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

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

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

Vemireddy NagaMalleswari, Assistant Profesoor, 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, image enhancement should be applied. The primary goal of image enhancement is to eliminate flaws from an image while retaining crucial features. Many studies proposed many types of improvement procedures that had favourable outcomes. This approach combines the Differential Evolution method and Adaptive Gamma Correction with Weighted Distribution to form the novel hybrid known as Optimised Gamma Correction with Weighted Distribution (OGCWD). The recommended method is an automated modification operation that attempts to increase the brightness of an image. In terms of structural Similarity Index (SSIM), Mean Square Error (MSE), and other metrics, the proposed OGCWD algorithm outperforms contemporary image improvement approaches.

**Keywords:** Image Enhancement, Adaptive gamma correction weighted distribution (AGCWD), Differential Evolution (DE).

1. **Introduction:**

Digital image processing systems are often used in everyday 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 most typical applications for core image processing components is the purpose of making the image seem consistent is to draw attention to the image and its characteristics to the image that is frequently seen. Most because the image quality rating technique is subjective, human input and judgment are required. However, in order to progress, this system must be made objective in order to reduce the need for human involvement. As a result, it is necessary to provide a function to aid in image evaluation by quantitatively quantifying the quality of the improvement. As a result, it is critical to identify a fitness function that may aid in image evaluation by providing a numerical rating of the image's quality. A method for increasing image contrast using the differential evolution algorithm. The differential evolution algorithm, a natural-inspired optimization tool, plays a dynamic role in image processing. Furthermore, it enhances image enhancement, restoration, segmentation, detection, and image creation.

1. **Literature Review on Existing Enhancement Techniques**

This section mainly focusing on detail explanation of the existing enhancement technique and proposed optimized Gamma Correction with weighing Distribution (OGCWD) algorithm.

**2.1 Existing Image Enhancement Method**

 From the decade many researchers introduced various enhancement techniques to develop the visual of an image according to user’s perspective. So in this article an image enhancement method have been used and explained as below [9-10].

* Patel S., Bharath K.P., Balaji S., Muthu R.K. (2020) Comparative Study on Histogram Equalization Techniques for Medical Image Enhancement. Soft Computing for Problem Solving, edited by Das K., Bansal J., Deep K., Nagar A., Pathipooranam P., and Naidu R. Advances in Intelligent Systems and Computing, vol 1048 Singaporean Springer. The Histogram Equalisation technique's traditional methods have some drawbacks and occasionally don't work. As a result, several further updated approaches for the Histogram Equalisation methodology are required. The modern versions of Histogram Equalization techniques. The histogram shows that in the initial image the number of the pixels on the gray scale are close together without spreading over the entire range of the gray scale after Histogram Equalization.[1]
* R. Sonkusare, A. Johnson, S. H. Gangolli, and Luke Fonseca "Image Enhancement using Various Histogram Equalization Techniques," GCAT 2019, Global Conference for Advancement in Technology BANGALURU, This paper focused on studying Image Enhancement performed using Histogram Equalization Technique. It was performed on an input image using MATLAB (R2014a) software. The comparisons of the images show that the image after Histogram Equalization is of somewhat higher contrast as compared to the initial image which has a lower contrast. The histogram shows that in the initial image the numbers of the pixels on the gray scale are close together without spreading over the entire range of the gray scale. After Histogram Equalization it is clearly seen that the histogram gets distributed entirely over the spectrum of the gray scale, with the number of pixels on each value of the spectrum increasing resulting in the increase in the brightness and the contrast [2].
* Chenigaram Kalyani, Kama Ramudu and Ganta Raghotham Reddy "Enhancement and Segmentation of Medical Images Using AGCWD and ORACM",. This section discusses the suggested image Contrast Improvement approach as well as image segmentation. An algorithm is planned to progress the contrast efficiently and sustain the brightness of input images. Segmentation is conducted on the augmented AGCWD image [3].
* Sanjay S. Gharde, Vijay A. Kotkar “Review of Various Image Contrast Enhancement Techniques,” Volume 2, Number 7, July 2013, International Journal of Innovative Research in Science, Engineering, and Technology To increase the efficacy of remote sensing image enhancement, Henan, Wu et al. presented an enhancement algorithm based on multi-scale Retinex in 2011. Calculations were made regarding the multi-scale Retinex and wavelet principles and recognition types. The results of the study on panchromatic and multicolor remote sensing image enhancement using the two techniques showed that the mean valve of the enhanced image produced by this algorithm is all around 125, the entropy and definition may be improved by 5% and 25% in comparison to wavelet algorithm, and remote sensing images may acquire better enhancement quality. Therefore, multi-scale Retinex is a better method for sensing image enhancement.

**2.1.1 Image Enhancement using Differential Evolution** **Method**

In the histogram equalization method, the cumulative distribution function is used as a transform curve to the gray values of an image. Let us consider I represent the image as well as the gray level values represented by L respectively. “I (i, j)” is the gray image intensity values with coordinates i and j. the number of pixels in the image is represented as N; the number of pixels with ‘k’ gray level is assumed as  so, the probability density function (pdf) of gray level image I is defined as the following eq. (1).

 z = 0, 1, 2, 3 . . . , L – 1. (1)

Similarly, the Cumulative distributive function (cdf) of the gray image I is given as:

 z = 0, 1, 2, 3 . . . , L – 1. (2)

The correlation between the input image and the CDF-based uniform gray scale image is as follows:

f (z) = (L − 1)×c(z) (3)

The basic histogram equalization procedure is the one of the approach which is implemented in real time to enhancement of the image. However, the increased brightness of the given image as a result of the grey level fusion is contrasting. The total number of pixels in the histogram for each colour variant. It’s complicated to equalize the histogram independently for red, green, and blue images because it results in unexpected colour balance shifts. Image failure or poor image fragmentation can be caused by insufficient lighting. Certain reversible effects, such as a low Peak SNR and a high MSE, are present in current practices. Weak image segments may occur when images cannot be obtained, for example. We need to use an automated transformation technology to improve contrast and eliminate poor image quality.

1. **EXISTING METHODS**

 This section largely focuses on a comprehensive description of the proposed optimised Gamma Correction with Weighing Distribution (OGCWD) approach and the augmentation schemes currently in use.

**3.1 Existing Image Enhancement Methods**

 Several academics have created a range of augmentation ways over the decade to change an image's visual according on the user's viewpoint. As a result, two techniques to image enhancement were used and reported in this study. The two paths to improvement are as follows:

• Adaptive gamma correction with weighted distribution (AGCWD)

 • Image enhancement using Differential Evolution (DE)

**3.1.1Adaptive gamma correction with weighted distribution (AGCWD):**

 This section discusses the suggested image Contrast Improvement approach as well as image segmentation. An algorithm is being developed to efficiently advance the contrast and maintain the brightness of input photos. On the augmented AGCWD image, segmentation is conducted. The proposed method is divided into steps, which are depicted in the flowchart. To increase image contrast, an adaptive gamma correction approach is suggested in which the proper gamma value is determined automatically depending on image statistics. As we all know, the fundamental disadvantage of the power-law transformation approach is that the gamma value must be entered manually for image improvement. The adaptive gamma correction weighted distribution approach was used to tackle this problem. In which the value of gamma is determined automatically using.

**3.1.2 Image enhancement using Differential Evolution (DE):**

 Image contrast may be increased using the differential evolution technique. The differential evolution algorithm is a nature-inspired optimisation approach that plays a dynamic role in image processing. It also improves image enhancement/restoration/segmentation/image

Detection/image fusion/image pattern recognition/image threshold, and so on. It also aids in the reduction of visual noise and blurriness. The DE seeks to optimise the fitness function by adjusting the intensity change function variables. Enhanced imaging is subjectively and critically evaluated, and it outperforms other ways in our DE-based technology [12-16]. The Differential evolutionary algorithm is a mathematical, efficient, and widely used Evolutionary computation technique designed to meet real numerical optimisation difficulties. DE is stable and pretty simple. In the field of image processing, natural optimization techniques are crucial. It also helps to improve images by reducing noise and blurriness from photos. So far, many optimization techniques for a variety of image processing systems have been developed. This article presents a short review of nature inspired optimization algorithm which is Differential Evolution algorithm. In the year 1995, storn and price, introduced an optimization algorithm called Differential Evolution which has become a successful population-depended approach.

**Calculation of Optimum weights using Differential Evolution Algorithm:**

 In the realm of image processing, the application of natural optimisation methodologies is critical. Noise and blurriness in photos are also decreased, which improves image quality. Many optimisation strategies have been developed thus far for a variety of image processing systems. This paper provides a quick overview of the Differential Evolution approach, which was inspired by nature. Storn and Price initially introduced Differential Evolution, an effective population-dependent optimisation approach, in 1995. The well-known ideas of mutation, fusion, and selection are used in this strategy. The population size, mutation scaling factor, and crossover rate are the tuning control factors. Several DE variants have been developed in the last 10 years to increase output.

**Mutation Operation:** A person may be produced using the following formula

 (4)

In the preceding equation (14), r1, r2, and r3 are represented as random integers, and the variance factor F is a real value between 0 and 2 that regulates the degree of amplification of the differential variable.

 (5)

Crossover Operation: The interoperability of the differential evolution algorithm is extended to the diversity of the new population. According to the crossover approach, old and new persons exchange a portion of their code to generate a new person. New citizens are classified as follows:

 i=1,2,3… (6)

Where,

j=1,2,3,….n (7)

 According to the preceding equation (7), ran db (j) is distributed uniformly within the interval [0,1], and the crossing probability is denoted as CR. M br I is a random number between [0, 1]

Selection Operation: Because the true candidate's commodity is all mutations and crossings, this is a greedy strategy.

 

 (8)

At which, f is the fitness function.

**Differential evolution Algorithm:**

 **Stage 1:** Begin by entering the population number NP, the average number of evolution Max inner, the scale factor, and the cross factor.

 **Stage 2** : Pop population is being created.

 **Stage 3** : Follow the DE/ rand/1/bin policy Compliance choices to produce a new generation of people.

 **Stage 4**: Mutation Stage.

 **Stage 5**: Crossover process.

 **Stage 6**: Selection process.

 **Stage 7**: Before it meets the termination requirements.

1. **Proposed Method:**

**4.1 Optimized Gamma Correction with Weighted Distribution (OGCWD)**

It incorporates the Differential Evolution method, Adaptive Gamma Correction, and Weighted Distribution. The suggested approach is an automated transformation procedure aimed at increasing the brightness of a reduced image. In terms of structural Similarity Index (SSIM), Mean Square Error (MSE), and Peak Signal to Noise Ratio (PSNR), the proposed OGCWD algorithm outperforms state-of-the-art image enhancing approaches. It combines traditional histogram equalisation with transform-based gamma correction[18]. This is a technique for improving the gamma correction and likelihood distribution in darkened image brightness. An optimal is used to compute the gamma value.

 (9)

The maximal intensity of input is. T transforms the intensity I of each pixel in the input image I. Different images may cause the parameter set to modify its intensity if a contrast is modified manually or immediately via a gamma adjustment. The probability density function is defined as follows:

 (10)

The number of l-intensity pixels is represented by nI. MN is the total number of pixels in a image. The probability density function is used to generate the cumulative distribution function, which is as follows:

 (11)

The traditional HE approach employs the cumulative distribution function (cdf) directly as,

 (12)

Formulated proposed optimized gamma correction is given as,

 (13)

The suggested optimal gamma correction formula is presented as, The weighted distribution function formula is expressed as,

(14)

According to equation (9), opt is an adjusted parameter; is for the highest pdf of a statistical histogram; and is for the least pdf. As a result, the reformed cdf is estimated as follows:

  (15)

The sum of is seen as,

 (16)

Finally, the optimized gamma parameter, which is based on the cumulative distribution function (cdf) in equation (8), is enhanced as follows:

 (17)



**Figure 1:** Flow chart for proposed method

1. **Simulation Results and Discussions**

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 1. 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. MATLAB 2020b software is used to simulate both the methods on various benchmark images taken from internet sources, same results are presented in Figure 2.

1. **Conclusion and Future Scope**

 The Opimal Gamma Correction with Weighted Distribution (OGCWD) approach suggested in this research is an unique hybrid method that includes the differences between gamma correction and weighted distribution. This method was invented by us. A computer-assisted transformation process is proposed for improving contrast and brightness in low-quality images. In terms of SSIM, MSE, and PSNR values, the proposed OGCWD procedure outperforms state-of-the-art image enhancement techniques. Similarly, the average values of the current AGCWD method results are 0.6781, 2.1608, and 13.2356. Finally, we can conclude that the proposed method outperforms the existing method in terms f average PSNR value, resulting in good enhancement results. In the future scope, further improve the enhancement of images using hybrid optimization algorithms such as PSO-DE, PSO-DE-GA and DE-GA etc.

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

**Column 1 Column 2 Column 3**

|  |  |  |
| --- | --- | --- |
|  (a) |  (b) |  (c) |
|  (a) |  (b) |  (c) |
| (a) | (b) | (c) |
| (a) | (b) | (c) |

**Figure 2** depicts the simulation results of existing HE and AGCWD methods as well as Proposed OGCWD. Column 1 (a) shows the original input images, column 2 (b) shows the enhanced output images using Histogram AGCWD methods respectively, column 3(c) images shows the enhancement output of proposed Optimized Gamma Correction with Weighted Distribution (OGCWD) method.

|  |  |  |
| --- | --- | --- |
| **Parameters** | **AGCWD Method** | **Proposed Optimized Gamma Correction with Weighted Distribution (OGCWD)** |
|  | **Image 1** | **Image 2** | **Image 3** | **Image 4** | **Average Value** | **Image 1** | **Image 2** | **Image 3** | **Image 4** | **Average Value** |
| SSIM | 0.8795 | 0.5319 | 0.2747 | 0.6484 | 0.6781 | 0.9621 | 0.8099 | 0.8652 | 0.9519 | 0.8972 |
| MSE | 2.7628 | 2.3270 | 1.8279 | 1.7258 | 2.1608 | 0.0075 | 0.0245 | 0.1238 | 0.0270 | 0.0457 |
| PSNR | 13.7174 | 14.4628 | 9.0745 | 15.6877 | 13.2356 | 21.2518 | 16.1059 | 19.6052 | 19.4225 | 19.0963 |

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