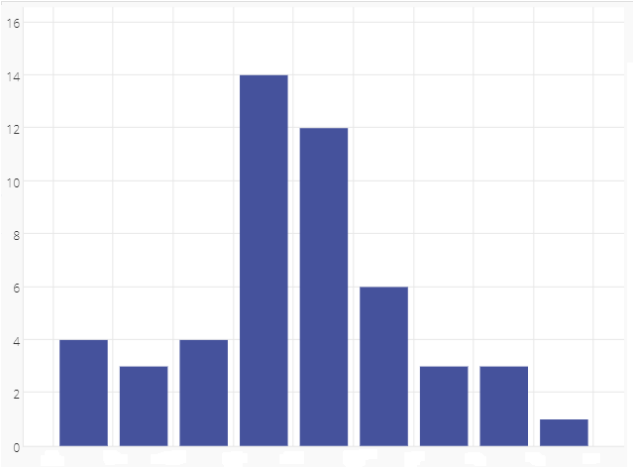
GRAYSCALE HISTOGRAM

HISTOGRAM

- In statistics, Histogram is a graphical representation showing distribution of data
- The histogram of an image represents the pixel intensity values.
  - This histogram is a graph showing the number of pixels in an image at each different intensity value found in that image
- 8-bit **grayscale** image: 256 different intensities



GRAYSCALE HISTOGRAM

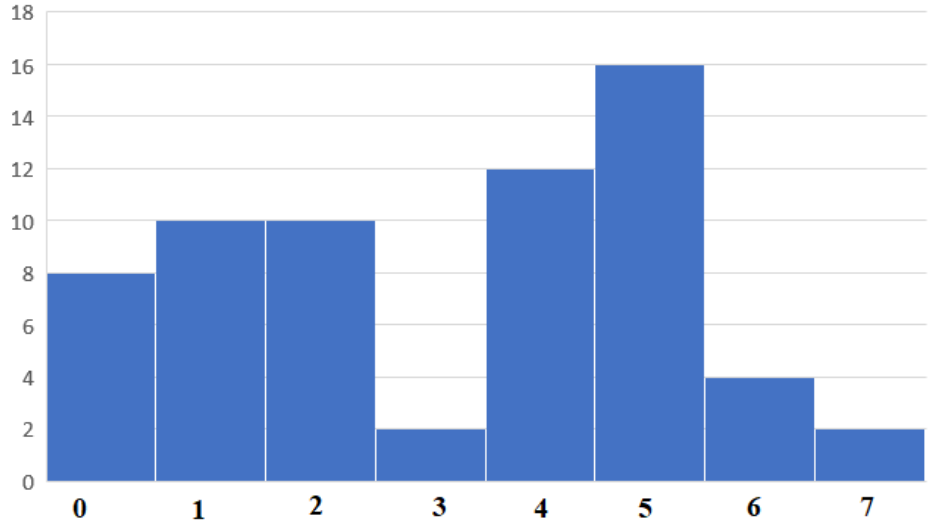
Histogram can be plotted in two methods:

- First Method:
  - X axis : each gray scale intensity levels and Y axis : no of pixels of each intensity
  - The histogram of a digital image with gray levels in the range (0, L-1) is a discrete function $h(r_k) = n_k$

    where r_k : k^{th} gray level , n_k : no of pixels

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

Gray Level	No. of Pixels
0	8
1	10
2	10
3	2
4	12
5	16
6	4
7	2

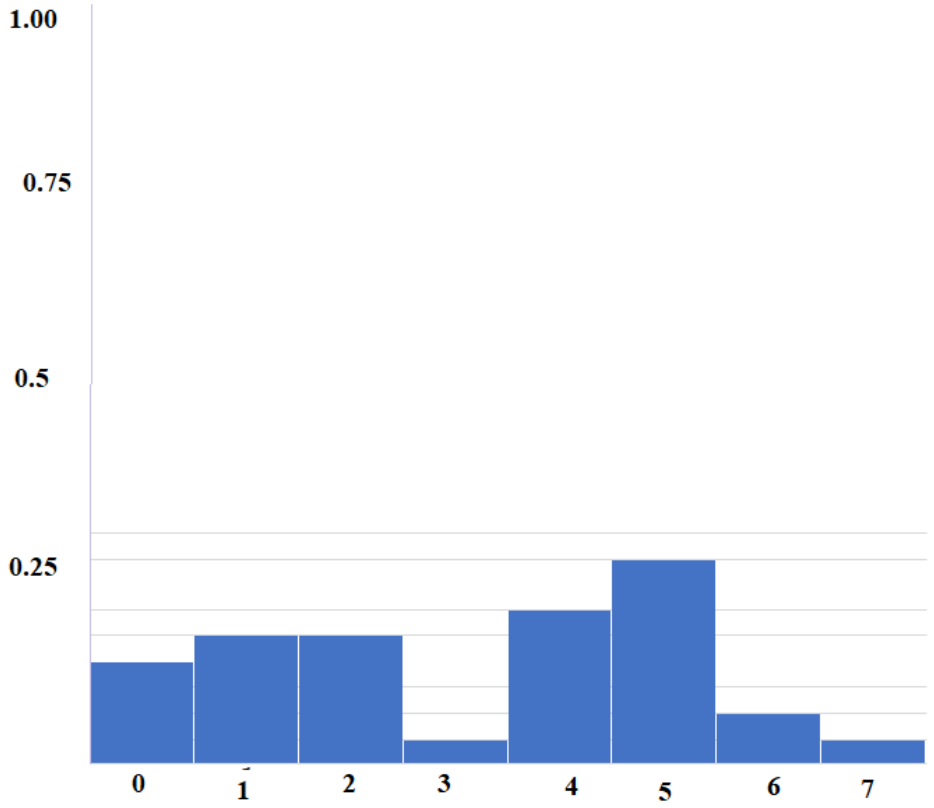


NORMALIZED HISTOGRAM

- Second method:
  - Dividing each histogram values with no of pixels
  - X axis has gray levels and Y-axis probability of occurrence of gray levels
  - $P(\mu_k) = nk/n$

    Where, μ_k – gray level, n_k – no, of pixels in k^{th} gray level, n – total number of pixels in an image.

Gray Level	No. of Pixels	Pr
0	8	0.125
1	10	0.15625
2	10	0.15625
3	2	0.03125
4	12	0.1875
5	16	0.25
6	4	0.0625
7	2	0.03125

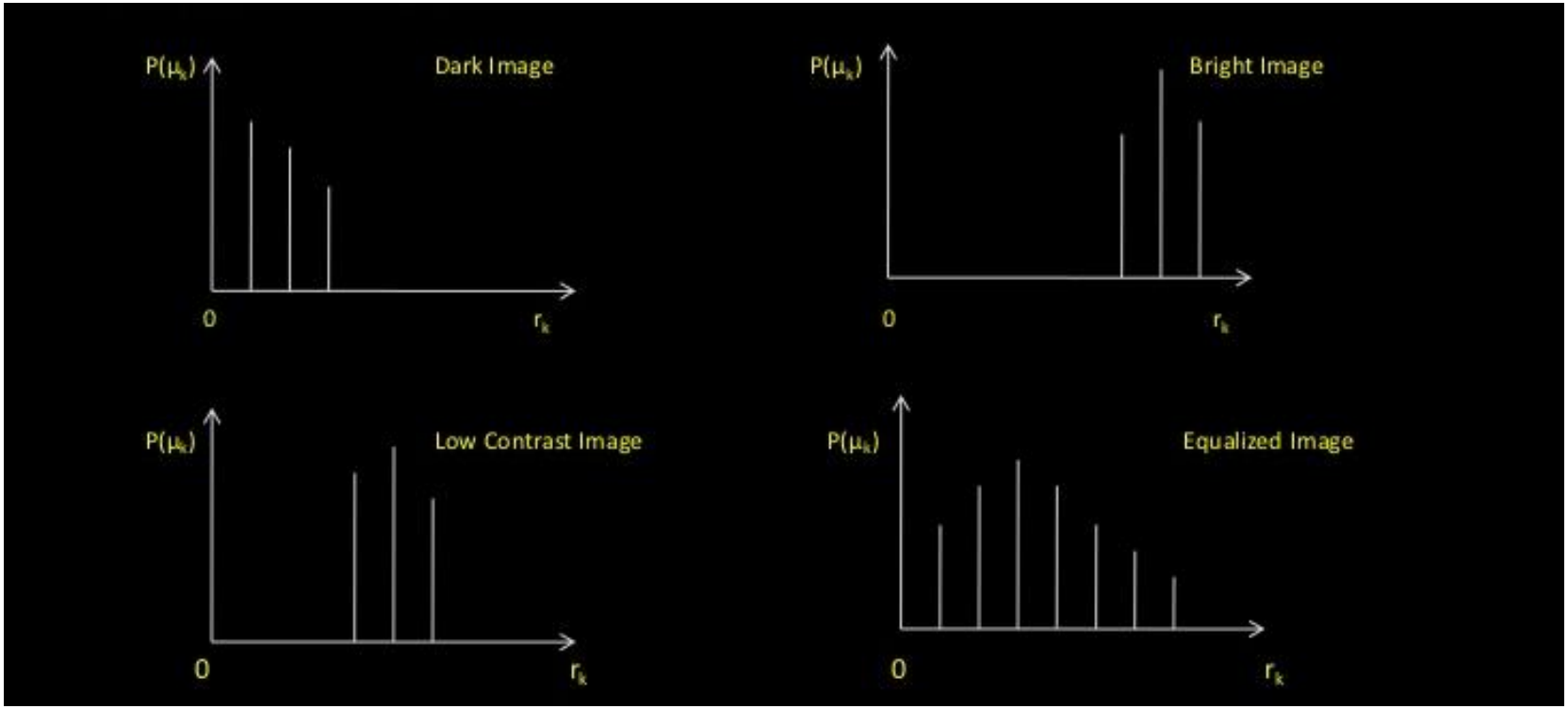


Why Histogram?

- Basis for numerous spatial domain processing techniques
- Used effectively for image enhancement
- Provide useful image statistics
- Useful in image processing applications such as image compression and segmentation

Histograms

- Great deal of information can be obtained just by looking at histogram

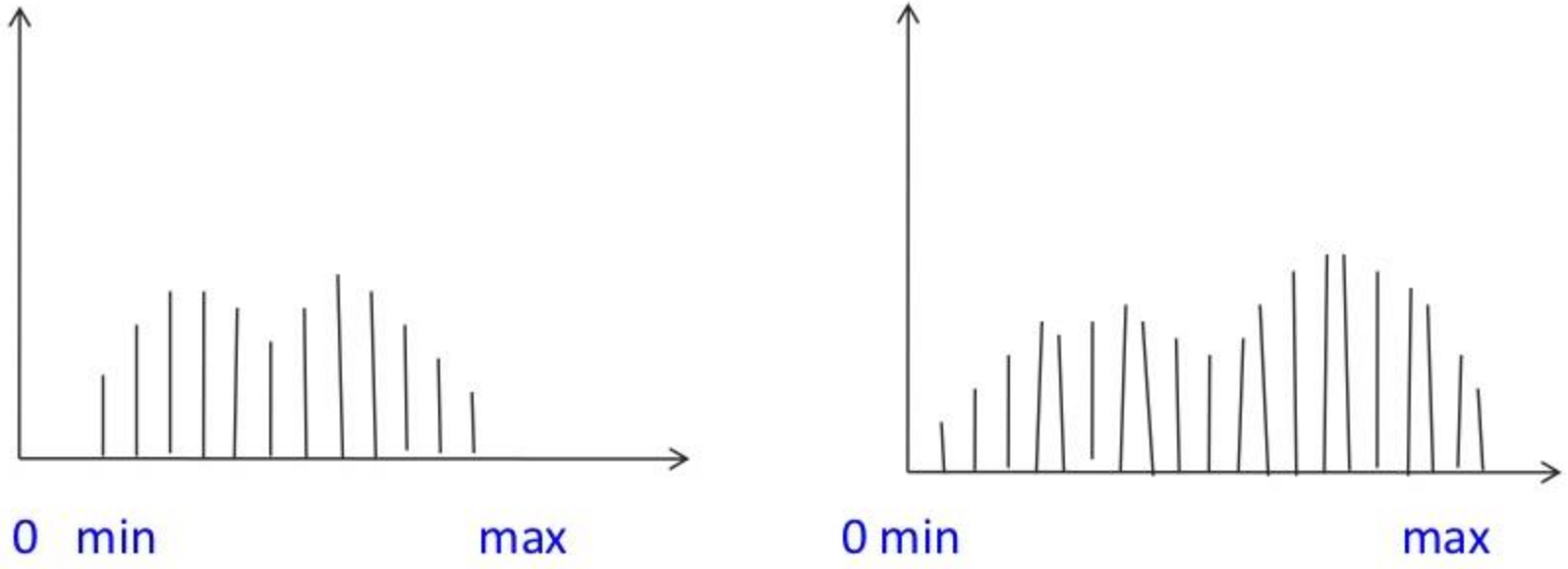


Histogram Processing

- Two methods of image enhancement:
  - Histogram stretching
  - Histogram equalization

Histogram Stretching

- Stretching increases the dynamic range of the image and hence improves the contrast of the image
- Basic shape is not modified but range if histogram values are stretched.



Histogram Stretching

$$S = T(r) = ((S_{max} - S_{min})/ (r_{max} - r_{min})) \times (r - r_{min}) + S_{min}$$

Where, S_{max} – max gray level of output image

S_{min} – min gray level of output image

r_{max} – max gray level of input image

r_{min} – min gray level of input image

Histogram Stretching

- Ex. 1) Perform histogram stretching so that the new image has a dynamic range of 0 to 7 [0, 7]

Gray Levels	0	1	2	3	4	5	6	7
No. of Pixels	0	0	50	60	50	20	10	0

- Ex. 1) Perform histogram stretching so that the new image has a dynamic range of 0 to 7 [0, 7]

Gray Levels	0	1	2	3	4	5	6	7
No. of Pixels	0	0	50	60	50	20	10	0

$S_{max} = 7$; $S_{min} = 0$; $r_{max} = 6$; $r_{min} = 2$

$S = ((S_{max} - S_{min})/(r_{max} - r_{min})) \times (r - r_{min}) + S_{min}$

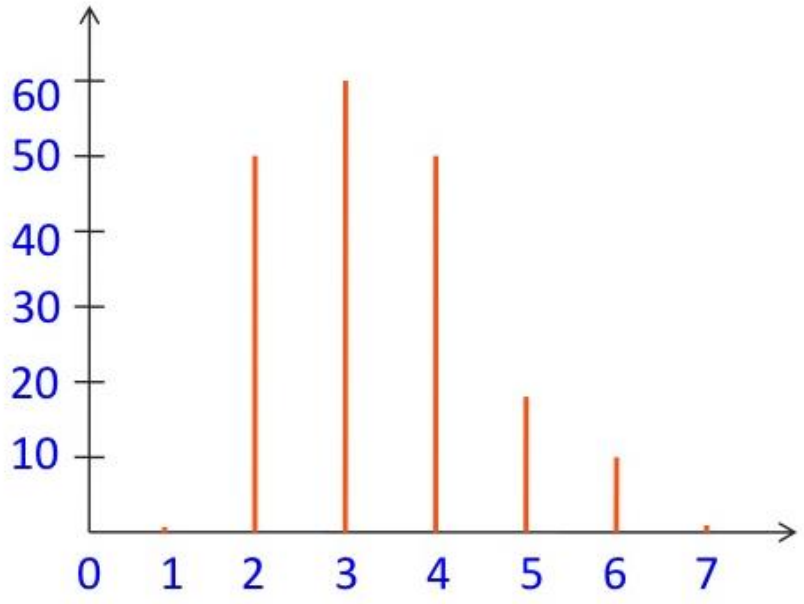
$= ((7 - 0)/(6-2) \times (r-2) + 0$

$S = (7/4) \times (r-2)$

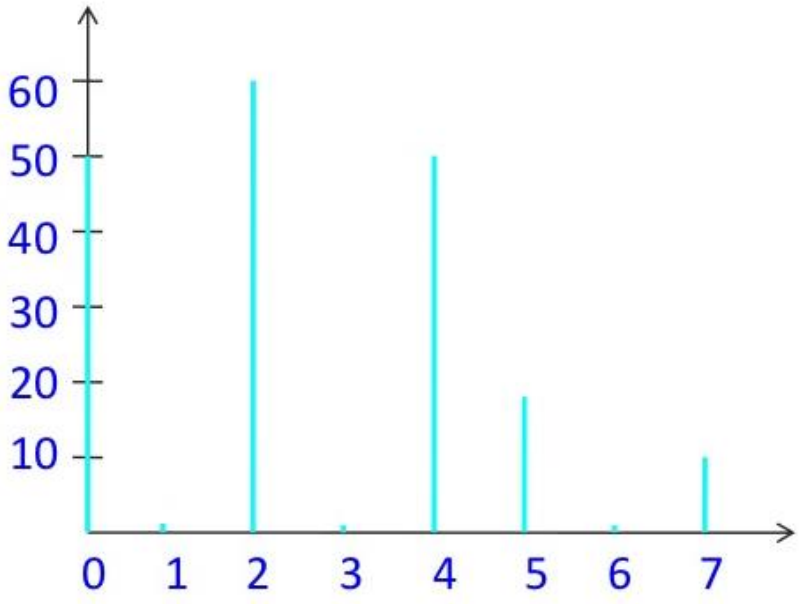
r	**(7/4)x(r-2)**	**= S**
2	(7/4) x 0	= 0
3	(7/4) x 1 = 1.75	= 2
4	(7/4)x 2 = 3.5	= 4
5	(7/4) x 3 = 5.25	= 5
6	(7/4) x 4	= 7

- Ex. 1) Perform histogram stretching so that the new image has a dynamic range of 0 to 7 [0, 7]

Gray Levels	0	1	2	3	4	5	6	7
No. of Pixels (Input)	0	0	50	60	50	20	10	0
No. of Pixels (Output)	50	0	60	0	50	20	0	10



Input



Output

Histogram Stretching

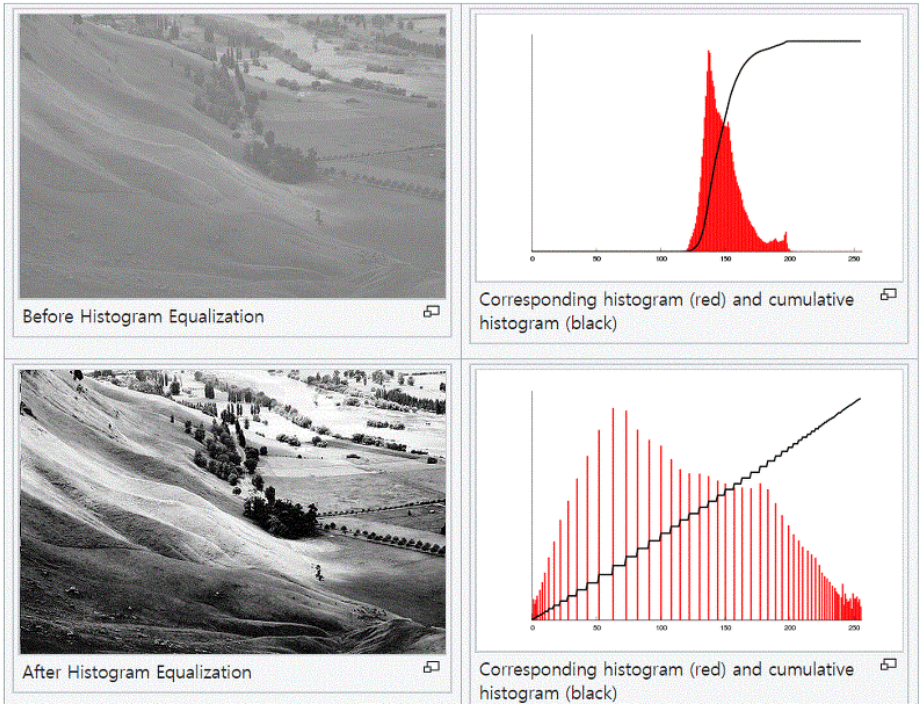
- Ex.2) Perform histogram stretching so that the new image has a dynamic range from 0 to 7.

Gray Levels	0	1	2	3	4	5	6	7
No. of Pixels	100	90	85	70	0	0	0	0

No. of Pixels (Output)	100	0	90	0	0	85	0	70

Histogram Equalization

- Linear stretching is a good technique but not perfect
- Equalization spread out the Gray levels in an image so that they are evenly distributed across the range
- The histogram of resultant image is made flat as possible



Histogram Equalization: Steps

1. Find the histogram values and the sum of values
2. Then normalize the histogram (Calculate the probability)
3. Then find the Cumulative Distribution Frequency (CDF)

$$CDF_i = \sum_{j=0}^{i} P_j$$

4. Multiply each value by max Gray level and round it, to get the Gray level of the output image
5. Plot the image using one to one correspondence

Histogram Equalization

- Ex 1. Perform histogram equalization on the following subset of an image

2	2	3	4	3
2	3	4	4	3
2	3	5	4	4
3	4	5	6	3
2	3	3	4	2

Gray Level	0	1	2	3	4	5	6	7
No. of Pixels	0	0	6	9	7	2	1	0

Gray Level	No. of Pixels	Pr	CDF	CDF x Max L	New Gray Level
0	0	0	0	0	0
1	0	0	0	0	0
2	6	0.24	0.24	1.68	2
3	9	0.36	0.6	4.2	4
4	7	0.28	0.88	6.16	6
5	2	0.08	0.96	6.72	7
6	1	0.04	1	7	7
7	0	0	1	7	7
	25				

Gray Level	0	1	2	3	4	5	6	7
No. of Pixels	0	0	6	9	7	2	1	0

No. of Pixels (Output)	0	0	6	0	9	0	7	3

2	2	3	4	3
2	3	4	4	3
2	3	5	4	4
3	4	5	6	3
2	3	3	4	2

2	2	4	6	4
2	4	6	6	4
2	4	7	6	6
4	6	7	7	4
2	4	4	6	2

HISTOGRAM MATCHING (HISTOGRAM SPECIFICATION)

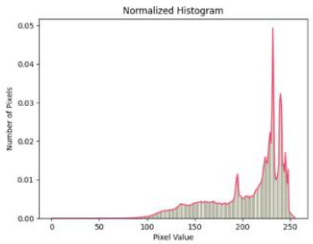
- The process of Histogram Matching takes in an input image and produces an output image that is based upon a specified histogram.
- Histogram matching modifies an image based on the contrast of another image

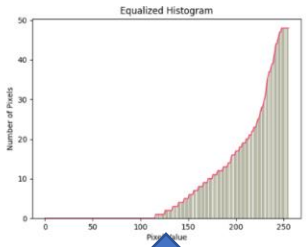
Input image

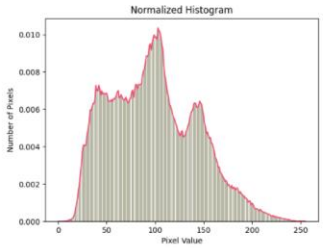
Specified image

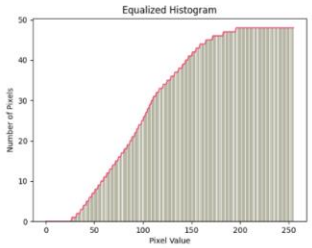
Output image

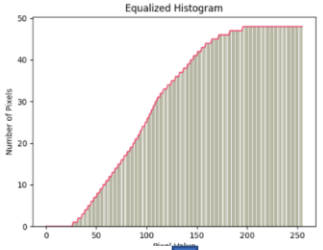
HISTOGRAM MATCHING











HISTOGRAM MATCHING

Ex.1 Perform histogram matching using the given image sets.

Input Image

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

Specified Image

4	6	5	6	6	7	5	5
5	5	4	4	4	7	4	4
5	6	4	5	5	6	6	5
5	4	7	4	5	4	6	7
4	5	5	5	4	4	6	5
6	5	4	5	6	6	7	4
6	4	5	4	7	4	6	5
7	6	6	5	4	5	6	7

HISTOGRAM MATCHING

Input Image Gray Level Distribution

Gray Levels	0	1	2	3	4	5	6	7
No. of Pixels	8	10	10	2	12	16	4	2

Specified Image Gray Level Distribution

Gray Levels	0	1	2	3	4	5	6	7
No. of Pixels	0	0	0	0	20	20	16	8

HISTOGRAM MATCHING

Input Image Gray Level Equalization

Gray Level	No. of Pixels	Pr	CDF	CDF x (L-1)	New Gray Level (H)
0	8	0.125	0.125	0.875	1
1	10	0.15625	0.28125	1.96875	2
2	10	0.15625	0.4375	3.0625	3
3	2	0.03125	0.46875	3.28125	3
4	12	0.1875	0.65625	4.59375	5
5	16	0.25	0.90625	6.34375	6
6	4	0.0625	0.96875	6.78125	7
7	2	0.03125	1	7	7
	64				

HISTOGRAM MATCHING

Specified Image Gray Level Equalization

Gray Level	No. of Pixels	Pr	CDF	CDF x (L-1)	New Gray Level (S)
0	0	0	0	0	0
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	20	0.3125	0.3125	2.1875	2
5	20	0.3125	0.625	4.375	4
6	16	0.25	0.875	6.125	6
7	8	0.125	1	7	7
	64				

HISTOGRAM MATCHING

Final Mapping

Gray Level	H	S	Map
0	1	0	4
1	2	0	4
2	3	0	5
3	3	0	5
4	5	2	6
5	6	4	6
6	7	6	7
7	7	7	7

HISTOGRAM MATCHING

Histogram of the Resultant Image

Gray Level	No. of Pixels (Input)	Resultant Map	No. of Pixels (Output)
0	8	4	0
1	10	4	0
2	10	5	0
3	2	5	0
4	12	6	18
5	16	6	12
6	4	7	28
7	2	7	6