# 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, 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 method along with the Adaptive Gamma Correction with the Weighted Distribution to form a novel hybrid 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. 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 with weighted distribution (AGCWD), Differential Evolution (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

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 the weighted distribution - (AGCWD)
- Image enhancement using Differential Evolution - (DE)

#### 3.1.1 Adaptive 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):

The differential evolution method can be used to boost image contrast. The differential evolution algorithm is a dynamic method to optimization that draws inspiration from nature. Additionally, it enhances picture enhancement, restoration, segmentation, image detection, image fusion, image pattern recognition, image threshold, and other processes. It also helps to lessen blurriness and visual noise. By modifying the intensity change function variables, the DE aims to optimize the fitness function. In our DE-based technique, enhanced imaging is evaluated subjectively and critically and performs better than existing methods [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. Differential Evolution is an optimization technique that was first developed by Storn and Price in 1995 and has since become a popular population-based strategy.

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

In the image processing, 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 various image processing systems. In this paper, it provides a quick overview of the Differential Evolution approach, which was inspired by the nature. Storn and Price initially introduced Differential Evolution, an effective population-dependent optimisation approach, in 1995. The known ideas of mutation, fusion as well as selection were used in this strategy. The population size, mutation scaling factor as well as crossover rate are the factors of tuning control. 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

$$X_{r1,G+1} = X_{r1,G+1} + F*(\mathrm{X}_{r2,G} - \mathrm{X}_{r3,G}) \quad (4)$$

At which r1, r2 and r3 represents as a random integers; F is the variance factor F which is a real value in between 0 and 2 that regulates the degree of an amplification of differential variables.

$$\mathrm{X}_{r2,G} - \mathrm{X}_{r3,G} \quad (5)$$

**Crossover Operation:** An interoperability of the DE algorithm extended to the diversity of a new population. According to the crossover approach, old as well as new persons exchange a bit of their code to create a new person. New citizens are classified as follows:

$$X_{i,G+1} = (\mathrm{x}_{1i,\mathrm{G}+1}, \mathrm{x}_{2i,\mathrm{G}+1}, \mathrm{x}_{3i,\mathrm{G}+1}, .... \mathrm{x}_{ni,\mathrm{G}+1}) \quad \text{i=1,2,3,4...} \quad (6)$$

At which,

$$X_{ji,G+1} = \begin{cases} V_{ji.G+1}, \\ if\ (\mathrm{randb(j)} \leq \mathrm{CR})\,\mathrm{or(j=mbr(i))}, \end{cases} \quad \text{j=1,2,3,4....n} \quad (7)$$

According to the equation (7), ran db (j) is distributed uniformly within the interval [0, 1], and the crossing probability is denoted as CR; mbr(i) is a random number in between [0, 1]

**Selection Operation:** Due to the true candidate's product are all mutations and the crossings, this is a greedy strategy.

$$X_{ji,G+1} = \{U_{i,G} if\,(\mathrm{f}(U_{i,G}) > \mathrm{f}(\mathrm{x}_{i,G+1}))$$

$$X_{ji,G+1} = \{x_{i,G+1}, if\,(\mathrm{f}(U_{i,G}) \leq \mathrm{f}(\mathrm{x}_{i,G+1})) \quad (8)$$

At which, f is a fitness function.

**Algorithm of Differential evolution:**

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

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

**Stage 3** : Follow DE/ rand/1/bin policy compliance choices to produce a new formation of people.

**Stage 4**: Mutation Stage.

**Stage 5**: Cross-over process.

**Stage 6**: Selection process.

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

# 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.

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

The input's highest possible intensity is. Each pixel's intensity I in the input image I is transformed by the factor T. If a contrast is manually changed or instantly changed via a gamma adjustment, different images may result in the parameter set changing its intensity. The probability density function is described as follows:

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

The number of l-intensity pixels is represented by nI. Total number of pixels in an image is MN. The probability density function is used to generate the function of cumulative distribution shown as follows:

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

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

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

Formulated proposed optimized gamma correction is given as,

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

The weighted distribution function formula is presented as,

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

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 of is seen as,

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

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

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

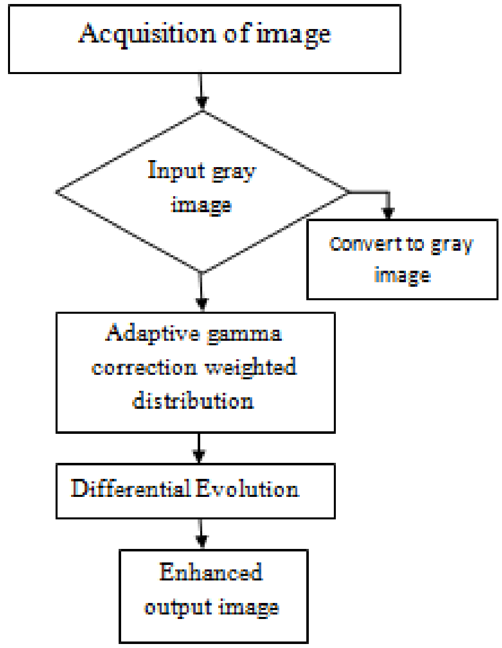


**Figure 1:** Proposed method flow chart.

## 5. 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.

## 5. 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.

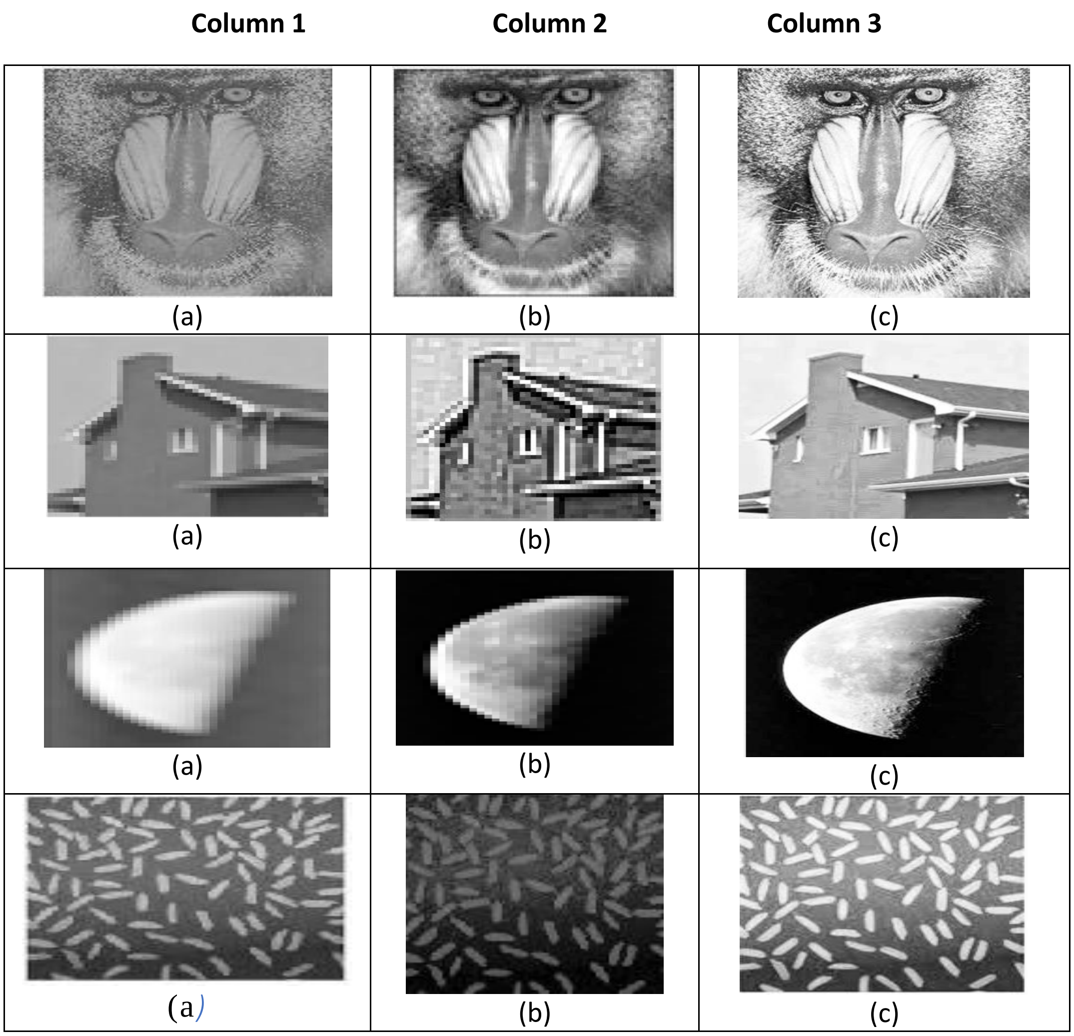


**Figure 2** depicts the simulation results of existing HE and AGCWD methods as well as Proposed OGCWD. Column 1 (a) shows the original input images, column 2 (b) shows the enhanced output images using Histogram AGCWD methods respectively, column 3(c) images shows the enhancement output of proposed Optimized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

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