Computer vision	Section (4)

Section Content:

- Image Enhancement in Spatial Domain
  - image negative
  - Contrast Stretching
  - Contrast contraction
  - Gray level slicing
  - Histogram Normalization
  - Histogram Equalization

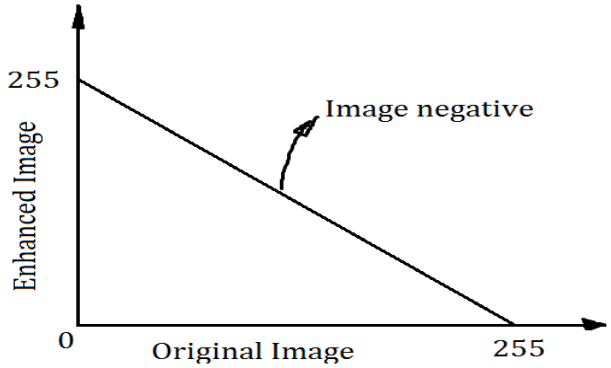
Image Enhancement

Image Enhancement:

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

1. Image Negative

- $0^{black} => 255^{white}$
  $255^{white} => 0^{black}$



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

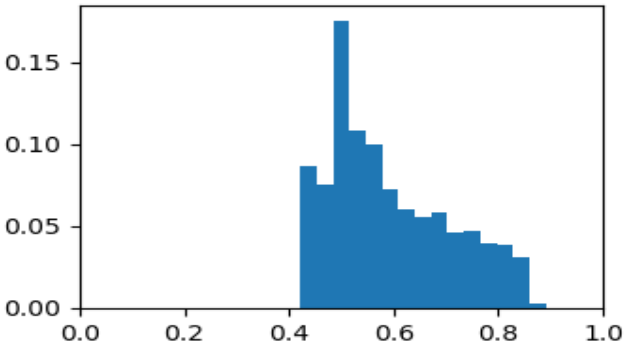
L=2^q (q=No. of bits. if q=8, then L=2^8 =256)

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
- Increases contrast by **expanding the intensity range**
- Best for Images with **low contrast** and a **narrow range of intensities**

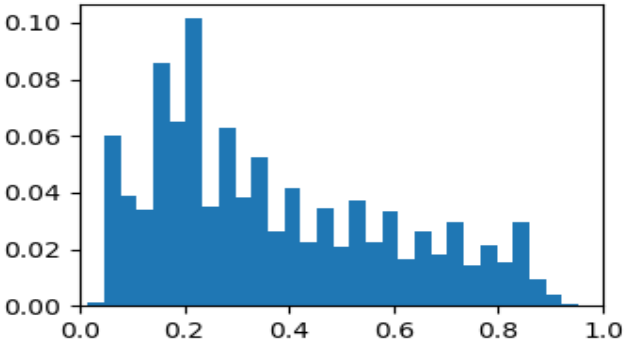
Low contrast orginal

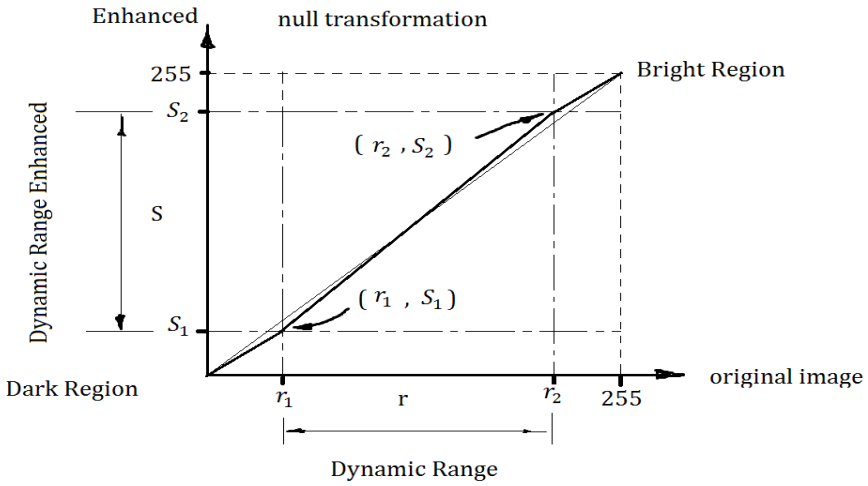
Histogram of low contrast image



Contrast Stretched

Histogram of contrast stretched image





- 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

r1=105, r2=175 s1=60, s2=220

r1>s1 & r2<s2

- 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

r1=60, r2=220 s1=105, s2=175

r1<s1 & r2>s2

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

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

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

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

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

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

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

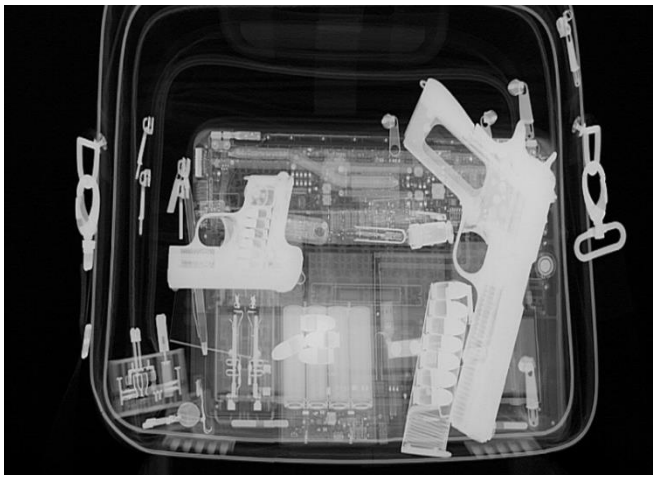
$$f'^{(x,y)}170 = 170 * \frac{175 - 105}{220 - 60} + 105 - 60 * \frac{175 - 105}{220 - 60} = 153$$

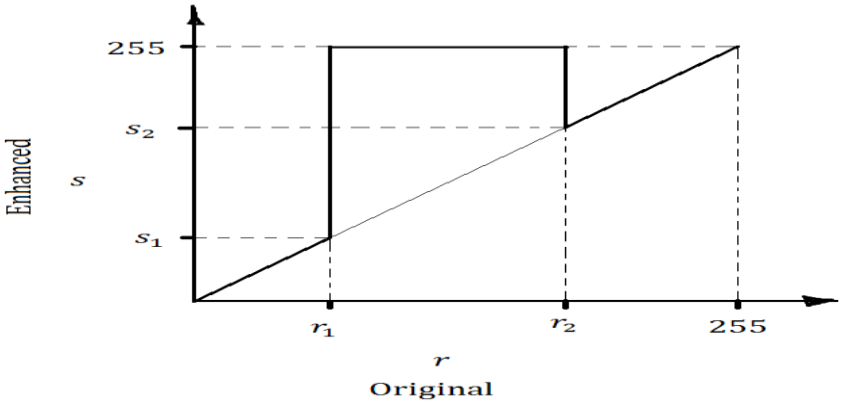
$$f'^{(x,y)}180 = 180 * \frac{175 - 105}{220 - 60} + 105 - 60 * \frac{175 - 105}{220 - 60} = 158$$

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: -
  1. **First line: $0 \rightarrow r_1$**
     (0 to 125)
     $f'(x,y) = f(x,y)$
  2. **Second line: $r_1 \rightarrow r_2$**
     (125 to 1)87
     $f'(x,y) = 255$
  3. **Third line: $r_2 \rightarrow 255$**
     (187 to 255)

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

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

$f'^{(x,y)}70 = 70$

$f'^{(x,y)}100 = 100$

$f'^{(x,y)}110 = 110$

$f'^{(x,y)}116 = 116$

$f'^{(x,y)}120 = 120$

$f'^{(x,y)}150 = 255$

$f'^{(x,y)}170 = 255$

$f'^{(x,y)}180 = 255$

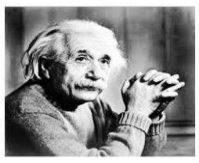
Gray level	**70**	**100**	**110**	**116**	**120**	**255**	**255**	**255**
Gray count	10	10	100	500	1000	400	100	80

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

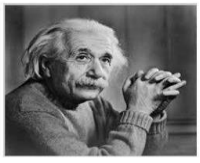
4. Histogram

- 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.
- Redistributes intensities to create a uniform histogram
- Images with **poor global contrast** and **imbalanced brightness distribution**

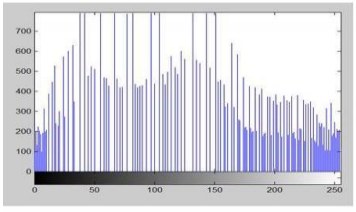
New Image



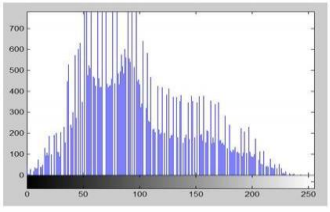
Old image



New Histogram



Old Histogram



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 * Δ → Δ = (max gray – 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= 2**
100	**10**	**10/2140**	**1/107**	**(1/107) *255= 3**
110	**100**	**100/2140**	**6/107**	**(6/107) *255= 15**
116	**500**	**500/2140**	**31/107**	**(31/107) *255= 74**
120	**1000**	**1000/2140**	**81/107**	**(81/107) *255= 194**
150	**400**	**400/2140**	**101/107**	**(101/107) *255= 241**
170	**100**	**100/2140**	**106/107**	**(106/107) *255= 253**
180	**20**	**20/2140**	**1**	**255**
Total →	**2140**	**1**		

Answer (in range)

Min gray = 70 **max gray= 180** **Δ = (180-70) =110**

Gray	Count (Histogram)	Probability (Normalized Histogram)	cumulative	Equalized (new gray)
70	10	10/2140	10/2140	70 +((10/2140) *110) = 71
100	10	10/2140	1/107	70 +((10/107) *110) = 81
110	100	100/2140	6/107	70 +((6/107) *110) = 77
116	500	500/2140	31/107	70 +((31/107) *110) = 102
120	1000	1000/2140	81/107	70 +((81/107) *110) = 154
150	400	400/2140	101/107	70 +((101/107) *110) = 174
170	100	100/2140	106/107	70 +((106/107) *110) = 179
180	20	20/2140	1	70 +(1*110) = 180
Total →	2140	1		

Note:

Equalized Histogram

- Full Range = comm.*255
- In Range = min + (comm.* Δ)
- Equalized to full range of 8-bits
  8-bits=2^8 ->256 (0 – 255)
  Equalized = comm.*255
- Equalized to range of 3-bits image
  3-bits=2^{83}-> 8 (0 – 7)
  Equalized = comm. * 7
- Quantized to 128 levels (0 – 127)

  Equalized = comm. * 127