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# TONE MAPPING AND IMAGE ENHANCEMENT USING RECURSIVE MEAN SEPARATE HISTOGRAM EQUALIZATION (RMSHE) TECHNIQUE

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**ABSTRACT**

This work aims to develop a Novel Image Enhancement technique to enhance contrast and tone of digital imagery. Contrast Enhancement and White Balancing used for Image Enhancement. Contrast Enhancement is achieved by Recursive Mean Separate Histogram Equalization (RMSHE). White Balancing is used for Tonal correction. Parameter such as PSNR, MSE, MAE are calculated to identify the better Histogram Equalization for contrast enhancement.

**Keywords:** contrast enhancement, white balancing, histogram equalization, mean absolute error, mean square error, meak signal to noise ratio, RMSHE.

## 1. INTRODUCTION

Enhancing digital image to extract true image; a desired goal in several applications such as digital image or video photography, liquid crystal display processing, and medical image analysis known as image enhancement. Image Enhancement required for both the aesthetic and pragmatic purposes. Performing the task automatically without human intervention is hard in image processing. Different approaches and techniques are to solve this problem one well established method, Histogram equalization automatically flattens and stretches the dynamic range of the histogram of the image. Hence, an enhancement of the contrast in the image achieved. Tone mapping techniques are used to transfer the image into a suitable dynamic range. The combined method of contrast and tone mapping technique developed for real time applications in the proposed method. White Balance is the global adjustment of the intensities of the colors (primary colors). An important goal of this adjustment is to render specific colors – particularly neutral colors – correctly. The Histogram Equalization method on color images is by applying the method separately to the Red, Green and Blue components of the RGB color values of the image. However, applying the same method on the Red, Green, and Blue components of an RGB image may yield dramatic changes in the image's color balance since the relative distributions of the color channels change as a result of applying the algorithm.

The Histogram Equalization method is used for contrast enhancement. Various existing histogram equalization methods are taken and compared to find the best method for contrast enhancement. A tone mapping algorithm such as white balancing is used for Image enhancement. Thus a novel image enhancement technique proposed and their performance continuously analyzed to increase the robustness of the input image.

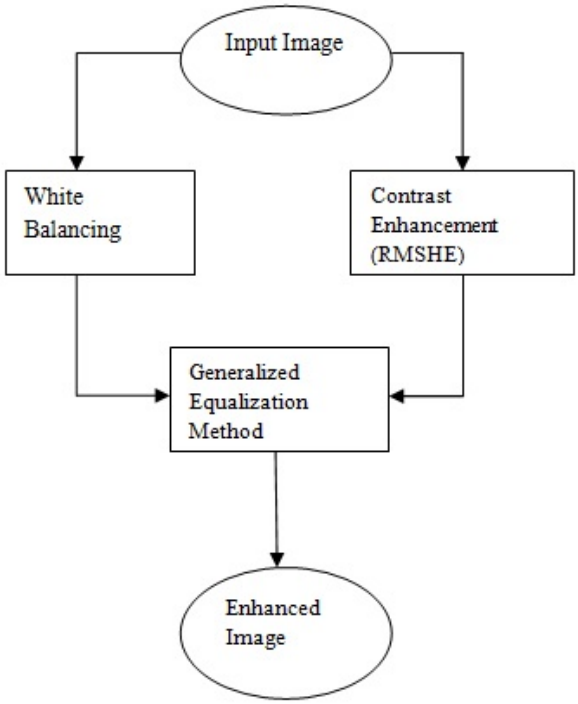


**Figure-1.** Block diagram of the proposed work.

Figure-1 shows the flow diagram in blocks of the proposed work. White balancing and contrast enhancement technique applied to the input image to obtain a novel image enhanced method for better quality image. This is achieved by applying white balance first to the color image, maximum RGB values are calculated and aggregated and then input image is corrected with respect to the mean values of red, green and blue respectively and then histogram equalization method is applied to the corrected image that is shown in Figure-2.

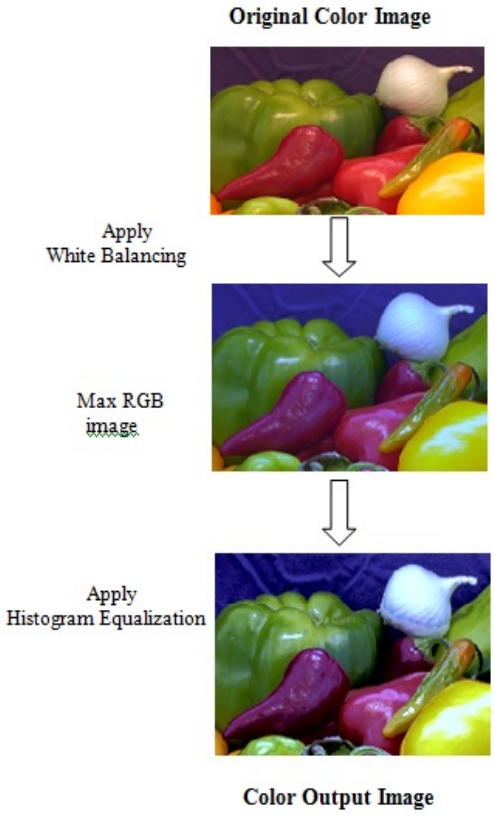


**Figure-2.** Flow diagram of the proposed work.

Figure-2 shows the steps involved in the proposed image enhancement technique. White balance applied to the input image from database to obtain the maximum RGB value in the image, then the histogram equalization technique applied to the white balanced image to get the final corrected output image with improved quality.

## 2. CONTRAST ENHANCEMENT

Contrast enhancement algorithms are widely used for the restoration of degraded media, among which Recursive Mean-Separate Histogram Equalization (RMSHE) [4] found to be best compared to other histogram equalization techniques such as Brightness Preserving Bi-Histogram Equalization (BBHE)[1], Dualistic sub-image histogram equalization(DSIHE)[2], Minimum Mean Brightness Error Bi-Histogram Equalization(MMBEBHE)[3], Adaptive histogram equalization(AHE), Contrast Limited Adaptive Histogram Equalization (CLAHE), Dynamic Histogram Equalization (DHE)[6][9], Multi Histogram Equalization (MHE)[7], Multi Peak Histogram Equalization (MPHE)[5], Weighted Threshold Histogram Equalization (WTHE)[10] [12], Global Peak Histogram Equalization (GPHE) [18].

In this paper, 50 photographic images have been taken for testing of our proposed method. Figure3 (a) shows a photographic image of a Lena and Figure3 (b) -(k), shows the effect of applying BPBHE, DSIHE, MMBEBHE, AHE, CLAHE, MHE, MPHE, WTHE, DHE, GPHE. Figure (l) shows the results after applying RMSHE method. The effect of the RMSHE method is convincing and is preferred for use.

Figure-4 (a) shows the histogram of the photographic image of a Lena and Figure-4 (b) -(k), shows the effect of applying BPBHE, DSIHE, MMBEBHE, AHE, CLAHE, MHE, MPHE, WTHE, DHE, GPHE. Figure-l shows the results after applying RMSHE method. The effect of the RMSHE method is convincing and is preferred for use.

Figure-5 shows the output after applying white balancing and contrast enhancement (RMSHE) method for Lena image.

Figure-6 (a) shows a photographic image of cow and Figure-6 (b) -(k), shows the effect of applying BPBHE, DSIHE, MMBEBHE, AHE, CLAHE, MHE, MPHE, WTHE, DHE, GPHE. Figure-(l) shows the results after applying RMSHE method. The effect of the RMSHE method is convincing and is preferred for use.

Figure-7 (a) shows the histogram of the photographic image of a cow and Figure-5 (b) -(k), shows the effect of applying BPBHE, DSIHE, MMBEBHE, AHE, CLAHE, MHE, MPHE, WTHE, DHE, GPHE. Figure-(l) shows the results after applying RMSHE method. The effect of the RMSHE method is convincing and is preferred for use.

Performance comparison of BPBHE, DSIHE, MMBEBHE, AHE, CLAHE, RMSHE, MHE, MPHE, WTHE, DHE, GPHE methods for Lena image are listed in Table-I. The RMSHE method has Mean Absolute Error (MAE) of 16.9 which is minimum compared to other methods BPBHE, MHE, WTHE, DHE, GPHE of about 30.3 and PSNR value is 21.14DB which is more by 4DB of MMBEBHE method. The computational time is 0.04 seconds, which is minimized to the DHE method by 0. 3 seconds.


**Figure-3.** Histogram equalization output for lena image (a) Original Image (b) BPBHE (c) DSIHE (d) MMBEBHE (e) AHE (f) CLAHE (g) MHE (h) MPHE (i) WTHE (j) DHE (k) GPHE (l) RMSHE.

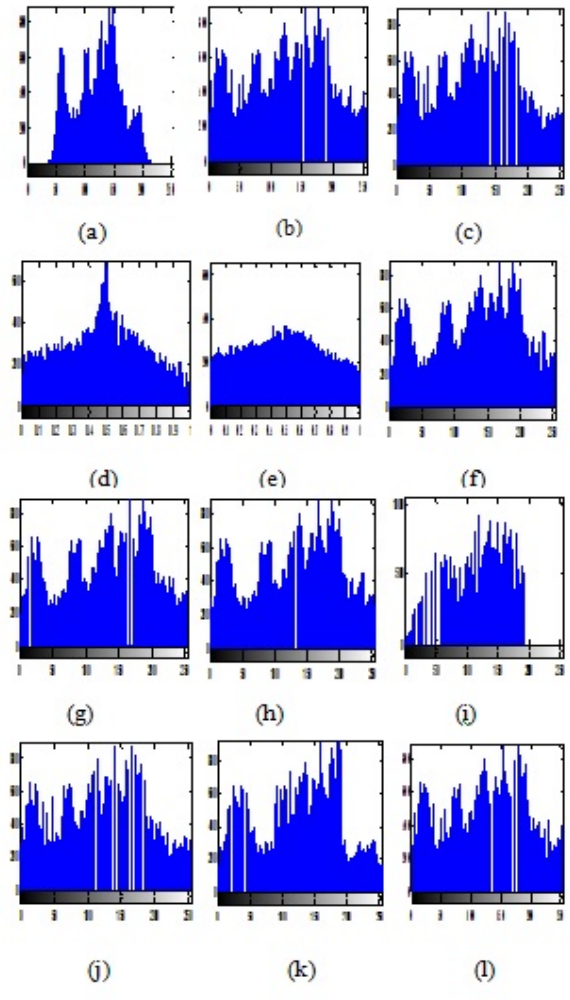


**Figure-4.** Histogram Equalization output for lena image (a) Original Image (b) BPBHE (c) DSIHE (d) MMBEBHE (e) AHE (f) CLAHE (**g)** MHE (h) MPHE (i) WTHE (j) DHE (k) GPHE (l) RMSHE.

**Table-1.** Performance comparison of various histogram equalization techniques for lena image.

| S. No | Bi-Histogram Equalization Methods | Mean Absolute Error (MAE) | Mean Square Error (MSE) | Peak Signal to Noise Ratio (PSNR) DB | Computational time (seconds) |
|---|---|---|---|---|---|
| 1. | BBHE | 30.2909 | 1.1775 | 17.4213 | 0.031438 |
| 2. | MMBEBHE | 30.0453 | 1.1204 | 17.6371 | 0.040503 |
| 3. | AHE | 122.0578 | 1.6562 | 5.9396 | 0.272301 |
| 4. | CLAHE | 122.0518 | 1.6556 | 5.9411 | 1.467149 |
| 5. | MHE | 30.3773 | 1.1921 | 17.3676 | 0.043605 |
| 6. | MPHE | 16.0278 | 1.8983 | 15.3473 | 0.020637 |
| 7 | GPHE | 29.9455 | 1.0851 | 17.7762 | 0.032634 |
| 8 | WTHE | 99.4856 | 1.6562 | 6.5673 | 0.023456 |
| 9 | DSIHE | 31.0456 | 1.2705 | 7.5674 | 0.03456 |
| 10 | DHE | 45.8765 | 1.4075 | 18.4566 | 0.07687 |
| 11 | **RMSHE** | **16.9035** | **500.6319** | **21.1356** | **0.046595** |


**Figure-5.** Histogram Equalization output for Cow image (a) Original Image (b) BPBHE (c) DSIHE (d) MMBEBHE (e) AHE (f)CLAHE (g) MHE (h) MPHE(i) WTHE (j) DHE (k) GPHE (l)RMSHE.

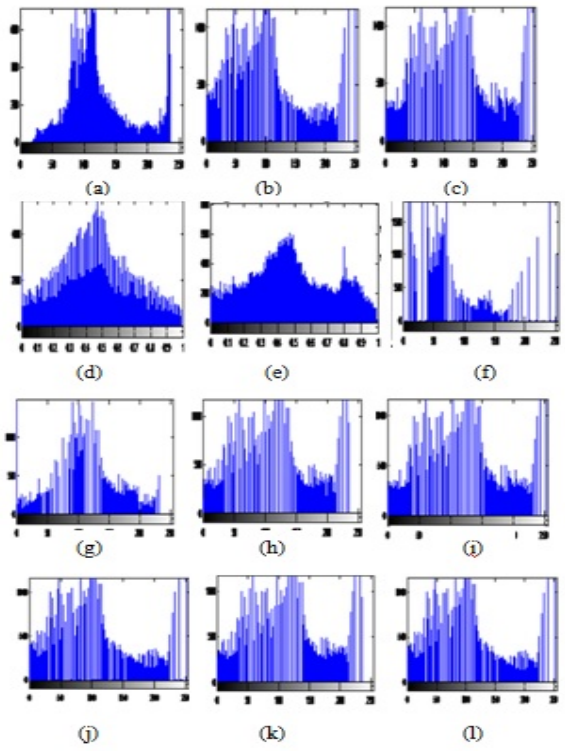


**Figure-6.** Histogram Equalization output for Cow image (a) Original Image (b) BPBHE (c) DSIHE (d) MMBEBHE (e) AHE (f) CLAHE (g) MHE (h) MPHE(i) WTHE (j) DHE (k) GPHE (l)RMSHE.

**Table-2.** Performance comparison of various histogram equalization techniques for cow image.

| S. No | Bi-Histogram Equalization Methods | Mean Absolute Error (MAE) | Mean Square Error (MSE) | Peak Signal to Noise Ratio (PSNR) DB | Computational time (seconds) |
|---|---|---|---|---|---|
| 1. | BBHE | 21.8429 | 749.3709 | 19.3838 | 0.107751 |
| 2. | MMBEBHE | 24.3237 | 768.1281 | 19.2765 | 0.055231 |
| 3. | AHE | 124.8419 | 1.8271 | 5.5131 | 0.175291 |
| 4. | CLAHE | 124.8477 | 1.8384 | 5.4865 | 1.341298 |
| 5. | MHE | 21.7730 | 739.6287 | 19.4407 | 0.057485 |
| 6. | MPHE | 29.6270 | 4.8141 | 11.3056 | 0.020360 |
| 7 | GPHE | 21.1747 | 627.2850 | 20.1562 | 0.065312 |
| **8** | WTHE | 99.4856 | 1.6562 | 6.5673 | 0.023456 |
| 9 | DSIHE | 31.0456 | 1.2705 | 7.5674 | 0.03456 |
| 10 | DHE | 45.8765 | 1.4075 | 18.4566 | 0.07687 |
| 11 | **RMSHE** | **14.4001** | **553.3026** | **20.7012** | **0.119094** |

## 3. WHITE BALANCE

The process of removing unrealistic color casts known as White balance, in which objects appear white in person, rendered white in photos. For proper white balance, color temperature taken into account. The color temperature of a light source; refer to the relative warmth or coolness of white light. Digital cameras often have great difficulty with auto white balance (AWB) and can create unsightly blue, orange, or even green color casts. Therefore, improving photos under a wider range of lighting conditions is necessary.

## 4. RESULTS AND DISCUSSIONS

The testing of our proposed method with the lena image is shown in the following figure. White balancing is a process of color correction. By applying white balancing the mean value of red, green and blue color are corrected. White balancing of the Lena image (low contrast color image) shown in Figure-7 with Red mean is 179.6, Green mean is 99, Blue mean is 107.3, all of three means is128.6. The corrected image (max RGB image) after applying white balancing by using corrected mean value of red, green and blue color is shown in figure 8. After applying contrast enhancement (RMSHE) method to max-RGB lena image is shown in Figure-9.

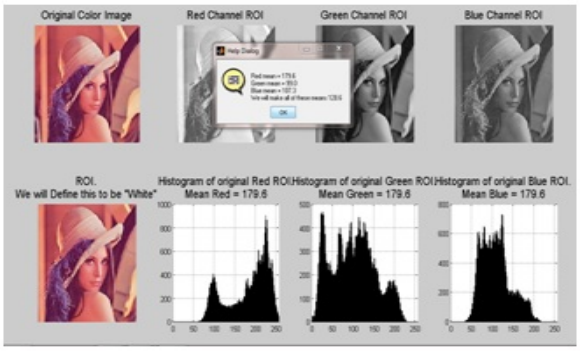


**Figure-7.** Applying max-RGB for Lena image (low contrast color image).

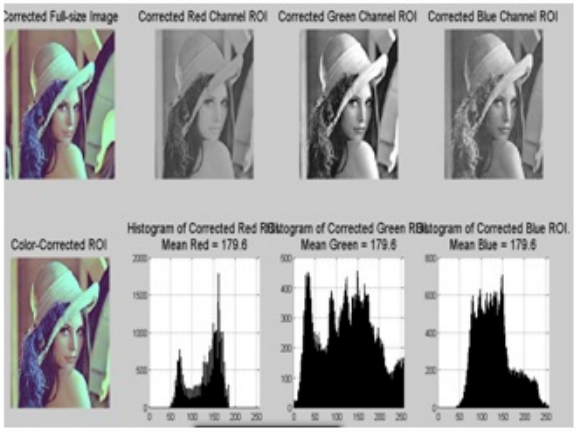


**Figure-8.** Max-RGB for Lena image.

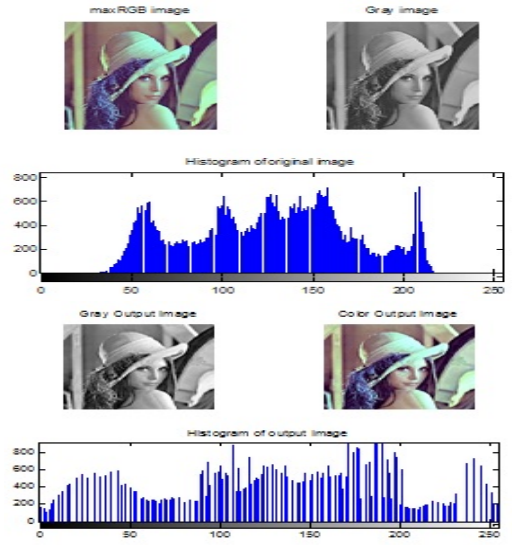


**Figure-9.** Output of the lena image after applying proposed method.

The testing of our proposed method with the Cow image is shown in the following figure. White balancing is a process of color correction. By applying white balancing the mean value of red, green and blue color are corrected. White balancing of Cow image (high contrast color image) shown in Figure-10 with Red mean is 179.6, Green mean is 99, Blue mean is 107.3, all of three means is128.6. The corrected image (max RGB image) after applying white balancing by using corrected mean value of red, green and blue color is shown in Figure-11. After applying contrast enhancement (RMSHE) method to max-RGB lena image is shown in Figure-12.

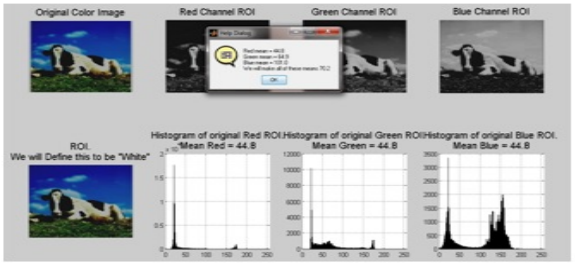


**Figure-10.** Applying max-RGB for cow image (High contrast color image).

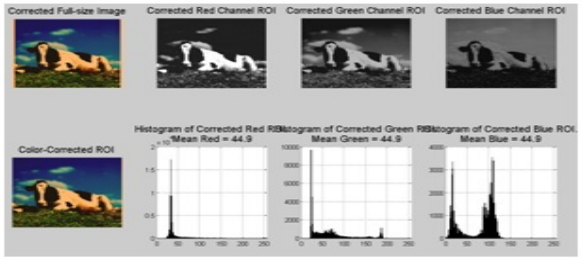


**Figure-11.** Max-RGB for cow image.

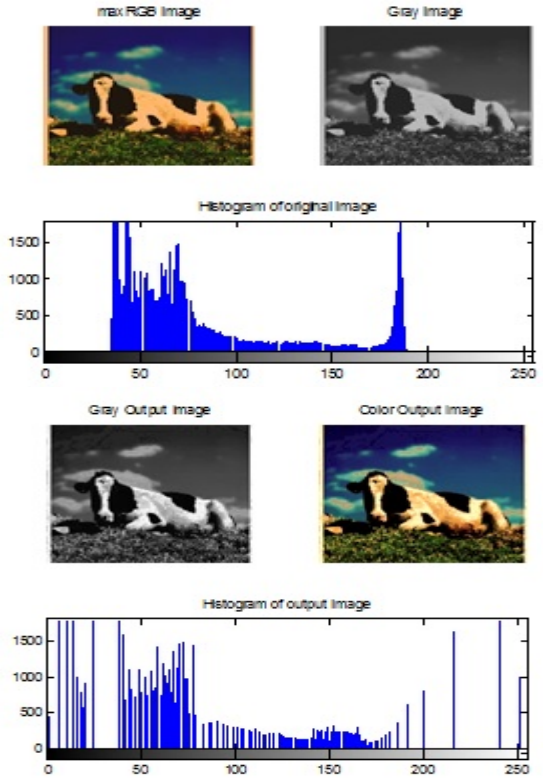


**Figure-12.** Output of the cow image after applying proposed method.

## 5. CONCLUSIONS

In proposed work, a novel contrast and tone enhancement method is used for digital imagery. It is a combination of both Contrast enhancement and Tone mapping. By comparing various Histogram Equalization analyzed that RMSHE shows better performance with PSNR value of 21.14 for lena image and 20.70 for cow image which is best to other techniques DHE by approximately 2 DB. Therefore for contrast enhancement Recursive mean Separation Histogram Equalization method is used and for tone mapping white balancing method is used for image enhancement. The proposed method produces PSNR value of 22.1 DB for lena image and 22.35 for Cow image and desired mean of 129.47 for lena image and 69.55 for cow image. Mean absolute error (MAE) as 15.15 for lena image and 12.71 for cow image. In future work it can be extended by using various other Histogram Equalization, which performs better than RMSHE if proven.

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