جَامعة المَنارة
MANARA UNIVERSITY

Computer vision

المحاضرة السابعة
Image Enhancement
العمليات على البكسلات باستخدام هيستوغرام الصورة

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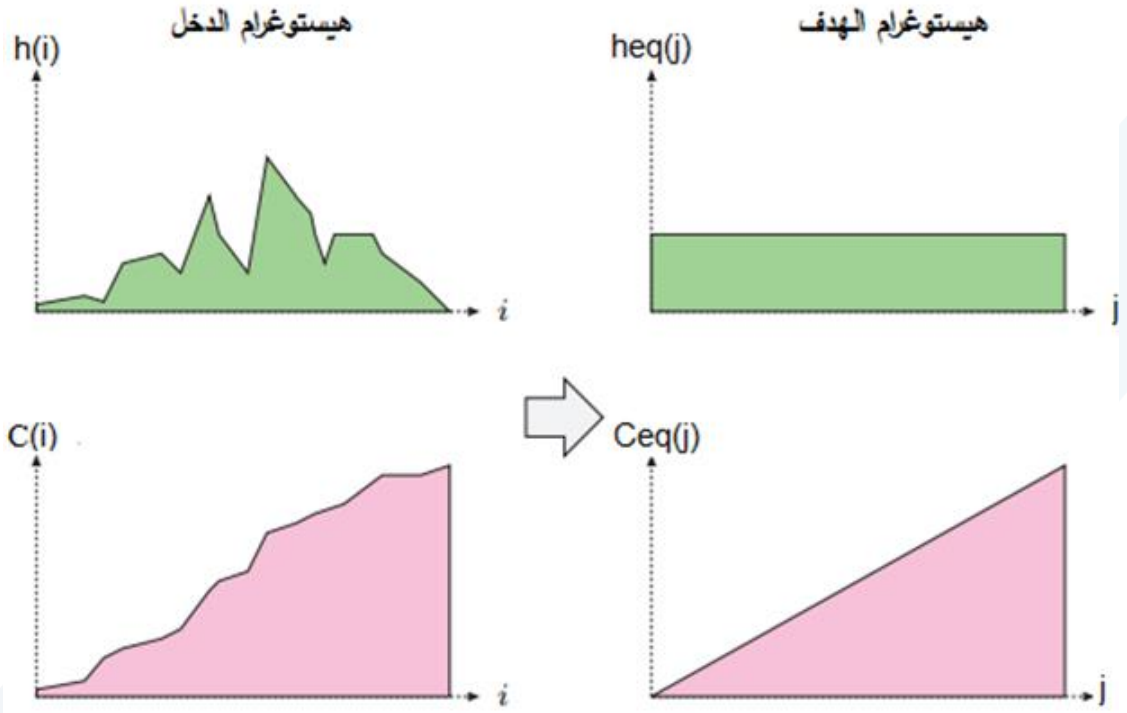
العمليات على الهيستوغرام
Histogram Processing

- The shape of the histogram of an image does provide useful info about the possibility for contrast enhancement.

- فيما يلي بعض المواضيع التي تندرج تحت معالجة الرسم البياني:
  - مساواة الرسم البياني Histogram Equalization
  - مطابقة الرسم البياني Histogram Matching

تسوية الهيستوغرام

- تحويل التوزع غير الخطي والفريد لبكسلات صورة الدخل إلى صورة خرج ذات هيستوغرام ذي توزع احتمالي موحد
- تحتوي الصورة الناتجة عن عملية تسوية الهيستوغرام في الحالة المثالية على عدد متساو من البكسلات التي تمثل كل سوية لونية في الصورة



مثال1: عملية تسوية الهيستوغرام

8 bits

140	140	140	137	140	142	145	153
142	142	145	145	145	147	147	150
140	142	145	145	147	147	150	155
147	147	147	147	147	153	155	163
163	155	155	153	155	165	170	170
173	170	170	170	173	173	173	181
181	181	178	178	178	181	181	183
188	186	186	186	188	188	188	186

مصفوفة الصورة

مثال1: عملية تسوية الهيستوغرام

القيمة I	التكرار #	التوزع التراكمي C	C/N	(L-1)*C/N floor	(L-1)*(C - Cmin)/(N - Cmin) floor
137	1	1	1/64	3	0
140	5	6	6/64	23	20
142	4	10	10/64	39	36
145	6	16	16/64	63	60
147	9	25	25/64	100	97
150	2	27	27/64	108	105
153	3	30	30/64	120	117
155	5	35	35/64	139	137
163	2	37	37/64	147	145
165	1	38	38/64	151	149
170	5	43	43/64	171	170
173	4	47	47/64	187	186
178	3	50	50/64	199	198
181	5	55	55/64	219	218
183	1	56	56/64	223	222
186	4	60	60/64	239	238
188	4	64	64/64	255	255

مثال1: عملية تسوية الهيستوغرام

مصفوفة الصورة

المصفوفة الناتجة عن تسوية الهيستوغرام

تمرين

- بفرض الصورة المبينة والمخزنة بعمق بكسل قدره 4

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

L=16

- ما هي صورة الخرج الناتجة عن تسوية الهيستوغرام

i	#	C	C/N	(L-1)*C/N	floor	(L-1)*(C - Cmin)/(N - Cmin) floor
0	2	2	2/25	1.2	1	15*(2-2)/(25-2)=0
1	4	6	6/25	3.6	3	15*(6-2)/(25-2)=2.6=2
2	5	11	11/25	6.6	6	
3	2	13	13/25	7.8	7	
4	3	16	16/25	9.6	9	
5	3	19	19/25	11.4	11	
6	3	22	22/25	13.2	13	
7	3	25	25/25	15	15	

				0
			2	2
	0			2
			2	

صورة الخرج

تمرين

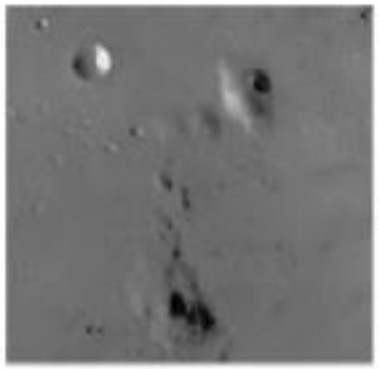
Intensity	# pixels	c
0	20	20
1	5	25
2	25	50
3	10	60
4	15	75
5	5	80
6	10	90
7	10	100
Total	100	

Accumulative Sum of P_r=C/N
20/100 = 0.2
(20+5)/100 = 0.25
(20+5+25)/100 = 0.5
(20+5+25+10)/100 = 0.6
(20+5+25+10+15)/100 = 0.75
(20+5+25+10+15+5)/100 = 0.8
(20+5+25+10+15+5+10)/100 = 0.9
(20+5+25+10+15+5+10+10)/100 = 1.0
1.0

تمرين

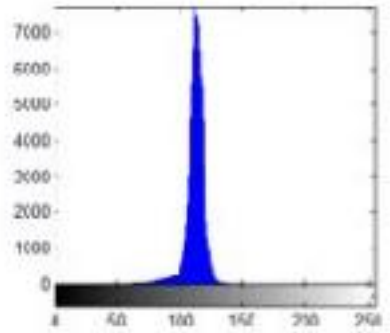
Intensity (r)	No. of Pixels (n_j)	Acc Sum of C/N=P_r	Output value: (L-1)C/N	Quantized Output (s) round	**(L-1)*(C - Cmin)/(N - Cmin)**
0	20	0.2	0.2x7 = 1.4	1	
1	5	0.25	0.25*7 = 1.75	2	
2	25	0.5	0.5*7 = 3.5	4	
3	10	0.6	0.6*7 = 4.2	4	
4	15	0.75	0.75*7 = 5.25	5	
5	5	0.8	0.8*7 = 5.6	6	
6	10	0.9	0.9*7 = 6.3	6	
7	10	1.0	1.0x7 = 7	7	
Total	100				

تطبيق عملية تسوية الهيستوغرام

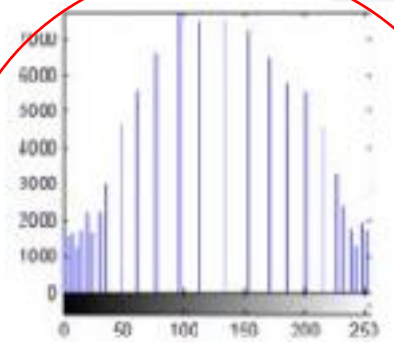


الصورة الأصلية

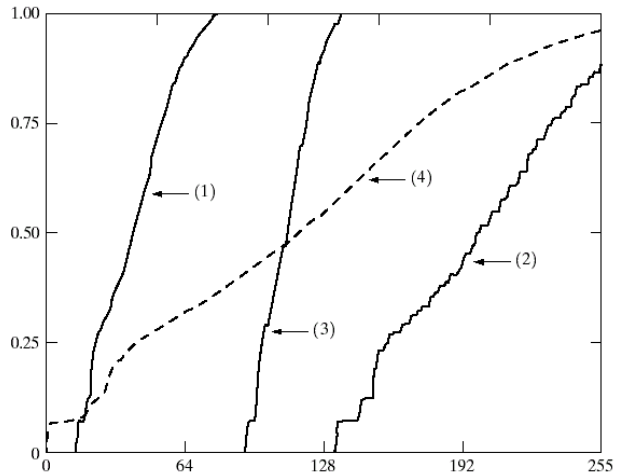
الصورة الناتجة عن تسوية الهيستوغرام

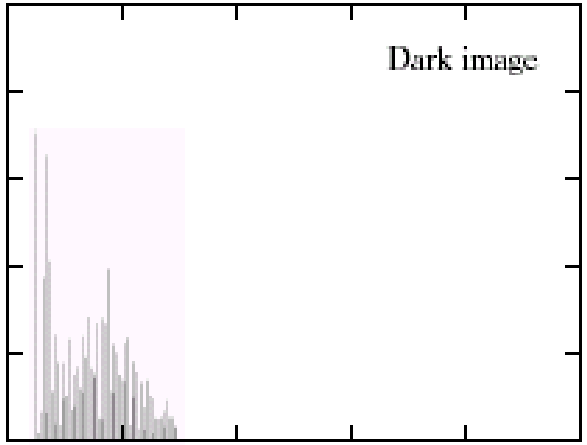


الهيستوغرام الأصلي

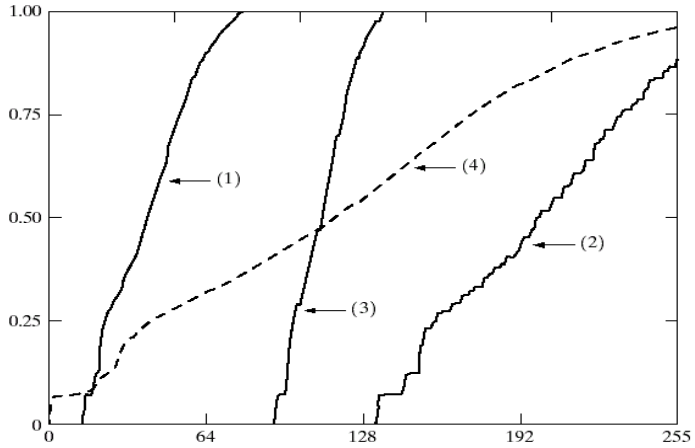


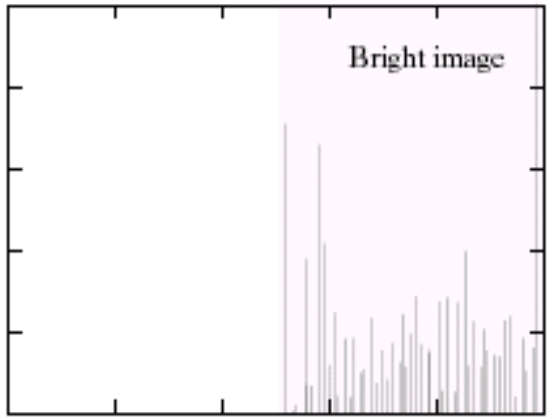
الهيستوغرام المسوّى


1.00
0.75
0.50
0.25
0
0
64
128
192
255
(1)
(2)
(3)
(4)


Dark image

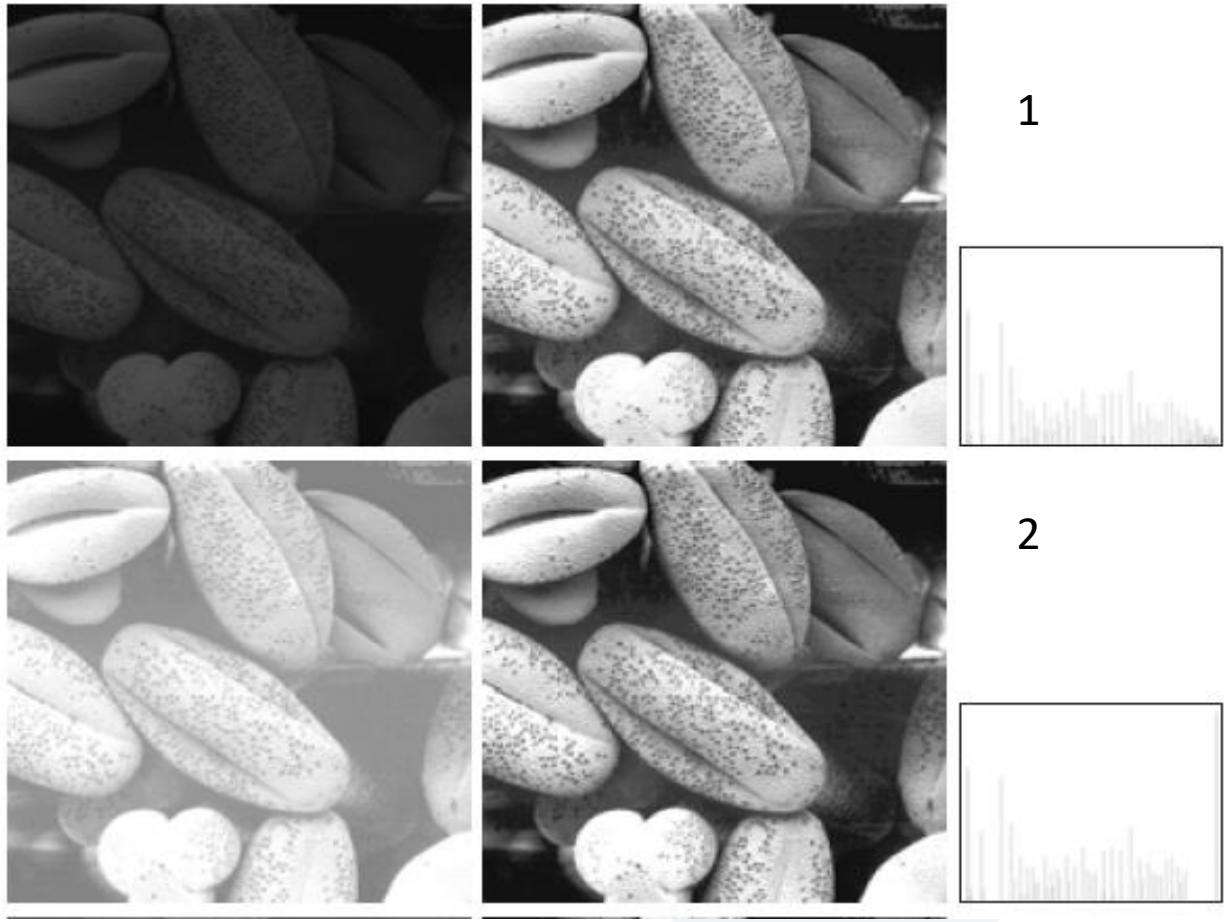
1

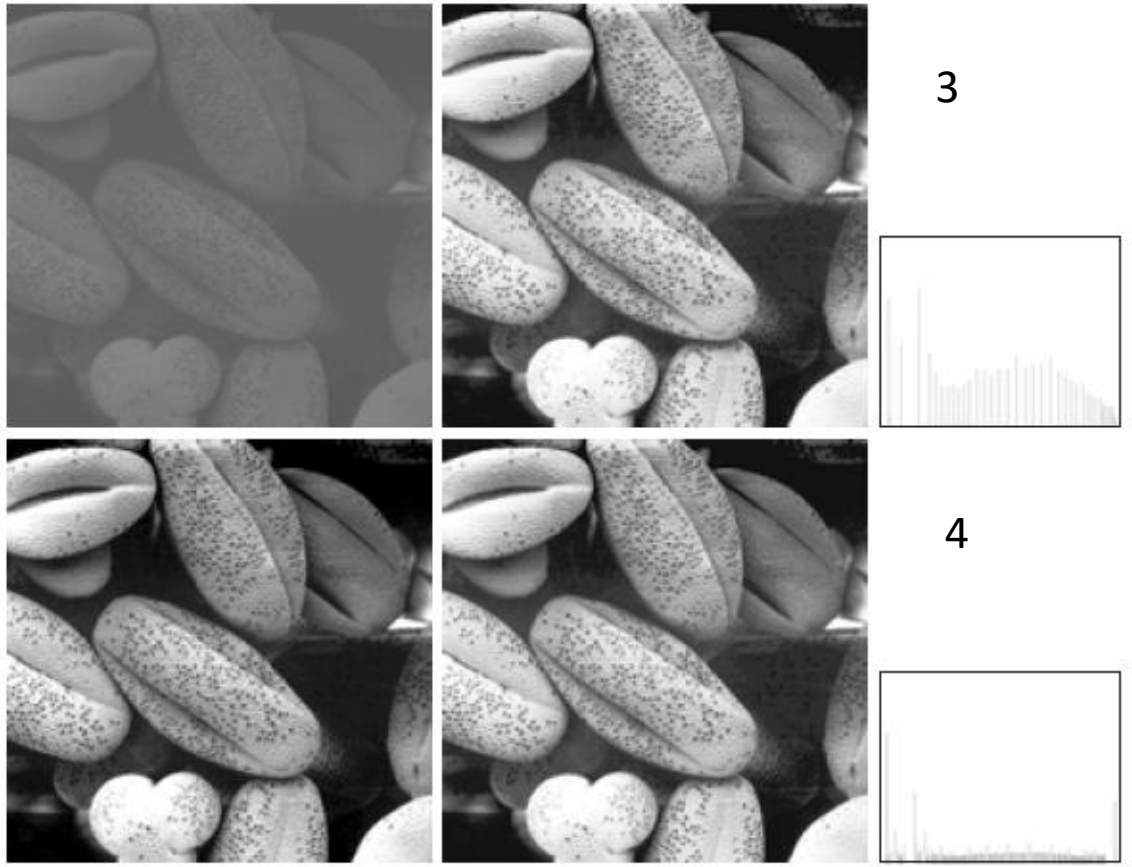

1.00
0.75
0.50
0.25
0
0
64
128
192
255
(1)
(2)
(3)
(4)


Bright image

2

مساواة الرسم البياني Histogram Equalization

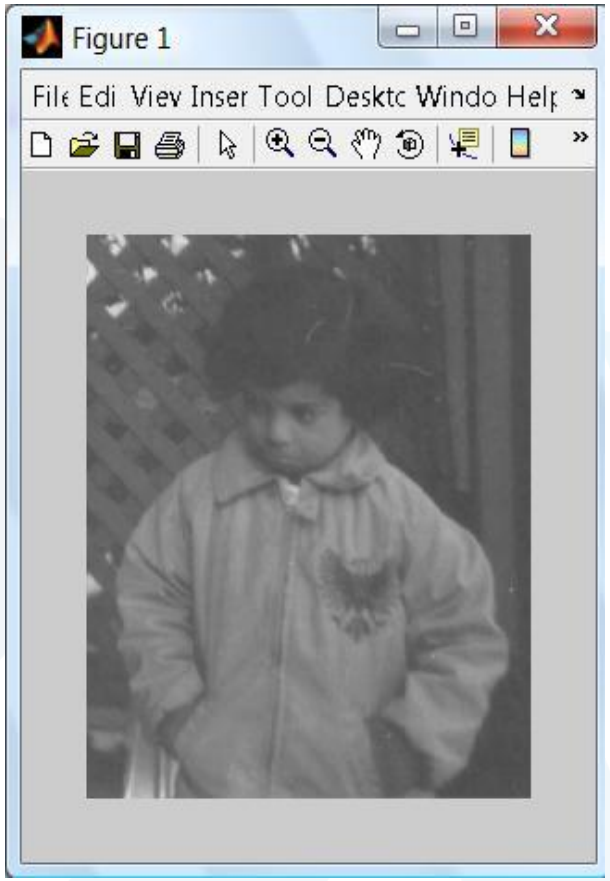


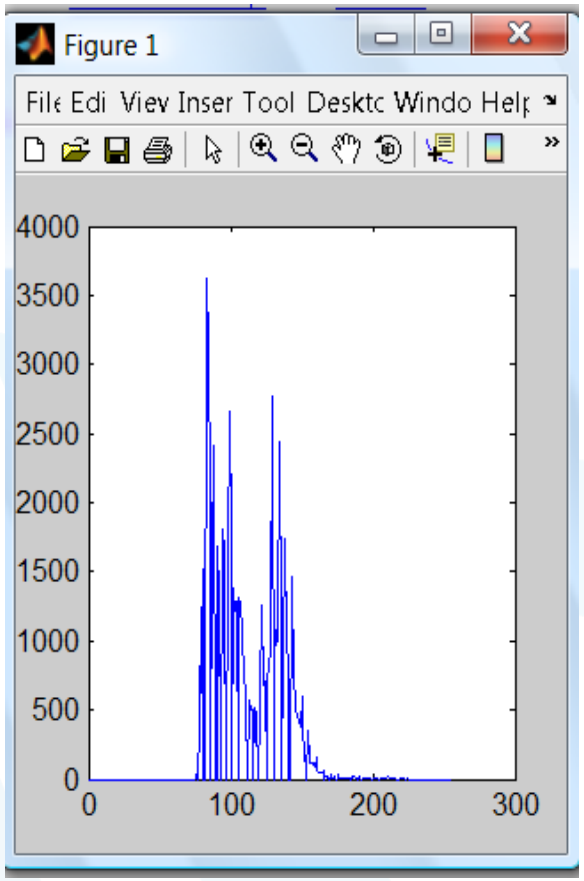


the image after histogram equalization becomes a low contrast image.

Histogram equalization of the image in MATLAB

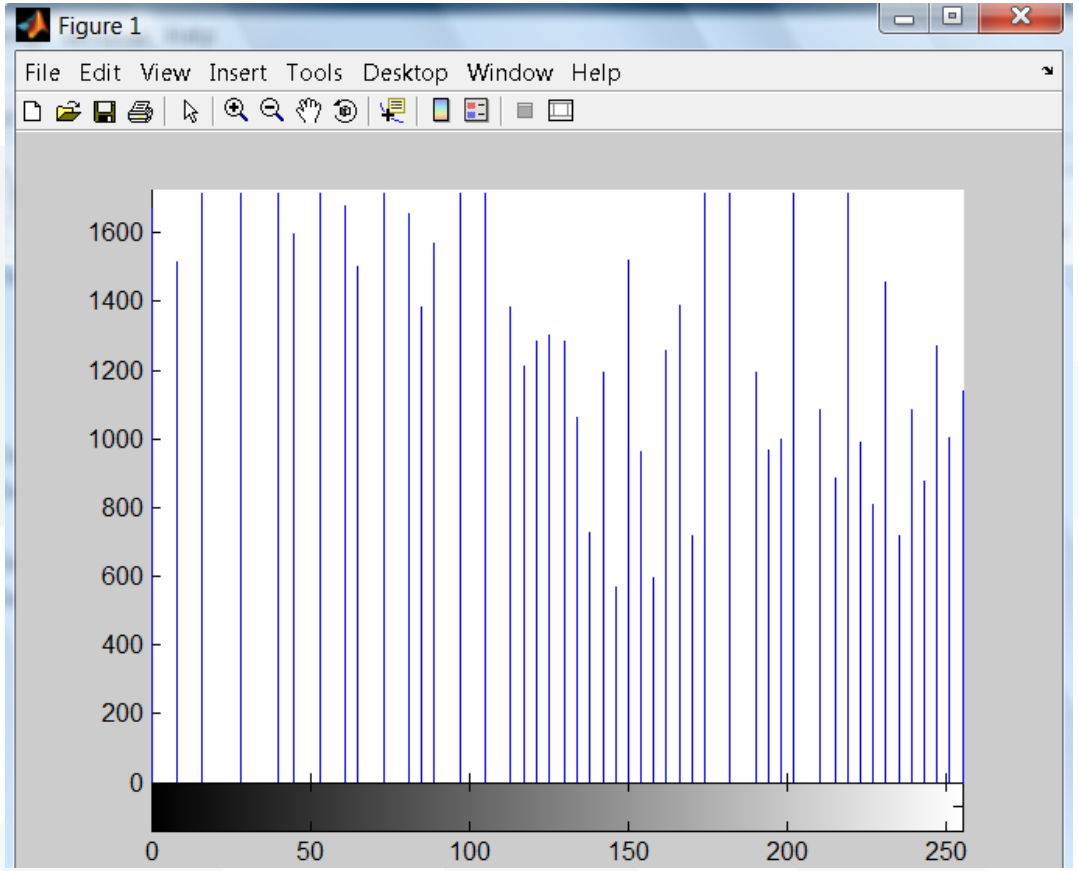
We have this image in matlab called pout.tif, when we plot its histogram it is showed like this:





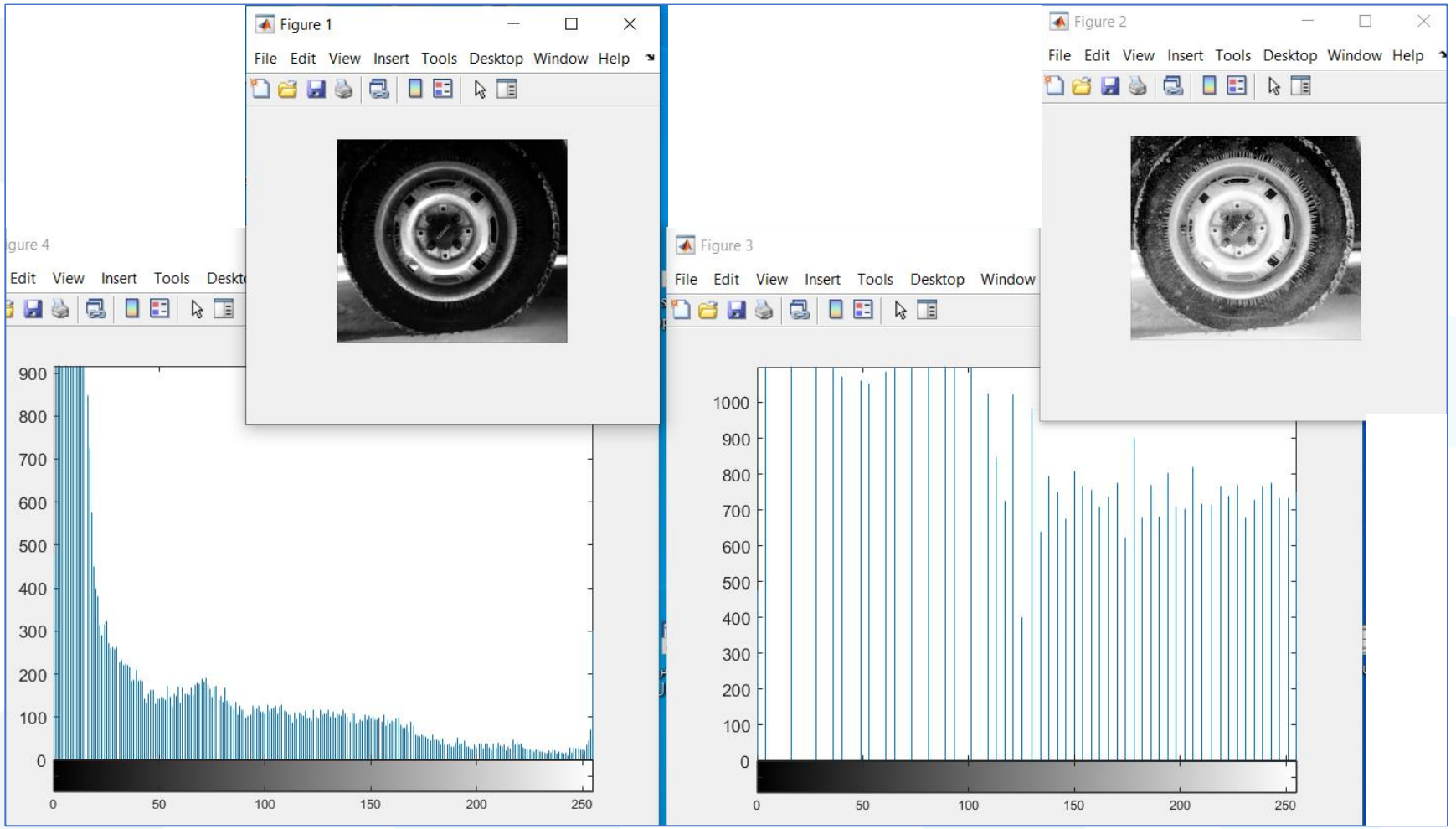
Notice that the pixels intensity values are concentrated on the middle (low contrast)

histogram equalization :
is the process of adjusting intensity values of pixels.
The process which increases the dynamic range of the gray level in a law contrast image to cover full range of gray levels.
In matlab : we use **histeq** function



Histogram produces pixels having values that are distributed throughout the range

```
clc
clear
I = imread('tire.tif');
 imshow(I)
 J = histeq(I);
 figure,imshow(J)
 figure, imhist(J)
 figure, imhist(I)
```



```
import cv2
import numpy as np
import matplotlib.pyplot as plt
image_path = 'noisy1.png'
img = cv2.imread(image_path, cv2.IMREAD_GRAYSCALE)
if img is None:
    print(f"Error: Could not load image from {image_path}. Please check the path and file existence.")
    exit()

# --- 3. Perform Histogram Equalization ---
# cv2.equalizeHist() takes a single-channel (grayscale) image and returns the equalized image.
equalized_img = cv2.equalizeHist(img)

# --- 4. (Optional) Calculate Histograms for comparison ---
hist_original = cv2.calcHist([img], [0], None, [256], [0, 256])
hist_equalized = cv2.calcHist([equalized_img], [0], None, [256], [0, 256])
```

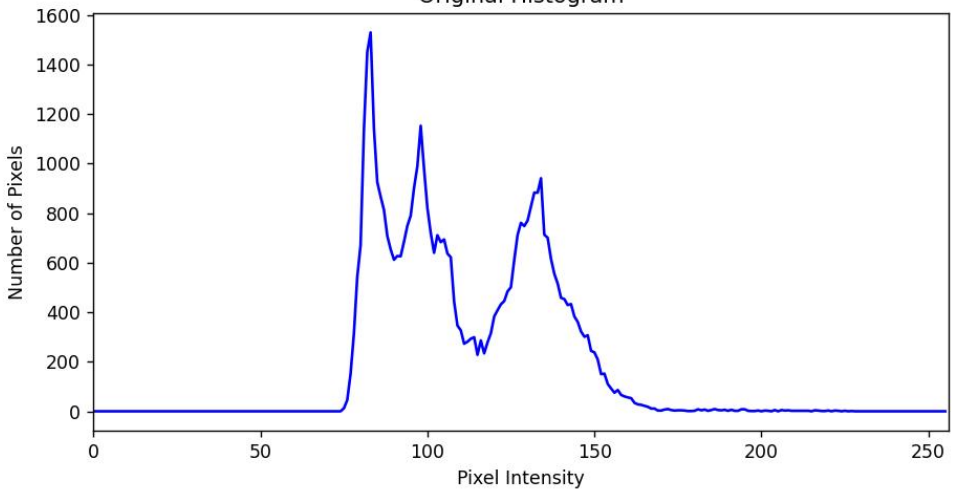
```
# --- 5. Display the original and equalized images with their histograms ---

plt.figure(figsize=(12, 8)) # Adjust figure size

# Subplot 1: Original Grayscale Image
plt.subplot(2, 2, 1) # 2 rows, 2 columns, first plot
plt.imshow(img, cmap='gray')
plt.title('Original Grayscale Image')
plt.axis('off')

# Subplot 2: Equalized Grayscale Image
plt.subplot(2, 2, 2) # 2 rows, 2 columns, second plot
plt.imshow(equalized_img, cmap='gray')
plt.title('Equalized Grayscale Image')
plt.axis('off')

# Subplot 3: Original Histogram
plt.subplot(2, 2, 3) # 2 rows, 2 columns, third plot
plt.plot(hist_original, color='blue')
plt.title('Original Histogram')
plt.xlabel('Pixel Intensity')
plt.ylabel('Number of Pixels')
plt.xlim([0, 256])

# Subplot 4: Equalized Histogram
plt.subplot(2, 2, 4) # 2 rows, 2 columns, fourth plot
plt.plot(hist_equalized, color='red')
plt.title('Equalized Histogram')
plt.xlabel('Pixel Intensity')
plt.ylabel('Number of Pixels')
plt.xlim([0, 256])

plt.tight_layout() # Adjust layout to prevent overlapping
plt.show()
```

Figure 1

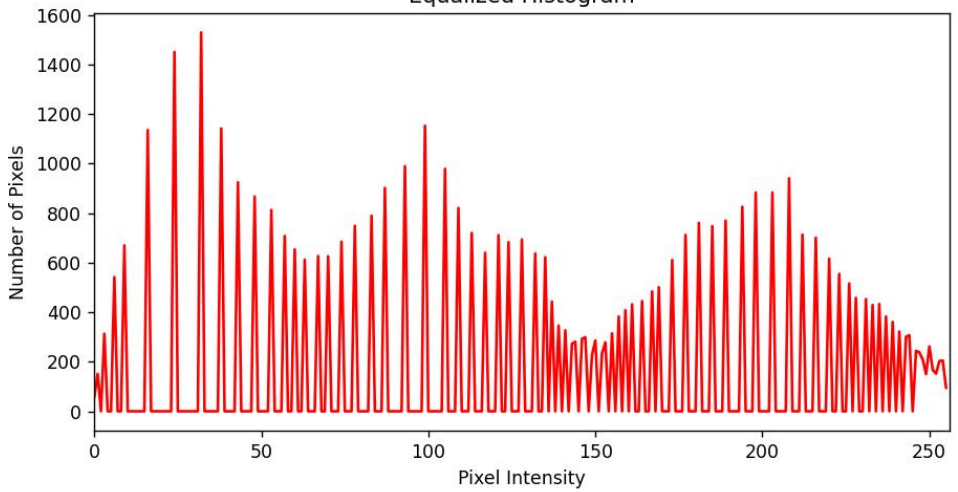
Original Grayscale Image

Equalized Grayscale Image

Original Histogram



Equalized Histogram

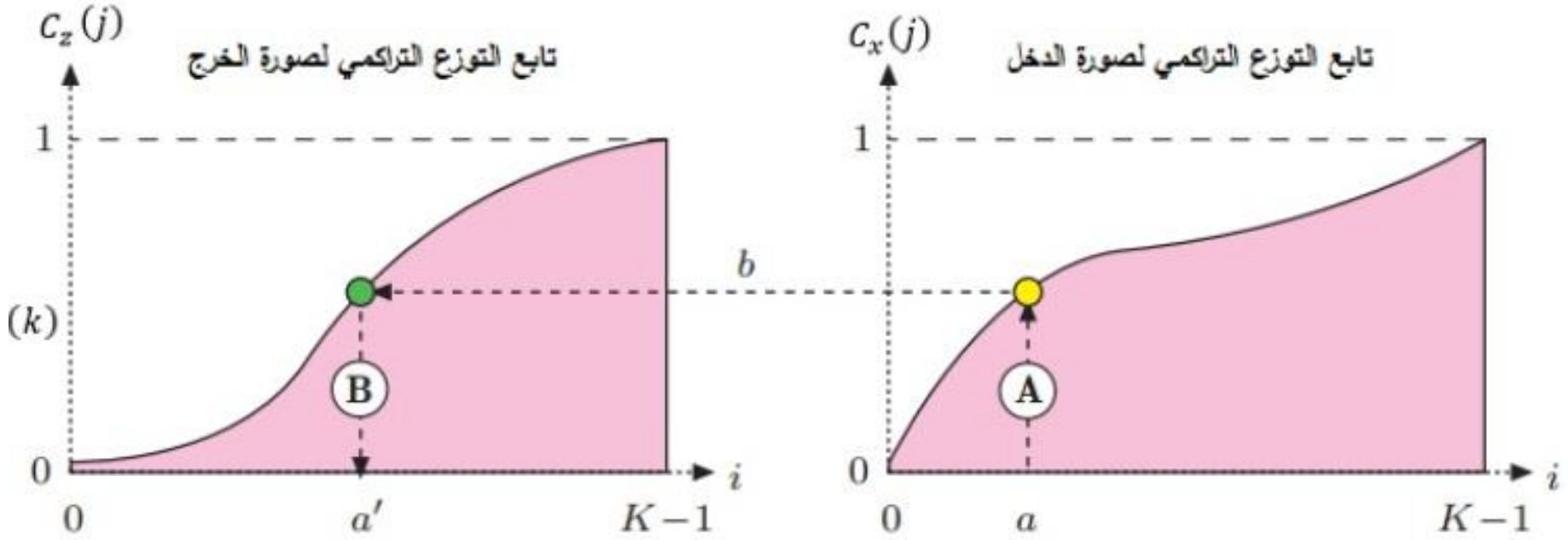


مطابقة الهيستوغرام

- Histogram matching

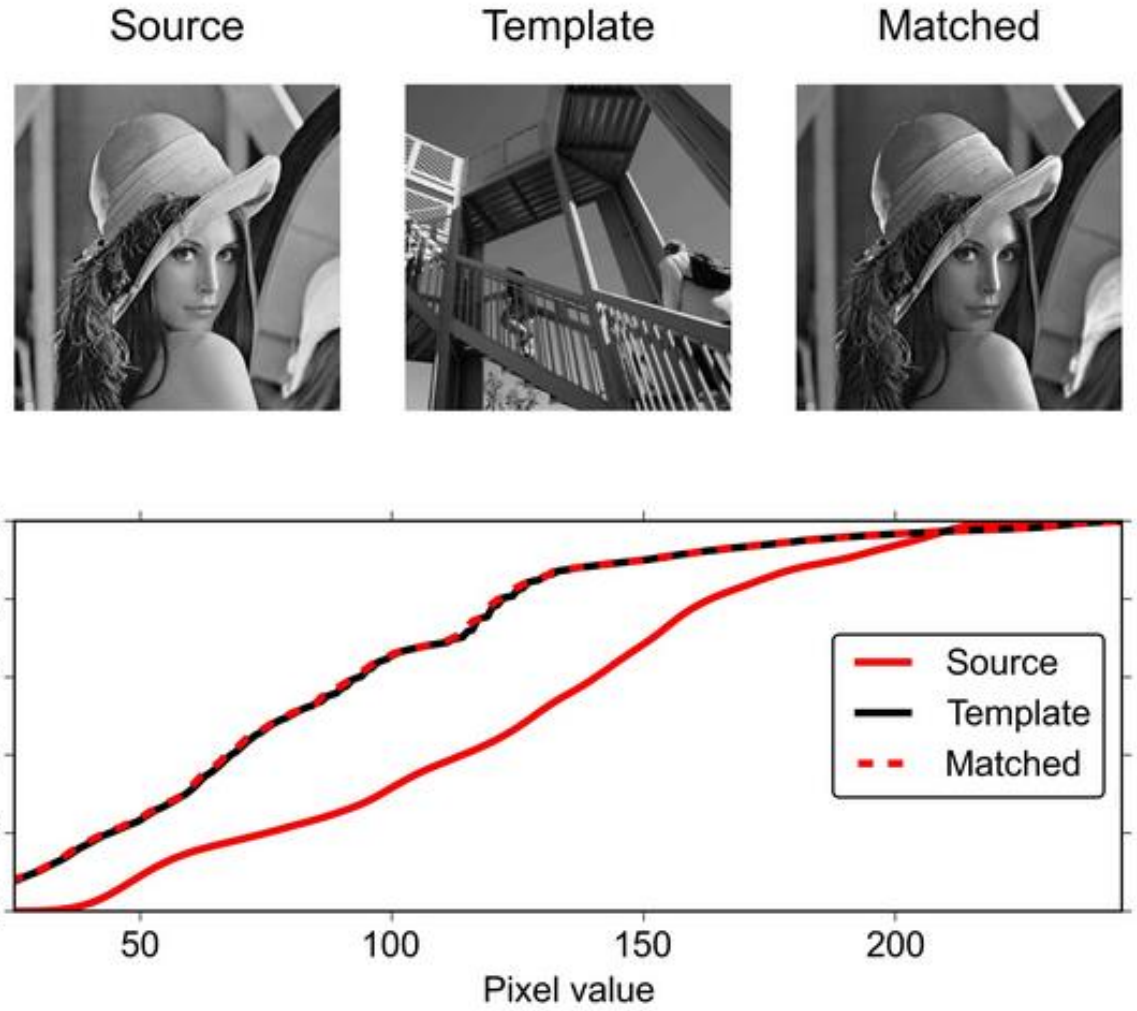
Making the histogram look like a defined graph

- هي عملية تعميم تسوية الهيستوغرام وتتطلب تحديد شكل الهيستوغرام المطلوب



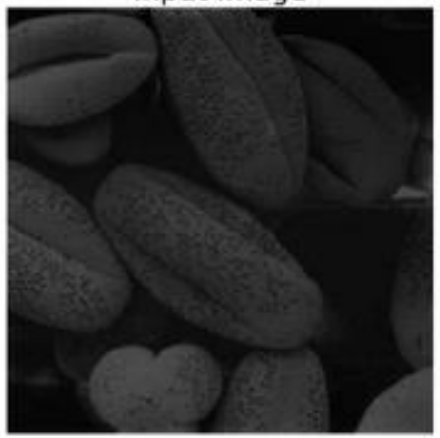
مثال 1

مثال 2


Source
Template
Matched
100
80
60
40
20
0
Cumulative %
50
100
150
200
Pixel value
Source
Template
Matched

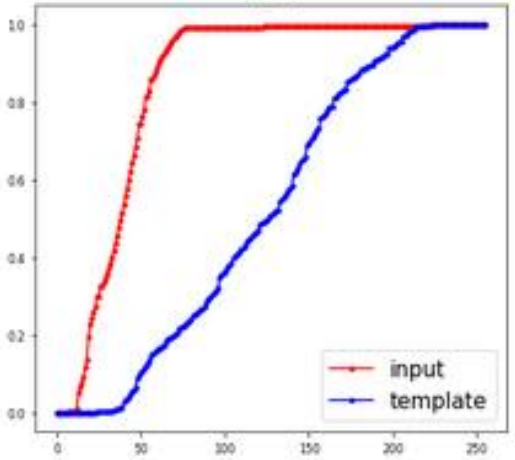
مثال 3

Input image



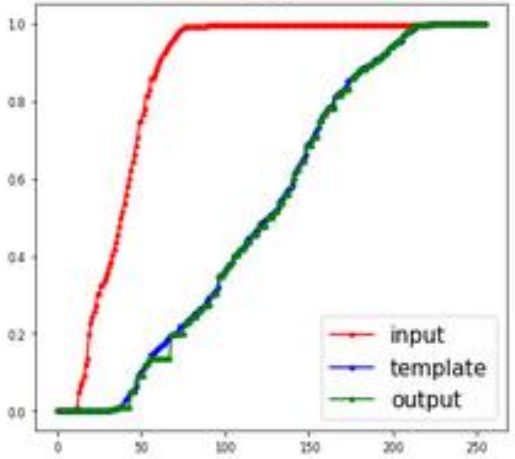
Template image

CDF



Output image with Hist. Matching

CDF



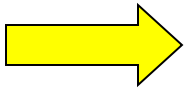
Histogram Matching Example

Example problem

The histogram of the input image

Intensity (s)	# pixels
0	20
1	5
2	25
3	10
4	15
5	5
6	10
7	10
Total	100

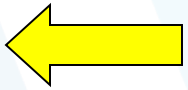
Initial data



Want the histogram of the output image to be as follows

Intensity (z)	# pixels
0	5
1	10
2	15
3	20
4	20
5	15
6	10
7	5
Total	100

User sets



Histogram Matching Example

1. Perform both histogram equalization tables

TOTAL=100
3bits

r	(n_j)	ΣP_r	s
0	20	0.2	1
1	5	0.25	2
2	25	0.5	4
3	10	0.6	4
4	15	0.75	5
5	5	0.8	6
6	10	0.9	6
7	10	1.0	7

$$s_k = T(r_k)$$

z	(n_j)	ΣP_z	v
0	5	0.05	0
1	10	0.15	1
2	15	0.3	2
3	20	0.5	4
4	20	0.7	5
5	15	0.85	6
6	10	0.95	7
7	5	1.0	7

$$v_k = G(z_k)$$

Histogram Matching Example

2. Get Table Map

r → s

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

s → v

v → z

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

Get to be

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

Actual Output Histogram

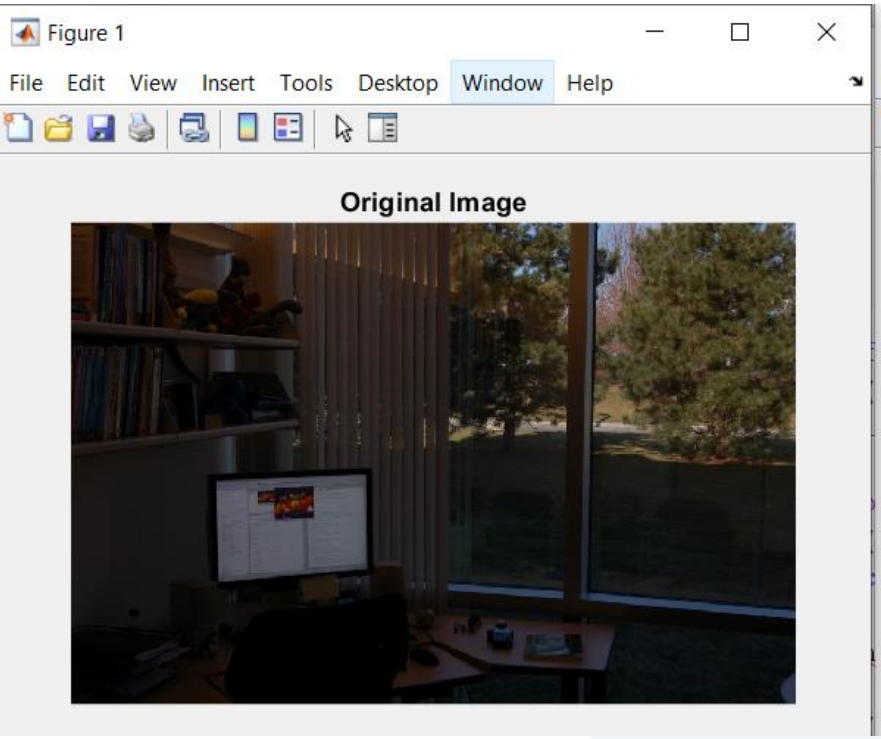
z	# Pixels
0	0
1	20
2	5
3	35
4	15
5	15
6	10
7	0

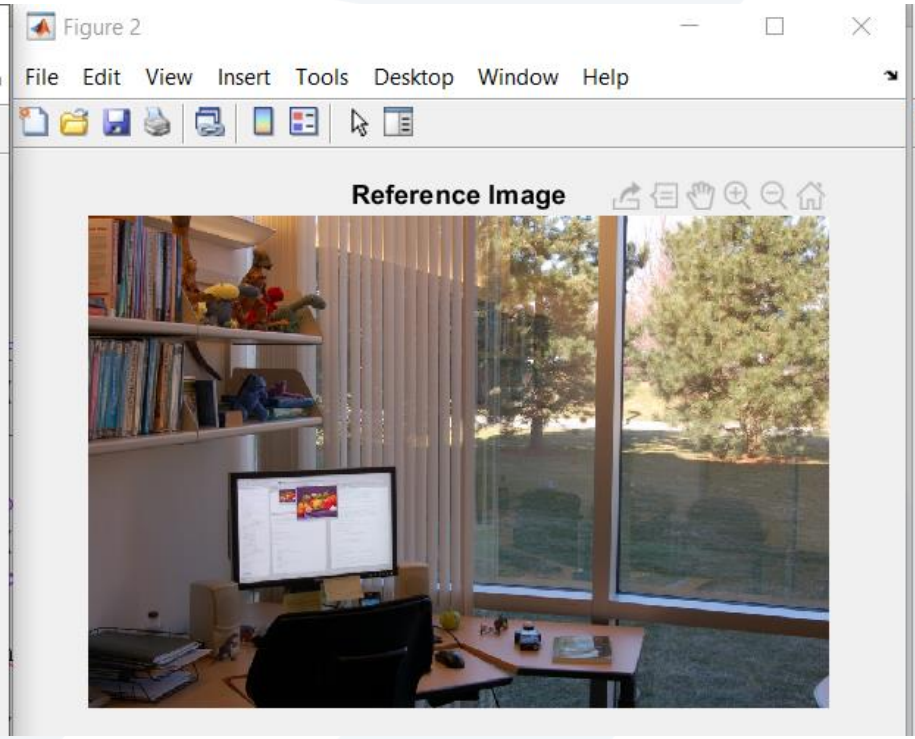
$s_k = T(r_k)$

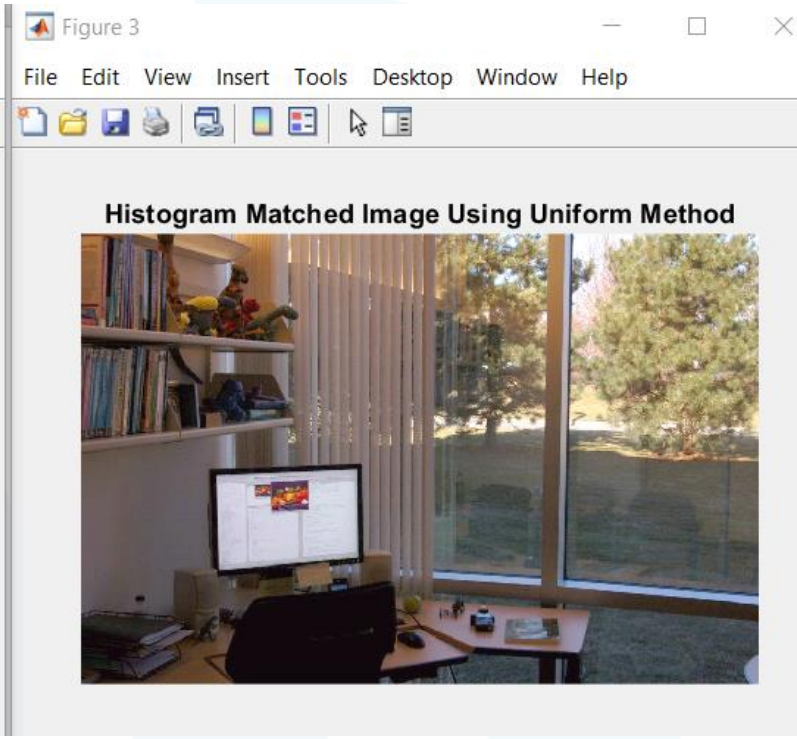
$z_k = G^{-1}(v_k)$

```
close all;clc;clear
A = imread('office_2.jpg');
figure, imshow(A, []);
title('Original Image');
 ref = imread('office_4.jpg');
figure, imshow(ref, []);
title('Reference Image');
```

```
B = imhistmatch(A, ref);

figure, imshow(B, []);
title('Histogram Matched
Image Using Uniform Method');
```



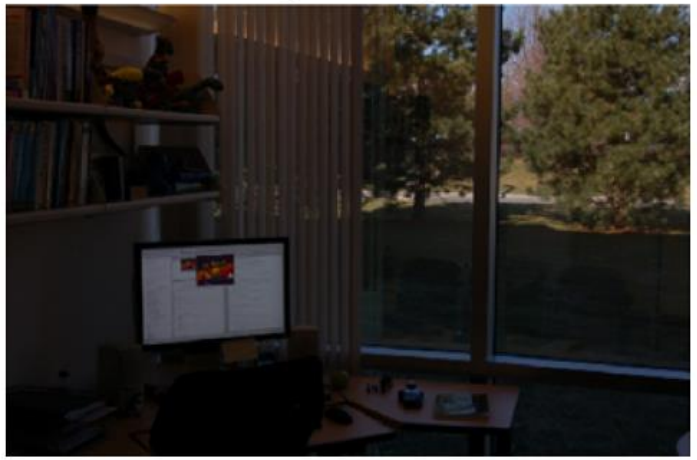




```
import cv2
import matplotlib.pyplot as plt
from skimage.exposure import match_histograms
import numpy as np


# Read the source image
A = cv2.imread('1.png')
A = cv2.cvtColor(A, cv2.COLOR_BGR2RGB)  # Convert from BGR to RGB

# Display the original image
plt.figure()
plt.imshow(A)
plt.title('original image')
plt.axis('off')

# Read the reference image
ref = cv2.imread('2.png')
ref = cv2.cvtColor(ref, cv2.COLOR_BGR2RGB)  # Convert from BGR to RGB

# Display the reference image
plt.figure()
plt.imshow(ref)
plt.title('Reference Image')
plt.axis('off')
```

```
# Perform histogram matching
B = match_histograms(A, ref)
image_clipped = np.clip(B, 0, 255).astype(np.uint8)



#B = cv2.cvtColor(B, cv2.COLOR_BGR2RGB)  # Convert from BGR to RGB

# Display the histogram matched image
plt.figure()
plt.imshow(image_clipped)
plt.title('Histogram Matched Image Using Uniform Method')
plt.axis('off')

# Show all figures
plt.show()
```

original image



Reference Image

Histogram Matched Image Using Uniform Method

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نهاية المحاضرة