AREL ÜNİVERSİTESİ
BİYOMEDİKAL GÖRÜNTÜ İŞLEME

GÖRÜNTÜ SIKIŞTIRMA

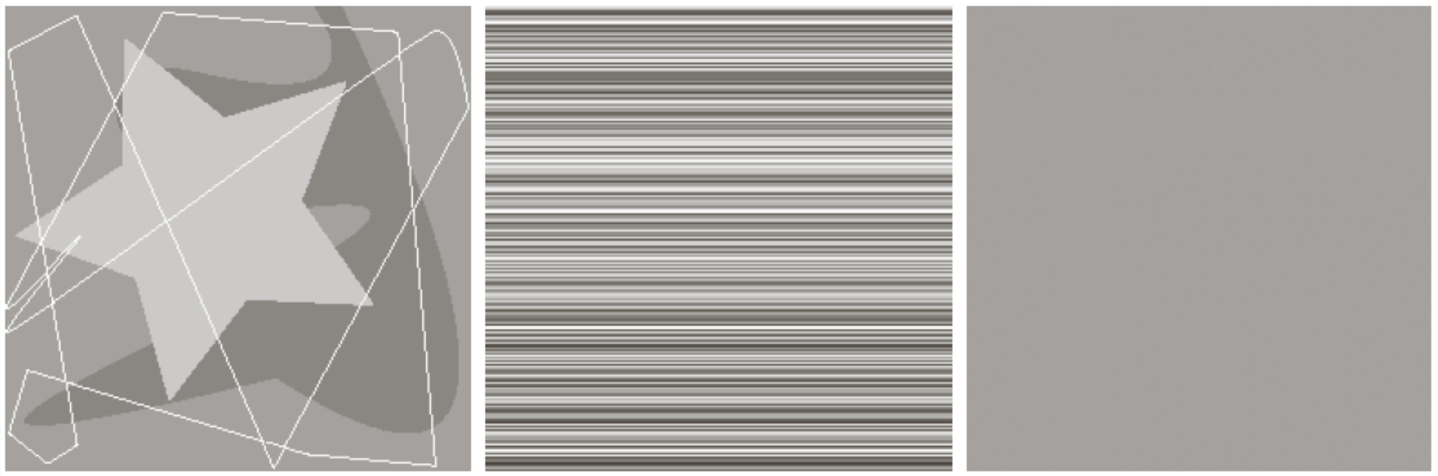
DR. GÖRKEM SERBES

Neden Sıkıştırmaya İhtiyaç Var?

İki saatlik bir film için, 720×480 standart çözünürlükte,

$$\left(30\,\frac{çerçeve}{saniye} \times (720 \times 480)\,\frac{piksel}{çerçeve} \times 3\,\frac{bayt}{piksel}\right) \times \left((60^2)\,\frac{saniye}{saat} \times 2saat\right) = 2.24 \times 10^{11} bayt$$

Nasıl sıkıştırma yapabiliriz?



a b c

FIGURE 8.1 Computer generated 256 × 256 × 8 bit images with (a) coding redundancy, (b) spatial redundancy, and (c) irrelevant information. (Each was designed to demonstrate one principal redundancy but may exhibit others as well.)

Veri Artıklığı ve Sıkıştırma Oranı

Veri Artıklığı

$$R_D = 1 - \frac{1}{C_R}$$

Sıkıştırma Oranı

$$C_R = \frac{n_1}{n_2}$$

Popüler Görüntü Sıkıştırma Standartları

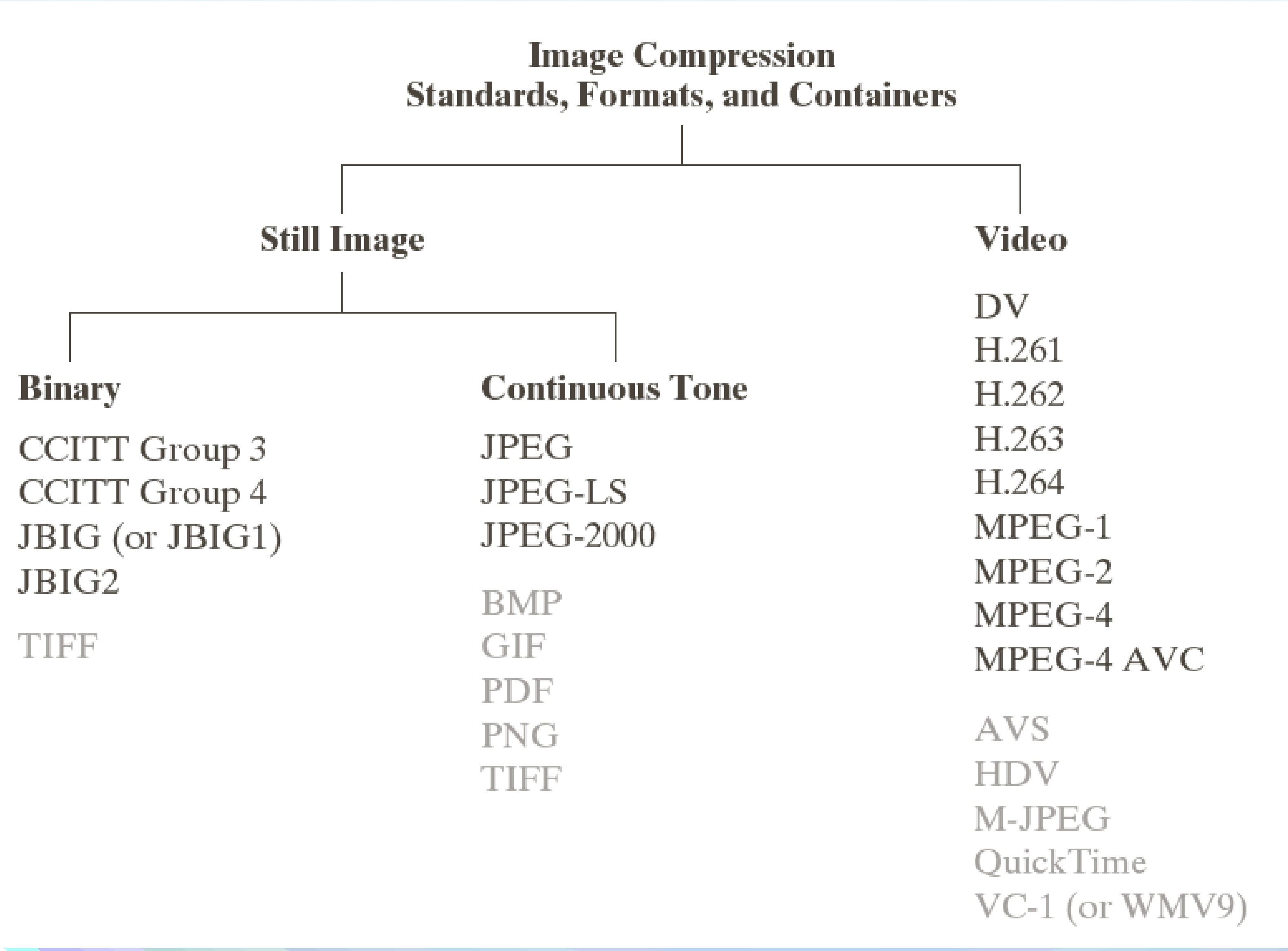


FIGURE 8.6 Some popular image compression standards, file formats, and containers. Internationally sanctioned entries are shown in black; all others are grayed.

Genel Görüntü Sıkıştırma Sistemi

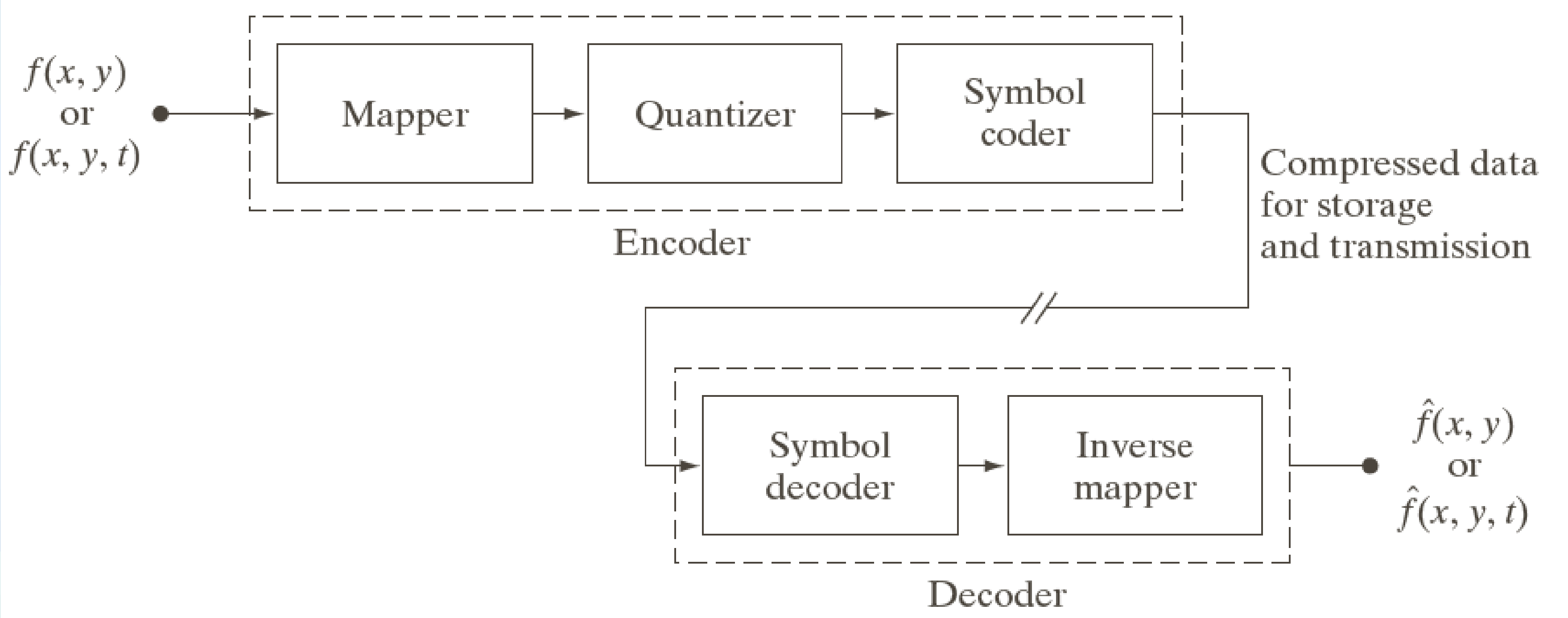
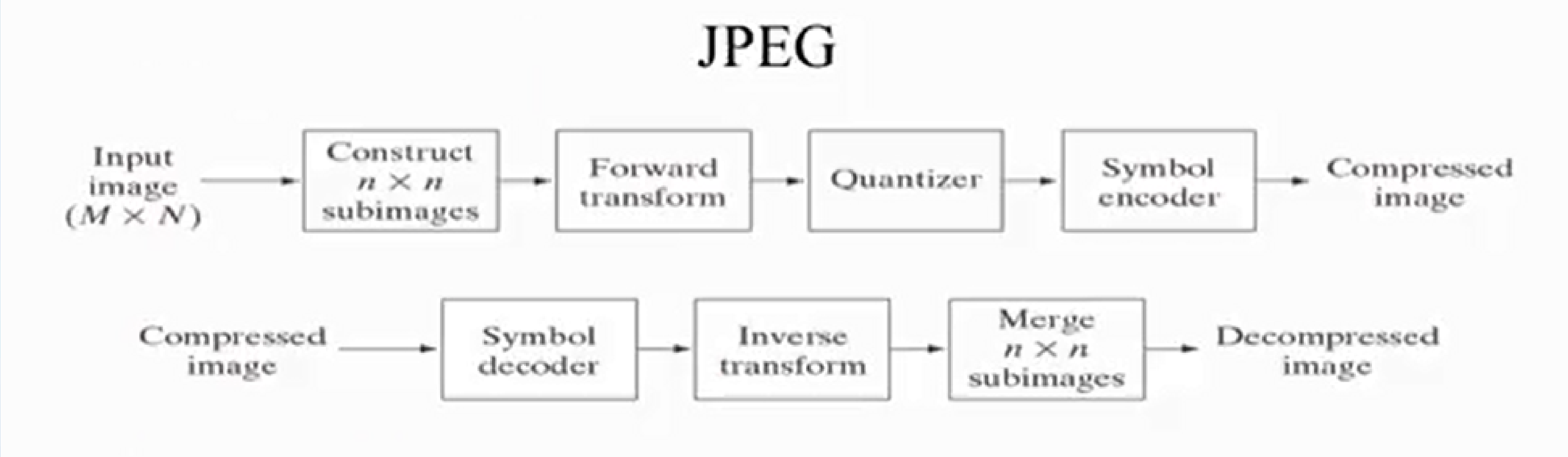
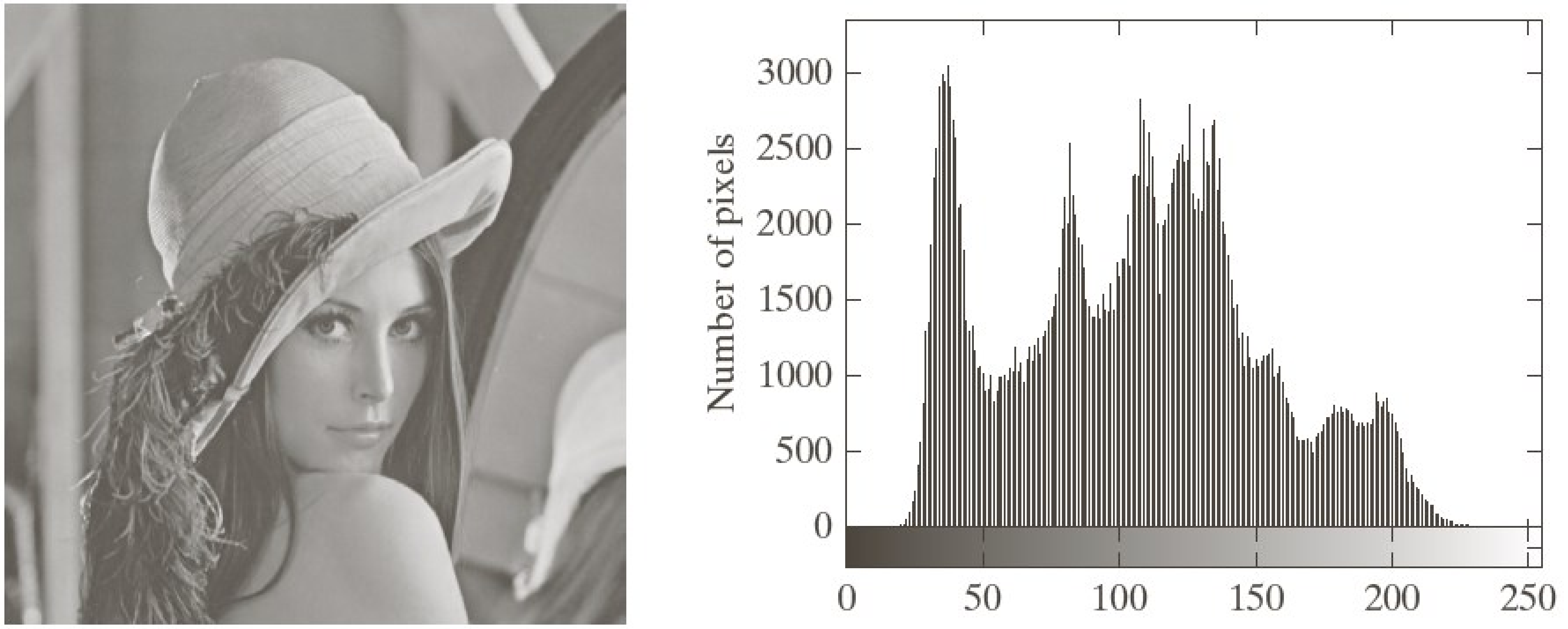


FIGURE 8.5 Functional block diagram of a general image compression system.

JPEG Görüntü Sıkıştırma Algoritması



Sembol Kodlayıcı – Huffman Kodlama



a b

FIGURE 8.9 (a) A 512 × 512 8-bit image, and (b) its histogram.

Sembol Kodlayıcı – Huffman Kodlama

Piksel yeğinlik değerleri aynı sayıda mıdır?

r_k	$p_r(r_k)$	Code 1	$l_1(r_k)$	Code 2	$l_2(r_k)$
$r_{87} = 87$	0.25	01010111	8	01	2
$r_{128} = 128$	0.47	10000000	8	1	1
$r_{186} = 186$	0.25	11000100	8	000	3
$r_{255} = 255$	0.03	11111111	8	001	3
r_k for $k \neq 87, 128, 186, 255$	0	—	8	—	0

Ne kadar sıkıştırma yapıldı?

$$0.25 \times 2 + 0.47 \times 1 + 0.25 \times 3 + 0.03 \times 3 =$$
$$1.81$$

Sembol Kodlayıcı – Huffman Kodlama

Original source		Source reduction			
Symbol	Probability	1	2	3	4
a_2	0.4	0.4	0.4	0.4	0.6
a_6	0.3	0.3	0.3	0.3	0.4
a_1	0.1	0.1	0.2	0.3	
a_4	0.1	0.1	0.1		
a_3	0.06	0.1			
a_5	0.04				

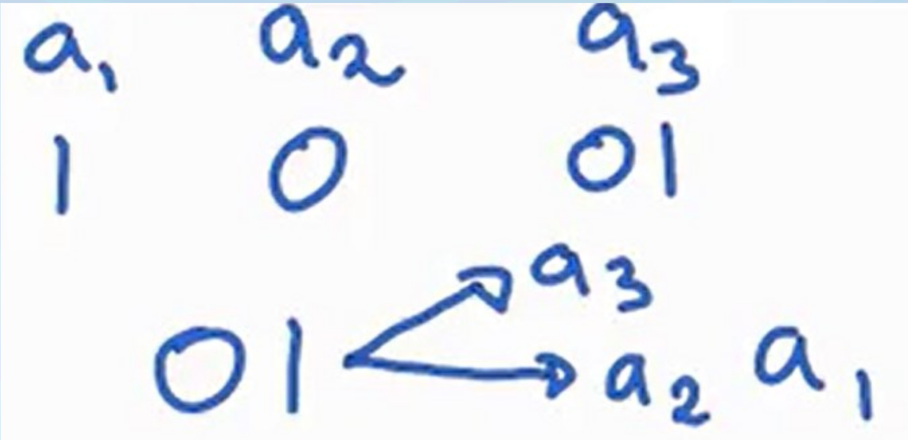
FIGURE 8.7
Huffman source reductions.

Sembol Kodlayıcı – Huffman Kodlama

FIGURE 8.8 Huffman code assignment procedure.

Original source			Source reduction							
Symbol	Probability	Code	1		2		3		4	
a_2	0.4	1	0.4	1	0.4	1	0.4	1	0.6	0
a_6	0.3	00	0.3	00	0.3	00	0.3	00	0.4	1
a_1	0.1	011	0.1	011	0.2	010	0.3	01		
a_4	0.1	0100	0.1	0100	0.1	011				
a_3	0.06	01010	0.1	0101						
a_5	0.04	01011								

Prefix Free



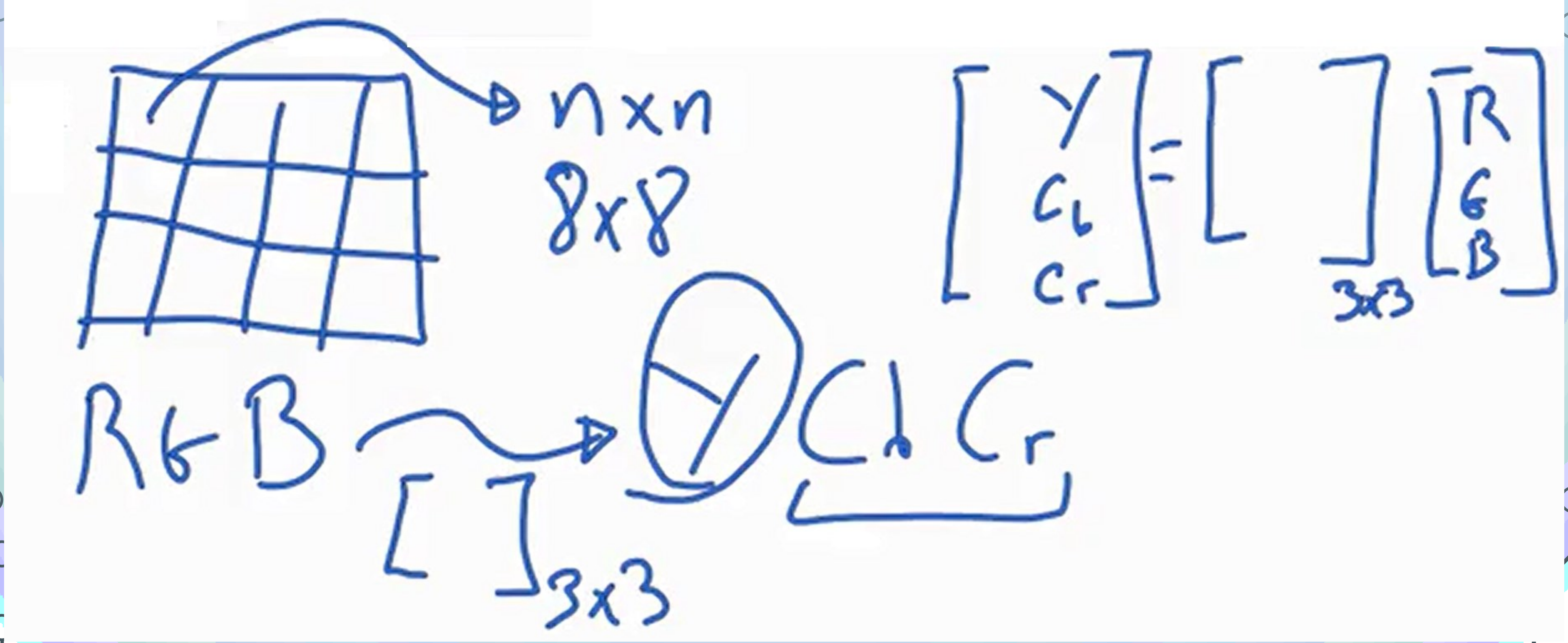
Sembol Kodlayıcı – Huffman Kodlama

FIGURE 8.8 Huffman code assignment procedure.

Original source			Source reduction							
Symbol	Probability	Code	1		2		3		4	
a_2	0.4	1	0.4	1	0.4	1	0.4	1	0.6	0
a_6	0.3	00	0.3	00	0.3	00	0.3	00	0.4	1
a_1	0.1	011	0.1	011	0.2	010	0.3	01		
a_4	0.1	0100	0.1	0100	0.1	011				
a_3	0.06	01010	0.1	0101						
a_5	0.04	01011								

$$\text{Entropy} = H = -\sum_{\text{symbols}} P(s) \log_2 P(s)$$

JPEG - 8×8 Bloklar



Ayrık Kosinüs Dönüşümü

Neden ihtiyaç var?

MSE = Mean Square Error

$$MSE = \left[\frac{1}{\#\text{ of pixels}} \sum_{\text{pixels}} (\hat{f} - f)^2 \right]^{1/2}$$

$n \times n$ kahunen-Loève

KLT

Ayrık Kosinüs Dönüşümü

Formül

$$T(u,v) = \sum_{x=0}^{n-1} \sum_{y=0}^{n-1} f(x,y)\, r(x,y,u,v)$$

$n \times n$

$$f(x,y) = \sum_{u=0}^{n-1} \sum_{v=0}^{n-1} T(u,v)\, s(x,y,u,v)$$

Ayrık Kosinüs Dönüşümü

$$r(x,y,u,v) = s(x,y,u,v)$$

$$= \alpha(u)\alpha(v)\cos\left[\frac{(2x+1)u\pi}{2n}\right] \cdot \cos\left[\frac{(2y+1)v\pi}{2n}\right]$$

$$\alpha(u) = \begin{cases} \sqrt{\frac{1}{n}} & u = 0 \\ \sqrt{\frac{2}{n}} & u \neq 0 \end{cases}$$

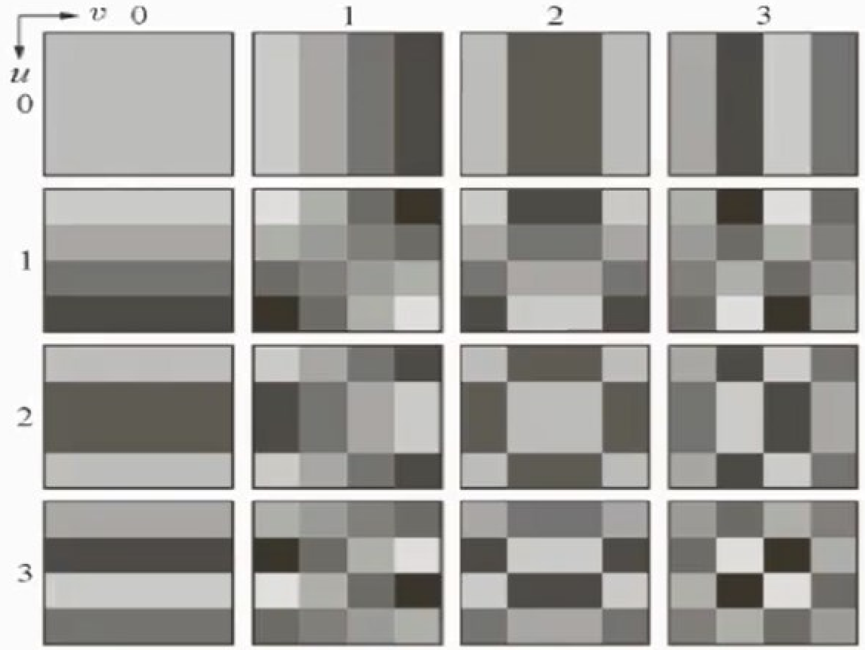
DCT

Ayrık Kosinüs Dönüşümü

$T(u,v)$

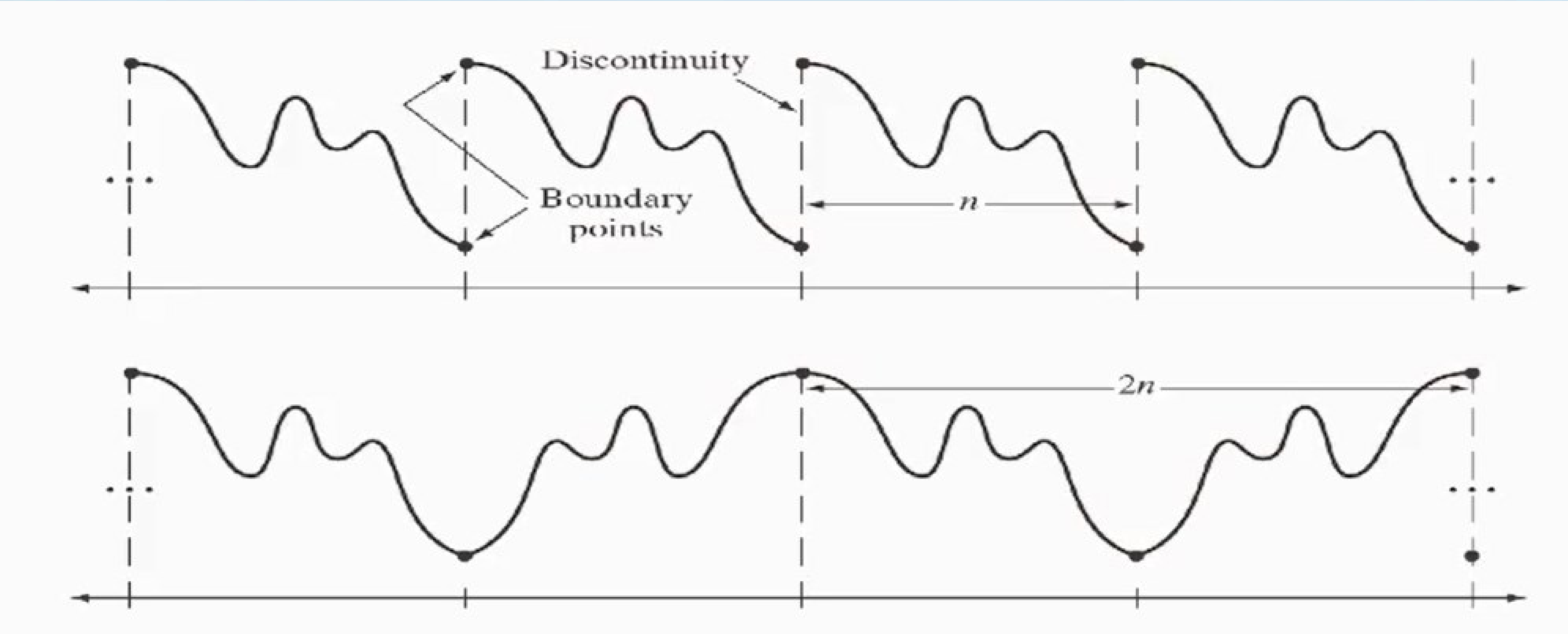
Discrete Cosine Transform

$n=4$



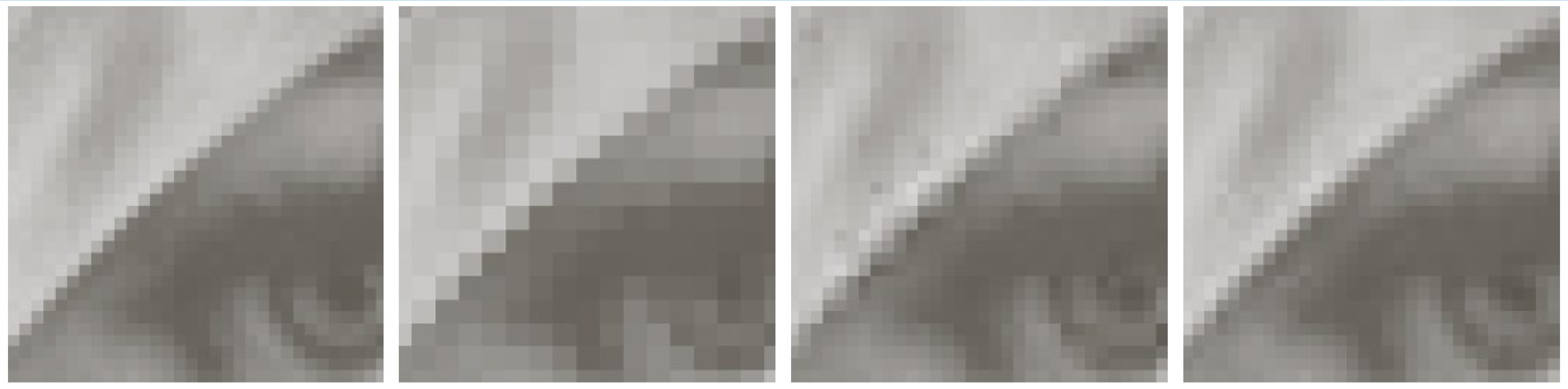
Ayrık Kosinüs Dönüşümü

Neden Ayrık Kosinüs Dönüşümü?



Ayrık Kosinüs Dönüşümü

Neden 8×8?



a b c d

FIGURE 8.27 Approximations of Fig. 8.27(a) using 25% of the DCT coefficients and (b) 2 × 2 subimages, (c) 4 × 4 subimages, and (d) 8 × 8 subimages. The original image in (a) is a zoomed section of Fig. 8.9(a).

Ayrık Kosinüs Dönüşümü

Sonuç?

a b
c d

FIGURE 8.28 Approximations of Fig. 8.9(a) using 12.5% of the 8×8 DCT coefficients: (a)—(b) threshold coding results; (c)—(d) zonal coding results. The difference images are scaled by 4.

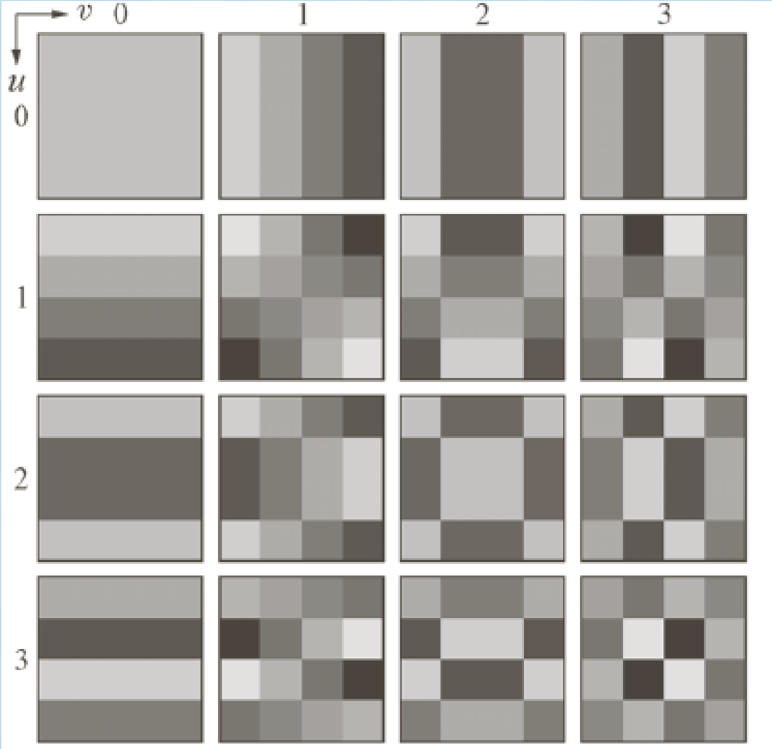
Quantization

1	1	1	1	1	0	0	0
1	1	1	1	0	0	0	0
1	1	1	0	0	0	0	0
1	1	0	0	0	0	0	0
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

8	7	6	4	3	2	1	0
7	6	5	4	3	2	1	0
6	5	4	3	3	1	1	0
4	4	3	3	2	1	0	0
3	3	3	2	1	1	0	0
2	2	1	1	1	0	0	0
1	1	1	0	0	0	0	0
0	0	0	0	0	0	0	0

1	1	0	1	1	0	0	0
1	1	1	1	0	0	0	0
1	1	0	0	0	0	0	0
1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	1	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

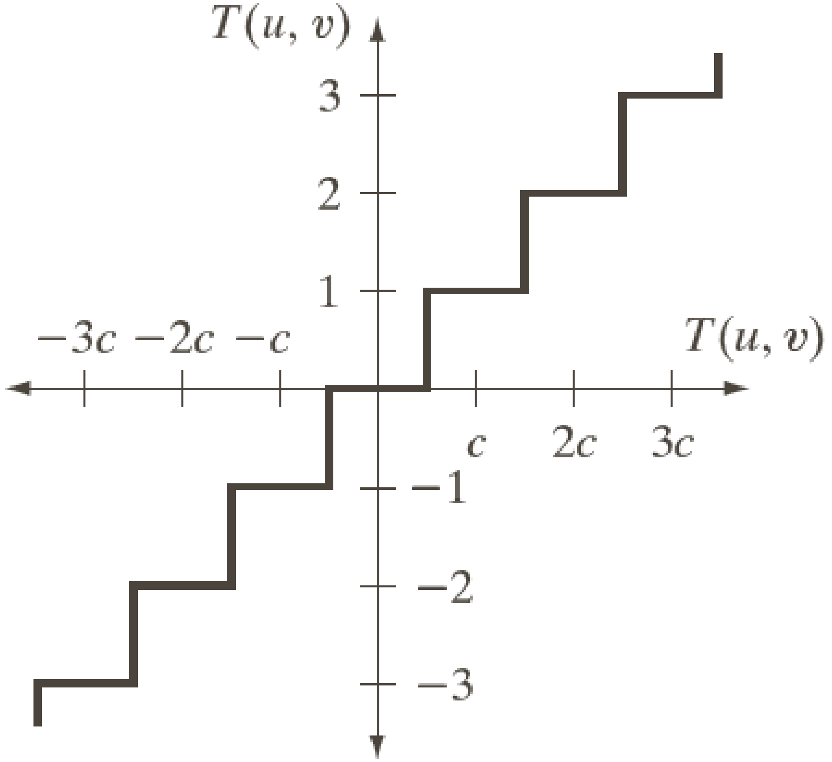
0	1	5	6	14	15	27	28
2	4	7	13	16	26	29	42
3	8	12	17	25	30	41	43
9	11	18	24	31	40	44	53
10	19	23	32	39	45	52	54
20	22	33	38	46	51	55	60
21	34	37	47	50	56	59	61
35	36	48	49	57	58	62	63



$$\underline{T(u,v)} = \sum_x \sum_y f(x,y)\, r(x,y,u,v)$$

$$\hat{f}(x,y) = \sum_u \sum_v \hat{T}(u,v)\, r(x,y,u,v)$$

Quantization



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

a b

FIGURE 8.30 (a) A threshold coding quantization curve [see Eq. (8.2-29)]. (b) A typical normalization matrix.

Quantization

FIGURE 8.31 Approximations of Fig. 8.9(a) using the DCT and normalization array of Fig. 8.30(b): (a) **Z**, (b) 2**Z**, (c) 4**Z**, (d) 8**Z**, (e) 16**Z**, and (f) 32**Z**.

Quantization

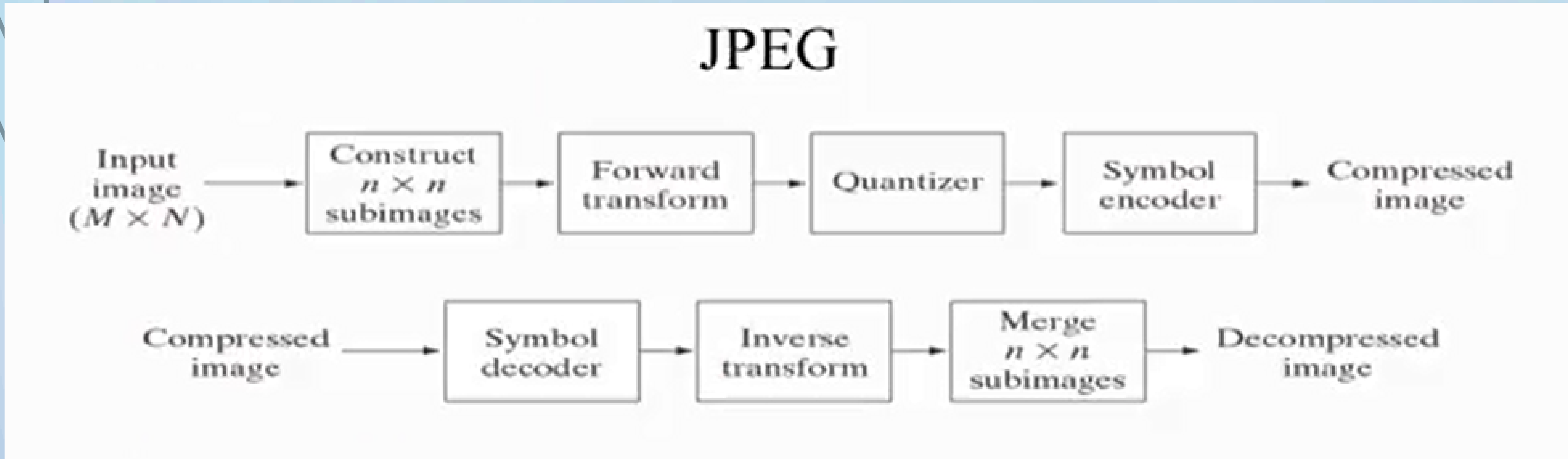
52	55	61	66	70	61	64	73
63	59	66	90	109	85	69	72
62	59	68	113	144	104	66	73
63	58	71	122	154	106	70	69
67	61	68	104	126	88	68	70
79	65	60	70	77	63	58	75
85	71	64	59	55	61	65	83
87	79	69	68	65	76	78	94

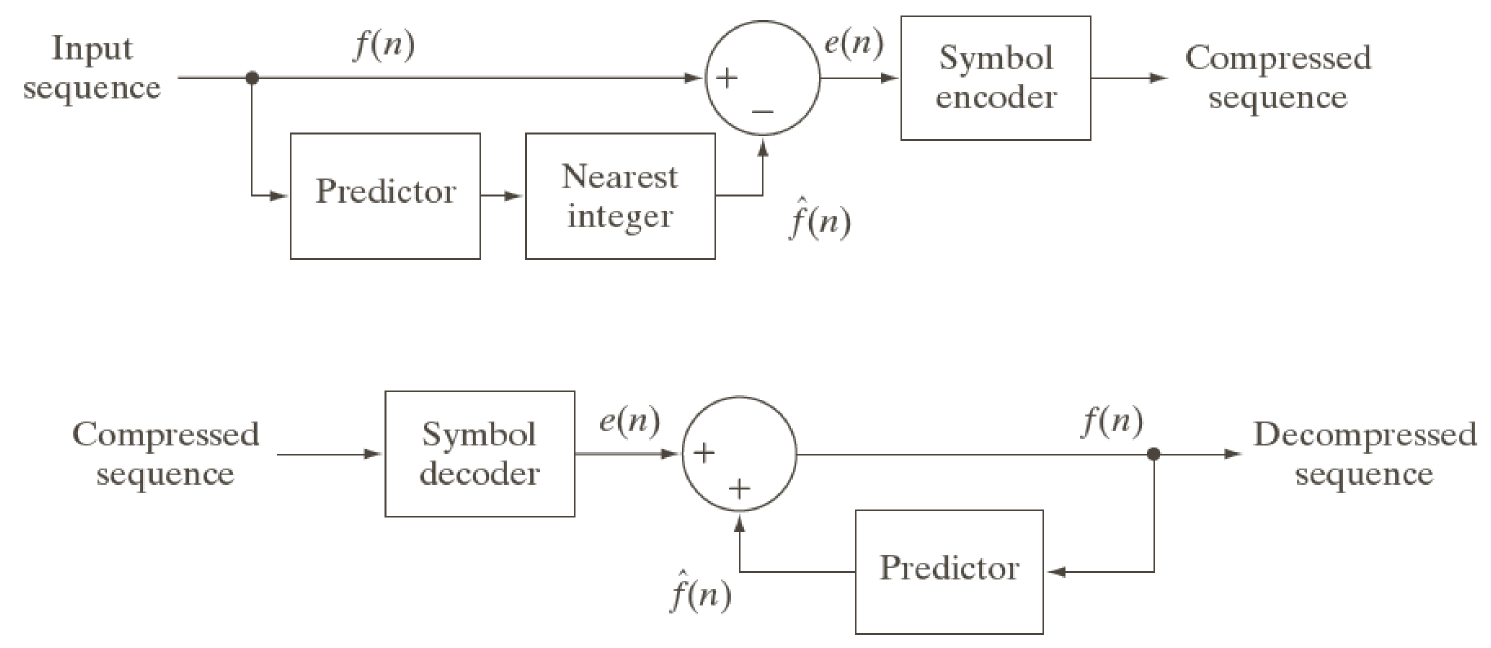
EXAMPLE 8.17: JPEG baseline coding and decoding.

Quantization

FIGURE 8.32 Two JPEG approximations of Fig. 8.9(a). Each row contains a result after compression and reconstruction, the scaled difference between the result and the original image, and a zoomed portion of the reconstructed image.

Kayıpsız Öngörücü Kodlama

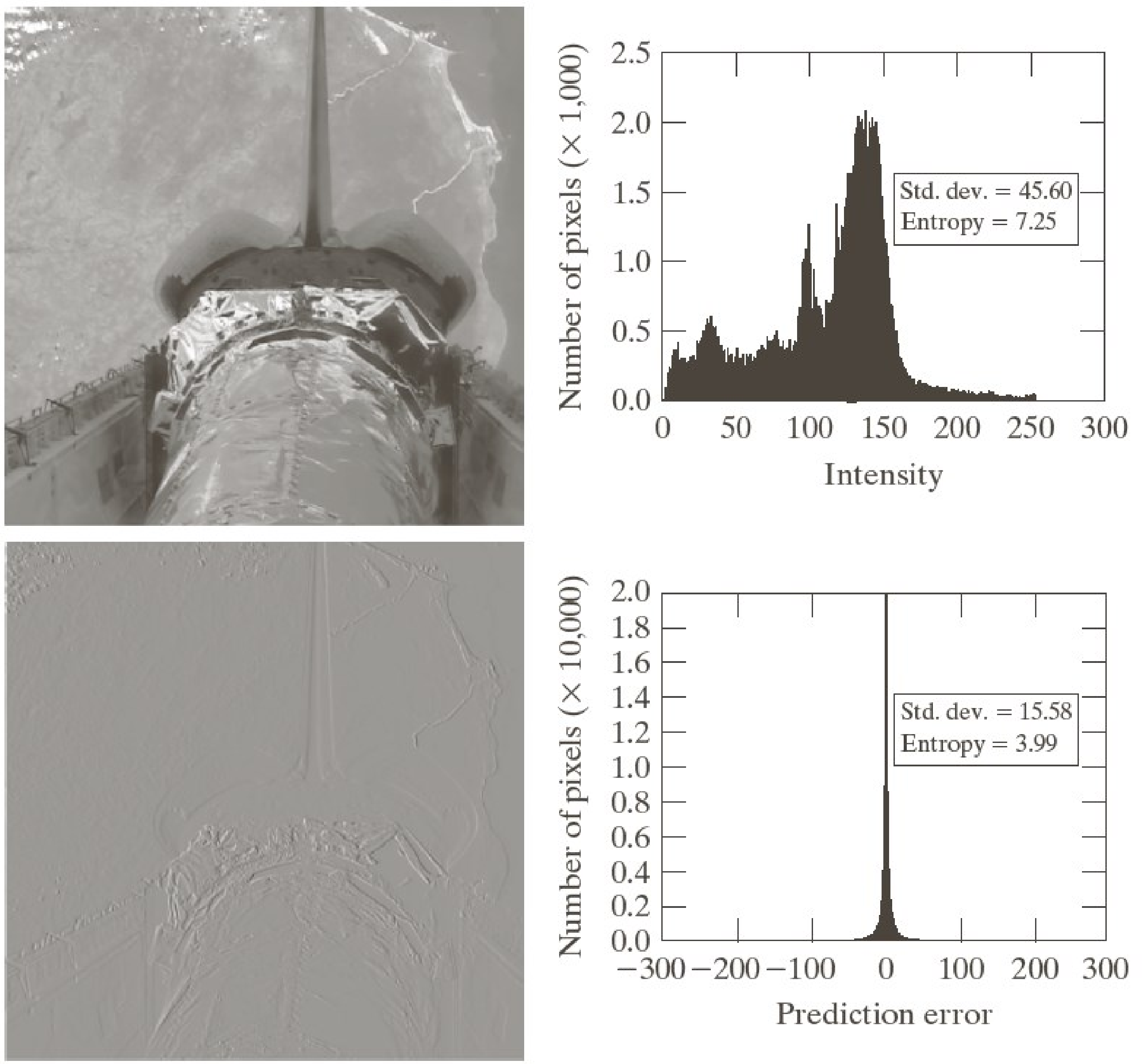




a
b

FIGURE 8.33 A lossless predictive coding model: (a) encoder; (b) decoder.

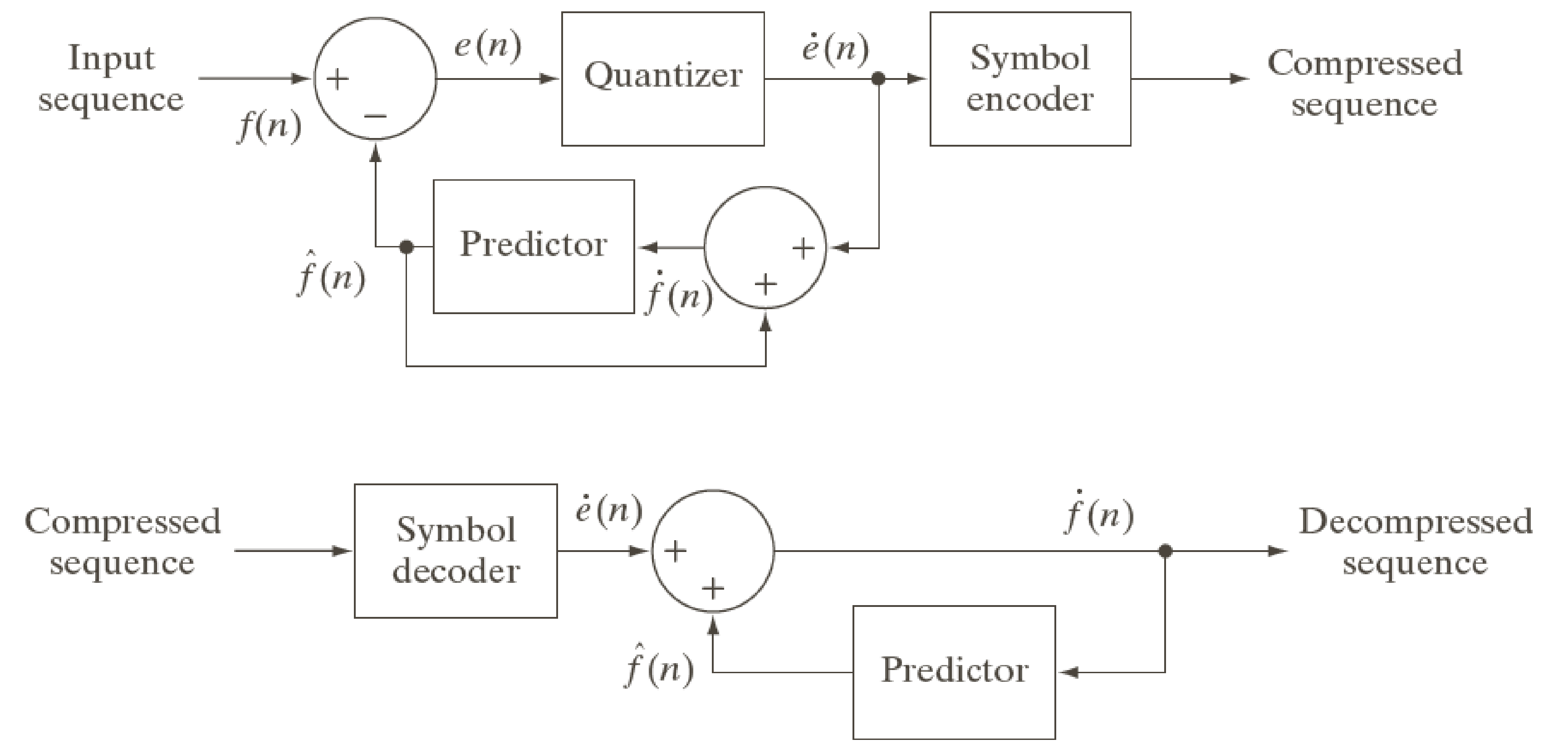
Kayıpsız Öngörücü Kodlama



a b
c d

FIGURE 8.34
(a) A view of the Earth from an orbiting space shuttle. (b) The intensity histogram of (a). (c) The prediction error image resulting from Eq. (8.2-34). (d) A histogram of the prediction error. (Original image courtesy of NASA.)

Kayıplı Öngörücü Kodlama



a
b

FIGURE 8.41 A lossless predictive coding model: (a) encoder; (b) decoder.

Video Sıkıştırma

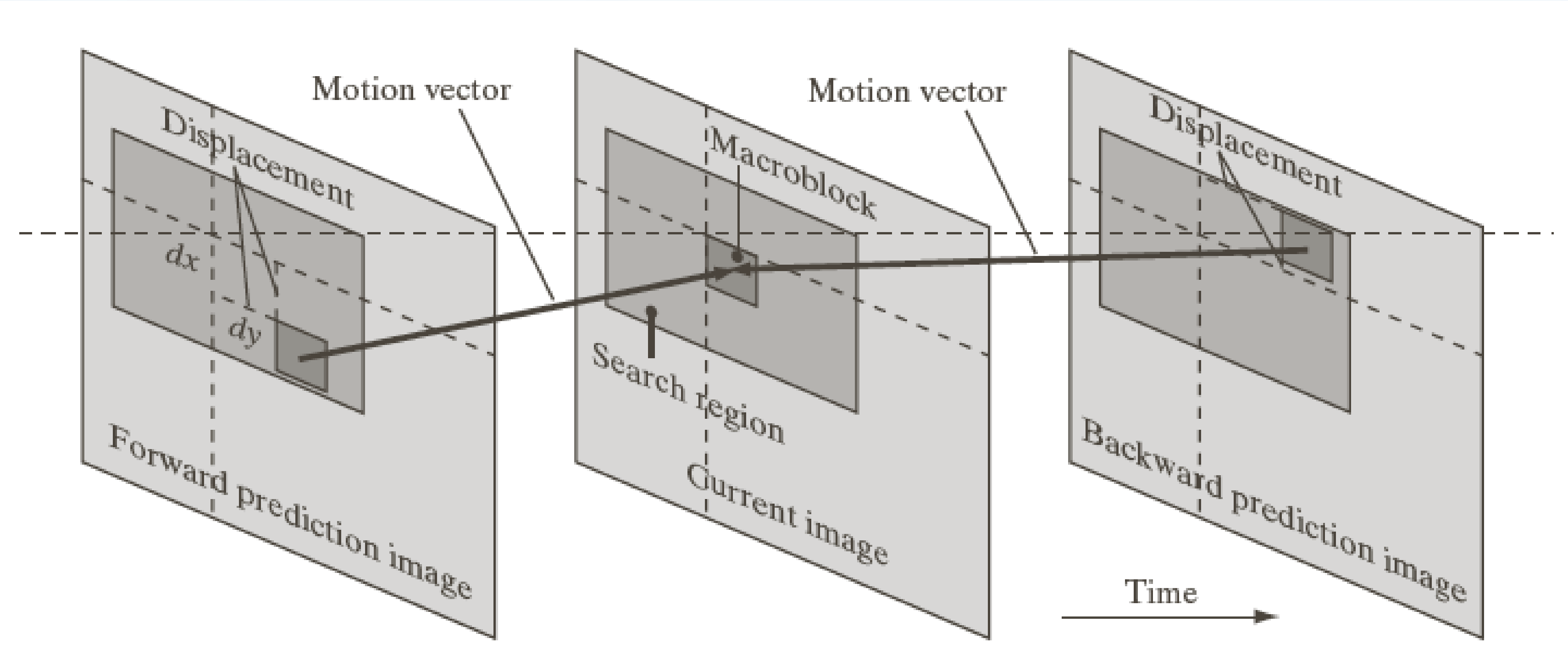
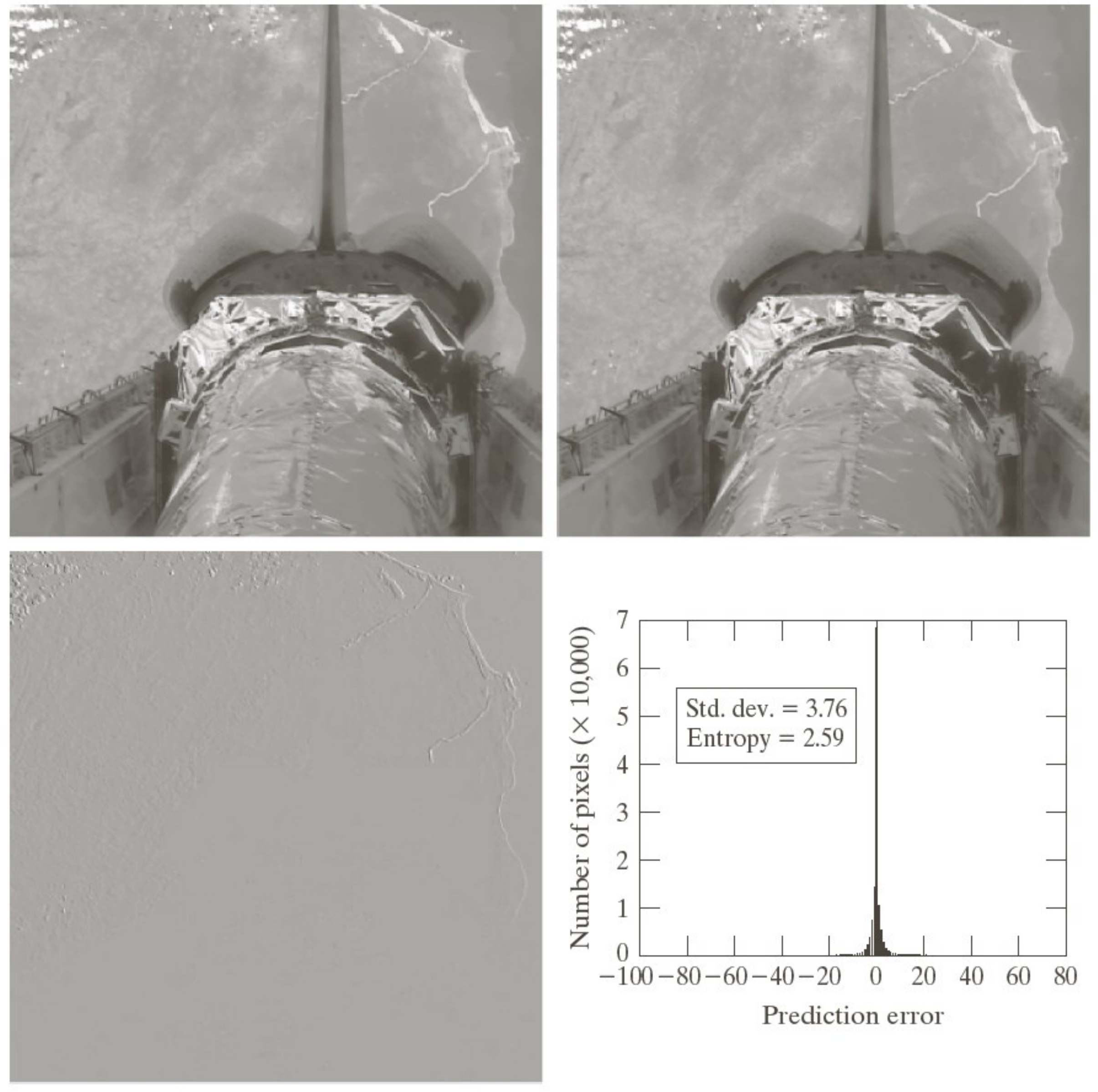


FIGURE 8.36 Macroblock motion specification.

Video Sıkıştırma



a b
c d

FIGURE 8.35 (a) and (b) Two views of Earth from an orbiting space shuttle video. (c) The prediction error image resulting from Eq. (8.2-36). (d) A histogram of the prediction error. (Original images courtesy of NASA.)

Video Sıkıştırma

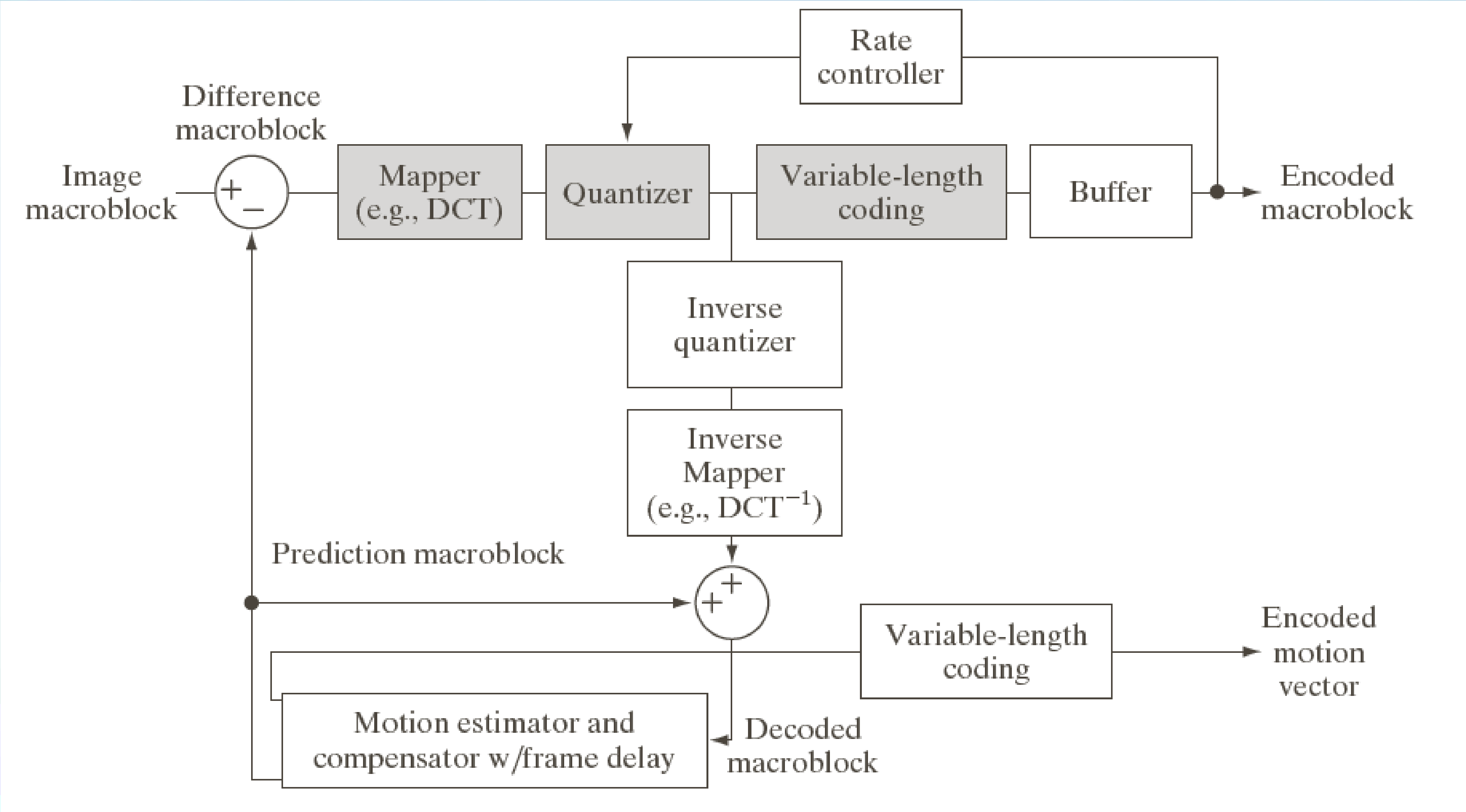


FIGURE 8.39 A typical motion compensated video encoder.