An Effective Algorithm for Image Contrast Enhancement Using HLIPSCS

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Abstract

Contrast is a crucial aspect of an image since low contrast results in less visibility of details, while strong contrast enhances the perception of details. The occurrence of the low-contrast effect is a result of several inevitable factors, and the need for high-quality image necessitates the creation of images with enhanced quality. It is necessary to handle the low-contrast effect accurately using an algorithm that operates quickly and maintains the crucial image data. A significant number of current algorithms fail to produce satisfactory outcomes since they have the potential to intensify the brightness, produce inadequate colours, introduce insufficient contrast, or develop processing artifacts. Therefore, a novel HLIPSCS algorithm is presented to circumvent the aforementioned limitations and incorporates many computational principles associated with hyperbolic, logarithmic, and statistical methodologies. The process begins by implementing two distinct hyperbolic techniques, followed by the integration of their outcomes using a modified logarithmic methodology. Subsequently, statistical and contrast stretching methodologies are employed to yield the expected result. The HLIPSCS algorithm is utilized on several genuine contrast-degraded grayscale and colour images. It is then compared with alternative algorithms, and the resulting comparisons are assessed using three distinct image assessment methodologies. During the comparisons and testing, the HLIPSCS demonstrated better processing capabilities, consistently achieving the highest image assessment ratings. Ultimately, the outcomes of HLIPSCS exhibit significantly improved visual qualities in terms of brightness, contrast, and colour depiction.

Keywords: HLIPSCS algorithm, Contrast Stretching, Hyperbolic functions, Logarithmic Image Processing, Statistical methods, ABCETP algorithm.

1. INTRODUCTION

Image processing is increasingly being studied in the field of computer science. The revolutionary development and rapid expansion of this technology have yielded advantages across several sectors like health, forensics, photography, biology, and astronomy.

Various fields extensively utilize digital images of different types, which are generated by a diverse range of technology with varying levels of accuracy. Image augmentation enhances the correctness of images, hence aiding in several fields of research. The quality of the image will be influenced by several variables, such as the camera's quality, its settings, the physical surroundings (including lighting conditions), and the operator's lack of skill, notably in terms of contrast as well as other forms of deterioration. A common problem seen in several imaging systems is the presence of poor contrast. Contrast enhancement (CE) techniques are employed to enhance the visual quality and improve resolution.

Through the utilization of a technique known as color enhancement, images may be enhanced to appear more visually appealing and aligned with the natural perception of the human eye. Commonly found in computer engineering (CE), a variety of procedures, such as increasing the distances between the items in the foreground and background, are often utilized. The processes encompassed under CE have the ability to enhance the brightness and/or contrast of an image, hence emphasizing its characteristics and facilitating better visibility. Consequently, the field of enhancement has great importance in both computer vision and human perception.

CE is extensively utilized across several industries and applications, such as remote sensing, biology, geographical research, medical imaging, video surveillance systems, and satellite image processing. Several techniques in computer engineering (CE) are specifically developed to address various elements of image enhancement, such as improving color representation [6], increasing noise tolerance, ensuring consistent contrast, and preserving brightness.

2. LITERATURE REVIEW ON EXISTING ENHANCEMENT TECHNIQUE

Low visual contrast can be attributed to multiple factors, including insufficient operator comprehension, partially visible environs, or poor capture equipment. Retrieving the information included in the photograph is challenging due to the poor image quality. Contrast enhancement addresses the problem by increasing the range of computerized pixel values [13]. The HLIPSCS algorithm is described, which integrates many processing ideas associated with logarithmic, hyperbolic, and statistical approaches [15]. Initially, two distinct hyperbolic methods are employed, followed by a modified logarithmic technique to combine the results. Next, statistical and contrast stretching methods [2] are employed to get the desired result. Utilizing this automated transformation technique [9] may result in poor image quality or possibly image malfunction caused by insufficient illumination conditions. The present techniques have several reversible consequences, including a low Peak Signal-to-Noise Ratio (SNR) and a high Mean Squared Error (MSE) [8]. For instance, inadequate image segments may occur when photographs are not displayed. To enhance image quality and improve contrast, it is necessary to employ a process that is computerized.

3. EXISTING METHOD

The present augmentation approach is extensively described in this section.

3.1 Existing Method of Image Enhancement

In order to alter the appearance of an image according to the viewer, researchers have developed a variety of augmentation techniques in the last decade. ABCETP method for improving images were applied. Here is one regions that might benefit from development:

- Image Enhancement Using an Ameliorated Balance Contrast Enhancement Technique

Ameliorated Balance Contrast Enhancement Technique

This study presents an enhanced version of the classic ABCETP method for enhancing visual contrast. The applied alterations include the incorporation of two supplementary enhancing strategies and the utilization of a modified parabolic function with a changed coefficient. These modifications enabled the attainment of results that exhibited improved visible attributes. Furthermore, a dataset consisting of many high-resolution color photographs with reduced contrast is employed to assess the developed technique. The strategy is then compared to other widely recognized methods and assessed using specialized Image Quality Assessment (IQA) metrics. Based on extensive testing and comparisons, the results indicate that the ABCETP technique [5] demonstrates a high level of proficiency in rapidly and efficiently processing images. This achievement is noteworthy since it requires few computations to get outcomes with impressive luminosity, natural contrast, and vivid hues. Future research efforts may further develop this technology to reach full automation and adapt it to enhance images obtained from different imaging devices. It proposes an ameliorated balance contrast enhancement approach (ABCETP) that uses a parabolic function to increase brightness, contrast, and color quality. The original BCETP operates by calculating a parabolic function with three coefficients. However, the suggested ABCETP computes a modified parabolic function with one changed and two preserved coefficients and employs two extra approaches to obtain adequate-quality results. It quickly processes incoming photographs and enhances them with authentic contrast and colors. The sole problem is that the client must manually calculate the values of λ and δ, making it not totally automated. Implementing a legacy approach requires balancing high-quality and rapid analysing, which can be challenging.

The technique suggested outscored rivals in several respects, achieving the study's purpose. ABCETP may be enhanced to cover additional applications in real life and achieve full automation. This ABCETP is tested with several genuine contrast-distorted image, compared to various contrast enhancement strategies, and the results are evaluated using two specific quality assessment measures. Data collected from numerous comparisons and trials demonstrated the favourability of ABCETP, which produced images of higher perceived standard and surpassed the comparing approaches in multiple aspects.

4. PROPOSED METHOD

This method distinguishes itself from earlier ones by utilizing a minimal number of existing processing models and modifying them to create a novel framework capable of rapidly enhancing contrast. The operational mechanism of this method is straightforward: initially, two distinct hyperbolic functions are employed to analyse the input image. Subsequently, the outcomes of these functions are combined by means of an enhanced

LIP [15] model. Two enhanced statistical methods are subsequently employed to do further processing.

Finally, the algorithm produces the result by implementing a contrast stretching approach [14]. More precisely, the input comprises a distorted image with varying contrast and a numerical value δ, which dictates the degree of augmentation to be performed. After receiving the input, the image is sent to two separate hyperbolic functions, namely hyperbolic sine and hyperbolic tangent, for further processing. It has been shown that these two functions alter the tone of the image by implementing an S-curve alteration. Both of these functions can be accurately expressed as:

$$HT = \exp(I) - \exp(-I) / \exp(I) + \exp(-I) \ldots\ldots\ldots (1)$$

$$HS = \exp(I) - \exp(-I) / 2 \ldots\ldots\ldots\ldots (2)$$

where I represent the input contrast-distorted image.

After processing image with the hyperbolic tangent, an image called HT is produced.

After processing image with the hyperbolic sine, an image called HS is produced.

Given that no transformation can achieve this result, the subsequent step involves combining the characteristics of the HT and HS images utilizing an appropriate LIP model to generate a distinct image that incorporates the characteristics of both images. The researchers have evaluated numerous LIP models and have proposed a new model that exceeds the earlier studied ones. The newly proposed model can be represented as:

$$L = \sqrt[m]{1 - \frac{(1-u^m)\cdot(1-v^m)}{1-u^m\cdot v^m}} \ldots\ldots\ldots\ldots (3)$$

The output of the LIP model, denoted as L, is obtained by multiplying the first image, u, with the subsequent one, v. In order to get a logarithmic-like model, the value of m is set to 1. In order to modify this model, an efficient methodology was employed, resulting in the derivation of an equation that effectively integrates the outcomes of the hyperbolic functions.

$$L = \left[1 - \frac{(1-HT^2)\cdot(1-HS^2)}{1-HT^2\cdot HS^2}\right]^{\delta} \ldots\ldots\ldots\ldots (4)$$

The parameter δ represents the enhancement value, with the condition that δ > 0. A higher value of δ results in a more significant improvement in contrast. The value of δ should be determined manually by the operator in order to get the required improvement.

Furthermore, the immaculate image's contrast is enhanced by the implementation of an alternative modified technique.

The sigmoid function (SF) [4] is commonly utilized as an S-curve transformation function in several research publications focused on enhancing image contrast through contrast amendment. The SF is represented in the following manner:

$$F = 1 / 1 + \exp(-I) \ \ldots\ldots\ldots (5)$$

This function will serve as a transformation function to raise each pixel in the pristine image to the power of a modified version of the sigmoid function.

This modified function will provide a non-linear contrast enhancement for the input image, based on the S-curve and LIP methods that were previously employed. Thus, the input image is improved utilizing the below equation:

$$S = (I)^{\left(\frac{\delta-1}{1+exp(-L)}\right)} \ \ldots\ldots\ldots(6)$$

where S is an improved contrast version of the original image. Next, S's brightness has to be increased as well because it was decreased during the contrast enhancement procedure.

To accomplish the aforementioned goal, an enhanced version of the cumulative distribution function of Gompertz distribution (CDFGD) [2-3] is employed.

This distribution has been applied in the past to boost brightness in image enhancement studies. The CDFGD is calculated as follows in:

$$w = 1 - \exp - \eta \, \gamma \cdot (\exp(\gamma \cdot I) - 1) \ \ldots\ldots\ldots (7)$$

where η is a scalar that can increase brightness; a larger value results in higher brightness. where ($\eta > 0$) and ($\gamma = 1$), and η is responsible for boosting the brightness. The CDFGD is used in this study to modify brightness in the following manner:

$$G = 1 - \exp(-(0.4 \cdot \delta) \cdot (\exp(S) - 1)) \ \ldots\ldots\ldots (8)$$

Right now, image G has different contrast and brightness levels. However, there is a restricted dynamic range in which its intensities can be distributed.

Therefore, to reallocate the values of G to the natural range, a contrast stretching technique like normalisation is used. The normalisation technique [13] in use is expressed as follows:

$$N = G - \min(G) / \max(G) - \min(G) \ \ldots\ldots\ldots (9)$$

where max and min denote the highest and lowest quantities, and N is the algorithm's final result.

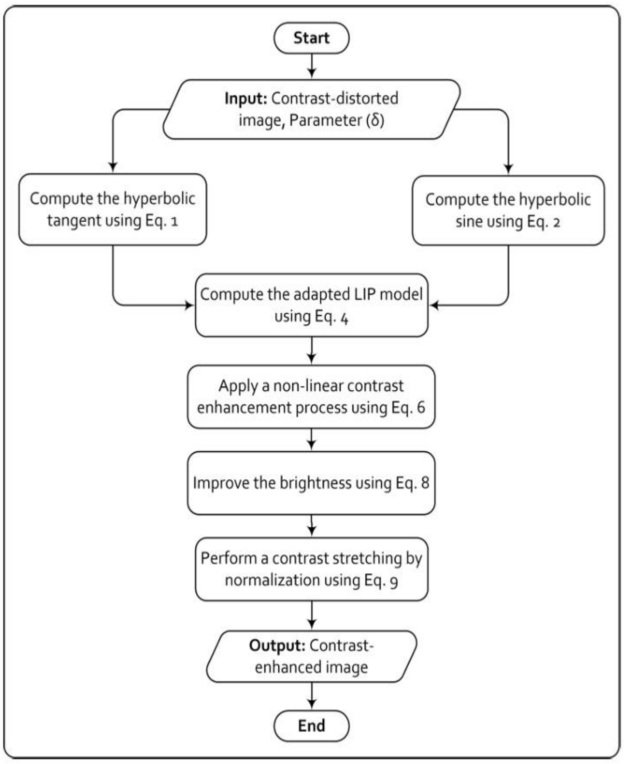

Fig 1: HLIPSCS workflow diagram.

5. SIMULATION RESULTS

This section provides essential details about the dataset, methodologies used for image assessment, comparison of different techniques, machine specs, results, and evaluation. The dataset consists of more than one hundred colour and grayscale image collected from different online sources. All of these images exhibit authentic contrast distortion. This demonstrates the mean ratings obtained when our method is compared to the Ameliorated Balance Contrast Enhancement Technique. The results obtained from the ABCETP algorithm exhibited a relatively desaturated colour palette and peculiar areas with intensified darkness. Due to this reason, it obtained a PSNR score. This suggests that while there was a somewhat sufficient difference, the clarity has been affected by the presence of additional unfavourable observations. This approach was evaluated as the most efficient in terms of processing time during the evaluation. Findings from a research investigation including a variety of colourful and grayscale images. Table 1 displays the findings of the tests conducted on the processing times and image rating procedures utilized. The values in column B represent the mean results, but the values in column C indicate superior outcomes. Regarding the grayscale images, there has been a significant improvement in contrast, reduction of brightness amplification [10], and overall result appearance that is much better than their original observations. When comparing the color images to their unprocessed counterparts, the original brightness has been preserved, the contrast has been significantly enhanced, and the colours appear more vivid. Based on the data in column C, the HLIPSCS approach demonstrated desirable contrast, maintained illumination, and created vivid colour representations, resulting in the top score in all categories. Furthermore, this strategy proved to be the most expedient for comparing results, and no computational errors were seen in the findings. This may be regarded as a successful accomplishment due to the fact that the approach yielded aesthetically pleasing outcomes with few calculations, rendering it appropriate for utilization with imaging modalities that demand less advanced technology.

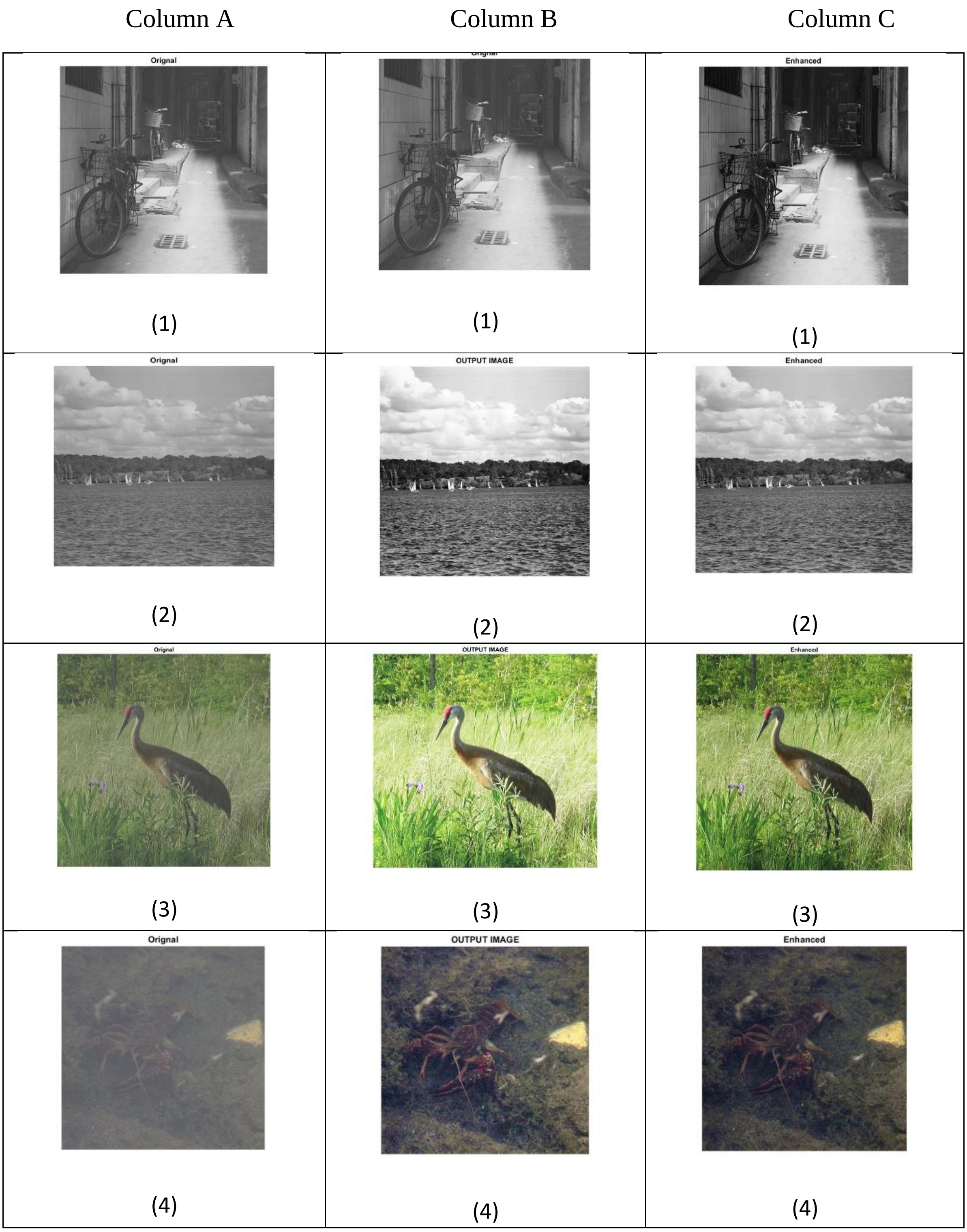

Fig 2: It depicts the simulation results of existing ABCETP method and proposed HLIPSCS method. Column A represents the original input image, Column B gives the enhanced output image through ABCETP method, Column C gives the enhanced output image through HLIPSCS method respectively.

Parameters	ABCETP Method				Proposed HLIPSCS Method			
	Image 1	Image 2	Image 3	Average Value	Image 1	Image 2	Image 3	Average Value
MSE	0.0255	0.0513	0.0440	0.04026	0.0067	0.0098	0.0373	0.01793
PSNR	15.9384	12.9030	13.5613	14.13423	21.7415	20.0934	14.2778	18.70423
Elapsed Time	0.18105	0.10585	0.31363	0.200176	0.05034	0.03762	0.122993	0.070317

TABLE 1: The scored image MSE, PSNR readings and the execution times of the compared algorithm ABCETP and proposed algorithm HLIPSCS.

From the Table 1 we can see that PSNR values of the images are high in the proposed HLIPSCS method compared to the ABCETP method, it means the PSNR [11] value gives the better images and the value of Mean Square Error in the HLIPSCS method is low.

6. CONCLUSION

This study introduces the HLIPSCS algorithm, which is designed to adjust contrast in colour and grayscale images. This technique utilizes many concepts such as statistics, hyperbolic functions, contrast stretching, and logarithmic image processing. The algorithm was assessed using images that had diminished inherent contrast. In addition, evaluations and analyses of the results were conducted. According to the obtained results, it is clear that not all algorithms in this field have the ability to provide satisfactory outcomes. Some algorithms need intricate computations, while others require a substantial number of inputs. These variables were considered throughout the creation of the HLIPSCS to ensure efficient and rapid recovery of varied colour and grayscale images, resulting in satisfactory outcomes. Therefore, the results demonstrate significantly enhanced visual quality as compared to the original files. Concerning the notable attributes of the image, the luminosity is preserved, the disparity is intensified, and the hues appear more vivid. Furthermore, it outperformed the comparison algorithms, as shown by the criteria for evaluating the images. This issue is important since the HLIPSCS used a simple architecture and minimal calculations. In further versions, the HLIPSCS has the potential to be completely automated or adjusted to be compatible with low-spec tools.

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