Data Compression
Fall 2022
Part 3-Lecture 3
JPEG

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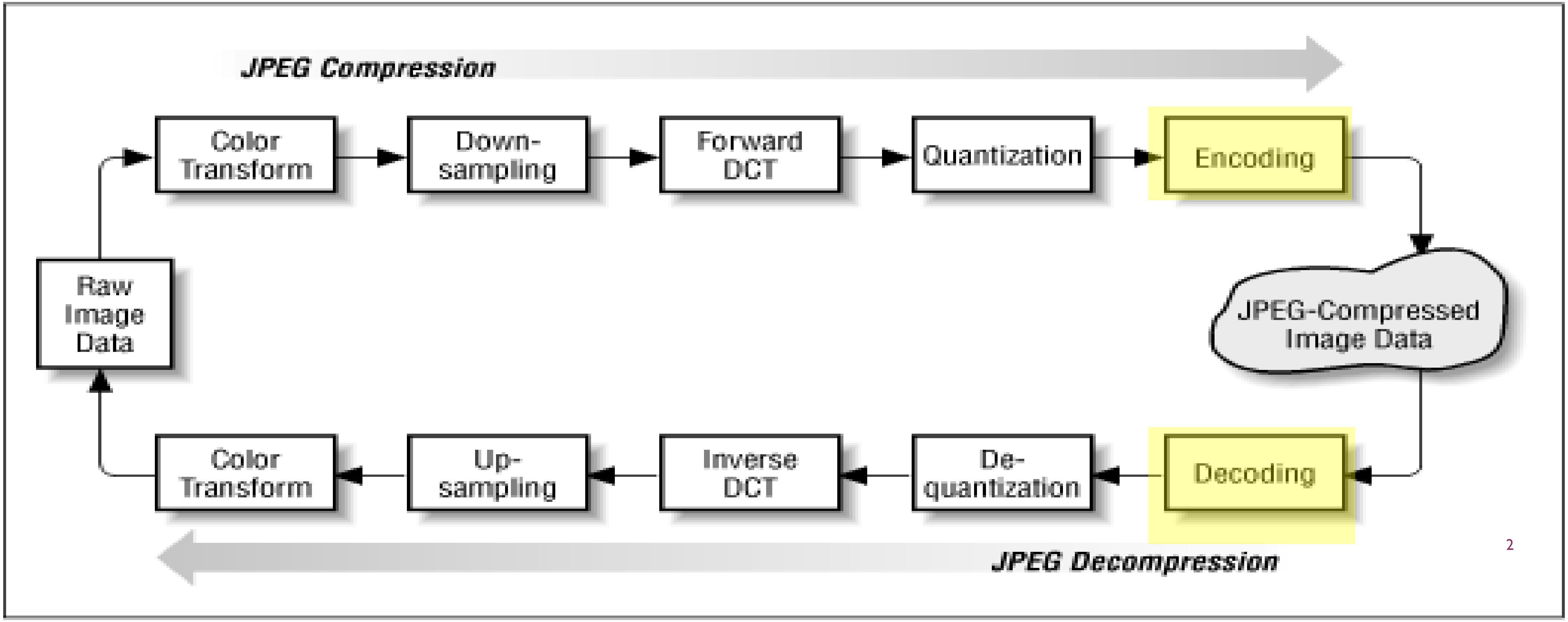
IT Dept.

JPEG



JPEG Compression
Color Transform
Down-sampling
Forward DCT
Quantization
Encoding
JPEG-Compressed Image Data
Raw Image Data
Decoding
De-quantization
Inverse DCT
Up-sampling
Color Transform
JPEG Decompression

4-JPEG: ENCODING

1. DC encoding
2. ZigZag order
3. AC encoding

DC TERM OF DCT COEFFICIENTS

- The first element in each transformed block is the DC coefficient Term
- DC term is a measure of the average of spatial block values (e.g luminance)
- The changes in DC coefficients values of consecutive blocks is small
- The DC coefficients are coded separately from the

  AC ones.

- ***Differential encoding*** (DPCM) is applied on all DC coefficients

DIFFERENTIAL ENCODING OF DC TERMS

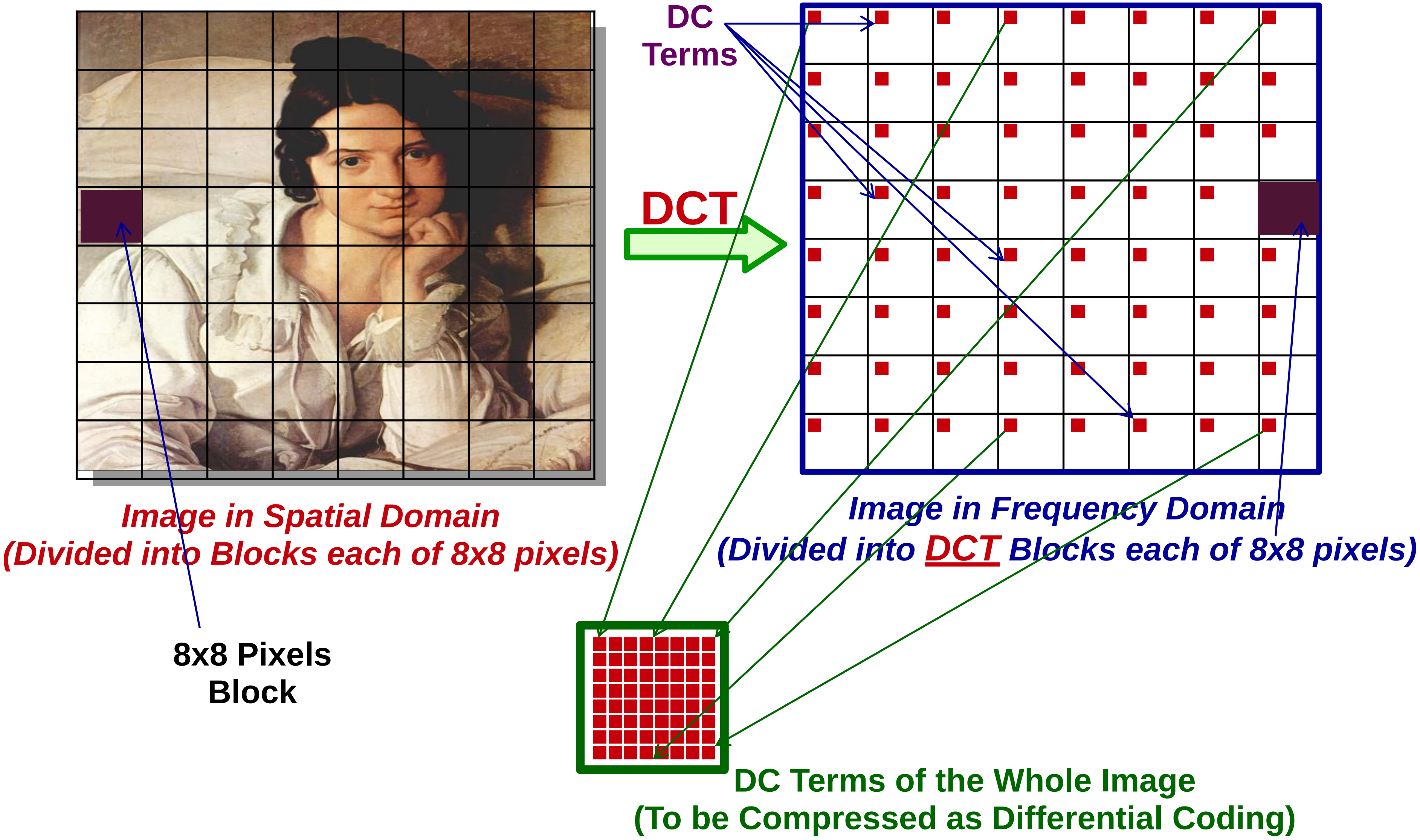


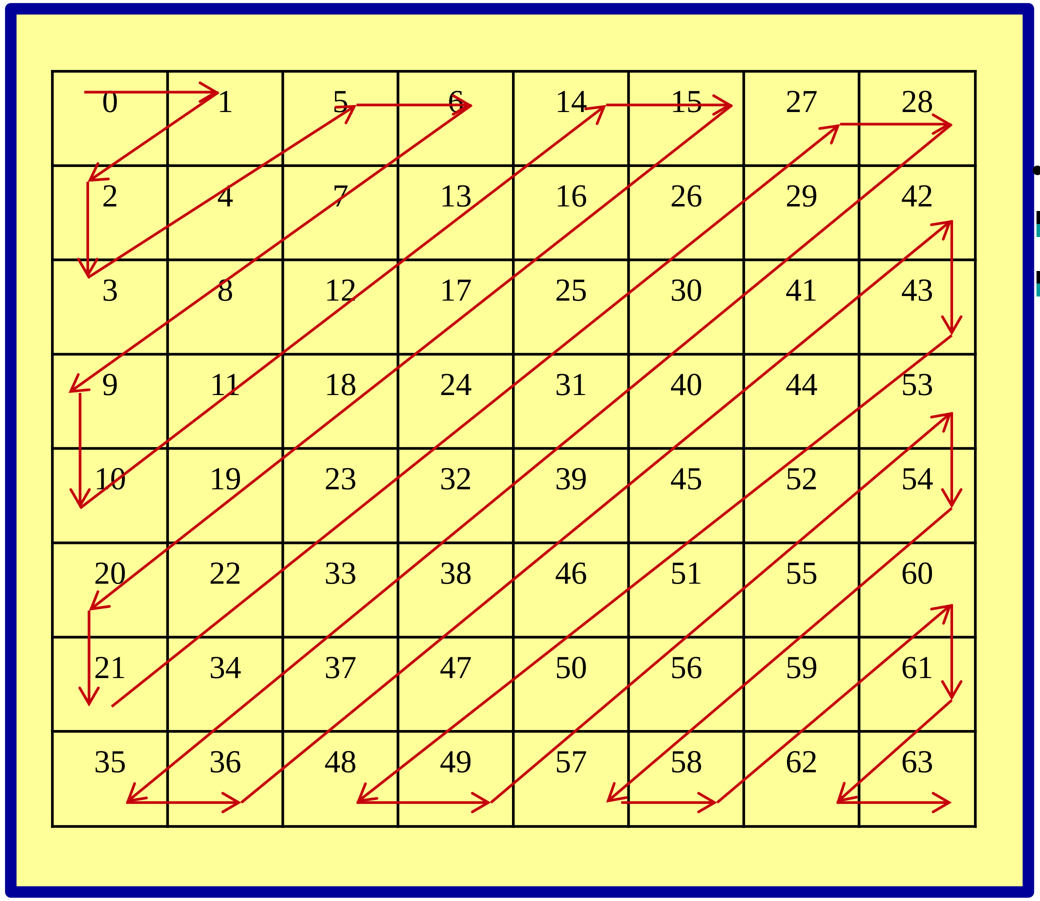
Image in Spatial Domain
(Divided into Blocks each of 8x8 pixels)

8x8 Pixels
Block

Image in Frequency Domain
(Divided into DCT Blocks each of 8x8 pixels)

DC Terms of the Whole Image
(To be Compressed as Differential Coding)

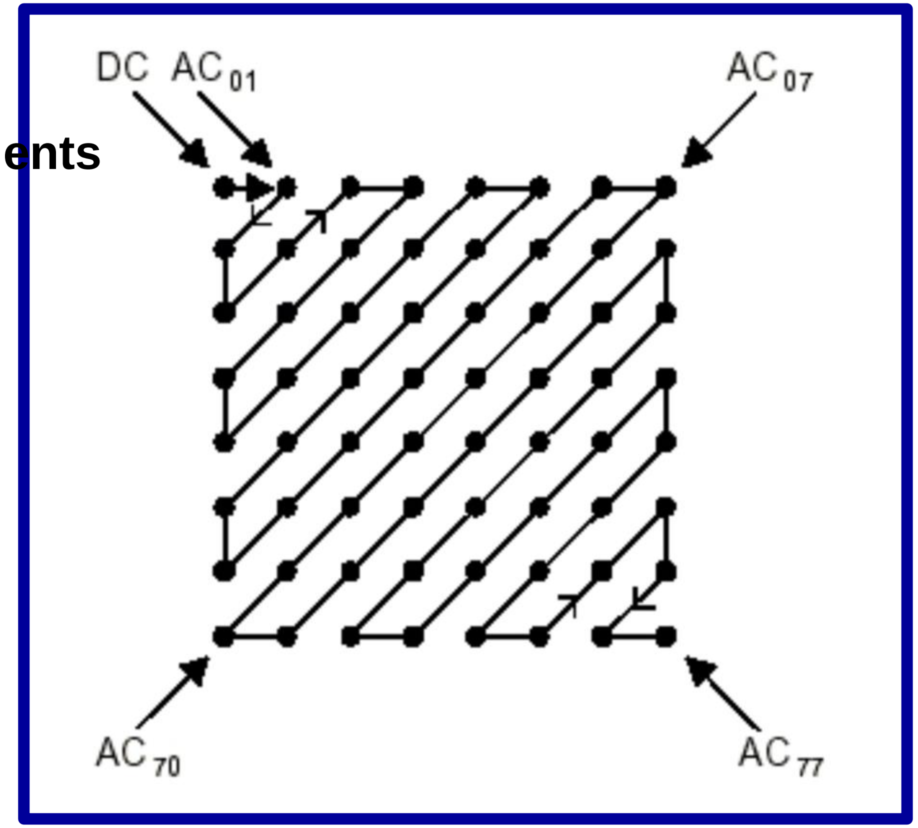
ZIGZAG SCAN OF DCT COEFFICIENTS



0	1	5	6	14	15	27	28
2	4	7	13	16	26	29	42
3	8	12	17	25	30	41	43
9	11	18	24	31	40	44	53
10	19	23	32	39	45	52	54
20	22	33	38	46	51	55	60
21	34	37	47	50	56	59	61
35	36	48	49	57	58	62	63

.Transform Coefficients

- DC coefficient
- AC coefficients



The DC coefficient and lower-frequency AC coefficients, both horizontal and vertical, are scanned first

HOW TO READ ZIGZAG ORDER?? EXAMPLE

ENCODING OF AC COEFFICIENTS

- The remaining 63 values in the vector are the AC coefficients

- Run Lenght Coding (RLE) followed by Entrpy Coding “Huffman” is applied on the AC coefficients.

- In RLE, AC coefficients are divided into pairs; each pair is made up of (*skip, value*) where skip is the number of zeros in the run and value is the next Non-Zero Value.

  {#-zeros-to-skip , next non-zero value}.

Encoding of AC Coefficients
“Steps”

1. Read AC coefficients in Zigzag order

2. Apply Run Length Code (*Use category number from category table not number it self*)

3. Apply Huffman coding on output of Run Length Code

4. Coding using Huffman code and additional bits

RLE, CATEGORIES TABLE

Note: *MSB of -ive “Additional Bits” is “0”*
MSB of +ive “additional Bits” is “1”

-ive: -7 -6 -5 -4
+ive: 4 5 6 7

Category	AC coefficient values	Additional Bits
1	-1,1	**0,1**
2	-3,-2,2,3	**00,01,10,11**
3	-7...-4,4...7	**000,001,010,011,100,101,110,111**
4	15...-8,8...15	**0000,0001,0010, 0011,.....**
5	-31...-16,16...31	
6	-63...-32,32...63	
7	-127...-33,33...127	
8	-255...-128,128...255	
9	-511...-256,256...511	
10	-1023...-512,512...1023	

RLE- HUFFMAN ENCODING FOR JPEG

Example:

-2,0,0,2,0,0,3,2,0,1,0,0,-2,0,-1,0,0,1,0,0,-1,000000000.........0000

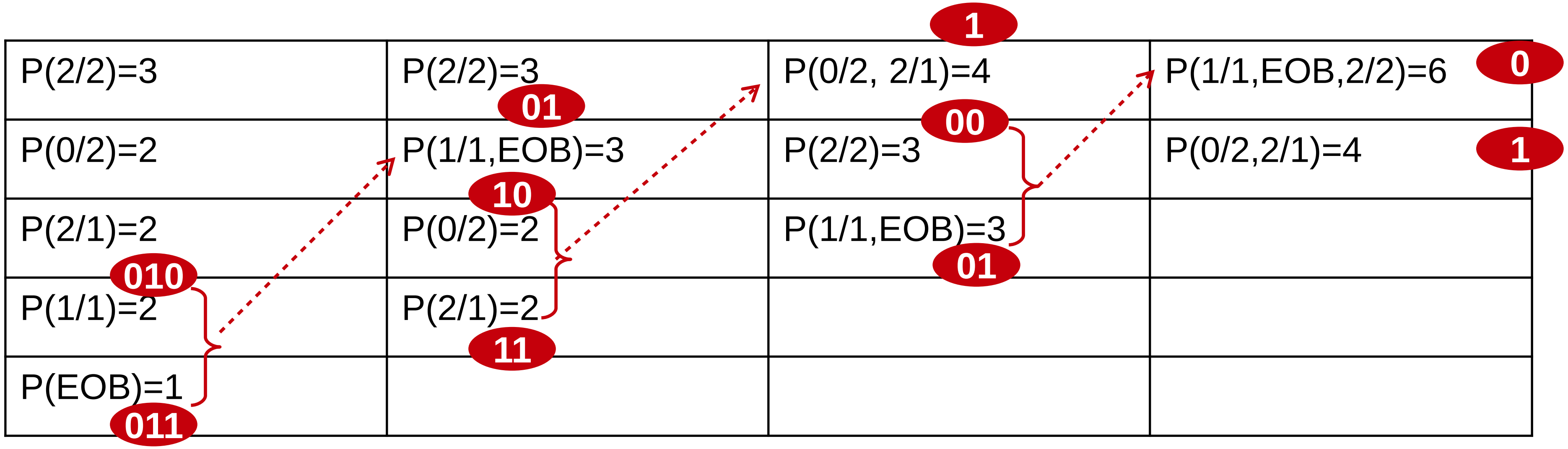
Apply RLE

-2, 0,0,2, 0,0,3, 2, 0,1, 0,0,-2, 0,-1, 0,0,1, 0,0,-1, EOB

0/2 2/2 2/2 0/2 1/1 2/2 1/1 2/1 2/1 EOB

Category number
Not number itself

Apply Huffman on Descriptors



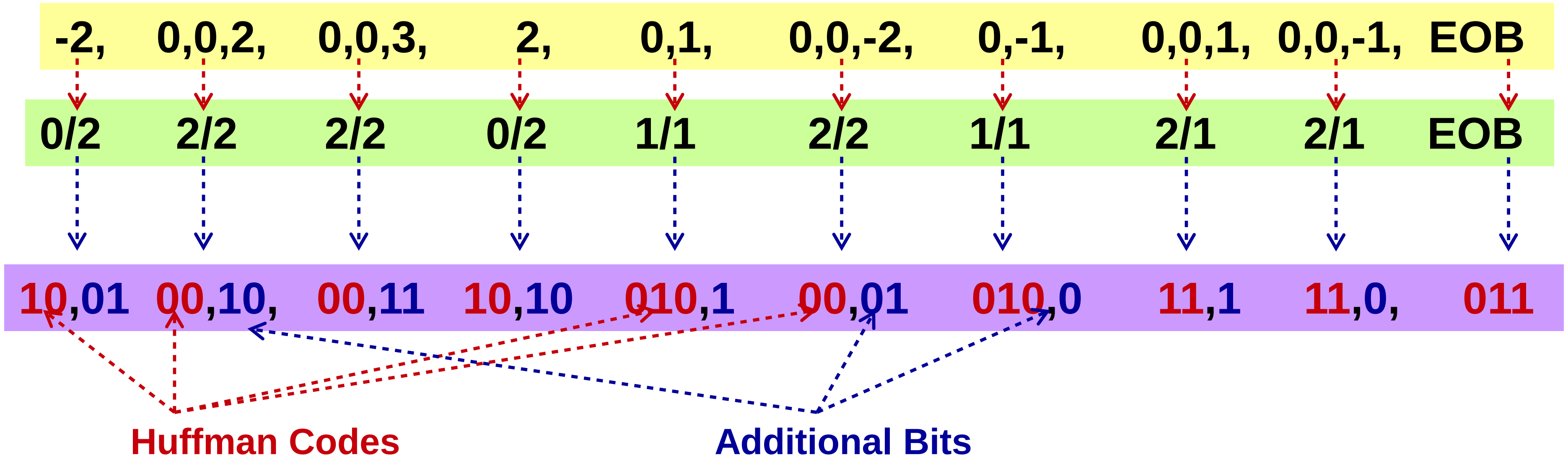
P(2/2)=3	P(2/2)=3 01	1 P(0/2, 2/1)=4	P(1/1,EOB,2/2)=6 0
P(0/2)=2	P(1/1,EOB)=3 10	00 P(2/2)=3	P(0/2,2/1)=4 1
P(2/1)=2	P(0/2)=2	P(1/1,EOB)=3 01	
010 P(1/1)=2	P(2/1)=2 11		
P(EOB)=1 011			

RLE- HUFFMAN ENCODING FOR JPEG

Encoding

Huffman Table

0/2	10
1/1	010
2/1	11
2/2	00
EOB	011

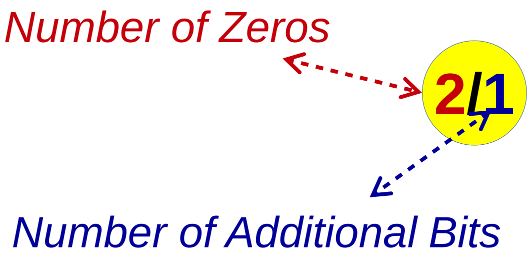


-2,	0,0,2,	0,0,3,	2,	0,1,	0,0,-2,	0,-1,	0,0,1,	0,0,-1,	EOB
0/2	2/2	2/2	0/2	1/1	2/2	1/1	2/1	2/1	EOB
10,01	00,10,	00,11	10,10	010,1	00,01	010,0	11,1	11,0,	011

Compressed Size =37 Bits

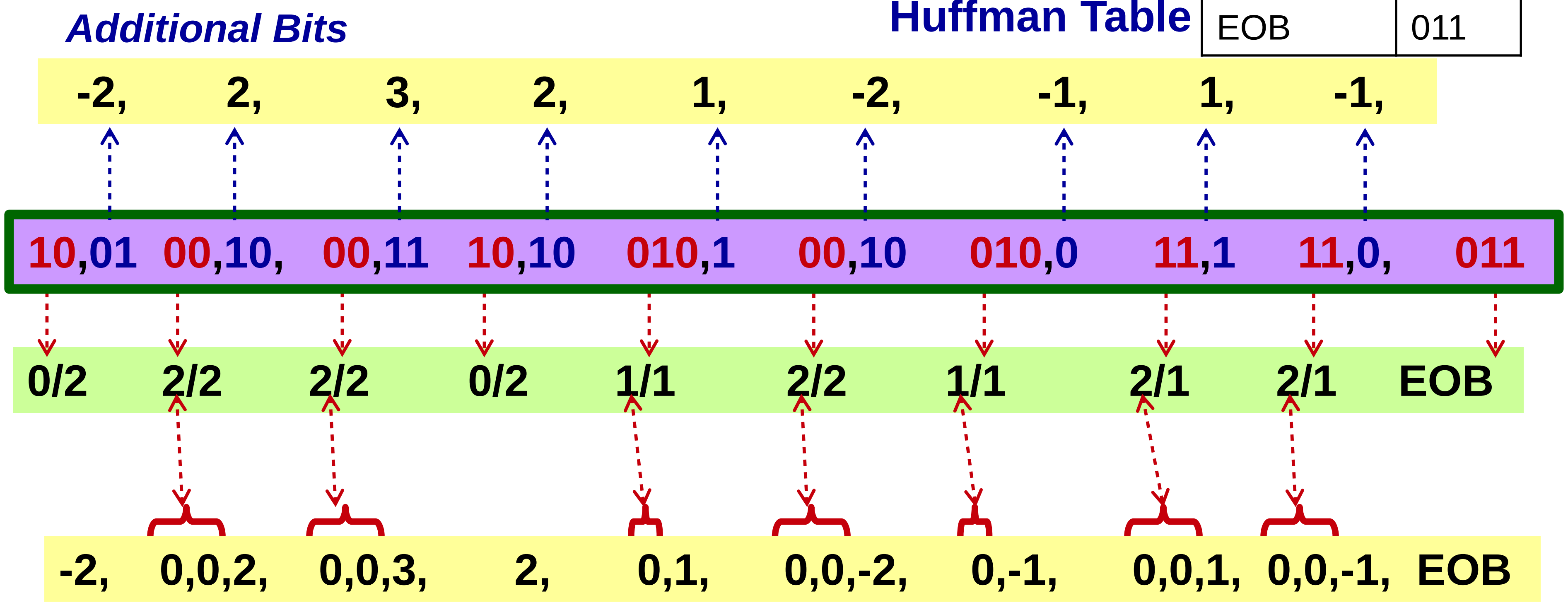
RLE- HUFFMAN ENCODING FOR JPEG

Decoding



Huffman Table

0/2	10
1/1	010
2/1	11
2/2	00
EOB	011



Additional Bits

-2, 2, 3, 2, 1, -2, -1, 1, -1,

10,01 00,10, 00,11 10,10 010,1 00,10 010,0 11,1 11,0, 011

0/2 2/2 2/2 0/2 1/1 2/2 1/1 2/1 2/1 EOB

-2, 0,0,2, 0,0,3, 2, 0,1, 0,0,-2, 0,-1, 0,0,1, 0,0,-1, EOB

COMPRESSED/DECOMPRESSED IMAGE

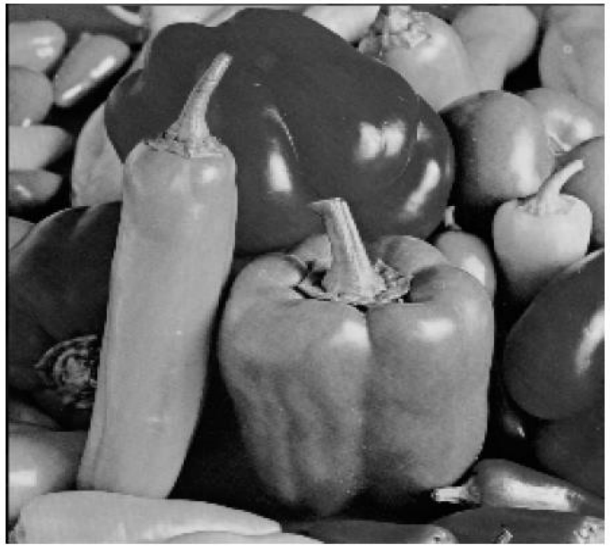


Figure 2 – Peppers

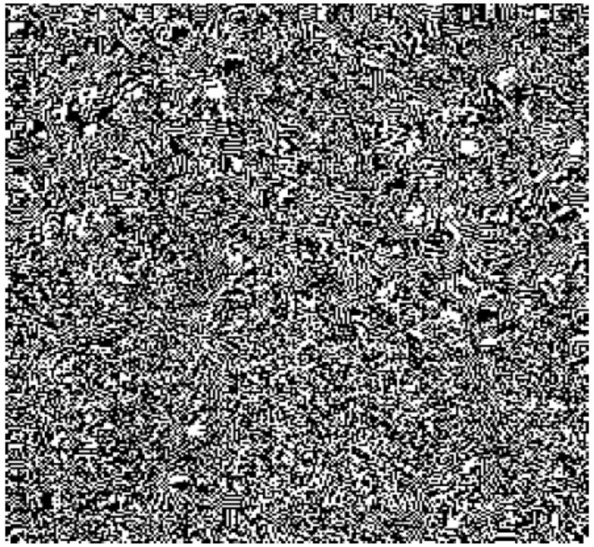


Figure 3 – DCT of Peppers

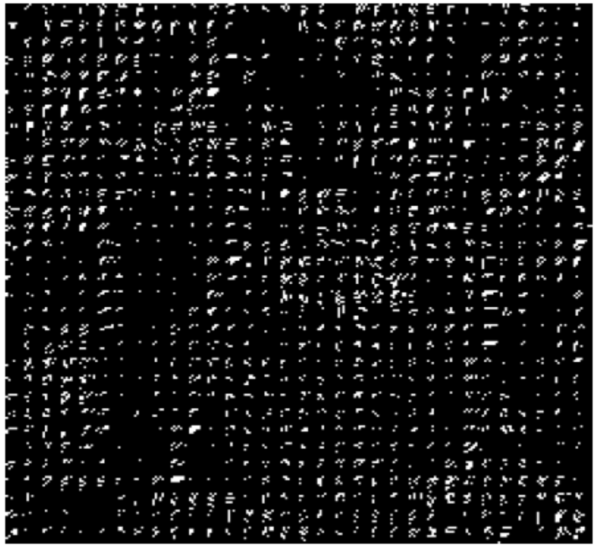


Figure 4 – Quantized DCT of Peppers

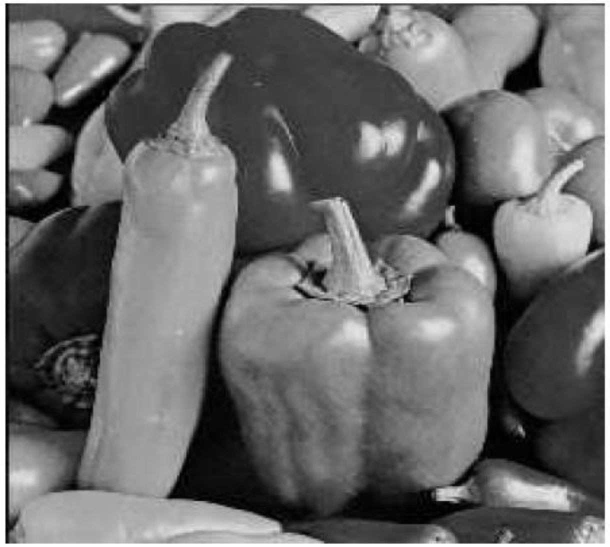


Figure 6 – Quality 50 – 84% Zeros

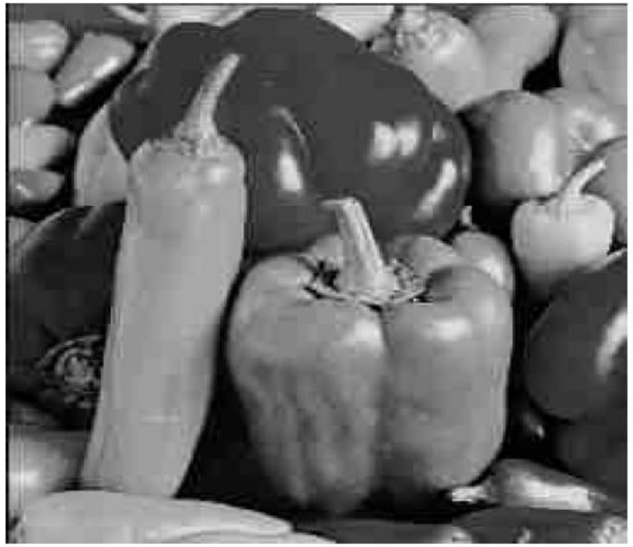


Figure 7 – Quality 20 – 91% Zeros

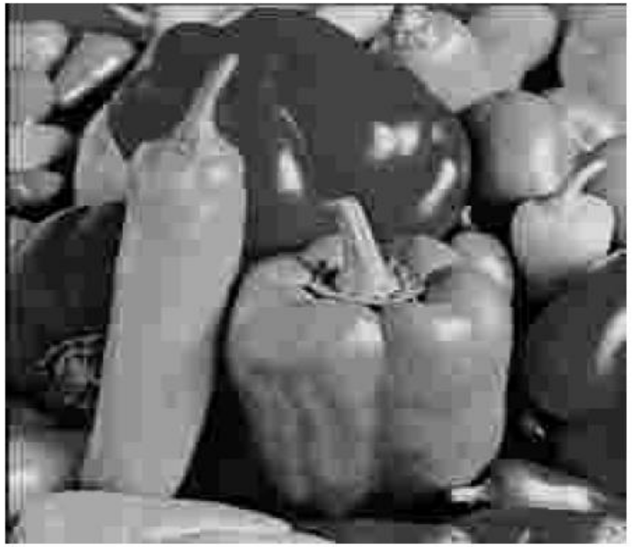
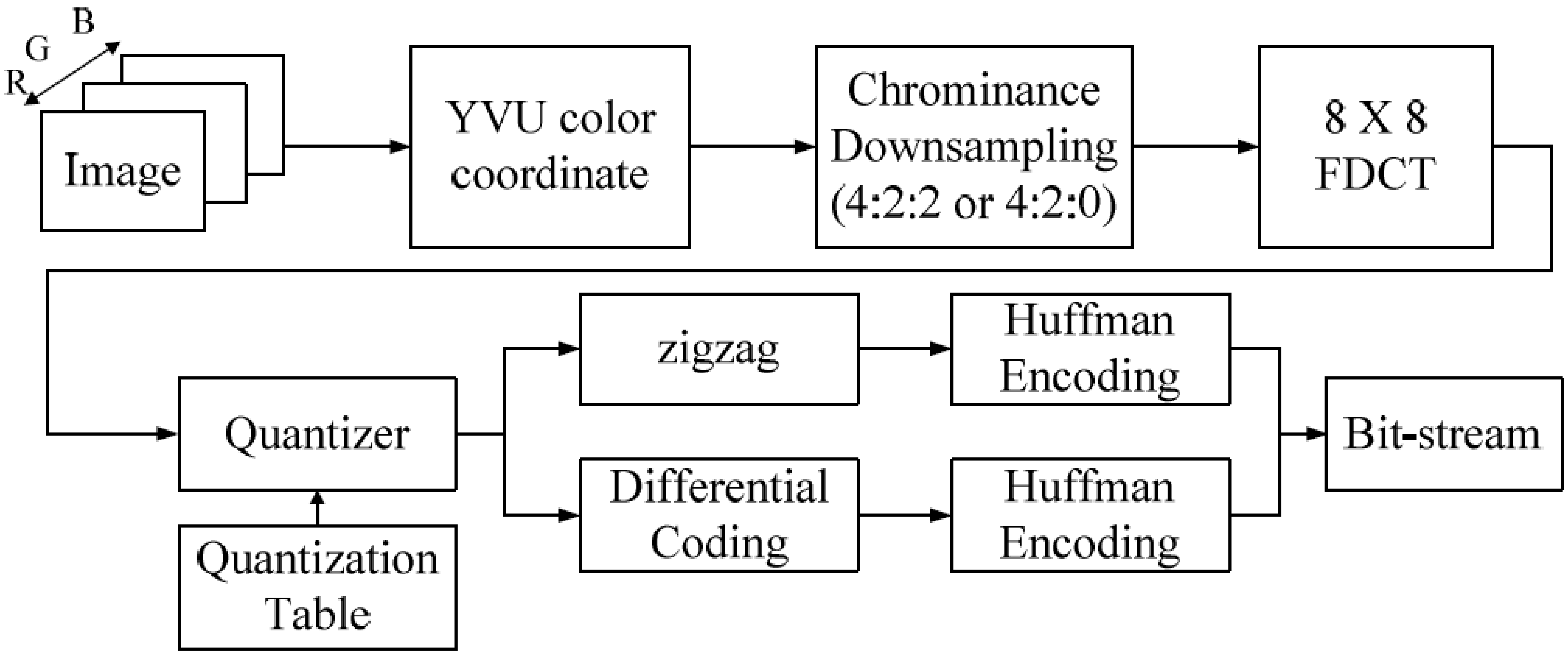


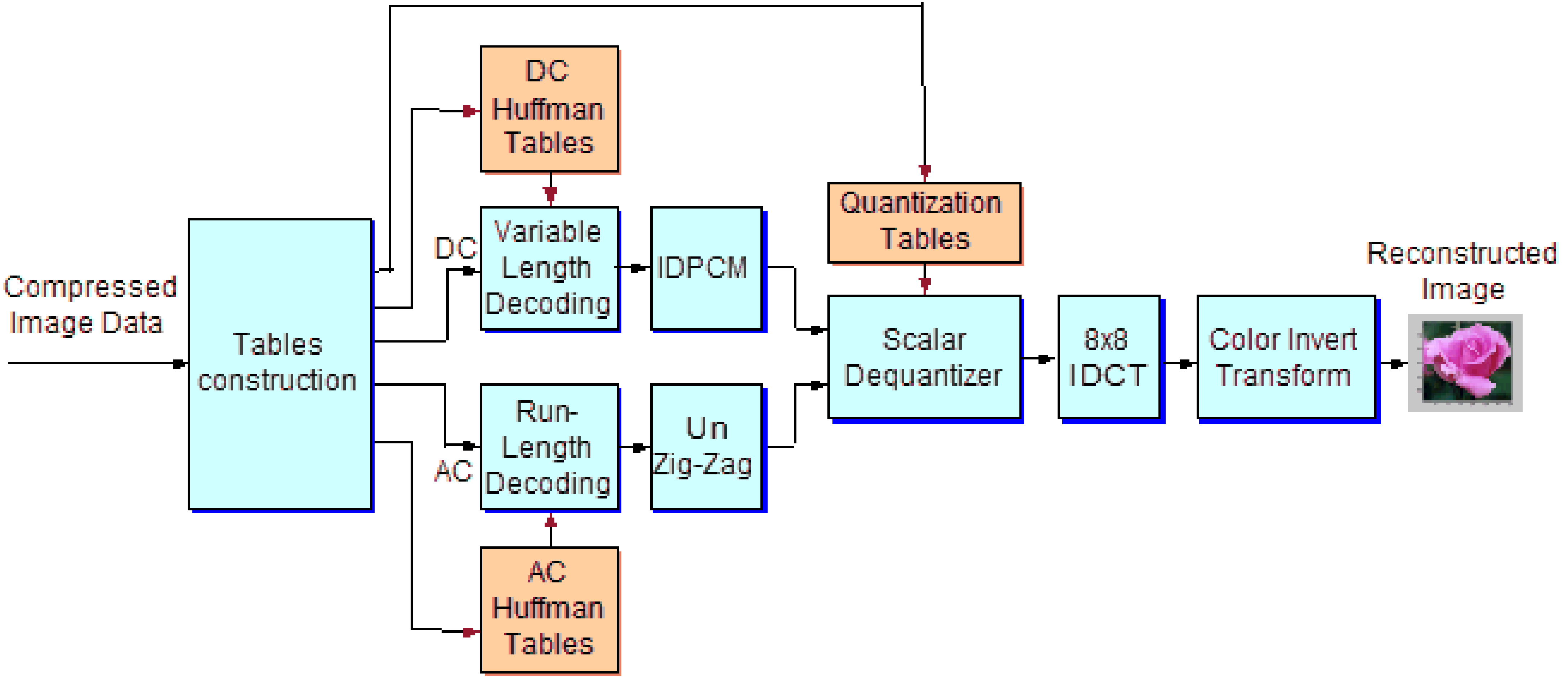
Figure 8 – Quality 10 – 94% Zeros

JPEG ENCODING



The Encoder model of JPEG compression standard

JPEG DECODING


Compressed Image Data
Tables construction
DC
AC
DC Huffman Tables
Variable Length Decoding
IDPCM
Run-Length Decoding
Un Zig-Zag
AC Huffman Tables
Quantization Tables
Scalar Dequantizer
8x8 IDCT
Color Invert Transform
Reconstructed Image