International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

A Review on Image Enhancement Using AI

Yash Pandey[1], Vikash Gautam[2], Vrushabh Mowade[3], Sanika Telang[4], Sujal Bhagat[5]

[1,2,3,4,5]Department of Artificial Intelligence, G H Raisoni College of Engineering and Management, Nagpur

ABSTRACT:
Image Enhancement is an important domain in image processing, as this helps to ensure the potentiality and visibility of images. With regular increase in image production, Image enhancement comes under use as most of the image gets dull or degraded while clicking, thus it is important to develop methods for image enhancement. Image enhancement is performed by various machine learning approaches, by decompressing, denoising and decomposing images. This is variously used in the field of medical, journalism, forensic investigation, satellite imaging, photography and security and surveillance. This paper provides an overview of the importance of image enhancement and various methods to apply it on images.

Keywords: Enhancement, Frequency Domain, Image enhancement, Spatial Domain, Morphological, Fourier transform

INTRODUCTION

Image enhancement is a critical area in image processing that focuses on improving the visual quality of images. The process involves various techniques that can be used for enhancing details, contrast, sharpness, and overall aesthetics of images. This can be useful in various fields like medical imaging, satellite imagery, also in everyday photography. There are usually multiple types of image enhancement techniques but in our project we have studied about major four techniques which are Spatial Domain Techniques, Color Image Enhancement Color, Morphological Operations, Frequency Domain Techniques.

Certainly as for every project there are certain objectives we have discussed in our project some of the following are Improving Visual Quality I.e. Enhancing the perceptual quality of images for better visual appearance and providing Correct imperfections and removing noise for clearer and sharper images. Another one is Detail Preservation I.e. to Preserve fine details and textures while enhancing the image and Avoiding over-smoothing and maintaining the natural looks in the image. Third one goes like Dynamic Range Enhancement I.e. Enhancing the dynamic range to reveal details in both shadows and highlights and perform HDR imaging to balance the exposure levels in the images.

One of the major discussions in our project is the reduction of noise in image as if to reduce or eliminate noise and artifacts present in image without compromising with the quality of image and apply denoising techniques to improve the overall clarity of the image. Image enhancement techniques work directly on images as if for Spatial Domain technique the algorithm directly works on Grey Scale manipulation, Image Smoothing, Sharpening and Histogram Equalization. Image enhancement is used to improve the quality,

usability and interpretability of images across a wide range of applications and industries.

The problem is that many digital images are not clear or of high-quality, which can make them hard to use and work with also applying certain conditions. It's difficult to understand them. Major Issues like Noise, low resolution, poor contrast and color problems can make images look bad and hide important details. In modern days multiple generative AI are in function to enhance , retouch and denoise image but the complementary method used in the AI are same as used in a Machine learning model that is training and testing model using multiple training techniques few of them are evolutionary training model etc., As of Here the image enhancement techniques as in used here are :

A. Spatial Domain Technique
B. Frequency Domain Technique
C. Color Image Enhancement Color
D. Morphological Operations

1. Spatial Domain Techniques:

Spatial domain techniques is a type of technique which directly works on pixels of an image. This technique manipulates pixels of an image for enhancing or extracting features from an image. This method first transforms images I.e. by using Fourier Transform before processing it further. Spatial Domain Technique include the following :

- **Gray Scale Manipulation :**In image gray is the most transparent and changeable color. Most of all image processing works on Gray color. Similarly, Gray Scale Manipulation is a technique used in image processing. This method works by adjusting the gray color in the image for various feature extraction. Gray scale method converts RGB (Red, Blue, Green) color into shades of gray color.
- **Image smoothing :** Image Smoothing in Spatial Domain is a technique used to reduce noise and fine details in image by applying Low-pass filters. This method works by removing or replacing each pixel value with an average of its neighbor pixels. As this works on pixels, this method is a slow process as checking up pixels is a time consuming process.
- **Sharpening :** Image smoothing and sharpening works side by side as image smoothing reduces noise with comparison of neighboring pixels. Sharpening works as enhancing details and contrast of image for making it more clear and focused.

2. Frequency Domain Techniques:

Frequency Domain Technique is a method usually used with signal processing , system analysis or system based on their frequency rather than their time-domain characteristics. This approach is technically used for dealing with signals as signals are the only device understood. For instance, a computer does not even know about binary language. It is the signals which are considered by a computer. Thus directly working on signals is more effective rather than dealing with time-based domain characteristics. A frequency domain represents signals in terms of constituent frequencies. The time based domain tells us about how signals change throughout time but the Frequency Domain shows how much signal lies between a particular band of frequency or range of frequency.

This approach is particular in dealing with signals that are periodic or the signals which can be described or termed as frequency. This technique is generally achieved by using mathematical tools like fourier transform. The modification includes the following tools:

- **Filtering :** Filtering and Fourier Transform are used together in Frequency Domain Technique for enhancing image. Filtering refers to removal of unwanted information from image in general terms

but in Frequency Domain Filtering refers to manipulating signals or images by directly manipulating its frequency components. Filtering method is used for noise reduction and image sharpening.

- **Fourier Transform :** Fourier Transform is a tool widely used in Image processing; this is an important aspect of image enhancement. Fourier Transform is majorly used in Spatial domain and Frequency Domain in image enhancement. This tool converts images from spatial domain to frequency domain. A method called fast fourier transform is adapted for image image processing. This method is used especially for large images. This works fast and efficiently. Fourier Transform is used for Noise reduction, Image compression and Pattern Recognition.

3. Color Image Enhancement Color:

Color Image enhancement techniques aim to improve visual quality and details of image.Color enhancement directly works on color distribution in images. The below lists up common techniques for image enhancement are :

- **Histogram Equalization :** Histogram Equalization enhances contrast by redistributing intensity across the histogram. This method spreads most intensity values , this method also improves the contrast of images.
- **Contrast Stretching :** The following technique adjusts range of intensity values to improve contrast. It maps original values of pixels to a new range, enhancing differences between pixels.
- **Gamma Correction :** This method is used in image enhancement; it adjusts brightness and contrast of an image by applying non linear transformation to pixel values in the image.

4. Morphological Operations:

These are based on the shape of features in an image. This method is used for analyzing the structure and shape of objects in images. Here, special probes are used for particular tasks such as image segmentation, noise removal and shape analysis in image. The following operations are in morphological operations in image processing are:

- **Erosion and Dilation:** Erosion and Dilation are terms used in morphological operations. For instance, Erosion shrinks the boundary of objects in image and Dilation expands boundary in shape of images. This directly works on shape and sizes in image. This method is widely used for
- **Opening and Closing:** Both of the methods work side by side for achieving solution to problems. Similarly, opening and closing combines erosion and dilation to remove noise or fill gaps.

Literature Review:

The paper provides an understanding survey about image enhancement techniques, including Spatial domain Technique, Morphological technique, Frequency Domain Technique and Color image enhancement technique I.e., Automatic image enhancement using various algorithms [1]. The dual color and texture enhancement based method for low-light enhancement proposes how to maintain color distribution and handles multiscale textures, overcoming color distortion and blurring issues in low-light images [2].

The paper proposed a technique for image enhancement using color moments. Firstly, the image is converted as grayscale, then the most gray ones are distorted or combined together for compression and decomposition this helps the image to be a bit reduced in size without affecting the quality of the image. Then, the image is considered as in RGB(Red, Green and Blue) colors and based on the combinations and decomposition the image is enhanced by the use of retinex algorithm which is based on transformer and

it is one-stage this guides illumination transformer effectively to enhance low-light images without corrupting them [3].

The paper proposed the multi feature fusion transform for low-light hyperspectral image classification using graph attention network. Here, the model used in paper combines 3D-CNN(convolutional neural network) and Optimized GAT(Gaussian technique) model, which significantly improve image classification performance with better accuracy and efficiently, with training only few or limited samples [4]

The paper proposes use of spatial domain learning technique where an image is transformed via a real-low to real-normal network by denoising, decomposing and contrast enhancing. This method first transforms images I.e. by using Fourier Transform before processing it further. Fourier Transform is a tool widely used in Image processing; this is an important aspect of image enhancement. Fourier Transform is majorly used in Spatial domain and Frequency Domain in image enhancement. This tool converts image from spatial domain to frequency domain [5]

The paper proposes the Diffusion model for object detection in enhancing the image here, the diffusionDet formulates object detection as a denoising diffusion process, progressively refining the noisy boxes to object boxes iteratively. The main reason for converting the boxes to object boxes is that object boxes are easily distinguishable and thus helps the model to identify the denoising. This helps model by increasing the accuracy of the image enhancement [6].

The paper nextly suggests the one transformer to rule universal image segmentation that works as multi-task training once to achieve state of the art performance over semantic, instance, and panoptic segmentation tasks. Segmentation refers breaking of images in multiple parts of distinguishable parts here, this helps the image for better understanding and training of the model becomes easy thus this reduces error combination in image enhancement proving the point of accuracy and efficiency of the enhancement done in image [7]

The next paper proposes object detection in image enhancement and how it is performed here, the object detection uses various machine learning techniques which are neural networks for replicating the image as humans recognize the image. Also, this method improves object detection accuracy in image scenes. This works as detecting and classifying images. [8]

The further paper tells us about the introduction of image enhancement, various methods used for enhancement and activities, prototypes and basics of image enhancement, this paper mainly focuses on spatial domain expansion technique and frequency domain technique [9].

The next paper is a survey of underground water, the study is done in the ocean where there is darkness at most of the part thus there will be a need for enhancement of images taken inside water. Deep sea is mostly abundant and dark so the need for enhancement comes under use in various ways in deep sea exploration. Underwater sea consist of many wildlife, sea species and various fishes which are usually dark in color so thus came use of enhancement in the survey [10]

The next paper was published by IEEE on 10, May 2012, where the paper tells us about the drawbacks of images taken under low light and the proper conditions to click images for various purposes and uses. The paper is based on an algorithm which produces AC-DOC transformation of image, under various conditions of images clicked. The paper analyzes contrast of image and group of image with similar characteristics[11].

This paper proposes an algorithm that enhances the contrast of an input image using interpixel contextual information. The Algorithm uses their 2D histogram and calculates the relationship between each pixel

and their neighboring pixels. This demonstrates the image enhancement technique used in the research paper. [12]

The paper tells us about the Retinex Model which is a useful and effective tool for image enhancement. These types of models are mostly handcrafted and made. In the training process, the Libraries used for decomposition in the retinex model are Decom.net. The retinex model mostly works on decomposition of images and is considered as any image can be decomposed into reflectant and illuminated images. This paper demonstrates a method that not only achieves visual pleasing quality but also provides a good representation of image decomposition.[13].

The upcoming paper is also a paper based on underwater study of biodiversity, the key goal of the paper is to retrieve images and videos through intelligent processing. To date, no metric has been proposed for underwater color image quality evaluation (UCIQE). UCIQUE is a simple and fast solution for real time underwater video processing. This paper mainly focuses on videos of underwater research and their enhancement.[14]

The next paper is a paper based on underwater research through various multi-retinex models. Image enhancement is one of the major challenges faced in underwater image analysis as mostly in deep sea sunlight is unable to reach thus there is darkness in deep sea. This darkness influences images and their quality thus there is a requirement of image enhancement in images clicked underwater for clear quality and better understanding. The term retinex is made up of two words that are ‘retina’ and ‘cortex’. In conclusion, this paper uses retinex algorithm for enhancement of low light deep sea images[15].

The paper is a systematic review and evaluation of existing single-low-light-image enhancement algorithms. This paper tells us about face detection, how it is performed and why to enhance face images for detection. As there are multiple filters, this is paper which diversifies scenes and contents as well as complex degradation of real scenarios, commonly called as vision enhancement in low light conditions [16].

The retinex theory of color vision is a journal published by an American author Edwin D. Land. This paper is a very well known paper published on the Retinex algorithm. The paper states as ‘ A retina and cortex system(retinex) may treat a color as a code for a three-part report from the retina, independent of the flux of radiant energy’ This paper is an informative paper solely on Retinex image enhancement algorithm [17].

An image captured in low light often results in complex degradation. It simply is filled with various noises and disturbances when clicked. Lighting is an important aspect for producing a good quality image and if lighting is disturbed an image can vary. This is totally explained in detail in this paper. Luminescence, distortion, noise and various inferior additions In image are covered in this research paper [18].

The following paper was published in IEEE on 13, March 1997, the paper tells us about use of gaussian filters in image enhancement. This paper mostly talks about decomposition and denoising in images. The place where retinex fails to prove and the images which violate the gray world assumption in retinex are also investigated in the following paper [19].

The upcoming paper was published on IEEE on 31, July 1997 Where this paper also tells us about retinex algorithm and its dynamic range compression, color- consistency and human vision color distortion and image tonal rendition. Here, this paper consists of extensive testing of retinex multiscale with color restoration on several test scenes. With hundreds and thousands of images where they did not show any pathological behavior [20].

A simple method called LIME: Low-light image enhancement method is discussed in the paper where the

working and basics design of the model is told this paper was published in IEEE on 14 December, 2016. The paper consists of the findings of the LIME technique and working of it. The paper also discusses how low-light images degrade the performance of a working model of many computer vision and multimedia algorithms; they are primarily designed for high-quality inputs [21].

CONCLUSION

This paper suggests the basics of image enhancement and various types of image enhancement processes commonly used. This paper is a detailed analysis of image enhancement with proper information and examples. Various approaches to image enhancement. We have mainly discussed basic parameters used for image enhancement such as Frequency Domain, Morphological, Spatial Domain and Color Image enhancement Technique. Here, this paper mainly focuses on Spatial Domain and Frequency domain technique.

References

1. " Automatic Image enhancement Using Evolutionary machine learning algorithm" by Anindita Chatterjee, Prannoy Dhar and Anish Chakraborty.
2. DCTE-LLIE : A Dual color and texture enhancement based method for low light image enhancement by Hua wang, Jianzhong Cao, Lei Yang and Jijang Huang.
3. "One-Stage retinex-based transformer for low-light image enhancement" by Cai. Y., Bian, H., Lin. J., Wang. H., Timofte. R,. Zhang. Y,.
4. MFFCG: Multi feature fusion for hyperspectral image classification using graph attention network by Bhatti, U.A,. Huang. M., Neira-Molina. H., Marjan. S., Baryalai. M., Tang. H., Wu. G., Bazai. S.U.,
5. " Low-Light image enhancement via real-low to real-normal network " by Hai. J.; Yang. R., Hao. Y:, Zou. F., Lin. F., Han. S;.
6. "Diffusion model for object detection" by Chen. S., Sun. P ,. Song. Y., Luo. P.,
7. One transformer to rule universal image segmentation published by IEEE/CVF by Jain. J., Li. J., Chiu. M.T.; Hassani. A., Orlov. N., Shi. H,.
8. "Object detection in 20 years : A survey" by Proc. IEEE 2023, 111, 257-276 by Zou. S., Chen. K., Shi. Z., Gou. Y., YE. J,.
9. A. Kaur and M. Kaur, 2015. " Review of image processing - introduction to Image enhancement techniques using particle swarm optimization, " International Journal of Artificial Intelligence and Applications for Smart Devices, 3(1):15-20.
10. S. Khunger, K. Sharma and A. Verma, 2016, " A Novel Approach for Underwater Image Enhancement," International Journal for Scientific Research and Development, 4(2):393-396.
11. A. A. R. Rivera, B. Ryu, and O. Chae, "Content-Aware Dark Image Enhancement Through Channel Division", 2012
12. Celik, T.; Tjahjadi, T. Contextual and variational contrast enhancement. IEEE Trans. Image Process. 2011, 20, 3431-3441.
13. Wei. C.; Wang, W.; Yang, W.; Liu, J. Deep retinex decomposition for low-light enhancement, arXiv 2018, arXiv:1808.04560.
14. Yang, M., Somwya, A.: An underwater color image quality evaluation metric. IEEE Trans. Image Process. 24(12), 6062-6071 (2015)

15. Zhang. S., Wang. T., Dong. J., Yu, H., Underwater image enhancement via extended multi-scale Retinex. Neurocomputing 245(5), 1-9 (2017)
16. Liu, J., Xu, D., Yang, W,. Fan, M., Huang. H., Benchmarking low-light enhancement and beyond. Int. J. Comput. Vis. 2021, 129, 1153-1184.
17. Land, E.H. The retinex theory of color vision. Sci. Am. 1974, 237, 108-128.
18. Guo, X., Hu, Q., Low-light image enhancement via breaking down the darkness. Int. J. Comput. Vis. 2023, 131, 48-66.
19. Jobson, DJ.; Rahman, Z-u.; Woodell, G.A. Properties and performance of a center/surround retinex. IEEE Trans. Image Process. 1997, 6, 451-462.
20. Jobson, DJ.; Rahman, Z-u.; Woodell, G.A. A multiscale retinex for bridging the gap between color images and the human observation of scenes, IEEE Trans. Image Process. 1997, 6, 965-976.
21. Guo, X., Li, Y., Ling, H., LIME: low-light image enhancement via image illumination map estimation. IEEE Trans. Image Process. 2016, 26, 982-993.