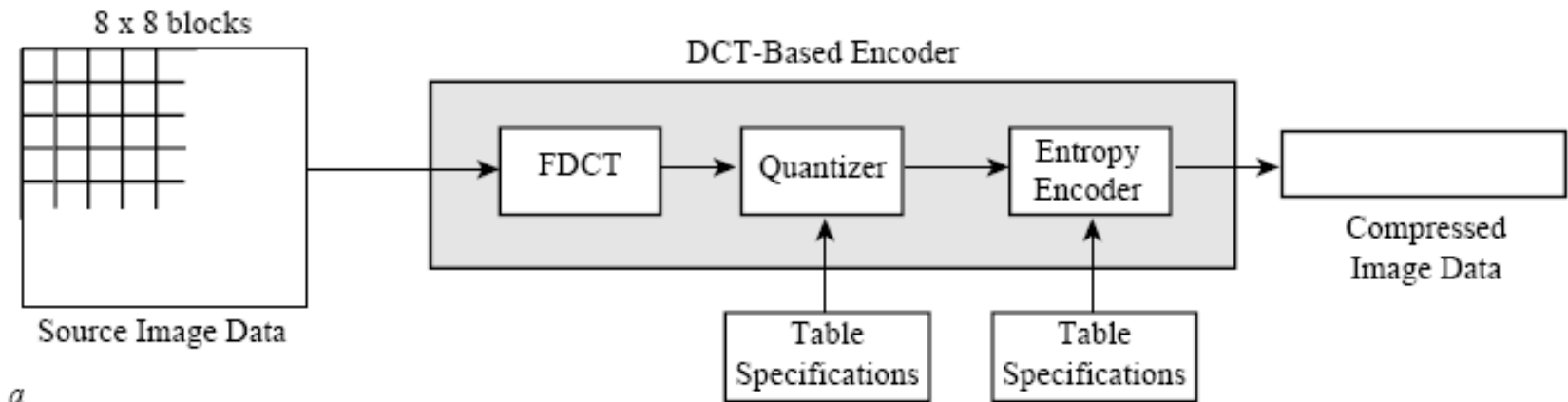


# JPEG and JPEG2000

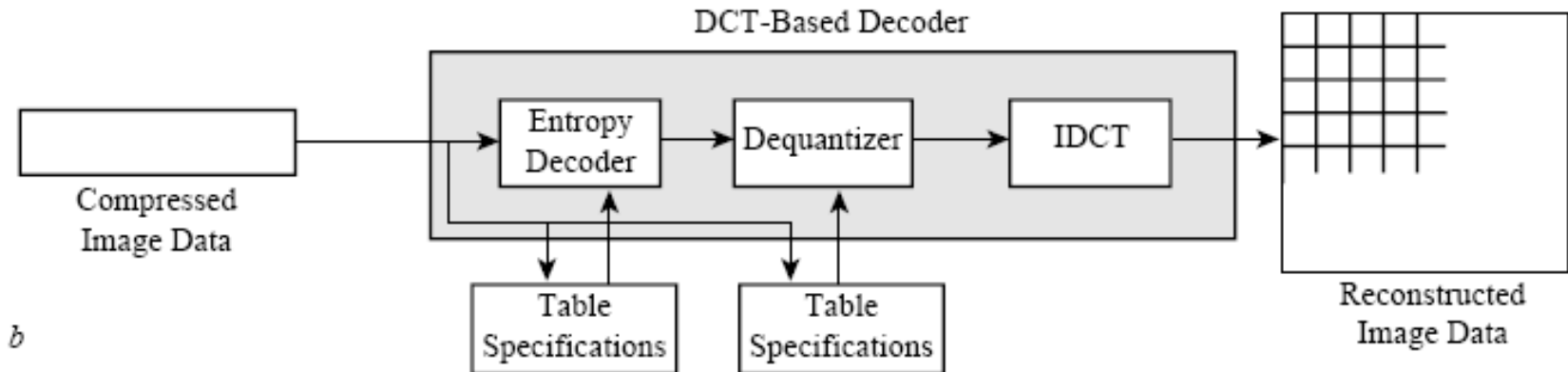
Jerry D. Gibson

ECE 241

# JPEG Encoder and Decoder

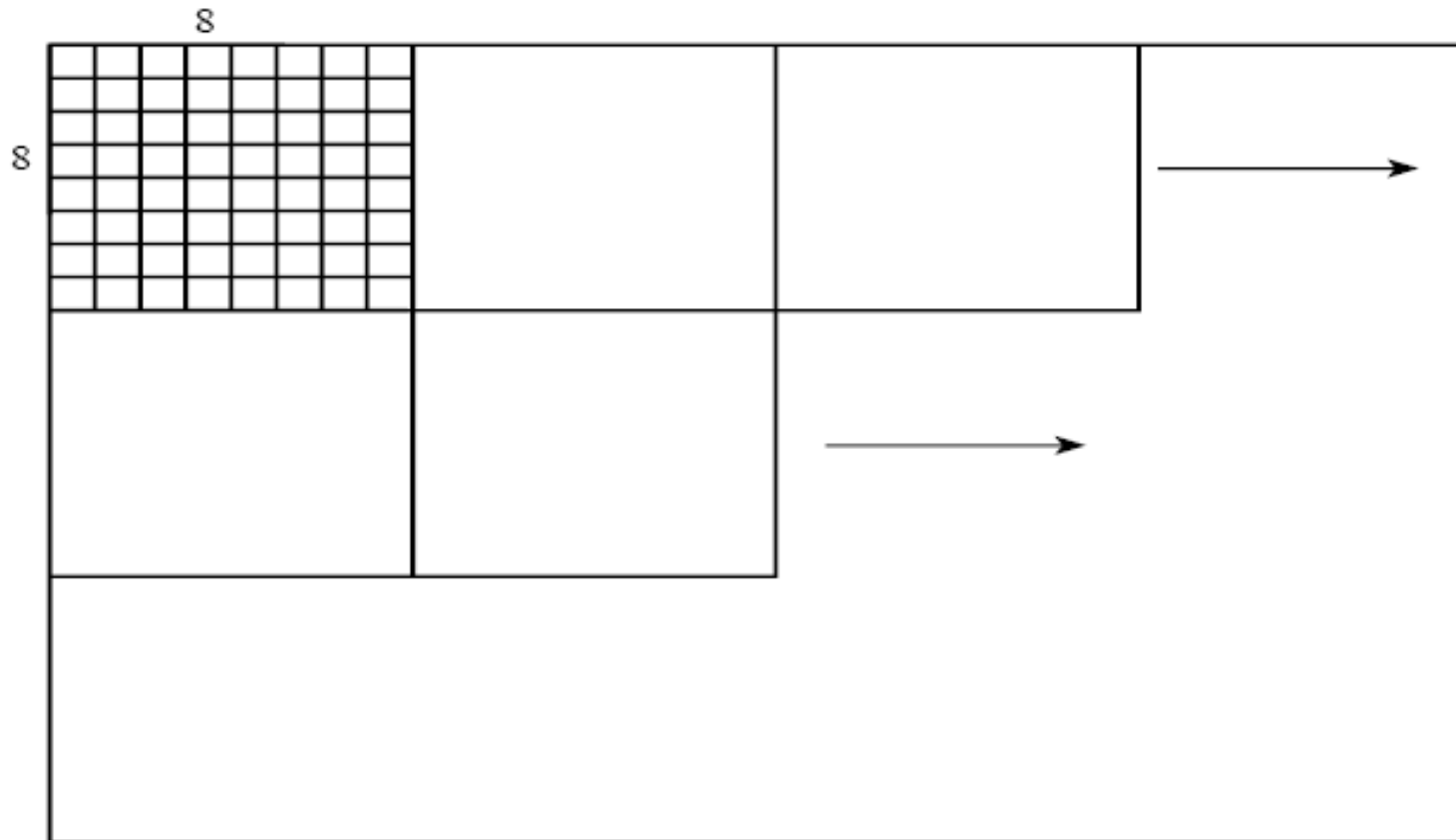


*a*

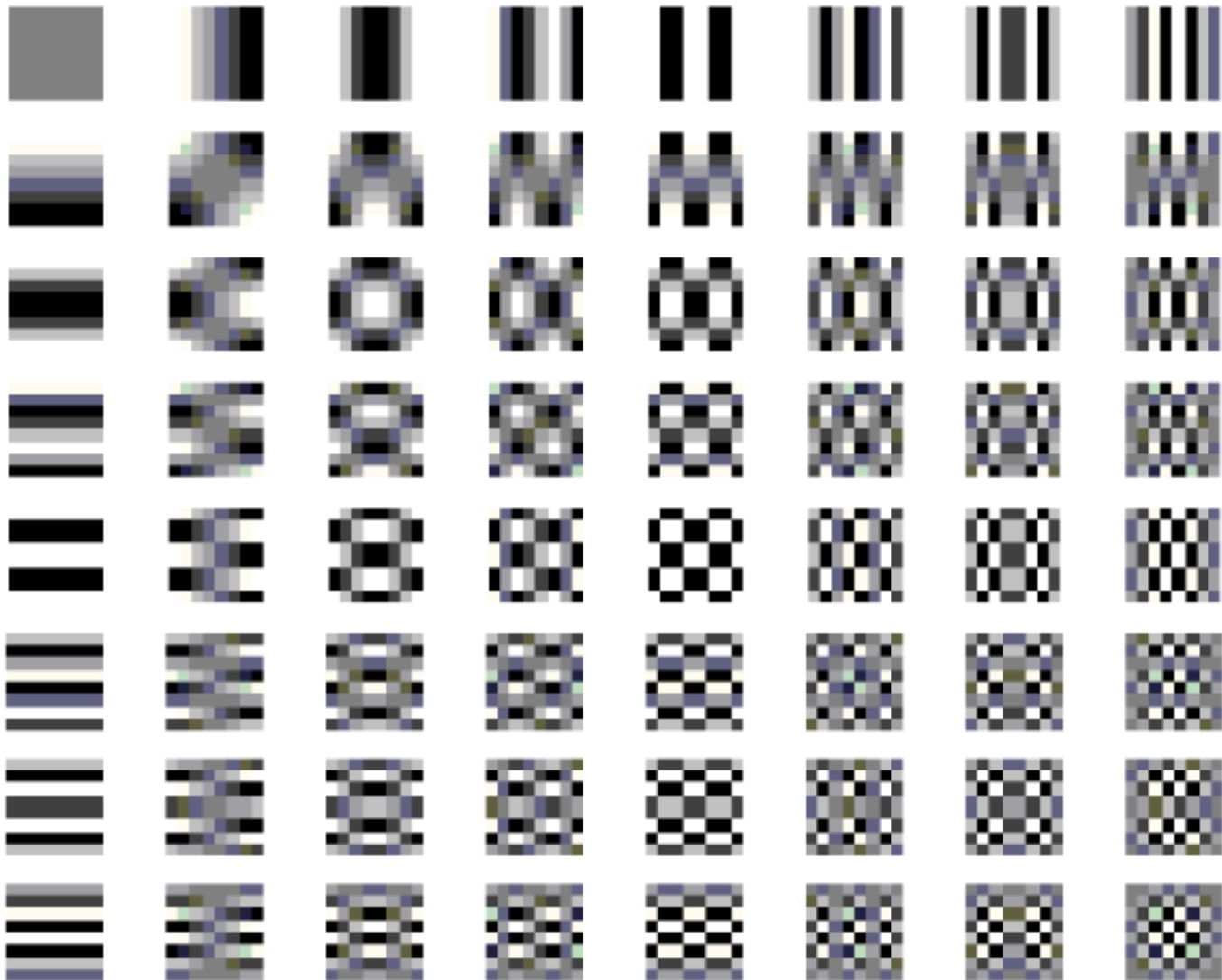


*b*

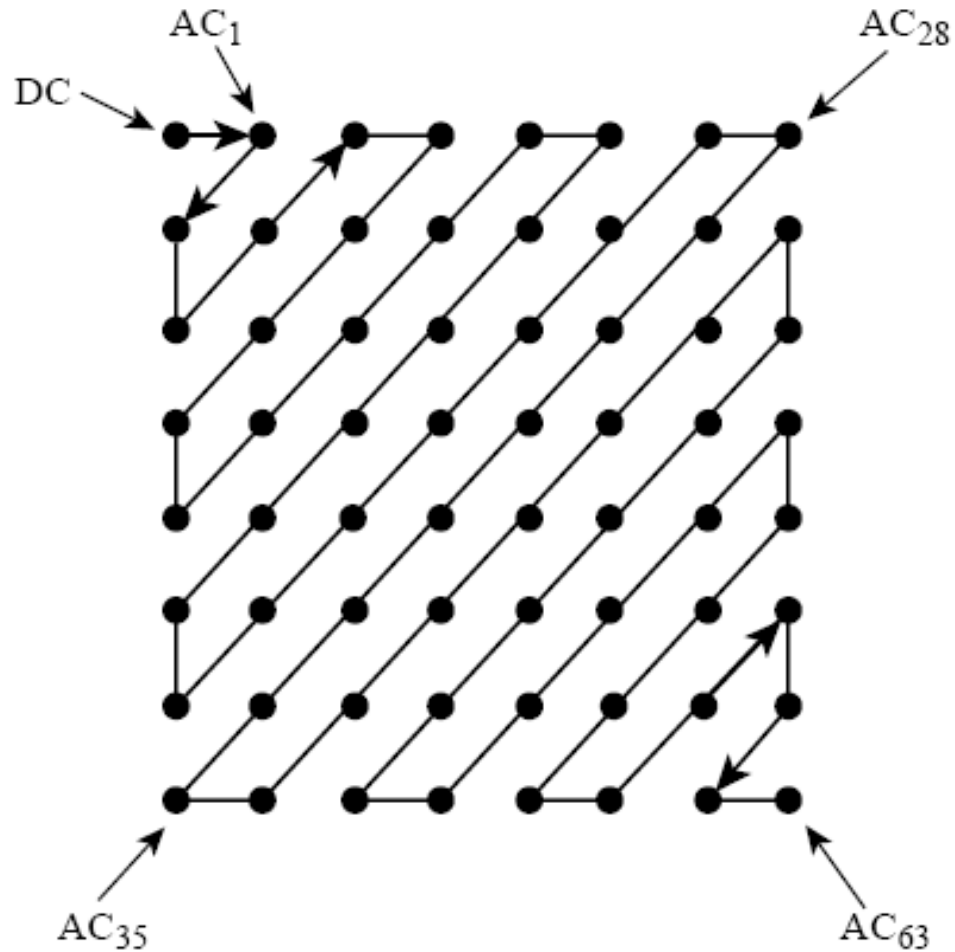
# Partitioning into 8 by 8 Blocks



# 2D-DCT Basis Functions

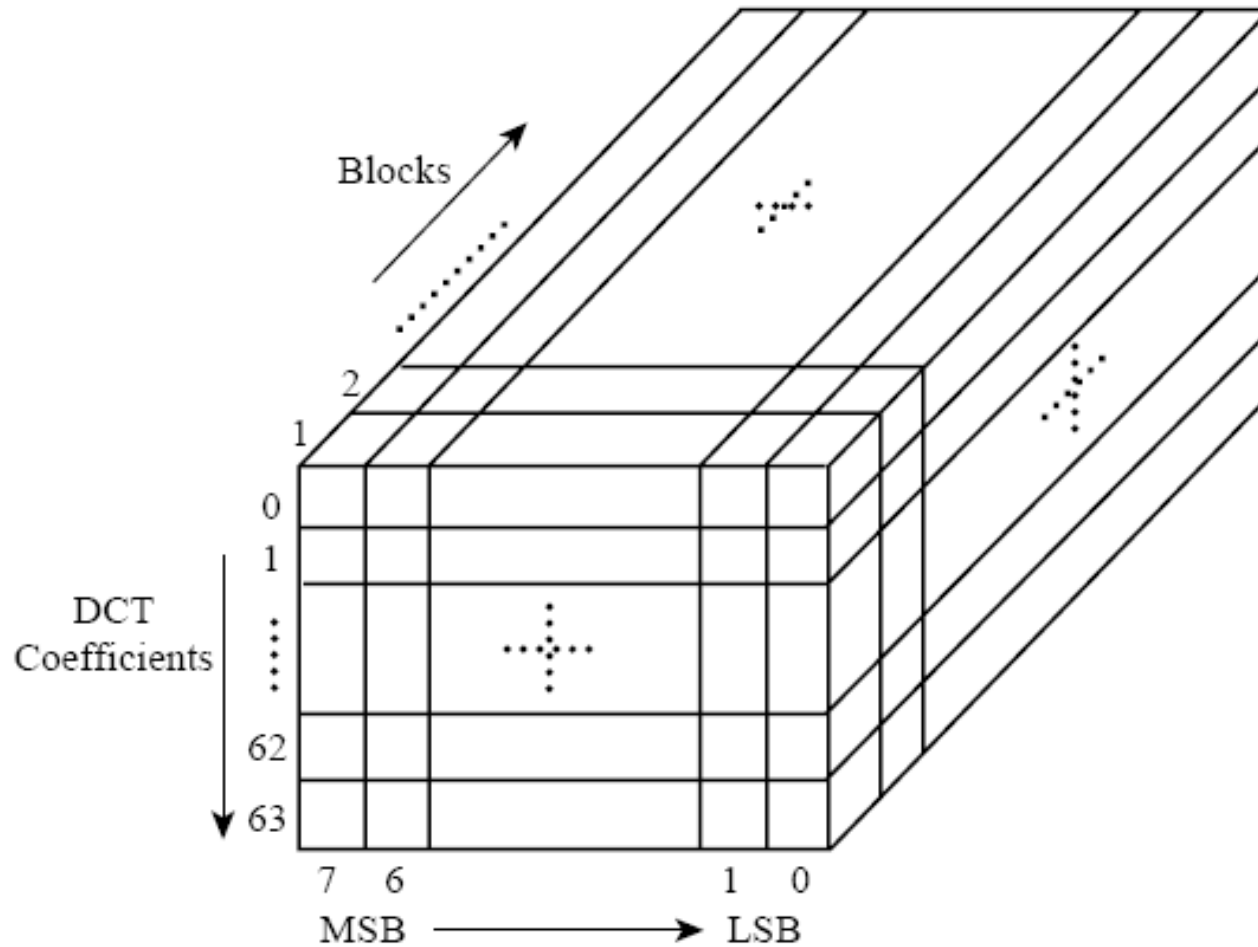


# Zig-Zag Coefficient Ordering



Zigzag Order

# Sequential Lossy Encoding

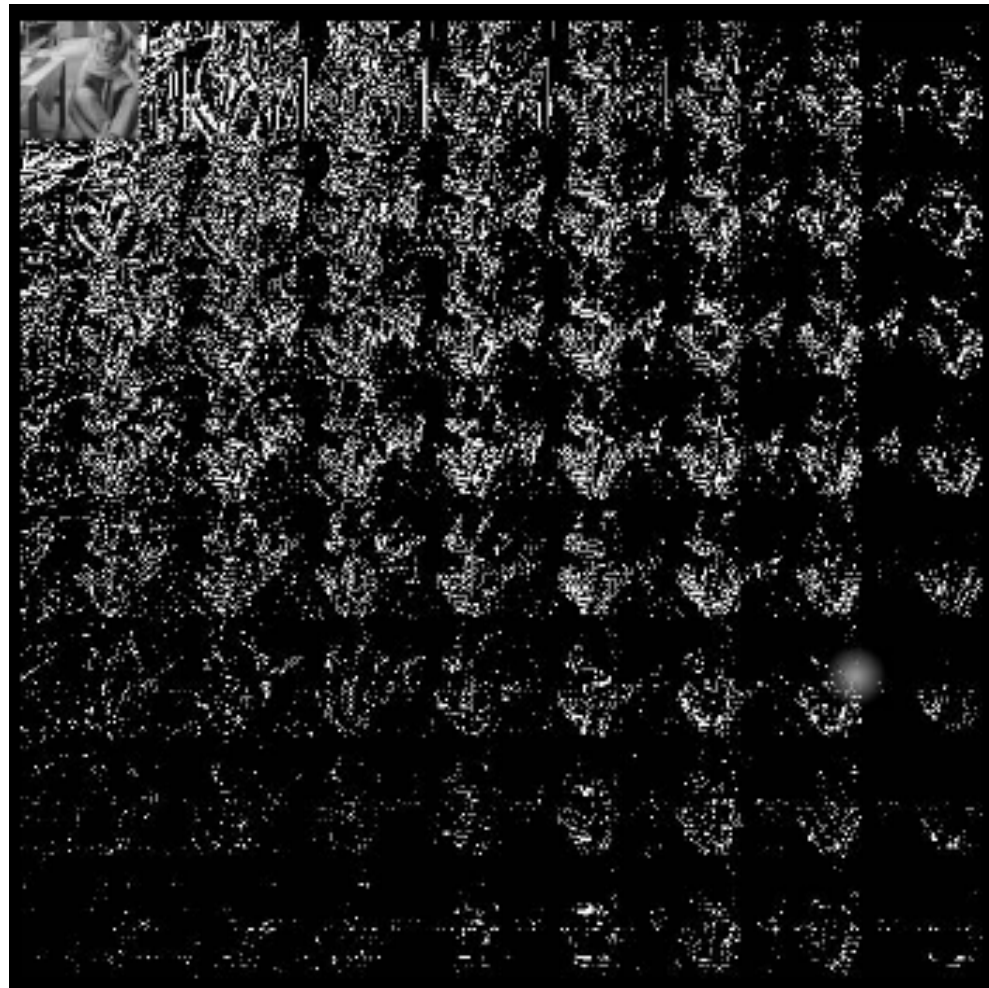


# Luminance Quantization Table

Luminance quantization table

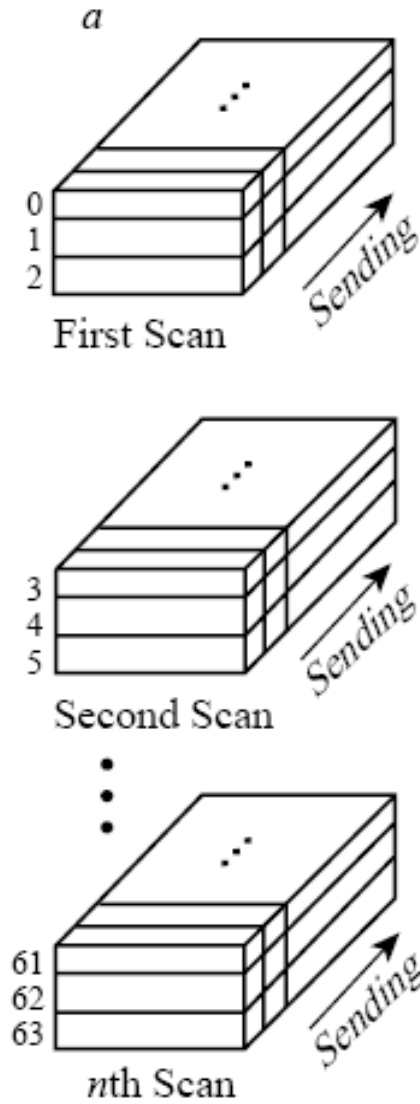
16	11	10	16	24	40	51	61
12	12	14	19	26	58	60	55
14	13	16	24	40	57	69	56
14	17	22	29	51	87	80	62
18	22	37	56	68	109	103	77
24	35	55	64	81	104	113	92
49	64	78	87	103	121	120	101
72	92	95	98	112	100	103	99

# Images Reconstructed from the Same Coefficient Taken from Each Block

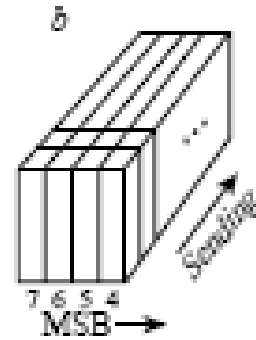




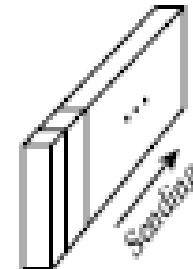
# Spectral Selection



# Successive Approximation

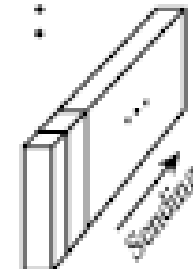


First Scan



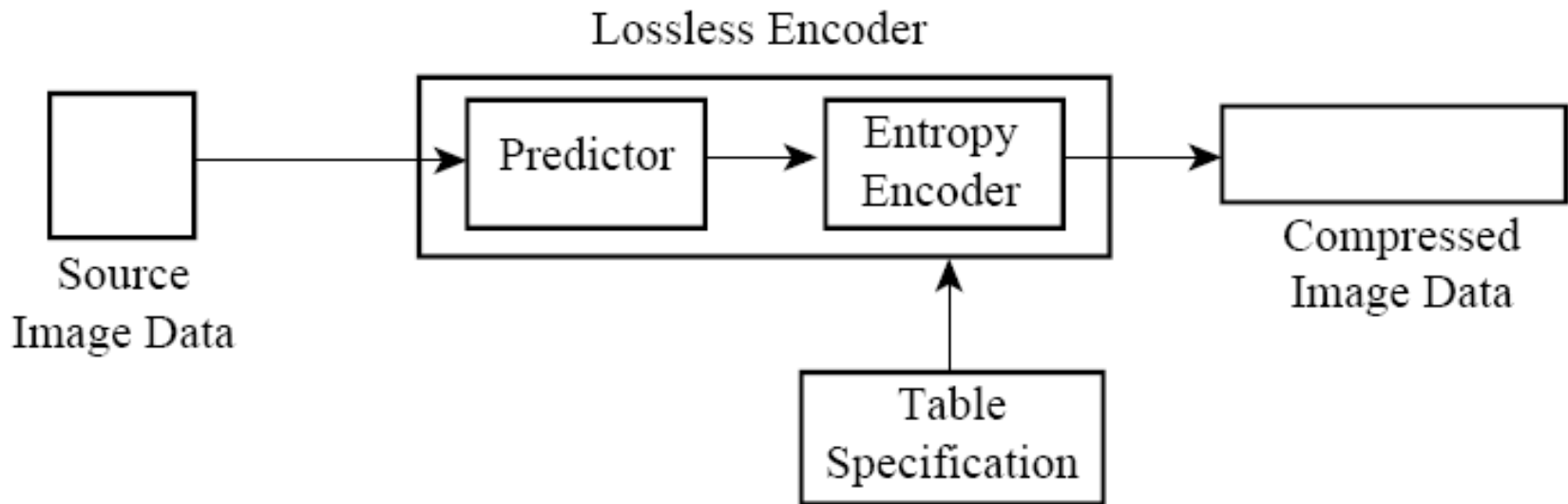
Second Scan

⋮

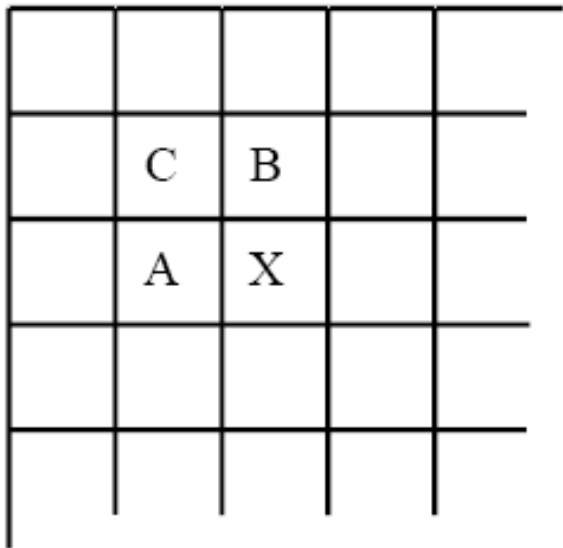


(LSB)  
nth Scan

# JPEG Lossless Encoder



# JPEG Predictors for Lossless Encoding



Predictors for Lossless Coding	
Selection Value	Prediction
0	No Prediction
1	A
2	B
3	C
4	$A + B - C$
5	$A + ((B - C)/2)$
6	$B + ((A - C)/2)$
7	$(A + B)/2$

# JPEG2000 Features

- Superior low bit-rate performance—below 0.25 bpp for highly detailed gray-scale images
- Lossless and lossy compression—lossless compression in the course of progressive decoding
- Progressive transmission by increasing pixel accuracy or spatial resolution

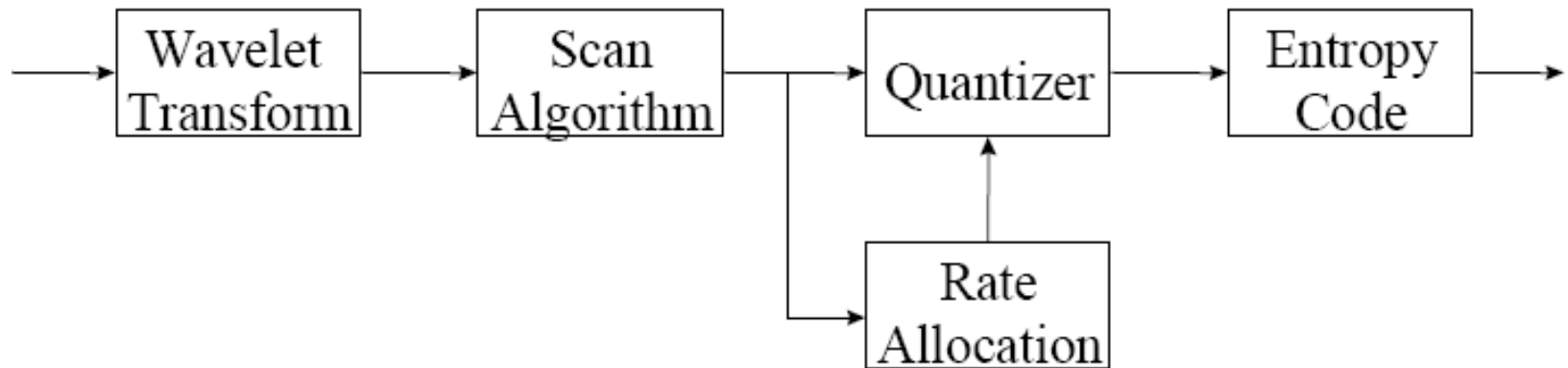
# JPEG2000 Features (cont'd)

- Region-of-interest (ROI) coding
- Random codestream access and processing
- Robustness to bit-errors
- Open architecture—a decoder is only required to implement the core tool set and a parser that understands the codestream
- Content-based description

# JPEG2000 Features (cont'd)

- Continuous-tone and bi-level compression—compress and decompress images with various dynamic ranges (1 to 16 bit) for each color component

# Basic Encoding Diagram





# Basic Encoding Steps

- Pre-processing of the image
- The image is decomposed into components
- The image/components are decomposed into tiles
- Tiling refers to partitioning the image into rectangular non-overlapping blocks, called tiles, which are compressed independently as if they are independent images

# Basic Encoding Steps (cont'd)

- A wavelet transform is applied on each tile
- Each tile is decomposed into different resolution levels
- The decomposition levels are made up of subbands of coefficients that describe the frequency characteristics of local areas of the tile-component
- The subbands of coefficients are quantized and collected into rectangular arrays of code blocks

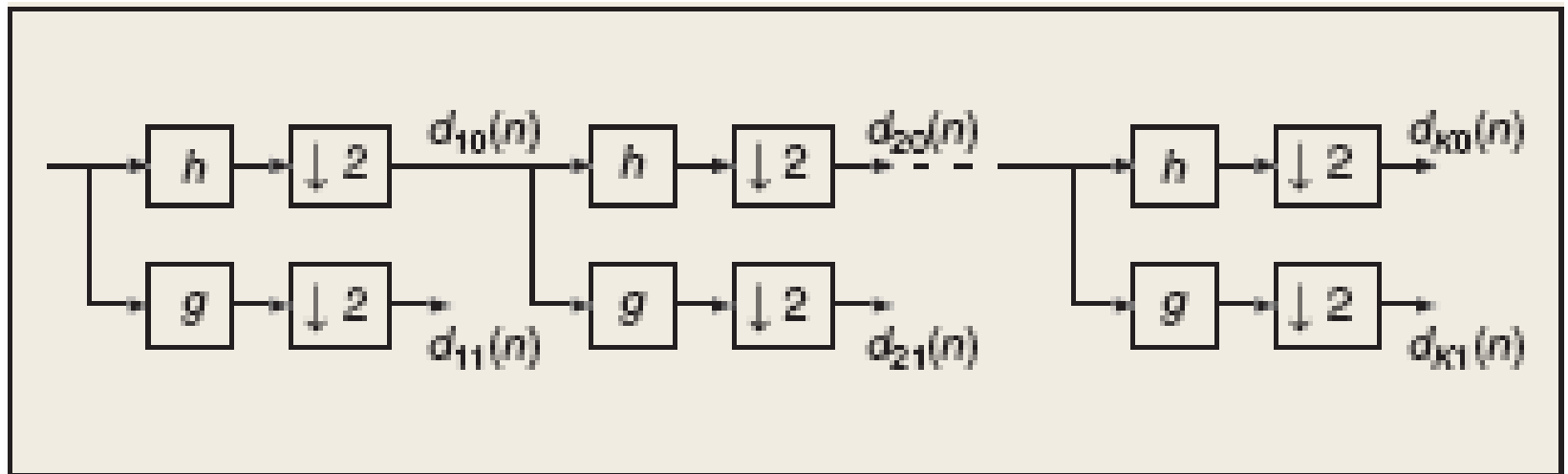
# Basic Encoding Steps (cont'd)

- The bit-planes of the coefficients in a cod-block are entropy coded
- ROI's can be encoded in higher quality than the background
- Markers are added in the bitstream for error resilience
- The codestream has a main header that describes the original image and the various decomposition and coding styles

# Basic Encoding Engine

- EBCOT—Embedded Block Coding with Optimized Truncation of the embedded bitstreams algorithm

# Subband Decompositions



# Biorthogonal, Linear Phase Wavelet Filter Coefficients

9/7 Filter Coefficients		5/3 Filter Coefficients		Filter Index
$b_0$	$g_0$	$b_0$	$g_0$	
0.852699	0.788486	1.060660	0.707107	0
0.377402	0.418092	0.353553	0.353553	-1, 1
-0.110624	-0.040689	-0.176777		-2, 2
-0.023849	-0.064539			-3, 3
0.037828				-4, 4

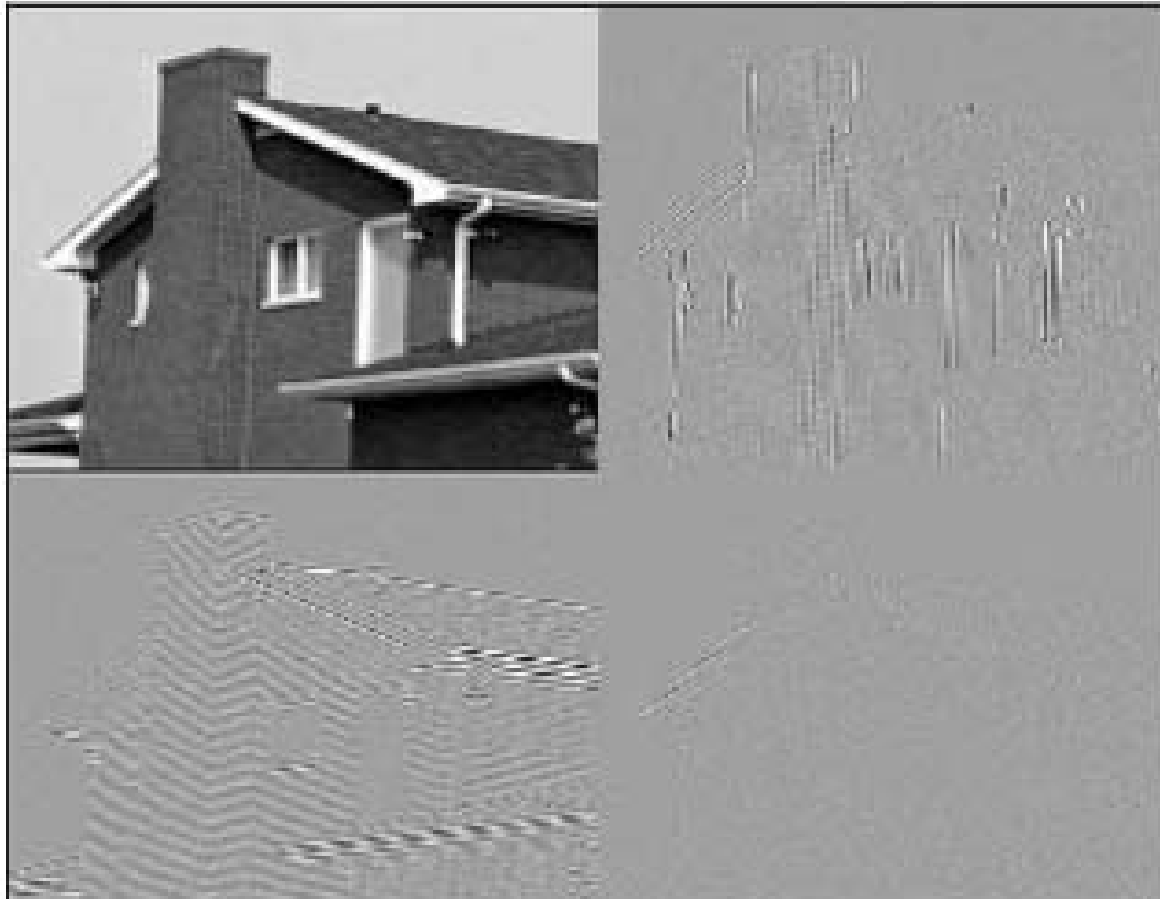
# Original Image



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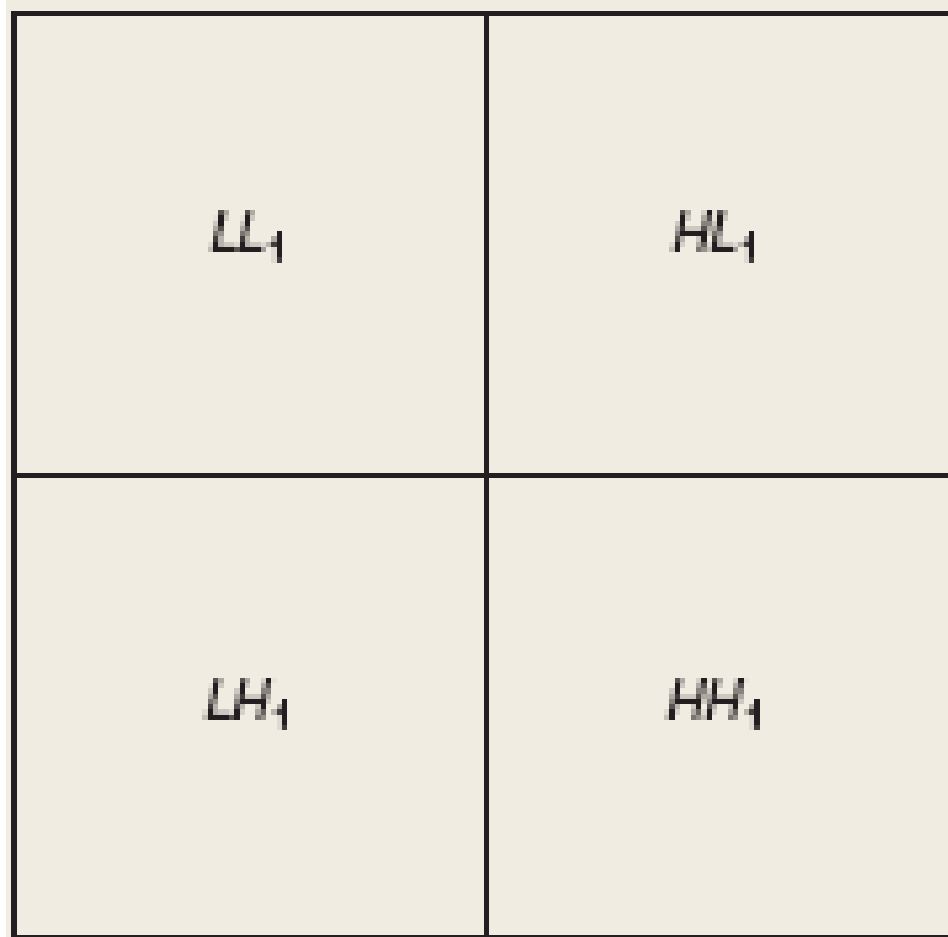


# One-Level 2-D Wavelet Transform





# Subband Labeling



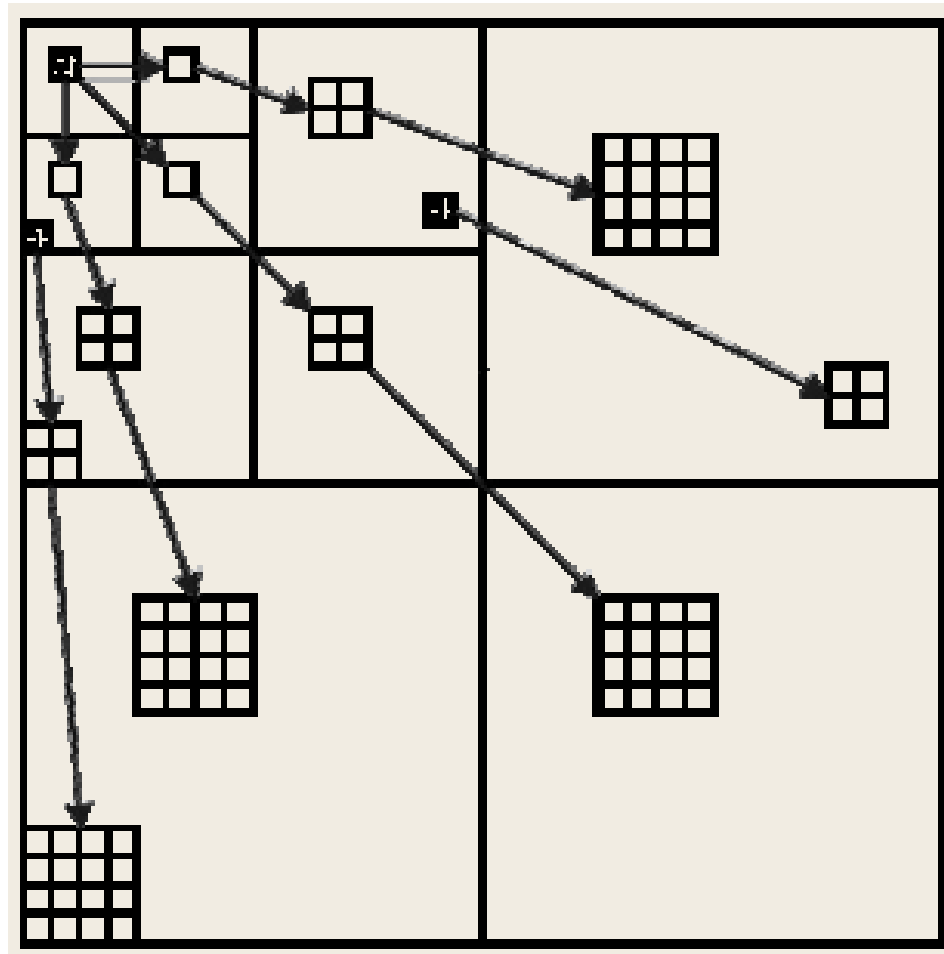
# Three-Level 2-D Wavelet Transform



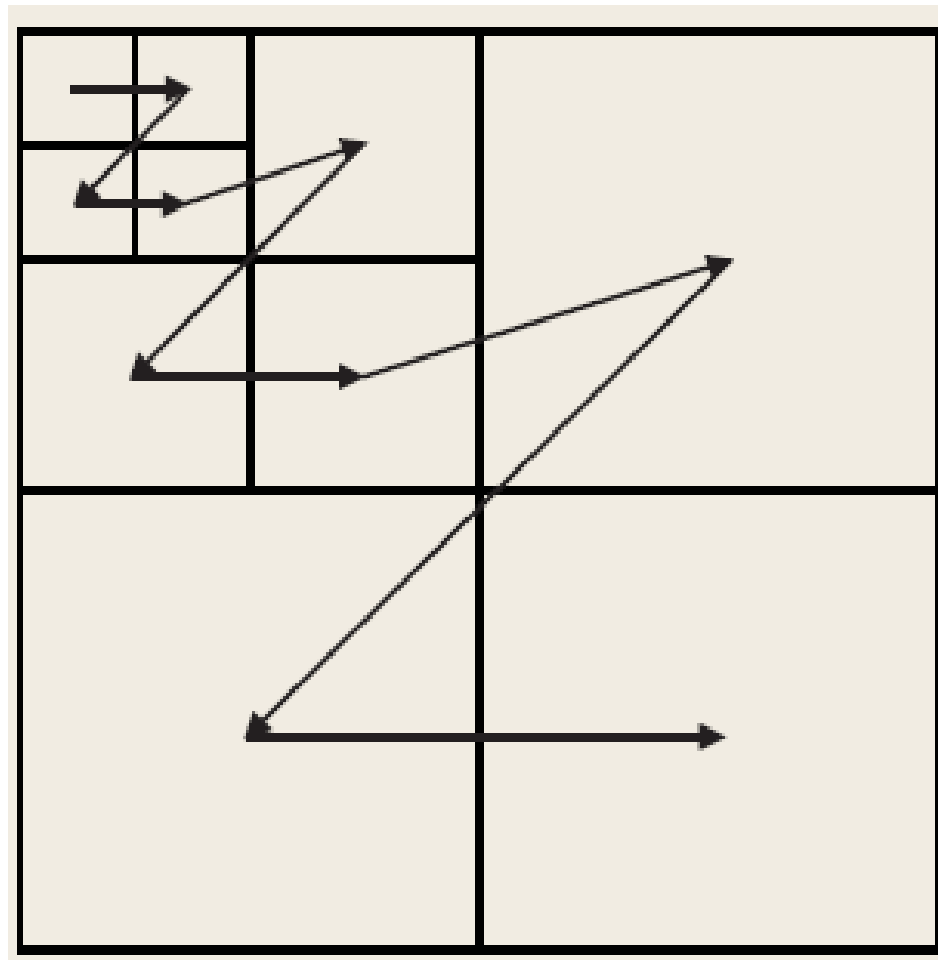
# Subband Labeling

$LL_3$	$HL_3$	$HL_2$	$HL_1$
$LH_3$	$HH_3$		
$LH_2$		$HH_2$	$HH_1$
$LH_1$			

# Assumed Relationship Between Quadtree Coefficients



# The Scanning Order for Dominant Passes of the EZW Algorithm



# JPEG at 0.125 bpp



# JPEG2000 at 0.125 bpp



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# JPEG at 0.25 bpp





# JPEG2000 at 0.25 bpp



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# JPEG at 0.125 bpp



# JPEG2000 at 0.125 bpp



# JPEG at 0.25 bpp



# JPEG2000 at 0.25 bpp



# Progressive by Resolution







# Progressive by Quality, 0.0625 bpp



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# Progressive by Quality, 0.125 bpp



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# Progressive by Quality, 0.25 bpp



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# Progressive by Quality, 0.5 bpp



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# Progressive by Quality, 1.0 bpp



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# Progressive by Quality, 2.0 bpp



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# Sources

- A. Skodras, C. Christopoulos, and T. Ebrahimi, “The JPEG 2000 Still Image Compression Standard,” *IEEE Signal Processing Magazine*, Sept. 2001, pp. 36-58.
- B. E. Usevitch, “A Tutorial on Modern Lossy Wavelet Image Compression: Foundations of JPEG 2000,” *IEEE Signal Processing Magazine*, Sept. 2001, pp. 22-35.
- D. S. Taubman and M. W. Marcellin, *JPEG2000: Image Compression Fundamentals, Standards, and Practice*, Kluwer, 2002.



## Sources (cont'd)

- M. Rabbani and D. Santa Cruz, “The JPEG2000 Still Image Compression Standard.”
- C. Christopolous and A. Skodras, “JPEG2000: The Next Generation Still Image Compression Standard,” Electronics Laboratory, University of Patras.