Lecture - 14
23.09.2025

Chapter 8 (Image Compression)

Compression → Lossy compression
↳ Lossless compression

Data → Raw fact

Information → Processed data

Redundant Data → Contain irrelevant or repeated information.

Relative data redundancy, $R = 1 - \frac{1}{C}$

where compression ratio, $C = \frac{b}{b'}$

[যে ২টার মধ্যে compare করবো সেখানে ১টা যদি b হয় অপরটা হবে b']

2-D intensity arrays suffer from 3 principal types of data redundancies:

1. Coding redundancy
2. Spatial and temporal redundancy
3. Irrelevant information

1. Coding redundancy

$$P_r(r_k) = \frac{n_k}{MN} ; \quad k = 0, 1, 2 \ldots L-1$$

r_k = random variable

$P_r(r_k)$ = Probability of r_k

n_k = the number of times that the k^{th} intensity appeares in the image

MN = Total pixel

$$L_{avg} = \sum_{k=0}^{L-1} l(r_k) P_r(r_k);$$

$l(r_k)$ = number of bits used to represent each value of r_k

Table - 8.1 (Page - 543)

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	10111010	8	000	3
$r_{255} = 255$	0.03	11111111	8	001	3

$$L_{avg} = 2(0.25) + 1(0.47) + 3(0.25) + 3(0.03)$$

$$= 1.81 \text{ bits}$$

Example :

10	10	15	15
10	10	15	15
20	20	15	15
25	25	25	25
25	10	15	30

$$\begin{cases} r_{10} = \frac{5}{20} = 0.25 \\ r_{15} = \frac{7}{20} = 0.35 \\ r_{20} = \frac{2}{20} = 0.10 \\ r_{25} = \frac{5}{20} = 0.25 \\ r_{30} = \frac{1}{20} = 0.05 \end{cases}$$

r_k	$P_r(r_k)$	Code 1	$l_1(r_k)$	Code 2	$l_2(r_k)$
$r_{10} = 10$	0.25	00001010	8	01	2
$r_{15} = 15$	0.35	00001111	8	1	1
$r_{20} = 20$	0.10	00010100	8	001	3
$r_{25} = 25$	0.25	00011001	8	0100	4
$r_{30} = 30$	0.05	00011110	8	111	3

$$L_{avg} = 2(0.25) + 1(0.35) + 3(0.10) + 4(0.25) + 3(0.05)$$

$$= 2.3$$

$$MNL_{avg} = 5 \times 4 \times 2.3$$

$$= 46$$

CamScanner

06·10·2025
Lecture-15

Compression Ratio, $C = \frac{b}{b'}$

$$= \frac{5 \times 4 \times 8}{5 \times 4 \times 2 \cdot 3}$$

$$\approx 3.478$$

Relative data redundancy $= 1 - \frac{1}{C}$

$$= 1 - \frac{1}{3.478}$$

$$= 0.712$$

$$= 71.2\ \%$$

2. Spatial and temporal redundancy:

10	10	10	10	(10, 4),
12	13	12	13	(12, 1),
10	10	12	12	(13, 1),

(12, 1),
(13, 1),
(10, 2),
(12, 2)

Question (theory)

Encoding example

image given → run length pair/encoding
encoding → corresponding image

3. Irrelevant information :

Most 2-D intensity arrays contain information that is ignored by human visual system and/or extraneous to the independent

$$I(E) = \log \frac{1}{P(E)} = -\log P(E)$$

entropy (কতটুকু এলোমেলো)

$$H = -\sum_{J=1}^{J} P_r(r_k) \log_2 P_r(r_k)$$

$$\bar{H} = -\sum_{k=0}^{L-1} P_r(r_k) \log_2 P_r(r_k)$$

Example 8.2 (using table 8.1 example)

r_k	$P_r(r_k)$
$r_{87} = 87$	0.25
$r_{128} = 128$	0.47
$r_{186} = 186$	0.25
$r_{255} = 255$	0.03

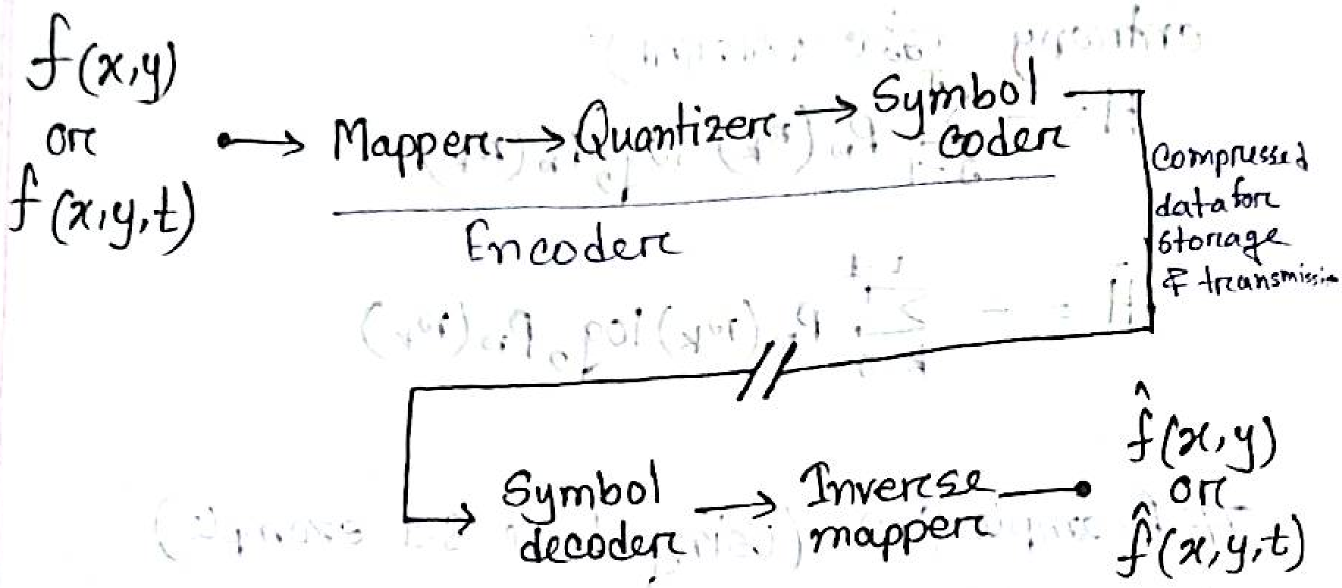
$$\bar{H} = -[0.25 \log_2 0.25 + 0.47 \log_2 0.47 + 0.25 \log_2 0.25 + 0.03 \log_2 0.03]$$

$$= -[0.25(-2) + 0.47(-1.09) + 0.25(-2) + 0.03(-5.06)]$$

$$= 1.6614 \text{ bits/pixel}$$

It is not possible to code the intensity values of the imaginary source (& thus the sample image) with fewer than $\bar{H}$ bits/pixel.

Image compression system block diagram.



Huffman Coding

Original source		Source reduction			
Symbol	Probability	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)				

Example:

a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8
0·2	0·35	0·04	0·01	0·3	0·03	0·02	0·05

Original source		Source reduction					
Symbol	Probability	1	2	3	4	5	6
a_2	0·35 (1)	0·35 (1)	0·35 (1)	0·35 (1)	0·35 (1)	0·35 (1)	0·65 (0)
a_5	0·3 (01)	0·3 (01)	0·3 (01)	0·3 (01)	0·3 (01)	0·35 (00)	0·35 (1)
a_1	0·2 (000)	0·2 (000)	0·2 (000)	0·2 (000)	0·2 (000)	0·3 (01)	
a_8	0·05 (00100)	0·05 (00100)	0·06 (0011)	0·09 (0010)	0·15 (001)		
a_3	0·04 (00101)	0·04 (00101)	0·05 (00100)	0·06 (0011)			
a_6	0·03 (00110)	0·03 (00110)	0·04 (00101)				
a_7	0·02 (001110)	0·03 (00111)					
a_4	0·01 (001111)						

Lecture-16
07.10.2025

LZW Coding

Example 8.7:

39	39	126	126
39	39	126	126
39	39	126	126
39	39	126	126

Currently Recognized Sequence	Pixel being Processed	Encoded Output	Dictionary Location	Dictionary Entry
	39			
39	39	39	256	39-39
39	126	39	257	39-126
126	126	126	258	126-126
126	39	126	259	126-39
39	39			
39-39	126	256	260	39-39-126
126	126			
126-126	39	258	261	126-126-39
39	39			
39-39	126			
39-39-126	126	260	262	39-39-126-126
126	39			
126-39	39	259	263	126-39-39

39	126			
39-126	126	257	264	39-126-126
126		126		

#LZW coding from given image

A	B	C
10	15	10
A	B	C
10	10	15

CRS	PBP	EO	DL (CW)	DE
	10			
10	15	10	256	10-15
15	10	15	257	15 - 10
10	10	10	258	10 - 10
10	10			
10-10	15	258	259	10-10-15
15		15		

Question type

কখন LZW কোনো কাজে আসবে কখন আসবে না

LZW disadvantages

Lecture - 17

13.10.2025

Example :

Frequency

A	B	C	D	E	F
5	9	12	13	16	45

Summation of frequencies,

$$\sum f = 5+9+12+13+16+45$$

$$= 100$$

Probability of,

$A = \frac{5}{100} = 0.05 \quad B = \frac{9}{100} = 0.09 \quad C = \frac{12}{100} = 0.12$

$D = \frac{13}{100} = 0.13 \quad E = \frac{16}{100} = 0.16 \quad F = \frac{45}{100} = 0.45$

Original source		Source reduction			
Symbol	Probability	1	2	3	4
F	0.45 (1)	0.45 (1)	0.45 (1)	0.45 (1)	0.55 (0)
E	0.16 (000)	0.16 (000)	0.25 (01)	0.30 (00)	0.45 (1)
D	0.13 (010)	0.14 (001)	0.16 (000)	0.25 (01)	
C	0.12 (011)	0.13 (010)	0.14 (001)		
B	0.09 (0010)	0.12 (011)			
A	0.05 (0011)				

Encod : CAB

C = 011

A = 0011

B = 0010

C A B
011 0011 0010

Decode :

Scanned Symbol	Stored Symbol	Decoded Symbol
0	0	—
1	01	—
1	011	C
0	0	—
0	00	—
1	001	—
1	0011	A
0	0	—
0	00	—
1	001	—
0	0010	B

disadvantages of LZW :

→ Not efficient for small files

→ Doesn't work well on already compressed data

→ High memory use

→ Dictionary can grow too large.

LZW works better when:

→ The data has lots of repeating pattern or sequences.

→ The input contains redundant or predictable data.

→ The file is large enough for the dictionary to build useful entries.

→ The data is uncompressed or raw.

Doesn't work well when:

→ The data is already compressed.

→ The file is small

→ ~~Contain~~ content is random or lacks repeating.

→ memory is limited.

DIP
21.10.2025

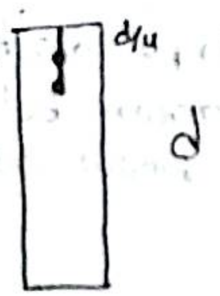
Chapter 9 (Morphological Image Processing)

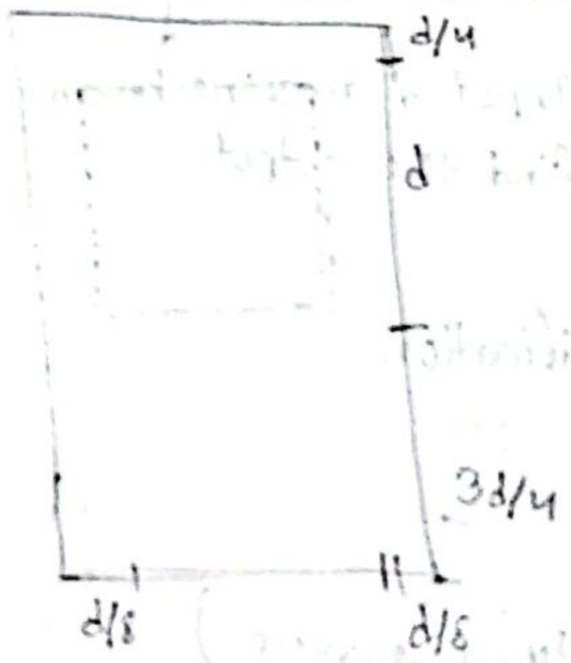
Page (638)

image, structure element given, find/draw output Fig 9.3

Erosion

~~Diala~~ Dilation





Morphological Analysis কর
Erosion
Dilation

03.11.2025
DIP

[4] Opening and Closing → Morphological PDF

Opening:
two parts → Erosion
→ Dialation

Closing
two parts → Dilation
→ Erosion

Opening & Closing comparison / what is it

Opening & closing performing on image

Erosion & Dilation also same {Show the measurement}

[5] Image Segmentation (Chapter-10)

(a) $\bigcup_{i=1}^{n} R_i = R$

(b) R_i is a connected set, for $i = 0, 1, 2, \ldots, n$.

(c) $R_i \cap R_j = \phi$ for all i & j. $i \neq j$

(d) $Q(R_i)$ = True for $i = 0, 1, 2, \ldots, n$

(e) $Q(R_i \cup R_j)$ = False for any adjacent regions R_i & R_j