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Analysis Equalization Images Contrast Enhancement and Performance Measurement

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Abstract

These days, image processing is crucial, particularly when it comes to enhancing brightness, contrast, and image quality. The goal of this research is to develop three distinct methods for manipulating images and evaluating them using histogram, entropy, and PSNR—two image-specific metrics. Frame Fusion produces excellent results in image contrast, brightness, and enhancement through the standards of PSNR, histogram, and entropy. In comparison to its competitors, the technology performed better in terms of high pixel uniformity in images, consistency efficiency, processing and execution speed, and contrast quality. The aforementioned findings lead us to the conclusion that exposure frame fusion technology is highly effective at figuring out how to improve the contrast and brightness of computer images. Three image processing techniques were used: exposure frame fusion, dynamic histogram equalization, and histogram equalization. A comparison of the techniques using quantitative and physical criteria revealed that histogram equalization outperformed dynamic contrast techniques in several areas, including image uniformity, contrast quality, efficiency, execution speed, and accuracy of results. It is advised to use exposure frame fusion in addition to histogram equalization since it is the brightest, clearest, and most like the original images.

Subject Areas

Computer Engineering

Keywords

Image Contrast Enhancement, Exposure Fusion Framework, Entropy, PSNR, Histogram

1. Introduction

"Contrast" describes taking pictures with a professional camera vs a cell phone.

One of the most crucial words a photographer understands is this one. However, when it comes to displaying a photo, contrast and adjustability are two of the most crucial elements that may be quite helpful. If we have sufficient knowledge about picture contrast, it may quickly change the desired photographs and provide the intended outcome. We'll talk about visual contrast in this part. The concept and uses of contrast, several methods of enhancing contrast, and other topics that can be quite helpful in our activities are explored [1].

This study deals with a specific set of techniques used to process images, as well as evaluating the performance of techniques used to increase the level of brightness, know the contrast of images and analyze them.

The degree of color or grayscale distinction between various visual components in analog and digital images is referred to as contrast. Those with greater contrast levels frequently show more color or grayscale variation than those with lower contrast levels [2]. The process of measuring an image's brightness, also referred to as luminous brightness, the degree of color or grayscale distinction between various visual components in analog and digital images is referred to as contrast. Those with greater contrast levels frequently show more color or grayscale variation than those with lower contrast levels [3]. The images are converted to grayscale and processed for clearer analysis.

The following sections represent this paper: Section 1: Introduction; Section 2: Related Work; Section 3: Methodology; Section 4: Experimental Outcomes; Section 5: Discussion; and Section 6: Conclusion.

2. Related Work

The goal of this study was to enhance images so that they could disclose information that is hidden from the observer because of low or weak contrast when the image is being acquired. They found that increasing contrast can improve the quality of images. Contrast enhancement is widely used in many different industries, such as medical imaging systems and satellite imaging systems since it enhances feature visibility. The survey resulted in the researchers' conclusion that structural information loss, brightness preservation, entropy preservation, etc. should all be taken into account while enhancing contrast. The method was validated by researchers using a variety of performance criteria, including both qualitative and quantitative approaches. Entropy is the most important performance metric when assessing algorithms. In our study, entropy was used for the same purpose to evaluate the techniques used [4].

Akila, K., Jayashree, L.S., *et al.* interested in the field of processing mammograms in contrast enhancement. Direct contrast enhancement and direct contrast enhancement are the two categories into which it can be divided. Indirect contrast enhancement entails altering the image's histogram. The most popular and straightforward indirect contrast enhancement method is histogram equalization (HE). It is crucial to compare these methods to select an appropriate algorithm for improvement and additional processing. In this work, it has been preprocessed the mammography images using a few methods for indirect contrast enhancement are MMBEBHE, RMSHE, CLAHE, BBHE, and histogram equalization. Effective measure of enhancement (EME) and peak signal-to-noise ratio (PSNR) are used to evaluate the effectiveness of the approaches. In our study, PSNR was used for the same purpose to evaluate the techniques used [5].

Maragatham, G. and others in this study are to give a thorough analysis and a survey of the current image enhancement techniques along with their descriptions. The majority of the photos have poor contrast because of factors such as bad weather, inadequate lighting, and the capturing device. An object in an image can be distinguished from other objects and the background thanks to contrast. By increasing the dynamic range of the input gray level, contrast enhancement enhances the visual quality of images for human observers. Many improvement methods have been developed, but none of them are thought to be universal, so their use is limited. From this study, we decided to choose the grayscale image, it is essential to give a thorough overview of these contrast enhancement methods used in digital image processing in such a situation [6]. Maragatham, G., and others in this study are to give a thorough analysis and a survey of the current image enhancement techniques along with their descriptions. The majority of the photos have poor contrast because of factors such as bad weather, inadequate lighting, and the capturing device. An object in an image can be distinguished from other objects and the background thanks to contrast. By increasing the dynamic range of the input gray level, contrast enhancement enhances the visual quality of images for human observers. Many improvement methods have been developed, but none of them are thought to be universal, so their use is limited. From this study, we decided to choose the grayscale image. It is essential to give a thorough overview of these contrast enhancement methods used in digital image processing in such a situation [6].

Image enhancement is crucial, particularly for the analysis and diagnosis of detailed data, as Mustafa, Wan Azani, *et al.* found. The majority of research on image enhancement concentrates on contrast normalization. In general, contrast controls how easily detail in an image can be identified, how information in an image can be understood, as well as the locations of interesting items. In-depth reviews of the spatial domain (Histogram Equalization, or HE), frequency domain (Discrete Wavelet Transform, or DWT), and homomorphic filtering methods for picture improvement are presented in this study. Systematic explanations were provided for method improvement and modification. This work aimed to compare the performance of the results and examine the benefits and limitations of each method. In addition, this study emphasizes the significance of contrast enhancement for enhancing the system's performance, particularly concerning accuracy and sensitivity, while concentrating on a variety of application kinds. To improve our understanding of picture enhancement, earlier research was examined and contrasted critically. Proposals for fresh approaches to picture enhancement research were made [7]. In addition, this study emphasizes the significance of contrast enhancement for enhancing the system's performance, particularly with regard to accuracy and sensitivity, while concentrating on a variety of application types. To improve our understanding of image enhancement, earlier research was examined and contrasted critically. Novel concepts for additional investigation and advancement in image enhancement were put forth [3].

3. Methodology

In this study, the goal was to enhance images to disclose information that is hidden from the observer because of low and weak contrast at the time of image acquisition. It has been found that increasing contrast can improve the quality of images. It turns out that in analog and digital images, contrast refers to how many different colors or grayscales can be distinguished between various image features. Higher contrast levels often exhibit more color or grayscale [8] contrast when compared to lower contrast levels in physical gradation images. It is concluded that while optimizing variance, it is important to take into account factors like brightness preservation, entropy preservation, and loss of structural information. The method was validated using a variety of performance criteria, including both qualitative and quantitative means. Entropy [9] is the standard by which algorithms are judged, along with metrics like PSNR and histogram that gauge how well pixels flow and coherence in an image [10].

There are different types of contrast: Tonal disparity, High contrast, and Low contrast. In this research [11], four images are used to apply three image enhancement and processing techniques that represent the mentioned types of contrast. The first technique is histogram equalization, the second is dynamic histogram equalization [12], and the third is Exposure Fusion Framework which is a new Image Contrast Enhancement Algorithm. Also, we are measuring performance of techniques by Entropy, PSNR and Histogram.

3.1. Exposure Fusion Framework

The most popular method for producing high dynamic range (HDR) images is exposure fusion, which combines exposure images taken of the same scene. However, conventional exposure fusion algorithms lose detail in the scene's brightest and darkest areas. Through the use of multi-exposure fusion, Exposure Fusion illustrates how image sequences with different exposures may be immediately formed into a low dynamic range image or tone-mapped to one after the high dynamic range has been recovered [13].

Three different approaches are frequently used to fuse images in the spatial domain: pixel-based methods, pixel-based methods, and source image-based methods. The fused image's pixel values are calculated directly from the source image's pixel values. Three different approaches are frequently used to fuse images in the spatial domain: pixel-based methods, pixel-based methods, and source image-based methods as in **Figure 1**. The fused image's pixel values are

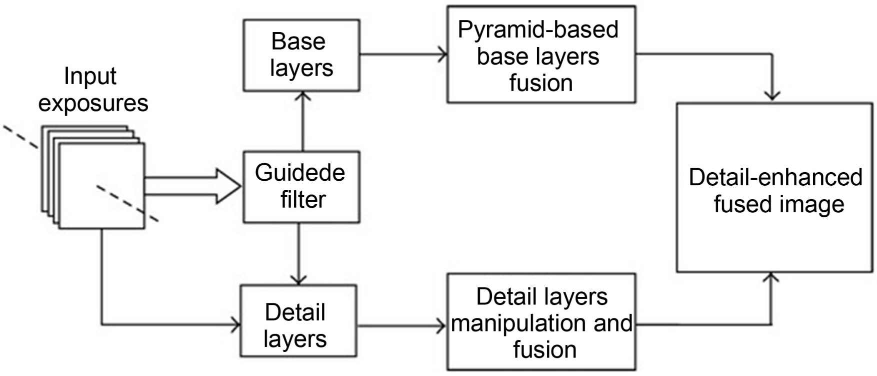


Figure 1. Exposure fusion framework [15].

calculated directly from the source image's pixel values [14].

3.2. The Entropy

Entropy is the quantity of thermal energy per unit temperature in a system that cannot be put to use in productive labor. Since work is created from organized molecular motion, entropy is a measure of molecular disorder, or unpredictability, in a system. The concept of entropy provides deep insight into the direction of spontaneous change for a wide range of everyday events. Rudolf Clausius, a German scientist, introduced it in 1850, marking a zenith of 19th-century physics [16].

$$H_1 = \sum_k p_k \log_2 (p_k) \tag{1}$$

where p_k is the probability connected to gray level k, gray levels are represented by K, while entropy is represented by H_1.

3.3. PSNR (Peak Signal-to-Noise Ratio)

It is possible to evaluate the quality of the coding as the PSNR criteria analyzes picture quality and shows pixel variations between the original and encrypted image. A PSNR value, consisting of eight bits per pixel, is determined by the pixel itself. The higher quality of the encryption techniques is indicated by the lower value [17]. The formula for calculating PSNR value is MAX, which is the highest value that a pixel can capture. MAX is 255 for the entire value. P represents the original, unencrypted image, C represents the encrypted image, and n, m denotes the image's width and height [18].

$$PSNR = 10 \times \log_{10} \left[\frac{MAX^2}{MSE} \right] \tag{2}$$

$$MSE = \frac{1}{n \times m} \sum_{i=1}^{n} \sum_{j=1}^{m} \left[P(i,j) - C(i,j) \right]^2 \tag{3}$$

3.4. The Histogram

The images and covariance values were extracted using histogram analysis. A visual representation of the numerical data is provided by indicating how many of the figure's data points fall inside a particular range. The graph displays the pixel density values' frequency distribution since the original pictures' pixel density values are dispersed, but the encoded images' pixel density values should be uniform. The difference between the encrypted and conventional picture histograms prevents data leaking [19].

4. Experimental Results

Three contrast operations—exposure frame fusion, dynamic histogram equalization, and histogram equalization are applied to four natural images that are representative of original images in grayscale as in **Table 1**, helps improve contrast and brightness differences between objects and backgrounds, as well as object visibility in the image [20]. To put it another way, the idea is to increase visibility by adjusting and reallocating pixel density. Contrast enhancement is an essential preprocessing step in realistic machine vision systems. Applications for contrast enhancement are numerous, spanning from manufacturing to astronomy to medicine, and they apply in any scenario where images are processed under less-than-ideal lighting. After that, PSNR, Entropy, and Histogram techniques are used to measure the contrast of images and find out the best techniques for contrast to find the best method to use.

Value results were collected for images, and the values were collected based on implementation. **Table 1** shows the contrast values of the four images and their size in bits for all three techniques. The Exposure Frame Fusion technique recorded the most contrast and clarity over the original images. Additionally, the size of the images in this technique is smaller than the rest of the techniques used and closest to the size of the original images, but this measurement alone is not sufficient, and standards are used. Others, such as entropy PSNR and histogram, to find the optimal image contrast method.

4.1. Histogram Analysis

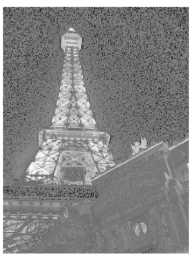
Table 2 shows the histograms of the four original images with the contrast images modified by the three techniques: exposure frame fusion, dynamic histogram equalization, and histogram equalization.

The graphs of the exposure frame fusion, dynamic histogram equalization, and histogram equalization-based enhancement images are displayed in **Table 2**. The pixel density on the graph was successfully distributed uniformly by exposure frame and histogram equalization. In comparison to the others, which scattered the pixel values in the graph and the pixel density values in the photographs' uniform, the exposure frame images were the most comparable to the original images.

4.2. PSNR Analyses

Table 3 illustrates the pixel change between the normal image and the modified images across all techniques, which is used to assess the contrast quality of

Table 1. Natural shapes and sizes of four original images enhancement.

Process	Image 1	Image 2	Image 3	Image 4
Original Images	 31,025 bytes	 40,019 bytes	 87,347 bytes	 35,477 bytes
Exposure Frame Fusion	 58,093 bytes	 46,276 bytes	 121,323 bytes	 38,565 bytes
Histogram Equalization	 91,314 bytes	 42,364 bytes	 148,682 bytes	 39,688 bytes
Dynamic Histogram Equalization	 85,823 bytes	 44,225 bytes	 155,867 bytes	 38,854 bytes

images by comparing the quality of the normal image with each of the three contrast techniques. Higher quality approaches and exposure frame and histogram equalization techniques result from the output's indication that the PSNR value in exposure and histogram images is lower than in dynamic images.

4.3. Entropy Analyses

Table 4 displays the entropy measurements for the first image for both the original and the contrast image created with the three suggested contrast methods. The location of each pixel in an image can be used to calculate its consistency and noise level. The entropy value decreases as the image's consistency increases.

It was concluded from the results that the consistency of images modified

Table 2. Natural shapes of four images histogram.

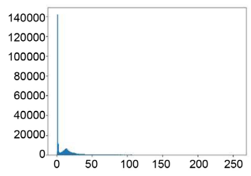
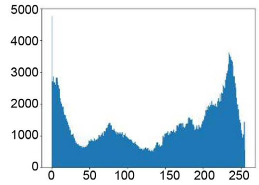
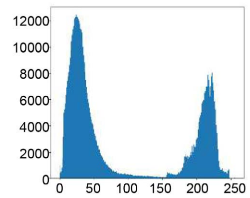
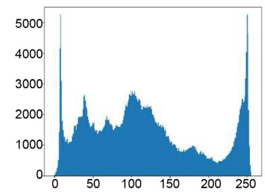
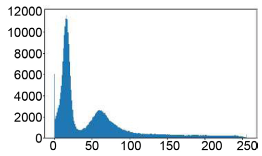
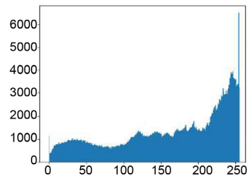
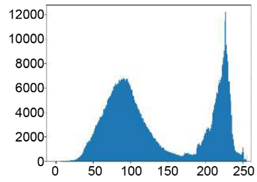
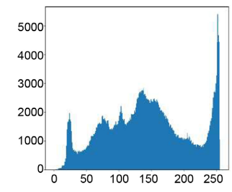
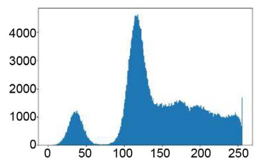
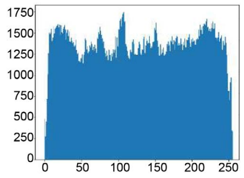
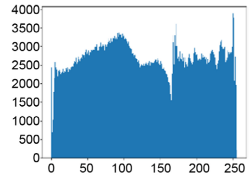
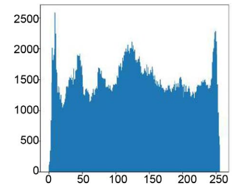
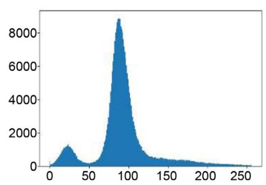
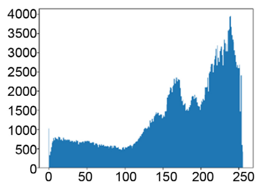
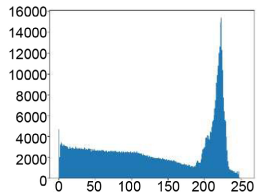
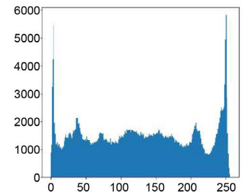
Process	Histogram Image 1	Histogram Image 2	Histogram Image 3	Histogram Image 4
Original Images Histogram				
Exposure Frame Fusion				
Histogram Equalization				
Dynamic Histogram Equalization				

Table 3. PSNR values.

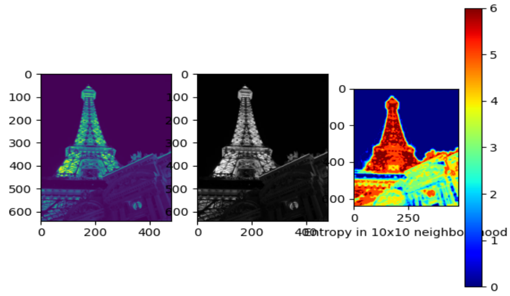
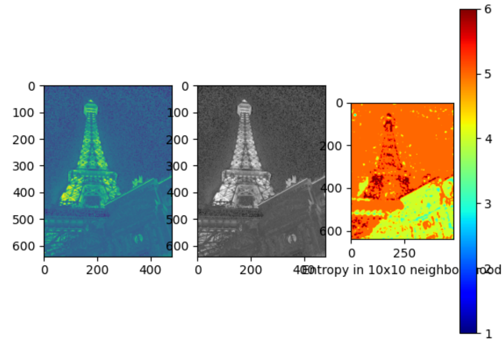
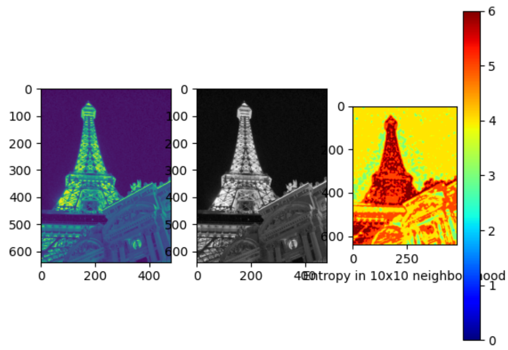
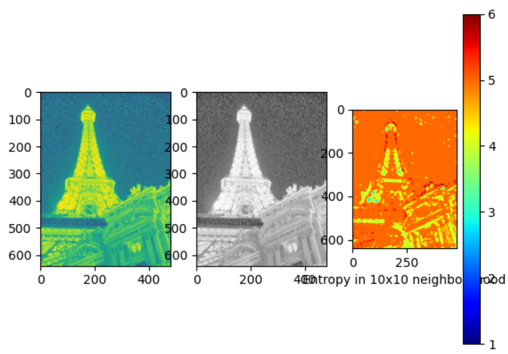
Images	PSNR Value of Image 1	PSNR Value of Image 2	PSNR Value of Image 3	PSNR Value of Image 4
Original + Dynamic	10.7643	16.2181	13.5473	23.7017
Original + Exposure	17.0802	18.9367	14.0029	18.8860
Original + Histogram	5.9146	21.9932	14.3029	24.6069

using Exposure is the best, unlike images modified using other techniques, which have a large entropy value.

5. Discussion

Through PSNR, histogram, and entropy criteria, exposure frame fusion technology delivered outstanding results in image contrast, brightness and enhancement. The technology outperformed the competition in terms of contrast quality, closeness to the original images, processing and execution speed, consistency efficiency, and high pixel uniformity in the images.

Table 4. Entropy for original, dynamic exposure and histogram image.

Image 1	Image Processing	Entropy
Original Image		
Dynamic Image		
Exposure Images		
Histogram Images		

6. Conclusion

Based on the aforementioned findings, we can conclude that the exposure frame merging technique is superior for identifying the best course of action for enhancing the contrast and brightness of computer system images. Histogram equalization, dynamic histogram equalization, and exposure frame fusion were the three image processing methods applied. Exposure frame performed better than dynamic contrast techniques in many areas, including image uniformity, contrast quality, and efficiency, speed of implementation, and accuracy of results, according to a comparison of the techniques using quantitative and physical criteria. Since this technology is the brightest, clearest, and most similar to the original images, it is advised to use it in addition to histogram equalization. As a result, it excelled in other criteria such as accuracy, efficiency, and reliability.

Conflicts of Interest

The authors declare no conflicts of interest.

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