Image Enhancement using Optimized Gamma Correction with Weighted Distribution through Differential Evolution Algorithm

Chenigaram Kalyani, Assistant Professor, Balaji Institute of Technology and Science,Narsampet, Telangana,E-mail:kalyanichenigaram@gmail.com

Manda Sridhar,Assistant Professor, Balaji Institute of Technology and Science,Narsampet, Telangana, E-mail: mandasridhar550@gmail.com

Vemireddy Nagamalleshwari,Assistant Professor, Balaji Institute of Technology and Science,Narsampet, Telangana, E-mail:gurralamalli49@gmail.com

Abstract

When an image obtained contains faults such as noise, poor quality, or a bad visual impression to the eyes. To improve the aesthetic appeal, we need to apply image enhancement. Goal of an image enhancement is to eliminate the flaws from an image while retaining the crucial features. Studies proposed the various types of improvement procedures that had the favourable outcomes. In this approach we just combine the Differential Evolution (DE) method along with the Adaptive Gamma Correction with the Weighted Distribution (AGCWD) to form a novel hybrid method known as Optimised Gamma Correction with the Weighted Distribution (OGCWD).Proposed method is an automated modification operation that attempts to increase the brightness of an image. Terms like Structural Similarity Index (SSIM), Mean Square Error (MSE) and Peak Signal to Noise Ratio (PSNR), the proposed OGCWD algorithm outperforms the contemporary image improvement approaches.

Keywords: Image Enhancement, AGCWD, DE.

1. Introduction

Digital image processing systems are used in day-to-day life for video monitoring, remote sensing tracking, industrial production, military applications and other objectives. While processing a image, there are a few uncontrollable factors that are considered as faults. These are due to the image being captured in poorly lit conditions, such as at night, on a cloudy day, inside, or with little light reflecting off the object's surface; as a result, the image quality deteriorated and was regarded a flaw. As a result, we use image enhancement

techniques to correct these issues. One of the greatest frequent uses of fundamental image processing elements is to emphasize an image's traits in order to bring attention to it and make it appear consistent. Most importantly, since the method for judging image quality is subjective, it needs human judgment. To advance, however, this system must be made objective in order to minimize the need for human input. As a result, it is essential to offer a feature that facilitates image evaluation by objectively evaluating the quality of the improvement. Therefore, it is crucial to find a fitness function that can help with image evaluation by offering a numerical assessment of the image's quality. The differential evolution algorithm is a technique for enhancing image contrast. In image processing, a dynamic role is played by the differential evolution algorithm, a tool for optimization with natural inspiration. Additionally, it improves image production, creation of images, segmentation, detection, and enhancement of images.

2. Literature Review on Existing Enhancement Technique

There are several reasons for poor image contrast, such as quality of capture devices, operator knowledge or partial observable environment. Due to poor image quality, it is not easy to extract the information that exists in the image. Contrast enhancement eliminates the problem by increasing the dynamic range of digital pixel values. An adaptive gamma correction with weighting distribution-AGCWD hybrid HM (histogram modification) strategy by integrating TGC-transform dependent gamma correction and THE-traditional histogram equalization approaches [8]. Inadequate illumination can result in image failure or bad image fragmentation when using this automated approach of transformation. Current methods have several impacts that can be reversed, such a low Peak SNR and a high MSE. When images are not available, for instance, weak image segments may develop. To increase contrast and get rid of bad image quality, we need to utilize an automatic transformation method.

3. EXISTING METHODS

The present augmentation approaches are extensively described in this section.

3.1 Existing Methods of Image Enhancement

Over the past decade, a number of academics have developed a variety of enhancement techniques to alter an image's appearance depending on the viewer. As a consequence, this study employed and reported on two picture enhancing strategies. The following are the two directions for improvement:

- Image enhancement using AGCWD
- Image enhancement using DE

3.1.1 Adaptive Gamma Correction with the Weighted Distribution (AGCWD)

The image contrast improvement approach as well as image segmentation will be discussed in this section. An algorithm is being developed to efficiently advance the contrast and to maintain the brightness of input photos. On an augmented AGCWD image, segmentation is conducted. The proposed method is divided into steps, which are depicted in the flowchart. An adaptive gamma correction method, in which the adaptive gamma value is automatically selected based on image statistics, is recommended to improve image contrast. We all know that the main drawback of the power-law transformation method is the manual entry of the gamma value for image enhancement. This issue was addressed using the adaptive gamma correction weighted distribution method, where the gamma value is computed automatically.

3.1.2 Image enhancement via Differential Evolution (DE)

Image contrast may be improved using the differential evolution approach. A dynamic approach to optimization that takes insights from nature is the differential evolution algorithm. It also improves other processes such as segmentation, image detection, image fusion, image pattern recognition, image threshold, image enhancement, along with image restoration. Additionally, it aids in reducing visual noise and blurriness. The DE tries to enhance the fitness function by adjusting the intensity change function variables. Enhanced imaging is assessed subjectively and objectively in our DE-based methodology and outperforms previous techniques [12–16]. The Differential Evolutionary Algorithm is a well-known, effective, and mathematically sound Evolutionary computing method created to address practical numerical optimisation challenges. DE is reliable and rather easy to use. Natural optimization methods are essential in the area of image processing. By lowering image noise and blurriness, it also aids in the improvement of photographs. For various image processing systems, numerous optimization methods have so far been devised. This article offers a succinct analysis of the Differential Evolution method, a nature-inspired optimization technique. It is an optimization technique that was first developed

by the Storn and Price in the year 1995 and has since become a well-known population based strategy.

4. Proposed Method:

4.1 Optimized Gamma Correction with Weighted Distribution (OGCWD)

Weighted Distribution, Adaptive Gamma Correction, and Differential Evolution are all included. The recommended method is an automated modification operation designed to boost the brightness of a reduced image. The suggested OGCWD algorithm beats cutting-edge methods for image boosting in terms of the Structural Similarity Index (SSIM), Mean Square Error (MSE) and Peak Signal to Noise Ratio (PSNR). It combines gamma correction with a transform-based histogram equalization technique [18]. The probability distribution and gamma correction in darkened image brightness may be improved using this strategy. The gamma value is determined by using an optimum.

$$T(\mathrm{I}) = \mathrm{I}_{MAX}(\mathrm{I}/\mathrm{I}_{MAX})^{\gamma_{optimized}} \tag{9}$$

The supplied image's pixel intensity I is altered by the factor T. Different pictures may cause the parameter set to change in intensity if a contrast is manually adjusted or instantaneously altered by a gamma modification. The following is a description of the probability density function:

$$pdf(\mathrm{I}) = \mathrm{n}_I / (\mathrm{MN}) \tag{10}$$

Number of I-intensity pixels is shown as '$\mathrm{n_I}$'. MN is the total number of pixels in an image. To generate the function of cumulative distribution using probability density function is shown as below:

$$cdf(\mathrm{I}_{opt}) = \sum_{k=0} pdf(\mathrm{k}) \tag{11}$$

The cumulative distribution function (cdf) directly shown as,

$$T(1) = \mathrm{cdf}(\mathrm{I})\,\mathrm{I}_{\max} \tag{12}$$

Proposed optimized gamma correction formulated as,

$$T(\mathrm{I}_{opt}) = I_{MAX}(\mathrm{I}/\mathrm{I}_{MAX})^{\gamma_{optimized}} = I_{MAX}(\mathrm{I}/\mathrm{I}_{MAX})^{1-CDF(\mathrm{I}_{opt})} \tag{13}$$

Formulated weighted distribution function is shown n below,

$$pdf_w(\mathrm{I}_{opt}) = \mathrm{pdf}_{\max}\left(\frac{pdf(\mathrm{I}_{opt}) - \mathrm{pdf}_{\min}}{\mathrm{pdf}_{\max} - pdf_{\min}}\right)^{\alpha_{opt}} \tag{14}$$

The reformed cdf is estimated as follows:

$$cdf_w(\mathrm{I}_{opt}) = \sum_{I=0}^{I_{\max}} \frac{pdf_w(\mathrm{I}_{opt})}{\sum pdf_w} \tag{15}$$

The sum is seen as,

$$\sum pdfw = \sum_{I=0}^{1_{\max}} Pdfw(1) \tag{16}$$

The optimized gamma parameter is subsequently enhanced in the manner described below, based on the cumulative distribution function (cdf) in equation (8):

$$\gamma = 1 - cdf_w(\mathrm{I}_{optimum}) \tag{17}$$

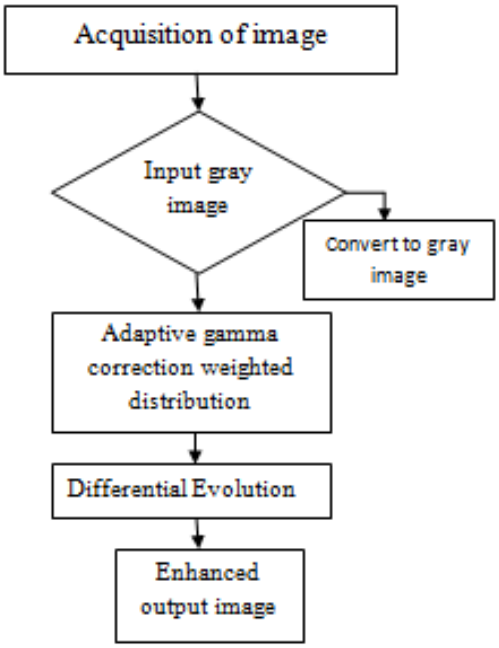

Figure 1: Flow chart for Proposed method.

5. Simulation Results

This segment describes the simulation results and discussions of existing and proposed enhancement methods. The simulation results of the proposed algorithm named optimized Gamma Correction with Weighted Distribution (OGCWD) are compared to those of state-of-the-art enhancement methods such as Histogram Equalization (HE) and Adaptive Gamma Correction with Weighted Distribution (AGCWD) as shown in figure 2. Both the methods, we calculated the parameters such as structural Similarity Index (SSIM), Mean Square Error

(MSE), and Peak Signal to Noise Ratio (PSNR) and analyzed the performances. The proposed enhancement method is outperforming the existing enhancement techniques. The SSIM values within the range of 0 to 1, higher the values of SSIM gives superior performance and lower the values leads the worst enhancement results. Similarly, MSE and PSNR for good enhancement results are low and very high values respectively and higher MSE and Lower PSNR values leads the worst enhancement results. Table 1 clearly shows that the proposed method evaluation parameters give superior performance over existing AGCWD Method. The evaluation parameters indicated in the table 1 such as SSIM, MSE and PSNR directly calculated based on MATLAB commands in figure 2.

Conclusion and Future Scope

The research suggests an innovative hybrid strategy called Optimal Gamma Correction with Weighted Distribution (OGCWD), which takes into account the variations between weighted distribution and gamma correction. The improvement of contrast and brightness in low-quality images is suggested using a computer-assisted transformation technique. Modern image enhancement methods are outperformed by the suggested OGCWD approach in terms of SSIM, MSE, and PSNR values. The average values of the outcomes of the current AGCWD approach are also 0.6880, 2.1055, and 12.8265. Last but not least, we can say that the suggested technique works better than the current way in terms of average PSNR value, yielding positive enhancement outcomes. Utilizing hybrid optimization methods like PSO-DE, PSO-DE-GA, and DE-GA, among others, will increase image improvement in the future.

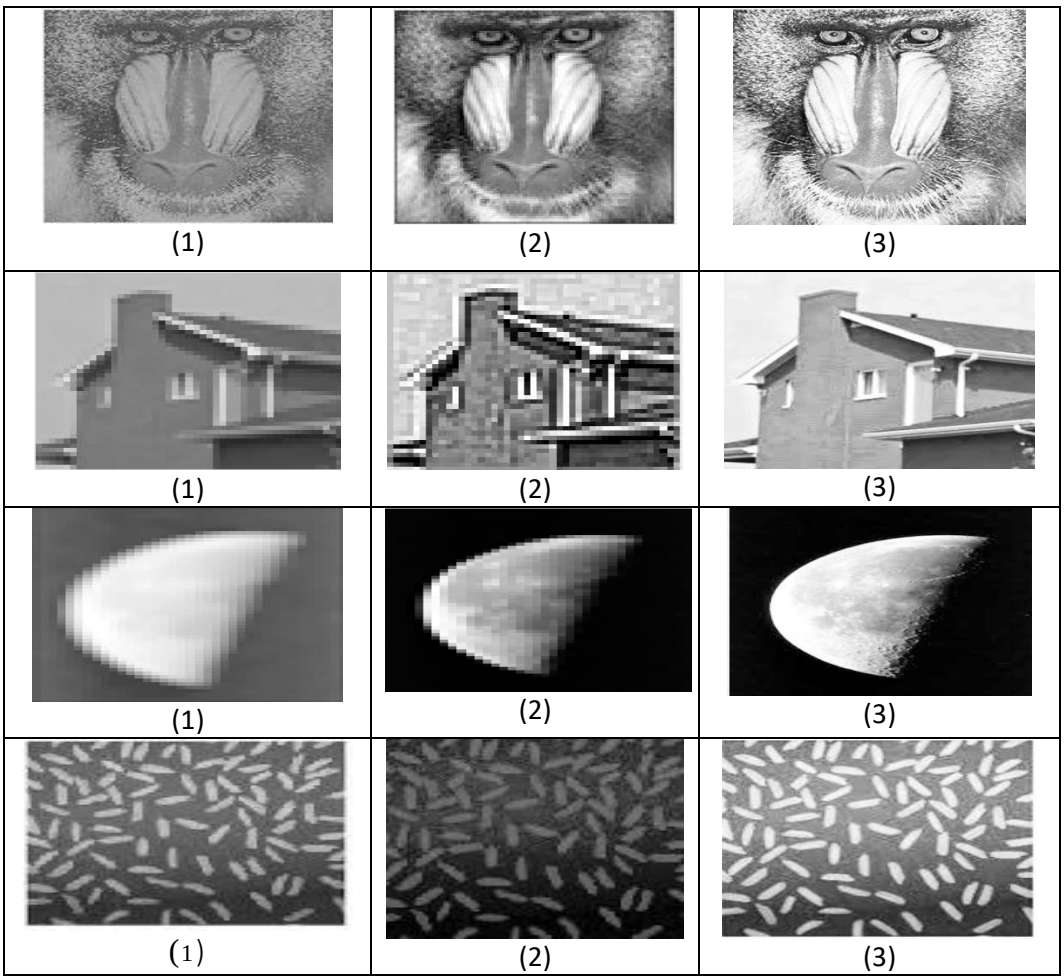

Figure 2 depicts the simulation results of existing HE and AGCWD methods as well as Proposed OGCWD. Column A (1) represents the original input images, column B (2) gives the enhanced output images through Histogram AGCWD methods respectively and column C(3) images represents the enhancement output of the proposed Optimized Gamma Correction with Weighted Distribution (OGCWD) method.

Table 1: Existing Method as well as Proposed Enhanced Method Performance Metrics

Parameters	**AGCWD Method**				**Proposed Optimized Gamma Correction with Weighted Distribution (OGCWD)**			
	Image 1	**Image 2**	**Image 3**	**Average Value**	**Image 1**	**Image 2**	**Image 3**	**Average Value**
SSIM	0.8785	0.2747	0.6484	0.6870	0.9621	0.8652	0.9519	0.9255
MSE	2.7628	1.8279	1.7258	2.1055	0.0075	0.1238	0.0270	0.0527
PSNR	13.7174	9.0745	15.6877	12.8265	21.2518	19.6052	19.4225	20.0931

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