

Section Content:

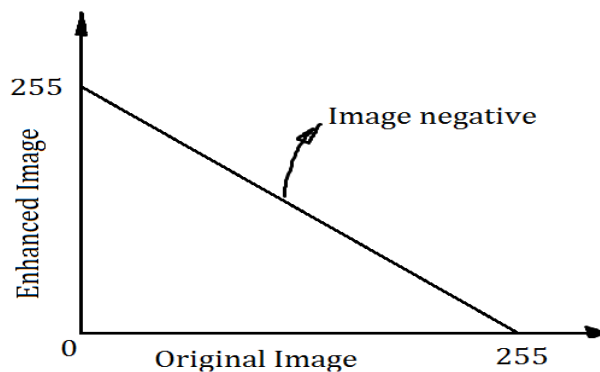
- ✚ image negative
- ✚ Contrast Stretching
- ✚ Contrast contraction
- ✚ Gray level slicing
- ✚ Histogram Normalization
- ✚ Histogram Equalization

Image Enhancement**Image Enhancement:**

- $T : f(x,y) \rightarrow f'(x,y)$
- T :-Transformation
- $f(x,y)$:-before transformation
- $f'(x,y)$:- after transformation (*enhanced image matrix*)

1. Image Negative

- $0^{black} \Rightarrow 255^{white}$
 $255^{white} \Rightarrow 0^{black}$



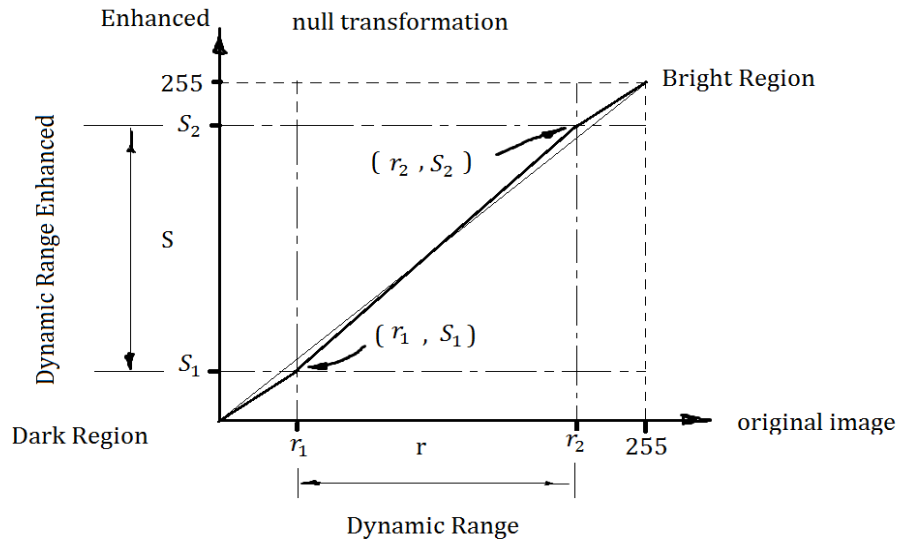
$$f'(x,y)_{negative\ Image} = (L - 1) - f(x,y)_{original\ image}$$

$L=2^q$ (q =No. of bits. if $q=8$, then $L=2^8=256$)

2. Contrast Stretching and contraction

- Range for gray images as: -
 - a. Too dark
 - b. Dynamic range
 - c. Too white

- The Dynamic Range: - It is the range in which the image details exist. So, the focus is to increase that range with contracting dark to towards darker and whiter towards whiter.
- The middle contains image information if we stretch it will increase difference between constituting elements → increase contrast



- First line: $0 \rightarrow r_1$

$$f'(x, y) = f(x, y) \frac{s_1}{r_1}$$

- Second line: $r_1 \rightarrow r_2$

$$f'(x, y) = f(x, y) \frac{s_2 - s_1}{r_2 - r_1} + s_1 - r_1 \frac{s_2 - s_1}{r_2 - r_1}$$

- Third line: $r_2 \rightarrow 255$

$$f'(x, y) = f(x, y) \frac{(L-1) - s_2}{(L-1) - r_2} + (L-1) - (L-1) \frac{(L-1) - s_2}{(L-1) - r_2}$$

Example 1: -

Gray level	70	100	110	116	120	150	170	180
Gray count	10	10	100	500	1000	400	100	80

find the histogram of the above image matrix after **stretching** the dynamic range from (105,175) to be (60,220).

Answer

$r_1=105$, $r_2=175$ $s_1=60$, $s_2=220$

$r_1 > s_1$ & $r_2 < s_1$

- Range for gray images as: -

1. First line: $0 \rightarrow r_1$

Dark (0 to 105)

$$f'(x, y) = f(x, y) \frac{s_1}{r_1}$$

2. Second line: $r_1 \rightarrow r_2$

Dynamic range (105 to 175)

$$f'(x, y) = f(x, y) \frac{s_2 - s_1}{r_2 - r_1} + s_1 - r_1 \frac{s_2 - s_1}{r_2 - r_1}$$

3. Third line: $r_2 \rightarrow 255$

White (175 to 255)

$$f'(x, y) = f(x, y) \frac{(L-1) - s_2}{(L-1) - r_2} + (L-1) - (L-1) \frac{(L-1) - s_2}{(L-1) - r_2}$$

$$f'(x, y)_{70} = 70 * \frac{60}{105} = 40$$

$$f'(x, y)_{100} = 100 * \frac{60}{105} = 57$$

$$f'(x, y)_{110} = 110 * \frac{220 - 60}{175 - 105} + 60 - 105 * \frac{220 - 60}{175 - 105} = 71$$

$$f'(x, y)_{116} = 116 * \frac{220 - 60}{175 - 105} + 60 - 105 * \frac{220 - 60}{175 - 105} = 85$$

$$f'(x, y)_{120} = 120 * \frac{220 - 60}{175 - 105} + 60 - 105 * \frac{220 - 60}{175 - 105} = 94$$

$$f'(x, y)_{150} = 150 * \frac{220 - 60}{175 - 105} + 60 - 105 * \frac{220 - 60}{175 - 105} = 163$$

$$f'(x, y)_{170} = 170 * \frac{220 - 60}{175 - 105} + 60 - 105 * \frac{220 - 60}{175 - 105} = 209$$

$$f'(x, y)_{180} = 180 * \frac{(256-1)-220}{(256-1)-175} + (256-1) - (256-1) \frac{(256-1)-220}{(256-1)-175} = 222$$

Gray level	40	57	71	85	94	163	209	222
Gray count	10	10	100	500	1000	400	100	80

Example 2: -

Gray level	70	100	110	116	120	150	170	180
Gray count	10	10	100	500	1000	400	100	80

find the histogram of the above image matrix after **contraction** the dynamic range from (60,220) to be (105,175).

Answer

$r_1=60, r_2=220 \quad s_1=105, s_2=175$

$r_1 < s_1$ & $r_2 > s_1$

- Range for gray images as: -

1. First line: $0 \rightarrow r_1$

Dark (0 to 60)

$$f'(x, y) = f(x, y) \frac{s_1}{r_1}$$

2. Second line: $r_1 \rightarrow r_2$

Dynamic range (60 to 220)

$$f'(x, y) = f(x, y) \frac{s_2 - s_1}{r_2 - r_1} + s_1 - r_1 \frac{s_2 - s_1}{r_2 - r_1}$$

3. Third line: $r_2 \rightarrow 255$

White (220 to 255)

$$f'(x, y) = f(x, y) \frac{(L - 1) - s_2}{(L - 1) - r_2} + (L - 1) - (L - 1) \frac{(L - 1) - s_2}{(L - 1) - r_2}$$

$$f'(x, y) \text{ 70} = 70 * \frac{175 - 105}{220 - 60} + 175 - 60 * \frac{175 - 105}{220 - 60} = \text{109}$$

$$f'(x, y) \text{ 100} = 100 * \frac{175 - 105}{220 - 60} + 175 - 60 * \frac{175 - 105}{220 - 60} = \text{123}$$

$$f'(x, y) \text{ 110} = 110 * \frac{175 - 105}{220 - 60} + 175 - 60 * \frac{175 - 105}{220 - 60} = \text{127}$$

$$f'(x, y) \text{ 116} = 116 * \frac{175 - 105}{220 - 60} + 175 - 60 * \frac{175 - 105}{220 - 60} = \text{130}$$

$$f'(x, y) \text{ 120} = 120 * \frac{175 - 105}{220 - 60} + 175 - 60 * \frac{175 - 105}{220 - 60} = \text{131}$$

$$f'(x, y) \text{ 150} = 150 * \frac{175 - 105}{220 - 60} + 175 - 60 * \frac{175 - 105}{220 - 60} = \text{144}$$

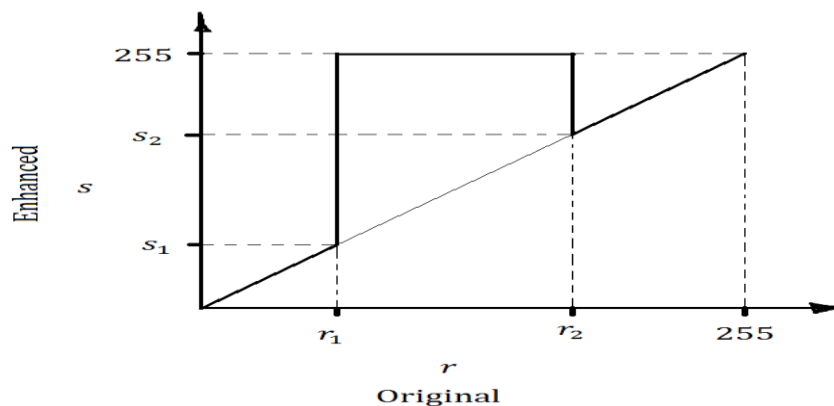
$$f'(x, y) \text{ 170} = 170 * \frac{175 - 105}{220 - 60} + 175 - 60 * \frac{175 - 105}{220 - 60} = \text{153}$$

$$f'(x,y) \text{ 180} = 180 * \frac{175 - 105}{220 - 60} + 175 - 60 * \frac{175 - 105}{220 - 60} = \text{158}$$

Gray level	109	123	127	130	131	144	153	158
Gray count	10	10	100	500	1000	400	100	80

3. Gray level slicing

- To High light range of interest colors/gray values.



Example 3: -

Gray level	70	100	110	116	120	150	170	180
Gray count	10	10	100	500	1000	400	100	80

find the histogram of the above image matrix after boosting up to range 125-187

Answer

- Range for gray images as: -
 - First line: 0 → r₁**
(0 to 125)
 $f'(x,y) = f(x,y)$
 - Second line: r₁ → r₂**
(125 to 178)
 $f'(x,y) = 255$
 - Third line: r₂ → 255**
(178 to 255)
 $f'(x,y) = f(x,y)$

Boosting up to range 125-178, then $f'(x, y) = 255$

$$f'(x, y) 70 = 70$$

$$f'(x, y) 100 = 100$$

$$f'(x, y) 110 = 110$$

$$f'(x, y) 116 = 116$$

$$f'(x, y) 120 = 120$$

$$f'(x, y) 150 = 255$$

$$f'(x, y) 170 = 255$$

$$f'(x, y) 180 = 255$$

Gray level	70	100	110	116	120	255	255	255
Gray count	10	10	100	500	1000	400	100	80

Gray level	70	100	110	116	120	255
Gray count	10	10	100	500	1000	580

4. Histogram

- Histogram of an image, like other histograms also shows frequency. But an image histogram, shows frequency of pixels intensity values. In an image histogram, the x axis shows the gray level intensities and the y axis shows the frequency of these intensities.

Example 4: -

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

- Find Histogram
- Find Normalized Histogram

Answer

Gray	Count (Histogram)	Probability (Normalized Histogram)
0	2	$2/25$
1	4	$4/25$
2	3	$3/25$
3	3	$3/25$
4	2	$2/25$
5	4	$4/25$
6	3	$3/25$
7	4	$4/25$
Total →	25	1

5. Histogram Normalization and Equalization

- Used for enhancing contrast of image
 - In range
 - Full range
- Full range rules:
 - Total count = ϵ count
 - Probability = $\frac{\text{Gray count}}{\text{Total count}}$
 - Cumulative = ϵ probability
 - Equalized= cumulative *255
- In range rules:
 - Total count = ϵ count
 - Probability = $\frac{\text{Gray count}}{\text{Total count}}$
 - Cumulative = ϵ probability
 - Equalized(new gray)= min gray + cumulative * $\Delta \rightarrow \Delta = (\text{max gray} - \text{min gray})$

Example 5: -

Gray level	70	100	110	116	120	150	170	180
Gray count	10	10	100	500	1000	400	100	20

find the full range and in range equalized histogram of the above image matrix

Answer (full range)

Gray	Count (Histogram)	Probability (Normalized Histogram)	cumulative	Equalized
70	10	10/2140	10/2140	$(10/2140) * 255 = 1.1915588$
100	10	10/2140	1/107	$(1/107) * 255 = 2.3831775$
110	100	100/2140	6/107	$(6/107) * 255 = 14.29906542$
116	500	500/2140	31/107	$(31/107) * 255 = 73.878504$
120	1000	1000/2140	81/107	$(81/107) * 255 = 193.03738$
150	400	400/2140	101/107	$(101/107) * 255 = 240.70093$
170	100	100/2140	106/107	$(106/107) * 255 = 252.6168224$
180	20	20/2140	1	255
Total →	2140	1		

Answer (in range)

Min gray = 70

max gray= 180

$\Delta = (180-70)=110$

Gray	Count (Histogram)	Probability (Normalized Histogram)	cumulative	Equalized (new gray)
70	10	$10/2140$	$10/2140$	$70 + ((10/2140) * 110) = 70.51401$
100	10	$10/2140$	$1/107$	$70 + ((10/107) * 110) = 80.28373$
110	100	$100/2140$	$6/107$	$70 + ((6/107) * 110) = 76.1682243$
116	500	$500/2140$	$31/107$	$70 + ((31/107) * 110) = 101.86915$
120	1000	$1000/2140$	$81/107$	$70 + ((81/107) * 110) = 153.2710$
150	400	$400/2140$	$101/107$	$70 + ((101/107) * 110) = 173.83177$
170	100	$100/2140$	$106/107$	$70 + ((106/107) * 110) = 178.9719626$
180	20	$20/2140$	1	$70 + (1 * 110) = 180$
Total →	2140	1		