Image Enhancement

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Abstract

In this project, an image is enhanced in multiple steps. Mainly three stages are implemented - Denoising, Edge Detection and Contrast Enhancement. First stage is noise reduction of image. Noise of the image has been reduced whether the given image contains noise or it is de-noised. Next stage is edge detection. To perform better enhancement, we need to detect certain edges to differentiate darker and lighter part of image. Aim of this operation is to find boundaries of distinct objects in the image and to obtain discontinuities in brightness. Blurred image has been subtracted from the original image. This process will sharpen the image. Further stage is contrast enhancement which produces more clearer image. Contrast enhancement is implemented here by Histogram equalization. Thus, Image has been enhanced after passing through multiple stages and what we get as a final output is a clearer and better-quality image.

1. Introduction

1.1) Problem Statement -- Since a normal image is not clear and it may not show some useful information or its brightness level seems inappropriate, then to get rid of such problems, we perform image enhancement to get a better and clearer image.

1.2) Why this topic was chosen --

1.2.1) To gain deeper knowledge of contrast enhancement.

1.2.2) To implement & understand the concepts of signals & system in the context of image processing.

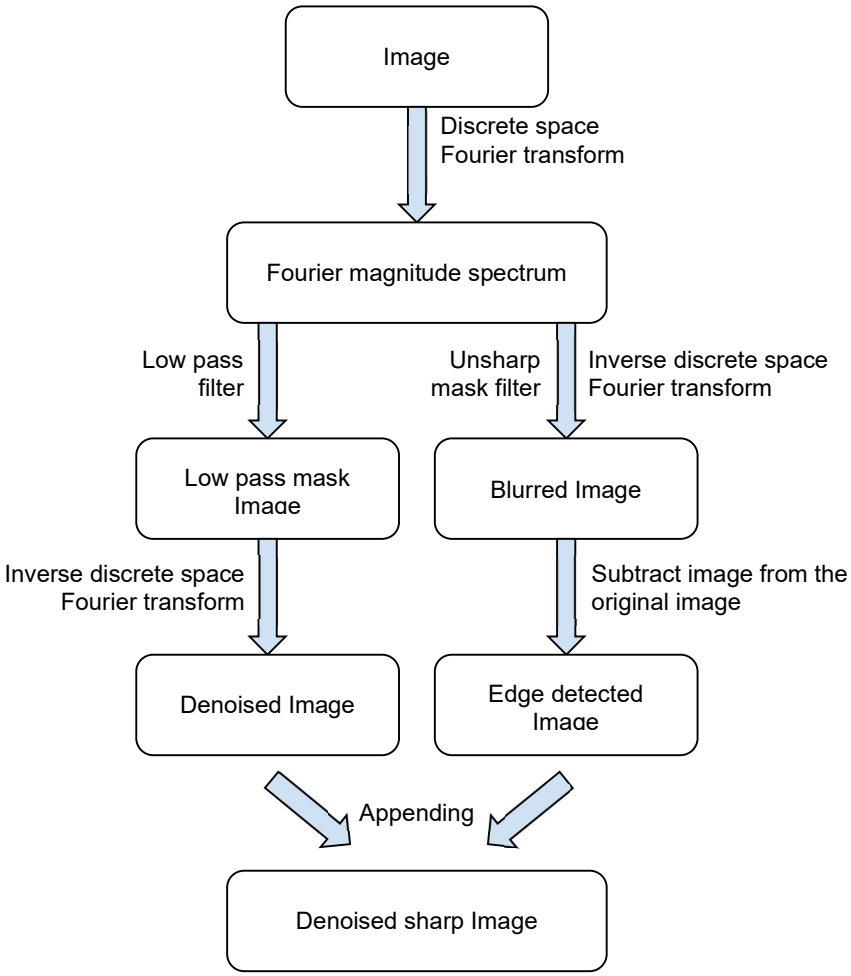
1.3) Tools we utilized -- Discrete Fast Fourier Transform [1], Fourier shift, Inverse Discrete Fast Fourier Transform [1], Inverse Fourier shift and Filters are some of the concepts of signals and systems that we have used.

2.1 Image Denoising, Edge Detection and Sharpening [2]

First step is to reduce noise in image. Noise in an image hide the details. To obtain denoised image, Fourier spectrum of original image is passed through low pass filter which removes signals of high frequencies.

Next stage is Edge Detection. To get the clearer edges of the image, the original image is subtracted from its blurred version. The blurred version of the image would be given by applying an Unsharp Mask Filter on the Fourier transform of original image.

Now we take the outputs of the above mentioned two steps and merge them both. This is achieved by taking the interpolated sum of each of the pixels of denoised & edge detected images.



2.2 Contrast Enhancement using Histogram Equalization[3]

Image histogram is a graphical representation of the intensity distribution of an image. The graph contains specific number of pixels for each intensity value.

In any image, usually the pixels seem to be clustered around the middle range intensities.

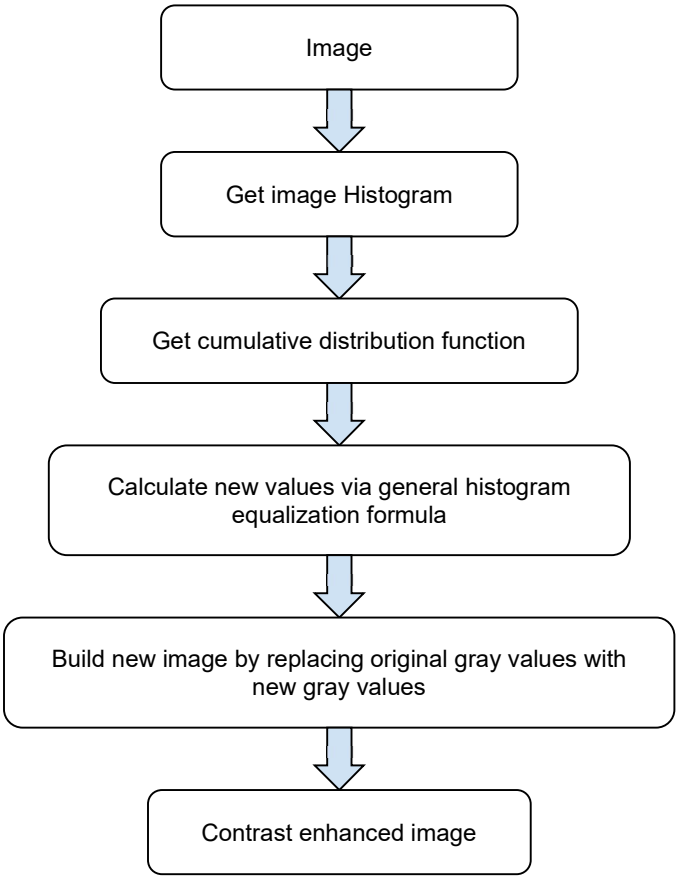
Histogram equalization is a technique for adjusting image intensities to enhance contrast. Its basic fundamental is to stretch out intensity range and get clearer image.

What it does is employ a monotonic, non-linear mapping which re-assigns the intensity values of pixels in the input image such that the output image contains a uniform distribution of intensities.

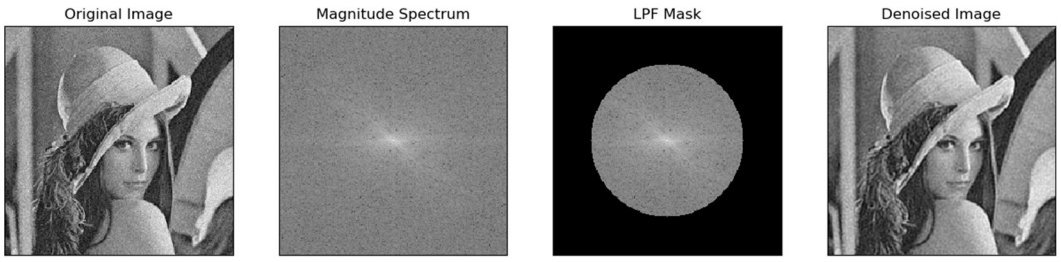
First, we take the image histogram and its cumulative distribution. Then new value of each pixel is calculated using the general histogram formula:

$$h(i) = \text{round}\left(\frac{cdf(1) - cdf_{min}}{MxN - cdf_{min}} * (L-1)\right)$$

where cdf_{min} is the minimum value of the cumulative distribution function, M x N are the image's number of columns and rows, L is the number of gray levels used (in most cases 256) and $\mathrm{cdf}(x) = \sum_{j=1}^{x} h(j)$ in which x is a gray value and h being the image's histogram.

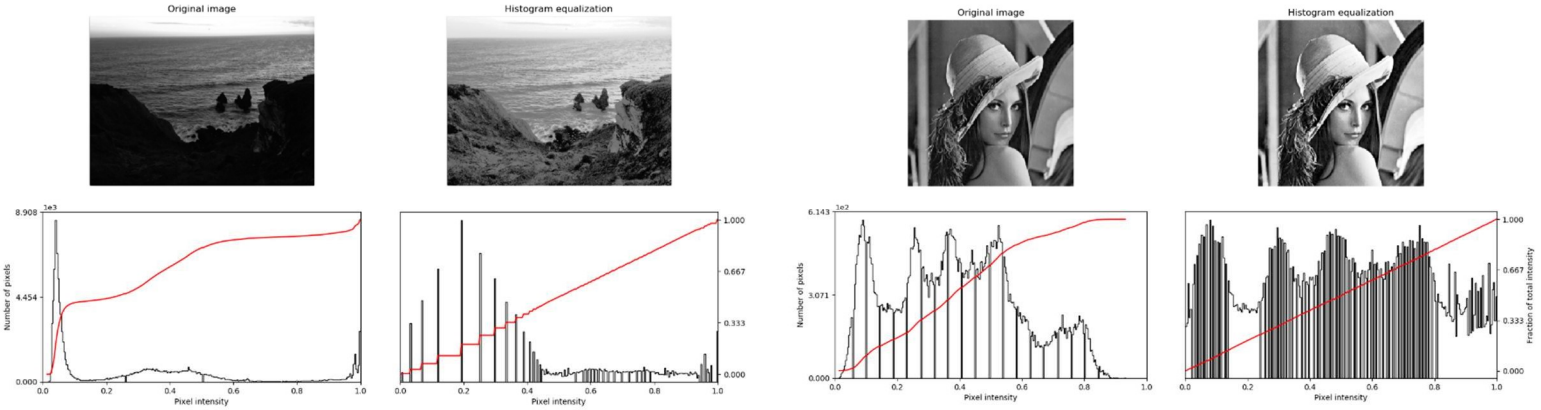


3. Results and Observations



Here output image is shown which contains less noise after passing through low pass filter.

Above shown is the blurred image & the edge detected image which is obtained by subtraction of blurred image from the original image using unsharp mask filter.



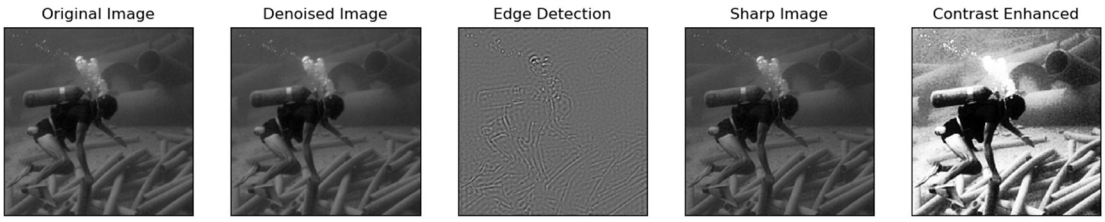
Above shown is the histogram of two images where the second one is the contrast enhanced version of the first image using histogram equalization technique.

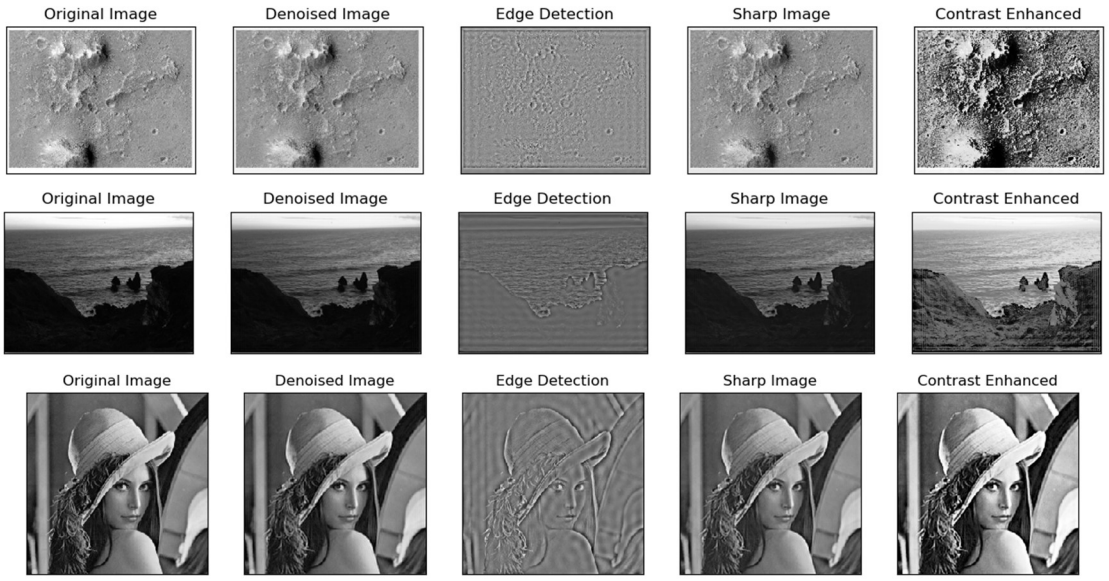
4. Conclusions and Limitations

Edges of the images have been successfully detected by subtracting its blurred image by using unsharp mask filter. Graphical representation has been obtained which contains stretched range of intensities of pixels. And enhanced image has been obtained through contrast enhancement using histogram equalization technique.

The used algorithm for denoising image is not optimized. Advanced, more efficient and optimized algorithms like Gaussian filtering, an improved Non-Local Means of denoising algorithm[4], etc. are available. Algorithm for appending could also be optimized using advanced concepts. Histogram equalization algorithm could be improved by replacing it with more advanced technique known as Adaptive Histogram Equalization[5] technique.

Some samples:





References

[1] Fast Fourier transform: https://en.wikipedia.org/wiki/Fast_Fourier_transform

[2] Image Filtering & Edge Detection by MIT Lab:

http://alumni.media.mit.edu/~maov/classes/vision09/lect/09_Image_Filtering_Edge_Detection_09.pdf

[3] Histogram Equalization: https://en.wikipedia.org/wiki/Histogram_equalization

[4] Improved NLM of Denoising Algorithm: https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8124523

[5] Adaptive Histogram Equalization: https://en.wikipedia.org/wiki/Adaptive_histogram_equalization