ECE462 – Lecture 19

JPEG 2000 overview

- Wavelet decomposition based compression standard for still images
- Introduced to provide rate distortion and subjective image quality performance superior to existing standards.
- Also, to provide additional features and functionalities
  - Lossless and lossy coding in same bitstream
  - Progressive transmission by pixel accuracy and by resolution
  - Robustness to bit errors
  - Region of interest (ROI) coding
  - Internet security
  - Up to 256 channels (satellite imagery)
  - Image sizes up to 2**31-1

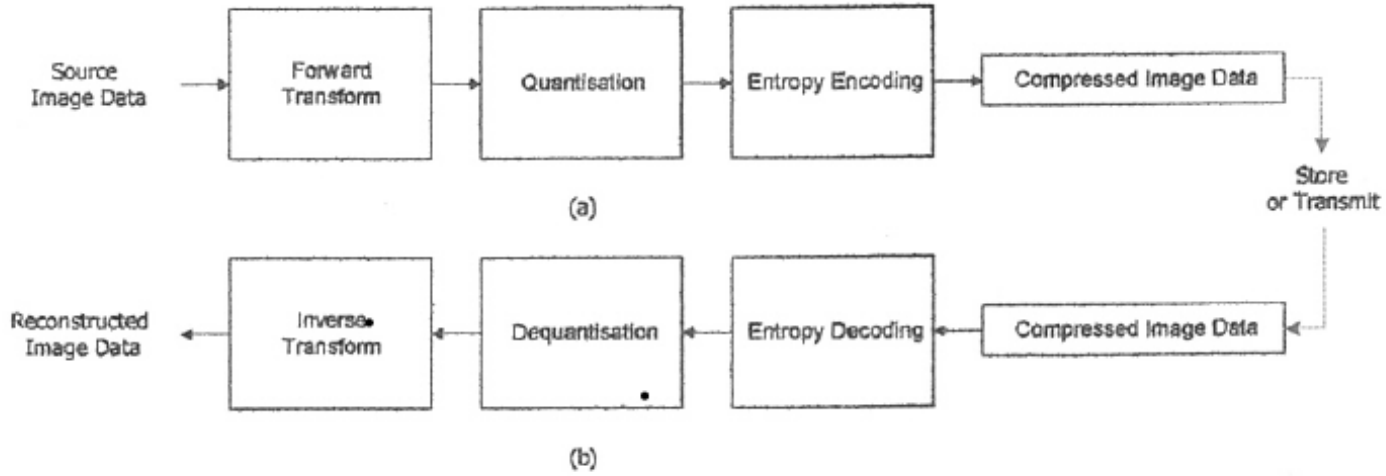
JPEG 2000 overview

n IEEE Transactions on Consumer Electronics, Vol. 46, No. 4, pp. 1103-1127, November 2000

In JPEG2000

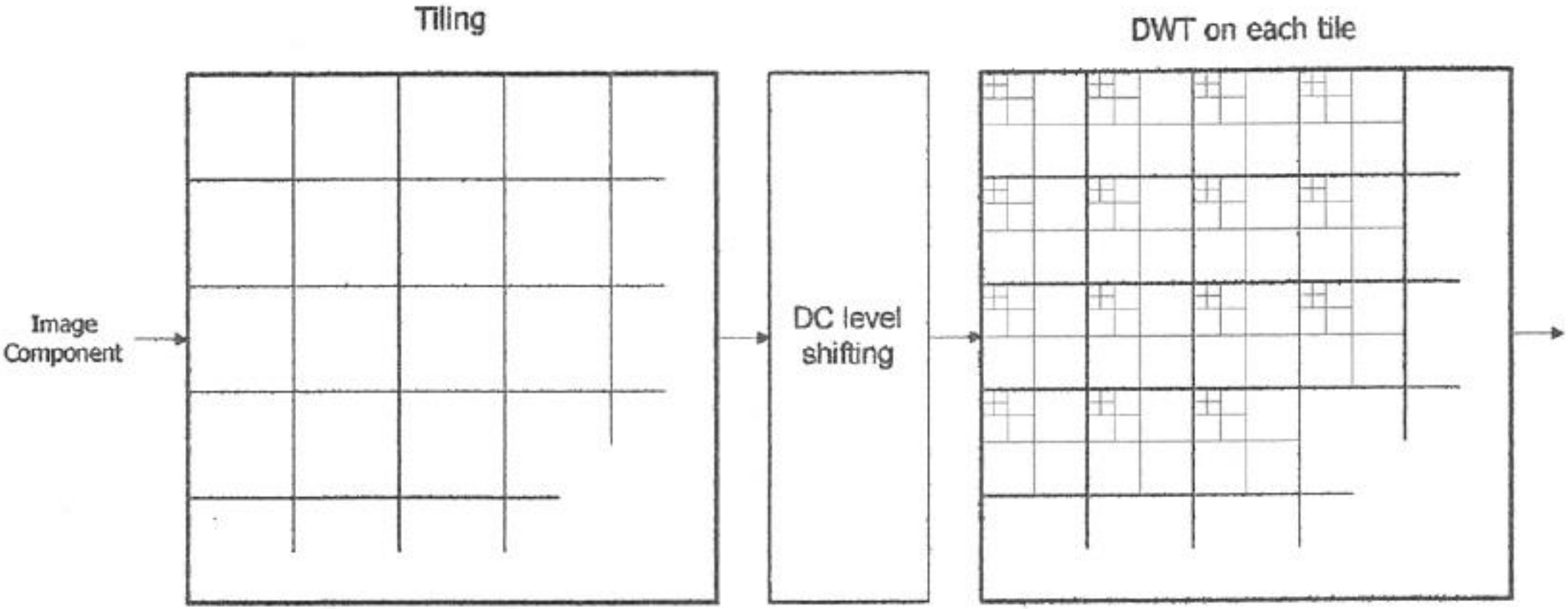
the encoding procedure is as follows

- The source image is decomposed into components.
- The image and its components are decomposed into rectangular tiles. The tile-component is the basic unit of the original or reconstructed image.
- The encoding can be done in such a way, so that certain ROI's can be coded in a higher quality than the background.
- Markers are added in the bitstream to allow error resilience.
- The codestream has a main header at the beginning that describes the original image and the various decomposition and coding styles that are used to



Block diagrams of the JPEG2000 (a) encoder and (b) decoder.

JPEG 2000 overview



Tiling, DC level shifting and DWT of each image tile component.

JPEG 2000 overview

Tiling, DC level shifting and DWT of each image tile component.

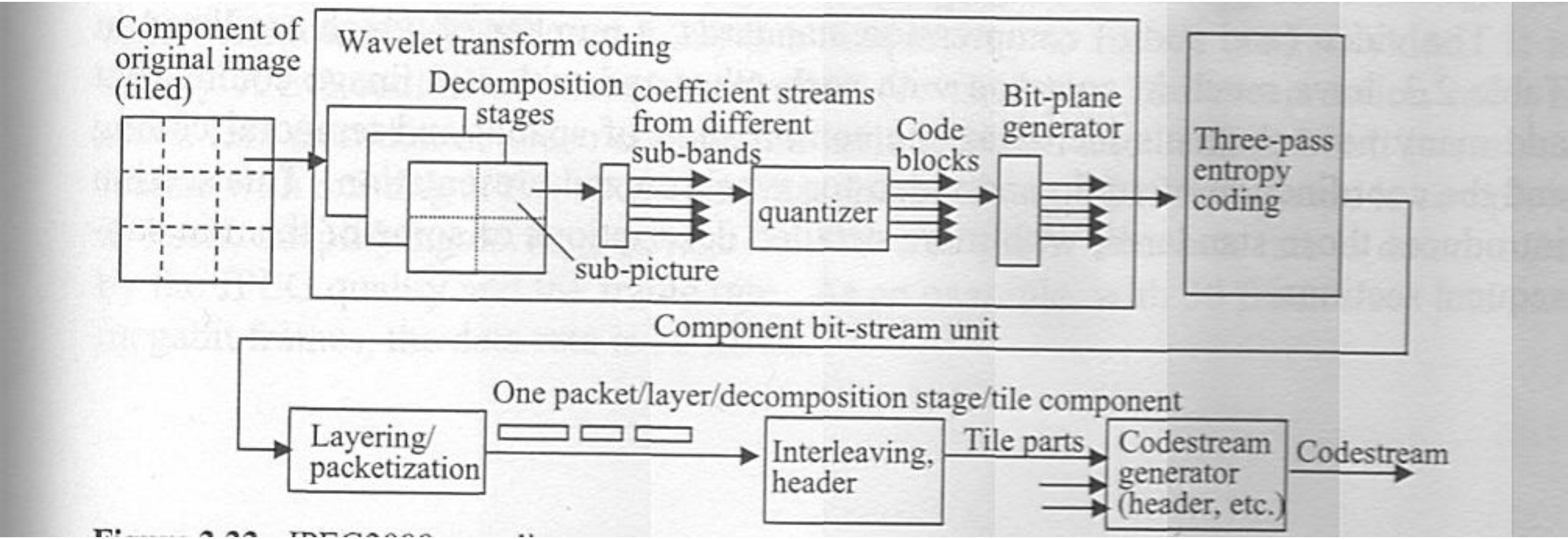
- The wavelet transform is applied on each tile. The tile is decomposed in different resolution levels.
- These decomposition levels are made up of subbands of coefficients that describe the frequency characteristics of local areas (rather than across the entire tile-component) of the tile-component.
- The subbands of coefficients are quantized and collected into rectangular arrays of "code-blocks".
- The bit-planes of the coefficients in a "code-block" are entropy coded.

locate, extract, decode and reconstruct the image with the desired resolution, fidelity, region of interest and other characteristics.

- The optional file format describes the meaning of the image and its components in the context of the application.

It should be noted here that the basic encoding engine of JPEG2000 is based on EBCOT (Embedded Block Coding with Optimized Truncation of the embedded bitstreams) algorithm

JPEG 2000 overview



JPEG 2000 overview

(a) (b)

Reconstructed images compressed at 0.125 bpp by means of (a) JPEG and (b) JPEG2000

(a) (b)

Reconstructed images compressed at 0.25 bpp by means of (a) JPEG and (b) JPEG2000

JPEG 2000 overview

Will JPEG 2000 replace JPEG? One potential obstacle is the increased complexity.

Compressive Data Hiding for Color Image Coding

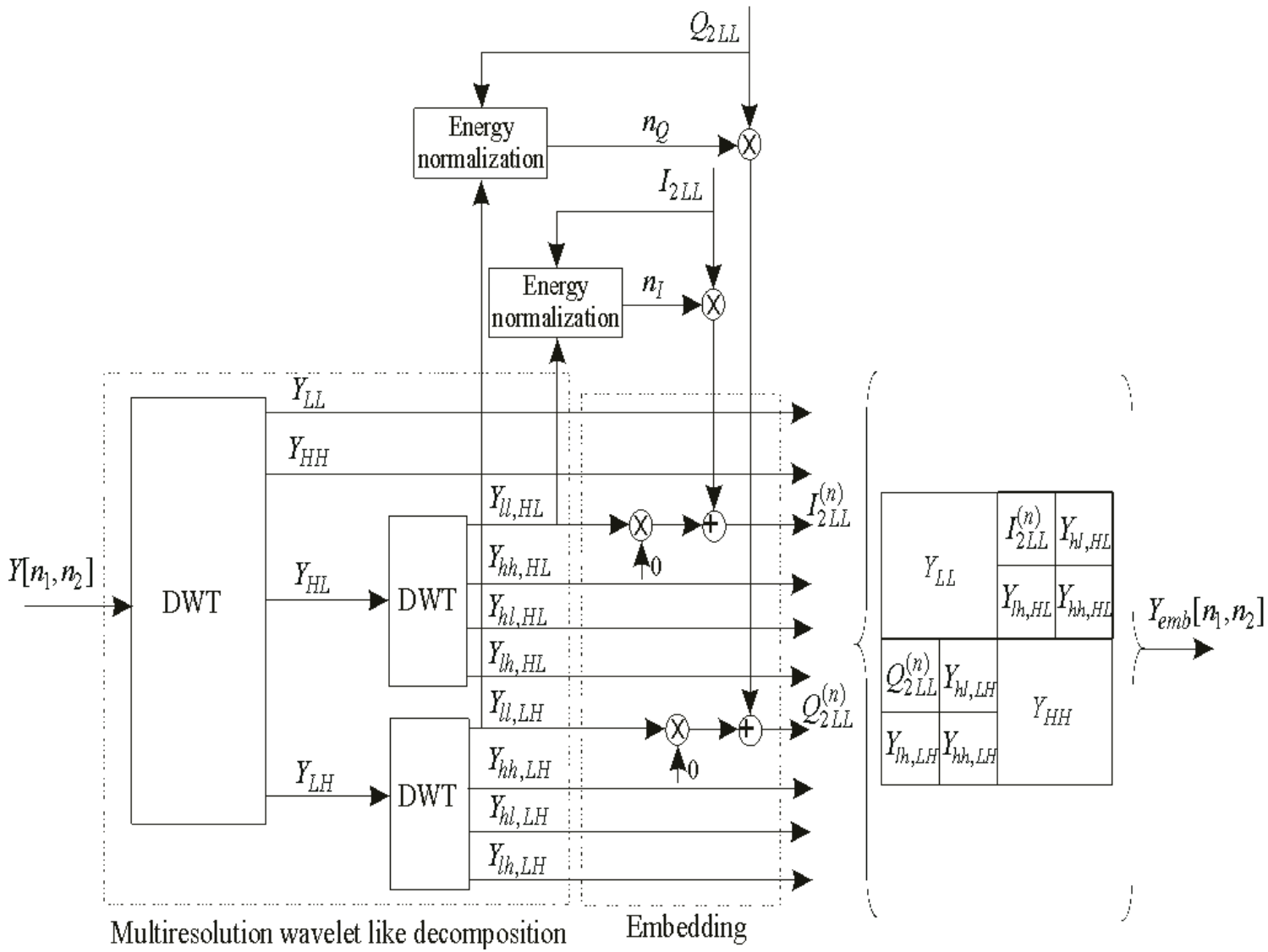
- Eurasip Journal on Applied Signal Processing, Vol. 2002, No. 2,
  pp.152 -163

- Wavelet based approach that can be applied as preprocessing step of other wavelet type methods for coding still color images.
- E.g.. SPIHT: “ Set partitioning in Hierarchical trees”

An extension of EZW approach.

Basic Idea: Hide color information into wavelet subbands of the Luminance wavelet decomposition. Then, code the resulting gray scale image using existing approaches.

Compressive Data Hiding for Color Image Coding



Compressive Data Hiding for Color Image Coding

- Data hiding principle: Insert data into an image so that the image remains perceptually unaltered: “watermarking” procedure.
- The operation must be reversible so that the hidden data be recoverable from the “watermarked” image.

Compressive Data Hiding

Embedding steps

(1) The color image $X[n_1, n_2]$ is split into its three color components in the YIQ color space.

(2) The luminance Y undergoes a multiresolution-like wavelet decomposition:
$Y \overset{DWT}{\rightarrow} (Y_{LL}, Y_{HH}, Y_{HL}, Y_{LH})$
$Y_{HL} \overset{DWT}{\rightarrow} (Y_{ll,HL}, Y_{hh,HL}, Y_{hl,HL}, Y_{lh,HL})$
$Y_{LH} \overset{DWT}{\rightarrow} (Y_{ll,LH}, Y_{hh,LH}, Y_{hl,LH}, Y_{lh,LH})$

(3) The chrominance components I and Q undergo a two-level wavelet decomposition and only the "lowpass" subbands at the coarsest resolution I_{2LL} and Q_{2LL} are kept.

(4) I_{2LL} and Q_{2LL} are normalized to the energy of $Y_{ll,HL}$ and $Y_{ll,LH}$ respectively thus obtaining $I^{(e)}_{2LL}$ and $Q^{(e)}_{2LL}$.

Compressive Data Hiding

(5) The subbands $Y_{HL}^{(e)}$ and $Y_{LH}^{(e)}$ are obtained as follows:

$$(I_{2LL}^{(n)}, Y_{hh,HL}, Y_{hl,HL}, Y_{lh,HL}) \overset{IDWT}{\rightarrow} Y_{HL}^{(e)}$$

$$(Q_{2LL}^{(n)}, Y_{hh,LH}, Y_{hl,LH}, Y_{lh,LH}) \overset{IDWT}{\rightarrow} Y_{LH}^{(e)}$$

Compression steps

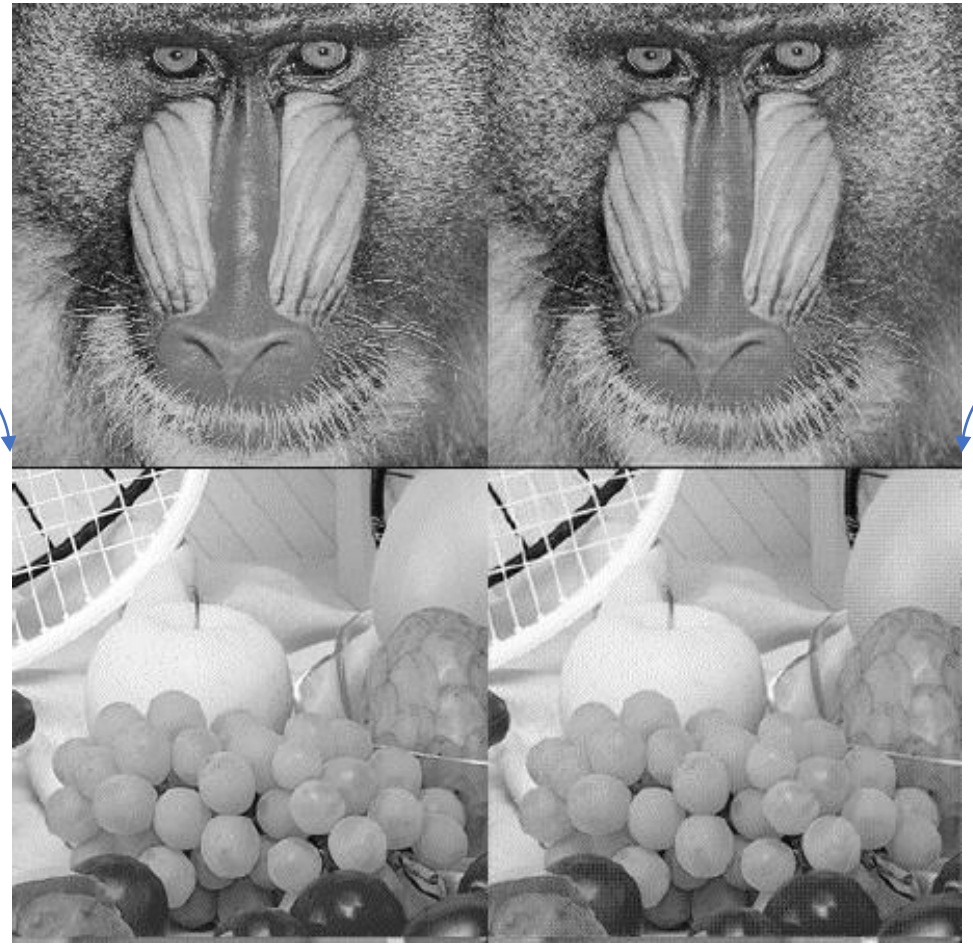
(6) The global bit rate b_{tot} and the bit rate b_{LL}, for the subband Y_{LL}, are chosen by the user.

(7) The bit rates b_{HH}, b_{HL}, b_{LH} corresponding to the remaining subbands are evaluated according to eqs.(10)-(12).

(8) Finally each subband is compressed using the SPIHT coder and the bit stream Y_{comp} is generated.

Compressive Data Hiding

Original grayscale
Image (luminance)



Luminance (Y) units
Chrominance components
(I, Q) embedded.

Compressive Data Hiding

Original grayscale
Image (luminance)

Luminance (Y) units
Chrominance components
(I, Q) embedded.

*Notice that periodically the images prior to and after data hiding are Indistinguishable.

Original Images (24 bpp)

Compressed (Data hiding + SPIHT) (0.15 bpp)

Compressed (SPIHT) (0.15 bpp)

JPEG 0.25 bpp

Original (24 bpp)

Data Hiding + SPIHT 0.45 bpp

SPIHT (0.45 bpp)

JPEG (0.45 bpp)