

# CS371 Digital Image Processing

## Exercise 2

### Point-wise Intensity Transformations

Alexandros Angelakis  
csd4334@csd.uoc.gr

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## 1 Discussion

The task of this assignment was to transform cardiac magnetic resonance images (MRI) in a way to emphasize areas of interest. In order to do that, we used three different types of transformations. The first one is the Gaussian, the second one is the Rice and the third one is based on the histogram equalization. Let's plot some images and compare the results.

Let's take for example this image below.

First of all, let's compare the MATLAB's histogram with mine by plotting them together.

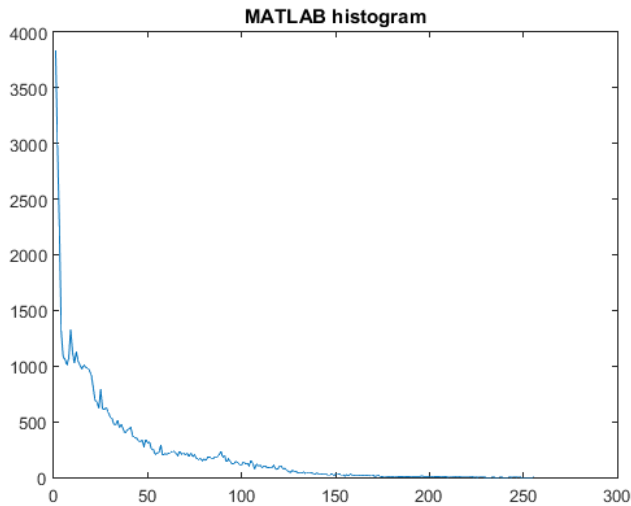


Figure 1: MATLAB's histogram

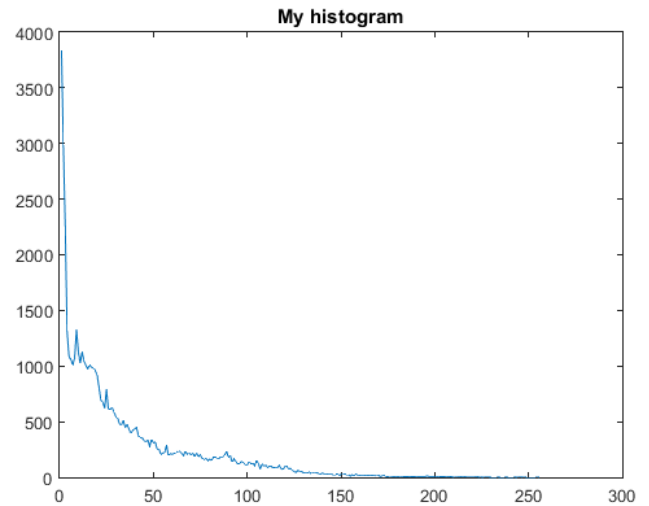


Figure 2: My histogram

We can not see any differences between those two plots, but if we look at the vectors in MATLAB, we can actually see that the 255th value of those two are different, making the Root Mean Squared Error between my pdf and matlab's to not be equal to zero, but a very small number,  $1.5985e-06$ . This however is a minor difference, we can not see any changes if the pixel with value 255 is one or zero. Now that we compared that, let's start commenting on our transformations.

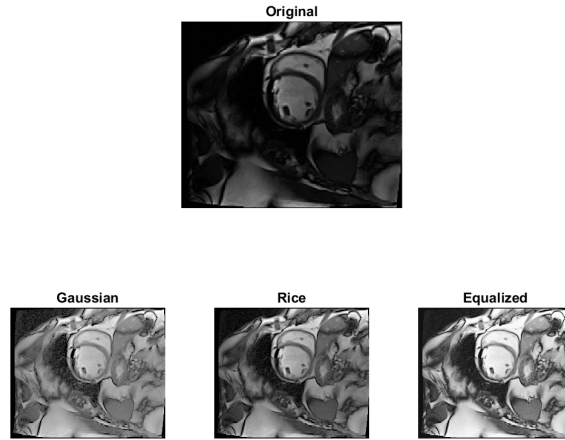


Figure 3: A0S9V9

The original image is really dark, we can not see any important details, neither we can see any of the areas of interest. By using the Gaussian transformation, we can see that the image is brighter but there is some blur, noise, in the very dark areas of the images. Despite that, it managed to show some of the details of the original image pretty good. As we can see from the Rice transformation, the image is more detailed but is also darker than the Gaussian one, but the noise of the Gaussian is now improved. We can confidently say that the Rice transformation is doing a better job for our image. Now let's see how the histogram equalization transformation performs. As we can see, the "equalized" image is a lot brighter than the other ones. The noise is the same as the Rice one, and the details are more visible. For this image, the best transformation in order to emphasize areas of interest is by using histogram equalization. Let's take a look at their transformations.

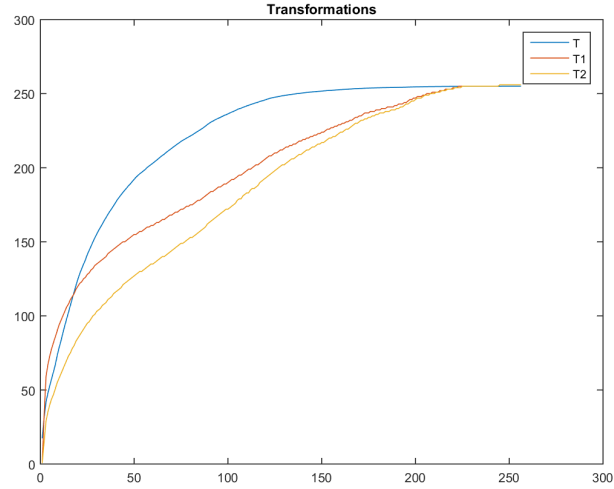


Figure 4: A0S9V9

By looking at the plot with the transformations, we can see that T (histogram equalization) begins to grow very quickly, compared to the other two transformations. This proves what we said before, that the histogram equalization makes the image brighter than the other two. We can also see that T1 (Gaussian) is growing a little bit faster than the T2 (Rice), so this is why the transformed image with the Gaussian is slightly brighter than the Rice one.

This happens because the Gaussian Distribution has higher values in the center of its values, unlike Rice that has higher values at the beginning. That means that the Rice distribution increases mostly the dark pixels (between 0-100), that's why the transformed image using the Rice distribution is darker, unlike the Gaussian where it increases the pixels with values between 100-150.

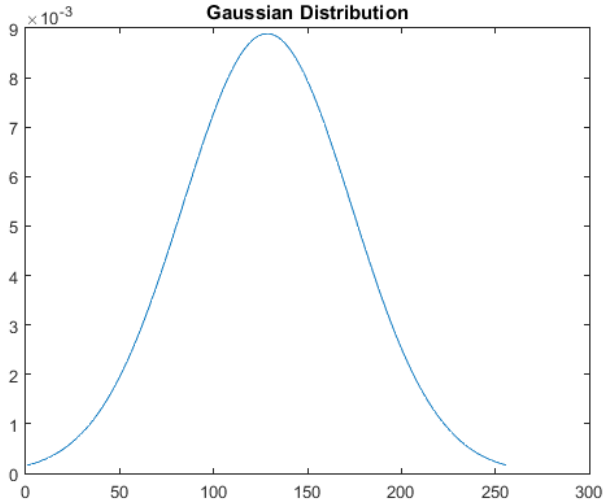


Figure 5: The Gaussian Distribution

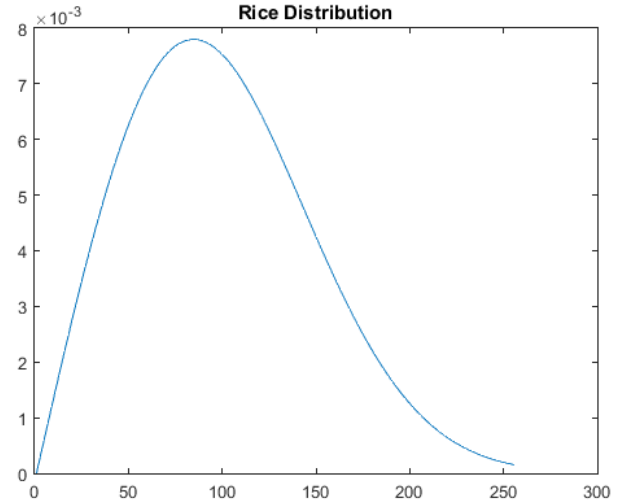


Figure 6: The Rice Distribution

Finally let's take a look at the histograms of the transformations and the original image.

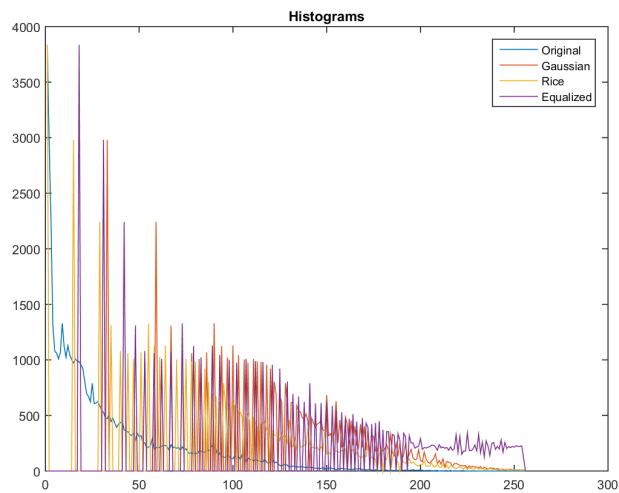


Figure 7: A0S9V9

We can see that the values of the original image are mostly at the dark pixels, while for the transformations, the values are more spreaded. That means that our image now is not mostly dark but we increased the insensity from some higher pixels in order to make out the details of the image and to emphasize any areas of interest. If we look close at the plot, we can see that the histogram of the equalized image (purple) is more evenly distributed in the x axis than the other two distributions.

Now let's take a look at a more brighter image and use the transformations to see how they perform.

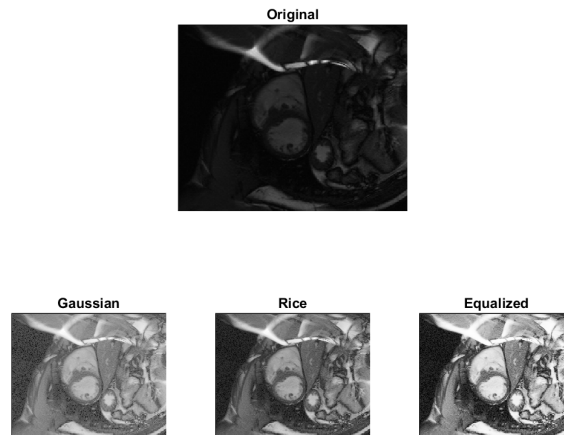


Figure 8: A4J4S4

The same goes for this image that has a bright area on the top. Although, we can see that the transformed images around that area have less details. We can say that the images in that area a little bit faded. All the transformations work perfectly for this image, showing all the details that can not be seen in the original image nonetheless. Because of the fact that the "equalized" image is a lot brighter than the other ones and has higher contrast, the Rice transformations is the best in this case.

All the things we said should be seen in the plot with the transformations.

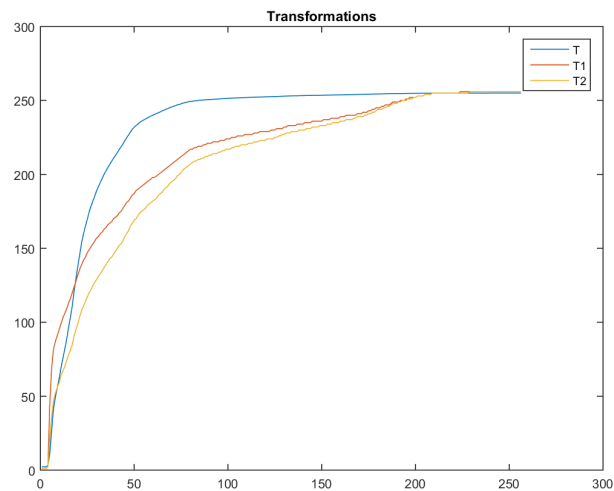


Figure 9: A4J4S4

As we can see, yes, it indeed shows what we've said. The T transformation (histogram equalization) makes the image brighter because it grows faster than the other two, the T1 (Gaussian) is the next more brighter and the Rice is the less brighter image.

Finally, the histograms of these images can be seen in the plot below.

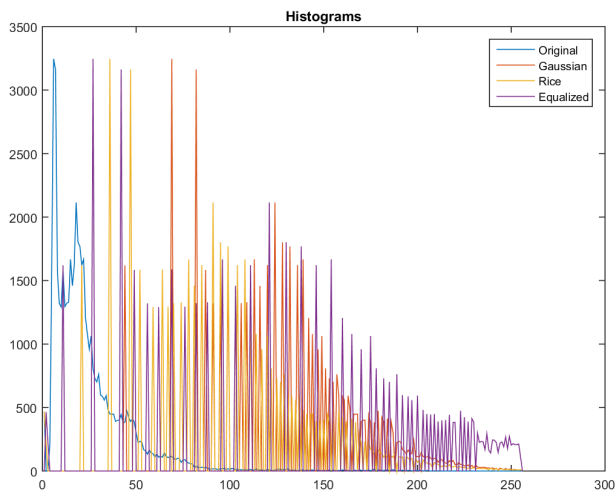


Figure 10: A4J4S4

Again, most of the pixels have very low values (near 0, dark) and by using the transformation we again spread the histogram for all the values.

The same goes for every other MRI, so I'm not going to explain and comment every image output.

For more examples, take a look at the "Demonstrations" section, where I have the plots for every image, transformation, histograms and CDFs.

## 2 Demonstrations

### 2.1 Images

In this section we can see all the images with their transformed ones.

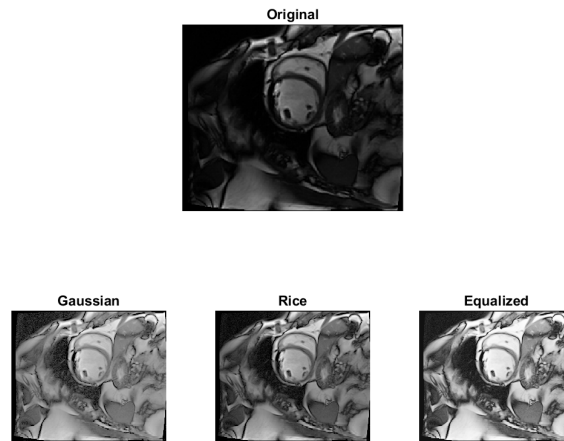


Figure 11: A0S9V9

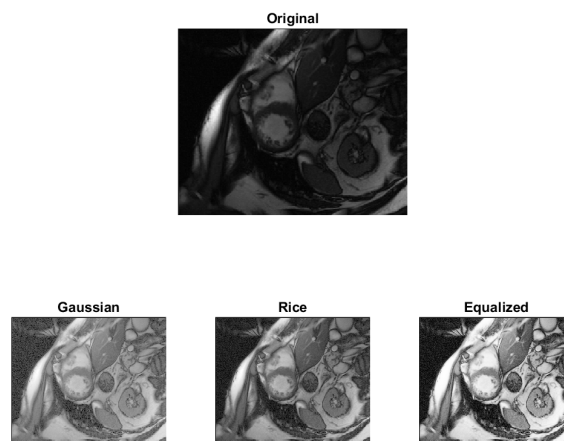


Figure 12: A2C0I1

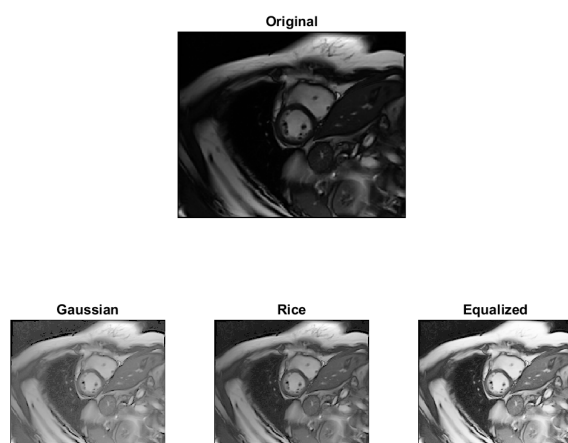


Figure 13: A2N8V0

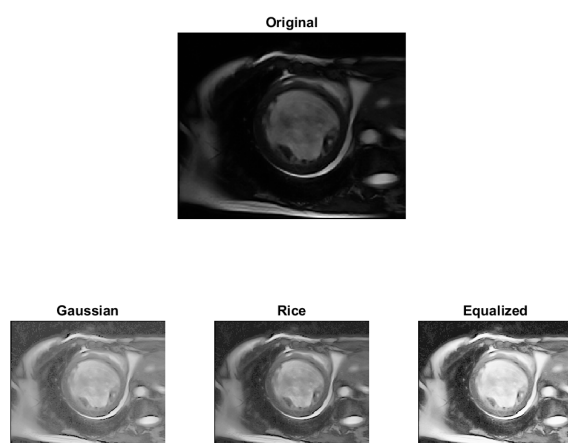


Figure 14: A4B5U4



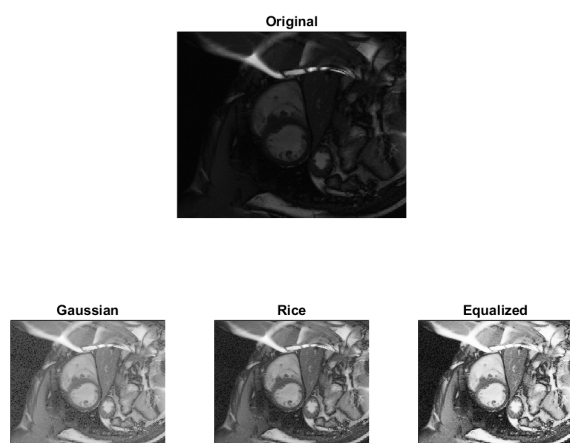


Figure 15: A4J4S4

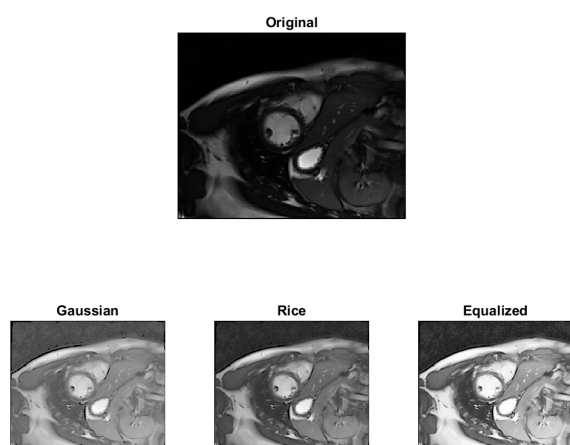


Figure 16: A4U9V5

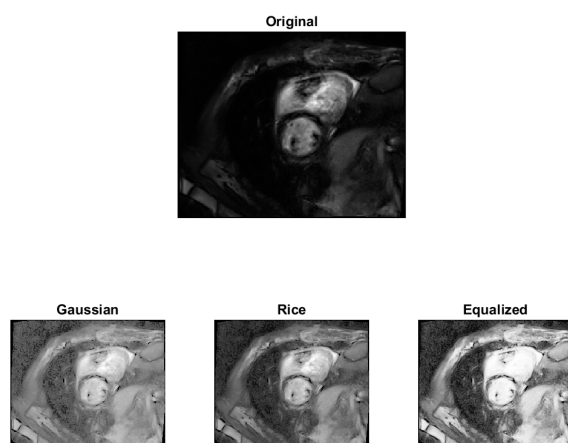


Figure 17: A7O4T6

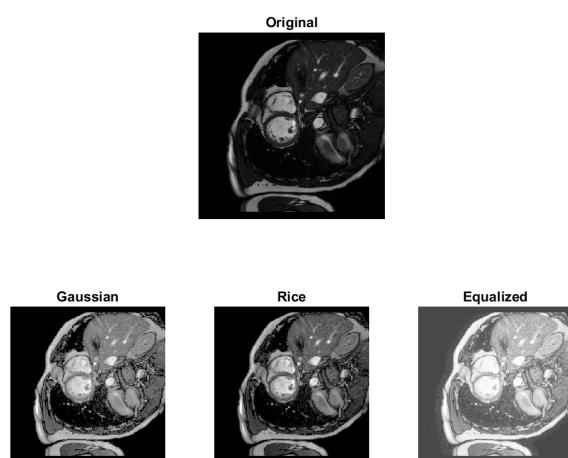


Figure 18: A9J8W7

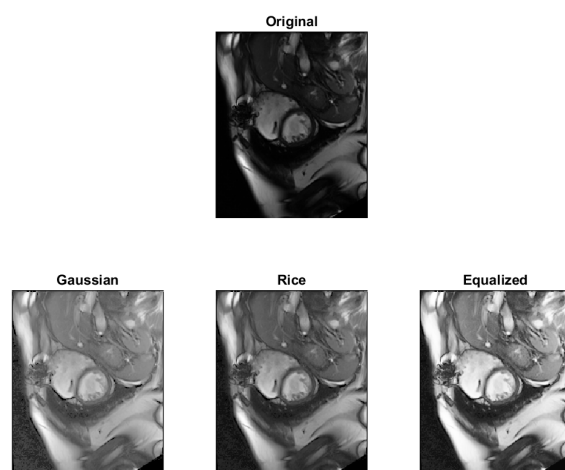


Figure 19: B0I2Z0

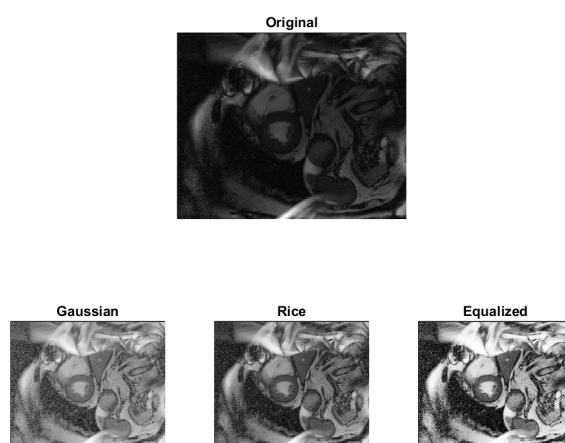


Figure 20: B2D9M2

## 2.2 Transformations

Here we can see the transformations for all the images.

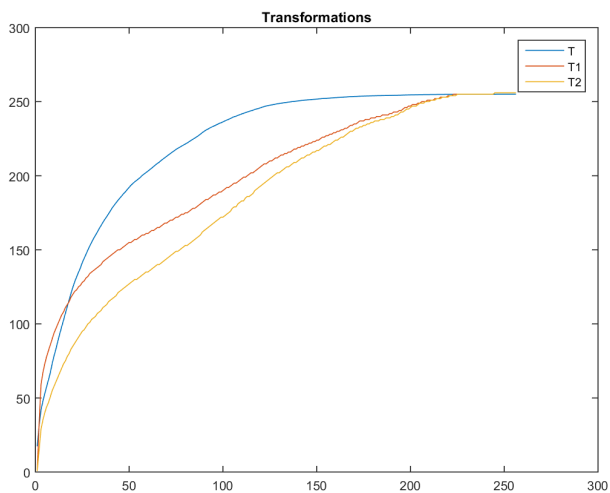


Figure 21: A0S9V9

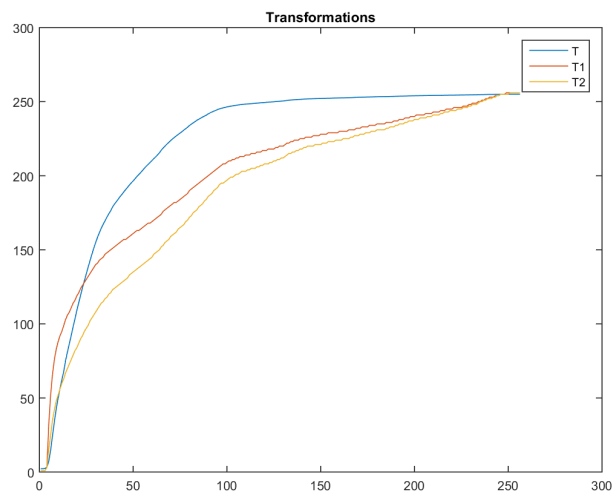


Figure 22: A2C0I1

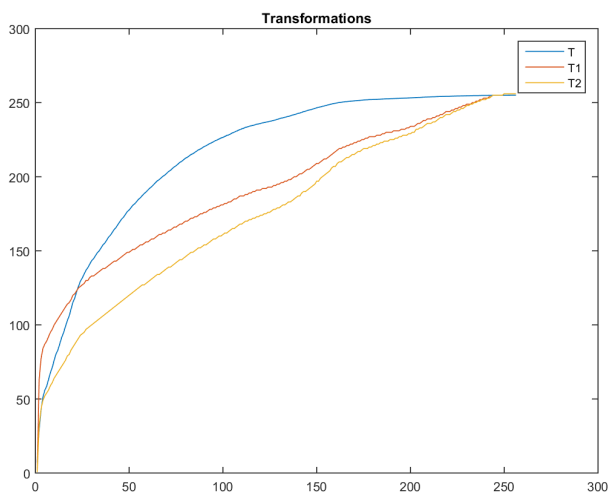


Figure 23: A2N8V0

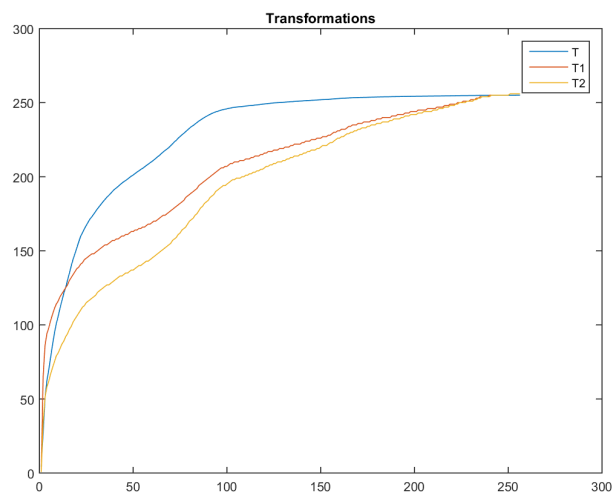


Figure 24: A4B5U4

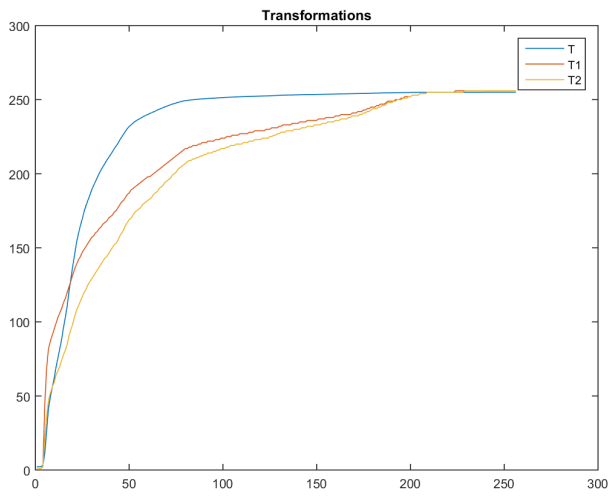


Figure 25: A4J4S4

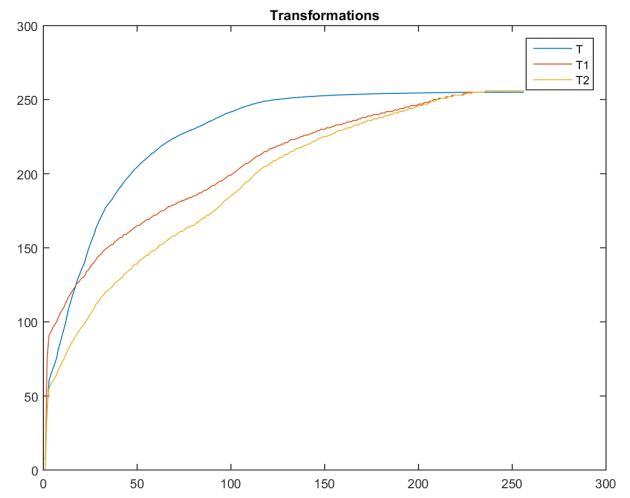


Figure 26: A4U9V5

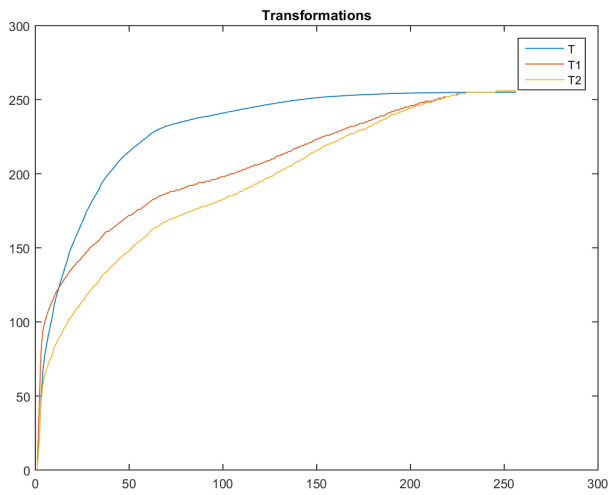


Figure 27: A7O4T6

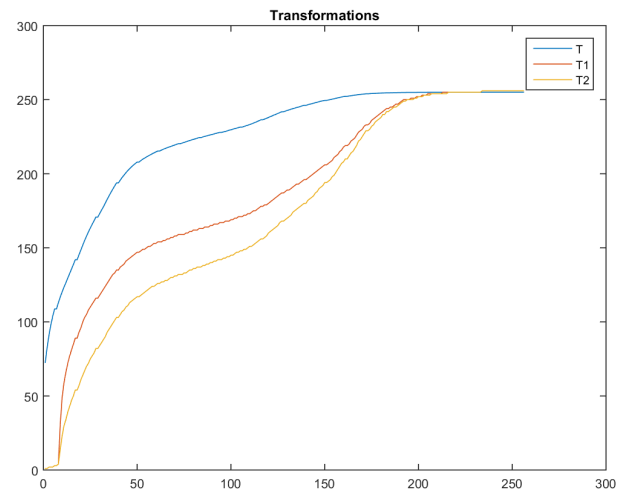


Figure 28: A9J8W7

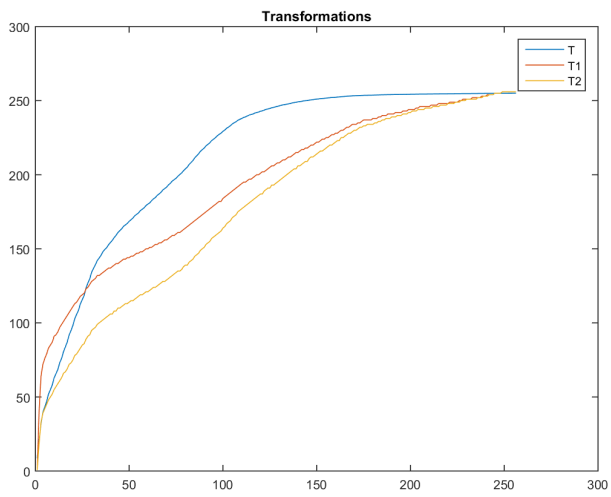


Figure 29: B0I2Z0

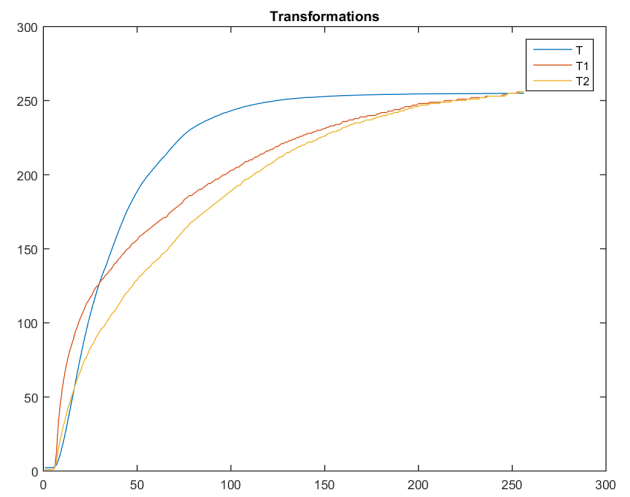


Figure 30: B2D9M2

## 2.3 Histograms

Here we can see the histograms for all the images and for each transformation.

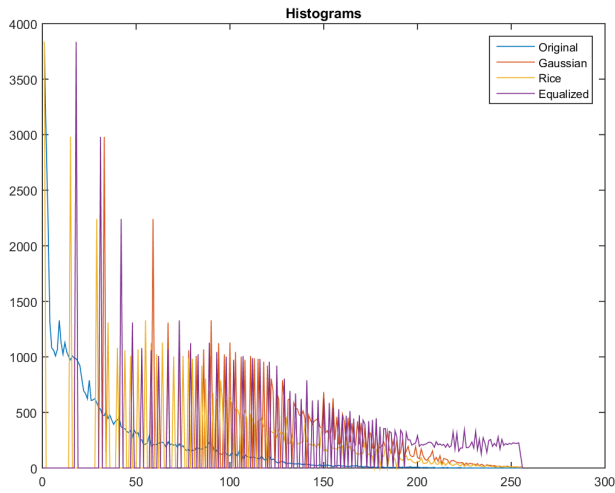


Figure 31: A0S9V9

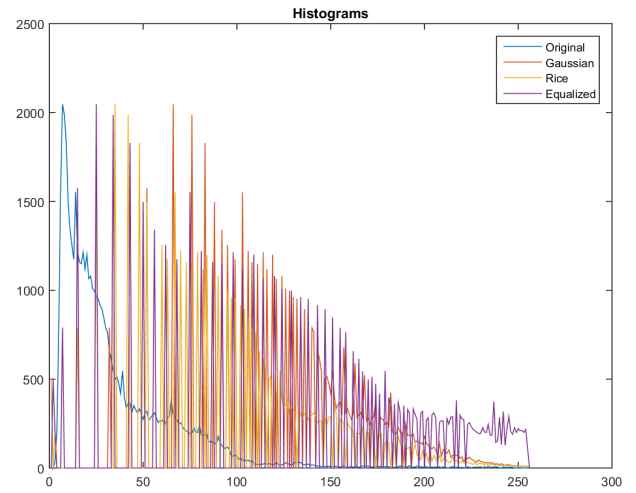


Figure 32: A2C0I1

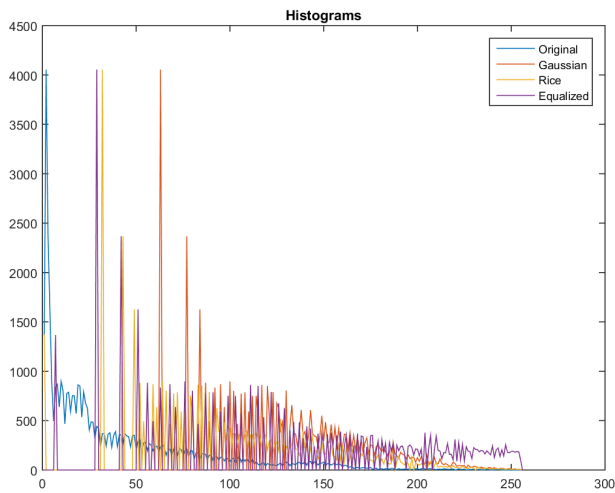


Figure 33: A2N8V0

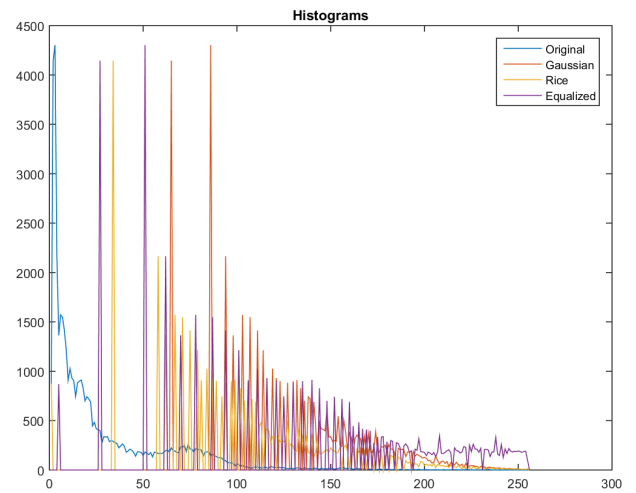


Figure 34: A4B5U4

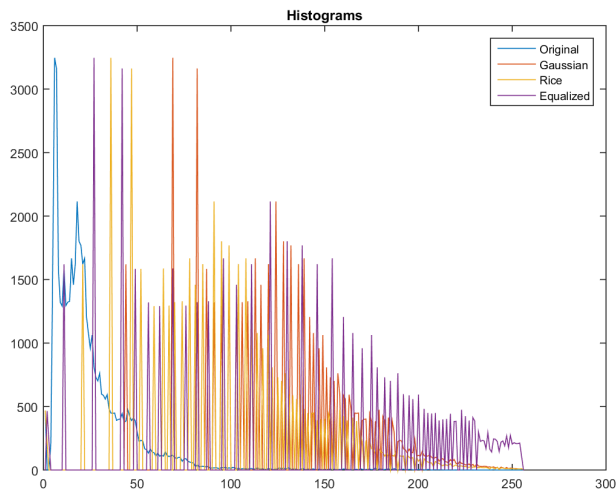


Figure 35: A4J4S4

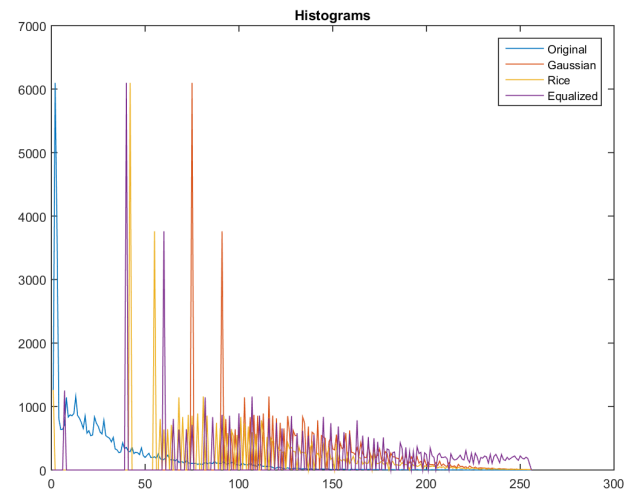


Figure 36: A4U9V5

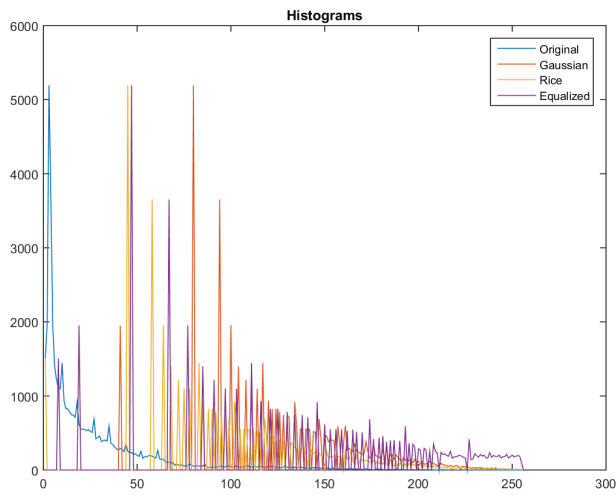


Figure 37: A7O4T6

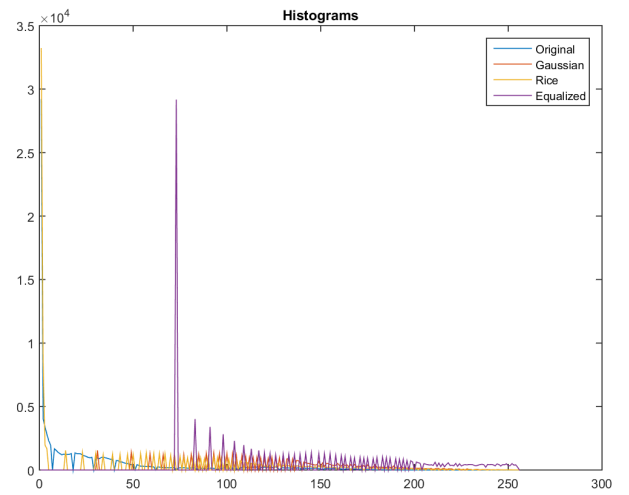


Figure 38: A9J8W7



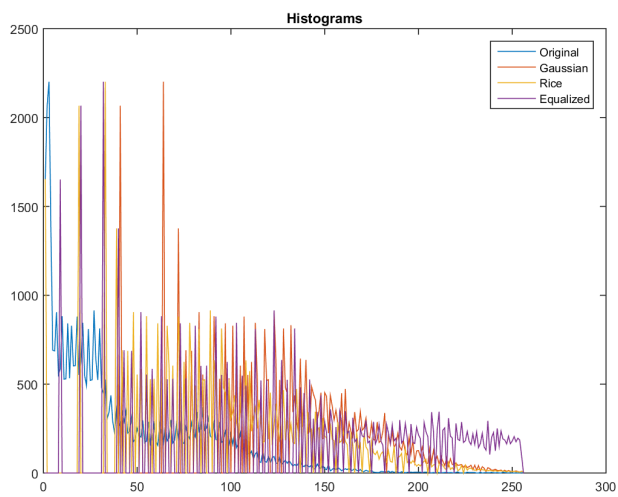


Figure 39: B0I2Z0

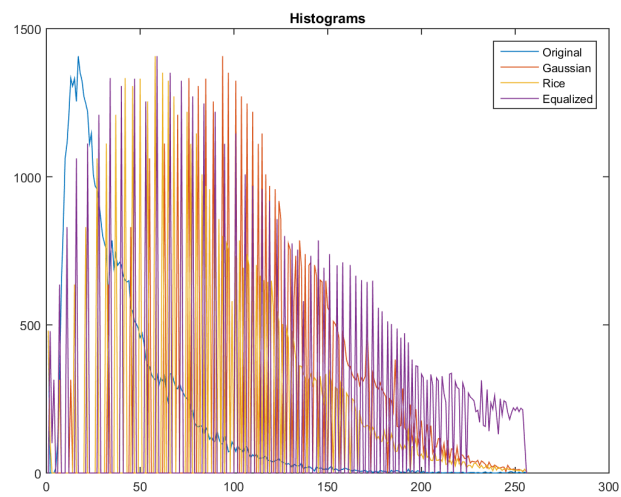


Figure 40: B2D9M2

## 2.4 CDFs

Here we can see the Cumulative Distribution Functions for all the images and for each transformation.

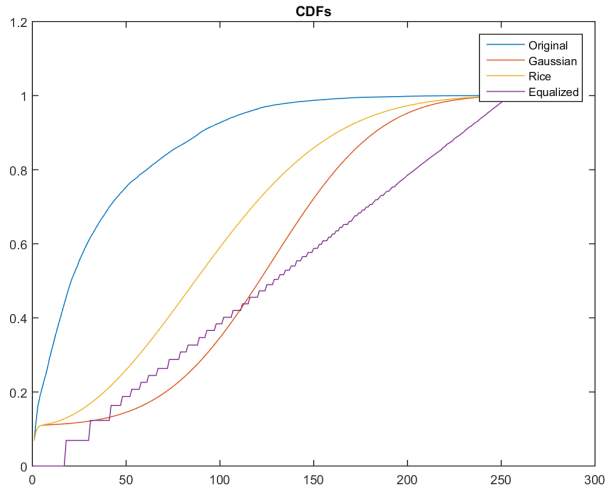


Figure 41: A0S9V9

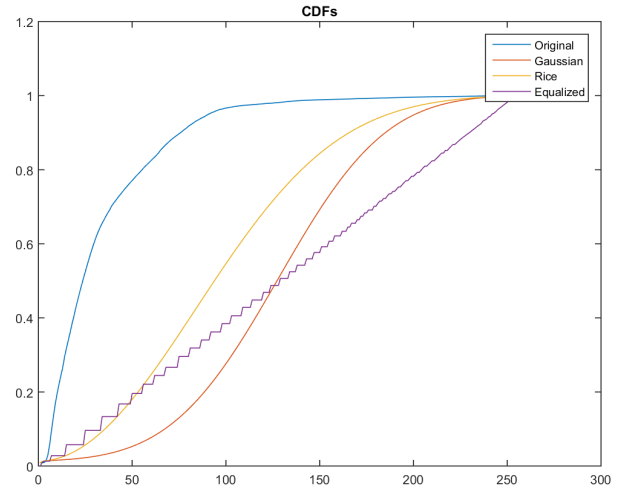


Figure 42: A2C0I1

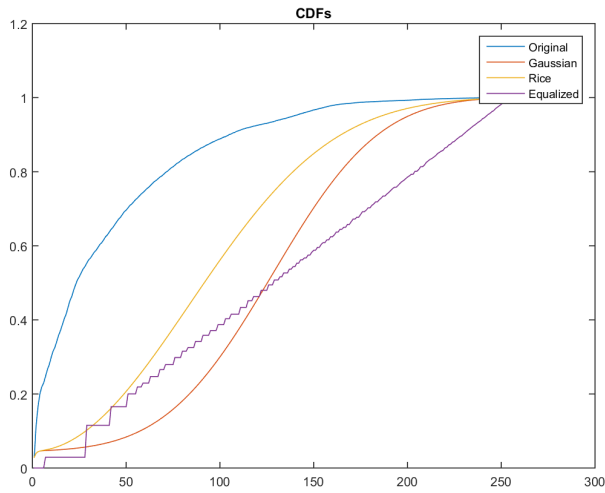


Figure 43: A2N8V0

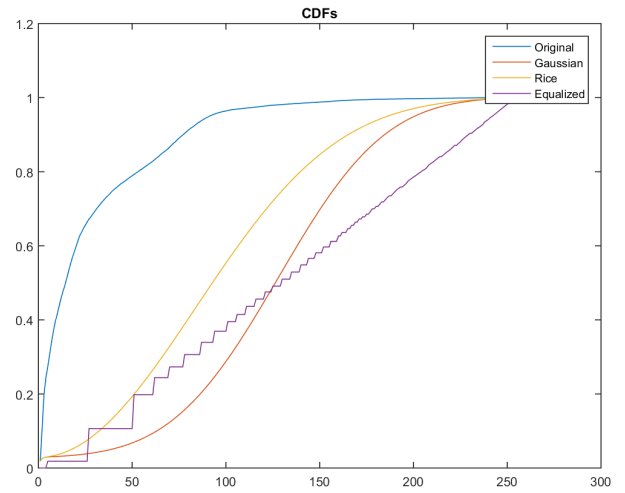


Figure 44: A4B5U4

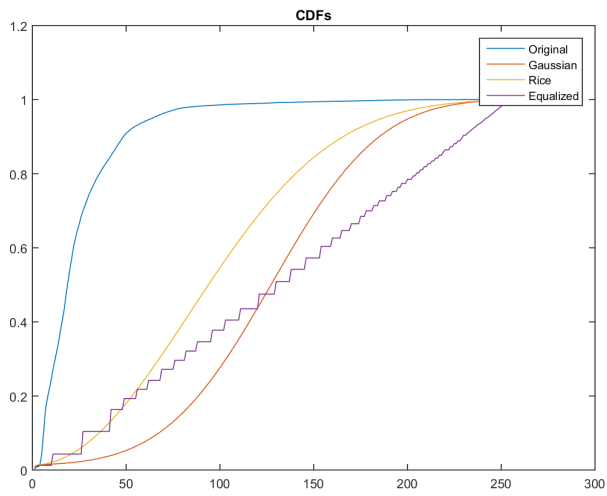


Figure 45: A4J4S4

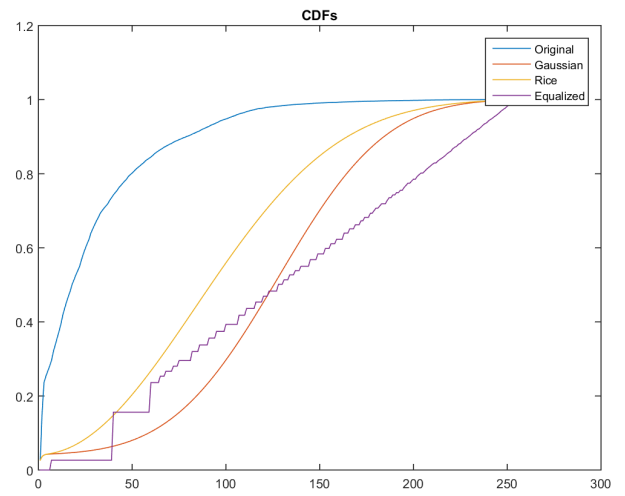


Figure 46: A4U9V5

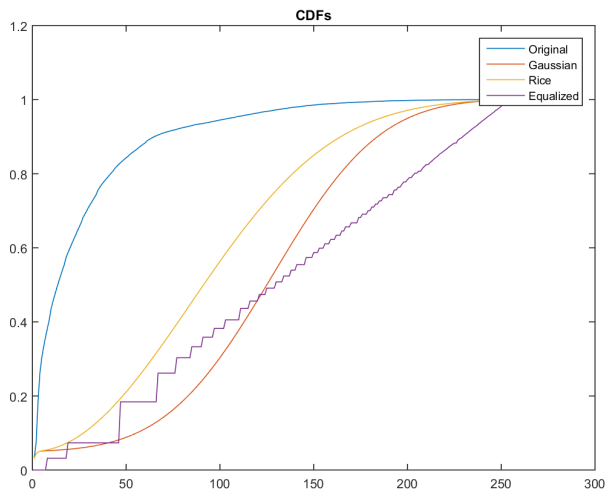


Figure 47: A7O4T6

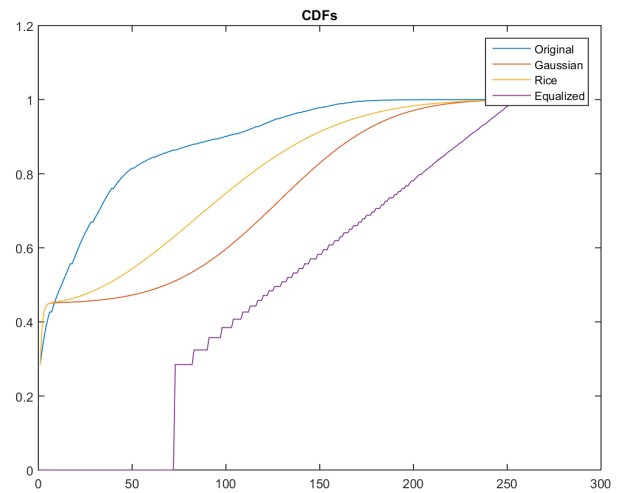


Figure 48: A9J8W7

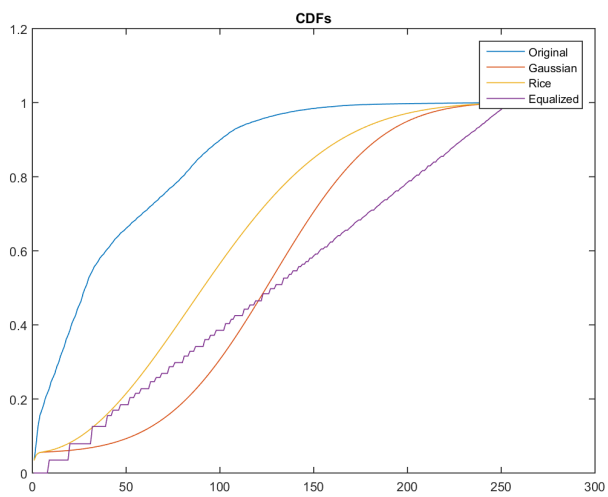


Figure 49: B0I2Z0

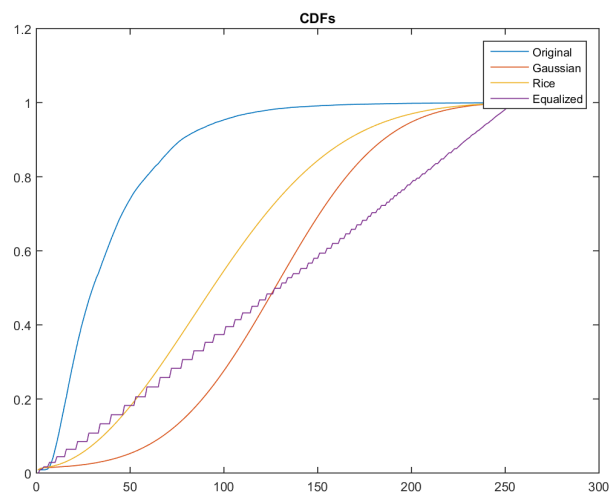


Figure 50: B2D9M2