Lab3: Histogram Processing

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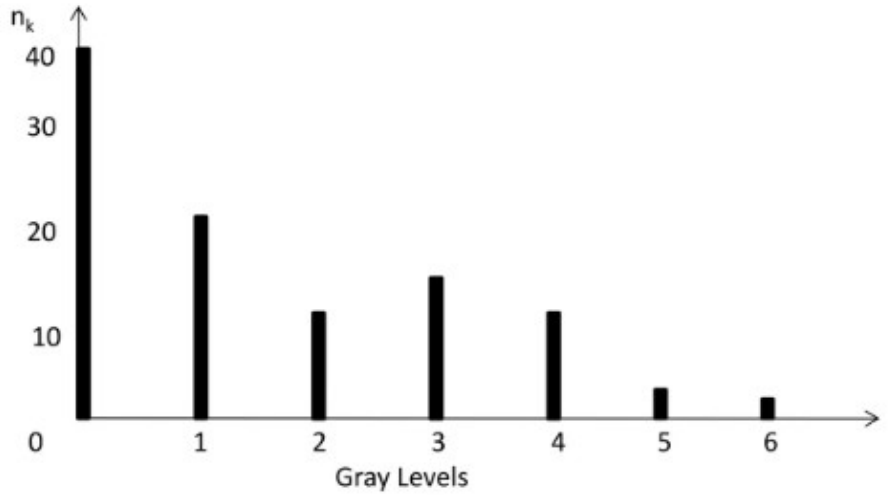
Histogram

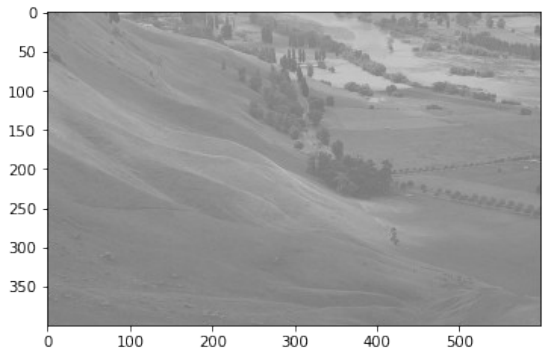
- The histogram of an image consists of the x-axis representing the intensity levels r_k and the y-axis denoting the $h(r_k)$ or the $p(r_k)$ functions.

$$\mathbf{h(r_k) = n_k}$$

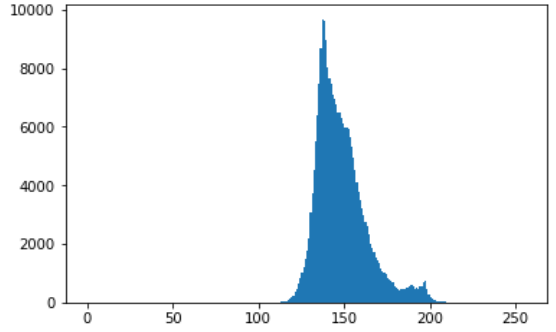


Histogram Equalization

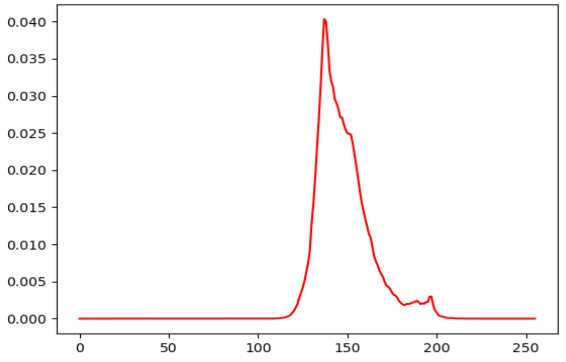
Histogram equalization is used to enhance contrast.



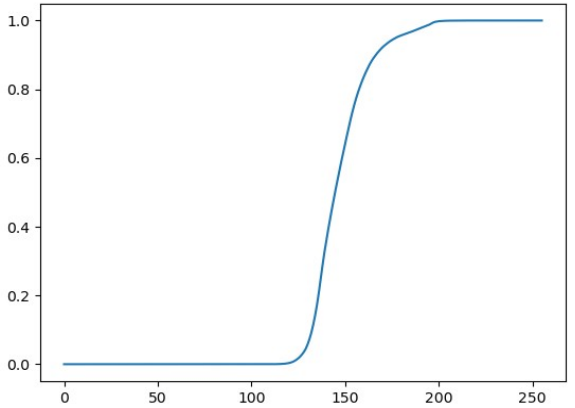
Input Image



Histogram of the Input Image

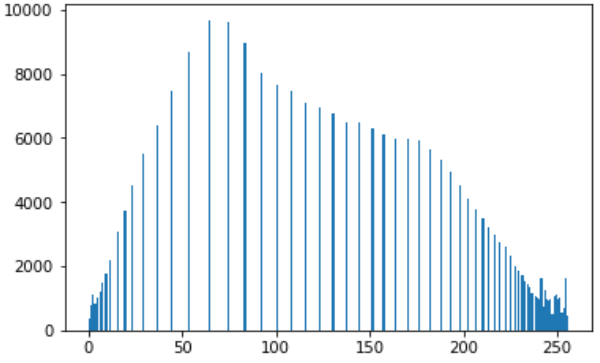


PDF of the Input Image

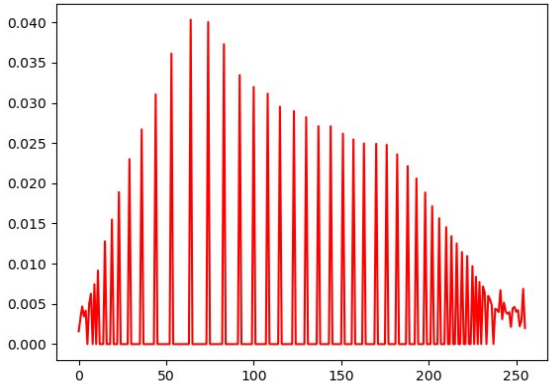


CDF of the Input Image

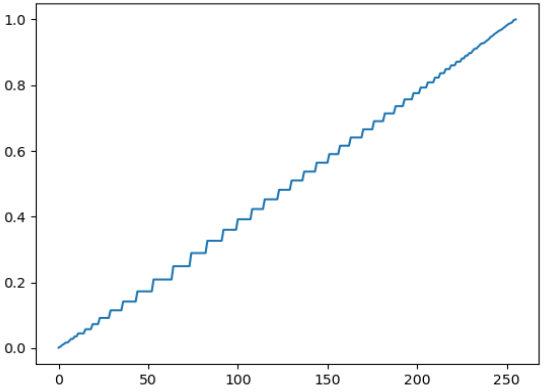
Equalized Image



Histogram of the Equalized Image



PDF of the Equalized Image



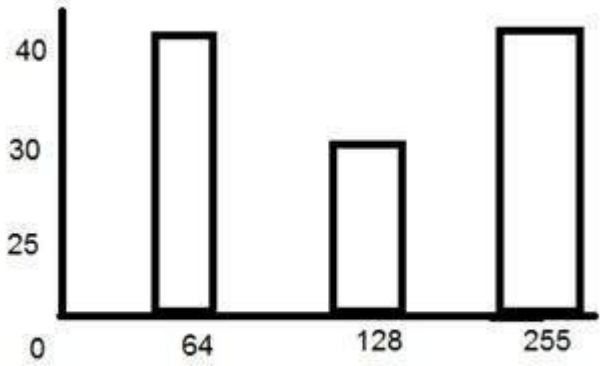
CDF of the Equalized Image

PDF

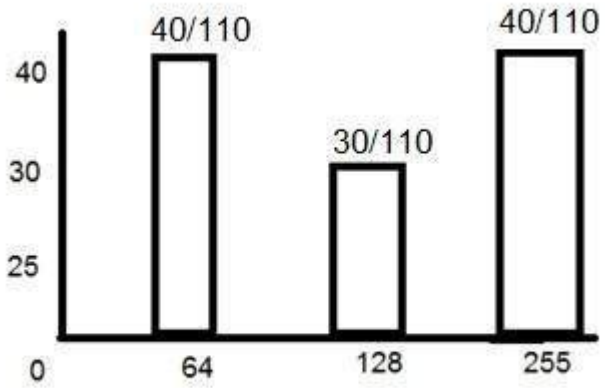
- **PDF** stands for probability density function. It's a function where you can think of the x values as the range of possible occurring values and y values as their probability of occurrence.

$$\boldsymbol{p(r_k) = \frac{n_k}{MN}} \quad k = 0,1,2 \dots \dots L-1$$

$\boldsymbol{n_k}$**:** the number of pixels in the image of size M × N with intensity r_k



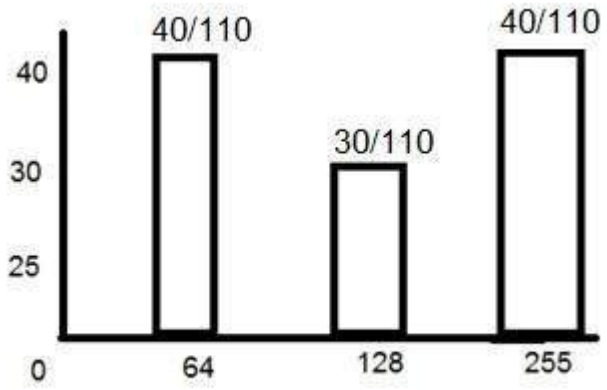
$\mathbf{n_k}$



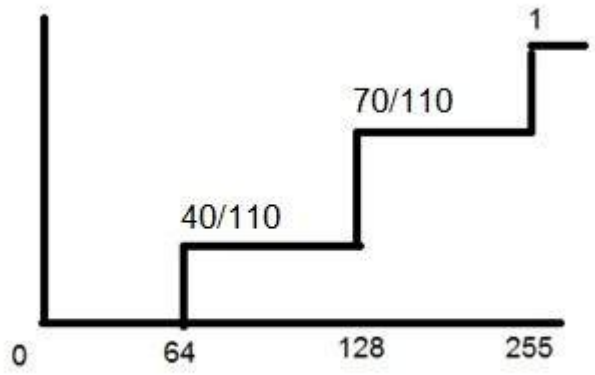
PDF

CDF

- **CDF** holds the probability of a probability distribution less than or equal to a particular value.
- It is a function that calculates the cumulative sum of all the values that are calculated by PDF.



PDF



CDF

Histogram Equalization

1. First calculate the PDF of all the pixels in this image.

$$\boldsymbol{p(r_k)} = \frac{\boldsymbol{n_k}}{\boldsymbol{MN}} \quad k = 0,1,2 \ldots \ldots L-1$$

2. Calculate CDF (cumulative distributive function) of the pixels.
3. Multiply CDF of each pixel value with the highest intensity to satisfy the transformation function.

$$S_k = T(r_k) = (L-1)\sum_{j=0}^{k} p_r(r_j)$$

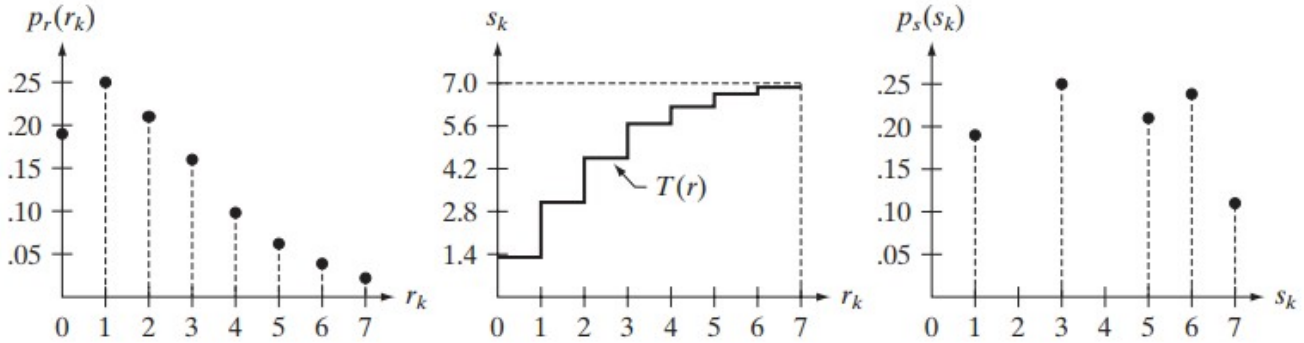
$$\boldsymbol{s_k} = \frac{\boldsymbol{L-1}}{\boldsymbol{MN}} \sum_{\boldsymbol{j=0}}^{\boldsymbol{k}} \boldsymbol{n_j}$$

4. The output image is obtained by mapping each pixel in the input image with intensity r_k into the corresponding pixel with level s_k in the output image.

Map s_k to its r_k

r_k	n_k	$p_r(r_k) = n_k/MN$
$r_0 = 0$	790	0.19
$r_1 = 1$	1023	0.25
$r_2 = 2$	850	0.21
$r_3 = 3$	656	0.16
$r_4 = 4$	329	0.08
$r_5 = 5$	245	0.06
$r_6 = 6$	122	0.03
$r_7 = 7$	81	0.02

s_k
$S_0 = 1.33 = 1$
$S_1 = 3.08 = 3$
$S_2 = 4.55 = 5$
$S_3 = 5.67 = 6$
$S_4 = 6.23 = 6$
$S_5 = 6.65 = 7$
$S_6 = 6.86 = 7$
$S_7 = 7.00 = 7$



a b c

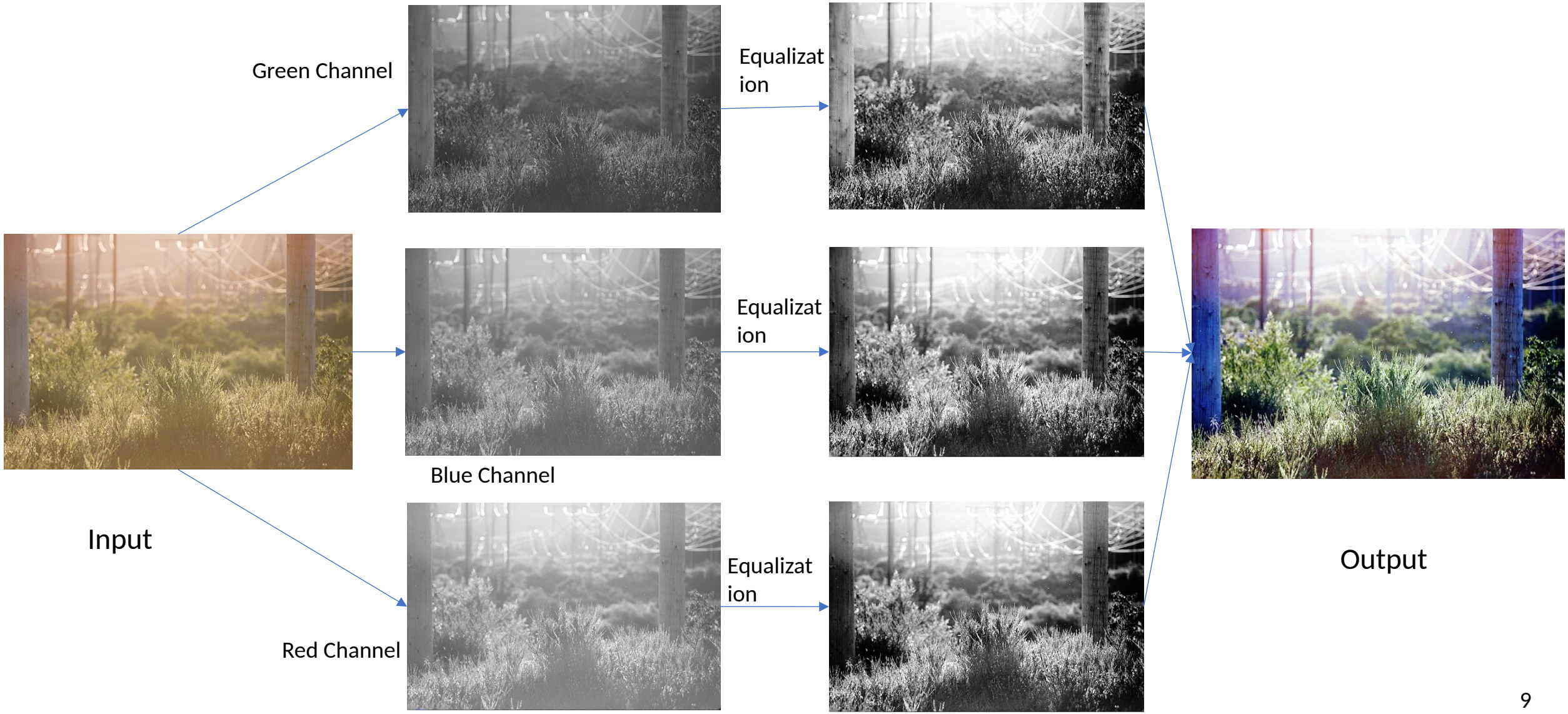
FIGURE 3.19 Illustration of histogram equalization of a 3-bit (8 intensity levels) image. (a) Original histogram. (b) Transformation function. (c) Equalized histogram.

Classwork

1. Take an input color image and apply histogram equalization to enhance contrast.
    1. For the RGB image, apply histogram equalization to each of the 3 channels separately. Merge the 3 channels to view the enhanced image.
    2. Convert the RGB image to the HSV image and apply histogram equalization only in the Value channel. Merge the new equalized value channel with the other two to generate the final output equalized image.

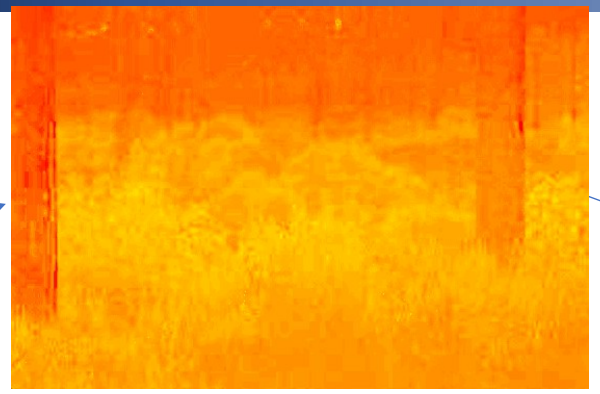
2. Show the histogram of input and the equalized image

Classwork


Green Channel
Equalization
Blue Channel
Equalization
Input
Red Channel
Equalization
Output

Classwork

Hue channel



Input

Saturation channel

Output

Value channel

Equaliz ation