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Padma mam

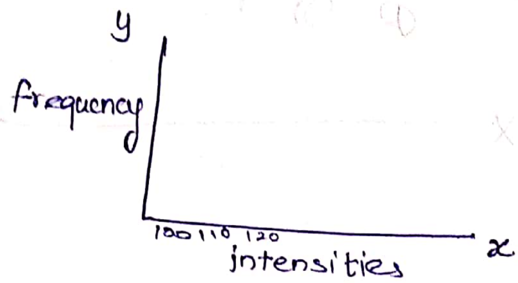
Image Enhancement

Histogram modification

Histogram modification performs a function similar to gray level mapping but works by considering histogram's shape & spread.

Gray level histogram of an image is the distribution of gray levels in an image.

Examination of the histogram is one of the most useful tools for image enhancement, as it makes



$$\begin{array}{r} 18 \\ \times 18 \\ \hline 144 \\ 18\times \\ \hline 324 \end{array}$$

The histogram can be modified by a mapping function, which will stretch, shrink (compress), slide.

Histogram stretch

Mapping function equation

which intensity to be change

$$\text{Stretch}(I(r,c)) = \left[\frac{\boxed{I(r,c)} - I(r,c)_{MIN}}{I(r,c)_{MAX} - I(r,c)_{MIN}}\right] \times [MAX - MIN] + MIN$$

$I(r,c)_{MAX} \rightarrow$ largest gray level value in the image $I(r,c)$,

$I(r,c)_{MIN} \rightarrow$ smallest gray level value in image $I(r,c)$

MAX & MIN correspond to the maximum & minimum gray level values possible.

Histogram Shrink

The mapping function equation

$$Shrink(I(r,c)) = \left[\frac{Shrink_{MAX} - Shrink_{MIN}}{I(r,c)_{MAX} - I(r,c)_{MIN}}\right] * \left[I(r,c) - I(r,c)_{MIN}\right] + Shrink_{MIN}$$

Histogram Slide

$$Slide(I(r,c)) = I(r,c) + OFFSET$$

OFFSET value → amount to slide the histogram.

Used to make an image either darker / lighter but retain the relationship b/w

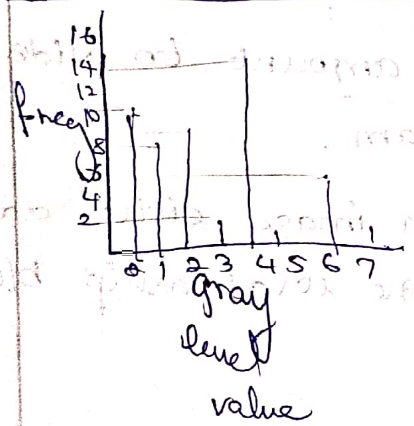
Histogram Equalization

A technique where the histogram of the resultant image is as flat as possible.

Eg:- 3 bits per pixel image - range 0 to 7

Normalized value	Gray level value	No. of pixels Histogram values	Running sum
$\frac{10}{51} = 0.1960784$	0	10	10
$\frac{18}{51} = 0.3529$	1	8	18
$\frac{27}{51} = 0.52941$	2	9	27
$\frac{29}{51} = 0.568627$	3	2	29
$\frac{43}{51} = 0.84313$	4	14	43
$\frac{44}{51} = 0.8627$	5	1	44
$\frac{49}{51} = 0.9607$	6	5	49
$\frac{51}{51} = 1$	7	2	51

Normalized value: max gray level value × $\frac{\text{cum. for each gray level}}{\text{Total no of pixel}}$	Histogram Equalized values
1.372549	~ 1
2.47058	~ 2
3.70588	~ 4
3.98039	~ 4
5.90196	~ 6
6.03921	~ 6
6.72549	~ 7
7	~ 7



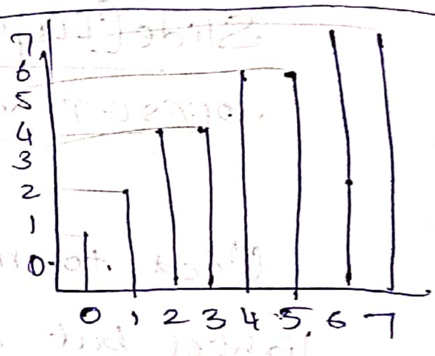


Image smoothing

What benefit ~~filters~~ of using filters with eg:-

Smoothing → to reduce noise

↳ Average filter

(10) images

Some images & noise variances

varies → 1st pixel add 10 intensities & ave

filters

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Consider the given image & calculate the O/P of the pixel (2,2) if ~~something~~ smoothing is done using 3×3 neighbourhood using all the filters below:-

i) Mean filter
ii) Median filter
iii) Min filter
iv) Max filter.

	0	1	2	3	4
0	1	8	8	0	7
1	4	7	9	5	7
2	5	4	6	8	6
3	4	2	0	1	5
4	0	1	0	2	0

i) Mean filter

$$= \frac{7+9+5+4+6+8+2+0+1}{9}$$

$$= \frac{42}{9}$$

$= 4.66 \simeq 5.$

~~fw~~ draw above image & replace 6 with 5.

ii) Median filter

sort 0 1 2 4 $\boxed{5}$ 6 7 8 9

draw above image & replace 6 with 5

iii) Min filter.
replace 6 with 0

iv) Max filter
replace 6 with 9

Which filter works best? Mean/Median filters

Apply averaging filter & median filter on the following image ~~like pixel replicate~~ ~~for~~ padding.

4	8	9
12	15	18
30	32	46

Draw these always for each filter.

0	0	0	0	0
0	4	8	9	0
0	12	15	18	0
0	30	32	46	0
0	0	0	0	0

~~best~~ filter Mean

4 ⇒ Mean filter $= \frac{4+8+12+15}{9}$ (20)

$= 4.3 \sim 4$

Median filter = 0 0 0 0 0 4 8 12 15

= 0

~~best~~

8 ⇒ Mean filter $= \frac{4+8+9+12+15+18}{9}$

$= \frac{66}{9} = 7.3 \sim 7$

Median filter = 0 0 0 4 8 9 12 15 18

~ 8

9 ⇒ Mean filter $= \frac{8+9+15+18}{9}$

$= \frac{50}{9} = 5.5 \sim 6$

Median filter = 0 0 0 0 0 8 9 15 18

= 0

$12 \Rightarrow$ Mean $f = \frac{4+8+12+15+30+32}{9}$

$= \frac{101}{9} = 11.22 \sim 11$

Median f = 0 0 0 4 8 12 15 30 32

~ 8.

$15 \Rightarrow$ Mean $f = \frac{4+8+9+12+15+18+30+32+46}{9}$

$= \frac{174}{9} = 19.33 \sim 19$

Median f = 4 8 9 12 15 18 30 32 46

$= 15$

$18 \Rightarrow$ Mean $f = \frac{9+8+15+18+32+46}{9}$

$= \frac{128}{9} = 14.22 \sim 14$

Median f = 0 0 0 8 9 15 18 32 46

~ 9

$30 \Rightarrow$ Mean $f = \frac{30+32+12+15}{9}$

$= \frac{89}{9} = 9.8 \sim 10$

Median f = 0 0 0 0 0 12 15 30 32

~ 0

$32 \Rightarrow$ Mean $f = \frac{12+15+18+30+32+46}{9}$

$= \frac{153}{9} = 17$

Median f = 0 0 0 12 15 18 30 32 46

~ 15.

$46 \Rightarrow$ Mean $f = \dfrac{15+18+32+46}{9}$

$= \dfrac{111}{9} = 12.3 \sim 12.$

Median $f = 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 15 \ 18 \ 32 \ 46$

~ 0

Apply averaging filter & median filter on the foll. image. Use pixel replication for padding

4	8	9
12	15	18
30	32	46

4	4	8	9	9
4	4	8	9	9
12	12	15	18	18
30	30	32	46	46
30	30	32	46	46

$4 \Rightarrow$ Mean $f = \dfrac{4+4+4+4+8+8+12+15+12}{9}$

$= \dfrac{71}{9} = 7.8 \sim 8$

Median $f = 4 \ 4 \ 4 \ 4 \ \boxed{8} \ 8 \ 12 \ 12 \ 15$

$= 8$

$8 \Rightarrow$ Mean $f = \dfrac{4+4+8+8+9+9+12+15+18}{9}$

$= \dfrac{87}{9} = 9.67 \sim 10$

Median $f = 4 \ 4 \ 8 \ 8 \ \boxed{9} \ 9 \ 12 \ 15 \ 18$

$= 9$

$9 \Rightarrow$ Mean $f = \dfrac{8+8+9+9+9+9+15+18+18}{9}$

$\Rightarrow \dfrac{103}{9} = 11.4 \sim 11$

Median $f = 8 \quad 8 \quad 9 \quad 9 \quad \boxed{9} \quad 9 \quad 15 \quad 18 \quad 18$

$\Rightarrow 9$

$12 \Rightarrow$ Mean $f = \dfrac{4+4+8+12+12+15+30+30+32}{9}$

$\Rightarrow \dfrac{147}{9} = 16.3 \sim 16$

Median $f = 4 \quad 4 \quad 8 \quad 12 \quad 12 \quad 15 \quad 30 \quad 30 \quad 32$

$= 12$

$15 \Rightarrow$ Mean $f = \dfrac{4+8+9+12+15+18+30+32+46}{9}$

$\Rightarrow \dfrac{174}{9} = 19.33 \sim 19$

Median $f = 4 \quad 8 \quad 9 \quad 12 \quad 15 \quad 18 \quad 30 \quad 32 \quad 46$

$= 15$

$18 \Rightarrow$ Mean $f = \dfrac{8+9+9+15+18+18+32+46+46}{9}$

$= \dfrac{201}{9} = 22.33 \sim 22$

Median $f = 8 \quad 9 \quad 9 \quad 15 \quad \boxed{18} \quad 18 \quad 32 \quad 46 \quad 46$

$= 18$

$30 \Rightarrow$ Mean $f = \dfrac{12+12+15+30+30+30+30+32+32}{9}$

$\Rightarrow \dfrac{223}{9} = 24.7 \sim 25$

Median $f = 12 \quad 12 \quad 15 \quad 30 \quad 30 \quad 30 \quad 30 \quad 32 \quad 32$

$= 30$

$32 \Rightarrow$ Mean $f = \dfrac{12+15+18+30+32+46+30+32+46}{9}$

$= \dfrac{261}{9} = 29$

Median $f = 12 \quad 15 \quad 18 \quad 30 \quad \boxed{30} \quad 32 \quad 32 \quad 46 \quad 46$

$= 30$

$46 \Rightarrow$ Mean $f = \dfrac{15+18+18+32+46+46+32+46+46}{9}$

$= \dfrac{299}{9} = 33.2 \sim 33.$

Median $f = 15 \quad 18 \quad 18 \quad 32 \quad \boxed{32} \quad 46 \quad 46 \quad 46 \quad 46$

$\sim 32.$

Mean f

15	18	18
32	30 ~~46~~	46
32	46	46

Median f

15	18	18
32	32 ~~46~~ 46 → 32	46
32	46	46

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Fourier Transforms in Image Processing

It is a mathematical technique used to transform a signal from its spatial domain into frequency domain.

When applied to images, the fourier transform can reveal the information about frequency content of the images.

Step-1: Convert the images to grayscale.

Step-2: Represent the image as a matrix

Step-3: Apply 2D fourier Transform

$$F(u,v) = \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x,y) \cdot e^{-i2\pi\left(\frac{ux}{M} + \frac{vy}{N}\right)}$$

$f(x,y) \rightarrow$ pixel intensity at position (x,y)

$F(u,v) \rightarrow$ fourier coefficient at freq coordinates (u,v) & M & N are dimensions of image.

Step-4: Shift the zero frequency component to the center.

Step-5: Compute the magnitude spectrum

$$\text{Magnitude}(u,v) = \sqrt{R(F(u,v)^2) + I(F(u,v)^2)}$$

Step-6: Apply a logarithmic transformation

for compression

$$\text{Log Magnitude}(u,v) = \log(1 + \text{Magnitude}(u,v))$$

Step-7: Visualize the frequency spectrum.

Step-8: Filter the image

Step-9: Apply inverse fourier transform

$$f(x,y) = \frac{1}{MN} \sum_{u=0}^{M-1} \sum_{v=0}^{N-1} F(u,v) \cdot e^{-i2\pi\left(\frac{ux}{M}, \frac{vy}{N}\right)}$$

Image matrix of Greyscale image

[Matrix Sum not for exam]

only steps

$$
\begin{array}{c|cccc}
 & 0 & 1 & 2 & 3 \\
\hline
0 & 50 & 80 & 90 & 120 \\
1 & 60 & 100 & 110 & 130 \\
2 & 70 & 110 & 120 & 140 \\
3 & 80 & 120 & 130 & 150
\end{array}
$$

1) Apply Fourier Transform

$F(0,0) = 50 + 80 + \_ + 150 = 1090$

$$F(0,1) = \sum_{x=0}^{3} \sum_{y=0}^{3} f(0,1) \cdot e^{-i2\pi\left(\frac{0x}{4} + \frac{1y}{4}\right)}$$

$\approx -25i$

$$
\begin{bmatrix}
1090 & -25i & 10 & 25i \\
-25i & 0 & 0 & 0 \\
10 & 0 & 0 & 0 \\
25i & 0 & 0 & 0
\end{bmatrix}
$$

2) Shift zero freq component to the center

$$
\begin{bmatrix}
0 & 0 & 0 & -25i \\
0 & 0 & 0 & 10 \\
0 & 0 & 0 & 25i \\
-25i & 10 & 25i & 1090
\end{bmatrix}
$$

3). Magnitude spectrum

$Mag(0,0) = \sqrt{0^2 + 0^2} = 0$

$Mag(0,3) = \sqrt{(0^2) + (-25)^2}$

$= 25.$

$$
\begin{bmatrix}
0 & 0 & 0 & 25 \\
0 & 0 & 0 & 10 \\
0 & 0 & 0 & 25 \\
25 & 10 & 25 & 1090
\end{bmatrix}
$$

4) $\log mag(0,0) = \log(1+0) = 0$

$$\begin{bmatrix} 0 & 0 & 0 & \log(\frac{26}{25}) \\ 0 & 0 & 0 & \log(14) \\ 0 & 0 & 0 & \log(26) \\ \log(26) & \log(11) & \log(26) & \log(1091) \end{bmatrix}$$

Filtering (optional) Low pass / High pass

Inverse Fourier Transform

$$\begin{bmatrix} 60 & 70 & 70 & 80 \\ 70 & 80 & 80 & 90 \\ 80 & 90 & 90 & 100 \\ 90 & 100 & 100 & 110 \end{bmatrix}$$

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Q) Why Image processing is better in frequency domain?

i) Filtering efficiency - (Low pass filter, High pass filter)

ii) Noise Reduction

iii) Image Compression → Easy to do under frequency

iv) Image Restoration Eg:- while patching in an image

(similar to mean)

Low pass filter $\Rightarrow \frac{1}{9}\begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$ → noise Reduction

Applied on freq domain

High pass filter $\Rightarrow \begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$ → edge deduction (sharpen img)

High pass filter

use padding before doing

$$\begin{array}{c|ccccc} & 0 & 1 & 2 & 3 & 4 \\ \hline 0 & 1 & 2 & 3 & 4 & 5 \\ 1 & 1 & 1 & 1 & 1 & 1 \\ 2 & 1 & 2 & 1 & 2 & 1 \\ 3 & 1 & 1 & 1 & 1 & 1 \end{array} \quad \begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix} \text{HPF}$$

$$mat[1][1] = -1-2-3-1+8-1-1-2-1$$
$$= -4$$

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1. fundamentals of digital image formation

$f(x,y)$

↳ 2D func

x & y → spatial coordi

Digital image processing

3 levels

Low-level

mid-level

high-level

Image processing

$f(x,y)$

$g(x,y)$ o/p.

$= f(tx(x,y), ty(x,y))$

tx → transformation w.r.to x.

Key Stages

1) Image acquision – illuminations reflecti

2) Image enhancement – histogram

↳ Based on appl/n. can inc & dec

Slide

Shrink

Stretch

3) Image Restoration

$f(x,y)$ Degradation   Restoration

↓

degradation function H → ⊕ → $g(x,y)$ Restoration filter → $f'(x,y)$

$\eta(x,y)$

noise

Types of noise → to remove noise what filter we

Types of filters

4) Morphological processing

w p to b pixel

b pixel to w pixel

used in biometric

5) Segmentation

Extracting region of interest

6) Object Recognition

boundary box

7) Representation & Description

Image Compression

dec size without data loss

Identify signficant & insignificant

↓

suppress

Colour Image Processing

Feature Extraction

1) Edge detection
   - Canny
   - Prewitt, Sobel operators

2) Corner detection – Harris corner detector

3) Blob detection
   - LOG
   - DOG
   - Hessian

4) Texture analysis
   - GLCM
   - LBP
   - Gabor filters

5) Shape - based
   - contour based
   - Region based

Why feature extraction is important ?

1) Reduce dimensionality
2) Enhanced accuracy
3) Enhanced performance
4) Noise reduction