STM JOURNALS

International Journal of
Radio Frequency Innovations

Volume 3, Issue 1, 2025
January–June
DOI (Journal): 10.37591/IJRFI

https://journals.stmjournals.com/ijrfi

Review IJRFI

# Image Enhancement Techniques for Digital Images

Ambresh Patel*, Abhinav Shukla, Hemant Rajoriya

**_Abstract_**

*In image processing, image enhancement is a challenging problem. Image enhancement aims to process an image in a way that makes the final product better suited for a particular application than the original. There are numerous ways to improve the quality of images using digital image enhancement techniques. It is crucial to use these techniques correctly. Image enhancement is a critical aspect of image processing, focusing on improving the visual quality of an image to make it more suitable for specific applications. This is achieved through various techniques that enhance features such as contrast, sharpness, and detail, while reducing noise or blurring. The primary goal is to transform an image into a format that is better suited for interpretation, analysis, or presentation. The numerous methods frequently employed for image enhancement are compiled and examined in this document. Applications for image processing include image enhancement as a key component. Image enhancement has been the subject of a great deal of recent research. Numerous methods for enhancing digital photos have been put forth. The results of a study on different image enhancement methods are presented in this research work.*

**Keywords:** Image enhancement, digital image processing, components, inferred image, CNN

## INTRODUCTION

The term "image enhancement" describes image processing that enhances aspects of an image. In essence, image enhancement enhances how information is perceived, or images are interpreted by human viewers while also improving the input for other automated image processing algorithms. The picture has a broad dynamic range and was taken in a natural environment. There are two main categories of image enhancement methods: spatial domain and frequency domain. Spatial domain methods modify the pixel values directly, using techniques like linear and non-linear filtering, histogram equalization, and point processing. These methods aim to adjust the image's intensity and contrast or smooth out noise. Frequency domain methods, on the other hand, involve transforming the image into the frequency domain (often using Fourier transforms) and manipulating the frequency components to improve the image. Given the expanding dynamic detection range of the human eye, these images are very challenging to see. The process of improving an image's quality and altering its characteristics to better suit a particular task or audience is known as image enhancement, which improves contrasts, edges, and increase the analytical and visual utility of image displays [1]. To make the functions selected for improvement more easily identifiable, the extension helps to expand their dynamic range without adding to the content of the data. An image's visual appearance can be improved, or it can be transformed into a better image that can be analyzed by humans or machines using a variety of techniques that constitute an image enhancement process. The results of image enhancement are shown in Figure 1, which illustrates the process of converting the original image into an improved one. Key techniques for enhancement include contrast stretching, sharpness enhancement, noise reduction, color enhancement, and edge enhancement.

***Author for Correspondence**
Ambresh Patel
E-mail: ambreshec@gmail.com

Assistant Professor, Department of Computer Science and engineering Sri Satya Sai College of Engineering, Bhopal, Madhya Pradesh, India

Received Date: March 05, 2025
Accepted Date: March 29, 2025
Published Date: April 08, 2025

**Citation:** Ambresh Patel, Abhinav Shukla, Hemant Rajoriya. Image Enhancement Techniques for Digital Images. International Journal of Radio Frequency Innovations. 2025; 3(1): 14–18p.

 

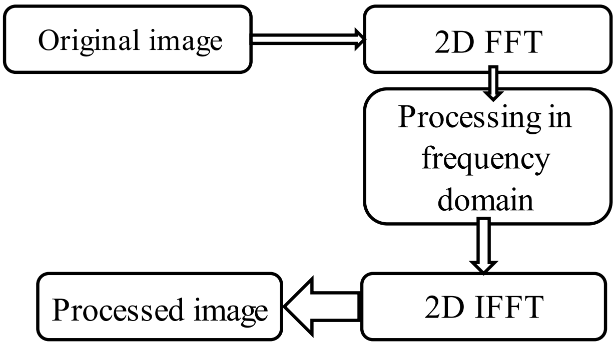

**Figure 1.** The frequency filters process.

These methods improve the image's quality, making features more visible and clearer. For instance, noise reduction techniques like median filtering help remove unwanted artifacts, while sharpening methods like unsharp masking improve edge definition. Additionally, edge detection techniques, such as Sobel or Canny edge detection, are used to highlight boundaries in images, making them more defined. Image enhancement is commonly used to highlight an object's edges, brighten dark images, and eliminate noise. Despite the variety of techniques available, image enhancement poses several challenges, such as over-enhancement leading to unnatural results or computational complexity in real-time applications. Recent advancements in deep learning, particularly using neural networks like CNNs and GANs, have shown promise in achieving more context-aware and perceptual-based enhancements. Future trends also include adaptive techniques that adjust enhancement based on content, making images more contextually accurate. The resulting image is more appropriate for some uses than the original. Techniques for improving images fall into two main categories: (1) The technique of spatial domain; and (2) The technique of frequency domain. Pixel values in an image are directly affected by the spatial domain method. The frequency domain approach, on the other hand, uses its Fourier transform to improve an image.

**Spatial Domain Enhancement Method**

The group of pixels that comprise an image is known as the name domain. Procedures that work directly with these composite pixels are known as spatial domain techniques.

**Frequency Domain method**

The process of improving frequency domain images is straightforward. The frequency filters produce a frequency-domain image.

## LITERATURE REVIEW

To conclude, low light poses a challenge to artificial vision and imaging, both for application-oriented tasks like detection and for enhancing contrast for improved visibility and quality. We found that the current tendency to look for ways to improve in low light levels has a significant effect on improving quality.

**Loh *et al*. [1]**

The focus has shifted to a more useful direction, which is an improvement in which functionality is restored first and foremost. Consequently, we suggest using the Gaussian process, which is produced at runtime from the data, to model the improvement in low light conditions as a set of localized functions. Information about the necessary functionality, like offering a reference, is gathered using a basic convolutional neural network (CNN). CNN then learns the relationship between characteristics and pixels by being trained on a lot of synthetic data that is based on the luminance distribution of real images in low light. Second, to enhance the assessment of high-level improvement algorithms that facilitate artificial vision tasks, we suggested two new scoring metrics: intensity histogram similarity and adaptation of local characteristics.

 

**Cai *et al.* [2]**

To create a SICE amplifier, it was suggested to use a convolutional neural network (CNN). Using pairs of images with low and high contrast to create a training dataset for end-to-end CNN learning is a major theme. To achieve this, we are compiling a sizable multi-exposure image data set, which consists of 4,413 images from 589 meticulously chosen high-resolution multiple exposure sequences. Subjective experiments are conducted to determine the optimal image quality for each scene, and 13 algorithms are used to fuse high dynamic range stack-based imaging with multi-exposure representative images to create images with improved contrast for each sequence.

**Gomez-Ojeda *et al*. [3]**

To get a lightweight CNN, Gomez-Ojeda *et al*. analyzed the process of examining the sequences produced by these two same architectures in various advanced VO algorithms like ORB-SLAM and DSO.

**Xiao *et al*. [4]**

Image contrast was improved by analyzing histogram-based image enhancement techniques. However, the brightness and contrast of the improved image cannot be freely adjusted using many histogram-based image enhancement techniques. Two novel image enhancement algorithms based on histograms are proposed in this paper. By altering two parameters, the suggested algorithms enable you to modify the contrast and brightness of an enhanced image. The concepts underlying parameter selection are also covered in this document. The experimental results show that the suggested approaches perform better than the current histogram-based approaches in terms of evaluating image quality and perception quality.

## CONTRAST ENHANCEMENT

It is possible to improve the image's overall visibility or quality without adding superfluous artifacts and an unrealistic visual facade. Luminance for bright pixels is greatly increased while luminance for dark pixels is decreased by the conventional technique of increasing overall contrast. To get enough contrast to enhance the image without compromising dynamic range compression, it is therefore better to adjust the contrast based on the neighborhood. It is separated into the following categories:

### Linear Contrast Enhancement

Increasing linear contrast is also known as contrast stretching. A new distribution can be created by linearly extending the original image. Increasing the initial value of an image allows you to use the entire sensitivity range of the digital camera. Images from remote sensing are the main application for this enhancement technique.

### Non-Linear Contrast Enhancement

An algorithm is used in nonlinear contrast enhancement, which suggests the histogram equalization method. Nonlinear contrast enhancement's drawback is that each value from the input image is repeated several times in the output image, which distorts the original object's brightness.

## CONTRAST STRETCHING

The contrast stretch is displayed on an image in a light-dark distribution. Contrast can be classified into three types:

### Low Contrast

Images with low contrast are either mostly bright or partially dark. One of the three regions on the histogram: the left, the right, or the center, is where each image pixel is concentrated. As the values of the pixels move toward the left, the image gets darker. Grouping the pixel values to the right makes the image appear brighter [5]. Image pixel composition in the middle of the histogram will result in an image that is neither too dark nor too light.

 

**Good Contrast**

The grayscale region is flat in a well-contrast image, preventing any one person from taking center stage. The histogram can be seen without a maximum or minimum point.

**High Contrast**

The high contrast is comparable to the gray width. Darkness and light, in sharp contrast, are the dominant colors. Consequently, the low and high gray levels are the two peaks in the resulting histogram.

## HISTOGRAM EQUALIZATION

A method for modifying contrast that makes use of the image histogram is called histogram adjustment. The quality of images may be enhanced by this histogram. This histogram works by increasing the histogram's peak while decreasing its minimum point [6]. This is done in such a way that each pixel's value can be distributed uniformly or not significantly differently. Histogram compensation with homogenized image density distribution increases dynamic range and thus image contrast [7]. The definition of histogram equalization is the histogram of I (x, y) contained in a pixel with the gray level being if (where i is 0, 1... k-1) and $ni$ is the number of pixels at II (, y) by the gray level being i.

$$\text{i}=\sum_{i=0}^{k-1}\frac{n_i}{N}=\sum_{i=0}^{k-1}p(i) \tag{1}$$

in which N is the total number of pixels in the image and $ni$ is the number of pixels with the gray degree. According to Eq. (1), any initial pixel intensity value between 0 and 255 can be mapped.

Additionally, it is assumed that the equalization histogram converts the input value of rk to sk, which in turn modifies the value from s to be defined as follows:

$$V_k=\text{T}(\text{S}_\text{k})=\frac{(L-1)}{n}\sum_{j=0}^{k}n_{rj}=\text{S}_\text{k} \tag{2}$$

In Eq. (2), sk is the gray intensity value of a pixel, L is the gray level, and $nrj$ is the number of pixel frequencies in the image (Figure 2).

## IMAGE ENHANCEMENT OF INFRARED IMAGES

Based on the infrared image model, this section explains how to enhance infrared images using two holomorphic spatial and patio-temporal filtering algorithms. Infrared light has a longer wavelength than visible light; visible red light, which is at the end of the visible spectrum, has a wavelength of 0.74 µm, while infrared light has a wider range of wave lengths, from 300 to 0.74 µm. Frequencies between 1 and 400 THz are represented by these wavelengths [8]. The algorithms for spatial and spatiotemporal hemimorphic filters are developed.

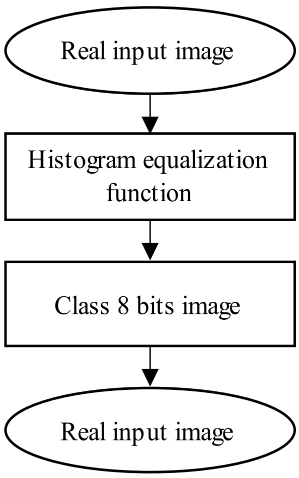


**Figure 2.** Histogram equalization flowchart.

 

In comparison to the spatially holomorphic filter, the spatiotemporal homomorphism filter improves more quickly by utilizing the temporal information that the image sequence provides [9]. STHF calculates an image in less time and iterations while maintaining a similar level of convergence. SHF images are generally better than optimized images. Some authors recommend using wavelets to detect edges and as an approximate match filter. Wavelets as edge detectors assume that the target edges of the image differ slightly from the interfering edges. In some cases, knowing the target from the start is essential when performing a ladder separation. Wavelets can also be configured to act as raw filters [10].

## CONCLUSION

Image enhancement techniques have emerged as a crucial preprocessing tool for digital image processing applications. This study has demonstrated how image enhancements have been successfully used to improve the quality of poor images using a variety of linear and nonlinear techniques. The review revealed that many existing techniques rely on processing methods that can introduce color artifacts.

## REFERENCES

1. Loh YP, Liang X, Chan CS. Low-light image enhancement using Gaussian Process for features retrieval. Signal Process: Image Commun. 2019 May 1; 74: 175–90.
2. Cai J, Gu S, Zhang L. Learning a deep single image contrast enhancer from multi-exposure images. IEEE Trans Image Process. 2018 Jan 15; 27(4): 2049–62.
3. Gomez-Ojeda R, Zhang Z, Gonzalez-Jimenez J, Scaramuzza D. Learning-based image enhancement for visual odometry in challenging HDR environments. In 2018 IEEE International Conference on Robotics and Automation (ICRA). 2018 May 21; 805–811.
4. Xiao B, Tang H, Jiang Y, Li W, Wang G. Brightness and contrast controllable image enhancement based on histogram specification. Neurocomputing. 2018 Jan 31; 275: 2798–809.
5. Wan M, Gu G, Qian W, Ren K, Chen Q, Maldague X. Infrared image enhancement using adaptive histogram partition and brightness correction. Remote Sens. 2018 Apr 27; 10(5): 682.
6. Ma J, Fan X, Yang SX, Zhang X, Zhu X. Contrast limited adaptive histogram equalization-based fusion in YIQ and HSI color spaces for underwater image enhancement. Int J Pattern Recognit Artif Intell. 2018 Jul 29; 32(07): 1854018.
7. Putra RD, Purboyo TW, Prasasti LA. A review of image enhancement methods. Int J Appl Eng Res. 2017; 12(23): 13596–603.
8. Singh G, Mittal A. Various image enhancement techniques-a critical review. International Journal of Innovation and Scientific Research (IJISR). 2014 Oct; 10(2): 267–74.
9. Ariateja D, Ardiyanto I, Soesanti I. A review of contrast enhancement techniques in digital image processing. In 2018 IEEE 4th International Conference on Science and Technology (ICST) 2018 Aug 7; 1–6.
10. Dougherty ER. Digital image processing methods. CRC Press; Florida, United States. 2020 Aug 27.

 