Point Operation

Histogram Modification

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학습 내용

- Histogram
- Histogram Modification

HISTOGRAM

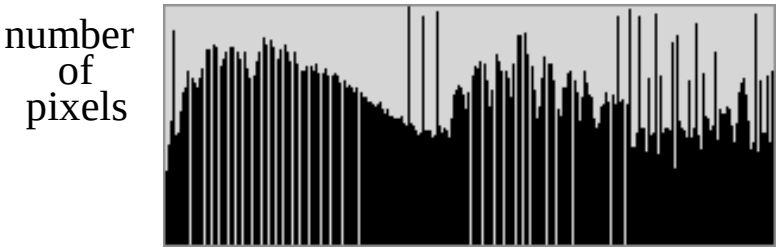
- A simple datum that gives **the number of pixels that a given value** in an image

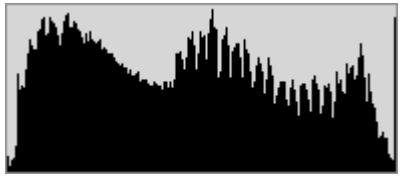
$$\frac{\text{count}}{\text{sum of count}} = \text{Normalized hist}$$

- Ex) a 8bit gray-scale image

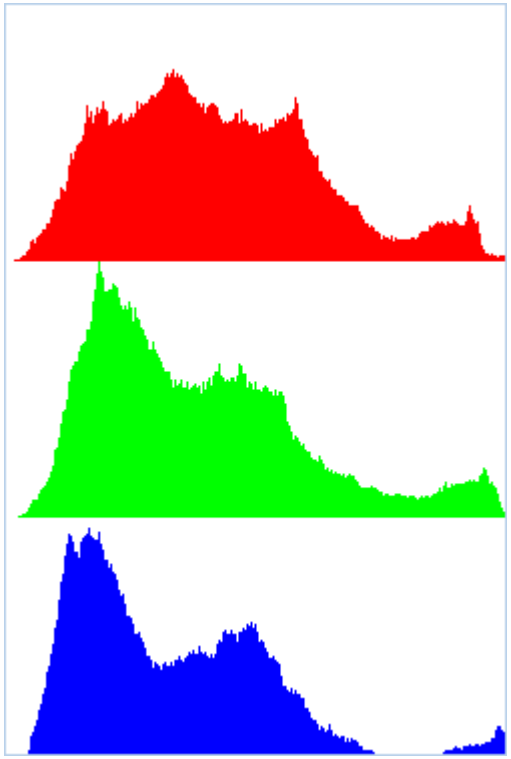
Normalized hist

Bin	Counts	Prob.
0	163	0.005
1	77	0.003
. . .		
255	1561	0.051

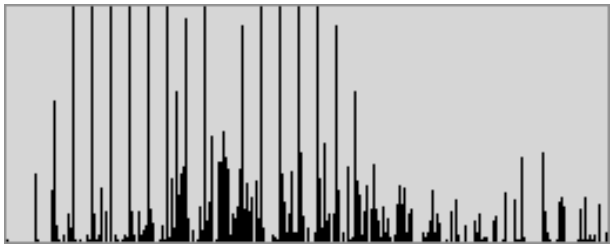




in color images



Color Quantization

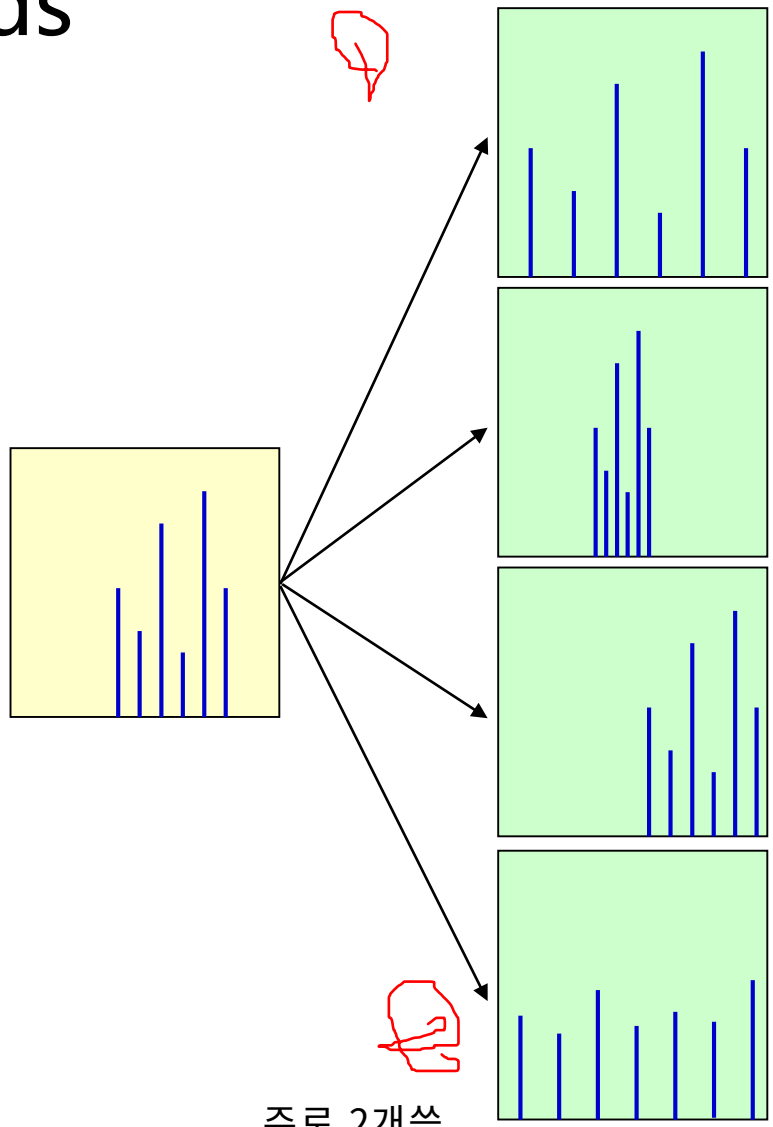


Histogram Modifications

Improving image contrast and brightness based on **histogram**

➡ Focus on the histogram shape and range

fields



Histogram Scaling
(Histogram Stretching)

Histogram Scaling
(Histogram Shrinking)

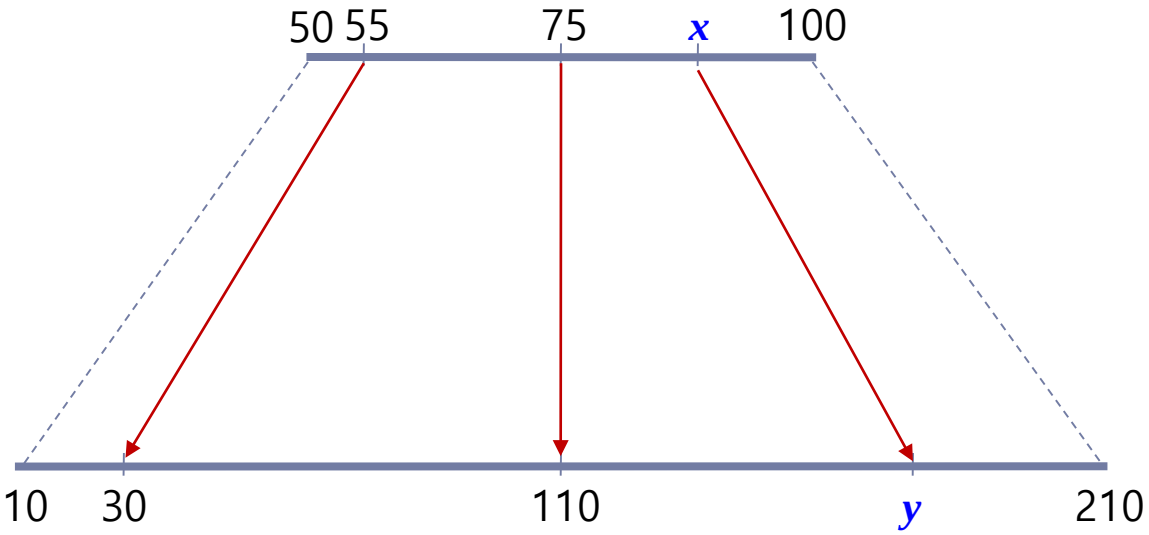
Histogram Sliding

Histogram Equalization
평활화

Normalization
정규화

주로 2개씀

Scaling



$$(100-50):(x-50)=(210-10):(y-10)$$

$$(y-10)*(100-50)=(x-50)*(210-10)$$

$$y=\frac{(x-50)*(210-10)}{(100-50)}+10=\frac{(210-10)}{(100-50)}(x-50)+10$$

$$I'(x,y)=\frac{(S_{\max}-S_{\min})}{(I_{\max}-I_{\min})}(I(x,y)-I_{\min})+S_{\min}$$

$$\mathbf{O}(x,y) = \left[\frac{S_{max} - S_{min}}{I_{max} - I_{min}}\right][\mathbf{I}(x,y) - I_{min}] + S_{min}$$

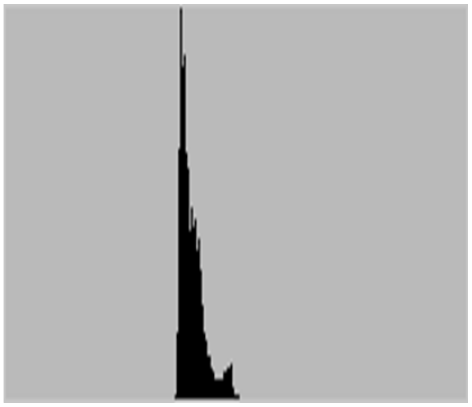
I_{max} : largest gray-level value in the image $\mathbf{I}(x,y)$

I_{min} : smallest gray-level value in $\mathbf{I}(x,y)$

S_{max} : maximum gray-level values possible

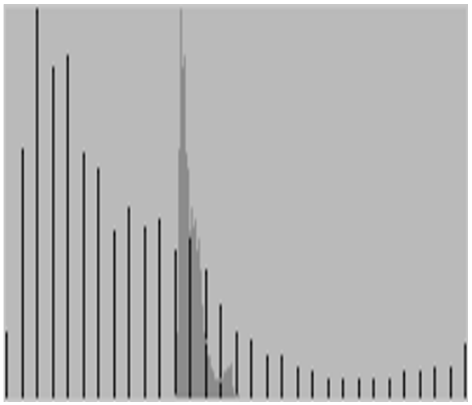
S_{min} : minimum gray-level values possible

Low-contrast image

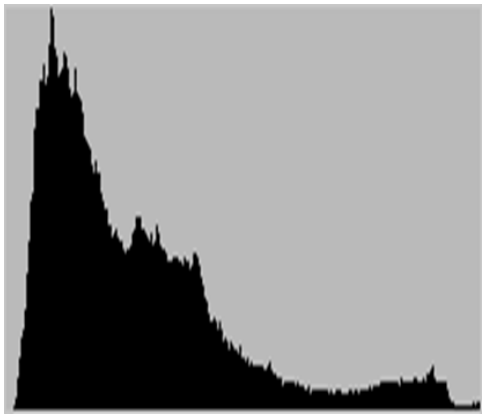


Histogram of low-contrast image

Image after histogram stretching

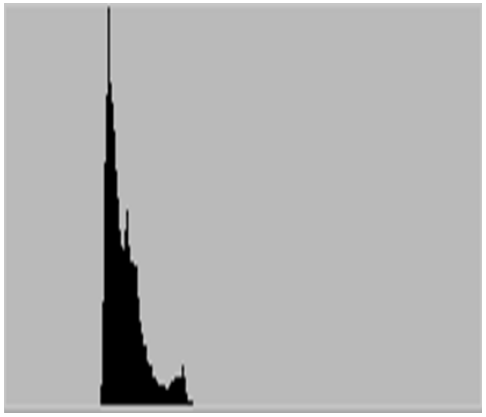


Histogram of image after stretching



Histogram of original image

Image after shrinking



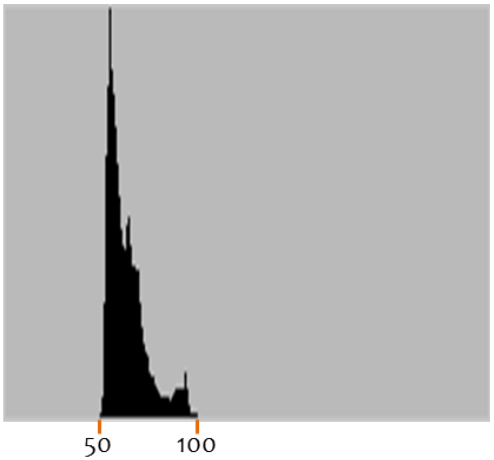
Histogram of shrinked image

Sliding

$$\mathbf{O}(x, y) = \mathbf{I}(x, y) + offset$$

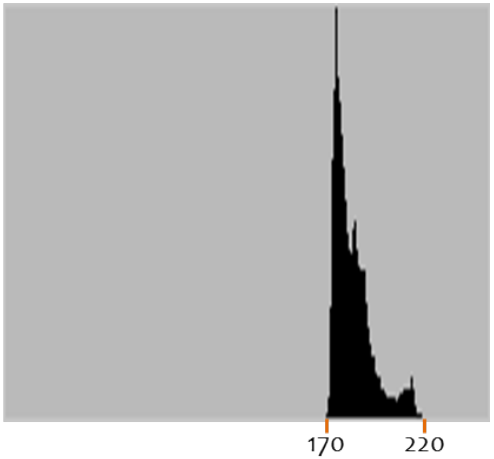
offset : amount to slide the histogram

Original image



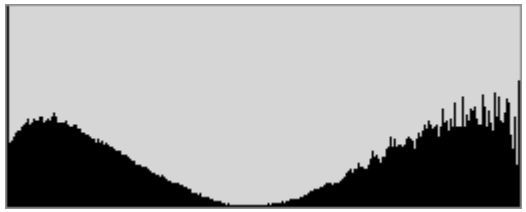
Histogram of original image

positive-value histogram sliding

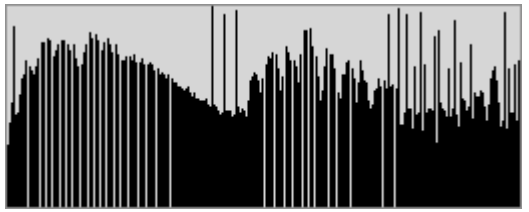


Histogram of image after sliding

Equalization

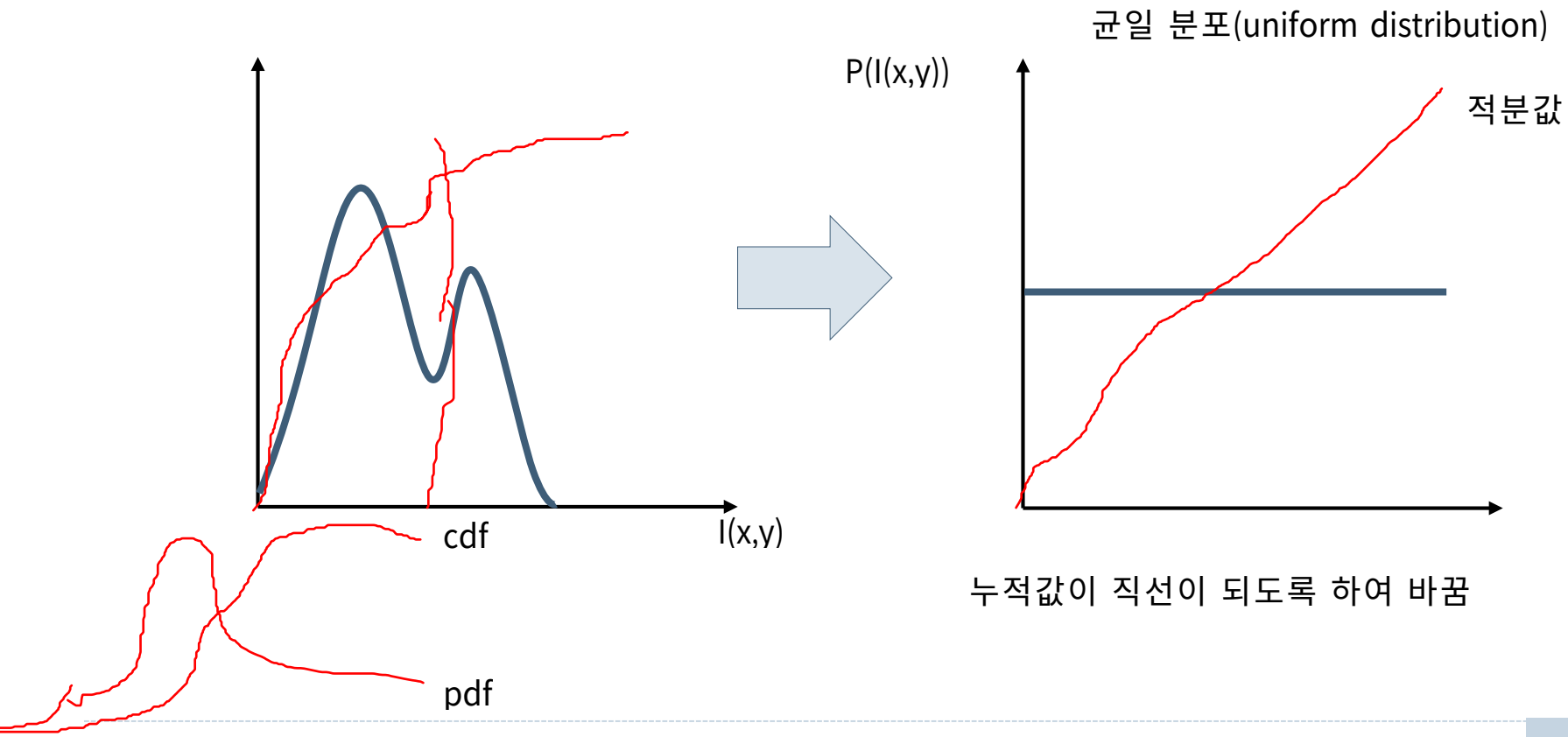


높은 contrast



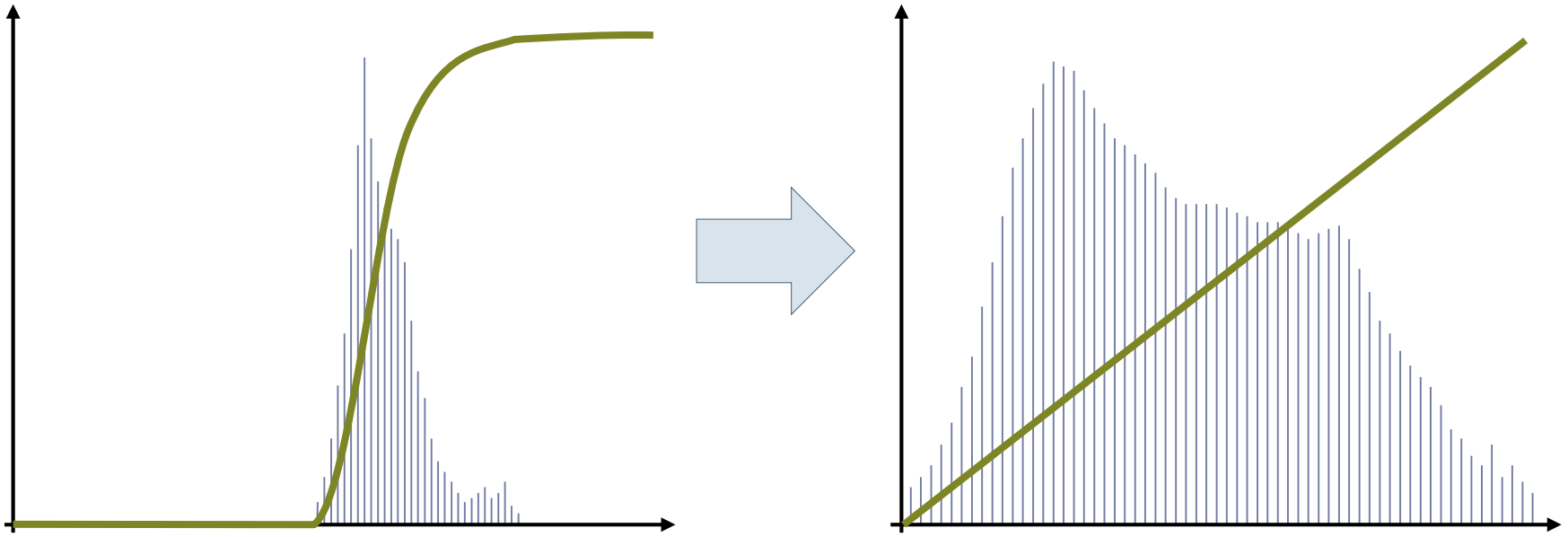
좋은 contrast

Aim to change a picture in such a way as to produce a picture with *flatter* histogram, where all levels are equiprobable



CDF

Cumulative Distribution Function



Deriving Algorithm (1)

$\mathbf{I}(l)\ and\ \mathbf{O}(l)\ (0 \leq l < L)$:
for the input and output image, the number of pixels per level

$$\sum_{l=0}^{L-1} \mathbf{I}(l) = \sum_{l=0}^{L-1} \mathbf{O}(l)$$

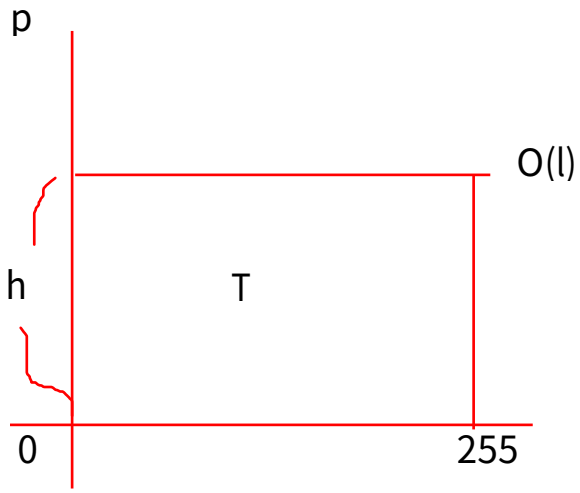
for an arbitrarily chosen level p in the input image

$$\sum_{l=0}^{p} \mathbf{I}(l) = \sum_{l=0}^{q} \mathbf{O}(l)$$

Deriving Algorithm (2)

Since the output histogram is uniformly flat
(T: total number of pixels in the image)

$$\mathbf{O}(l) = \frac{T}{N_{\max} - N_{\min}}$$



So the cumulative histogram of the output image

$$\sum_{l=0}^{q} \mathbf{O}(l) = q \times \frac{T}{N_{\max} - N_{\min}} = \sum_{l=0}^{p} \mathbf{I}(l)$$

Deriving Algorithm (3)

Output pixels at level q is given by

$$E(q, \mathbf{I}) = q = \frac{N_{\max} - N_{\min}}{T} \times \sum_{l=0}^{p} \mathbf{I}(l)$$

255

픽셀 개수
I(X,Y)
히스토그램

픽셀개수

Equalizing function (E) of the level (q) and the image (I)

The output image is then

$$\mathbf{O}_{x,y} = E\left(\mathbf{I}_{x,y}, \mathbf{I}\right)$$

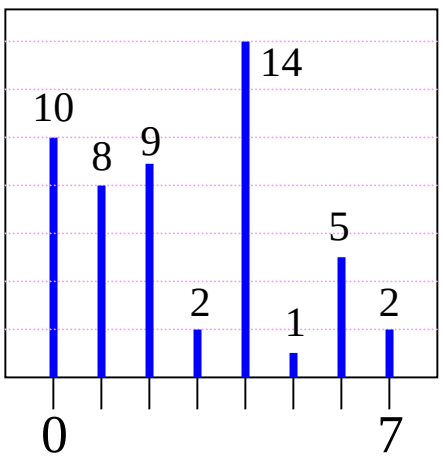
algorithm

① 입력 영상의 히스토그램의 값을 누적시켜 각 레벨에서의 히스토그램 누적 합 계산

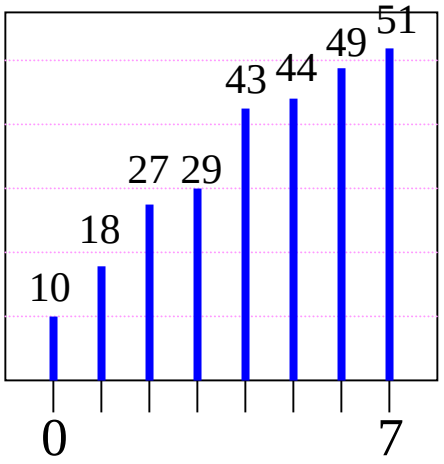
② 히스토그램의 누적 합을 전체 픽셀의 개수로 나누어 값을 정규화함

③ 정규화된 값에 최대 gray level 값을 곱한 후 반올림을 수행

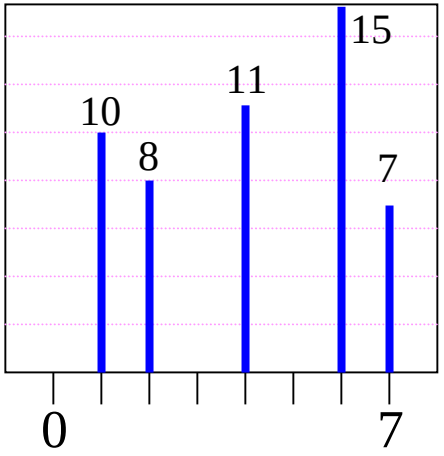
④ 입력 영상의 각 gray level에 대해 변환 값으로 대응



히스토그램



누적값



균일화 결과

$$\frac{(10,18,27,29,43,44,49,51)}{51}\times 7$$

$$\approx (1.37,2.47,3.71,3.98,5.90,6.04,6.73,7.00)$$

$$\approx (1,2,4,4,6,6,7,7)$$

LUT

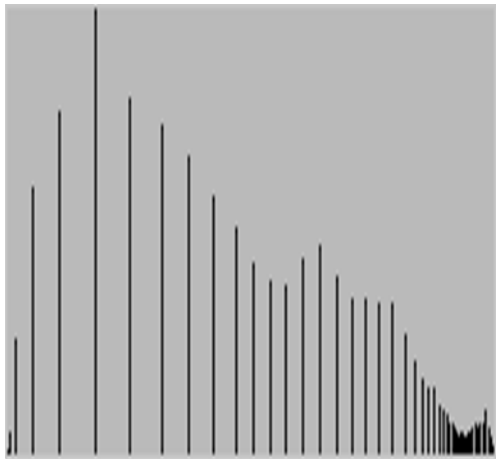
4	5	3	6	7
4	2	2	4	6
0	2	2	5	7
0	0	2	3	5
0	1	2	4	4

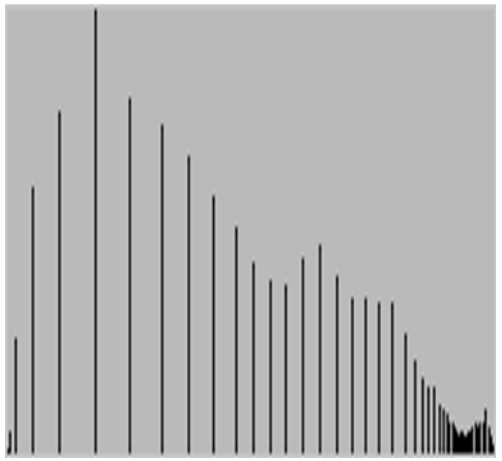
입력레벨	개수	누적값	균일화	결과레벨
0	10	10	1.37	1
1	8	18	2.47	2
2	9	27	3.71	4
3	2	29	3.98	4
4	14	43	5.90	6
5	1	44	6.04	6
6	5	49	6.73	7
7	2	51	7.00	7

6	6	4	7	7
6	4	4	6	7
1	4	4	6	7
1	1	4	4	6
1	2	4	6	6

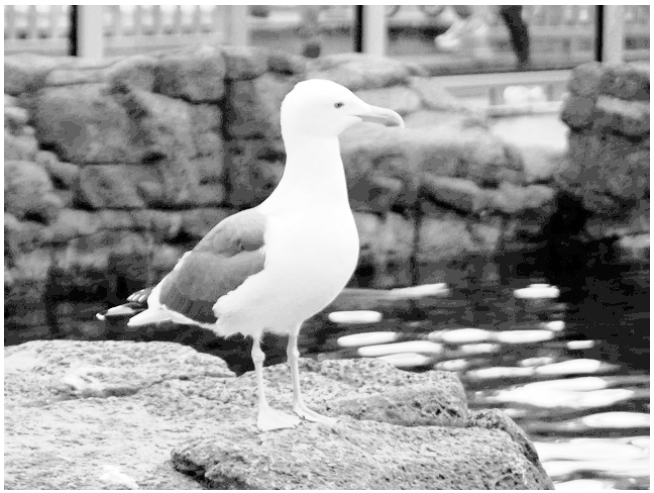
histogram의 분포를 x=y직선에 맞춘 결과

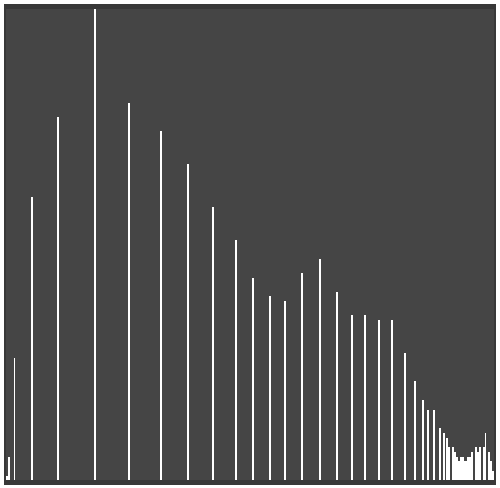




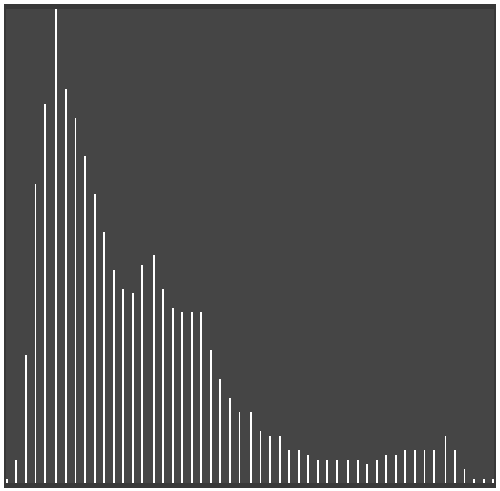



Histogram normalization vs. equalization





equalization



normalization

DISADVANTAGE

- Background noise can be increased
- The image quality in a near-constant region may be degraded

REFERENCE

- R. Gonzalez, R. Woods, **Digital Image Processing (2nd Edition),** Prentice Hall, 2002
- Scott E Umbaugh, **Computer Imaging**, CRC Press, 2005
- Mark Nixon and Alberto Aguado, **Feature Extraction & Image Processing**, ELSEVIER, 2008
- Frank SHIH, **Image Processing and Pattern Recognition**, IEEE Press, 2010