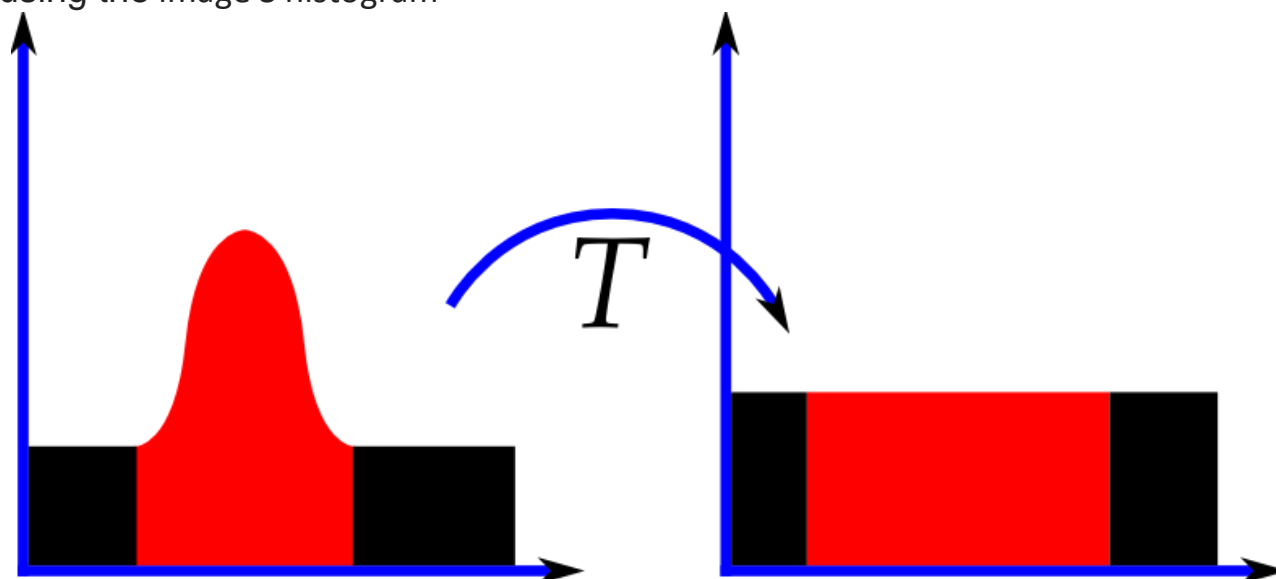


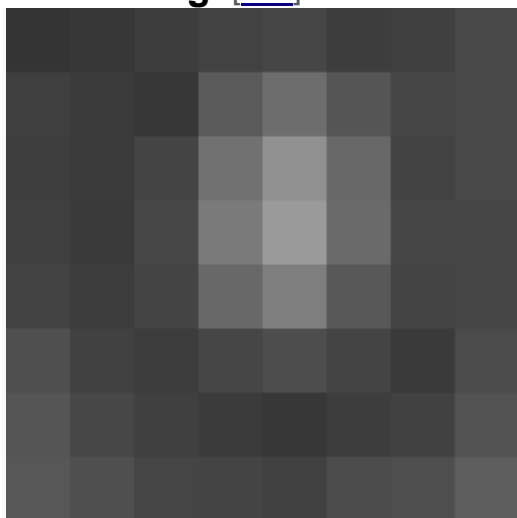
Histogram equalization is a method in image processing of contrast adjustment using the image's histogram



Histograms of an image before and after equalization.

For consistency with [statistical](#) usage, "CDF" (Cumulative distribution function) should be replaced by "cumulative histogram", especially since the article links to cumulative distribution function (**In probability theory and statistics, the cumulative distribution function (CDF) of a real-valued random variable X , or just distribution function of X , evaluated at x , is the probability that X will take a value less than or equal to x . In the case of a continuous distribution, it gives the area under the probability density function from minus infinity to x . Cumulative distribution functions are also used to specify the distribution of multivariate random variables**). which is derived by dividing values in the cumulative histogram by the overall amount of pixels. The equalized CDF is defined in terms of rank as pixel count.

Small image[\[edit\]](#)



The 8x8 sub-image shown in 8-bit grayscale

The 8-bit grayscale image shown has the following values:

The histogram for this image is shown in the following table. Pixel values that have a zero count are excluded for the sake of brevity.

Value	Count	Value	Count	Value	Count	Value	Count	Value	Count
52	1	64	2	72	1	85	2	113	1
55	3	65	3	73	2	87	1	122	1
58	2	66	2	75	1	88	1	126	1
59	3	67	1	76	1	90	1	144	1
60	1	68	5	77	1	94	1	154	1
61	4	69	3	78	1	104	2		
62	1	70	4	79	2	106	1		
63	2	71	2	83	1	109	1		

The [cumulative distribution function](#) (cdf) is shown below. Again, pixel values that do not contribute to an increase in the cdf are excluded for brevity.

v, Pixel Intensity	cdf(v)	h(v), Equalized v
52	1	0
55	4	12
58	6	20
59	9	32

60	10	36
61	14	53
62	15	57
63	17	65
64	19	73
65	22	85
66	24	93
67	25	97
68	30	117
69	33	130
70	37	146
71	39	154
72	40	158
73	42	166
75	43	170
76	44	174
77	45	178

78	46	182
79	48	190
83	49	194
85	51	202
87	52	206
88	53	210
90	54	215
94	55	219
104	57	227
106	58	231
109	59	235
113	60	239
122	61	243
126	62	247
144	63	251
154	64	255

This cdf shows that the minimum value in the subimage is 52 and the maximum value is 154. The cdf of 64 for value 154 coincides with the number of pixels in the image. The cdf must be normalized to $[0, 255]$. The general histogram equalization formula is:

$$h(v) = \text{round} \left(\frac{cdf(v) - cdf_{min}}{(M \times N) - cdf_{min}} \times (L - 1) \right)$$

where cdf_{min} is the minimum non-zero value of the cumulative distribution function (in this case 1), $M \times N$ gives the image's number of pixels (for the example above 64, where M is width and N the height) and L is the number of grey levels used (in most cases, like this one, 256).

Note that to scale values in the original data that are above 0 to the range 1 to $L-1$, inclusive, the above equation would instead be:

$$h(v) = \text{round} \left(\frac{cdf(v) - cdf_{min}}{(M \times N) - cdf_{min}} \times (L - 2) \right) + 1$$

where $cdf(v) > 0$. Scaling from 1 to 255 preserves the non-zero-ness of the minimum value.

The equalization formula for the example scaling data from 0 to 255, inclusive, is:

$$h(v) = \text{round} \left(\frac{cdf(v) - 1}{63} \times 255 \right)$$

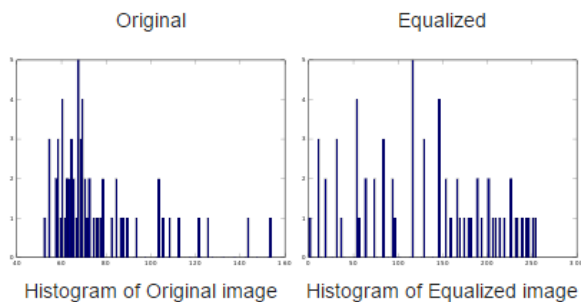
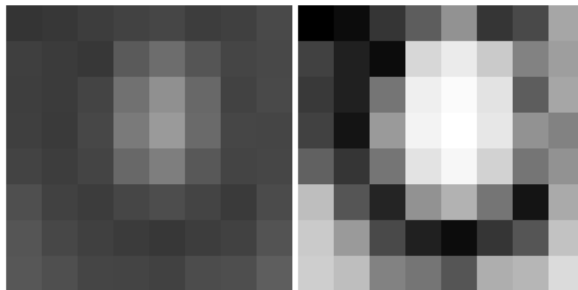
For example, the cdf of 78 is 46. (The value of 78 is used in the bottom row of the 7th column.) The normalized value becomes

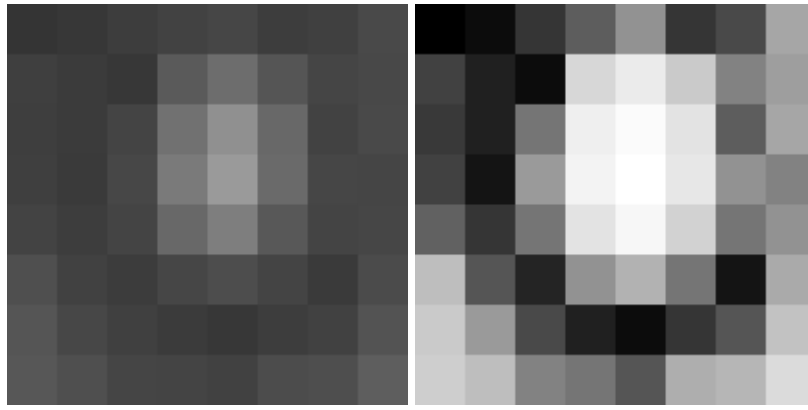
$$h(78) = \text{round} \left(\frac{46 - 1}{63} \times 255 \right) = \text{round} (0.714286 \times 255) = 182$$

Once this is done then the values of the equalized image are directly taken from the normalized cdf to yield the equalized values:

0	12	53	32	146	53	174	53
57	32	12	227	219	202	32	154
65	85	93	239	251	227	65	158
73	146	146	247	255	235	154	130
97	166	117	231	243	210	117	117
117	190	36	190	178	93	20	170
130	202	73	20	12	53	85	194
146	206	130	117	85	166	182	215

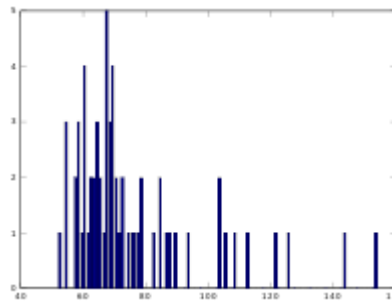
Notice that the minimum value (52) is now 0 and the maximum value (154) is now 255.



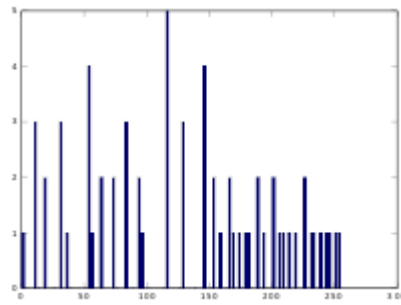


Original

Equalized



Histogram of Original image

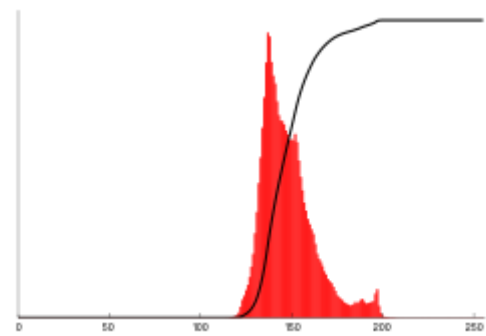


Histogram of Equalized image

Full-sized image



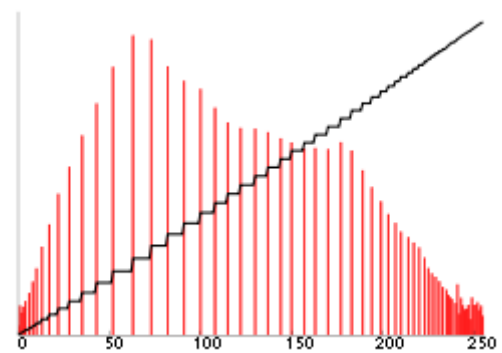
Before Histogram Equalization



Corresponding histogram (red) and cumulative histogram (black)



After Histogram Equalization



Corresponding histogram (red) and cumulative histogram (black)