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To Enhance the Visual Quality of an Image by Employing an Integrated Approach via Histogram Specification

Maninder Kaur, Mohit Trehan

Department of Computer Science, GCET, Gurdaspur, India

ABSTRACT: Image enhancement with histogram specification is a sophisticated digital image processing technique employed to elevate the visual quality of an image. This approach involves the application of non-linear image enhancement methods to alter the pixel values, thereby achieving enhanced contrast, improved brightness, and overall superior visual quality in the resulting image. Following the non-linear enhancement process, histogram specification is typically implemented to fine-tune the overall brightness and contrast levels of the image to desired standards. Throughout this process, various image characteristics may be selectively modified, tailored to the specific task at hand. In the realm of color images, the RGB color space is commonly used for representation. However, for enhanced human perceptibility, RGB values are often converted into HSV values. In this scheme, the (H) component denotes the spectral composition of color, (S) represents the clarity of colors, and (V) signifies the brightness or luminance value of colors. The proposed method entails two key processes: adaptive intensity enhancement and contrast enhancement. Adaptive intensity enhancement employs a specially designed nonlinear transfer function capable of adjusting the intensity of bright areas while simultaneously enhancing the intensity of darker regions. Contrast enhancement, on the other hand, dynamically adjusts the intensity of each pixel based on the characteristics of its neighboring pixels. This dissertation introduces a novel hybrid approach by integrating non-linear image enhancement methods with dynamic restoration. Through comprehensive evaluation metrics such as Bit Error Rate, Mean Difference, Peak Signal to Noise Ratio, and Mean Square Error, this method has demonstrated superior performance, establishing itself as a highly effective technique for image enhancement and restoration.

I. INTRODUCTION

Outline:

The primary objective of this chapter is to define the research motivation and the objectives of this dissertation. This chapter also provides different steps and methodologies that will be used to successfully accomplish this research work.

1.1 Image:

Images may be 2-Dimensional, such as a photograph taken by digital camera, screen display, and moreover, a 3-Dimensional, such as a figure. They may be taken by optical devices like lenses, microscopes, cameras, etc. and natural objects and phenomena, such as the human observer or water surfaces. The expression image is also used in the wider sense of any 2-D figure like, a map, a pie chart, or conceptual painting. In this broader sense, images can also be made manually, such as by drawing by using pencil or colors, painting, carving the statue or monument, made manually by printing using printer or computer graphics technology, or created by a grouping of methods.

1.2 Digital Image Processing:

Digital images are composed of pixels. Each color describes the pixel color at a single point in the image; basically, a pixel is like a tiny dot for specific color. By measuring the color of an image at huge number of points, one can create a digital estimation of the image from which a copy of real is rebuilt. Pixels are small like grain particles in a conventional photographic, but arranged in a normal pattern of rows and columns and store information differently.

Digital image processing is electronic data processing on a two-dimensional array of numbers. The array is a quantized representation of an image. A true image is created on a sensor when an energy release hits the sensor with ample intensity to produce a sensor output. The energy emission can have number of possible sources. When the energy

production is in the form of electromagnetic rays within the band limits of the individual eye, it is called visible light. Some images reflect only electromagnetic radiation while rest generates their own, using a fact called radiancy.

Digital image processing allows the improvement of visibility for detail in images using methods that apply arithmetic and numerical procedures to stored pixel values, instead of the traditional darkroom manipulations for filtration of time-dependent voltages mandatory for analog images and video signals. After digital images have been captured, before initiating processing of algorithm applications, every image should be evaluated with respect to its general characteristics, including haze, blur, background intensity variations, brightness and contrast, and the general pixel value distribution. Digital image processing allows the use of quite composite algorithms, and can offer both more classy presentation at easy tasks, and the implementation of methods which would be impossible by analog means.

An image may be defined as a 2-D function, $f(x, y)$, where x and y represents spatial coordinates, and the magnitude of at any pair of coordinates (x, y) is called the strength or gray level of the image at that point. When x , y , and the magnitude values of f are all limited, distinct quantities, the image is called a digital image. The area of digital image processing represents the processing digital images by ways of a digital computer. The digital image is made up of number of elements and each element has a specific location and value. Pixel is the word most broadly used to indicate the elements of a digital image. Visualization is the most sophisticated of senses, so it is not astonishing that images play the particular most significant role in human perception. However, unlike humans, who are narrow to the vision band of the electromagnetic (EM) spectrum, imaging equipment cover up approximately the whole EM spectrum, ranging from gamma to radio waves. They can work on images developed by sources that humans are not familiar to associating with images. Digital image processing ranges a broad and diverse area of applications. There is no general union between authors about where image processing stops and other related fields, such as image analysis and computer vision, begin. At times a difference is made by referring image processing as a field in which the input and output of a procedure are images. For example, under this description, even the insignificant mission of computing the average strength of an image (which yields a single number) would not be measured an image processing act. While, there are areas likes computer vision whose final objective is to use computers to follow human vision, including knowledge and being able to make inferences and take events based on vision inputs. This field itself is a branch of artificial intelligence (AI) whose main aim is to follow human aptitude. The area of AI is in its initial stages of early life in terms of growth, with development having been much slower than at first anticipated. The field of image analysis (also called image understanding) is among image processing and computer visual system. There are no straightforward limits in the range from image processing at one end to computer visual system at the other.

II. LITERATURE REVIEW

The objective of the literature review is to find and explore the benefits of image enhancement algorithms and also what are the different problems in existing algorithms and techniques. The main goal of this literature review is to find the gaps in existing research and methods and also what will be the possible solutions to overcome these holes.

Kim et al. (2020) [1] has discussed that the intensity of a scene can be altered following the histogram equalization, which is because of the flattening attribute of the histogram equalization. **KIM (1997) [6]** proposed histogram equalization referred to as mean preserving bi-histogram equalization to conquer the disadvantage of the histogram equalization. The essence of the proposed algorithm is to conserve the mean intensity of an image while the contrast is enhanced. Given method initially break an input image into two sub-images based on the mean of the input image. One of the sub-images is the set of specimens that are less than or equal to the mean whereas the other one is the set of specimens greater than the mean.

Tae et al. (2021) [2] has discussed a block-overlapped histogram equalization system for enhancing contrast of image sequences using various applications such as video door phone, security video cameras. The conventional histogram-based contrast enhancement technique is limited in real time application due to a large computational and storage requirement and it also exhibits quality degradation caused by possible loss of infrequently distributed pixel intensities, which may result in disastrous loss of important information. **Tae et al. (1998) [2]** proposed a contrast enhancement system for image sequences which can enhance local contrast with suppressing undesired noise amplification based on spatio-temporal processing.

Yue et al. (2023) [3] has discussed a non-linear image enhancement method based on Gabor filters, which allows selective enhancement based on the contrast sensitivity function of the human visual system. The selective enhancement of the given approach is especially suitable for digital television applications to improve the perceived visual quality of the images due to various reasons, including interpolation. Yue et al. (2005) [3] has proposed an evaluation method for measuring the performance of the proposed method.

Saibabu et al. (2022) [4] has proposed an image enhancement algorithm for digital images captured under such extremely non-uniform lighting conditions. The new technique constitutes three issues viz, adaptive intensity enhancement, contrast enhancement and color restoration which were considered separately to make the algorithm more adaptable to the image characteristics. The adaptiveness of the transfer function, depending on the mean of each pixel's neighborhood makes the algorithm more flexible and easier to control. Saibabu et al. (2006) [4] has conclude that the proposed algorithm gives results that are visually optimal, with images captured under extreme lighting conditions.

Nyamkhagva et al. (2020) [5] has proposed a new method called Brightness Preserving Weight Clustering Histogram Equalization that can simultaneously preserve the brightness of the original image and enhance visualization of the original image. Given method assigns each nonzero bit of the original image's histogram to a separate cluster, and computes each cluster's weight. To reduce the number of clusters, three criteria are used (cluster weight, weight ratio and widths of two neighboring clusters) to merge pairs of neighboring clusters. The clusters obtain the equal partitions as the result image histogram. At last, transformation functions for each cluster's sub-histogram are calculated, and the sub-histogram's gray levels are mapped to the result image by the equivalent transformation functions.

Fan et al. (2022) [6] has proposed a new method for image contrast enrichment which is especially suitable for multiple-peak images. The given method has been used to remove the two disadvantages of HE algorithm i.e. firstly the input image has been convolved by a Gaussian filter with optimum parameters. Then, the original histogram has been divided into various areas by the valley values of the image histogram. The given method out performs others on the aspects of simplicity and adaptability. The result demonstrates that the proposed algorithm has good performance in the area of image enrichment. Due to its simplicity, it can be realized by simple hardware and consumer electronics.

III. PROBLEM DEFINITION

The non-linear enhancement algorithm operates within the HSV color space to enhance the image, focusing exclusively on the V (intensity) component while leaving the H (hue) and S (saturation) components unaltered. This approach comprises two primary processes: adaptive intensity enhancement and contrast enhancement. Adaptive intensity enhancement employs a specially crafted nonlinear transfer function capable of attenuating the intensity of bright regions while concurrently augmenting the intensity of darker regions. Contrast enhancement fine-tunes the intensity of each pixel based on the characteristics of its neighboring pixels. However, it's recognized that solely enhancing the intensity component may not consistently yield optimal results. Altering brightness alone can sharpen the image, but it lacks the capability to adjust color strength, an essential aspect of image enhancement. To address this limitation and further refine the non-linear image enhancement technique, we propose integrating it with histogram specification. Histogram specification not only adjusts the colors and saturation of the image but also complements the non-linear enhancement process, potentially yielding superior outcomes. Given the efficacy of non-linear image enhancement in accurately enhancing intensity, we will apply histogram specification exclusively to the H and S components. This approach ensures that the image's quality is enhanced comprehensively, balancing intensity improvements with refined color and saturation adjustments.

3.1 Objectives:

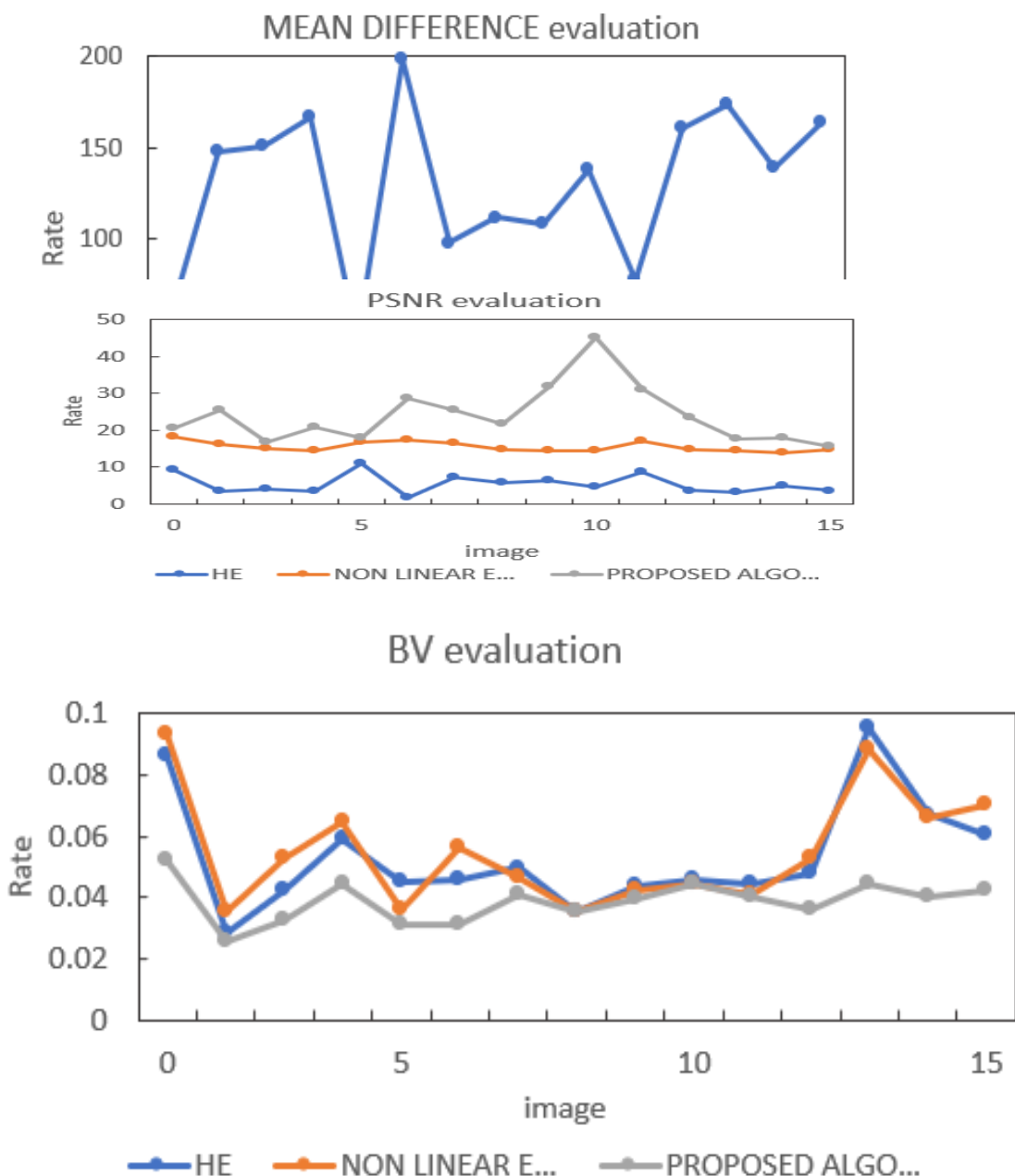
The main objective is to improve the result of the proposed algorithm over existing enhancement algorithms. To quantize the quality of proposed algorithm following sub-objective are selected.

1. In order to enhance the efficacy of non-linear color enhancement, a novel integrated approach will be introduced. This approach will fuse non-linear image enhancement with histogram specification, focusing specifically on the H and S components.

2. To substantiate the effectiveness of the proposed algorithm, a series of experiments will be conducted using a standardized set of images.
3. The evaluation and comparison of Detail Variance (DV) and Background Variance (BV) between the existing non-linear image enhancement technique and the proposed approach will be performed to gauge their relative performance.

IV. EXPERIMENTAL RESULTS

Fig5.2.1BEREvaluation



V. CONCLUSION AND FUTURE WORK

6. Conclusion and Future Work:

The utilization of image enhancement techniques holds paramount importance in the realm of digital image processing. This dissertation demonstrates the effectiveness of nonlinear image enhancement in enhancing the quality of blurred images through the concept of light source enhancement. It delves into various image enhancement methodologies, highlighting their significance in improving image appearance and perceptibility, especially in the case of degraded images. Numerous techniques have been devised to enhance the quality of digital images, aiming to refine and extract pertinent information from input images while reducing noise and artifacts. Image enhancement serves as a visualization system that diminishes image noise, eliminates artifacts, and accentuates informative aspects, thereby facilitating analysis, interpretation, and future utilization. The primary objective of this dissertation is to explore the limitations of existing image enhancement approaches and propose a novel enhancement technique to enhance the detailed variance within images. The proposed method is implemented in MATLAB using the image processing toolbox and evaluated on various images, yielding notably enhanced results across most cases.

Future endeavors may involve the incorporation of adaptive gradient smoothing to further refine and enhance results. Additionally, future research may explore the integration of proficient filtering methods to augment the efficacy of image enhancement techniques.

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