Computer Vision

CS – GY – 6643

Histogram Equalization Report

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a. Include a brief introduction and description of how histogram equalization works.

Histogram Equalization:

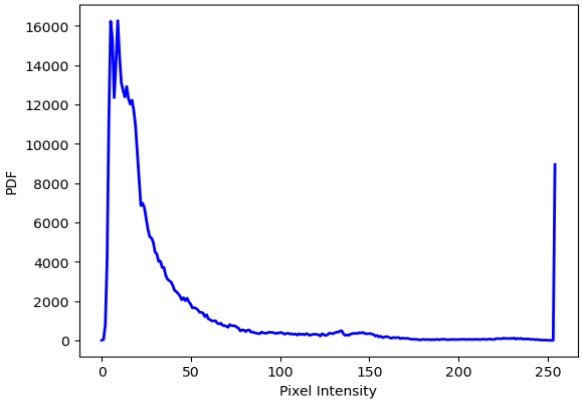
Using a technique called histogram equalization, one can improve an image's contrast by dispersing the intensity values throughout the whole range. The fundamental concept behind histogram equalization is to adjust the pixel intensities so that the image's histogram's cumulative distribution function (also known as the CDF) is represented as a linear function. Through this technique, the intensity values are effectively spread out, resulting in a more uniformly distributed histogram for the image.

Process of Histogram Equalization:

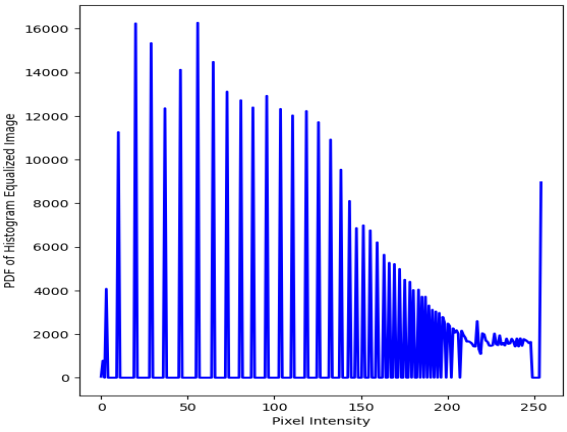
a. Compute Histogram: As an image is given as an input, create a histogram of the input that gives the frequency of pixels at each pixel intensity.
b. Compute PDF: Once histogram is computed, the frequencies are normalized, i.e., each frequency at a pixel intensity is divided by total count of pixels.
c. Compute CDF: With the PDF values, calculate the cumulative sum of counts of pixels. The range of this CDF is from 0 to total number of pixels. Then, calculate the normalized CDF values.
d. Histogram Equalization Enhancement: Each pixel at a particular intensity will be denormalized again, i.e., the CDF of that intensity is multiplied by 255 and placed in the resulting equalized image.

b. Show people.png before and after histogram equalization, and the corresponding histograms (PDFs).

"**people.png**" before the histogram equalization and PDF:



"**people.png**" after the histogram equalization and PDF:

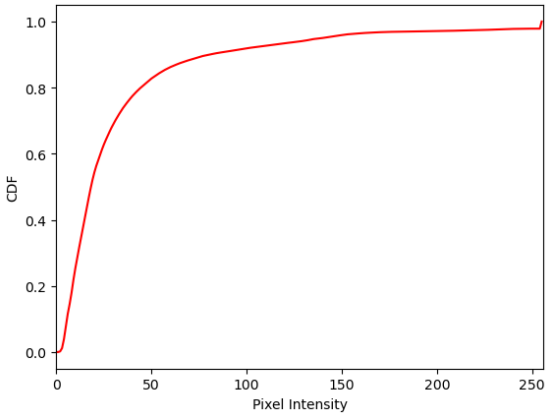


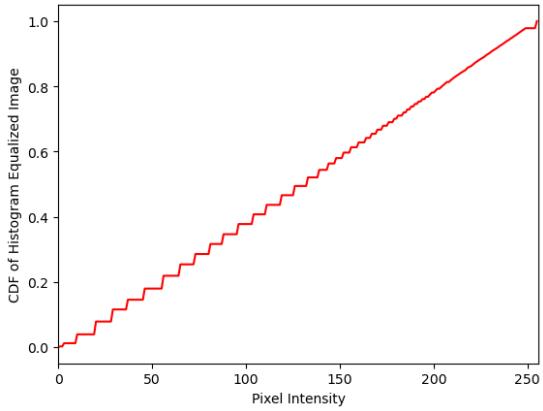
c. Discuss how the image and histogram have changed, and connect it back to your description.

Change in the image:
The original image has a darker shade to it. Once the histogram equalization is applied on the image, the intensity level has an approximately equal probability. The resultant image is now brighter. We can say that the contrast is increased which makes the darker places of the image brighter.

Change in the Histogram:
Initially, the histogram is biased on the left side and then on the rightmost end. This means that there are a lot of dark pixels and very few light pixels. The histogram is not uniformly distributed across the pixel intensity range.
After the histogram equalization is applied on the input image, the pixel intensities have been spread equally along the pixel intensity range. The resultant histogram is uniformly distributed. This is relatively more uniform than the input image's histogram.

d. Show the cumulative distribution function before and after histogram equalization in a side-by-side figure. Describe what you see. Explain the shape of each CDF and relate it back to image contrast and intensity histogram shape.





The Cumulative Distribution Function (CDF) represents the cumulative probability of pixel intensities in an image.

Before Histogram Equalization:

Shape of CDF:

In the input image, the CDF tends to start from 0 and gradually increases. The shape is influenced by the distribution of pixel intensities in the original image.

If the histogram has peaks or biases towards certain intensity levels, the CDF will exhibit a steeper slope in those regions. We can see the slopes being steep between the pixel intensities 0 – 50.

Relation to Image Contrast:

A steep CDF slope indicates regions in the image with high contrast, where pixel intensities are concentrated. Steep CDF slope depicts that there is an abrupt change in pixel intensity. Spikes in the original histogram means that there is a sharp increase in the CDF, indicating abrupt changes in pixel intensities.

After Histogram Equalization:

Shape of CDF:

After histogram equalization, the CDF becomes approximately linear. This linearity signifies a more uniformly distributed set of pixel intensities. There is a periodic increase in slope.

A flat CDF suggests that each intensity level has an approximately equal probability.

Relation to Image Contrast:

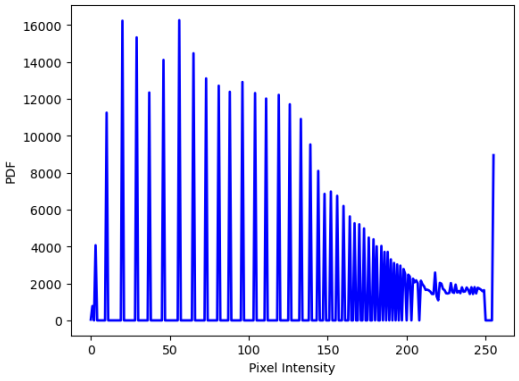
The flatter CDF means an improved contrast in the image. The process of histogram equalization redistributes pixel intensities, stretching or compressing the original intensity range to enhance visibility of details.

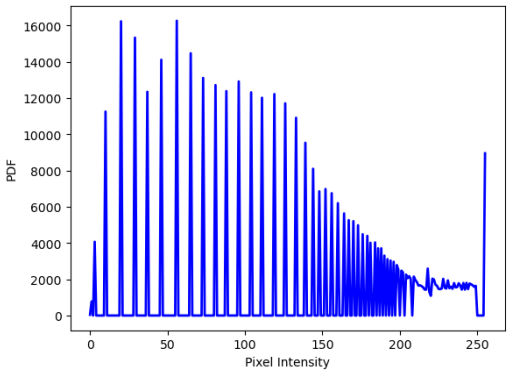
Spikes and valleys in the original histogram are more frequent and evident, resulting in a more frequent update of slope. This results in balanced distribution of pixel intensities, which is reflected in the linear CDF. In the interval 200 – 250, there is lesser spikes and valleys. So we do not find many slope updates.

e. Reapply the histogram equalization procedure on the corrected image. Show and discuss the results.

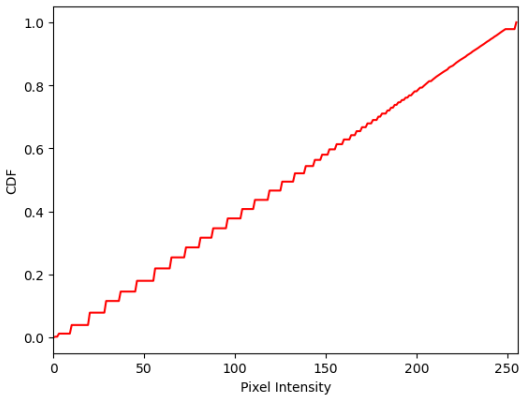
As shown in the comparison, there is no noticeable change when Histogram Equalization is applied on an already equalized image. The method enhances the contrast of the image at the very first time. There is no improvement if applied again to the image. There maybe adverse effects, like saturation, if applied again.

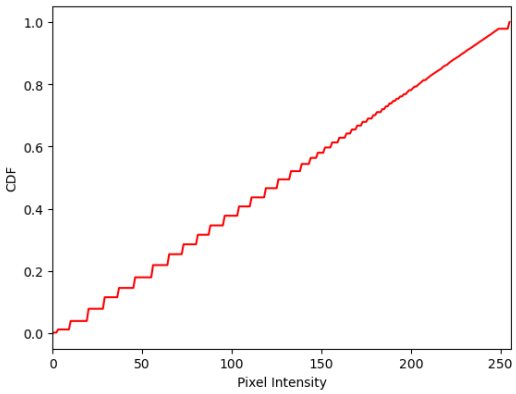
PDFs:





CDFs:





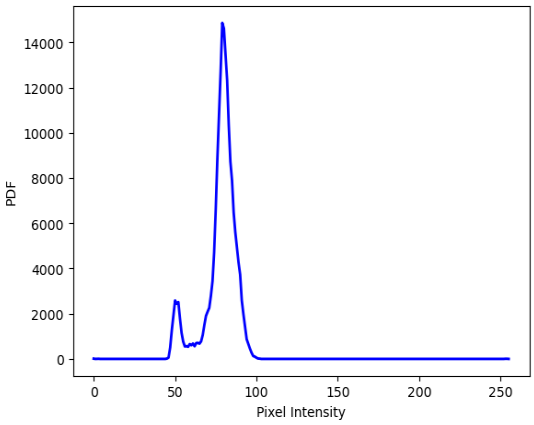
Furthermore, the CDFs and PDFs of the respective images show no difference. From this, we can say that there is no impending adverse effects.

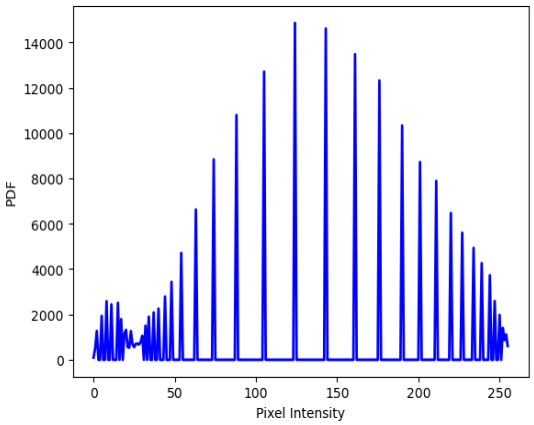
f. Apply histogram equalization to your own low contrast image (greyscale). Show and discuss the results.

New Image:

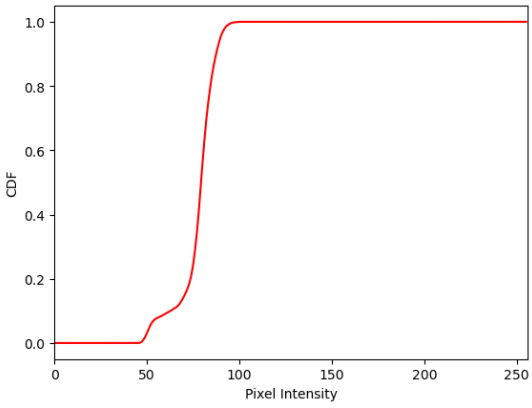
Histogram Equalized Image:

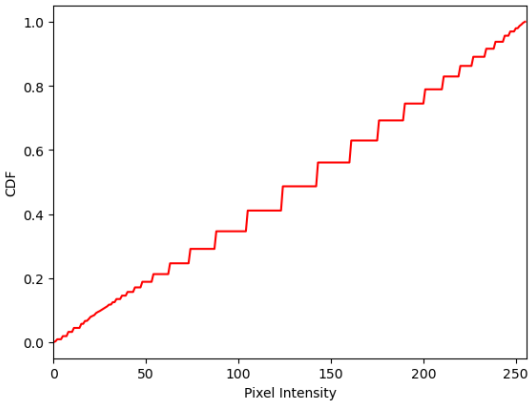
PDFs:





CDFs:





The input low contrast image, considering the PDF, has a lot of pixels within the intensity range 60 – 100 and very less to nil in the remaining range. Considering the CDF, there is a steep increasing slope in the same pixel intensity range, 60 – 100. This means that the image is not definite in terms of pixel distribution across the intensity range.

Upon applying the histogram equalization on the low contrast grayscale image, we can see an evident change in the contrast. There is a noticeable change in the PDF and CDF of the enhanced image. There are multiple spikes and valleys in the PDF, which says that the pixel distribution is performed definitely across the pixel intensity range. Because of this, the CDF has an evident and a periodical increase in the slope. Comparatively, the CDF is linear in the enhanced image. This means that the pixels are distributed across the pixel intensity range equally. the intensity level has an approximately equal probability.