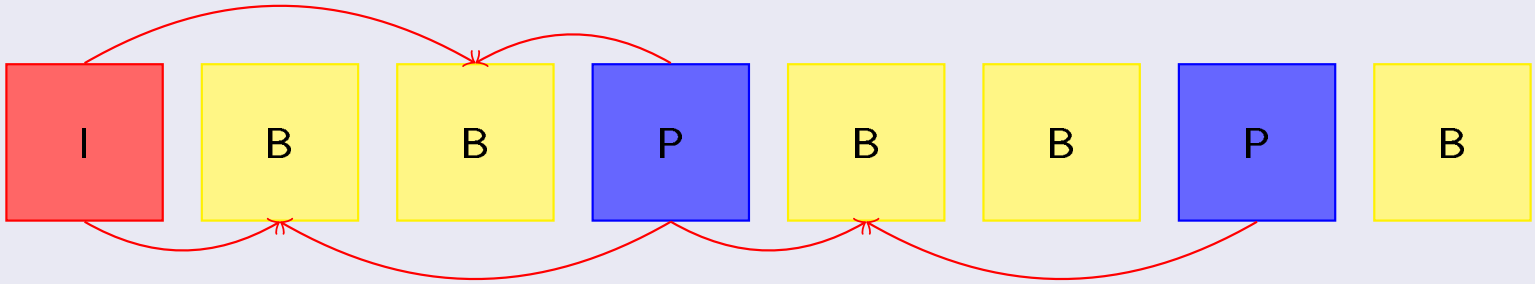
## Backward prediction




- A backward-predicted macroblock depends on decoded pixels from the immediately following anchor picture;
- This mode can only be used to encode macroblocks in B pictures.

# MC Prediction

## Bi-directional prediction




Bi-directional prediction

- A bi-directionally-predicted macroblock depends on decoded pixels from the anchor pictures immediately following and immediately preceding;
- This mode can only be used to encode macroblocks in B pictures.

# MB modes

## I picture

- Intra:
  - → DCT frame
  - → DCT field

## P picture

- Forward frame:
  - → DCT frame
  - → DCT field
- Forward field:
  - → DCT frame
  - → DCT field
- Intra:
  - → DCT frame
  - → DCT field
- NoMC:
  - → Skip MB if and only if the quantized coefficients are nul and the motion vector is null.

# MB modes

## B picture

- Forward frame:
  - → DCT frame
  - → DCT field
- Forward field:
  - → DCT frame
  - → DCT field
- Backward frame:
  - → DCT frame
  - → DCT field
- Backward field:
  - → DCT frame
  - → DCT field
- Bidir frame:
  - → DCT frame
  - → DCT field
- Bidir field:
  - → DCT frame
  - → DCT field
- Intra:
  - → DCT frame
  - → DCT field
- Skip MB:
  - → the quantized coefficients are nul;
  - → the motion vector is null.