Image
PRE-PROCESSING

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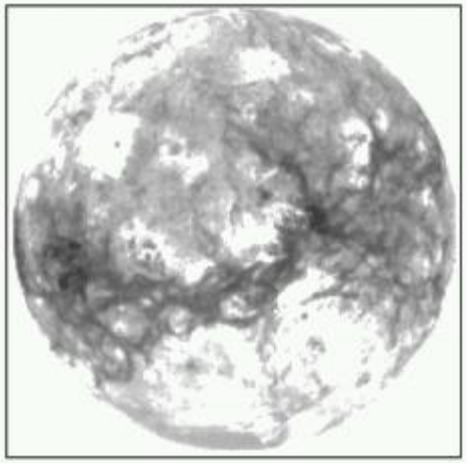
Definition

- Image pre-processing is the direct manipulation of pixel values. A variety of operations are possible:

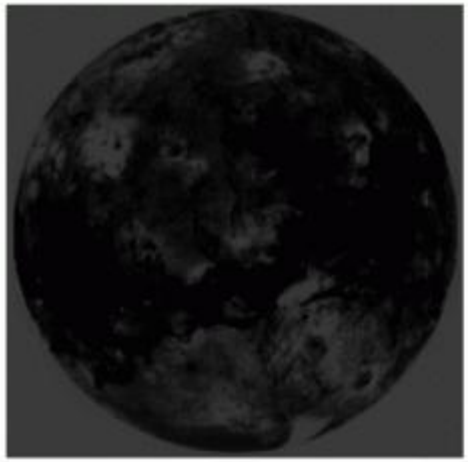
1. **Resizing**
2. **Gray scaling**
3. **Noise reduction**
4. **Normalization (stretching)**
5. **Binarization**
6. **Contrast enhancement(Histogram equalization)**

BRIGHTNESS

- An image must have the proper **brightness** and **contrast** for easy viewing.
- **Brightness** refers to the overall lightness or darkness of the image, increasing brightness make every pixel in the image become lighter .



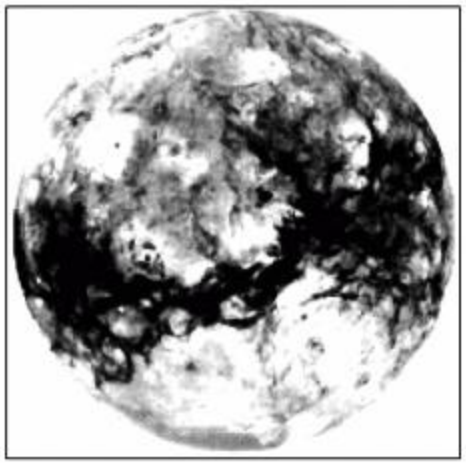
a. Brightness too high



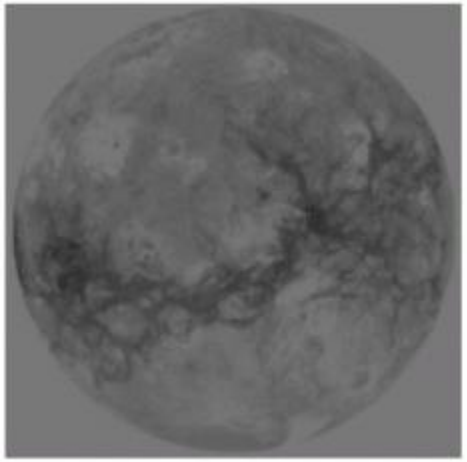
b. Brightness too low

CONTRAST

- **Contrast** is the *difference* in brightness between objects or regions, increasing contrast make the lighter area lighter and dark areas darker, contrast can be simply explained as the difference between maximum and minimum pixel intensity in an image.



c. Contrast too high

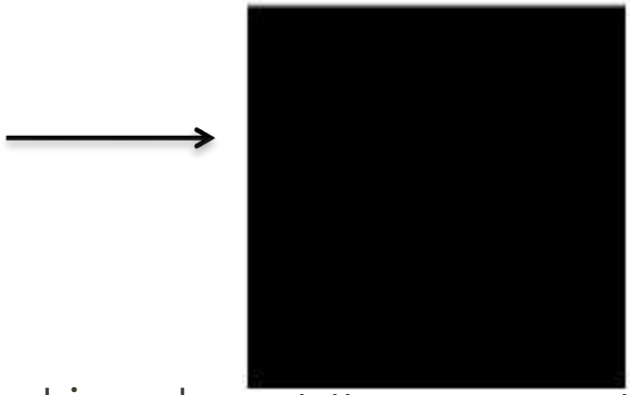


d. Contrast too low

How to make an image brighter

- Brightness can be simply increased or decreased by simple addition or subtraction, to the image matrix.
- Consider this black image of 5 rows and 5 columns

0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0



- add 50 to each of the matrix value of the image above and see what the image has become.

50	50	50	50	50
50	50	50	50	50
50	50	50	50	50
50	50	50	50	50
50	50	50	50	50

How to calculate contrast

The maximum value in this matrix is 100.

The minimum value in this matrix is 100.

Contrast = maximum pixel intensity(subtracted by) minimum pixel intensity = 100 (subtracted by) 100

- = 0
- 0 means that this image has 0 contrast.

100	100	100	100	100
100	100	100	100	100
100	100	100	100	100
100	100	100	100	100
100	100	100	100	100

Histogram Objectives

- **Histogram** is an accurate representation of the distribution of numerical data.
- in image Histograms are used to depict image statistics in an easily interpreted visual format
- Useful during image capturing: now already in digital cameras
- Used to improve the visual appearance of an image
- Can also be used to determine what type of processing has been applied to an image.

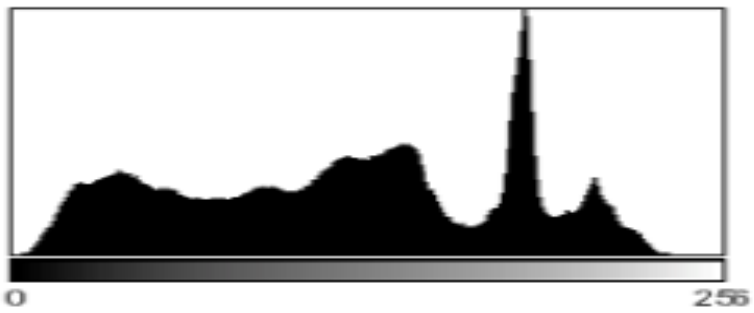


Image Histograms

- In image processing context, the histogram of an image normally refers to a histogram of 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.

- An image histogram is a plot of the gray-level frequencies (i.e., the number of pixels in the image that have that gray level).

0	0	1	0	2	0
1	0	7	7	7	0
0	7	0	0	7	0
1	0	0	7	2	0
0	0	7	1	0	1
1	0	7	7	7	0

frequencies

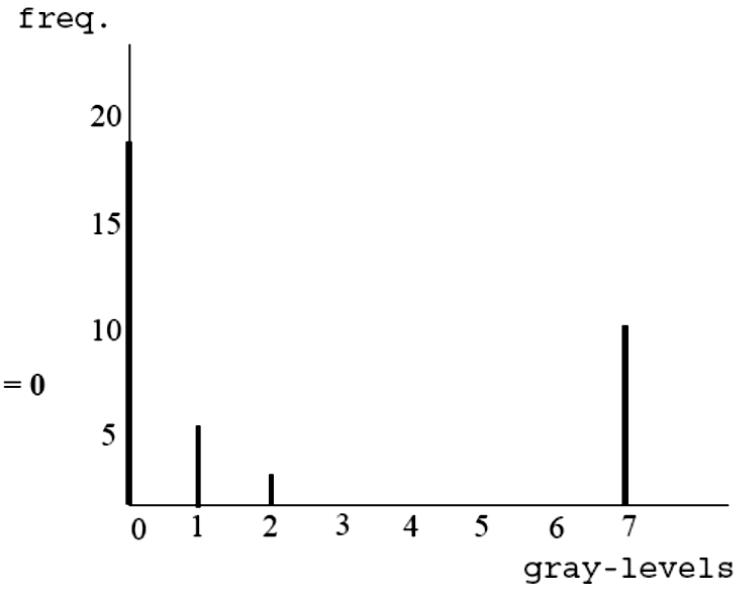
f(0)= 18

f(1)= 6

f(2)= 2

f(3)=f(4)=f(5)=f(6) = 0

f(7) = 10



Probabilities

- Divide frequencies by total number of pixels to represent as probabilities.

$$p_k = n_k / N$$

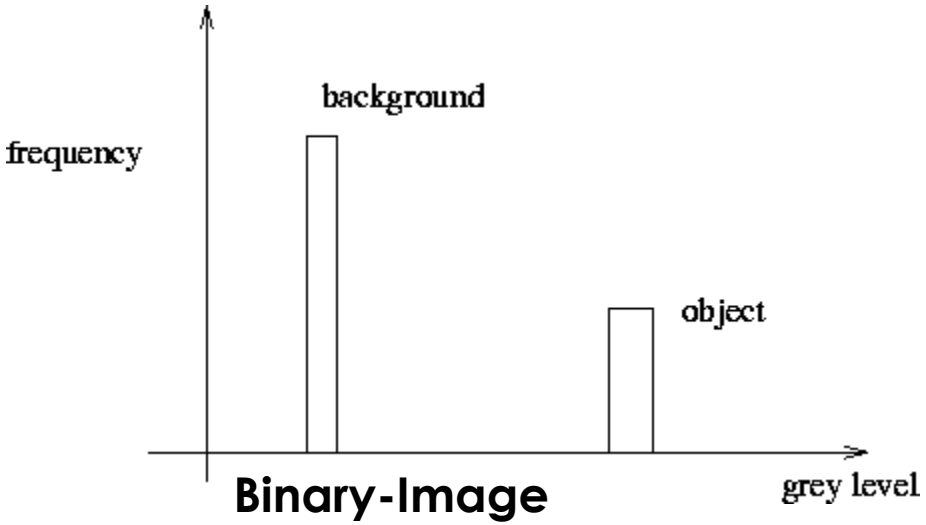
$$P(0) = \frac{f(0)}{36} = \frac{1}{2} \qquad P(1) = \frac{f(1)}{36} = \frac{1}{6}$$

$$P(2) = \frac{f(2)}{36} = \frac{1}{18} \qquad P(3) = P(4) = P(5) = P(6) = 0$$

$$P(7) = \frac{f(7)}{36} = \frac{5}{18}$$

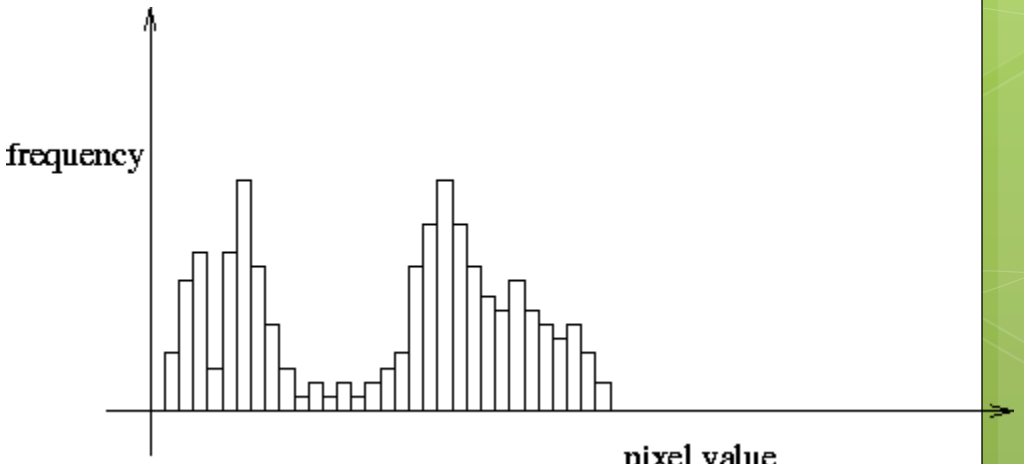
Image Histograms

- The ideal histogram of a light object on a darker plain background



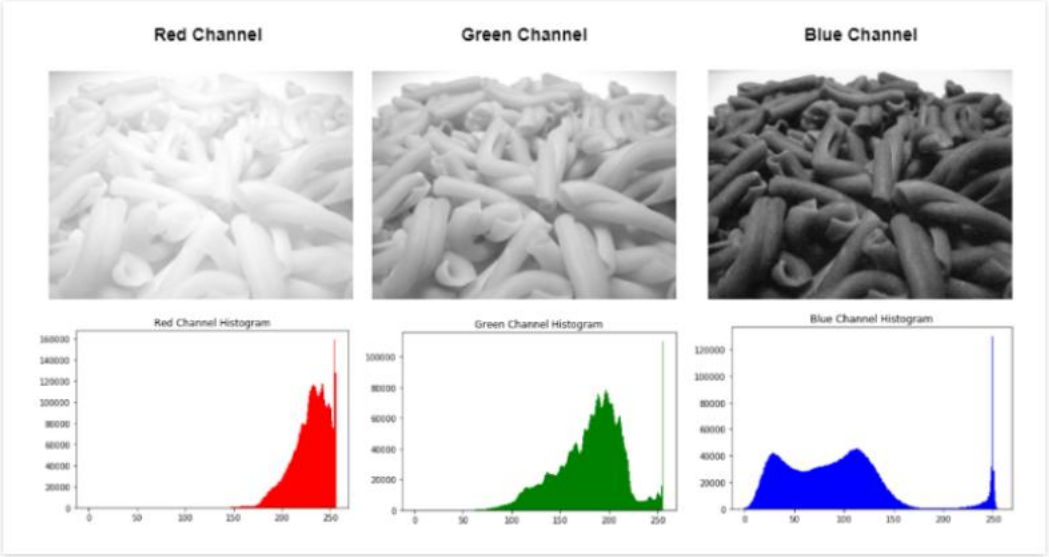
Binary-Image

- The histogram of an image showing the frequency of occurrence of each grey scale value.



Gray-Image

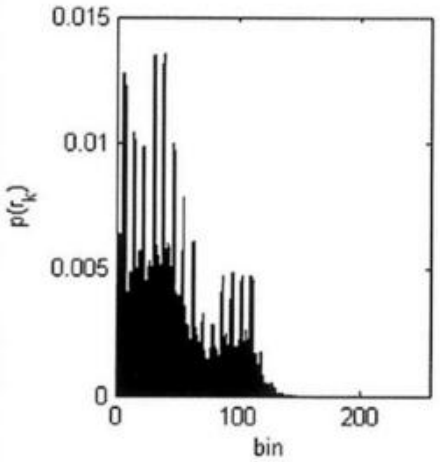
Original Color Image



Properties of Image Histograms

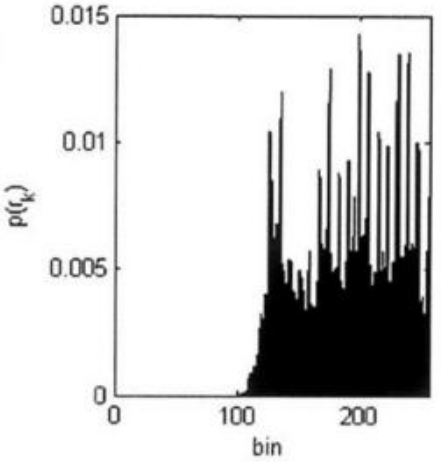
- Histograms clustered at the low end correspond to **dark** images.
- Histograms clustered at the high end corresponc to **bright** images.

(a)



(b)

(c)

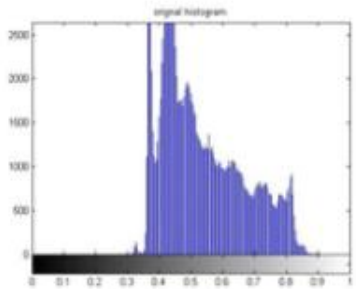


(d)

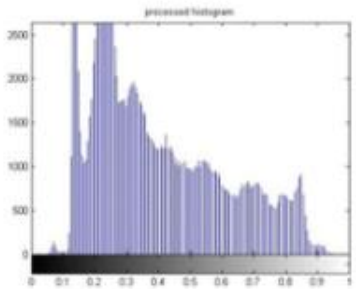
Comparison of dark vs. bright images, (a) Dark image, (b) Dark image histogram, (c) Bright image, (d) Bright image histogram.

Properties of Image Histograms (cont'd)

- Histograms with small spread correspond to **low contrast** images
- Histograms with wide spread correspond to **high contrast** images.



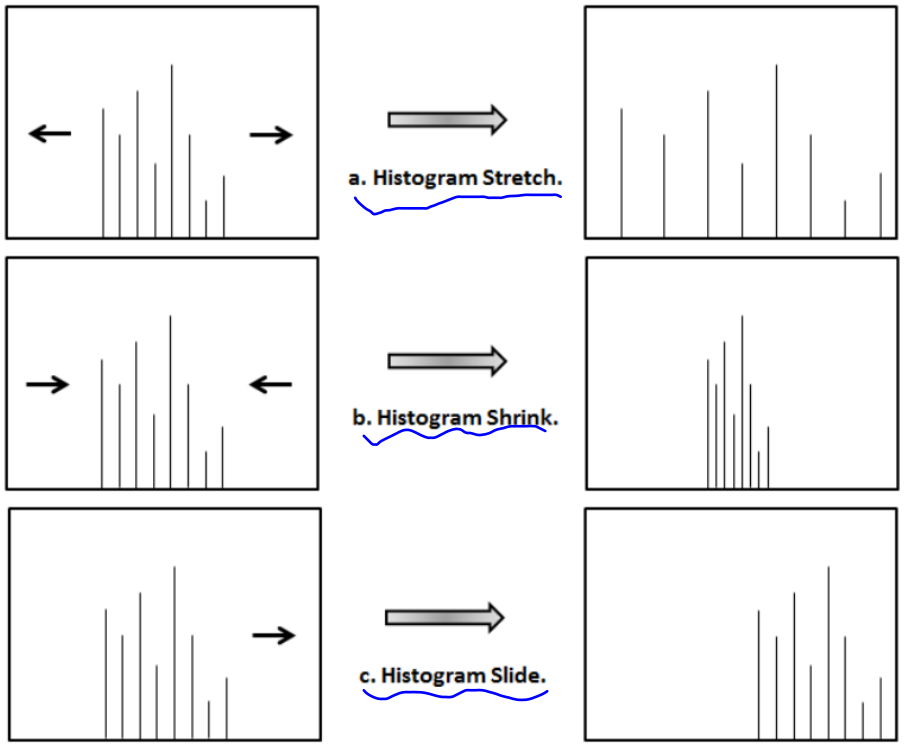
Low contrast



High contrast

Histogram Modification

- **Histogram Equalization**
- **Histogram Stretching**
- **Histogram Shrinking**
- **Histogram Sliding**

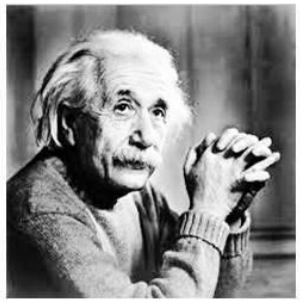


Histogram equalization

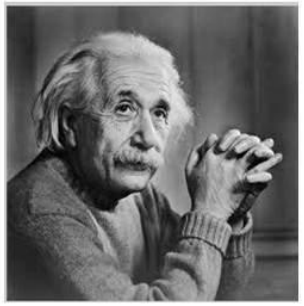
- Histogram equalization is a method to process images in order to adjust the contrast of an image by modifying the intensity distribution of the histogram.

During histogram equalization the overall shape of the histogram changes, whereas in **contrast stretching** the overall shape of histogram remains same

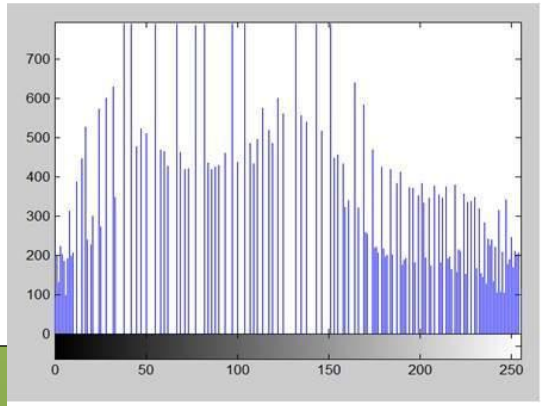
New Image



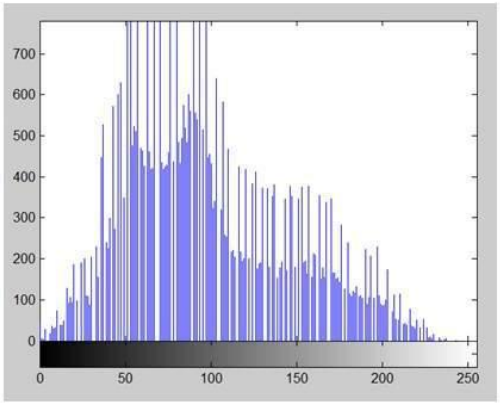
Old image



New Histogram



Old Histogram

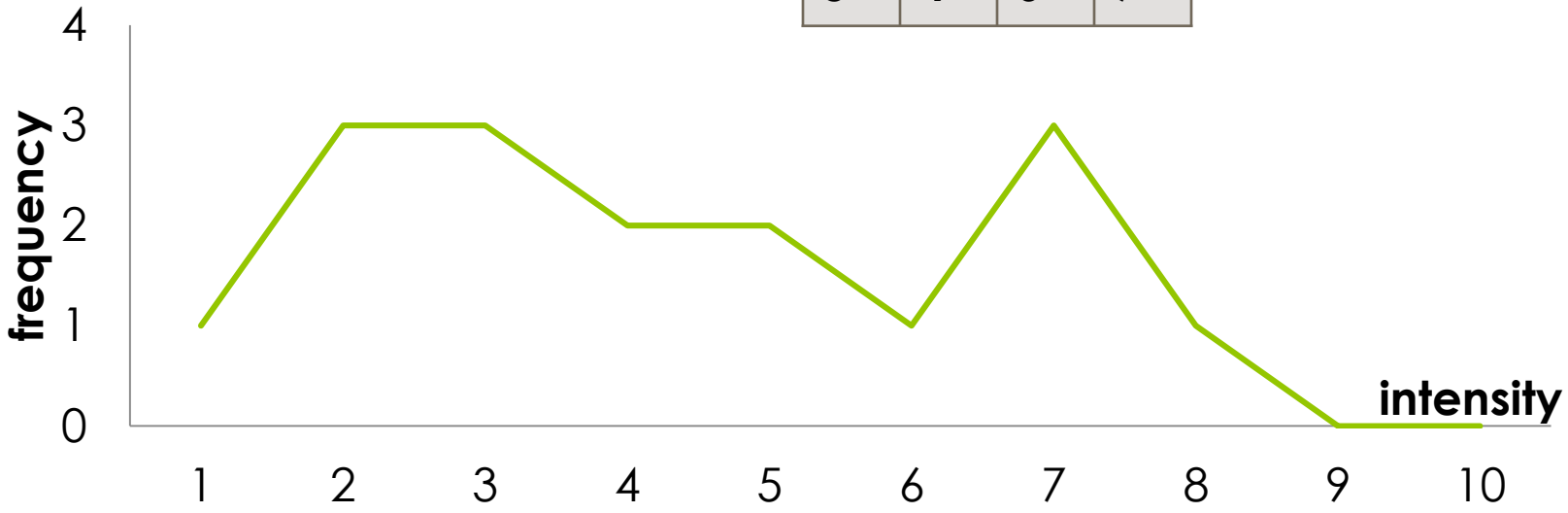


Histogram equalization

- Histogram equalization steps:

1. Count total number for pixels associated with each pixel intensity. (for example intensity between 1-20 but pixel verity from 1-8).

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



Pixel intensity	1	2	3	4	5	6	7	8	9	10
No. of pixel	1	3	3	2	2	1	3	1	0	0

2. Calculate probability of the pixel intensity in the image matrix .

probability =total number of pixel/no of pixel

For example 1/16=.0625

Pixel intensity	1	2	3	4	5	6	7	8	9	10
No. of pixel	1	3	3	2	2	1	3	1	0	0
probability	**.0625**	**.1875**	**.1875**	**.125**	**.125**	**.0625**	**.1875**	**.0625**	**0**	**0**

3. Calculate cumulative probability:

Pixel intensity	1	2	3	4	5	6	7	8	9	10
No. of pixel	1	3	3	2	2	1	3	1	0	0
probability	.0625	.1875	.1875	..125	..125	.0625	.1875	.0625	0	0
cumulative probability	.0625	.25	.4374	.5625	.6875	.75	.9375	1	1	1

+

=

Cumulative P_{i+1} =(Cumulative P_i)+(P_{i+1})

4. Since we want change intensity to 1-20 Multiply cumulative probability by intensity (20) .
5. Round CP to floor rounding

Pixel intensity	1	2	3	4	5	6	7	8	9	10
No. of pixel	1	3	3	2	2	1	3	1	0	0
probability	.0625	.1875	.1875	..125	..125	.0625	.1875	.0625	0	0
cumulative probability	.0625	.25	.4374	.5625	.6875	.75	.9375	1	1	1
CP*20	1.25	5	8.75	11.25	13.75	15	18.75	20	20	20
Floor rounding	1	5	8	11	13	15	18	20	20	20

Origen

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

After equalizing

8	5	11	13
18	18	20	5
8	1	5	8
13	11	15	18

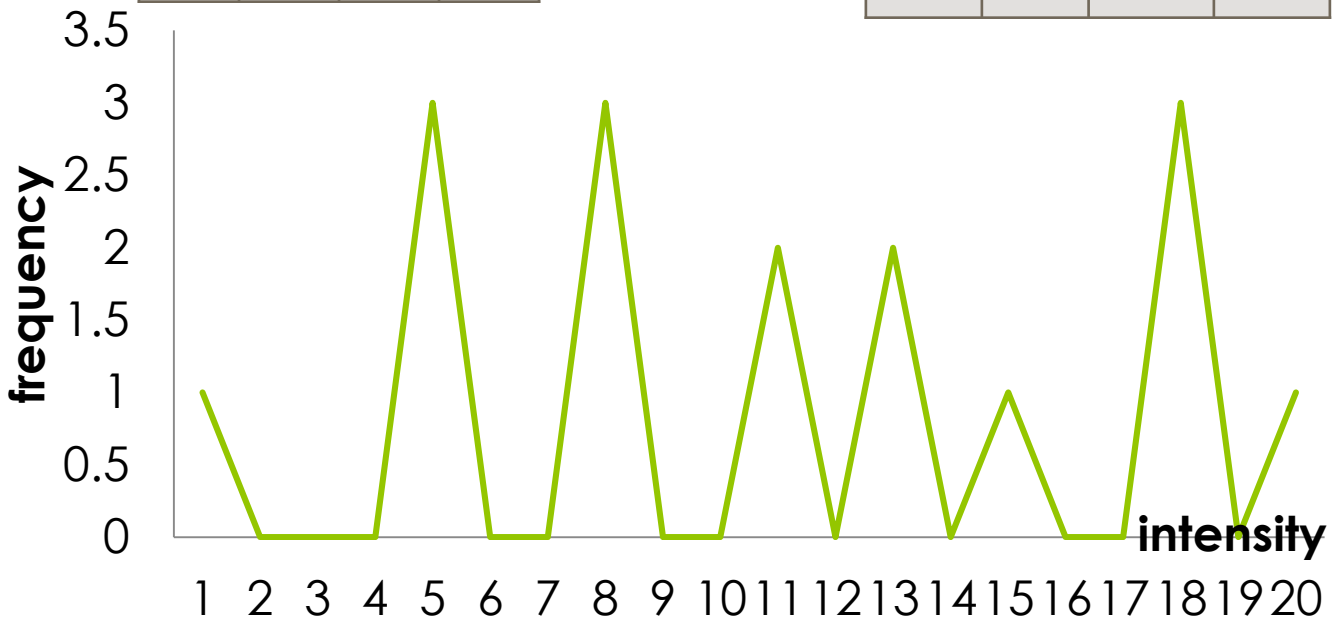


Diagram After equalizing

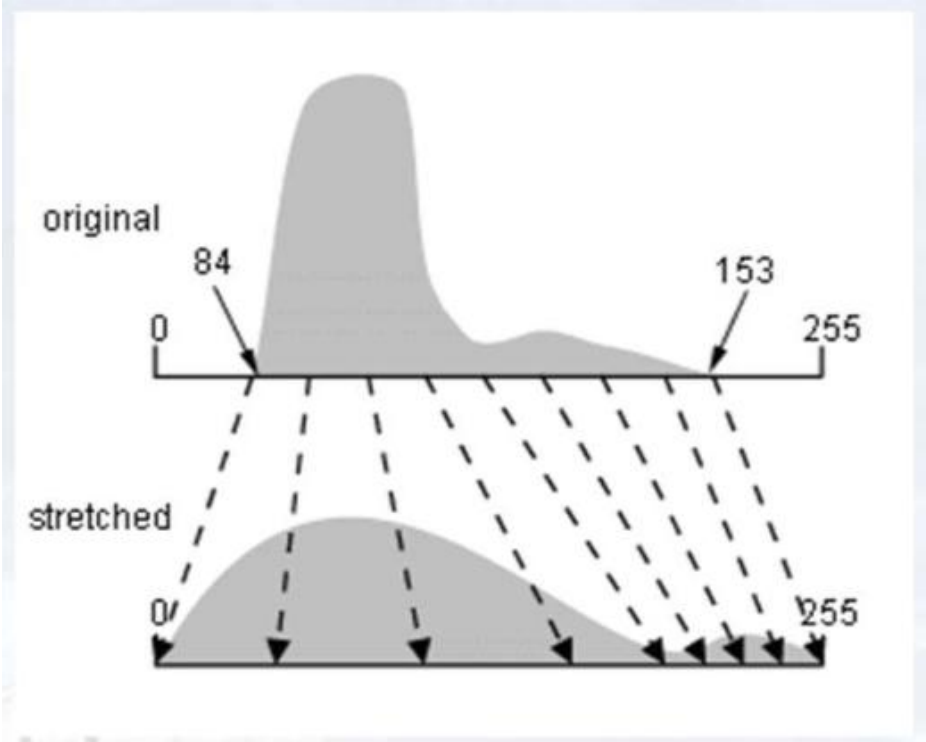
Exercise

Example: Find the new distribution using histogram equalization method for the following block of image and plot the histogram before and after equalization?

G	0	1	2	3	4	5	6	7
Hist(G)	14	10	0	6	15	15	28	12

Histogram Stretching

Contrast stretching (often called normalization) is a simple image enhancement technique that attempts to improve the contrast in an image by `stretching' the range of intensity values it contains to span a desired range of values



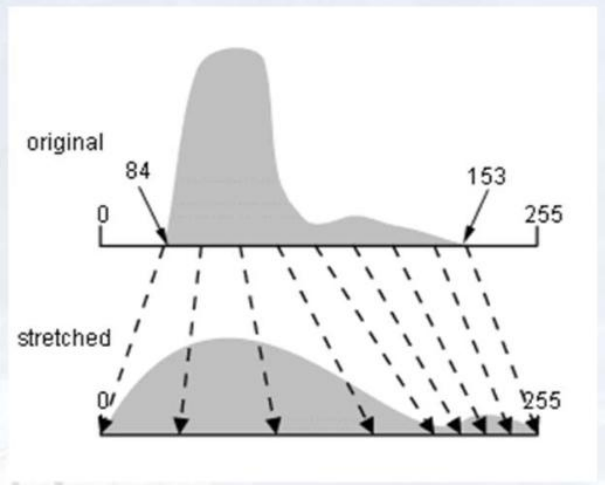
Histogram Stretching

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

Where, $I(r,c)_{max}$ is the largest gray- level in the image I(r,c).

$I(r,c)_{min}$ is the smallest gray- level in the image I(r,c).

MAX and MIN correspond to the maximum and minimum gray – level values possible (for an 8-bit image these are 255 and 0).




Low-contrast image

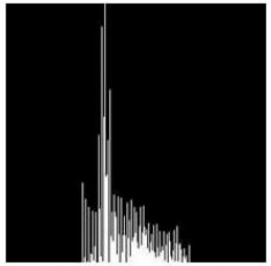
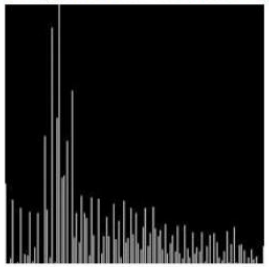

Histogram of low-contrast mage


Image after histogram stretching


Histogram of image after stretching

Histogram Stretching

Example: Find the new distribution using histogram stretching method for the following block of image and plot the histogram before and after stretching when MIN=0 and MAX=255?

G_{Old}	50	70	85	105	110	140	155	165
Hist(G)	14	10	0	6	15	15	28	12

$$Stretch(I(r,c)) = \left\lfloor \frac{I(r,c) - I(r,c)_{min}}{I(r,c)_{max} - I(r,c)_{min}} \right\rfloor (MAX - MIN) + MIN$$

Stretch(50)=$\left\lfloor \frac{50-50}{165-50} \right\rfloor .[255-0]+0 = 0$

Stretch(70)= $\left\lfloor \frac{70-50}{165-50} \right\rfloor .[255-0]+0 = 44.3$

Stretch(85)

Stretch(105)

.

.

.

Stretch	0	44	77	121	133	199	232	255

Example

Q/ Apply histogram stretching for the following sub image ?

$$\begin{pmatrix} 7 & 12 & 8 \\ 20 & 9 & 6 \\ 10 & 15 & 1 \end{pmatrix}$$

Sol:

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

$I(r,c)_{min} = 1$; $I(r,c)_{max} = 20$; Max =255 ; Min =0

I(0,0) = [7-1 / 20-1] * [255 – 0] + 0 = 80.5
I(0,1) = [12-1 / 20-1] * [255 – 0] + 0 = 147.6
I(0,2) = [8-1 / 20-1] * [255 – 0] + 0 = 93.9
I(1,0) = [20-1 / 20-1] * [255 – 0] + 0 = 255
I(1,1) = [9-1 / 20-1] * [255 – 0] = 107.3
I(1,2) = [6-1 / 20-1] * [255 – 0] + 0 = 67.1
I(2,0) = [10-1 / 20-1] * [255 – 0] + 0 = 120.7
I(2,1) = [15-1 / 20-1] * [255 – 0] + 0 = 187.8
I(2,1) = [1-1 / 20-1] * [255 – 0] + 0 = 0

Istretch = $\begin{pmatrix} 80.5 & 147.6 & 93.9 \\ 255 & 107.3 & 67.1 \\ 120.7 & 187.8 & 0 \end{pmatrix}$

Histogram Shrinking

- The opposite of a histogram stretch is a histogram shrink, which will decrease image contrast by compressing the gray levels. The mapping function for a histogram shrinking can be found by the following equation:

$$Shrink(I(r,c)) = \left[\frac{shrink_{max} - shrink_{min}}{I(r,c)_{max} - I(r,c)_{min}}\right] [I(r,c) - I(r,c)_{min}] + shrink_{min}$$

- Shrink max and shrink min correspond to the maximum and minimum desired in the compressed histogram.
- In general, this process produces an image of reduced contrast and may not seem to be useful an image enhancement

Histogram Shrinking

Example: Find the new distribution using histogram shrinking method for the following block of image and plot the histogram before and after shrinking when $Shrink_{MIN}$=50 and $Shrink_{MAX}$=100?

G_{Old}	0	54	60	80	110	160	190	255
Hist(G)	14	10	0	6	15	15	28	12

$$Shrink(I(r,c)) = \left[\frac{shrink_{max} - shrink_{min}}{I(r,c)_{max} - I(r,c)_{min}}\right] [I(r,c) - I(r,c)_{min}] + shrink_{min}$$

$$shrink\ 0 = \left[\frac{100-50}{255-0}\right].[0-0] + 50 = 50$$

$$shrink\ 54 = \left[\frac{100-50}{255-0}\right].[54-0] + 50 = 60$$

shrink	50	60	62	66	72	81	87	100

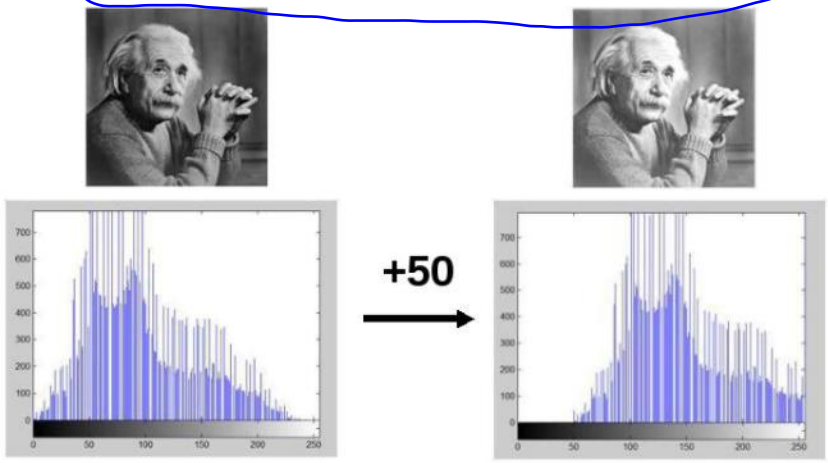
Histogram sliding

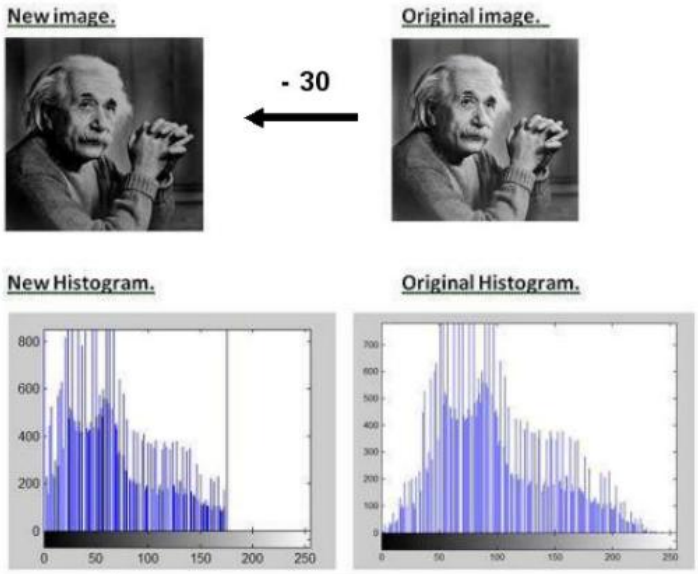
This can be a accomplished by simply adding or subtracting a fixed number for all the gray-level values, as follows:

$$\text{Slide } (I(r,c)) = I(r,c) + \text{OFFSET}.$$

Where OFFSET values is the amount to slide the histogram.

- Brightness is changed by shifting the histogram to left or right.



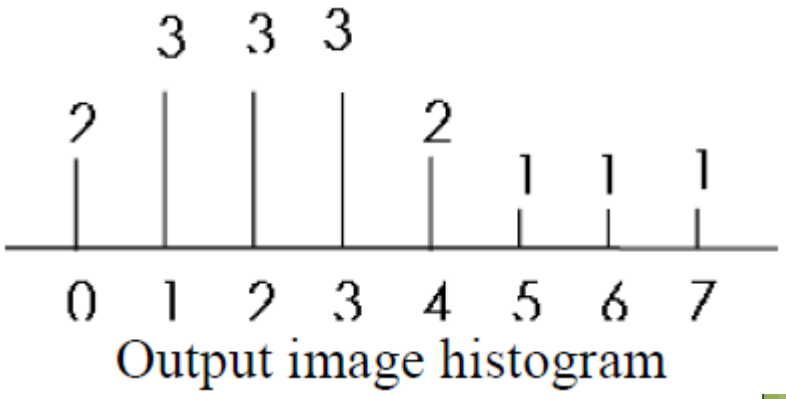


Questions

1) Suppose that you have been given the 3-bit 4x4 image shown in the figure below.

0	0	0	4
1	1	1	5
1	2	2	7
2	2	2	7

a) Show the output image as a result of histogram equalization.
b) Using the same image matrix, show the output image as the desired histogram is as follows:



Output image histogram

2. **Find new distribution using histogram equalization method for the following blocks of image and plot the histogram before and after equalization**

Pixel intensity	0	1	2	3	4	5	6	7
No. of pixel	14	10	0	6	15	15	28	12

Discussion (Q/A)

References:

- https://www.roborealm.com/forum/index.php?thread_id=4350
- https://homepages.inf.ed.ac.uk/rbf/CVonline/LOCAL_COPIES/OWENS/LECT2/node3.html
- https://uomustansiriyah.edu.iq/media/lectures/9/9_2017_11_01!08_38_28_PM.pdf