INDIAN INSTITUTE OF TECHNOLOGY
KHARAGPUR

DIGITAL IMAGE PROCESSING LABORATORY

A REPORT ON
Experiment-2

Histogram Equalization and Matching

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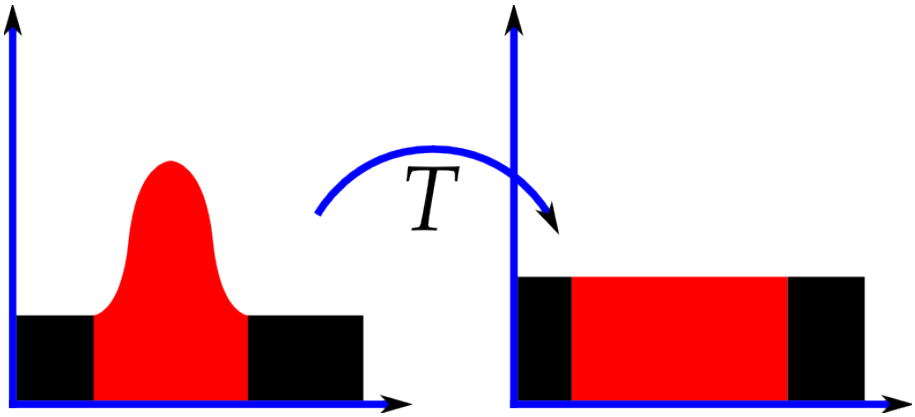
1 Introduction

1.1 Histogram Equalization

Histogram equalization is a method in image processing of contrast adjustment using the image's histogram. This method usually increases the global contrast of many images, especially when the usable data of the image is represented by close contrast values. Through this adjustment, the intensities can be better distributed on the histogram. This allows for areas of lower local contrast to gain a higher contrast. Histogram equalization accomplishes this by effectively spreading out the most frequent intensity values.



The method is useful in images with backgrounds and foregrounds that are both bright or both dark. In particular, the method can lead to better views of bone structure in x-ray images, and to better detail in photographs that are over or under-exposed. In theory, if the histogram equalization function is known, then the original histogram can be recovered. The calculation is not computationally intensive. A disadvantage of the method is that it is indiscriminate. It may increase the contrast of background noise while decreasing the usable signal.

1.2 Histogram Matching

Histogram matching is a process where an image or higher dimension scalar data is modified such that its histogram matches that of another (reference) dataset. A common application of this is to match the images from two sensors with slightly different responses, or from a sensor whose response changes over time.

2 Algorithms

Histogram Equalization :

1. Image is read using **imread()** function
2. If it is a color image it is converted to HSI plane from RGB plane using **convert_RG_To_HSI** function.From Intensity information I , histogram is obtained using **intensityToHistogram** function.
3. If the image is grayscale, then the histogram is obtained using **imageTopdf** function(i.e counting the number of pixels corresponding to each intensity value).
4. Then the transfer function(i.e cdf) is obtained using the **get_tf** function.
5. Using the tf obtained intensity are mapped accordingly so as to get the equalised image using **intensityMapping** function.
6. Later again converted to RGB plane in case of color images using **convert_HSI_To_RGB** function.
7. Output Image is stored using **imwrite()** function

Histogram Matching :

1. Histograms, as well as the transfer function(cdf) of both the input and target images, are obtained same way as the Histogram Equalization.
2. Now the cdf values of input are mapped with the target image according to the nearest value to the target image cdf values using the **histogramMatching** function.
3. Using the hist array pixel intensity values are changed accordingly.
4. Later again converted to RGB plane in case of color images using **convert_HSI_To_RGB** function.

HSI Color Model :

1. **Hue** represents dominant color as perceived by an observer It is an attribute perceived by an observer. It is an attribute associated with the dominant wavelength.
2. **Saturation** refers to the relative purity or refers to the relative purity or the amount of white light mixed with a hue. The pure spectrum colors are fully The pure spectrum colors are fully saturated. Pink and lavender are less saturated.
3. **Intensity** reflects the brightness.

Conversion Between RGB and HSI

- Converting color from RGB to HSI

$$H = \begin{cases} \theta & \text{if } B \le G \\ 360 - \theta & \text{if } B > G \end{cases} \quad \text{with } \theta = \cos^{-1}\left\{ \frac{\frac{1}{2}[(R-G)+(R-B)]}{[(R-G)^2+(R-B)(G-B)]^{\frac{1}{2}}} \right\}$$

$$S = 1 - \frac{3}{(R+G+B)}[\min(R,G,B)]$$

$$I = \frac{1}{3}[R+G+B]$$

- Converting color from HSI to RGB

RG sector (0≤H<120)

$$B = I(1-S)$$

$$R = I\left[1 + \frac{S\cos H}{\cos(60-H)}\right]$$

$$G = 1-(R+B)$$

GB sector (120≤H<240)

$$R = I(1-S)$$

$$G = I\left[1 + \frac{S\cos(H-120)}{\cos(60-(H-120))}\right]$$

$$B = 1-(R+G)$$

BR sector (240≤H<360)

$$G = I(1-S)$$

$$B = I\left[1 + \frac{S\cos(H-240)}{\cos(60-(H-240))}\right]$$

$$R = 1-(G+B)$$

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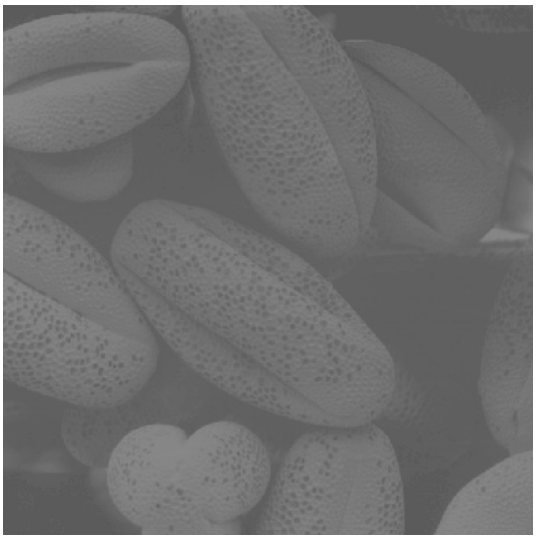
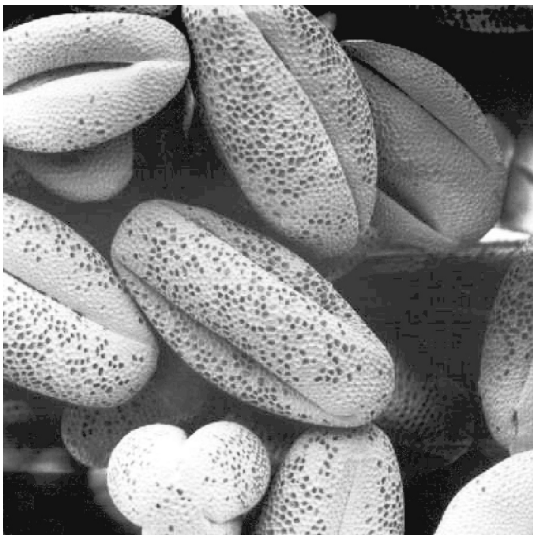
3 Results

Histogram Equalization

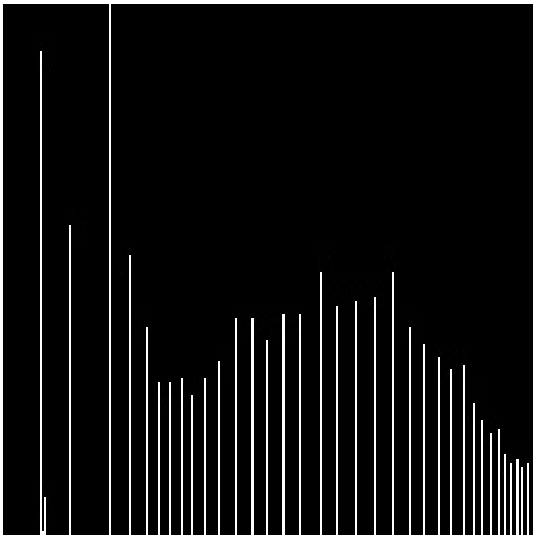


(a)

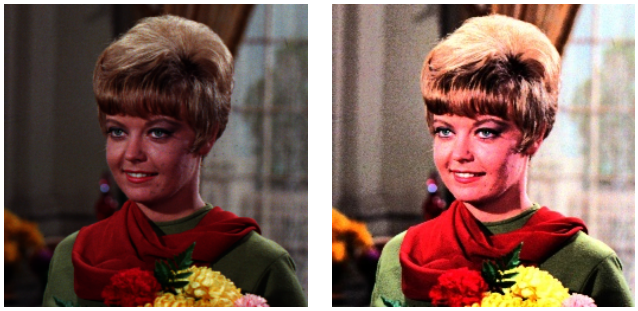


(b)

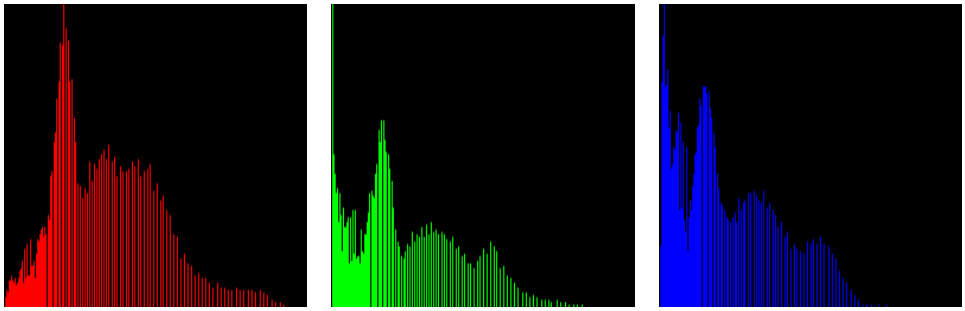
(a)



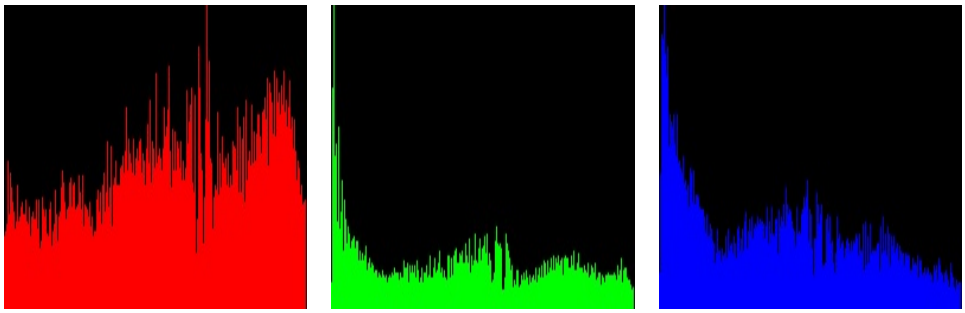
(b)



(a) (b)



(a) (b) (c)



(a) (b) (c)

Histogram Matching

(a) (b) (c)

Figure 1: ((a)input image (b)matched image (c)target image

(a) (b) (c)

Figure 2: ((a)input image (b)matched image (c)target image

4 Analysis

1. Histogram equalization method is used to improve an image's contrast by stretching its histogram over the entire scale. The target histogram is one that closely resembles a uniform distribution.
2. Histogram matching is the method of modifying an image's histogram to match that of a reference histogram. Histogram equalization is a special case of histogram matching wherein the reference histogram is a uniform histogram.
3. Camera today has a High Dynamic Range feature wherein the image is successively captured with the increasing amount of light entering the lens.
4. The final image is formed by the superimposition of all these images after histogram equalization. This allows the camera to capture details that are visible in both high-lighting and low-lighting conditions.
5. Effect of histogram equalization is well observed in the case of lena_gray_dark image where the output is clear and visible.
6. Due to rounding off, during equalization and matching the obtained output histogram is not identical to the reference histogram but differs by a small amount for each intensity value.
7. Color images are equalized by converting them to the HSI plane as equalizing them directly on 3 planes individually would lead to change in hue information while equalization is done to improve only the contrast of the image.