

TDM	729.89	915.51	185.62▲25.43%	FLR	660.27	745.28	85.01▲12.88%
HUM	749.73	924.29	174.56▲23.28%	UVD	155.59	181.57	25.98▲16.70%
DMW	833.72	1004.01	170.29▲20.43%	QUV	440.55	540.21	99.66▲22.62%
YZJ	903.49	1127.46	223.97▲24.79%	HZT	285.51	344.98	59.47▲20.83%
GLY	982.07	1219.39	237.32▲24.17%	PCW	811.44	1029.66	218.22▲26.89%
VDA	113.74	143.41	29.67▲26.09%	AIK	361.77	451.39	89.62▲24.77%
UVV	468.08	535.41	67.33▲14.38%	ZJJ	858.36	994.57	136.21▲15.87%
HJS	545.49	659.05	113.56▲20.82%	RHJ	894.79	1046.68	151.89▲16.97%
EQC	566.96	664.69	97.73▲17.24%	VGV	425.08	509.95	84.87▲19.97%

PPJ	912.63	1038.36	125.73▲13.78%	ZBK	391.59	491.48	99.89▲25.51%
UAQ	1309.55	1655.62	346.07▲26.43%	BNY	969.21	1130.65	161.44▲16.66%
DAQ	1295.17	1641.66	346.49▲26.75%	SDM	735.44	913.39	177.95▲24.20%
PNR	654.33	775.84	121.51▲18.57%	TQQ	1323.91	1646.42	322.51▲24.36%
ZTM	581.00	700.00	118.99▲20.48%	OIS	543.42	667.24	123.82▲22.79%
...

Image Histogram

Image Histogram

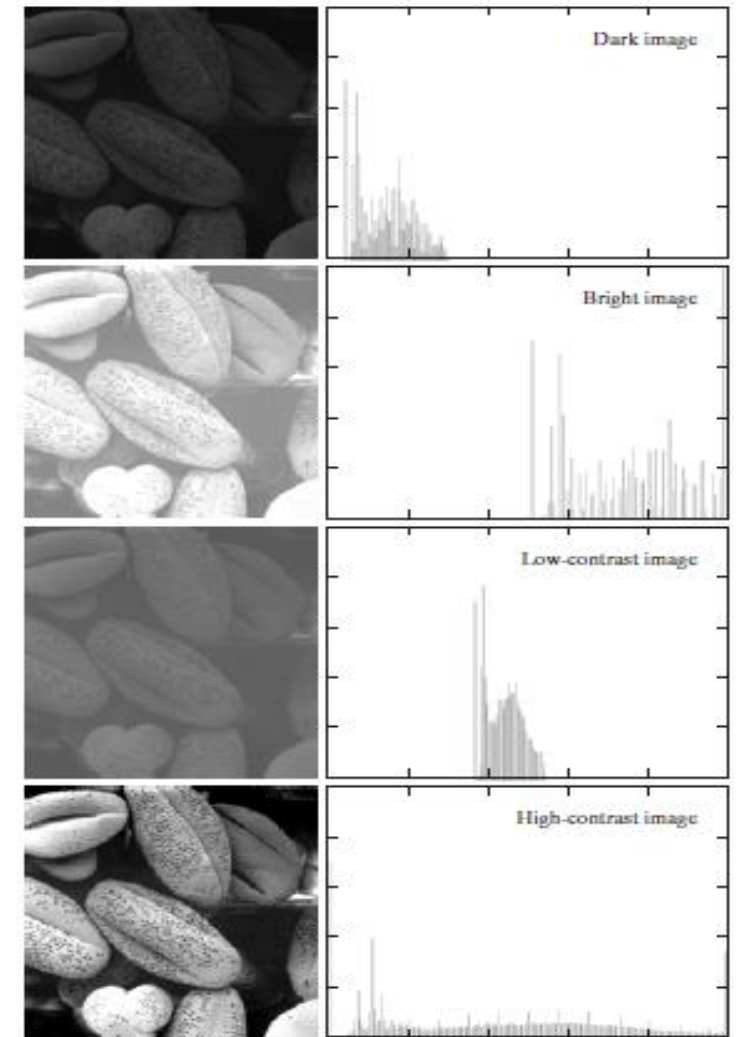
- Histogram

$$h(r_k) = n_k$$

Where r_k is the k th gray level and n_k is the number of pixels in the image having gray level r_k

- Normalized histogram

$$p(r_k) = n_k / n$$



a b

FIGURE 3.15 Four basic image types: dark, light, low contrast, high contrast, and their corresponding histograms. (Original image courtesy of Dr. Roger Heady, Research School of Biological Sciences, Australian National University, Canberra, Australia.)

Image Histogram Algo

```
// Initialize the histogram
```

```
for (g = 0; g <= 255; g++)
```

```
h(g) = 0
```

```
// Compute the histogram
```

```
for (i = 0; i < MAXcolumn; i++)
```

```
for (j = 0; j < MAXrow; j++)
```

```
h(f(i,j))++
```

Calculating Histogram in OpenCV

- `cv2.calcHist(images, channels, mask, histSize, range)`
- `hist = cv2.calcHist([img],[0],None,[256],[0,255])`

Histogram Equalization

- Histogram equalization can be used to improve the visual appearance of an image.
- Histogram equalization automatically determines a transformation function that produce and output image that has a near uniform histogram.

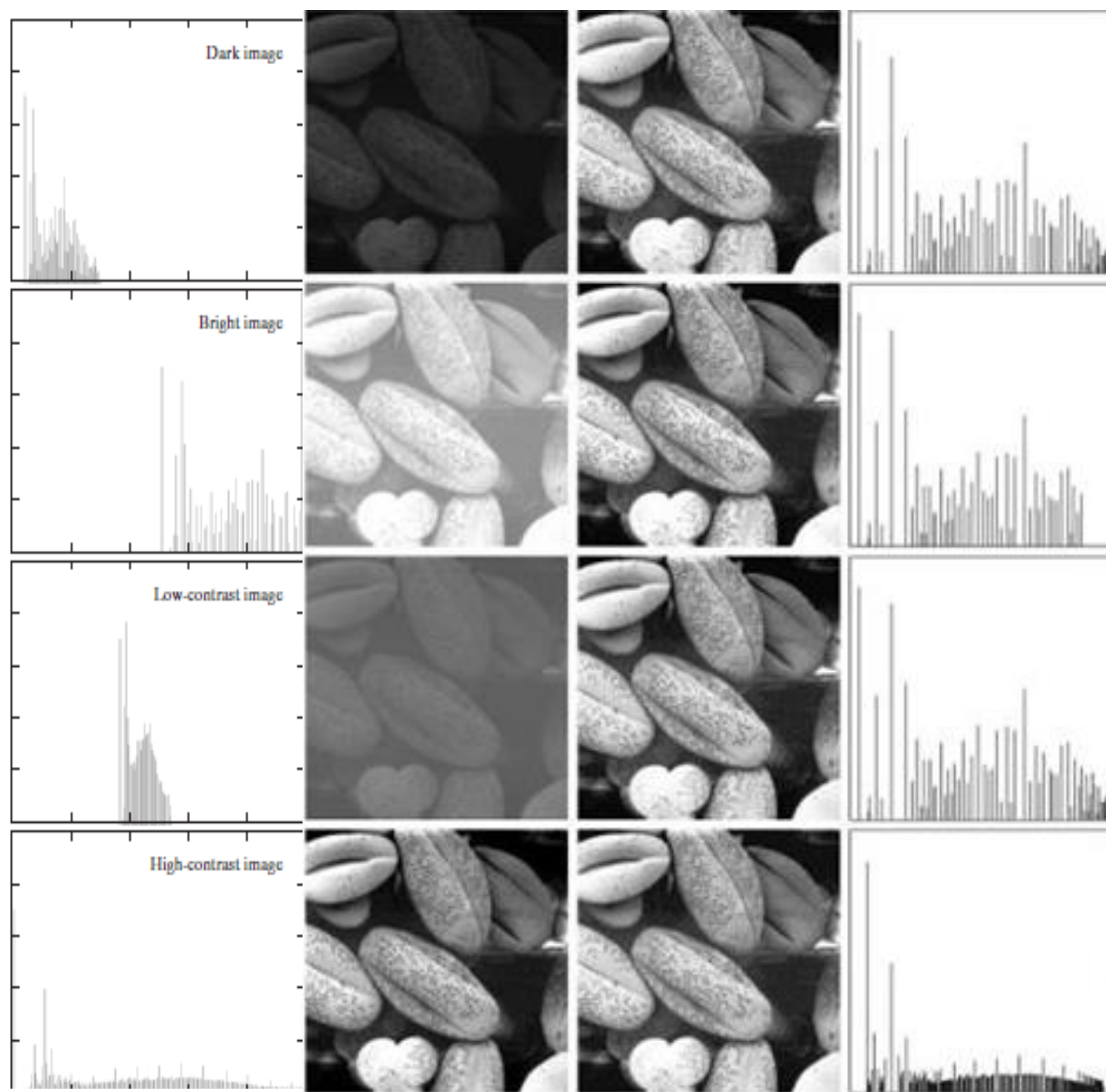


FIGURE 3.20 Left column: images from Fig. 3.16. Center column: corresponding histogram equalized images. Right column: histograms of the images in the center column.

Histogram Equalization

- Let r_k , $k \in [0..L-1]$ be intensity levels and let $p(r_k)$ be its normalized histogram function.
- The intensity transformation function for histogram equalization is

$$\begin{aligned} s_k &= T(r_k) = (L-1) \sum_{j=0}^k p_r(r_j) \\ &= \frac{L-1}{MN} \sum_{j=0}^k n_j, k = 0, 1, 2, \dots, L-1 \end{aligned}$$

Histogram Equalization - Example

- Let f be an image with size 64×64 pixels and $L=8$ and let f has the intensity distribution as shown in the table

r_k	n_k	$p_r(r_k) = n_k/MN$
0	790	0.19
1	1023	0.25
2	850	0.21
3	656	0.16
4	329	0.08
5	245	0.06
6	122	0.03
7	81	0.02

$$s_0 = T(r_0) = 7 \sum_{j=0}^0 p_r(r_j) = 7 p_r(r_0) = 1.33$$

$$s_1 = T(r_1) = 7 \sum_{j=0}^1 p_r(r_j) = 7(p_r(r_0) + p_r(r_1)) = 3.08$$

$$s_2 = 4.55, s_3 = 5.67, s_4 = 6.23, s_5 = 6.65, s_6 = 6.86, s_7 = 7.00.$$

$$s_0 = 1.33 \rightarrow 1$$

$$s_4 = 6.23 \rightarrow 6$$

$$s_1 = 3.08 \rightarrow 3$$

$$s_5 = 6.65 \rightarrow 7$$

$$s_2 = 4.55 \rightarrow 5$$

$$s_6 = 6.86 \rightarrow 7$$

$$s_3 = 5.67 \rightarrow 6$$

$$s_7 = 7.00 \rightarrow 7$$

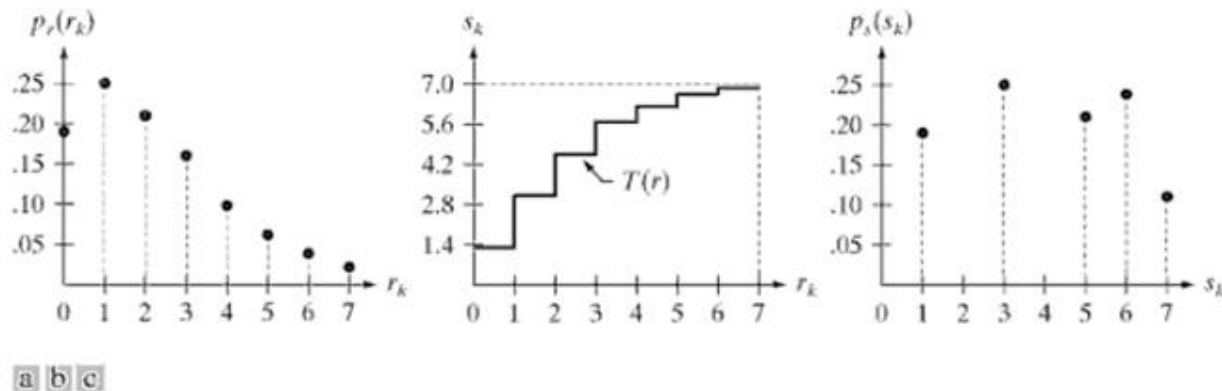


FIGURE 3.19 Illustration of histogram equalization of a 3-bit (8 intensity levels) image. (a) Original histogram. (b) Transformation function. (c) Equalized histogram.