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Restoration of a Poorly Exposed Images

Bi-Histogram Equalization

In this method, the histogram of the original image is separated into two sub histograms based on the mean of the original image. The two sub-histograms are equalized independently by using the intensity value of the pixels.

Let the mean of gray be Im and assume that Im ranges {0,L-1}, Based Im, the image is separated into sub-images,fi and fj.

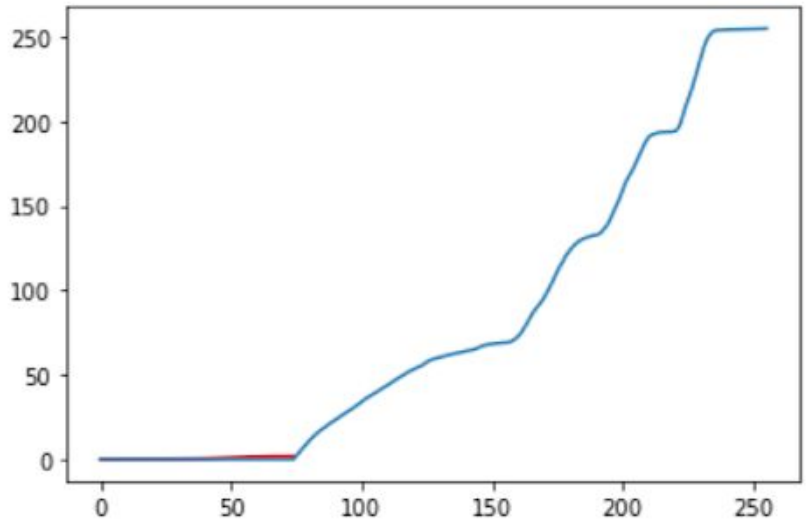
fi={f(x,y)<=Im}

fj={f(x,y)>Im}

Now find the probability density function of each sub-images fi and fj. After that, find the cumulative density function of each sub-image equalize each sub-image independently using histogram equalization. Merge the two sub-images after equalization. In doing so, the equalize some of the sub-images in their ranges toward the mean and others away from the mean, depending on respectives histogram. Thus the resulting equalized sub-images preserve the overall mean brightness.

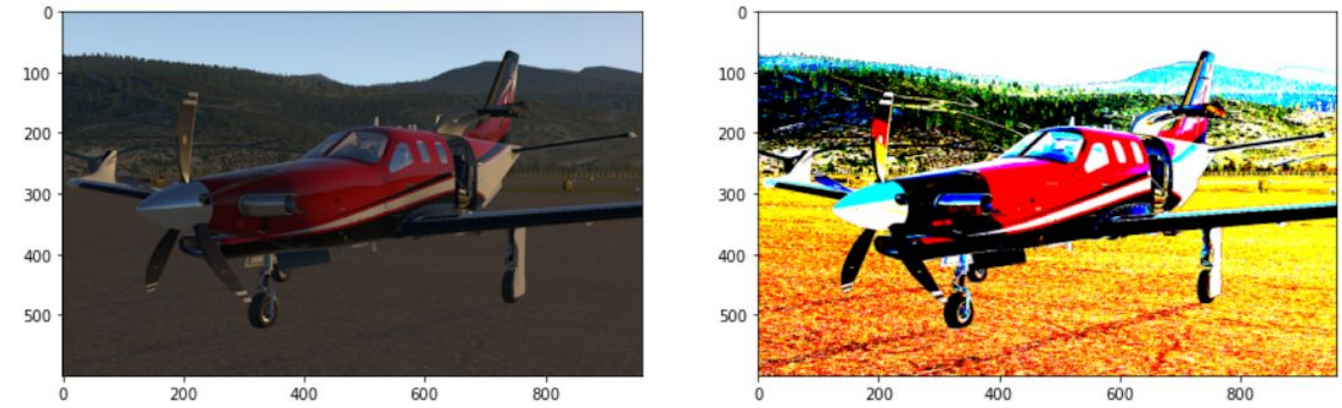
Drawbacks.

The main drawback of this method is that it does not improve the local. Also when equalizing, the fi is supposed to be equalized using Im and fi by 255 since this is the highest gray value in the images. But this is not the case sometimes. When you look at the plot of the two sub-images below, where the red curve is for fi and light blue for fj. For you to get a better image, the value that you equalize fi has to be something that makes the two curve merge together.

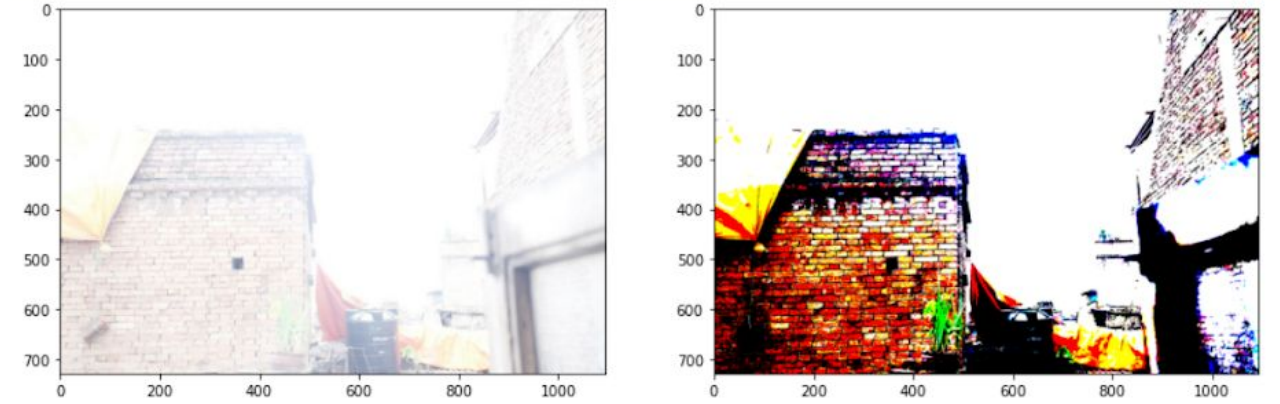


Result

As you see below, on the right side is the output images. And you can see some of the fine details that were initially missing from the original images like the wheels track, the winding road on the hill and differentiating the forest and hill behind it

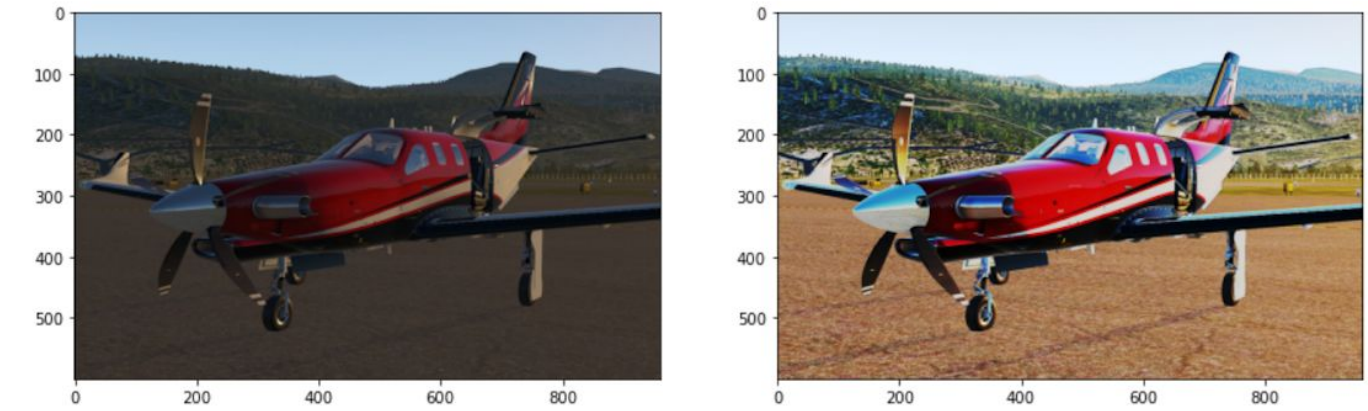


Result of underexposed image



Result of over Exposed image

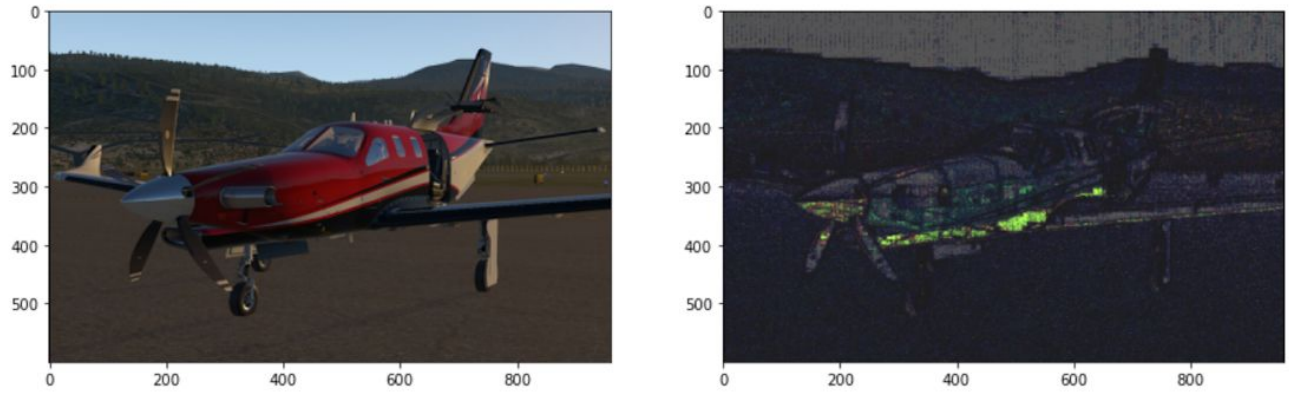
This method perform also better than global histogram equalization as you the result of global histogram equalization below



Result of global histogram equalization

Other methods,

The other method I tried was local histogram equalization. This method did not turn out the way I expected. The image became darker even as you can see from the figure below.



Result of local histogram equalization

Instruction on how to run the code.

1. Code is in notebook(ipynb). Download it and run on python notebook.
2. The test image should be in the same folder as the notebook file running the program.
3. Changes the image in the code from the top.
4. For a better result, try changing the value 1.8 in for two curves to merge as I explained in the drawbacks.

```
# numerator & denomenator
nj1 = (cs1 - cs1.min()) *1.8
```

5. Then you will have a result display for you.

References

1. **N. Sengee, A. Sengee and H. Choi, "Image contrast enhancement using bi-histogram equalization with neighborhood metrics," in IEEE Transactions on Consumer Electronics, vol. 56, no. 4, pp. 2727-2734, November 2010, doi: 10.1109/TCE.2010.5681162.**
2. **Z. Yao, Z. Lai, C. Wang and W. Xia, "Brightness preserving and contrast limited bi-histogram equalization for image enhancement," 2016 3rd International Conference on Systems and Informatics (ICSAI), Shanghai, China, 2016, pp. 866-870, doi: 10.1109/ICSAI.2016.7811072.**