Improving Saturation Weighting Color Constancy with Fuzzy Membership and Edge Preservation

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Abstract— Generally, color constancy is a method of which calculates the particular impact involving discrete light sources using a digital image. The exacting figure documents with a camera determined by several components such - the actual physical information with the picture, the particular illumination occurrence within the scene, and the features with the digital camera. Our paper has explained the key purpose to modify saturation weighting dependent color constancy applying fuzzy membership based color improvement in addition to edge preserving filtering. As fuzzy membership based saturation weighting may be slow up the impact of the light due to it decreases the sharpness on the image and results in an amount of noise. Therefore a conflict has been arisen and we have needed to remove by using an integrated effort of the edge based color constancy with the histogram stretching, and edge preserving filtering. Experimental results have been shown the efficiency of our approach which carried out certain performance matrices such - MSE, RMSE and PSNR. Our proposed method has given better performance on the basis of performance matrices as compared to the previous methods.

Keywords— Color Constancy, Saturation Weighting, Edge Based Color Constancy, Fuzzy Membership.

I. INTRODUCTION

Color is borrowed at the time of three mechanisms, i.e., the reluctance of the object, the acceptability of cones, as well as the illumining spectra. Of such mechanisms, the illumining spectrum is the smallest amount of constant. The different phases depend in relation to the illumination changes, as an instance daytime (daylight, noon, and evening) or inside/outside situations.

Fig.1. Image under different illuminations adapted from dataset [25]

As per the review done by us in our previous paper “Color constancy algorithms: significant study”. Previously, no effort has been done over fuzzy membership. In this paper work has been done on fuzzy membership based color image enhancement and edge preserving filtering. The difficulty appears to be acceptable and have great impact on vision application because fuzzy membership based saturation weighting which has reduced the impact of the light but it also reduced the sharpness of the image and furthermore may result in some noise so to remove this problem, we have used an integrated attempt of the edge based color constancy alongside with the histogram stretching and edge preserving filtering. In previous paper we proposed a methodology as given below:

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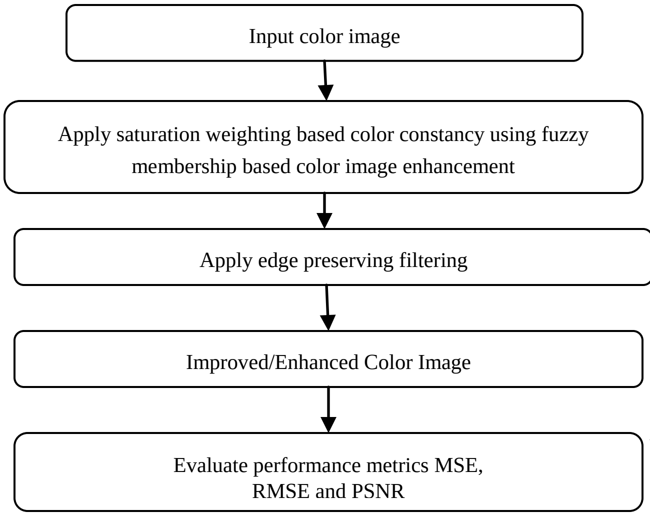

Fig.1.1. Proposed Methodology (adapted from [19])

Step 1: Initially, Input Image has been taken.

Step 2: Then fuzzy membership have been added with saturation weighting technique in order to improve the results.

Step 3: After that saturation weighting technique has been applied along with fuzzy logic.

Step 4: But if in some cases, the edges of the image has been loose then in that case we have applied the edge preserving filter as a post processing.

Step 5: Final image has been obtained.

II. Implementation

A. Dataset

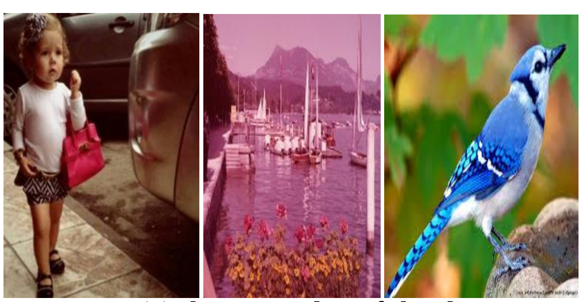

Fig.2.1 (a) the examples of the datasets (adapted from [25])

Fig.2.1 (b) the examples of the datasets (adapted from [25])

In this dataset, we have taken total number of images 25 which has taken at different positions. Few examples have shown in the Fig.2.1 (a) and Fig.2.1 (b) respectively. Dataset named follows - 51959-color-constancy, which is available online(https://in.mathworks.com/matlabcentral/fileexchange/51959-color-constany) [25].

B. Proposed Algorithm

Step 1: First of all color input has been accepted and changed into the digital image then we have located the dimension of an image using the equation:

$$[M, N, \sim]=SIZE\ (I) \quad (1)$$

Where M represents row, N represents column, ~Represents any channel i.e. red, green or blue and I represents the image.

Step 2: Now eliminate saturation color points i.e. the colors which have greatly affected by the light source via following equations:

(a) Initially we compute all the three channels with the following equations:

$$T_r = \sum\sum(I_r) \quad (2)$$
$$T_g = \sum\sum(I_g) \quad (3)$$
$$T_b = \sum\sum(I_b) \quad (4)$$

Where T_r, T_g, T_b represents total red, green and blue color and I_r, I_g, I_b represents red, green and blue image.

(b) After calculating R, G, B channel , compute the mean of all the three channels with the following equation:

$$g_m = \sum(r_m g_m b_m)/3 \quad (5)$$

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Where g_m represents global mean and $r_m g_m b_m$ represents mean of all individual channel.

(c) Now color aggregation have been used elsewhere to eliminate the saturation points by means of the following equations:

$$a_{r=} {}^{g_m}/_{r_m} \quad (6)$$

$$a_{g=} {}^{g_m}/_{r_g} \quad (7)$$

$$a_{b=} {}^{g_m}/_{r_b} \quad (8)$$

Where $a_r a_g a_b$ represents aggregate function for red, green and blue channel.

(d) Now later than removing the saturation points we have obtained new images by using these equations:

$$\text{Ni(red)}=a_{r*I_r} \quad (9)$$
$$\text{Ni(green)}=a_{g*I_g} \quad (10)$$
$$\text{Ni(blue)}=a_{b*I_b} \quad (11)$$

where Ni represents new image.

Step 3: Now we have removed the effect of light by edge based 2nd order derivation color constancy method by means of the equation as given below:

(a) Initially we have estimated the luminance value to signify the gray edge hypothesis by using the equation:

$$\text{Ew}=\sqrt{wr * 2 + wg * 2 + wb * 2} \quad (12)$$

where Ew represents effect of light and wr, wg, wb represents effect of red, green and blue color.

Step 4: Now after estimating the light source, color normalization have taken place in organize to balance the effect of the poor light.

(a) Firstly compute the effect of red, green and blue channel by using these equations:

$$wr = wr/ew \quad (13)$$
$$wg = wg/ew \quad (14)$$
$$wb = wb/ew \quad (15)$$

Where wr, wg, wb represents effect of red, green and blue color and ew represents the effect of light.

(b) Now normalize red, green and blue color separately.

$$OI_r = OI_r/wr * \sqrt{3} \quad (16)$$

$$OI_g = OI_g/wg * \sqrt{3} \quad (17)$$

$$OI_b = OI_b/wb * \sqrt{3} \quad (18)$$

Step 5: Now apply fuzzy membership which have enhanced only those objects which demand the enhancement, in systematize to get the final color constant image.

Calculating Fuzzy membership function

Membership function used is triangular membership function. A triangular membership function is based on three constraints {a, b, c} as follows:

$$\text{Triangle } (x; a, b, c) = \begin{cases} 0, & x \leq a \\ \frac{x-a}{b-a}, & a \leq x \leq b \\ \frac{c-x}{c-b}, & b \leq x \leq c \\ 0, & c \leq x \end{cases}$$

Step 6: End.

C. Fuzzy Enhancement

The initial step in the projected technique has to change the given RGB image of size P × Q into HSV along with computing the histogram h(x) where x Є V. h(x) specifies the amount of pixels in the figure by means of intensity value x. Projected scheme has been used two strengthening parameters M and K, which handled the amount at which the power value x has to be increased. The factor M has separated the histogram h(x) into two divisions or classes. The first class C1 contained pixels values in the range [0, M − 1] and the second class C2 in the range [M, 255]. The stretching of V component has been approved out supported on two fuzzy membership values µD1and µD2, calculated for C1and C2class of pixels correspondingly.

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Parameter M has a major function in the working out of fuzzy membership values; µD1 and µD2. Enhancement parameter K has made a decision the stretching intensity to determine the enhanced intensity values x_e for the two classes C1and C2. Parameter K has been come to a decision the stretching point to which the intensity values x should be stretched based on the membership values μ_{d1} and μ_{d2}. The value for K may possibly be computed empirically according to what level the stretching as been required. From the investigational study, we predetermined the value 128 for K, which gives better results for the low contrast and low bright color images.

Once the membership value for x has been calculated, the contrast enhanced value x_e for class C2 can be computed. The substitution of the previous x values of the V factor with the improved x_e values have reason the V component to be extended resulting in contrast and brightness enhanced componentV_e. This enhanced achromatic information V_e may possibly be joint with the preserved chromatic in series (Hue and Saturation works) to obtain enhanced image HSV_e which has finally been altered to enhanced RGB_e image.

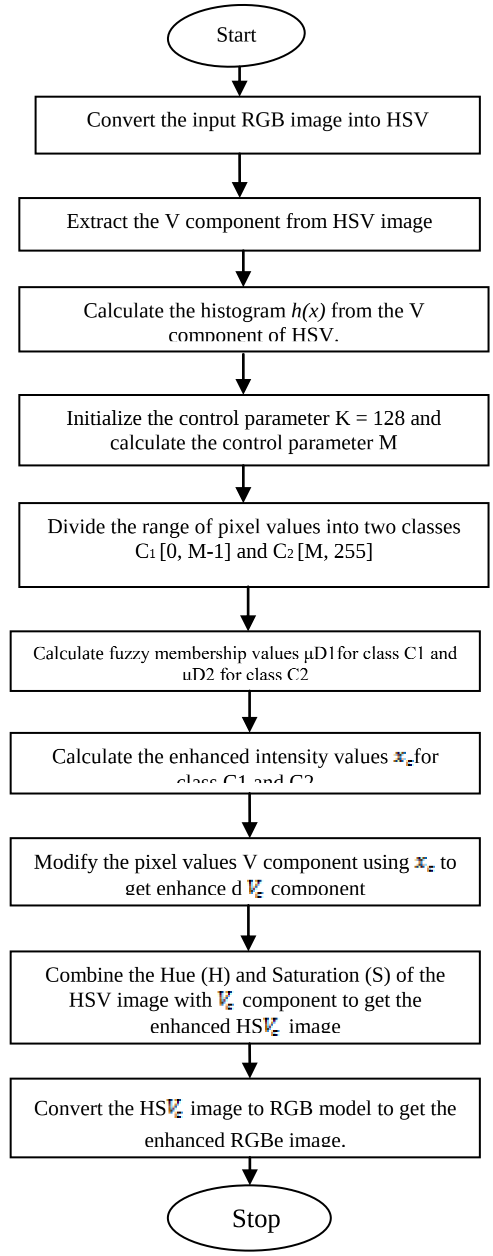

Fig.2.2. Flowchart of fuzzy enhancement

III. EXPERIMENT SIMULATIONS AND RESULT ANALYSIS

Fig.3. Input Image

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Fig.3 has revealed the input image for investigational reason. The image has little intensity and some more effect of the red color. The overall goal is to constant the color effect on image and reduces the effect of the red channel.

A. *Gray Edge Using First Order Derivative*

Figure 3.1 has shown the output image taken by the gray edge using first order. The image has enclosed too much brightness and some more effect of the red color. However the difficulty of this procedure has been found to be some artifacts which have degraded the quality of the image

Fig.3.1. Gray Edge Using First Order

B. Gray Edge Using Second Order Derivative

Figure 3.2 has shown the output image taken by the gray edge using second order technique. The image has contained too much brightness and some more effect of the red color. However the difficulty of this technique has been found that the consequence of the red channel has not been minimized as expected.

Fig.3.2. Gray Edge Using Second Order

C. Modified Gray World

In this method, we have added the saturation weighting function into the gray world method, which has been reduced the brightness of the image than the gray edge using first and second order derivative. Figure 3.3 has shown the output image taken by the integrated technique of the gray world method with saturation weighting technique. But the image still has an effect of the red color.

Fig.3.3. Modified Gray World

D. Modified Gray World with Edge Preserving Filter

Modified Gray World which has been reduced the impact of the light and thus reduced the sharpness of the image and possibly have result in some noise so to remove this problem; we have been used an integrated effort of the modified Gray World color constancy with an edge preserving filtering. It not only removed noise but also preserved edges. An edge preserving filter has been utilized to reduce the noises. The edge-preserving filter has provided extensively noise reduction.

Fig.3.4. Modified Gray World with Edge Preserving Filter

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E. Final Proposed Image

Figure 3.5 has shown the output image taken by the fuzzy enhancement integrated with edge preserving filter. The image has contained the balanced brightness and the effect of the red channel has also been reduced. Compared with other method the proposed has shown quite significant result with respect to all cases. The effect of the individual channel has also been normalized as well as the effect of the brightness has also been normalized.

Fig.3.5. Final Proposed Image

IV. PERFORMANCE EVALUATIONS

This section has contained the fractious confirmation between existing and proposed techniques. Some familiar image performance constraints for digital representations have been decided to prove that the performance of the proposed algorithm has moderately better than the available methods.

In order to execute the proposed algorithm, design and implementation has been done in MATLAB R2010a version 7 using image processing toolbox

A. Mean Square Error

Table 1 has given away the quantized analysis of the mean square error. As mean square error needs to be reduced therefore the projected technique has shown the better results than the available methods as mean square error is less in every case.

Table1. Mean Square Error Evaluation

Images	**Gray Edge 1**	**Gray Edge 2**	**Modified gray world**	**Modified gray world with Edge Preserving Filter**	**Proposed Results**
1.	**0.0215**	**0.0205**	**0.0171**	**0.0161**	**0.0148**
2.	**0.0339**	**0.0297**	**0.0227**	**0.0211**	**0.0169**
3.	0.0589	0.0549	0.0486	0.0467	0.0413
4.	**0.0253**	**0.0236**	**0.0177**	**0.0172**	**0.0156**
5.	0.0558	0.0518	0.0487	0.0481	0.0343
6.	0.0387	0.0361	0.0325	0.0317	0.0264
7.	0.0482	0.0460	0.0403	0.0377	0.0305
8.	0.0389	0.0363	0.0332	0.0324	0.0223
9.	**0.0210**	**0.0205**	**0.0194**	**0.0185**	**0.0183**
10.	0.0786	0.0701	0.0614	0.0596	0.0457
11.	**0.0216**	**0.0189**	**0.0162**	**0.0151**	**0.0110**
12.	0.0786	0.0701	0.0614	0.0596	0.0457
13.	0.0299	0.0287	0.0241	0.0233	0.0208
14.	**0.0329**	**0.0283**	**0.0210**	**0.0197**	**0.0106**
15.	0.0521	0.0469	0.0362	0.0347	0.0245

It has visibly demonstrated that the images 1, 2, 4, 9, 11, 14 respectively have less MSE values of modified gray world with edge preserving filter. So the proposed technique has worked efficiently.

B. Root Mean Square Error

Table 2 has been shown the comparative analysis of the Root Mean Square Error. It has clearly demonstrated that the root mean square error is quite less in the case of the proposed algorithm; therefore proposed algorithm has provided the better results.

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For example in given table it has clearly shown that the images 1,2,4,8,9,14 respectively have less RMSE values of modified gray world with edge preserving filter. So the proposed technique has worked efficiently.

Table2. Root Mean Square Error Evaluation

Images	Gray Edge 1	Gray Edge 2	Modified gray world	Modified gray world with Edge Preserving Filter	Proposed Results
1.	**0.1467**	**0.1432**	**0.1308**	**0.0161**	**0.0148**
2.	**0.1842**	**0.1724**	**0.1506**	**0.1451**	**0.1302**
3.	0.2427	0.2344	0.2205	0.2162	0.2032
4.	**0.1592**	**0.1537**	**0.1329**	**0.1312**	**0.1247**
5.	0.2363	0.2277	0.2206	0.2193	0.1852
6.	0.1968	0.1901	0.1802	0.1781	0.1625
7.	0.2195	0.2146	0.2007	0.1941	0.1747
8.	**0.1973**	**0.1904**	**0.1821**	**0.1800**	**0.1494**
9.	**0.1448**	**0.1432**	**0.1393**	**0.1360**	**0.1353**
10.	0.2804	0.2647	0.2478	0.2442	0.2139
11.	0.1471	0.1375	0.1273	0.1227	0.1050
12.	0.2804	0.2647	0.2478	0.2442	0.2139
13.	0.1729	0.1695	0.1554	0.1525	0.1441
14.	**0.1814**	**0.1683**	**0.1448**	**0.1404**	**0.1028**
15.	0.2281	0.2164	0.1902	0.1863	0.1564

C. Peak Signal to Noise Ratio

Table 3 has shown the relative study of the Peak Signal to Noise Ratio (PSNR). It has clearly shown that the PSNR is maximum in the case of the projected algorithm. Therefore proposed algorithm has been provided the superior results than the available methods.

It has clearly demonstrated that the images 1, 2, 4, 9, 11, 14 respectively have more PSNR values of modified gray world with edge preserving filter. So the proposed technique has worked efficiently.

Table3**.** Peak Signal to Noise Ratio Evaluation

Images	Gray Edge 1	Gray Edge 2	Modified gray world	Modified gray world with Edge Preserving Filter	Proposed Results
1.	**64.8019**	**65.0119**	**65.7959**	**66.0637**	**66.4248**
2.	**62.8244**	**63.3984**	**64.5739**	**64.8967**	**65.8409**
3.	60.4300	60.7323	61.2629	61.4354	61.9730
4.	**64.0918**	**64.3945**	**65.6591**	**65.7740**	**66.2108**
5.	60.6606	60.9838	61.2580	61.3117	62.7803
6.	62.2483	62.5523	63.0167	63.1180	63.9132
7.	61.3018	61.4988	62.0800	62.3682	63.2860
8.	62.2279	62.5371	62.9230	63.0260	64.6414
9.	**64.9166**	**65.0140**	**65.2542**	**65.4587**	**65.5064**
10.	59.1784	59.6761	60.2482	60.3753	61.5273
11.	**64.7806**	**65.3633**	**66.0357**	**66.3536**	**67.7069**
12.	59.1758	59.6761	60.2482	60.3753	61.5273
13.	63.3729	63.5477	64.3036	64.4637	64.9580
14.	**62.9601**	**63.6105**	**64.9144**	**65.1837**	**67.8928**
15.	60.9665	61.4237	62.5454	62.7288	64.2464

V. COMPARATIVE ANALYSES

Graph 5.1 has exposed the relative study of the Mean Square Error. The projected

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algorithm has shown the better results than the available methods as mean square error is less in every case.

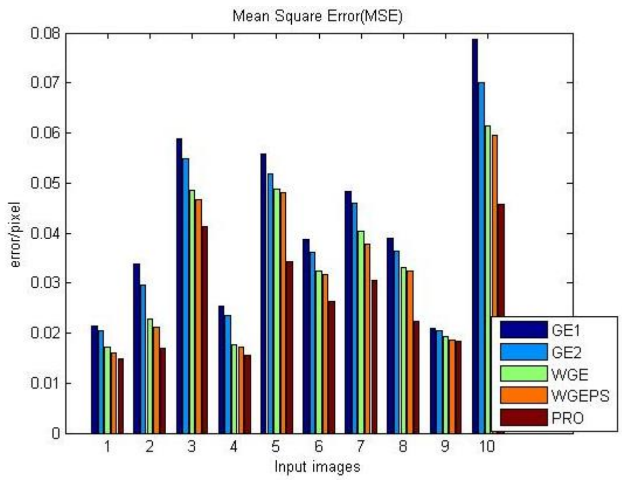

Fig.5.1 Mean Square Error

Graph 5.2 has given the comparative analysis of the Root Mean Square Error. It has been clearly demonstrated that the root mean square error is quite less in the case of the projected technique; therefore projected algorithm has been provided the better results.

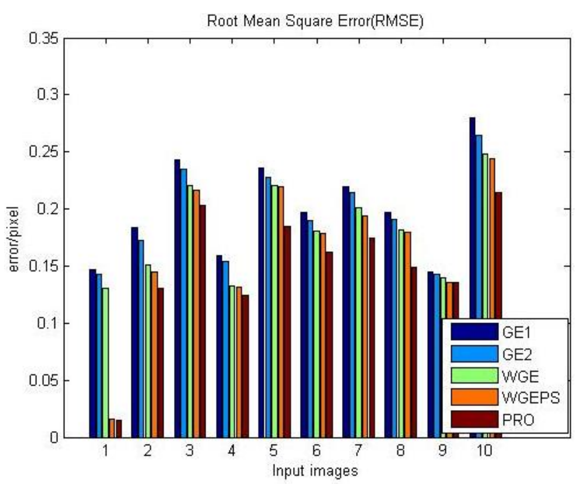

Fig.5.2 Root Mean Square Error

Graph 5.3 has evidently revealed that the PSNR is maximum in the case of the projected method therefore projected technique has been provided the better results than the available methods.

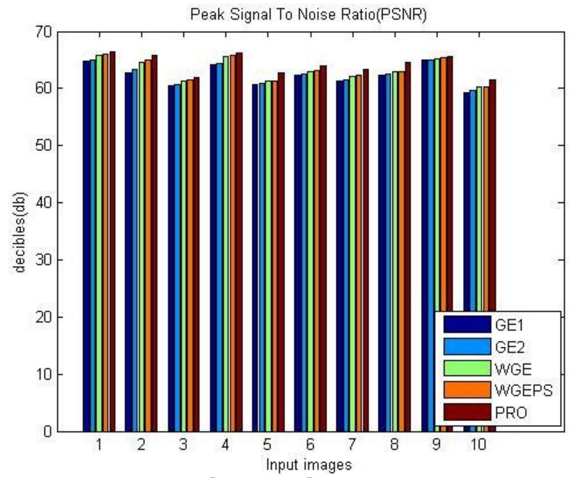

Fig.5.3 Peak Signal to Noise Ratio

VI. CONCLUSION

In this research paper, the main focus has been done to validate the concert of the projected algorithm design and implementation has undoubtedly been done in MATLAB R2010a version 7 using image processing toolbox. The contrast along with state of art methods has been drawn by taking into consideration the familiar image processing performance metrics.

This research work has not considered any soft computing method to evaluate the optimistic value of a light source. Also the effect of the noise has been ignored, therefore in near future we will use some well known image filters.

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