INDIAN INSTITUTE OF TECHNOLOGY

KHARAGPUR

DIGITAL IMAGE PROCESSING LABORATORY

A REPORT ON

EXPERIMENT 02

Histogram Equalisation and Matching

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Group No. 16

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Introduction

Histogram equalization is a method in image processing of contrast adjustment using the image's histogram. This method usually increases the global contrast of the image, 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. A key advantage of the method is that it is a fairly straightforward technique and an invertible operator. So 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.

In image processing, histogram matching or histogram specification is the transformation of an image so that its histogram matches a specified histogram. The well-known histogram equalization method is a special case in which the specified histogram is uniformly distributed.

It is possible to use histogram matching to balance detector responses as a relative detector calibration technique. It can be used to normalize two images, when the images were acquired at the same local illumination (such as shadows) over the same location, but by different sensors, atmospheric conditions or global illumination.

Algorithm

Histogram Equalisation

1. Read the image using opencv library
2. If the image is color, convert it to a grey-scale image.
    a. The corresponding grey-scale intensity = ((0.3 * R) + (0.59 * G) + (0.11 * B)) [1].
3. To obtain a histogram of the image, we first need frequencies of all the pixel intensities
4. Later cumulative frequency is calculated for each pixel intensity.
5. We then map each original pixel to its normalised cumulative sum multiplied by (L - 1).
6. This mapping is applied back to the image, for color image, we apply this mapping to all channels.

Histogram Matching

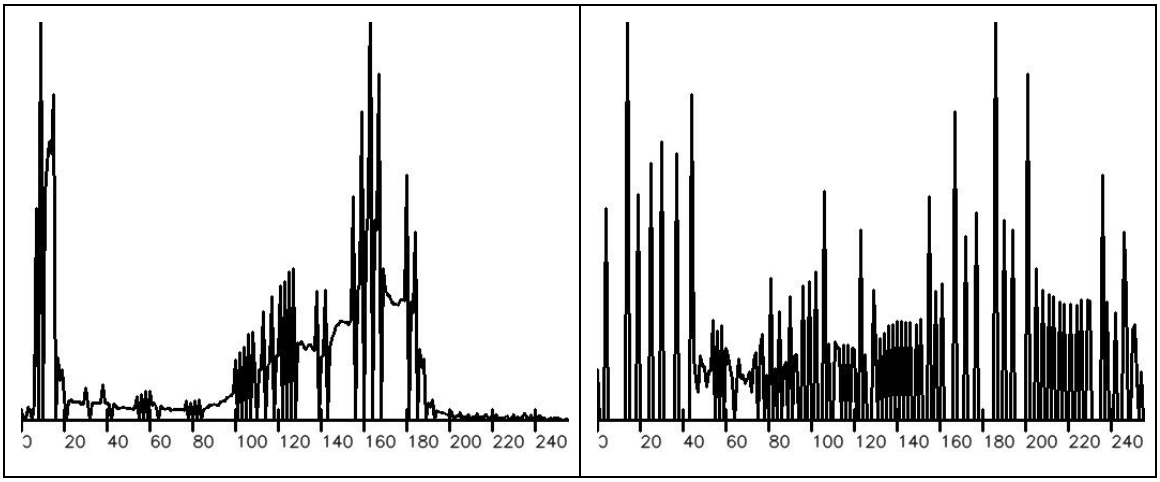
1. Read source and target images as input using open cv.
2. If the image (source/ target) is color, convert it to a grey-scale image.
    a. The corresponding grey-scale intensity = ((0.3 * R) + (0.59 * G) + (0.11 * B)) [1].
3. We obtain the cumulative histogram mapping of both source and target by the above algorithm.
4. For each source pixel mapping, we identify the closest target pixel mapping.
5. Replace the corresponding source pixel mapping with the target mapping.
6. This mapping is then applied back to the image, for color image, we apply this mapping to all channels.

Results

Histogram Equalisation

1. Cameraman

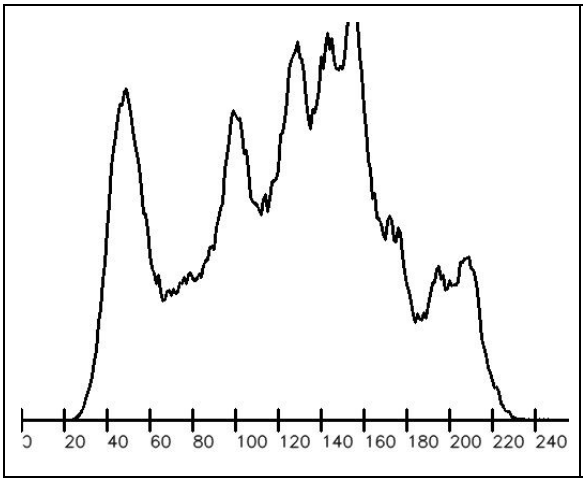
Before Equalisation After Equalisation

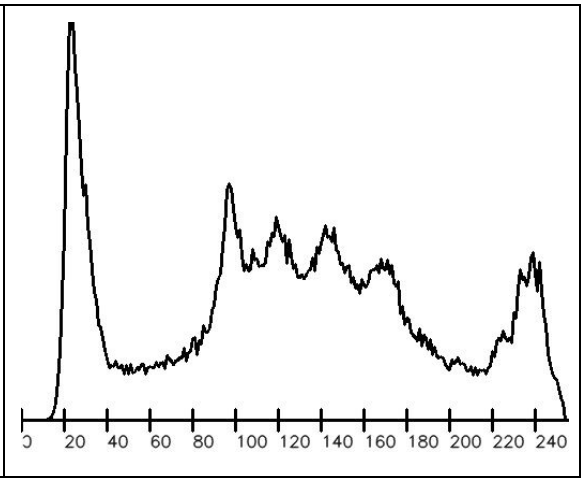


2. Lena_color

Before Equalisation

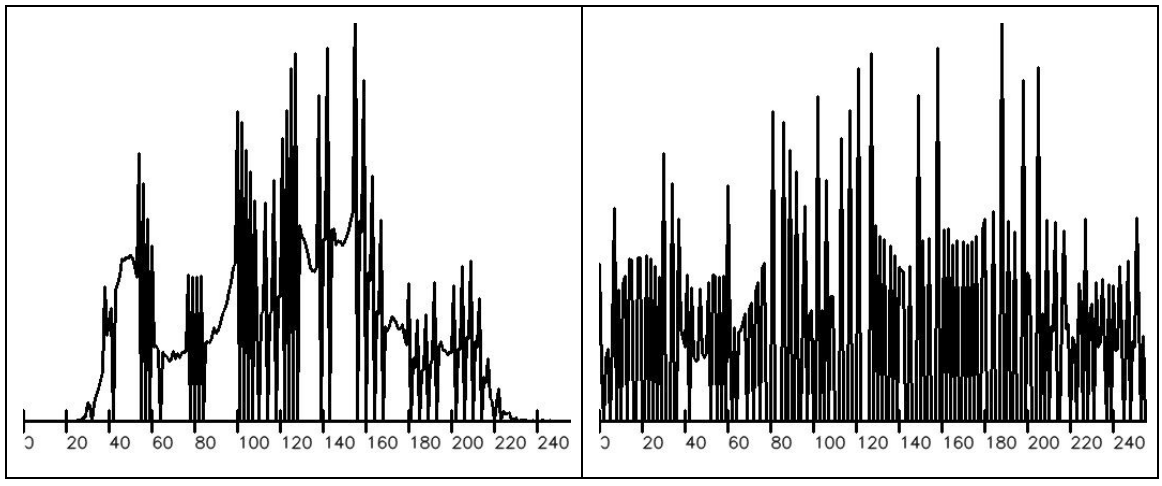
After Equalisation





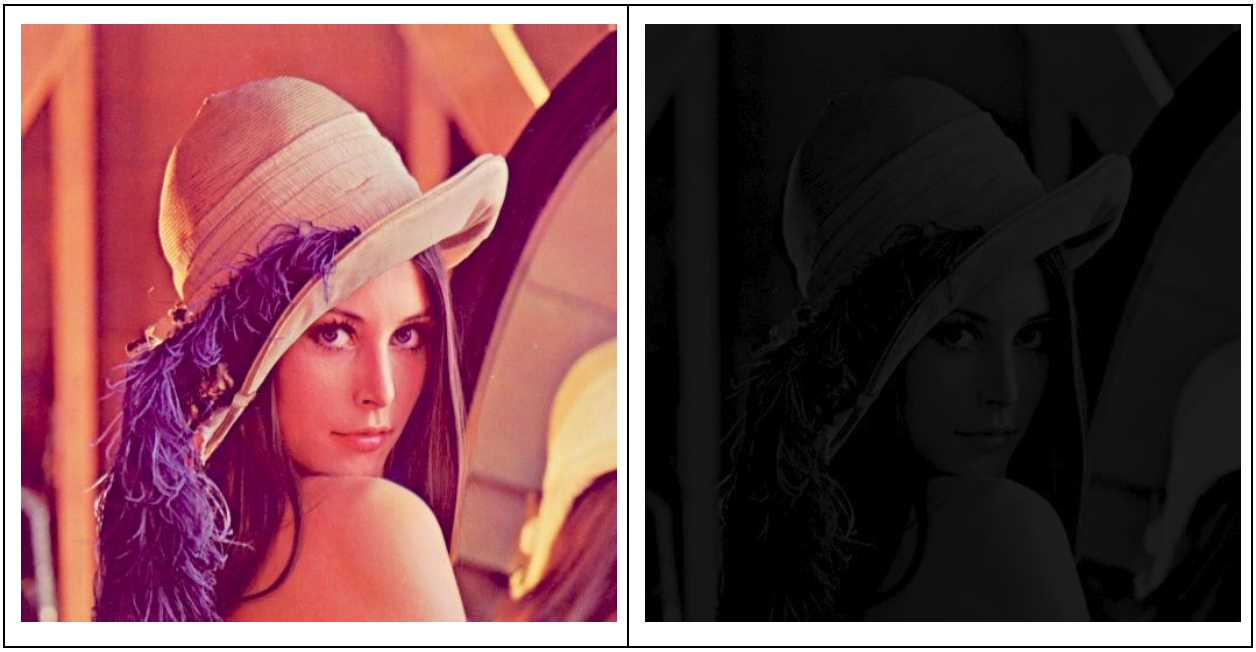
3. Lena_gray

Before Equalisation After Equalisation

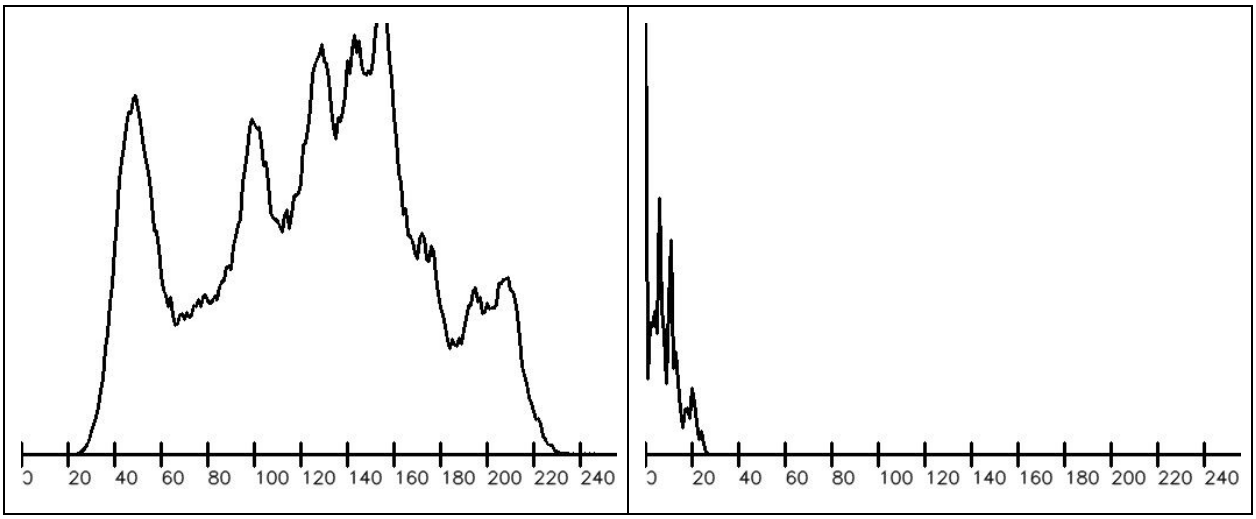


Histogram Matching

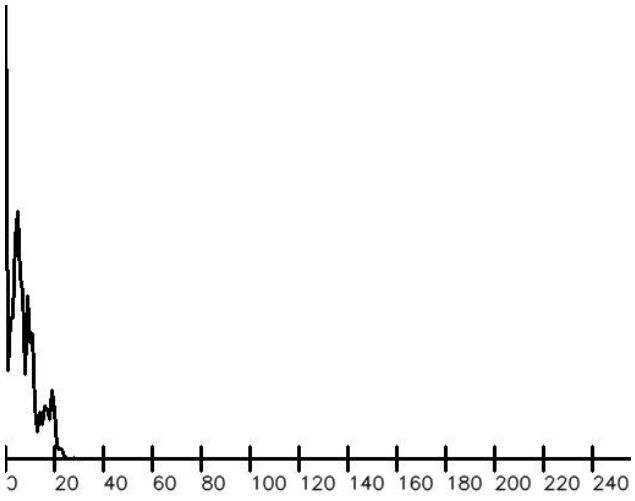
1. Source Target



Histogram before matching

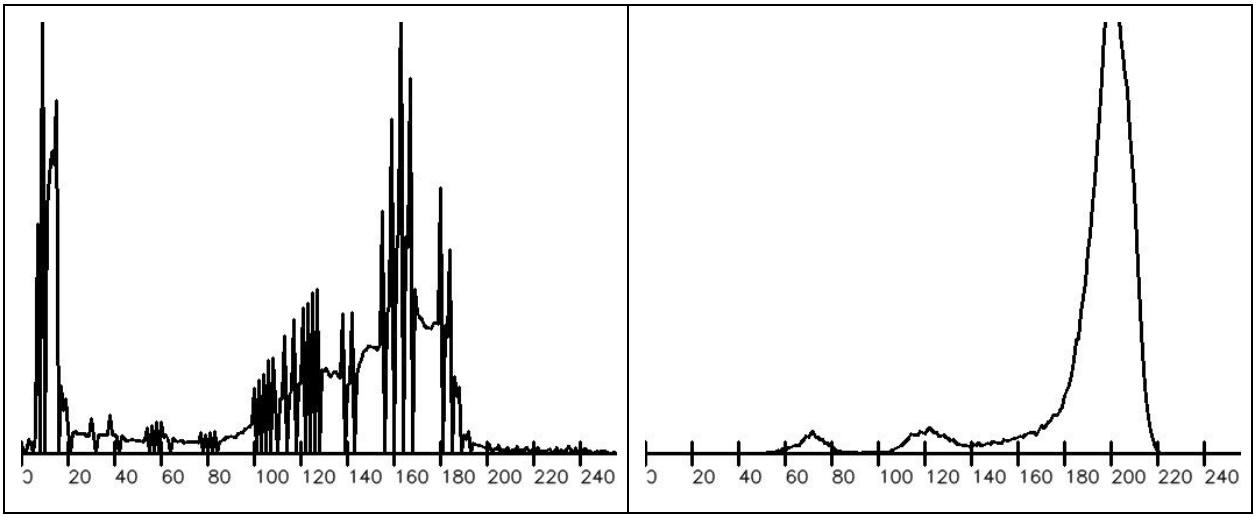


After Matching

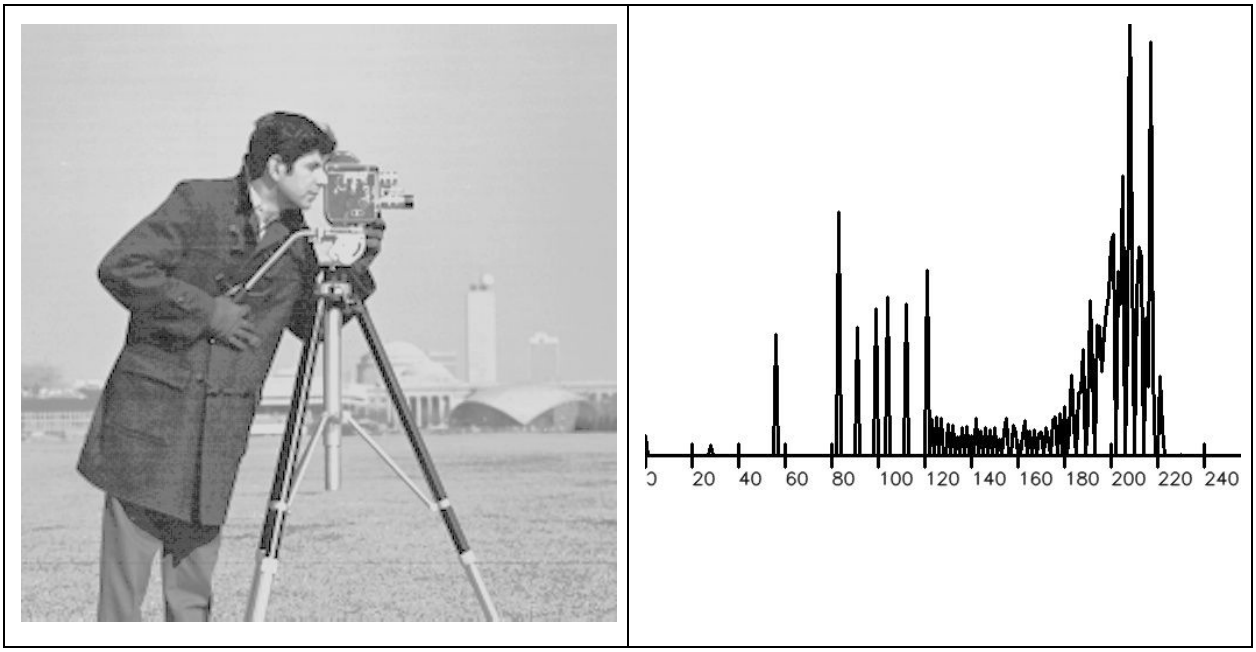


2. Source Target

Histograms before matching

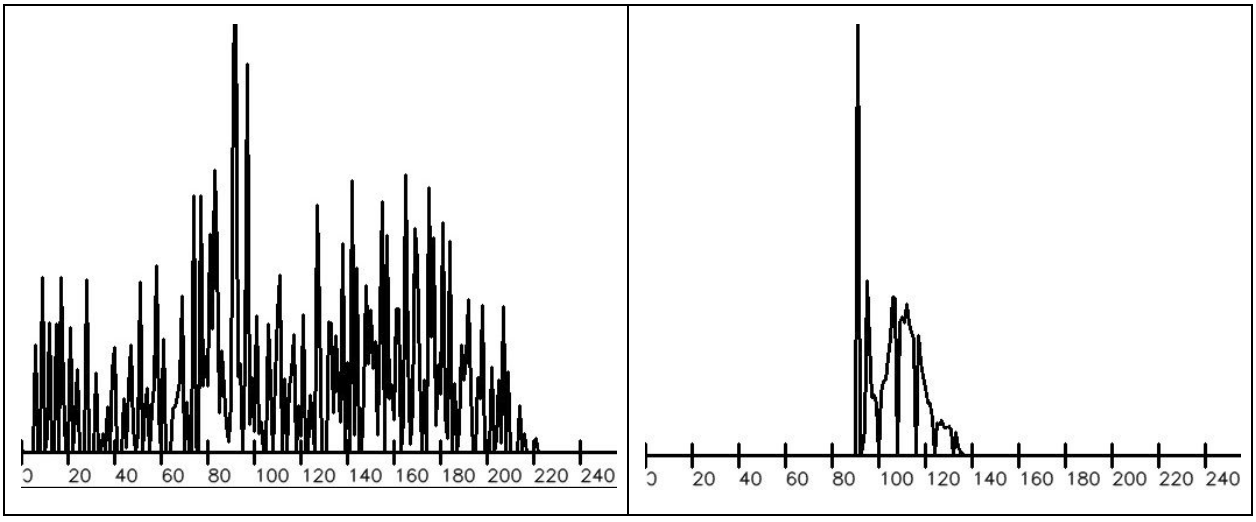


After matching

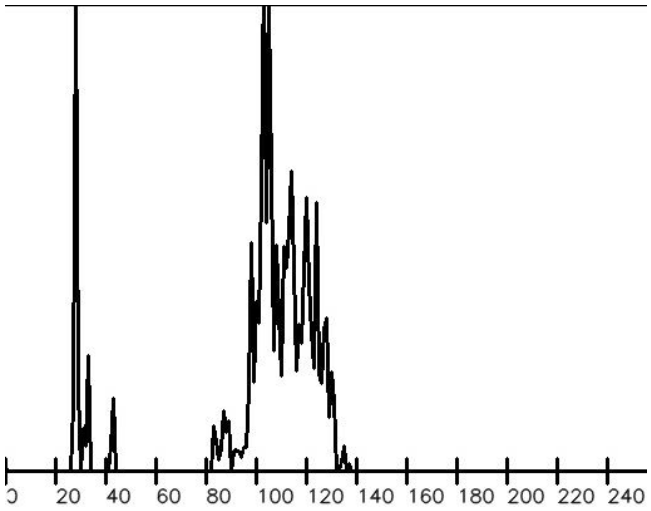


3. Source Target

Histogram before matching



After Matching



Analysis

- In-case of histogram matching and equalisation, we transformed the color images to gray-space and performed all the required operations. Then the transformed mapping is applied to all channels of color image.
- There can be other methods where we can separate the pixel intensities from color space and perform the operations in that intensity domain.
- We are not obtaining a perfectly uniform histogram during equalisation as we are dealing with digital images, and there is loss due to quantization.
- The loss due to quantization is also observed in case of histogram matching as evident above.
- We observed that histogram equalisation increased the contrast of the images in almost all cases.
- Histogram matching can either improve the contrast of the image or degrade it. For example, in the first case, we took lena_color_512 as source and lena_dark_gray as target. As a result, the contrast of input is completely destroyed.
- The histogram plots of color images are obtained after converting them to gray-scale.

References

1. https://en.wikipedia.org/wiki/Histogram_equalization
2. https://en.wikipedia.org/wiki/Histogram_matching#:~:text=In%20image%20processing%2C%20histogram%20matching,specified%20histogram%20is%20uniformly%20distributed.
3. https://www.tutorialspoint.com/opencv/index.htm