Image Enhancement by Histogram Manipulation

Applied Physics 186 - Activity 5

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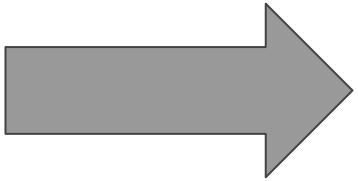
Fig 1. An example of a poorly lit scene from the popular HBO series Game of Thrones. This was a snapshot of a scene from the iconic episode “The Long Night” which was criticized as being too dark for any watcher to make sense of.

Poorly lit images and videos are usually a concern for a number of people. As such, images which are considered either poorly lit and of poor color contrast are usually discarded and are usually retaken.

Histogram manipulation provides an alternative method to treat such images and videos as rather than taking another photo, it aims to correct the general appearances of images using histograms via back-propagation on ideal cumulative distribution function.



Initially, we convert the image from RGB to a grayscale image. We then determine its maximum and minimum gray values and ensure that the maximum is not equal to neither 1 nor 255 and the minimum value is not 0. If ever it does not fit into these requirements, we utilize a different scene

Figure 2. Grayscale image of the input image.

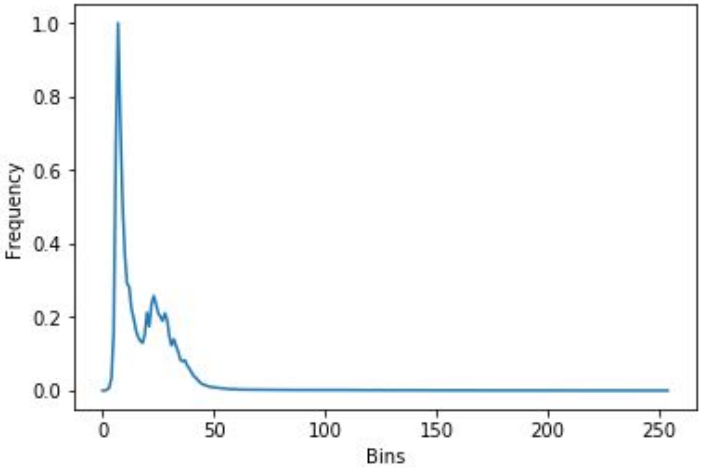
Figure 3. Contrast stretched image of the grayscale image.

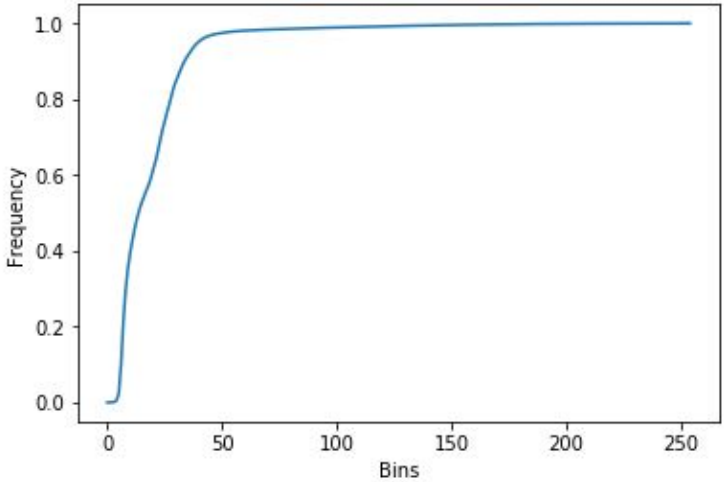
As a means of comparing other image enhancement methods, we first utilize contrast stretching using the following equation:

$$I'(x,y) = \frac{I(x,y) - I_{min}}{I_{max} - I_{min}}$$

Whereas, I(x,y) are the corresponding pixel values of each pixel while I_min and I_max are the respective minimum and maximum values of the pixel values.

Comparison of these two images on the right shows that by using contrast stretching, the resulting image would become slightly brighter. Observing the Night King, we can see that his armor was slightly illuminated towards the middle and we can see it a bit more clearly.





We then determine the histogram with basis on the frequency that each gray value occurs within the image.

Figure 4.(left to right) Normalized Probability Distribution Function (PDF) and Normalized Cumulative Distribution Function (CDF) of the image

Afterwards, we determine the cumulative distribution function or CDF by extracting the probability distribution function from the histogram. We then normalized both of these distribution functions.

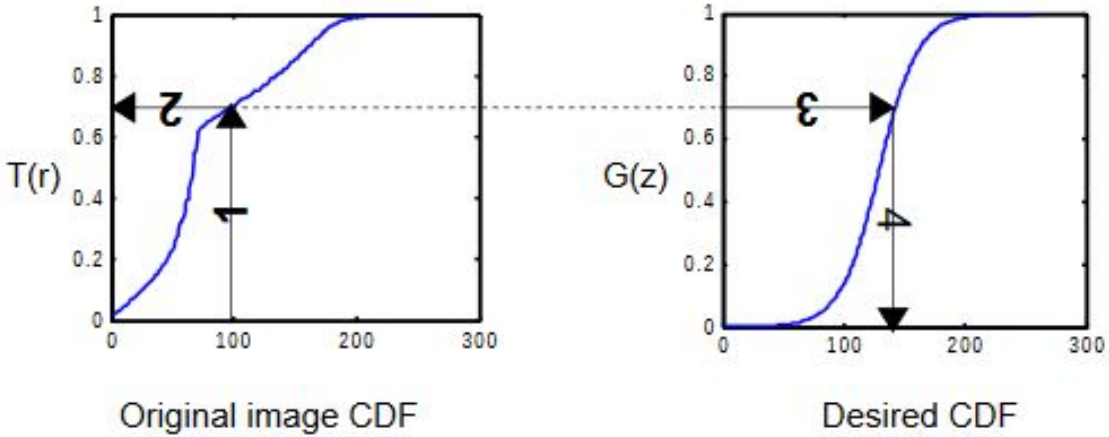


Figure 4. A diagram on how the back-projection method works. The image on the right is the CDF of our original image, while the image on the right is the desired or the ideal CDF which we want to mirror onto our final image. The initial step is to initialize a loop which scans through each pixel value of the image. For each iteration, it maps the corresponding CDF value for each pixel. Afterwards, the corresponding CDF value is projected onto the ideal CDF plot. We then create a dummy matrix which would contain pixel values equal to that of the desired CDF.

Using various CDFs as the desired CDF, we used back-propagation on our snapshot of the Game of Thrones episode as to explore which CDF would suffice as a way to clarify or enhance the image in question. The resulting images and plot are as follows:

Image Enhancement using various desired CDFs

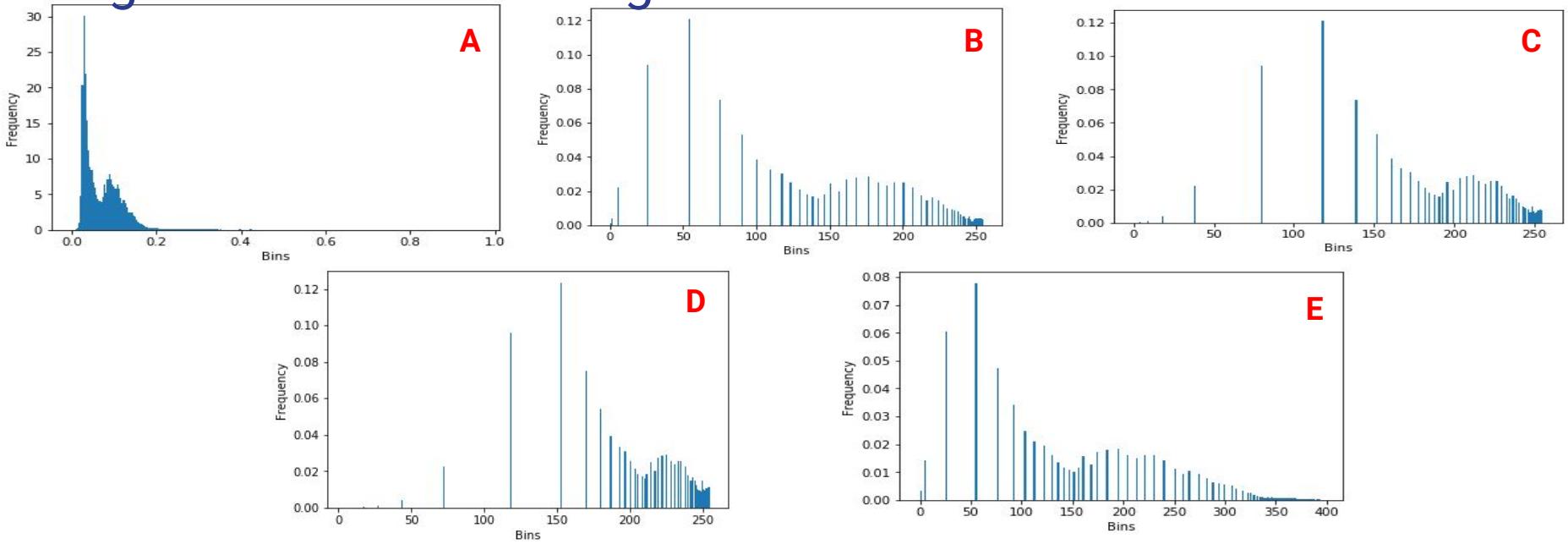


Figure 4. Corresponding histograms using various desired CDFs as a basis for histogram manipulation. (A) Original Image (B) Linear CDF (C) Square CDF (D) Cubic CDF (E) Sin Function

Image Enhancement using various desired CDFs

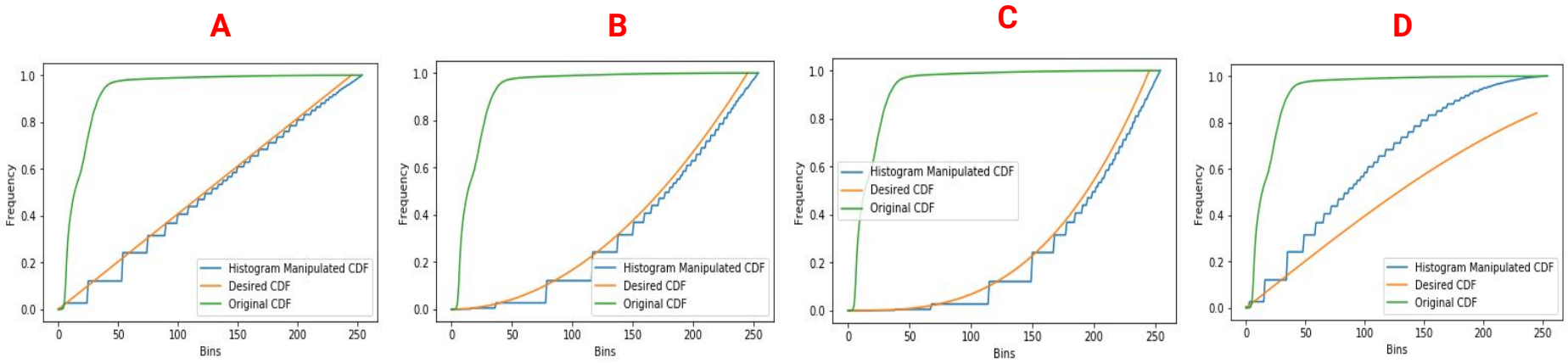


Figure 5. Comparison of histograms various desired CDFs acquired using a desired CDF of (A) Linear CDF (B) Square CDF (C) Cubic CDF (D) Sin Function

Image Enhancement using various desired CDFs

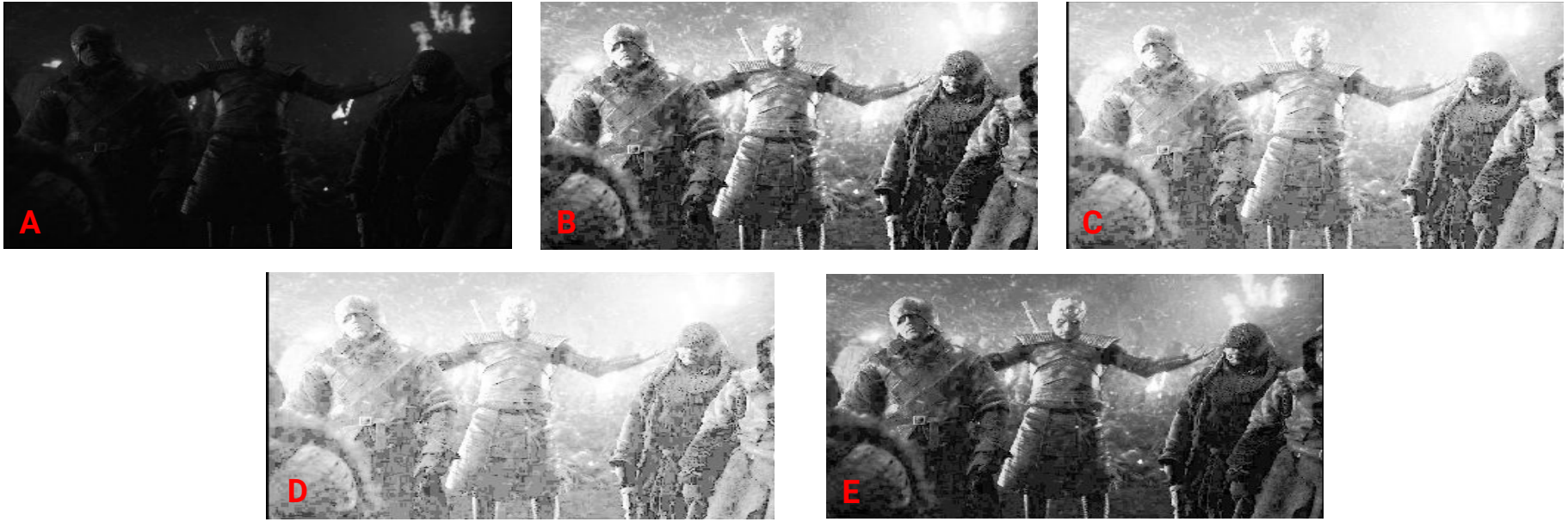


Figure 6. Image transformations using various desired CDFs.
(A) Original Image (B) Linear CDF (C) Square CDF (D) Cubic CDF (E) Sin Function

Image Enhancement using various desired CDFs

From our observations, we saw that using different CDFs had different on the input image, whereas,

A) Linear CDF
   a) Images were illuminated by a significant amount. A large amount of detail was uncovered such as the snow in the background was now observable as well as various objects that were previously hard to see. Looking at its corresponding CDF comparison, we can observe that by using back-propagation we were somehow able to mimic the general shape of the desired CDF. Increasing the amount of bins would resolve the difference in shapes.

B) Square and Cubic CDF
   a) Using power functions such as these two, the resulting images were increasingly more brighter as we increase the power. From our observations, we also noticed that the shadows were now fading and were harder to distinguish as the amount of brightness overwhelmed the contrast between the two. Looking at their respective histograms, we observed that the frequencies were more evenly distributed along the range of bins in comparison to the input image. In addition, he had also noticed that as we increase the power function, larger frequencies would tend toward the larger valued bins. Similar observations with the linear CDF were found ,whereas, the general shape of the CDF was outlined by the resulting CDF on the tradeoff for the resolution of the curve.

- Sin Function
    - Backpropagation using the Sine Function as the desired CDF yielded the best results, whereas, a more even distribution of the brightness and shadows is observed. In contrast to brighter image yielded the linear CDF, the image generated by the sin function was able to retain information such as the shading and shadows within the image. This may be attributed to the larger spread of bins and the distribution of frequencies within the range of bins. Although some discrepancy was observed for the CDF comparison, this may be attributed to the limitations of using numpy and its accuracy for computing such values.

CONCLUSION

- Using different CDFs would yield different effects when using histogram manipulation on images.
- Histogram manipulation is an effective method for analyzing and enhancing images.
- Not all bad pictures should be discarded, we can try to salvage them using image processing.

Technical correctness - 4
Quality of presentation - 4
Initiative - 1