Comparative Analysis of Image Enhancement Methods for Degraded Images

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Abstract- Digital image processing relies heavily on image enhancement techniques to make an image useful for a variety of applications. This method is used to restore some of the quality to damaged images. The degradation typically varies from region to region rather than being distributed evenly across the image. Our goal is to first identify the area that needs improvement so we can then focus on making that area better without affecting the nearby neighborhood, which is already in good condition. In this research paper, we proposed an image enhancement technique which is used to enhance the quality of degraded images. The effectiveness of the suggested algorithm is examined and compared against the two existing histogram equalization approaches and finally, the best technique can be chosen by comparing each of these techniques to one another

Keywords – Histogram, Histogram Equalization, Image, Image enhancement and Image Processing.

I. INTRODUCTION

As more and more things become digital, researchers working on image processing research have focused their attention on maintaining the quality of digital images, which has resulted in the development of image improvement techniques. These techniques are used to improve the clarity and resolution of images[1].The final outcome of digital image processing is a "raw" digital image, which is made up of an enormous number of values, each of which indicates the brightness of a pixel in the image.Figure1 below illustrates the working of image processing.

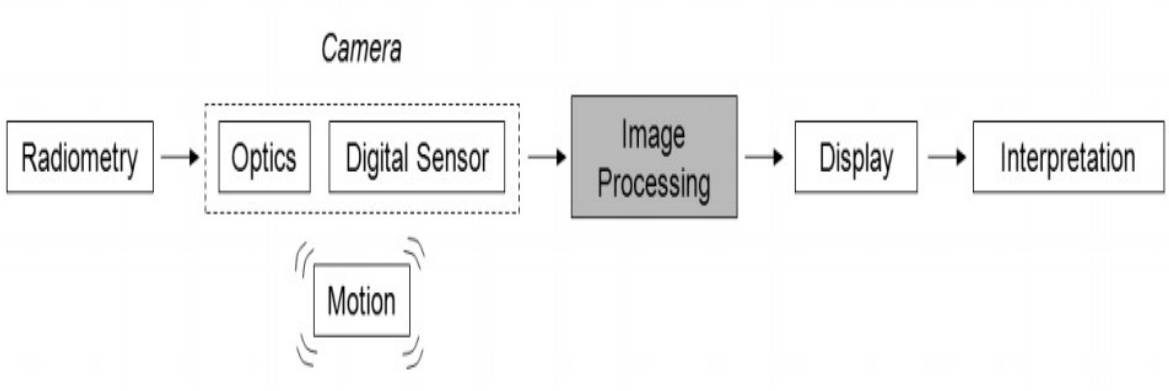


Figure 1:Working of Image Processing

Image enhancement refers to the process of improving the quality of an image[2]. It involves adjusting the image's visual features, such as brightness, contrast, color balance, and sharpness, to make it more visually appealing. Some common image enhancement techniques include[3]:

Histogram equalization: This technique adjusts the image's brightness levels to improve the contrast[4].

Filtering: This technique uses filters such as median filters, Gaussian filters, and sharpening filters to reduce noise and improve image clarity.

Color correction: This technique adjusts the image's color balance and saturation to produce more natural-looking colors.

Image restoration: This technique is used to recover degraded images. It involves techniques such as de-blurring, de-noising, and inpainting.

Image super-resolution: This technique increases the resolution of an image, making it appear more detailed.

These methods are frequently employed in a variety of applications, including surveillance, satellite imaging, and medical imaging. However, the appropriate technique to use depends on the particular requirements of the image and the desired outcomes.Thresholding is a vital preprocessing technique for enhancing the quality of damaged images. The required area of the image is separated from the background region using a threshold value. The background region of the image can be extracted based on the grayscale distribution in the image. Thresholding divides an image into foreground and background regions by assigning values to all pixels whose intensity values are higher than a threshold[5].When using thresholding techniques, the image's white pixels represent the foreground details, and its black pixels represent the image's background (or vice versa). Local threshold refers to a threshold where the function depends only on gray-level values, while dynamic threshold refers to a threshold where the function depends on the local property of the image[6].In this research paper, we employ histogram equalization (HE) techniques to increase the quality of degraded images. Here, we describe our proposed algorithm and then compare it with two existing histogram equalization techniques. Finally, the best technique can be chosen by comparing each of these algorithms to one another.

The structure of research work is broken down as follows:Section 2 outlines the concept of Histogram Equalization and section 3includes Proposed methodology. Section 4 includes the result analysis and finally section 5 discusses the conclusion of research paper.

2. HISTOGRAM EQUALIZATION

The bar graph that aids in visualizing an image's intensity distribution is called a histogram. Collecting and categorizing the data is the first step in creating a histogram. The histogram's vertical axis indicates the dependent variable, and its horizontal axis depicts the independent variable.Histogram Equalization is an operator that is closely related to the histogram. By balancing the image histogram, the image's quality can be increased [7].By evenly distributing the intensity levels, the histogram equalisation methods aim to enhance an image's visual appeal. When the image's usable data is represented by close contrast values, it typically improves the image's overall contrast.This equalizing concept can be used to distribute the intensity levels of the histogram evenly.This improves the local contrast of the image without affecting its overall contrast. This is accomplished by histogram equalization, which successfully distributes the most prevalent intensity values[8]. The equalized image may still contain the high and low points if they found in the histogram of original image, but they will be distributed evenly. Based on the transformation function that was applied to each pixel's previous intensity level, the histogram's pixels are each given a new intensity value.

There are numerous local techniques for improving the quality of image. In this research work, we primarily discuss two techniques forincreasing the quality of image that are: Contrast-limited adaptive histogram equalisation (CLAHE) and adaptive histogram equalisation (AHE). The best contrast enhancing method is adaptive histogram equalisation as it calculates the various histograms, each of which corresponds to a different area of the image, and then redistributes the contrast of the image. Adaptive histogram equalisation has two drawbacks: slow computer speed and excessive noise enhancement[9].CLAHE is the AHE replacement technique as the excessive noise enhancement issue that exists in AHE is resolved by it[10].

Traditionally, the histogram equalisation technique applies the same transformation method to each pixel of the image to achieve the desired results.When the pixel values in the image are evenly distributed, this technique produces the best results. On the other hand, if the image contains lighter or darker areas, the contrast is not sufficiently improved.All the image's pixels are transformed by AHE using the transformation function which is obtained from the neighbourhood region[11]. The cumulative distribution function of the nearby pixel values and the transformation function are directly proportional to each other [12].

3. PROBLEM FORMULATION

The existing image enhancement techniques magnifies the impact of background noise pixels while applying histogram equalisation and overall image enhancement.As a result, after the

enhancement is complete, the noise that was not as noticeable in the input image can now be seen significantly, resulting in the failure of the entire process.Additionally, it frequently has a tendency to blur the image's background details after the equalisation is completed. AHE and CLAHE techniques can solve this problem because they increase contrast locally rather than globally. Although they significantly reduce noise amplification, but they frequently fall short of significantly increasing contrast compared to their global counterpart.

3.1 SUGGESTEDTECHNIQUE

In the above discussed approaches, the first technique tends to overamplify input, while the second technique under amplifies to minimize the impacts of over-amplification. The suggested method attempts to achieve a level of enhancement or amplification that is neither too much nor too little by balancing the AHE and CLAHE algorithms. The flowchart of suggested technique is shown in Figure 2, assumes that only specific regions of the image need to be improved, leaving the rest of the image unaffected. This means that the improvement is not necessary for the whole image.The steps of the proposed technique are as follows:

1. Firstly, an image is loaded and converted into a grayscale image.
2. Apply the threshold operator to the image generated in the previous step using an exposure threshold. As a result, the image has portions of over and under exposure.
3. On the thresholded image, apply clipping.
4. Adaptive histogram equalisation is applied to the subdivisions to improve the contrast in the areas of the image that require it.
5. After completing the aforementioned step, the enhanced image is generated.

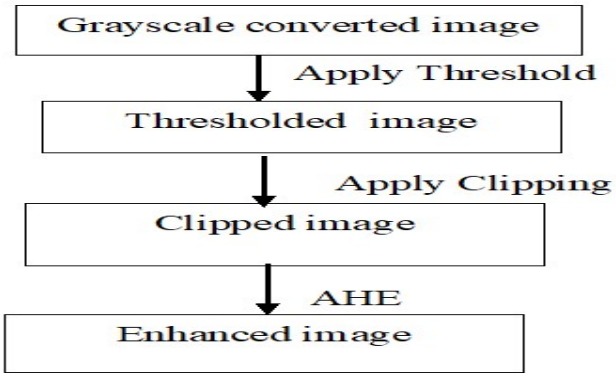
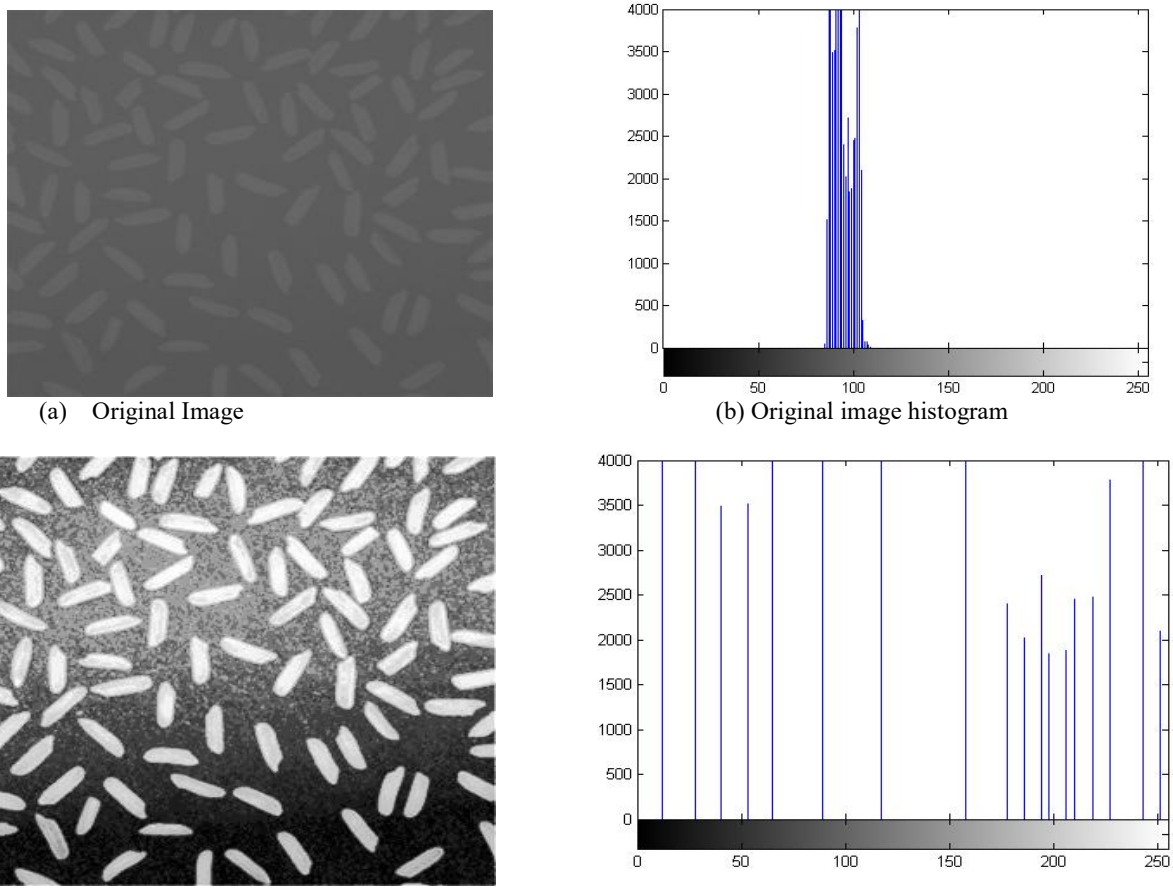


Figure 2: Flowchart for the suggested technique

4. RESULTANALYSIS

This section compares the findings of proposed approach with other existing image improvement approaches such as the Histogram Equalization and CLAHE technique.



(a) Original Image

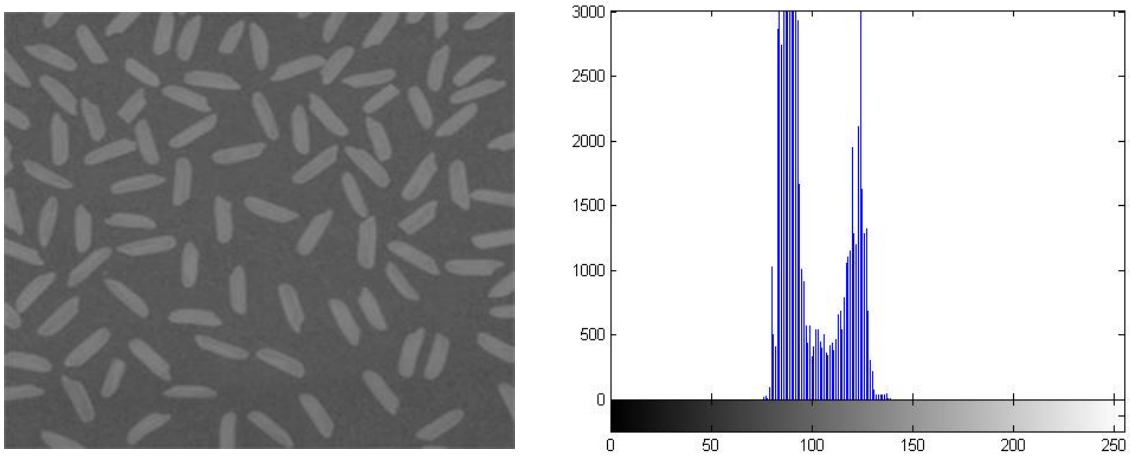
(b) Original image histogram

(c) Result of HE technique on original image

(d) HE technique histogram

Figure 3: Illustration of HE technique on input image

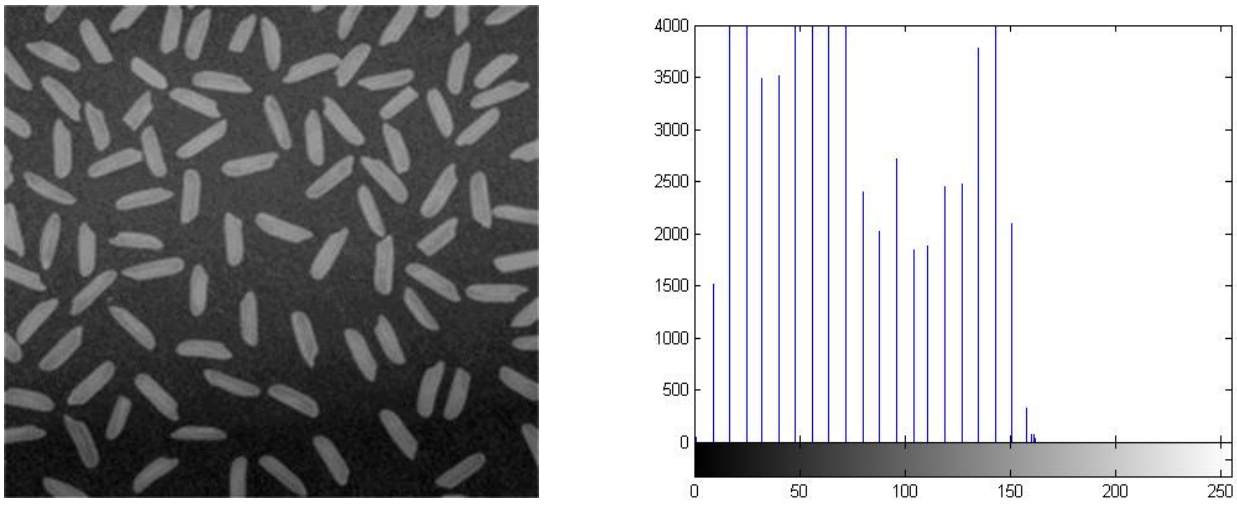
Histogram equalization significantly increases contrast of the original image, but it also increases the noise in the input image. Fig. 3(b) depicts the effects of noise amplification. After applying the HE technique to the original image, the outcome is the improved image, or HE image. The introduction of noise has made the black background inconsistent as shown in figure 3(c).



(a) Result of CLAHE enhancement technique (b) Histogram of CLAHE technique

Figure 4: Illustration of CLAHE technique on input image

Fig. 4(a) demonstrates that when CLAHE approach is applied on an input image then it prevents noise amplification, but it limits contrast amplification in the process. Therefore, there are no noticeable contrast gains in the output image. The histogram of CLAHE technique is demonstrated in Figure 4(b).



(a) Result of suggested approach (b) Histogram of proposed technique

Figure 5: Illustration of proposed technique on input image

Figure 5(a) and 5(b) depict the results of the suggested technique. The output images of the suggested technique demonstrate that background noise is much less when compared to the HE approach and the contrast amplification of the input image is greater than the CLAHE technique.

5. CONCLUSION

A crucial step in the processing of digital images is image enhancement. This research paper proposed a new image enhancement technique which improves the quality of the degraded images while limiting noise amplification. A few existing image improvement approacheslike HE and CLAHE were also studied, and the outcomes of the suggested technique are contrasted with the existing approaches.The proposed technique demonstrates how to effectively increase image contrast while minimizing background noise by outperforming the existing techniques. The Suggested approachalso has the advantage of requiring no parameter settings.

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