REPORT ON IMAGE ENHANCEMENT TECHNIQUES

EC-357 DIGITAL IMAGE PROCESSING

PROJECT

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SUBMITTED BY:
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INTRODUCTION:

Image enhancement may be defined as the procedure of improving the quality and information content of original data before processing. In essence it means improving the condition of an image before it is processed further without changing the original content. This process is highly subjective and depends on the user for interpretation as to whether the image is improved or not.[1] Since the process is user-specific it is also domain specific and has no clear-cut set of rules governing as to which technique should be applied for a given image that is to be enhanced. During the process of image acquisition some undesirable information may be present; this can be removed by the wide variety of techniques and methods available in the field of digital image processing. This report explores some of these techniques, with especial focus on spatial domain methods for image enhancement. [2]

Image enhancement techniques are considered as the basic step in image processing. It can be seen as a primary step towards further processing of images. In this study we are concentrated on improving a series of low-light images, through image enhancement techniques. One of the major setbacks these techniques suffer from is that the images as a result of enhancement process are subjective in nature. This means that ultimately, it's the user who decides which technique is best suited for a particular image. There is a plethora of techniques available to enhance an image. Hence our primary objective of the project is to objectify this approach. We also strive to suggest a top two or three techniques best suited for a particular king of low-light image.

Dataset:

The dataset comprises of 60 low-light images, which are to be processed using image enhancement techniques to attain better quality of these images. These images have been scraped from trusted online sources for reliability purposes and are enough in number to derive a meaningful conclusion out of the study.

All these images have histograms which are concentrated towards the lower end of the grayscale. These images differ ever so slightly in their histograms, but this difference is what we intend to capitalize on.

Techniques Used:

For image enhancement I have used 7 techniques that are described below.

1. Histogram Equalization: It is a histogram modelling technique based on the histogram of the original image. It basically modifies the dynamic range to improve the contrast of an image. In other words, it stretches out the intensity range of the image. Usually the histogram obtained after processing is flat or uniformly distributed over the intensities.

2. Contrast Stretching: Also called as Normalization this technique is a point operation and improves the image by stretching the range of intensity values to the required range. Contrast stretching is a linear and monotonically increasing method hence, can only apply linear scaling function to the pixel intensity values.

3. CLAHE: Contrast Limited Adaptive Histogram Equalization or CLAHE is variation of AHE technique. The contrast stretching in this technique is limited or the contrast amplification is limited. This is done in order to reduce the problem of noise amplification. It performs histogram equalization in localized areas to increase accuracy.

4. Unsharp Masking: Unsharp masking is an image sharpening technique that is used for image enhancement as well. This process is carried out in two stages where the image is blurred initially and the negative image (formed by Laplacian) is used to create a mask.

This mask is then combined with the original image to form the result.

5. Log: Logarithmic image enhancement technique is a point processing technique. Following the log transformation, the dark intensity pixels in the image are mapped to the to the higher pixel values according to the formula. The higher intensity pixel values are compressed in log transformation. This result in following image enhancement.

6. Gamma: Also referred to as power-law transformation. It is also a point processing technique. The transformations can be given by the expression: $s=cr^{\gamma}$. Variation in the power i.e. gamma (γ) results in different levels of enhancement. It basically maps the intensity of pixel value according to the expression given above.

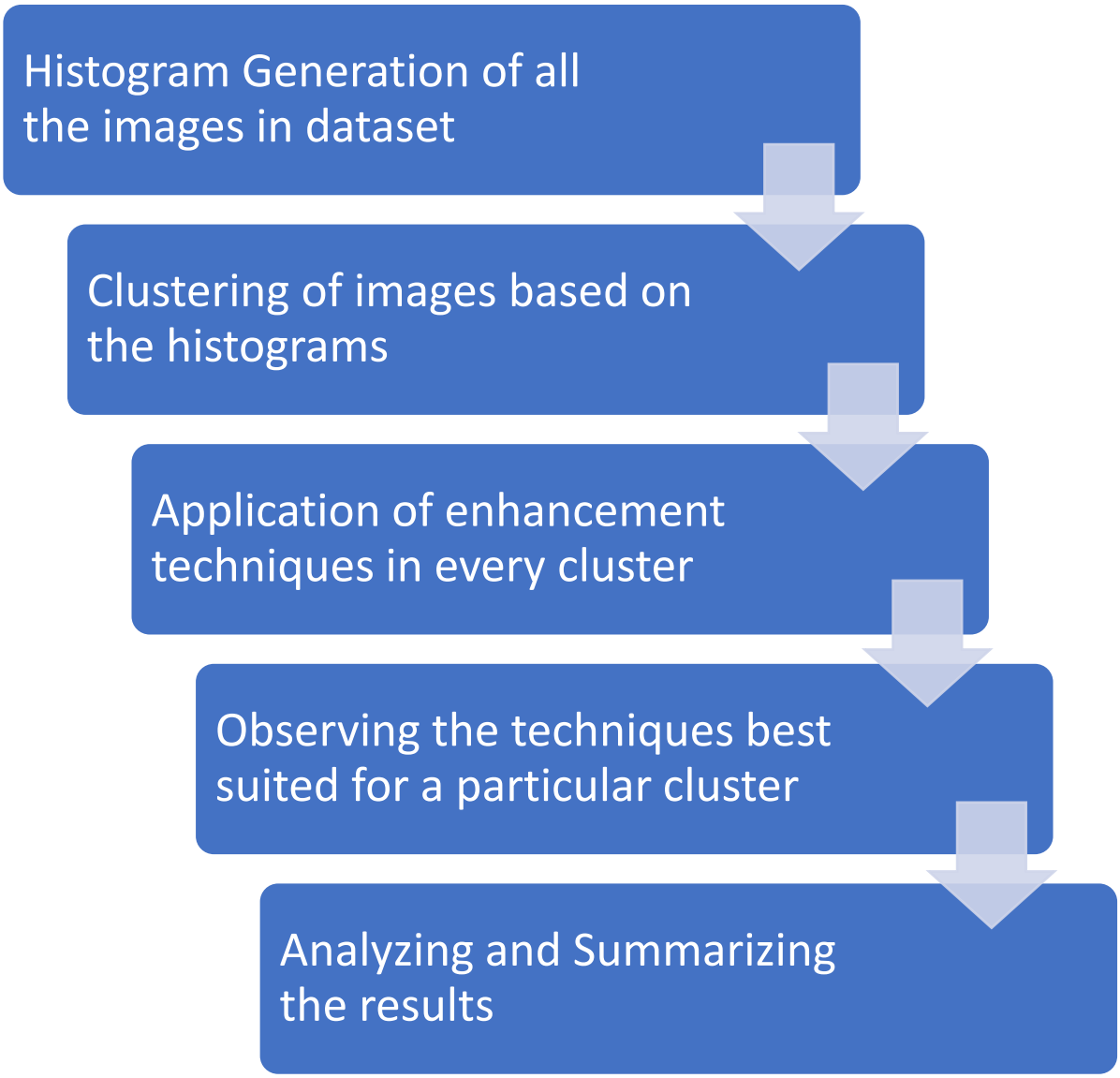
7. Median: Median filtering is a special type of enhancement technique. It is a non-linear filtering method, where the intensity value of the pixel is replaced by the median value in the neighbourhood of the pixel. It is usually used to reduce noise in an image.

Proposed Approach & Algorithm:

As mentioned in our objective the aim was not just to provide an overview of the techniques but also to objectify the process somewhat. Keeping that in mid, to objectify the process the images had to be grouped or clustered together, so that a particular set of technique could work well on that group compared to the others. This means that the low-light images had to be clustered based on some features.

Intuitively, histograms formed by the images was selected as the features. The images having similar histograms were grouped together. Optimum number of clusters were converged to using some metric. Image enhancement techniques were then employed on select images of these clusters.

If for a certain cluster a set of techniques produced visually superior results than other than, for all images having similar histograms that particular set of techniques would work best. This idea formed the basis of the study.

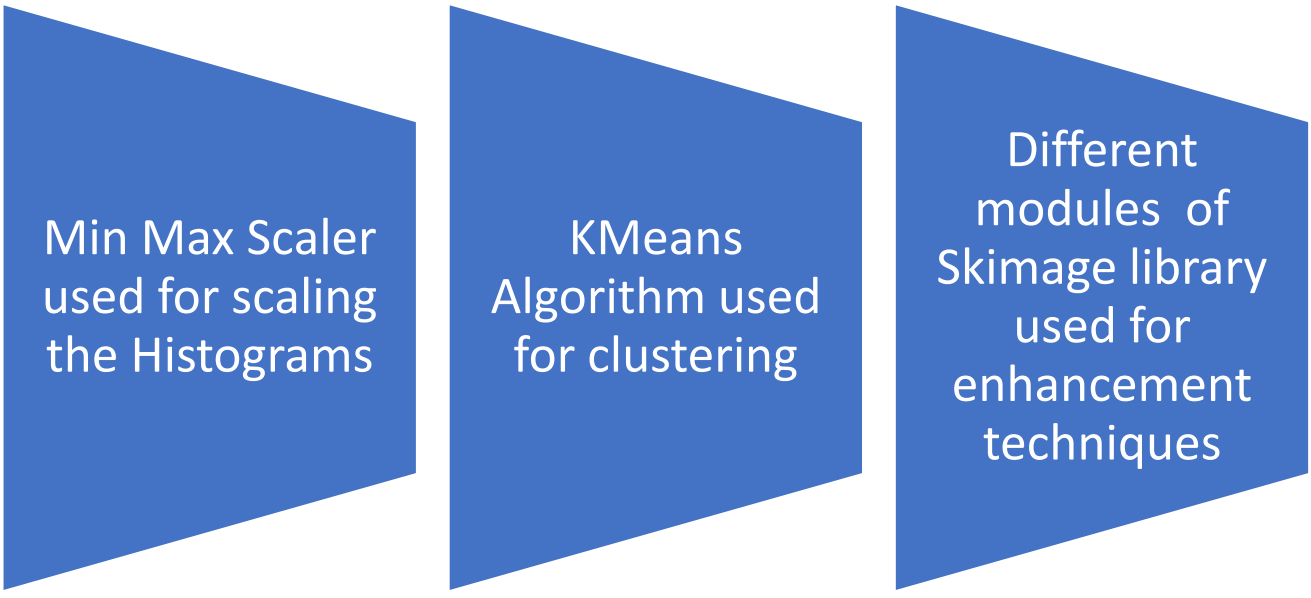


Flow-chart representing the algorithm followed in the study

Implementation Details:

Programming Language	Python
Library Used	Skimage
	os
	Matplotlib
	Numpy
	Sklearn

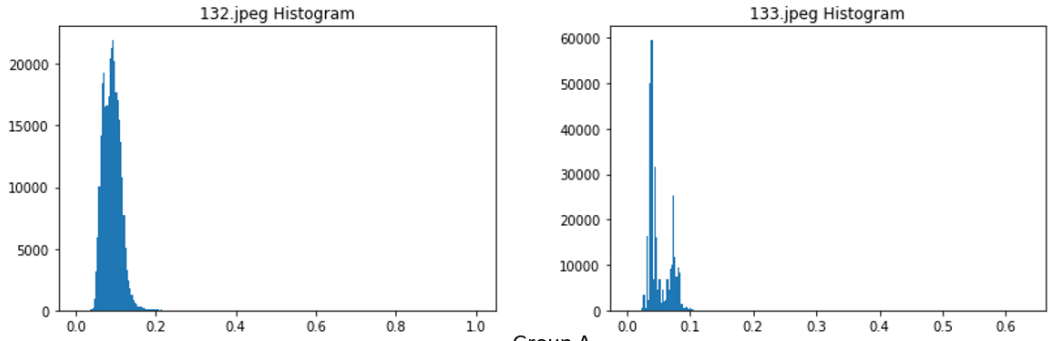
Parameters Used in certain Techniques	
Contrast Stretching	Percentile= 0-98
CLAHE	Clip limit Varies
Unsharp Masking	Radius = 200 & amount = 1
Log	C=1
Gamma	γ= 0.4



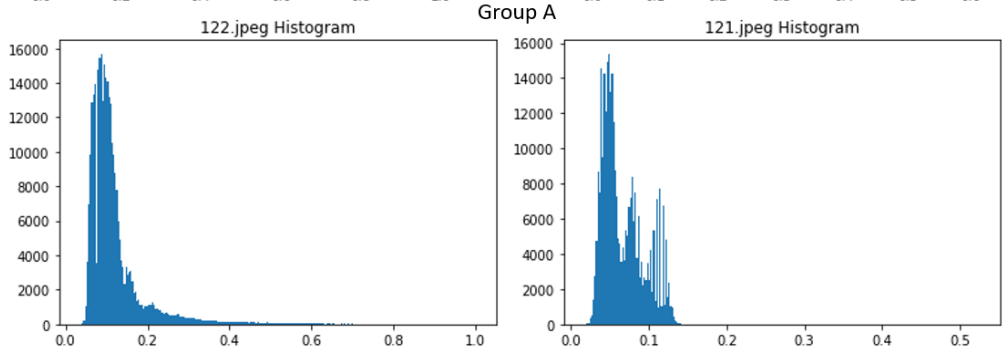
Results & Observations:

Based on the WCSS scores the optimum number of clusters were obtained as **4**.

Following pictures show 4 samples of histograms of different images in the 4 clusters and which set of techniques are best suited for each of the clusters.

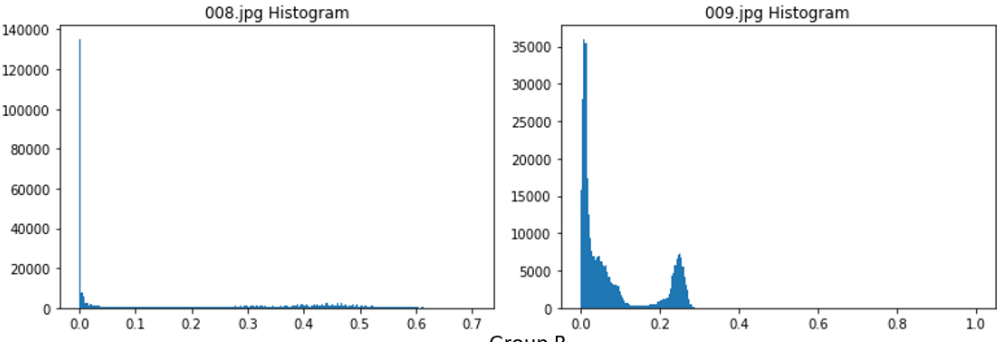


Group A

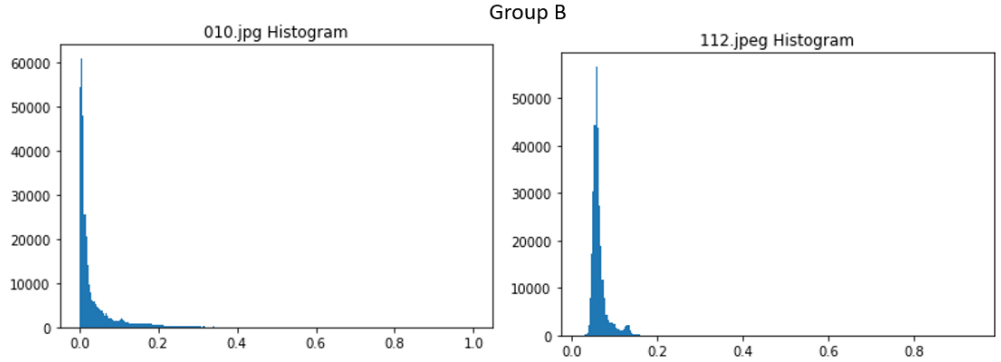


CLAHE

Contrast Stretching

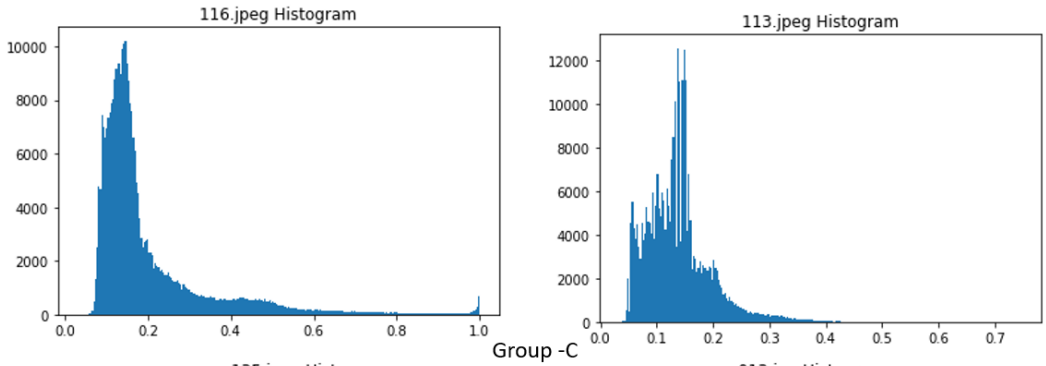


Group B



CLAHE

Histogram Equalization

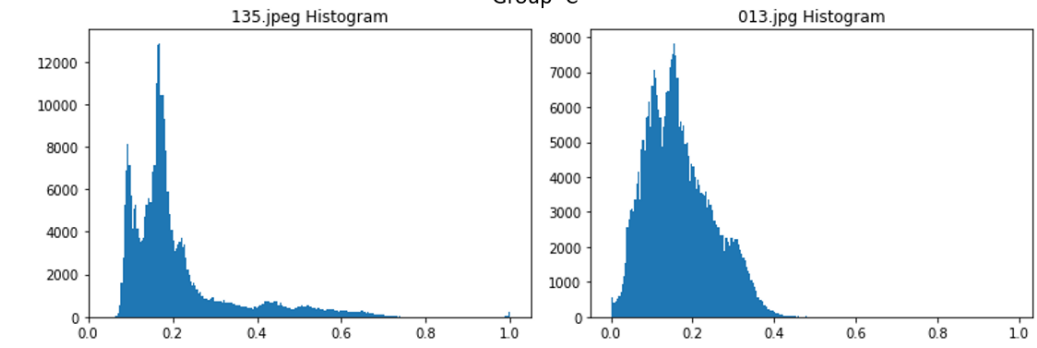


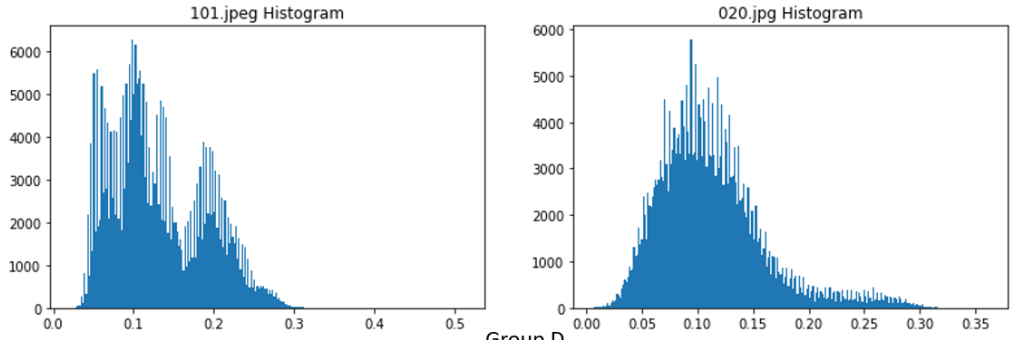
Group -C

Histogram Equalization

Contrast Stretching

Gamma

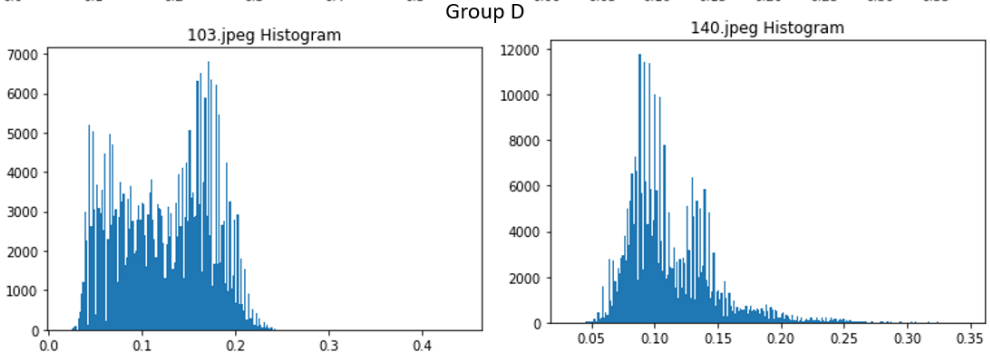




Group D

Histogram Equalization

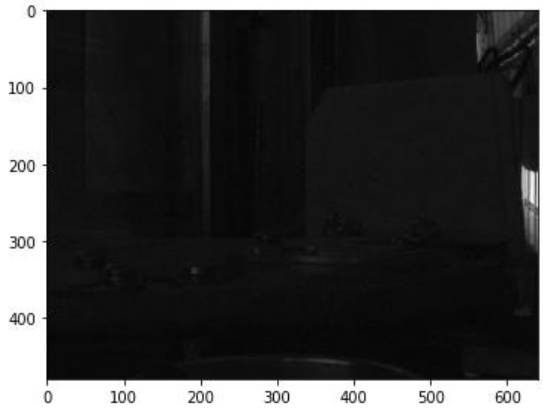
Contrast Stretching



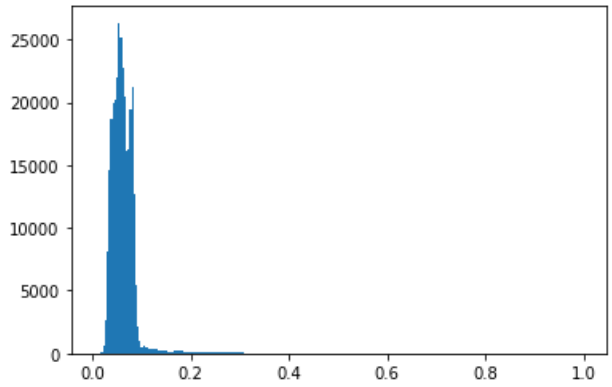
The 4 clusters and 3 techniques best suited for image enhancement

Given below are the images along with the results as a result of application of these techniques.

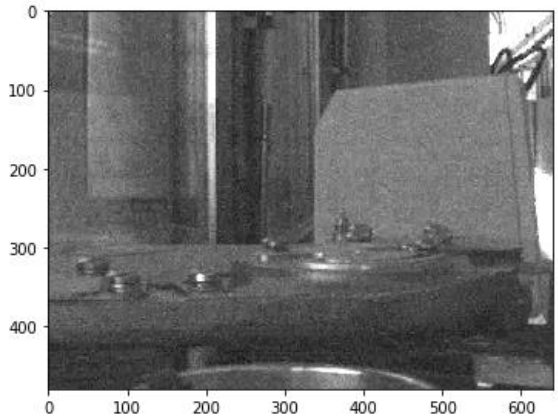
Image belonging to Group-A:



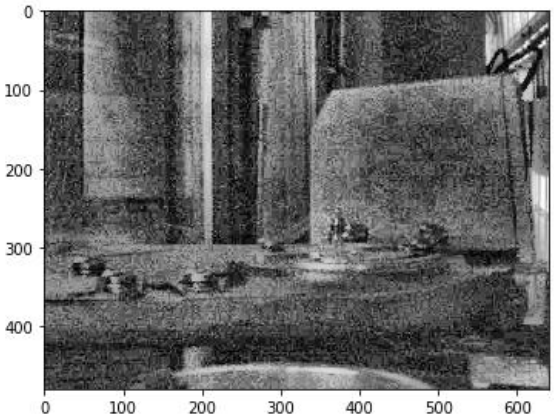
Original Image



Histogram Of Original image

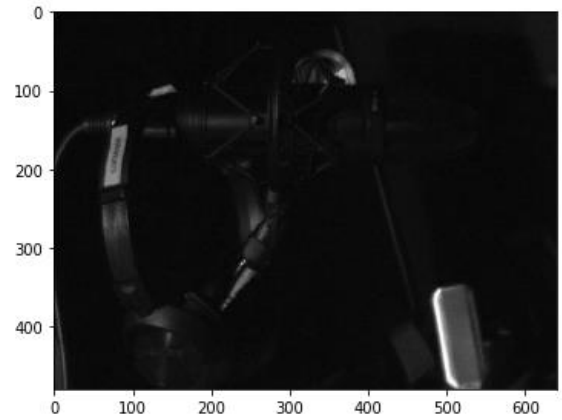


Contrast Stretching Result

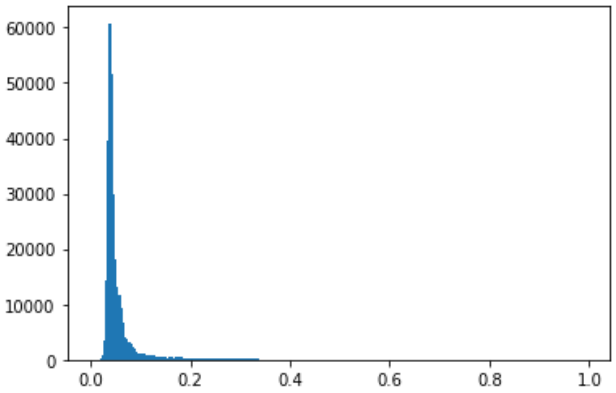


CLAHE (limit = 0.07) Result

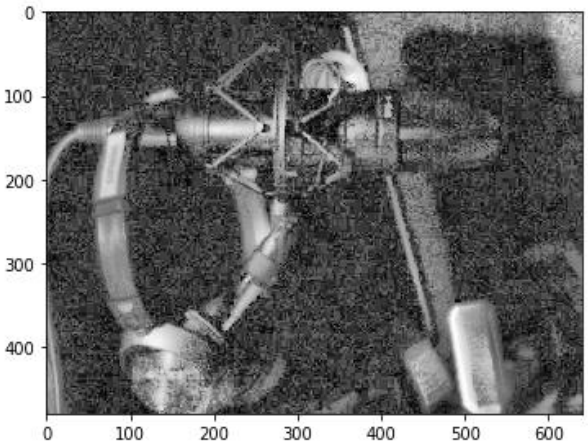
Image belonging to Group-B:



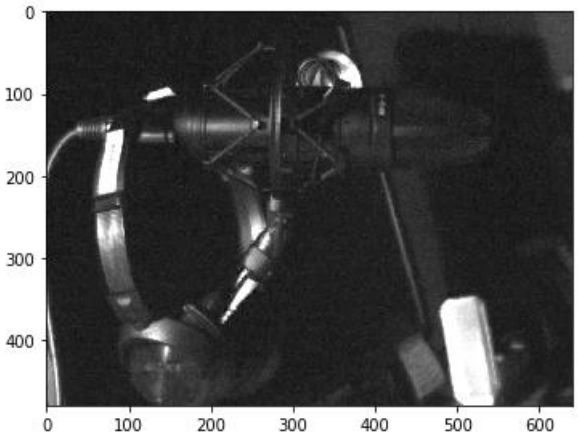
Original Image



Histogram of Original image

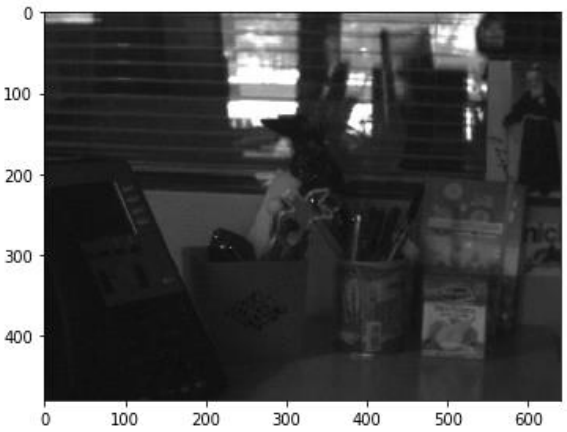


CLAHE (limit=0.07) Result

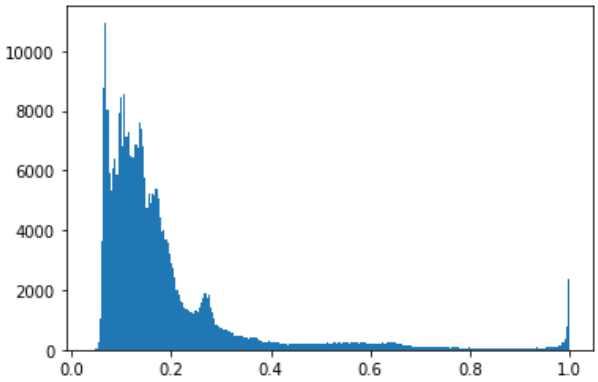


Histogram Matching

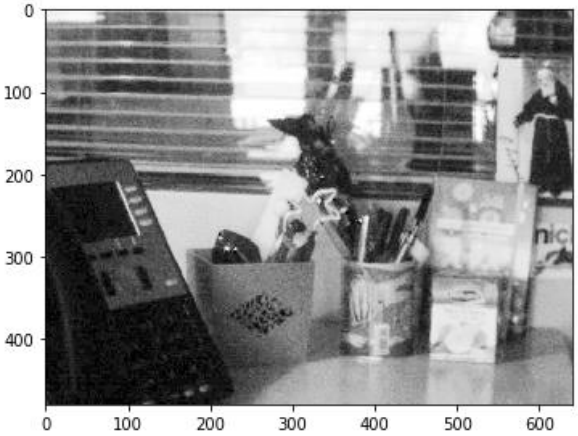
Image belonging to Group-C:



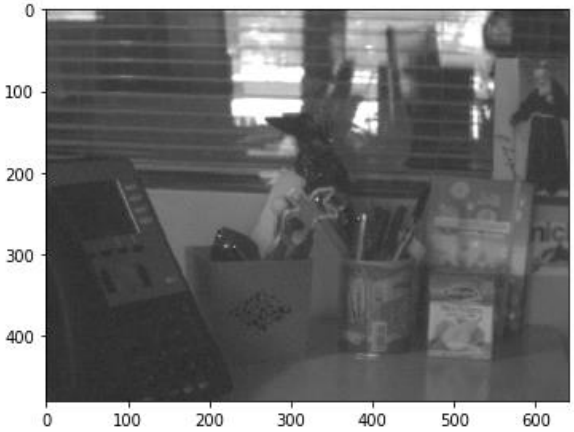
Original Image



Histogram of Original image



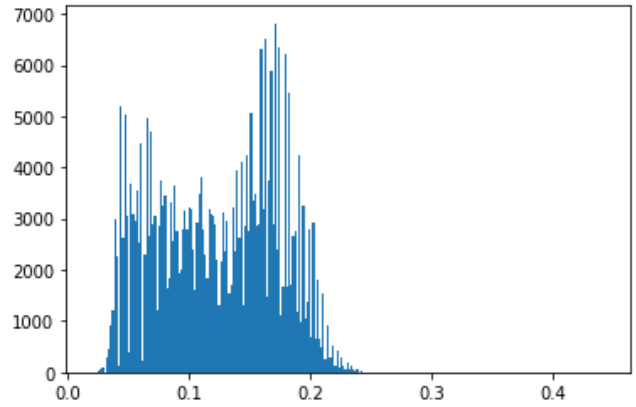
Histogram Equalization Result



Gamma (0.6) Result

Image belonging to Group-D:

Original Image



Histogram of Original image

Contrast Stretching Result

Histogram Equalization Result

Conclusion:

The observations provide a comprehensive analysis of some of the image enhancement techniques. We see clearly that a lot of methods are available for enhancement which is a subjective process and each method can visibly improve the low-light image to a certain extent. The decision of choosing a technique depends on image content, qualities, and application of the processed image. Our aim was to identify the techniques producing the best results for a particular type of image characterized by its

histograms, we did indeed end up concluding 2/3 techniques for the 4 types of clusters.

Power Law enhancement techniques (Gamma & Log) improved the overall contrast of the image, and are suitable where the entire image's dynamic range is concentrated on the lower side. Log technique proves to be best in case of a dark image which has almost no higher intensity pixels.

Histogram Equalization, CLAHE and contrast Stretching provide much better results in case of low contrast spread histogram i.e. a washed-out image.

All of these techniques maybe followed by Median Filtering to remove the grainy or impulsive features in the image, especially after histogram equalization median filtering refines the image by smoothing it.

References

[1] A. Makandar and B. Halalli, "Image Enhancement Techniques using Highpass and Lowpass Filters," *Int. J. Comput. Appl.*, vol. 109, no. 14, pp. 21–27, 2015, doi: 10.5120/19256-0999.

[2] A. Chourasiya and N. Khare, "A Comprehensive Review Of Image Enhancement Techniques," *Int. J. Innov. Res. Growth*, vol. 8, no. 6, pp. 60–71, 2019, doi: 10.26671/ijirg.2019.6.8.101.