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

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**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 primarily focuses on a detailed discussion of both the proposed optimised Gamma Correction with Weighing Distribution (OGCWD) method and the current augmentation technique.

**2.1 Existing Image Enhancement Method**

 Since the decade, numerous researchers have developed a variety of augmentation approaches to shape an image's visual according to the user's viewpoint. Accordingly, an image enhancement technique has been applied and is discussed 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 work examined the Histogram Equalisation Technique used in image enhancement. It was carried out using the MATLAB (R2014a) programme on an input image. The photos may be compared, and it can be seen that the image after histogram equalisation has a little bit more contrast than the initial image, which has less contrast. According to the histogram, the initial image's grayscale pixels are clustered together rather than spanning the complete grayscale spectrum. After histogram equalisation, it is evident that the histogram becomes evenly distributed across the grayscale spectrum, with an increase in the number of pixels on each spectrum value leading to an increase in contrast as well as brightness [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. To effectively advance the contrast and maintain the brightness of input photos, an algorithm is planned. On the improved AGCWD image, segmentation is done [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**

The cumulative distribution function is applied as a transform curve to the grey values of a picture in the histogram equalisation procedure. Let's assume that L represents the values of the grey levels, while I represents the image. “I (i, j)” is the i and j-dimensional grey picture intensity values. the image's pixel count is denoted by the letter N; the number of pixels with ‘k’ gray level is assumed as  so, The following equation (1) defines the probability density function (pdf) of grey level picture I.

 (1)

According to this, the grey picture I's Cumulative Distributive Function (cdf) is provided as:

 (2)

The input image and the CDF-based uniform grey scale image have the following correlation:

 (3)

The fundamental histogram equalisation process is one of the methods used in real time to improve the image. Contrastingly, the enhanced brightness of the provided image as a result of the fusion of the grey levels. the total number of pixels in each colour variant's histogram. Because it causes unanticipated changes in colour balance, equating the histogram separately for red, green, and blue photos is challenging. Inadequate lighting may result in image failure or poor image fragmentation.

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. The use of natural optimisation approaches is essential in the field of image processing. The noise and blurriness in shots is also reduced, which enhances the quality of the images. Numerous optimisation methods have so far been developed for a wide range of image processing systems. The Differential Evolution method, which was inspired by nature, is briefly reviewed in this article. Differential Evolution, an improvement technique distributed by Storn and Price in 1995, has shown to be an effective based on populations strategy.

**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:

 (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 section discusses existing and suggested enhancement techniques as well as the simulation findings. Figure 1 compares the simulation outcomes of the proposed algorithm, optimised Gamma Correction with Weighted Distribution (OGCWD), to those of cutting-edge enhancement techniques like Histogram Equalisation (HE) and Adaptive Gamma Correction with Weighted Distribution (AGCWD). We calculated the performance metrics for both techniques, including the structural similarity index (SSIM), mean square error (MSE), and peak signal to noise ratio (PSNR). The suggested augmentation strategy performs better than the ones already in use. The SSIM values fall between 0 and 1, with higher values indicating better performance and lower values indicating worse results from augmentation. Similar to this, low and extremely high MSE and PSNR values lead to favourable enhancement outcomes, whereas higher MSE and lower PSNR values lead to the poorest enhancement results. Table 1 demonstrates unequivocally that the suggested method evaluation parameters outperform the current AGCWD Method. MATLAB commands were used to directly calculate the evaluation parameters listed in Table 1, such as SSIM, MSE, and PSNR. The same outcomes are shown in Figure 2 after simulating both approaches using the MATLAB 2020b software on a variety of benchmark photos obtained from online sources.

**Conclusion and Future Scope**

The method called Opimal Gamma Correction with Weighted Distribution (OGCWD) proposed in this study is a special hybrid strategy that takes into account the distinctions between weighted distribution and gamma correction. We came up with this technique. For enhancing contrast and brightness in poor-quality photos, a computer-assisted transformation technique is suggested. The suggested OGCWD strategy surpasses cutting-edge image improvement methods in terms of SSIM, MSE, and PSNR values. The average outcomes of the current AGCWD approach are 0.6781, 2.1608, and 13.2356, respectively. In summary, the proposed method provides better enhancement outcomes than the current method in terms of average PSNR value. Continue to enhance pictures utilising hybrid optimisation algorithms like PSO-DE, PSO-DE-GA, and DE-GA, among others, in the future.



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



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