Still Image Compression Standards

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Content

Definitions of some key terms

DCT: Discrete Cosine Transform.

JPEG: Joint Photographic Expert Group.

JPEG200: the current standard that emphasizes lossy compression of images.

JPEG-LS: An upcoming standard that focuses on lossless and near-lossless compression of still images

JBIG: Joint Bilevel Image Group.

Wavelets: A time-scale decomposition that allow very efficient energy compaction in images.

INTRODUCTION

What is image compression?

Image data can be compressed without significant degradation of the visual (perceptual) quality b/c image contain a high degree of:

- Spatial redundancy
- Spectral redundancyPsycho-visual redundancy

Why Standardization?

Compression is one of the technologies that enable the multimedia revolution to occur.

However for technology to be effective there has to be some degree of standardization so that the equipment designed by different vendors can talk to each other.

Type of still image compression standards:

- (JPEG) Joint Photographic Experts Group
  a- Lossy copression of still images
  b- Lossless compression of still images
- (JBIG) Joint Bilevel Image Group
- (GIF) Graphics Interchange Format. de facto
- (PNG) Portable Network Graphics. De facto

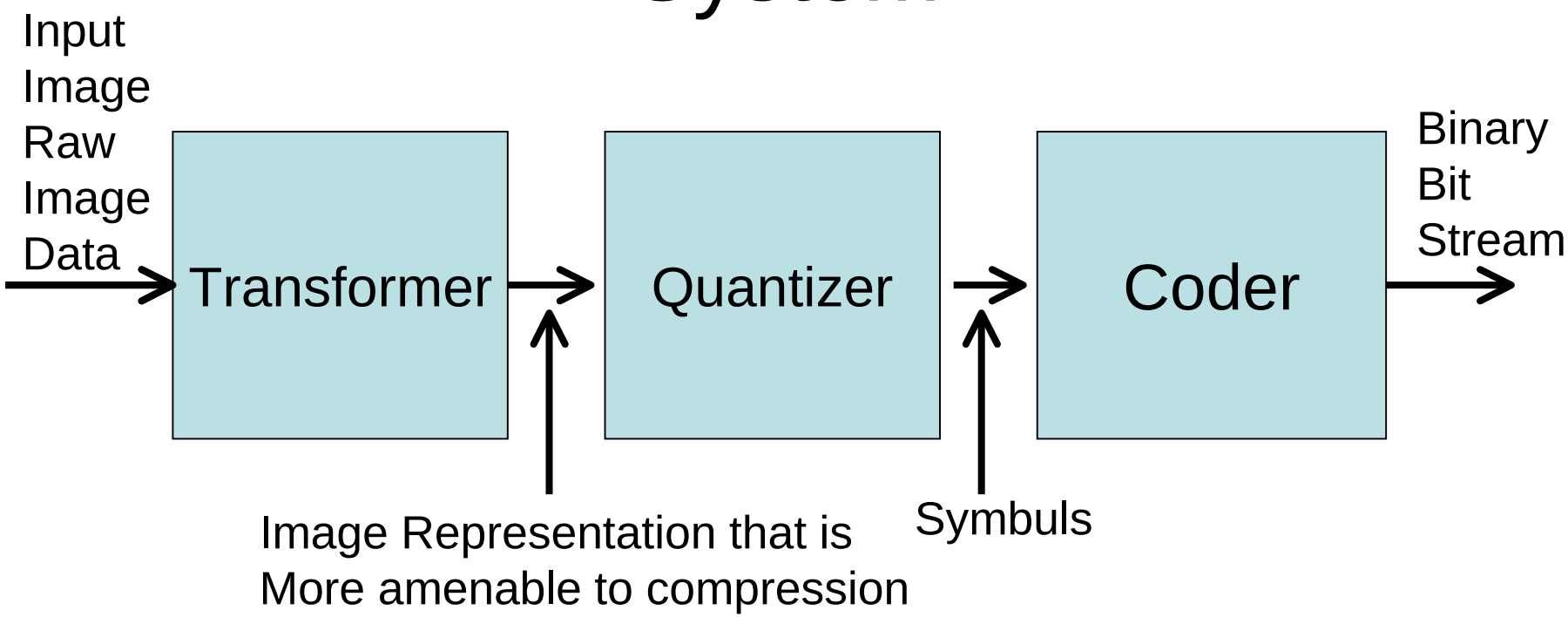
Compression scheme

In any compression scheme there are:

Step 1- Removal of redundancy based on implicit assumption about the structure in the data

Step 2- Assignment of binary codewords to the information deemed nonredundant.

Typical Image Compression System



Transformer

Applies a one-to-one transformation to the input image data.

Output of the transformer is an image representation which is more amenable to efficient compression than the raw image data.

Quantizer

Generates a limited number of symbols that can be used in the representation of the compressed image.

Quantization is a many-to-one mapping which is irreversible.

Coder

Coder assigns a cod word, a binary bit stream , to each symbol at the output of Quantization.

The coder may employ a Fixed-Length or Variable-Length codes. VLC, also known as Entropy Coding, assigns a codeword in such a way as to minimize the average length of the binary representation of the symbols.

Lossy Compression System

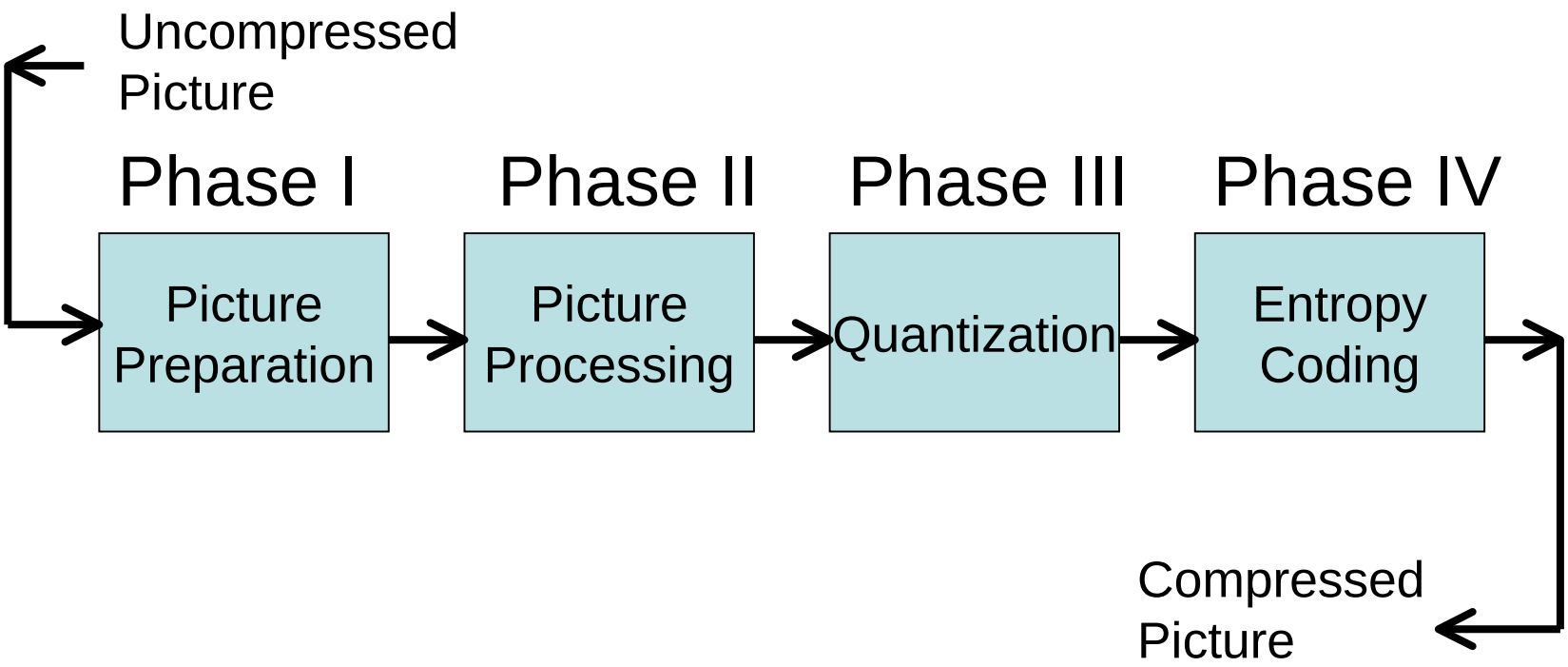
Lossy CS, which aim at obtaining the best possible fidelity for a given bit-rate (or minimizing the bit-rate to achieve a given fidelity measure).

Lossless Compression System

Lossless CS which aim at minimizing the bit rate of the compressed output without any distortion of the image

The decompressed bit-stream is identical to original bit-stream.

Basic Units of Encoder



JPEG Standard

JPEG refers to a wide variety of possible image compression approaches that have been collected to a single standard that include:

1- Lossy component

2- Losless component

3- Entropy coding

   a- Huffman coding

   b- Binary arithmetic coding

Huffman Coding

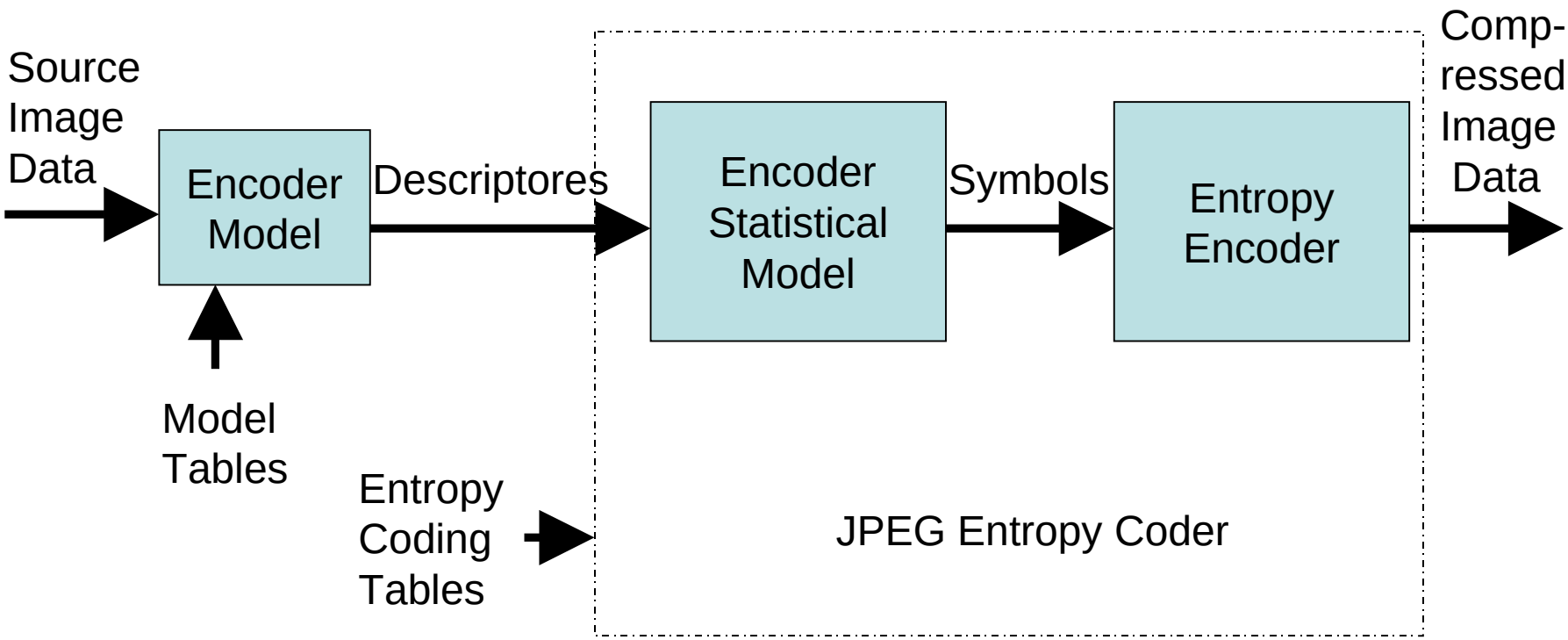
Huffman coding is based on the frequency of the occurrence of a character (or a octet in the case of images).

The principle is to use lower number of bits to encode the character that occurs more frequently. The codes are stored in a codebook.

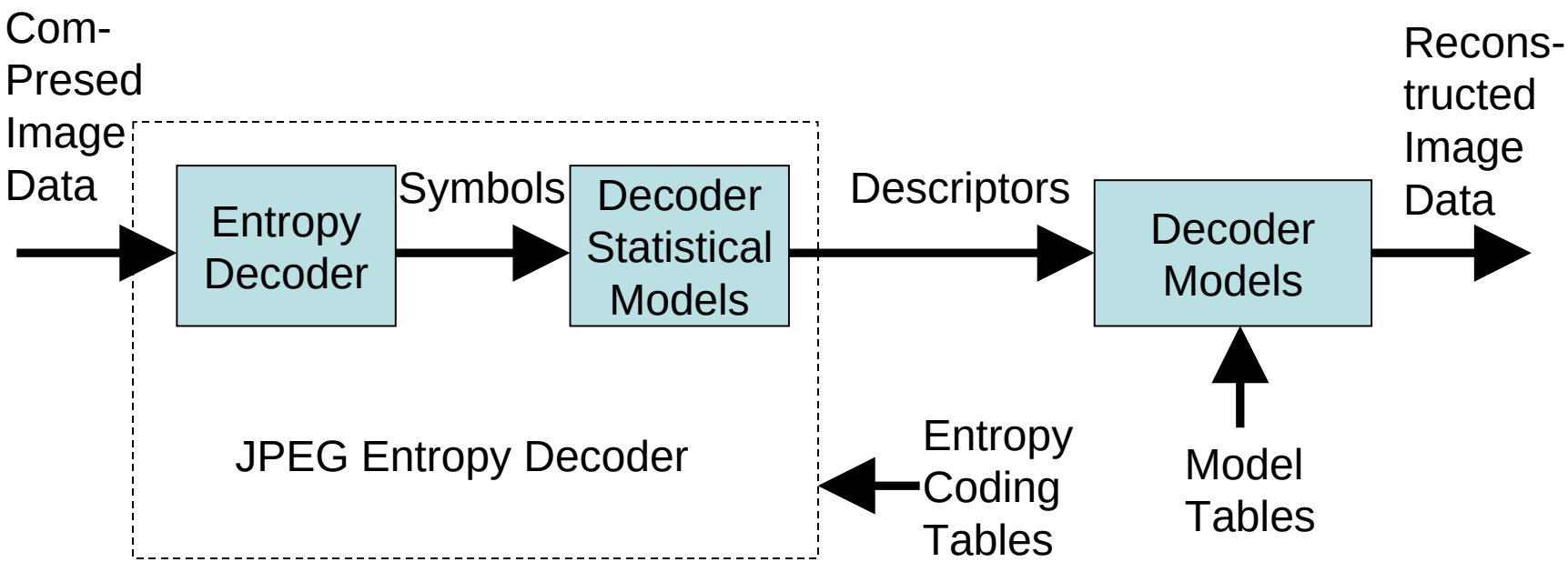
The codebook maybe constructed for every image or for a set of images.

Example: Character: a b c d e Frequency: 15 3 2 7 18 Cod: 1100 0101011 0010011 01000 1011

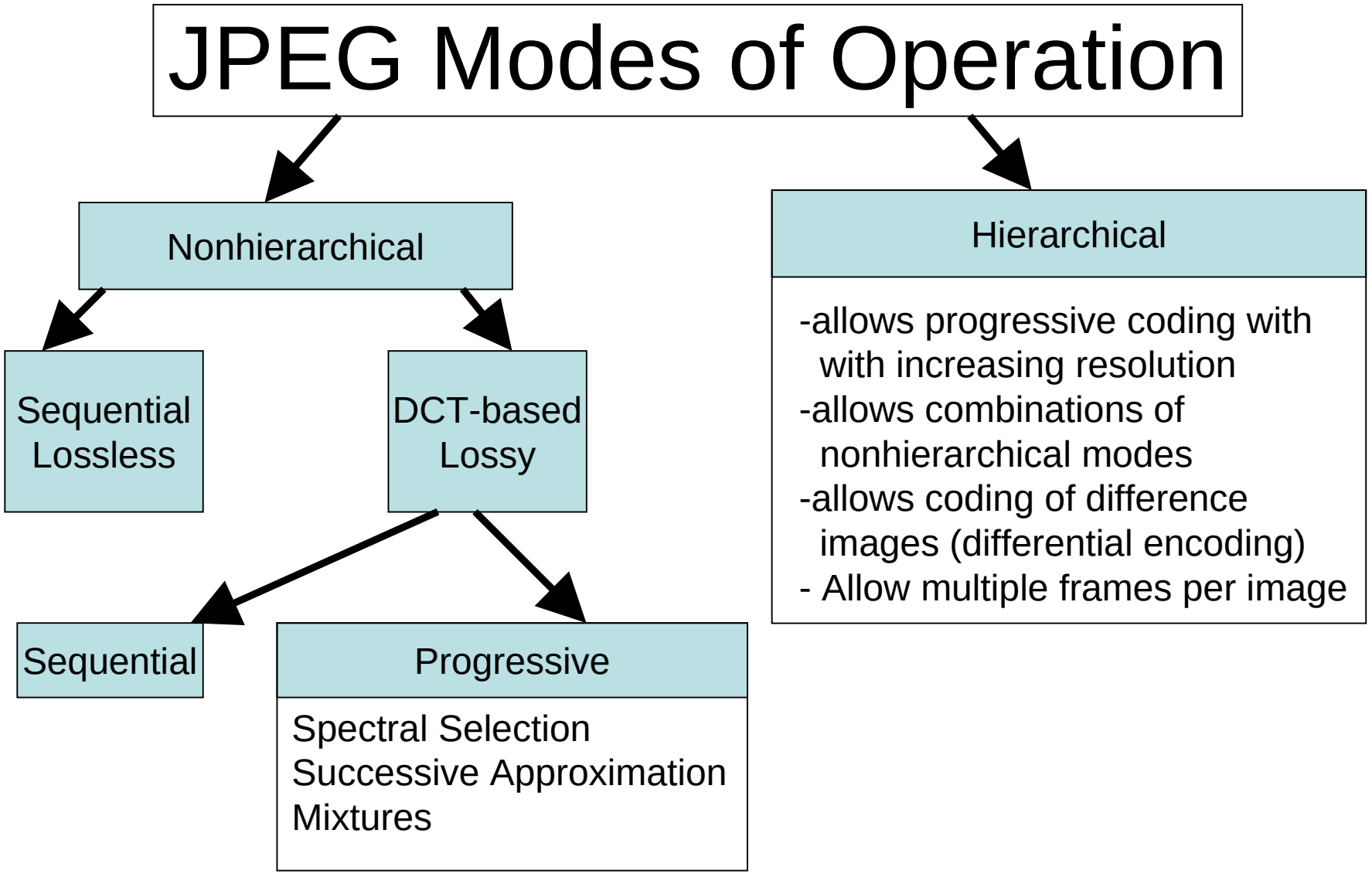
General JPEG encoder models



JPEG Lossy Compression



JPEG Modes of Operation



DCT- Based Image Compression

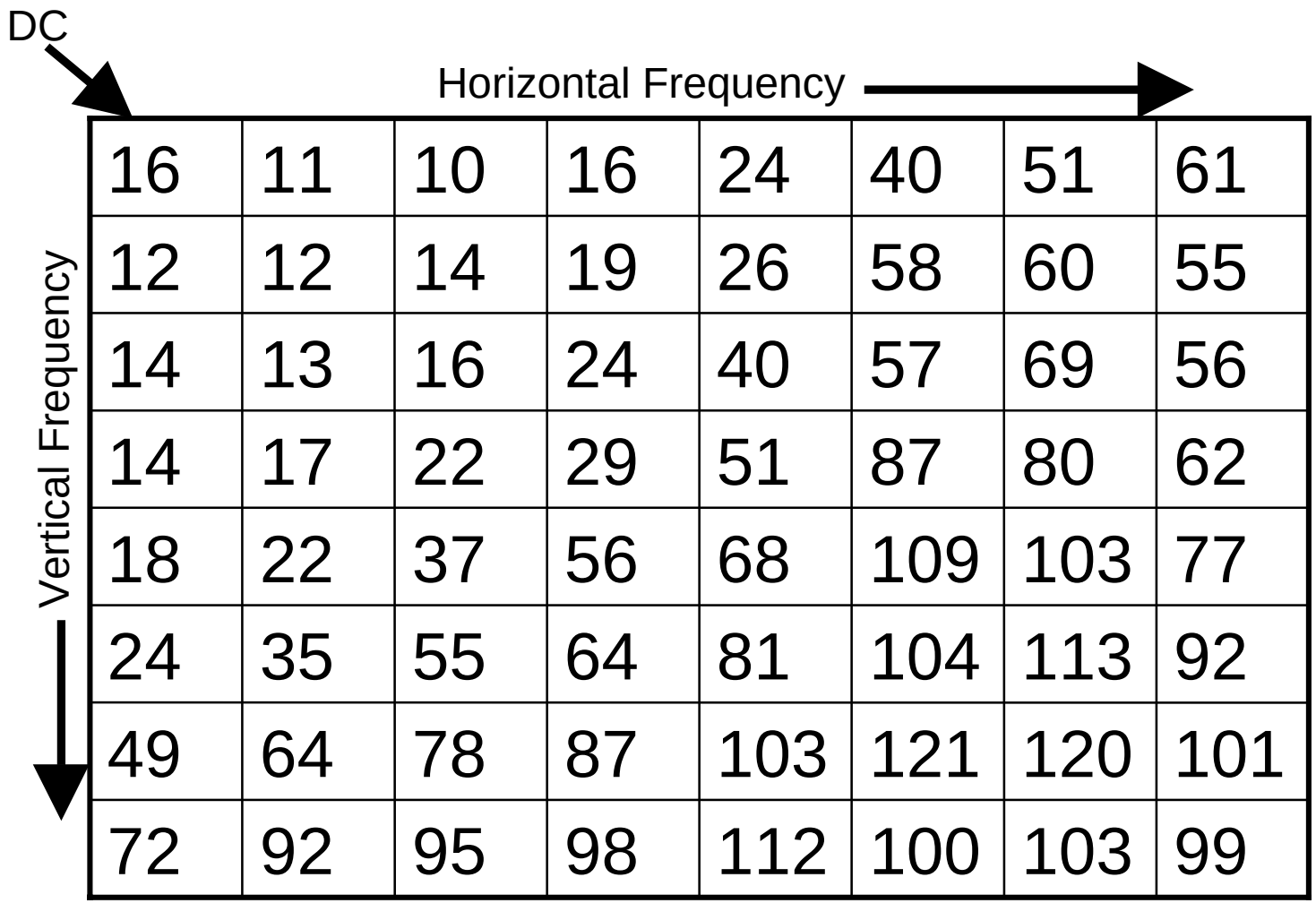
The basis for JPEG´s lossy compression is two-dimensional DCT.

The image is broken into 8 x 8 blocks on which the transform is computed.

Image compression is obtained through quantization of these DCT coefficients to a small set of values.

Values are entropy coded and stored as a compressed version of the image.

An example of quantization table for the luminance DCT coefficients



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
72	92	95	98	112	100	103	99

Zigzag Scan Order for 8 x 8 DCT Coefficients

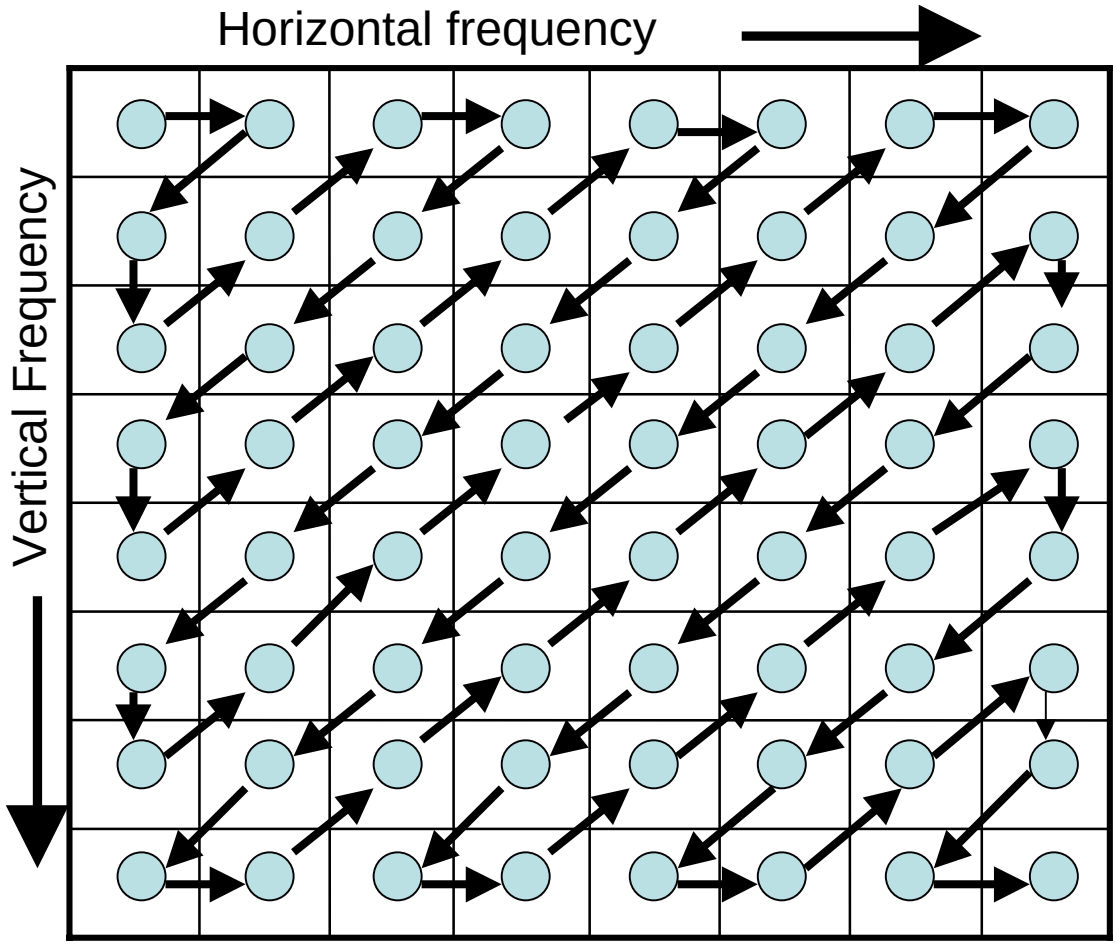


Fig. 5.5

Sequential Transmision / Progressive Transmission

In sequential transmision, the entire image is compressed using 8x8 blocks, scaning the image from left to right and top to bottom.

The full precision-compressed representation is provided as the image is decoded and reconstructed block by block.

Syntax for nonhierarchical JPEG data

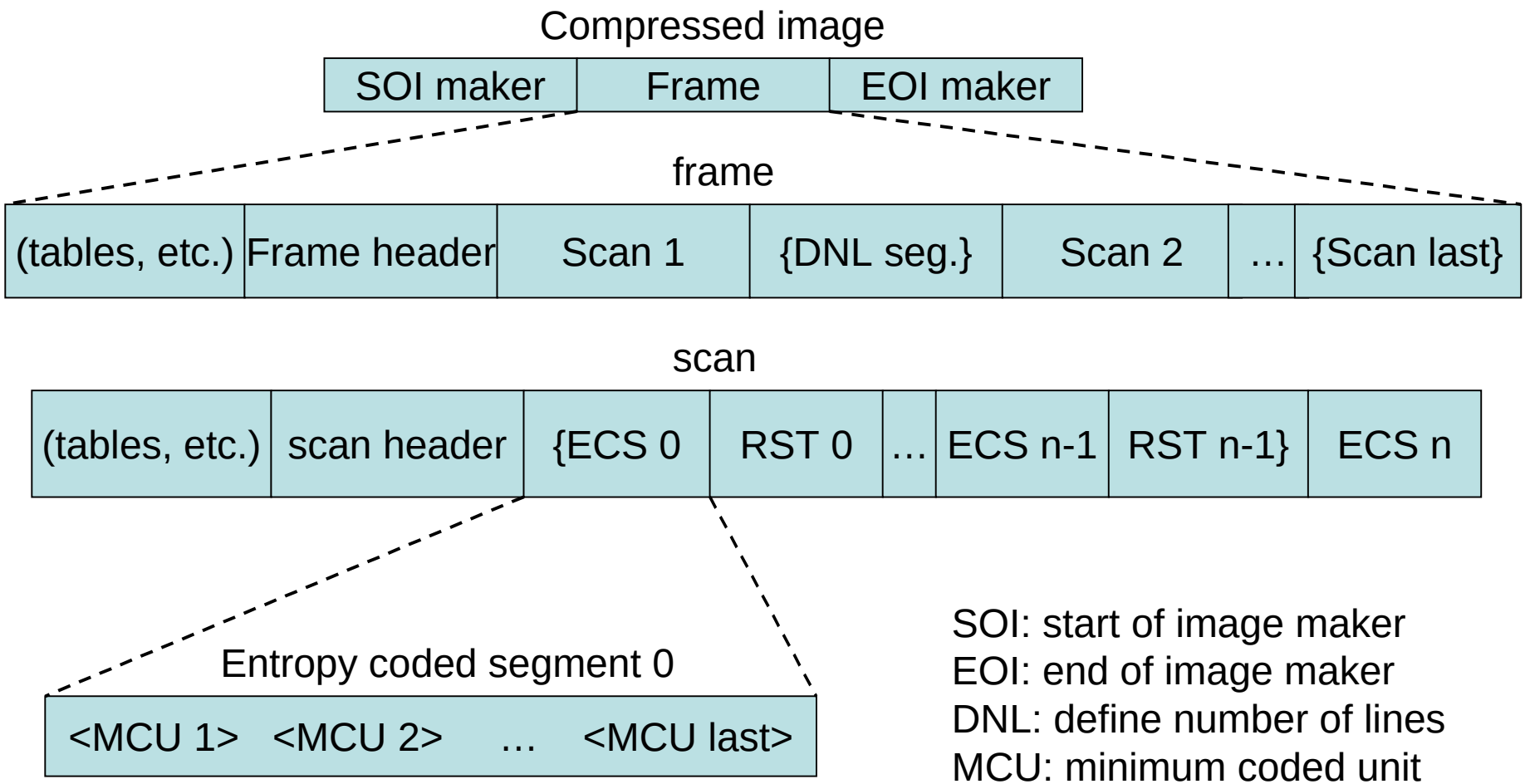


Fig. 5.6

General Syntax and Data Ordering

Fig. 5.6 illustrates the general syntax for JPEG

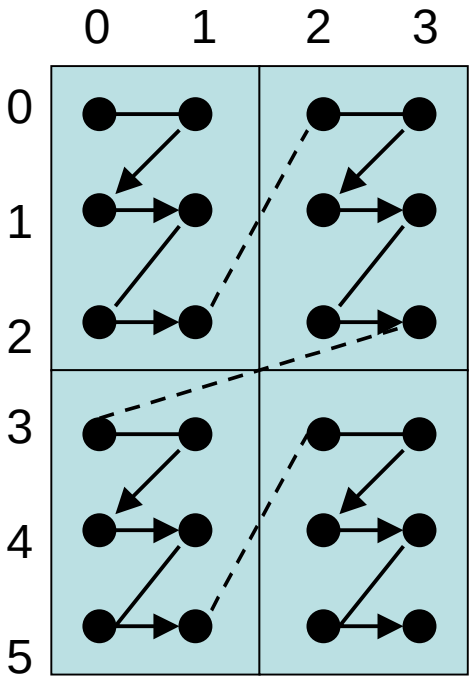
Why JPEG is a common standard?

- JPEG allows multiple components for images .Example color image.
- It allows multiple components of a image to be interleaved or noninterleaved.
- JPEG defines sampling factors for the horizontal and vertical dimensions of each scan component.
- Individual portion of a image with multiple components can be reconstructed with minimum buffering. Fig. 5.7

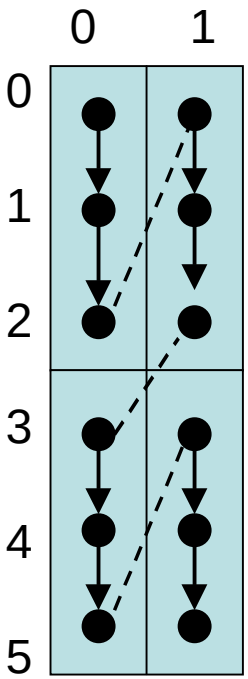
The element specified in JPEG S

- A encoder
- A decoder
- A interchange format

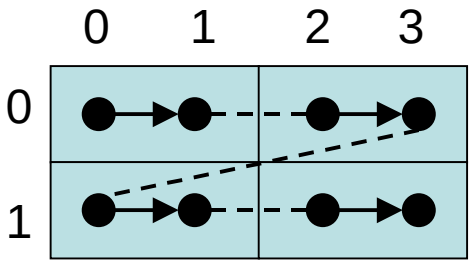
Order for data interleaving in a single scan



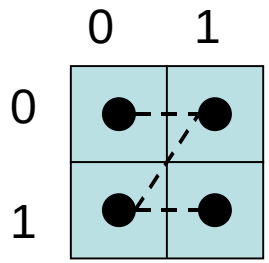
Cs1: H1=2, V1=3



Cs2: H2=1, V2=3



Cs3: H3=2, V3=1



Cs4: H4=1, V4=1

MCU1: d1(00,01,10,11,20,21) d2(00,10,20) d3(00,01) d4(00)
MCU2: d1(02,03,12,13,22,23) d2(01,11,21) d3(02,03) d4(01)
MCU3: d1(30,31,40,41,50,51) d2(30,40,50) d3(10,11) d4(10)
MCU4: d1(32,33,42,43,52,53) d2(31,41,51) d3(12,13) d4(11)

Where d1 data is from Cs1, d2 data is from Cs2, etc.

Entropy Coding

- Either binary arrhythmic coding or Huffman can be used with JPEG.
- In Huffman coding two separate are used for coding the DC and AC coefficients.
- For DC coefficients the difference between the current DC value and that of previous DC value for that same component is encoded.

Huffman coding, extra bits and possible differences for DC coefficients

Required Additional Bits	DPCM Differences
0	0
1	–1, 1
2	–3, –2, 2, 3
3	–7, . . ., –4, 4, . . ., 7
4	–15, . . ., –8, 8, . . ., 15
5	–31, . . ., –16, 16, . . ., 31
6	–63, . . ., –32, 32, . . ., 63
7	–127, . . ., –64, 64, . . ., 127
8	–255, . . ., –128, 128, . . ., 255
9	–511, . . ., –256, 256, . . ., 511
10	–1023, . . ., –512, 512, . . ., 1023
11	–2047, . . ., –1024, 1024, . . ., 2047
12	–4095, . . ., –2048, 2048, . . ., 4095
13	–8191, . . ., –4096, 4096, . . ., 8191
14	–16383, . . ., –8192, 8192, . . ., 16383
15	–32767, . . ., –16384, 16384, . . ., 32767

Fig. 5.8

JPEG 2000 improved the following deficiencies

- Poor subjective performance at rates below 0.25 bits per pixel (bpp)
- Lack of ability to provide lossy and lossless compression in the same codestream
- Lack of robustness to bit errors in the compressed image
- Poor performance with computer-generated imagery
- Poor performance with compound documents (text and image)

Pixel values reflected across the left boundary of an image

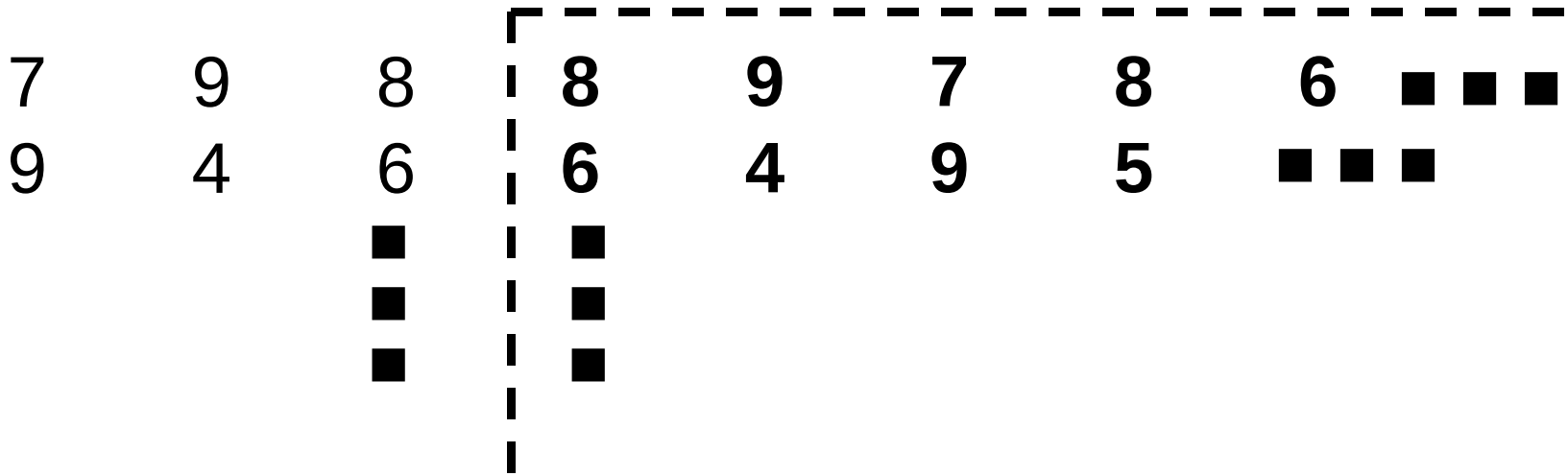


Fig. 5.9

Subband decomposition of an N x M image

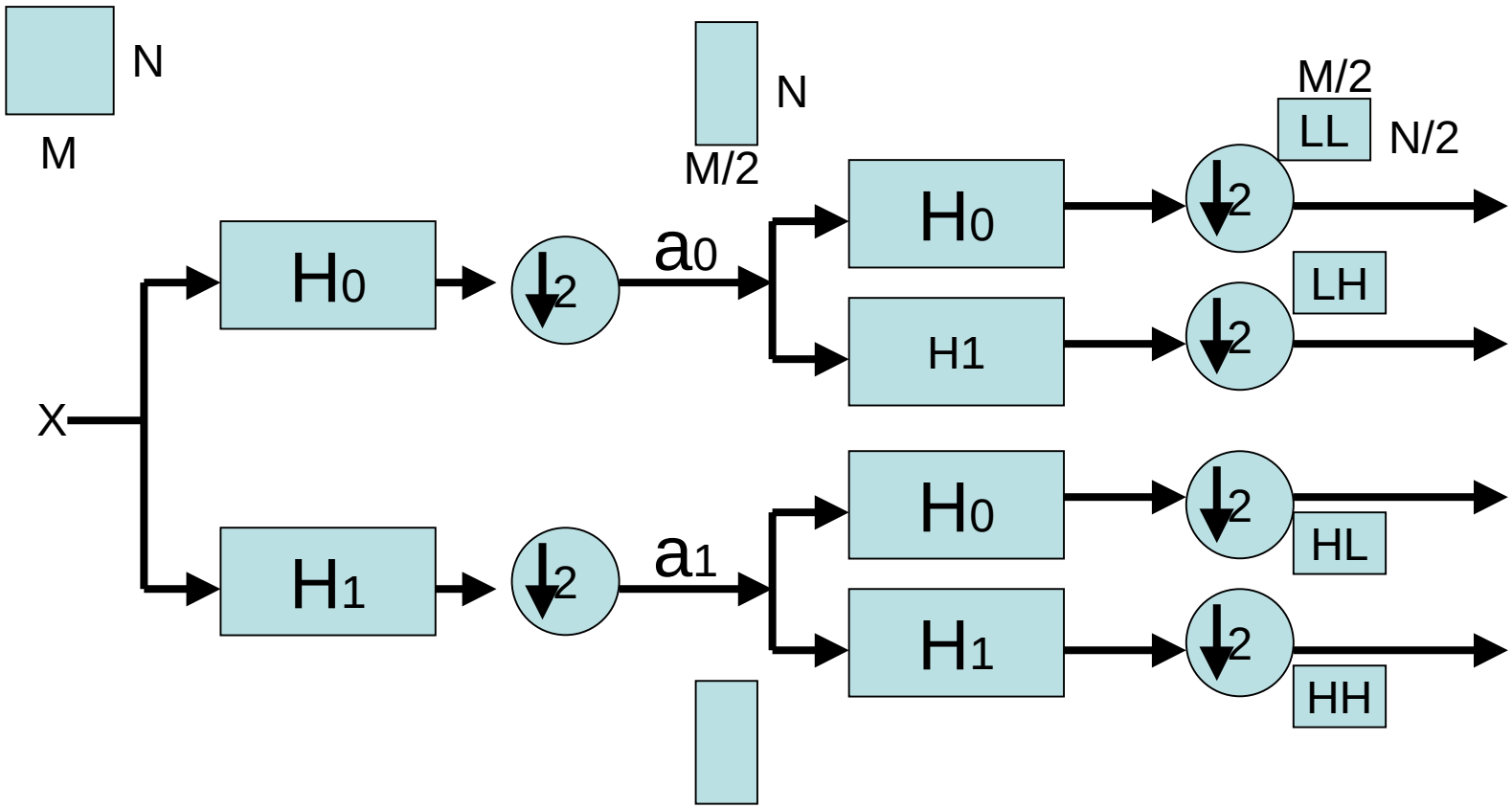


Fig. 5.10

First level decomposition

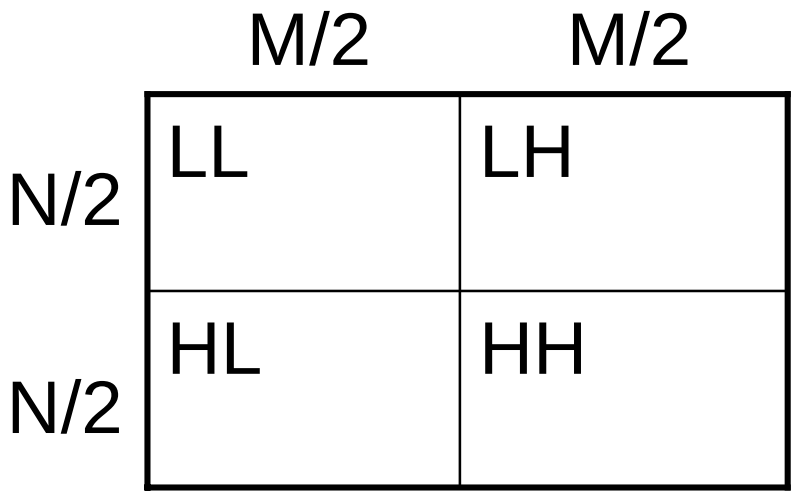


Fig. 5.11

Subband structures in the verification model

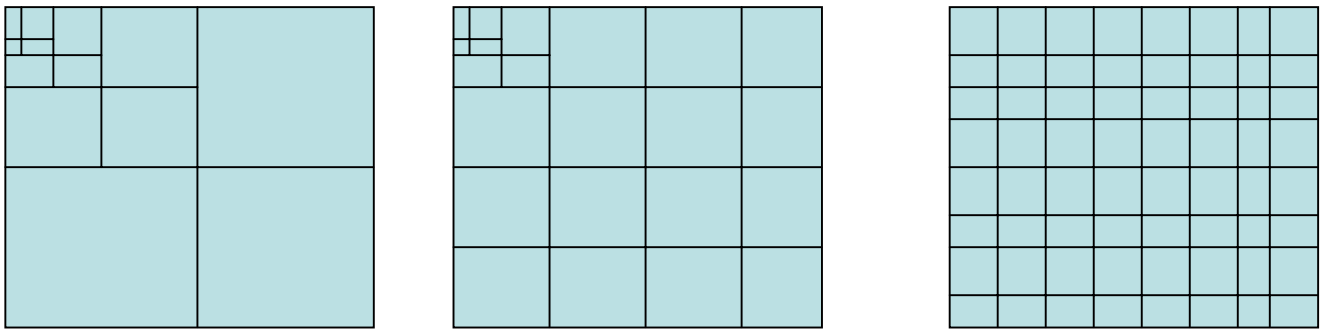


Fig. 5.12

7 predictors of Lossless JPEG

- $\hat{I}(i, j) = I(i-1, j)$ (1)

2 $\hat{I}(i, j) = I(i, j-1)$ (2)

3 $\hat{I}(i, j) = I(i-1, j-1)$ (3)

- $\hat{I}(i, j) = I(i, j-1) + I(i-1, j) - I(i-1, j-1)$ (4)
- $\hat{I}(i, j) = I(i, j-1) + (I(i-1, j) - I(i-1, j-1))/2$ (5)
- $\hat{I}(i, j) = I(i-1, j) + (I(i, j-1) - I(i-1, j-1))/2$ (6)
- $\hat{I}(i, j) = (I(i, j-1) + (I(i-1, j))/2$ (7)

Here $I(i, j)$ is the (i, j)th pixel of the original image, and $\hat{I}(i, j)$ is the predicted value for the (i, j)th pixel.

JPEG-LS

- JPEG-LS provides lossless and near lossless modes of operation
- The near lossless mode allow users to specify a bound (referred to as NEAR) on the error introduced by the compression algorithm.
- JPEG-LS exploits local structure and repetitive context within images to achieve efficient lossless and near lossless compression.

Bilevel Image compression

ITU-T Recommendation T.82 also ISO/IEC 11544, popularly known as JBIG standard, and its update release in final committee draft in Des 1999, which is known as JBIG2

JBIG Image Compression S

JBIG (Joint Bi-level Image Group) is an advanced compression scheme utilizing lossless, predictive methods.

the JBIG compression algorithm is defined by ISO/IEC S 11544:1999. It defines the compression scheme not the file format.

The main characteristic of JBIG

- Compatible progressive/sequential coding. This means progressively coded image can be decoded sequentially and the other way around
- JBIG will be a lossless image compression S: all bits in the image before and after the compression and decompression will be exactly the same.

JBIG resolution reduction and coding

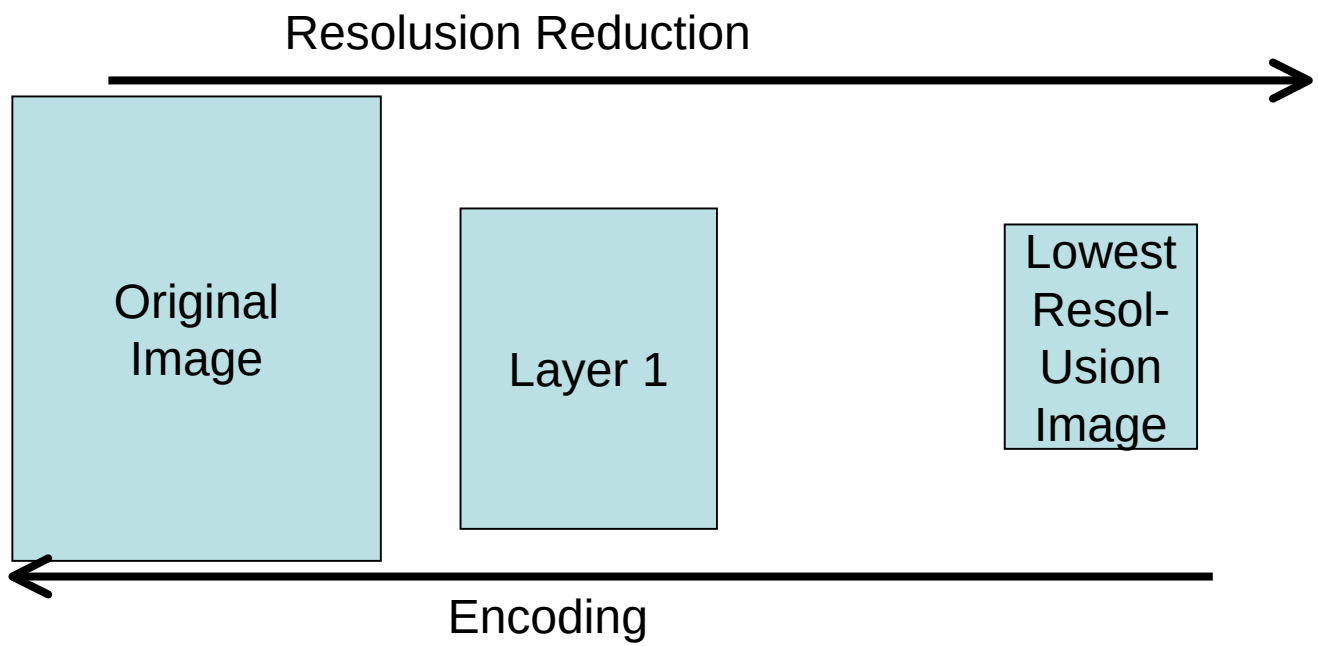


Fig. 5.16

Pictorial representation of Higher and Lower Resolution Layer

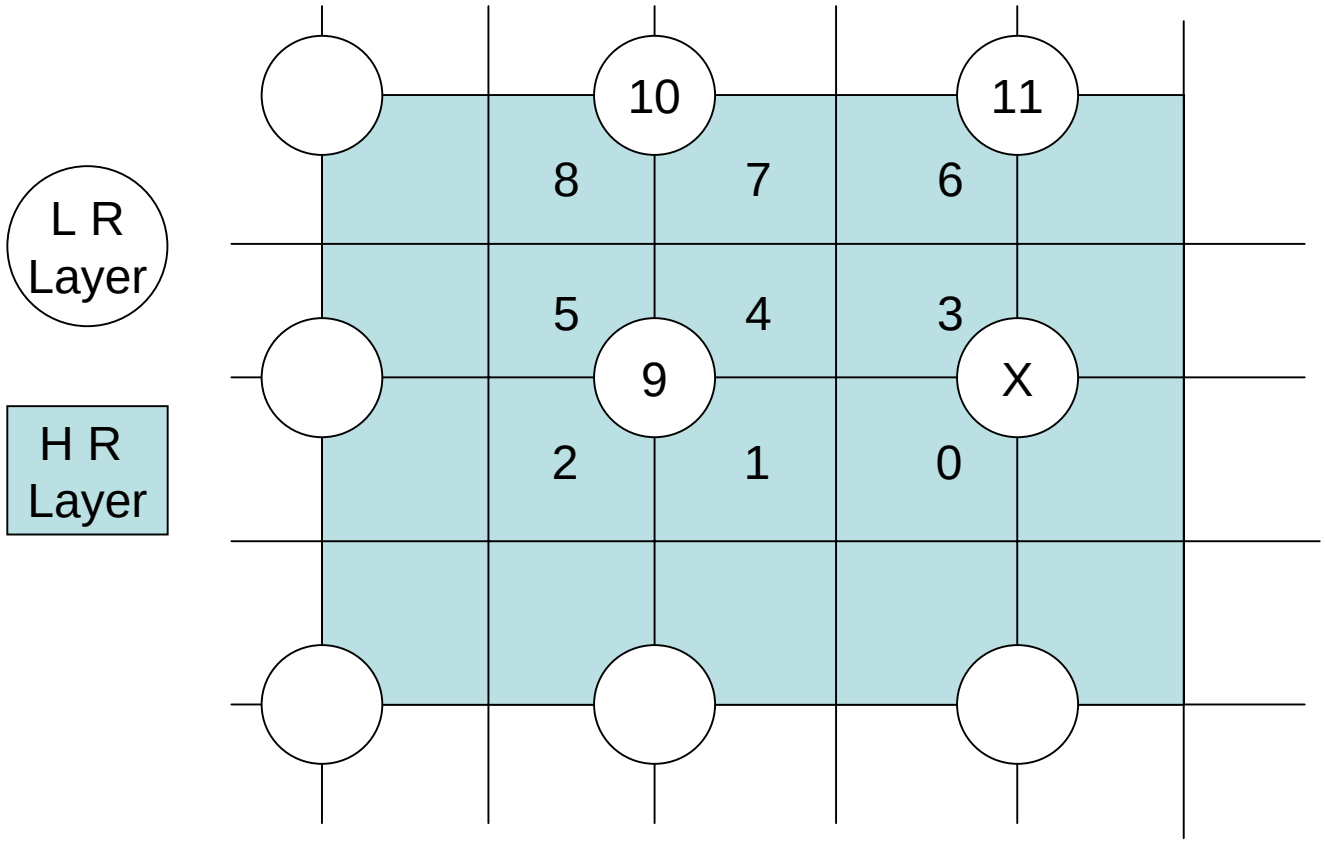
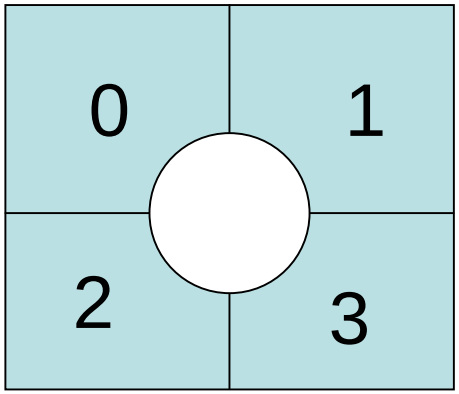
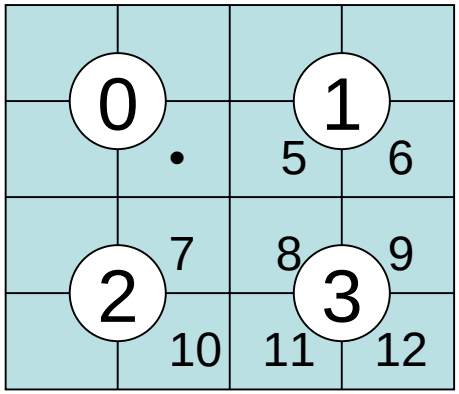


Fig. 5.16



The 4 different orientation of HR pixels with respect to LR pixels referred as “phase” of HR image.



Numbering scheme used for DP.

Fig. 5.18 and fig. 5.19

Construction of Index for DP for Different Orientation

Phase	Pixel to be Predicted	Pixels used to construct Index into DP Table	Number of Hits (Using Default Resolution Reduction
0	8	0, 1, 2, 3, 4, 5, 6, 7	20
1	9	0, 1, 2, 3, 4, 5, 6, 7, 8	108
2	11	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10	526
3	12	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	1044

Table 5.1

JBIG2

- The JBIG2 S provides a highly effective method for lossless compression of a generic bilevel image
- JBIG2 is the improved version of JBIG
- The JBIG2 takes advantage of the properties of the source material.
- It gives the user option of using lossy compression, which increase the amount of compression that can be obtained.

Conclusion

Questions