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Review and Analysis of Image Transformation and Enhancement Techniques

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ABSTRACT:

One of the difficult problems in image processing is picture correction and restoration. The goal of image enhancement is to modify a photo so that the final product is better suited for a certain purpose than the original photo. Digital image enhancement methods offer a variety of options for enhancing the aesthetic appeal of photographs. The imaging normalization, the task at hand, and the viewing circumstances all have a significant impact on the appropriate choice of such procedures. This essay will give a summary of the various methods used frequently for improving images, analyze them, and explain which method to use when.

Keywords— Digital Image Processing, Picture correction, Histogram Equalization, Image Enhancement & Imaging Modality.

I. Introduction

Digital image processing is a large domain that involves composite mathematical procedures, but the fundamental concept behind it is simple. The primary objective of image processing is to utilize the information within an image to enable the system to understand, recognize, interpret and reconstruct the processed elements. Image enhancement techniques are commonly employed to uncover corrupted details or highlight specific features of interest. In the image enhancement process, one or more attributes of the image are modified. Image enhancement and restoration finds applications in various scientific and engineering domains. In addition to illumination conditions, the quality of images can be adversely affected by external factors such as noise and climatic disturbances, including ambient pressure and temperature fluctuations. Consequently, image enhancement becomes necessary as it is quite natural. Image enhancement (IE) has made significant contributions to research advancements in signal processing diverse fields. Approaches such as contrast-limited image enhancement, which involve stretching histograms within a reasonable dynamic range, and multi-scale adaptive histogram equalization, can be developed. Adaptive algorithms can be applied globally or locally to accommodate the intensity distribution of the image. By separately handling fine and detailed areas of an image, the algorithm avoids additional values of noise. In many cases, the quality of images is compromised by atmospheric and water mediums, thus necessitating the need for image enhancement.

II. Areas Utilizing Image Enhancement

Image enhancement finds wide applications in various domains, as highlighted below .

Atmospheric Sciences: Image pixel restoration is employed to minimize the impact of blur, fog, and troublesome weather in climatic observations. It aids in detecting shape and structure of remote objects for environmental sensing. Satellite images undergo restoration and enhancement to eliminate noise.

Forensics: Image enhancement is crucial for identification, collecting required information, and surveillance purposes. It enhances images obtained from fingerprint identification, security video analysis, and crime scene investigations, aiding in culprit identification and victim protection.

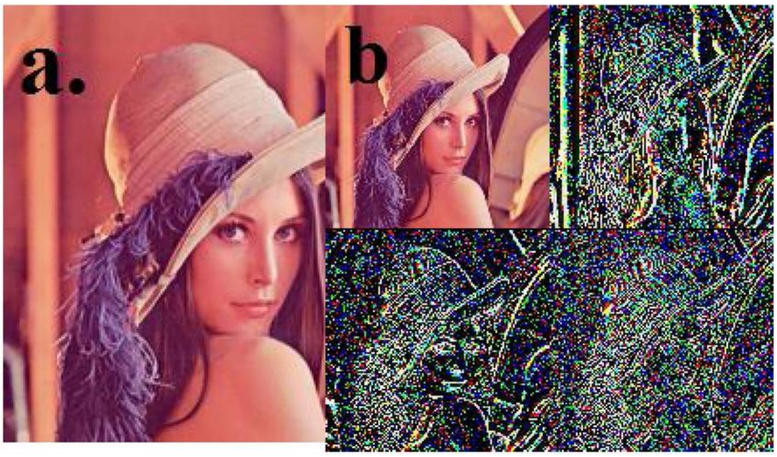
Astrophotography: IE minimizes challenges posed by light and noise pollution in astrophotography. Cameras often incorporate built-in IE functions for real-time sharpening and contrast enhancement. Additionally, various software tools allow for editing and improving astrophotography results.

Oceanography: Enhanced images unveil significant features related to water flow, sediment concentration, geomorphology, and bathymetric patterns in oceanography. Image enhancement helps overcome issues posed by moving targets, low light conditions, and obscured surroundings.

Numerous other fields, including law enforcement, microbiology, biomedicine, bacteriology, among others, benefit from diverse image enhancement techniques. These profits extend beyond professionals and businesses, reaching common users who employ image enhancement for cosmetic improvements and image correction.

A. Histogram Equalization

Histogram equalization is a commonly used as a process for image restorationby stretching out the gray levels across the entire pixel spectrum, histogram equalization improves image clarity and enhances contrast for human inspection. It can also normalize illumination variations in image understanding applications .This global technique adjusts the pixel levels based on the original image's brightness, using a transformation function to equalize the histogram. The goal is to achieve a more uniformly distributed histogram, as shown in Figure.



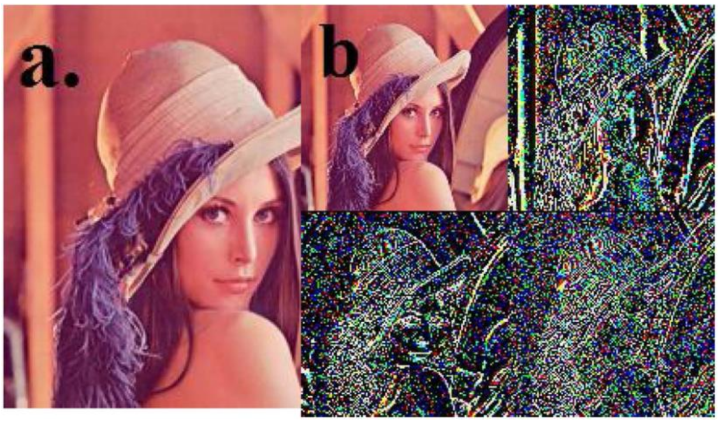
Lena Image after Histogram Equalization

B. Local Enhancement

To overcome the limitations of global methods, local enhancement is employed. This technique involves defining a neighborhood (pixels) and moving its center from pixel to pixel. For each neighborhood, the histogram is calculated, and histogram equalization/specification is applied to map the gray levels of the centered pixel element. By using new pixel values and previous histograms, subsequent histograms can be computed. The result of local histogram enhancement is demonstrated in Lena Image(120,120).

C. Log Transformations

Logarithmic transformations expand a narrow range of low input gray level values into a wider range of output pixel values. This is particularly useful when dealing with images that have an extensive range of values. Log transformations can compress the dynamic range of pixel values, allowing better visibility of details in both bright and dark areas. The log transformation is expressed as $g(x, y) = c. \text{Log}(1 + r)$. The inverse log transformation performs the opposite operation. An example illustrating the effect of log transformations values is shown in Figure given below.



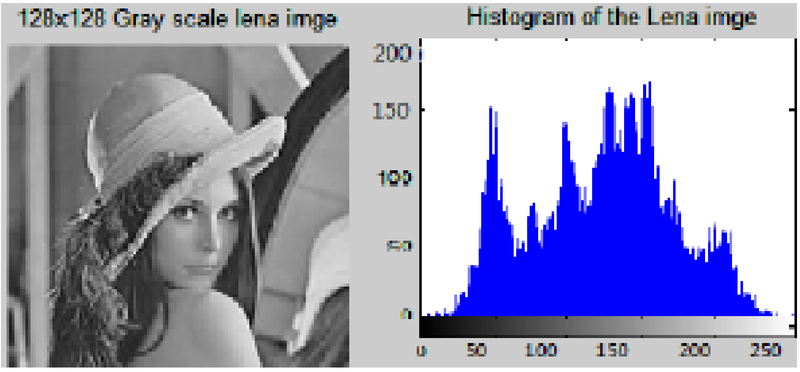
Lena Image(120,120) after log values Transformation

D. Thresholding Transformations

Thresholding impose are valuable for image segmentation, separating objects of interest from the background. Global thresholding methods choose a single threshold value for the entire image, based on the estimation of the background level from the intensity histogram. Local adaptive thresholding, on the other hand, assigns different thresholds to each pixel based on local area information. This approach is suitable for images with non-uniform background illumination or complex backgrounds. It addresses cases where global thresholding fails due to multiple peaks in the histogram. Figure 4 depicts the result of thresholding techniques .

E. Contrast Stretching

Contrast stretching is utilized to increase the range of brightness values in an image, allowing for optimal display according to the analyst's preferences. Low illumination or in proportionate settings in the acquisition sensor device can cause variations in image contrast, necessitating contrast manipulation during image restoration . The objective of contrast stretching is to increase the dynamic range of gray levels in the processed image. By modifying the dynamic range of gray levels, the contrast of low-contrast or high-contrast images can be adjusted. The linear contrast stretch algorithm is a simple technique that extends the pixel values across the entire image spectrum from 0 to (L-1), where L represents the maximum gray level . The result of contrast stretching can be observed in Figure below.



Lena Image after contrast stretching application

F. Unsharp Masking

The unsharp masking (UM) technique involves adding a fraction of the high-pass filtered image to the original image to enhance details. The signal input/output relationship of the unsharp masking filter is expressed as given below.

output image = input image + (positive constant) * high-pass filtered image

The unsharp masking structure is illustrated in Figure 6. While this method is straightforward, it has two notable drawbacks. Firstly, it enhances the noise present in the image. Secondly, it can lead to excessive overshoot on sharp edges, enhancing sharp transitions beyond necessary levels. These drawbacks should be taken into consideration when applying unsharp masking for image enhancement.

TABLE I. COMPARATIVE ANALYSIS OF IMAGE ENHANCEMENT TECHNIQUES

S.NO	TECHNIQUES	ADVANTAGES
1	Histogram Technique	- Simple technique
		- Global histogram equalization can be done completely automatically
2	Local Enhancement	- Simple to use
		- Allows for defining a square or rectangular neighborhood and moving the center from pixel to pixel
3	Log Transformation	- Useful for enhancing details in darker regions of the image
		- Can expand the range of low input grey level values into a wider range of output values
4	Thresholding Addition	- Particularly useful for segmentation tasks, isolating objects of interest from the background
5	Linear Contrast Stretch	- Simple contrast stretch algorithm that expands the dynamic range of pixel values
		- Can enhance low-contrast and high-contrast images
6	Unsharp Masking	- Simple method for enhancing images
7.	Double-derivative Technique	- Adds a fraction of the high-pass filtered image to the original image to enhance corrected Image.
8.	Fuzzy Logic technique	- Major drawbacks include enhancing noise pixels in the image and excessive values on coloured pixels and sharp edges

CONCLUSIONS AND FUTURE WORK

In this paper, we have surveyed various areas where image enhancement techniques are applied. We have discussed the most applicable techniques for enhancing grayscale images in digital image processing techniques The above table presented above highlights different techniques and their advantages.

While this article focused on the advantages of each technique, it is important to consider the computational cost when choosing an enhancement technique for live-time applications. The computational efficiency of mentioned techniques can play a critical role in their practical implementation.

Furthermore, it is worth noting that while each algorithm discussed in this paper is effective when applied individually, there is potential for even greater enhancement by combining multiple methods. Future work could involve exploring and developing hybrid approaches that leverage the strengths of different techniques to achieve more effective image enhancement.

Overall, image enhancement techniques continue to evolve, and there is ongoing research and development in this field. The advancements in computational power and algorithms provide opportunities for further improvements in image enhancement, making it an exciting area for future exploration.

REFERENCES

1. Zhengmao Ye, HabibMohamadin, Su-Seng Pang, SitharamaIyengar. "Contrast Enhancement and Clustering Segmentation of Gray Level Images with Quantitative Information Evaluation."Weas Transaction on Information Science & Application, Vol. 5, pp. 181, February 2008.
2. SasiGopalan, Madhu S Nair, and Souriar Sebastian."Approximation Studies on Image Enhancement Using Fuzzy Technique." International Journal of Advanced Science and Technology, Vol. 10, pp. 11-26, September 2009.
3. Jianwei Ma and GerlindPlonka."Curvelets and Recent Applications." 2010.
4. Shen, X., Zhang, X., Wang, Y.: Color enhancement algorithm based on Daltonization and image fusion for improving the color visibility to color vision deficiencies and normal trichromats. J. Electron. Imaging **29**, 053004–053004 (2020)
5. Wan, S., Xia, Y., Qi, L., Yang, Y.-H., Atiquzzaman, M.: Automated colorization of a grayscale image with seed points propagation. IEEE Trans. Multimed. **22**, 1756–1768 (2020)
6. Liu, E., Li, S., Liu, S.: Color enhancement using global parameters and local features learning. In: Computer vision—ACCV 2020, pp. 202–216. Springer International Publishing, Cham (2021)
7. Manovich, L.: Computer vision, human senses, and language of art. AI Soc. **36**, 1145–1152 (2021)
8. Ngugi, L.C., Abelwahab, M., Abo-Zahhad, M.: Recent advances in image processing techniques for automated leaf pest and disease recognition—a review. Inform. Process. Agric. **8**, 27–51 (2021)
9. Pei, Y., Huang, Y., Zou, Q., Zhang, X., Wang, S.: Effects of image degradation and degradation removal to CNN-based image classification. IEEE Trans. Pattern Anal. Mach. Intell. **43**, 1239–1253 (2021)
10. Ramella, G.: Evaluation of quality measures for color quantization. Multimed. Tools Appl. **80**, 32975–33009 (2021)