Lecture-1

DIP

21/7/25

$\boxed{\begin{matrix}2, 3, 5 \\ 8, 9, 10\end{matrix}}$

Analog Image

Digital Image

→ pixel is the main element

→ two-dimentional function $f(x, y)$

→ Process digital image by means of computer, it cover low, high level processes.

Lecture-2

DIP (Ch-1) 22/7/25

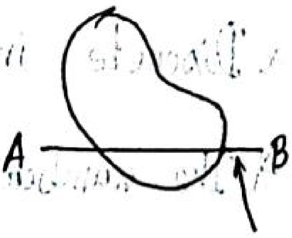
- Image Acquisition Process ✓

0 → black
255 → White.

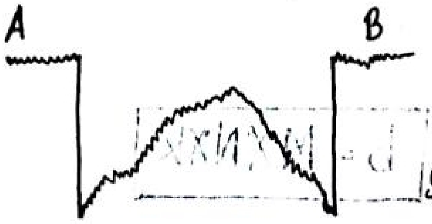
- formation model - $\underbrace{f(x,y)}_{\text{intensity at the point }(x,y)} = \underbrace{i(x,y)}_{\text{illumination}} \cdot \underbrace{r(x,y)}_{\substack{\text{Reflectance} \\ \text{Range }(0-1)}}$

- Image Sampling and Quantization.

[nyquest theorem needed]

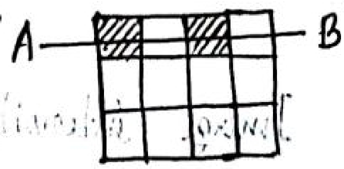


Scan line

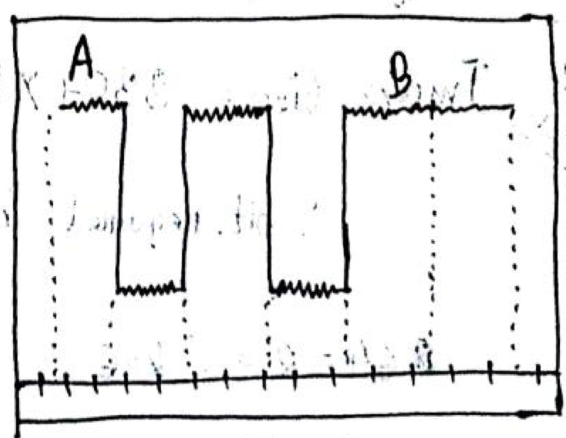


Illumination & gray level intensity line.

Suppose →



→



Intensity line.

Question

Draw the intensity line from the Scan line AB.

⊞ Image sampling : ~~digitlize of~~ x- axis digitalization

⊞ Quantization : Digitalize of y axis.

⊞ Representing Digital Image : $M \times N$ numerical array matrix.

$$f(x,y) = \begin{bmatrix} f(0,0), & f(0,1) & \cdots & f(0,n-1) \\ \vdots & \vdots & & \vdots \\ f(m-1,0), & \cdots & \cdots & f(m-1,n-1) \end{bmatrix}$$

* Discrete intensity ~~level~~ interval $[0, L-1]$, $L = 2^k$

* The number b of bits required to store a $M \times N$ digitized image.

$$\boxed{b = M \times N \times k}$$

~~Image~~ Image Resulation $= M \times N$.

☆ Question

Image Size $= 3304 \times 1640$; Image intensity interval $= 0$-63.

$\therefore$ bit required to Store $b = M \times N \times k$

$= 3304 \times 1640 \times 6$

$= 32511360$ bits.

$64 = 2^6$ $\therefore k = 6$

Spatial and Intensity Resulation :

→ A measure of the resulation

Lecture-3

28/7/25

Basic Relationships between Pixels :-

Neighbors of a pixel p at cordinates (x, y) :-

4 neighbors of p, → $N_4(P)$

4 diagonal neighbors of p → $N_D(P)$

8 neighbores of P → $N_4(P) \cup N_D(P) = N_8(P)$

Adjacency - 4 → Let V be the set of intensity values.

m-adjacency : Two pixels p and q with values from V are m-adjacency if,

(i) q is in the set $N_4(P)$, or

(ii) q is in the set $N_D(P)$ and the set $N_4(P) \cap N_4(q)$ has no pixels whose values are from V.

Slide-60 Question

Question

Finding m-adjacency where $V = \{1, 2, 3\}$

$P, Q = (0,1), (1,1)$

$P_2, Q_2 = (1,1), (2,2)$

$P_3, Q_3 = (2,3), (3,3)$

0	1	0	0
3	2	0	0
0	0	1	3 P
2	0	0	1 Q

here, $P = (0,1) \rightarrow 1$

$Q = (1,1) \rightarrow 2$

0	1 P	0	0
3	2 Q	0	0
0	0	1	3
2	0	0	1

For 1P, 2Q it fullfill the first condition

q in in the set $N_4(P)$

So, they are m-adjiencency.

here, $P = (1,1) \rightarrow 2$

$Q = (2,2) \rightarrow 1$

0	1	0	0
3	2 P	0	0
0	0	1 Q	3
2	0	1	1

here the $N_4(P) \cap N_4(q) = \{0, 0\}$

and no pixels is in values of V,

So they are m-adjecency

Question: Is it possible to find the path using m-adjacency here

then find the m-path

$$\begin{matrix} 0 & \overset{(x_0,y_0)\ p}{1} & 0 & 0 \\ 3 & 2^{\,Q} & 0 & 0 \\ 0 & 0 & 1^{\,p} & 3^{\,Q} \\ 2 & 0 & 0 & 1_{\,(x_n,y_n)} \end{matrix}$$

Connected in S

$(x_0, y_0), (x_1, y_1), \ldots\ldots (x_n, y_n)$

where $\forall i, 0 \le i \le n, (x_i, y_i) \in S$ P65

Lecture 4

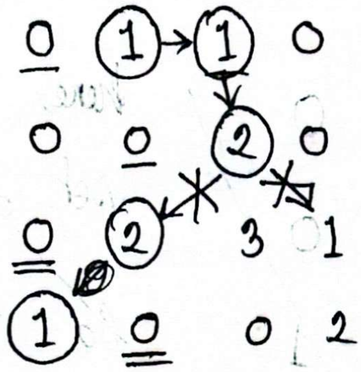
29/7/25

Question: Find 4-adjacency, 8-adjacency and m-adjacency path where

$V = \{1, 2\}$

$$\begin{array}{cccc} & (x_0, y_0) & & \\ 0 & 1 & 1 & 0 \\ 0 & 0 & 2 & 0 \\ 0 & 2 & 3 & 1 \\ (x_n, y_n)\ 1 & 0 & 0 & 2. \end{array}$$

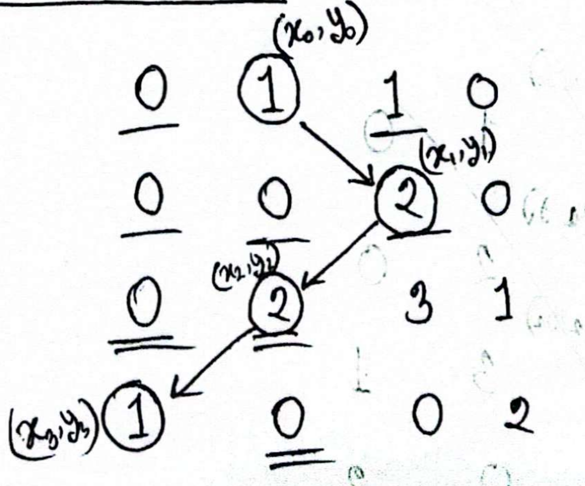
finding 4-adjacency :



Not possible

No path with 4-adjacency.

finding 8-adjacency :



finding m-adjacency : $V = \{1, 2\}$

$$
\begin{array}{rcccc}
 & & p & & \\
 & 0 & 1 & 1 & 0 \\
 & 0 & 0 & 2 & 0 \\
 & 0 & 2 & 3 & 1 \\
(x_n, y_n) = & 1 & 0 & 0 & 2
\end{array}
$$

here, Q is in the set of $N_4(P)$

So, they are m-adjacent

Now.

$$
\begin{array}{rcccc}
 & & (x_0, y_0) & & \\
 & 0 & 1 & 1 & 0 \\
 & 0 & 0_p \; (x_1, y_1) & 2 & 0 \\
 & 0 & 2_q & 3 & 1 \\
(x_n, y_n) & 1 & 0 & 0 & 2
\end{array}
$$

~~here, Q is in the set of $N_4(P)$~~

~~So~~

Now.

$$
\begin{array}{rcccc}
 & & (x_0, y_0) & & \\
 & 0 & 1 & 1 & 0 \\
 & 0 & 0 \; (x_1, y_1) & 2 & 0 \\
 & 0 & 2 \; (x_2, y_2) & 3 & 1 \\
(x_n, y_n) & 1 & 0 & 0 & 2
\end{array}
$$

Boundary (or border)

- The boundary of ~~a~~ the region R is the set of pixels in the region that have one or more neighbors that are not in R.

- If R happens to be an entire image, then its boundary is defined as the set of pixels in the first and last rows and colums of the image.

Foreground and background

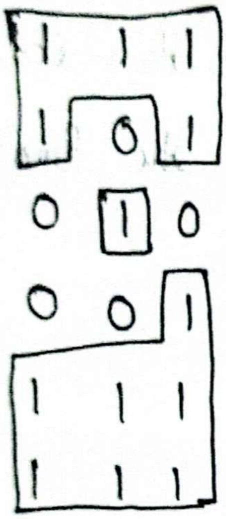
- An ~~image~~ image contains k disjoint regions, (R_k). $k = 1, 2, 3 \ldots k$. Let R_u denote the union of all the k regions. Let $(R_u)^c$ denote it's complement.

☆ Slide page - 67,68 Question

1. Part - 1, 2 is adjacent using 4-ad ? No

2. How many regions are here ? 3

3. What is the foreground and background ? $\underset{\text{F}}{1}$, $\underset{\text{B}}{0}$



Boundary
→ কোনো Region এর কমপক্ষে একটি Neighbore বাইরে থাকবে.

8 এবং 4 adjacency দেখিয়ে করতে হবে.

Lecture 5

4/8/25

Distance Measures:

Given pixels p, q and z with coordinates (x, y), (s, t), (u, v) respectively, the distance function D has following properties:

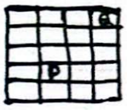
a) $D(p,q) \geq 0$ $[D(p,q)=0$, iff $p=q]$ $\boxed{\text{iff (if and only if)}}$

b) $D(p,q) = D(q,p)$

c) $D(p,z) \leq D(p,q) + D(q,z)$

Distance measuring questions ★★★

Three types of distance measurement method.



a) Euclidean distance: $D_e(p,q) = [(x-s)^2 + (y-t)^2]^{\frac{1}{2}}$

b) City Block distance: $D_4(p,q) = |x-s| + |y-t|$

		2		
	2	1	2	
2	1	0	1	2
	2	1	2	
		2		

c) Chess Board distance: $D_8(p,q) = \max(|x-s|, |y-t|)$

$P = (3,3)$, $Q = (4,5)$

$D_8(p,q) = \max(|3-4|, |3-5|)$

$= \max(1, 2)$

$= 2$

2	2	2	2	2
2	1	1	1	2
2	1	0	1	2
2	1	1	1	2
2	2	2	2	2

Ques:

$$
\begin{matrix}
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 1 & 1 & 0 \\
0 & 1 & 1 & 0 & 0 \\
0 & 1 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0
\end{matrix}
$$

Suppose

Origin is in lower left.

So, $P = (2,3)$

$Q = (4,5)$

using chess board distance,

$$D_8(p,q) = \max(|x_1 - x_2|, |y_1 - y_2|)$$

$$= \max(|2-4|, |3-5|)$$

$$= \max(2, 2)$$

$$= 2$$

using city block distance,

$$D_4(p,q) = |x-s| + |y-t|$$

$$= 2 + 2$$

$$= 4$$

Chapter 2

Mathematical Operation.

11/8/25

Linear and Nonlinear Operation:

$$\boxed{\mathcal{H}[f(x,y)] = g(x,y)}$$

Now,

$$\mathcal{H}[af_1(x,y) + bf_2(x,y)] = a\mathcal{H}[f_1(x,y)] + b\mathcal{H}[f_2(x,y)]$$

$$= a g_1(x,y) + b g_2(x,y)$$

Suppose, $a = 1$, $b = -1$

$$f(x,y) = \begin{bmatrix} 0 & 2 \\ 2 & 3 \end{bmatrix}, \quad f_2(x,y) = \begin{bmatrix} 4 & 5 \\ 6 & 7 \end{bmatrix}$$

$$\sum [af_1(x,y) + bf_2(x,y)]$$

$$= \sum \left[(1) \cdot \begin{bmatrix} 0 & 2 \\ 3 & 3 \end{bmatrix} + (-1) \begin{bmatrix} 4 & 5 \\ 6 & 7 \end{bmatrix} \right]$$

$$= \sum \left[\begin{bmatrix} 0 & 2 \\ 2 & 3 \end{bmatrix} + \begin{bmatrix} -4 & -5 \\ -6 & -7 \end{bmatrix} \right]$$

$$= \sum \begin{bmatrix} -4 & -3 \\ -4 & -4 \end{bmatrix}$$

$$= -15$$

$$a\sum f_1(x,y) + b\sum f_2(x,y)$$

$$= 1 \sum \begin{bmatrix} 0 & 2 \\ 2 & 3 \end{bmatrix} + (-1) \sum \begin{bmatrix} 4 & 5 \\ 6 & 1 \end{bmatrix}$$

$$= 1 \cdot 7 + (-1) \cdot 22$$

$$= -15$$

So, the operator Σ is a linear operator.

Arithmatic Operation

Used in noise removal.

Quss! How addition of Noise can be used for noise removal or noise reduction explain with example

Noiseless image = $f(x,y)$

Noise = $n(x,y)$

Corrupt image = $g(x,y)$

Qus 2// noise reduce math

So, $g(x,y) = f(x,y) + n(x,y)$

Reducing noise by adding a set of noisy images $\{g_i(x,y)\}$

$$\bar{g}(x,y) = \frac{1}{k}\sum_{i=1}^{k} g_i(x,y)$$

Lecture-6

18/8/25

Set and Logical Operation :

Let A be the ~~im~~ elements of a gray-scale image.

$A = \{(x, y, z) \mid z = f(x, y)\}$ z is intensity at the point (x,y)

The complement of A is denoted as A^c

Ques: find comp of A. $A^c = ?$ $z = ?$

$A^c = \{(x, y, K - z) \mid (x, y, z) \in A\}$

$K = 2^k - 1$; k is the number of intensity bits used to represent z.

* Not, And, AndNot, XOR operations. P-93

Slide-2

Chapter-3

Intensity Transformation and Spatial Filtering

* Spatial Domain: Image plane, directly process the intensity values of the image plane.

* Transfrom Domain:

Spatial Doman Process:

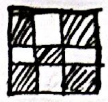
$T \rightarrow$ intensity value transfrom

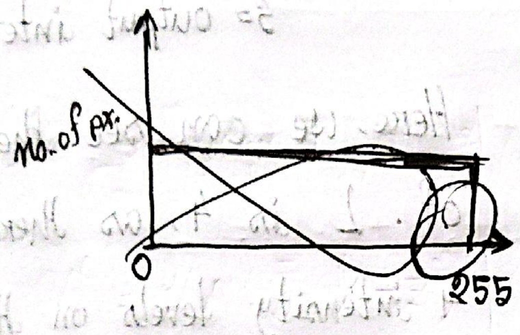
T: an operator

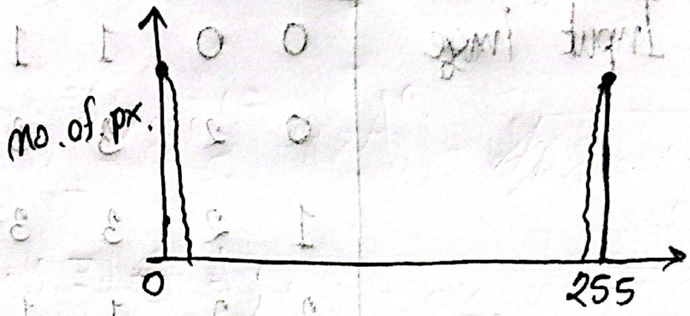
0 → black
255 → white

Intensity Transformation Function:

histrogram of chess board:







for a white page:

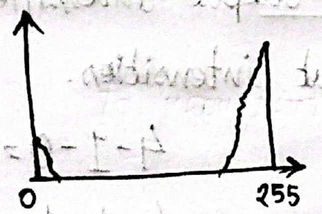


Image Negative- $S = (L-1) - r.$

$L \rightarrow 256$, $r \rightarrow 255.$

Quest ★ Intensity Levels Question-

Lecture-7

25/8/25

Image Negetive - $S = L - 1 - r$ [We know]

$L \downarrow$ Level

where,

r = input intensity

S = output intensity

Input image

0	0	1	1
0	2	3	3
1	2	3	3
3	3	1	1
1	1	2	2

Here, we can see the value of L is 4, as there are 4 intensity levels on the provided image. Now, calculating the output intensities from the input intensities.

$4-1-0=3$

$4-1-1=2$

$4-1-2=1$

Output ~~Image~~ -

~~3 3 2 2~~

~~3 1 0 0~~

input	Output
0	$S = 4 - 1 - r = 0$
1	$S = 4 - 1 - 1 = 2$
2	$S = 4 - 1 - 2 = 1$
3	$S = 4 - 1 - 3 = 0$

So, after replacing the pixel values with the output intensities, we got,

3	3	2	2
3	1	0	0
2	1	0	0
0	0	2	2
2	2	1	1

Log Transformation:

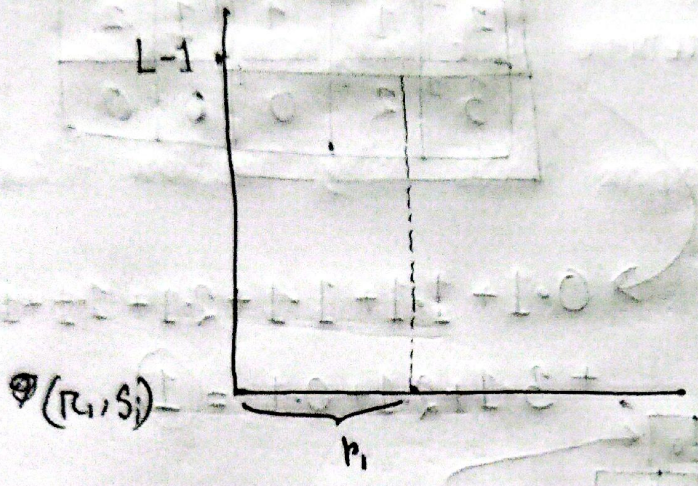
$$\boxed{S = c \log(1+r)}$$

where, C = Constant

Power ~~Log~~ Law (GAMMA) Transformation:

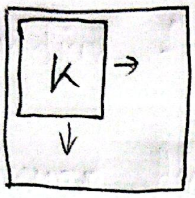
$$\boxed{S = C r^{\gamma}}$$

Contrast Stretching:

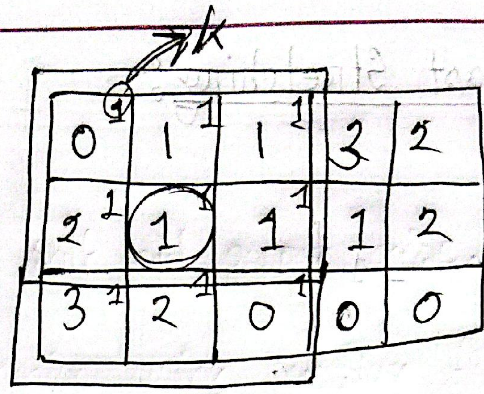


Lecture-8 26/8/25

Spatial Filtering:

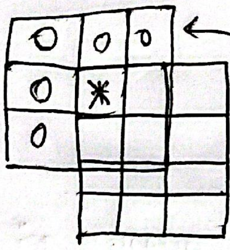


K= kernel.



$0\cdot1+1\cdot1+1\cdot1+2\cdot1+1\cdot1+1\cdot1$
$+3\cdot1+2\cdot1+0\cdot1 = 1$

Kernel Padding.



$\frac{3}{2} = 1.5$

Correlation & Convolution:

Question

	origin f	W	Result
(a)	0 0 0 1 0 0 0 0	1 2 4 2 8	

(b) 0 0 0 0 0 1 0 0 0 0 0

×1 ×2·0 4·0 2·0 8·0

1 2 4 2 8 $= 1\cdot0+2\cdot0+4\cdot0+2\cdot0+8\cdot0 =$ 0

(c) 1 2 4 2 8 = 8

(d) 1 2 4 2 8 = 2

(e) 1 2 4 2 8 = 4

(f) 1 2 4 2 8 = 2

(g) 1 2 4 2 8 = 1

Similarly after 2 more shift = 0 8 2 4 2 1 0 0

Convolution is similar to correlation But we have to rotate ω 180°.

Box filter kernel:

Using low pass / smothing kernel reduce noise

Suppose an noisy image:-

10	11	10	13	10
15	90	75	17	12
10	11	89	16	15
12	13	10	11	12
10	15	17	16	16

Question

So, for 75 :-

$$\frac{1}{9} \times \left[90 \cdot 1 + 75 + 17 + 11 + 10 + 13 + 11 + 89 + 16 \right]$$

$= 36.89 \approx 37$

P.176.

Lecture-9

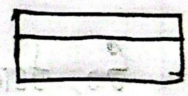
1/9/25

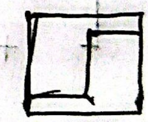
Linear & Nonlinear filters:

* median filters can remove salt and pepper noise.

* Remove the salt and pepper noise using median filter.

Derivative:

1. Must be zero in areas of constant intensity. 

2. Must be nonzero at the onset of an intensity step or ramp 

3. Must be nonzero along intensity ramp 

Page-180

we will get sharp photo on 2nd derivative.

Laplacian kernel —

$$\begin{matrix} 0 & 1 & 0 \\ 1 & -4 & 0 \\ 0 & 1 & 0 \end{matrix}$$

Summation must be zero.

* Practice: Box filter kernel :-

Suppose a noisy image- change the value of noise pixel.

10 1	12 1	13 1	10	10
11 1	12 1 $\boxed{14}$	30 1	12	10
15 1	14 1	13 1	18	12
30	35	32	51	50
50	52	52	50	50
53	53	50	50	51

So, for 12-

$$= \frac{1}{9}(10+12+13+11+12+30+15+14+13)$$

$$= 14$$

Now 12 will replace with 14

This is how the pixel will replace