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Modified Color Correction Using Clahe & Edge Based Color Constancy

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Abstract-Color constancy is a visual perception system which allows people to perceive colors under numerous conditions and enable to visualize some constancy in the color. Number of color constancy algorithms is available like gray world, white patch, gray world 1st order derivative, gray world 2nd order derivative. This work emphasis on using the gray world 2nd order derivative since this method is based on 8 neighbors. This paper has proposed Improved Edge Based Color Constancy using CLAHE and Edge preservation using gradients methods. The problem is seem to be valid and will have great impact on vision application for the reason that edge based color constancy will decrease the impact of the light but it also decreases the sharpness of the image and also may result in poor brightness and also may lost its edges; so to eliminate this problem an integrated approach has been proposed for the edge based color correction along with CLAHE and Edge preserving using gradients for efficient results.

Keywords— Color constancy, Edge based hypothesis, Gray world, CLAHE and Chromaticity neutralization.

I. Introduction

Human vision has a natural ability to recognize the original color of objects of a scene irrelevant to the illumination. human vision [1-17] system has the ability to see the almost constant colors from object under multiple light sources. this ability to recognize the color of an image irrelevant to the color of the illumination by humans is called as color constancy. humans have ability to adjust the sensitivity depending upon the illumination so as to receive the actual color. human color constancy fails when there is an unnatural light source falls on an image such as vapors of some chemical substance. color constancy is capability to evaluate colors of objects, invariant to the color of illumination. color correction provides that the perceived color of objects remains comparatively constant under changeable illumination conditions. most of the computer approaches are pixel-based, improvement of an image must be done so that it should fulfill the assumptions like, the standard intensity of the sight under usual light is white light, or there are restricted number of colors in a real-world for the known illumination. an image is end result of illumination that falls on object, reflectance properties of the objects and camera sensitivity function i.e.

Image values f=$(f_r, f_g, f_b)^T$ for Lambertian surface

$$f_c = m(X) \int_\omega I(\lambda)\, \rho_c(\lambda) S(X,\lambda)\, d\lambda$$

Where I (λ) is the color of light source, S(x, λ) is surface reflectance and $\rho(\lambda) = \left(\rho_r(\lambda), \rho_g(\lambda), \rho_b(\lambda)\right)^T$ is camera sensitivity function, λ is wavelength, x is spatial coordinate, ω is visible spectrum, m(x) is Lambertian shading, c={R, G, B}

The color of illumination e is estimated by using the following equation:

$$e = \begin{pmatrix} e_R \\ e_G \\ e_B \end{pmatrix} = \int_\omega I(\lambda)\rho(\lambda)\, d\lambda$$

Color Constancy is a phenomenon that shows the human skill to estimate the actual color of the scene regardless of the color of the illuminance of that scene. Light falling on scene changes based on distinct aspects, i.e. the time of day(morning, afternoon, evening) This skill is generally recognized to the Human Visual System, although exact information remain unknown.

The human visual system has the ability to correct color variations due to the dissimilarity in light source, known as color constancy. In contrast to human visual system, unfortunately, imaging machines are not successful to attune their spectral reaction to cope with dissimilar lighting environment; as a outcome, the captured colors of the image get affected towards the color of the light source. Color constancy aims to provide the supposed colors approximately independent of light source. Radiance occurs in an image that has been excited adequately to cause it to glow visibly.

Fig.1 Objects under different illumination (adapted from [35])

Color constancy plays vital role for the human visualization because it provides optical sign to humans that helps to resolve multiple visual job such as identification, object remembrance, classification and many more. Two different types of methods are used, that is, normalization and constancy. Color normalization makes a new picture of the scene by neutralizing source light effects whereas color constancy straightway evaluates the color of the light source so as to map the colors of the scene into achromatic version.

II. CLAHE

The images degraded by haze undergo ill-fated contrast. So as to eliminate the effect of haze from the image, a Contrast Limited Adaptive Histogram Equalization (CLAHE) is used. CLAHE confines noise enrichment by creating a greatest value. CLAHE has been effectively used in the medical imaging field. The contrast of scenes in haze is commonly affected by visual spreading of light. The light received by the human eye is tremendously sprinkled by fog. Increase in image deepness spoils the contrast exponentially. Reduced visibility for number of outdoor observation systems in a haze is a main hurdle which is hard to resolve.

CLAHE method is used to re-establish despoiled color images. Any estimated metereology information is not essential in this approach. Firstly, the color images taken by digital camera in haze conditions are transformed from RGB to HSI color space. The cause of transformation in the HSI constitutes colors resemblance in the way human vision sense colors. Second, the intensity part of the scene is processed by CLAHE. The hue and saturation both are unaffected. Lastly, image processed in HSI color space will be transformed again to RGB color space.

(a) (b)

Fig.2 (a) Original fog-degraded image (b) CLAHE Output (adapted from [36])

III. METHODS OF COLOR CORRECTION

A. Gray World Algorithm

Gray World algorithm is based on the hypothesis that given an input image with ample quantity of color variations, the usual value of the R, G, and B components i.e Red, Green and Blue of the image must average to a regular gray value. This hypothesis is seized very well: in a actual world image, it is typically true that there are a lot of various color variations. The variations in color are casual and not dependent; the average would congregate to the average value, gray, by given sufficient amount of samples. Color balancing methods can apply this hypothesis by forcing its images to have a ordinary mean gray value for its Red, Green, and Blue components. In the case an image is taken by a digital camera under a specific lighting environment, the effect of the particular lighting cast can be eradicated by imposing the gray world hypothesis on the image. As a result of estimate the color of the scene is graetly nearer to the true scene.

In the first step, mean color [7] within the image is calculated, as shown below

$$a_i = \frac{1}{MN}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1}\{f_i(x,y)\}$$

Where M and N are the number of columns and rows, respectively. Likewise, a_i can be represented by

$$a_i = \frac{1}{MN}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1}G(x,y)R_i(x,y)I_i$$

$$a_i = I_i \frac{1}{MN} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} G(x,y) R_i(x,y)$$

$$a_i \approx I_i E[GR_i] = I_i E[G] E[R_i]$$

Where G is the geometry factor and R_i is reflectance. Because there is no relation among the color and the figure of an object so both variables can be assumed independent of each other. Assuming that there is huge number of colors is there in the scene, the reflectance can be measured from the range [0, 1]

$$E[G]E[R_i] = E[G]\left(\int_0^1 x\,dx\right) = E[G]\frac{1}{2}$$

$$a_i \approx I_i E[G] \frac{1}{2}$$

Once I_i, illumination is calculated. Assuming that orientation of object is perpendicular to the camera E [G] =1

$$\emptyset = \frac{2}{E[G]} = 2$$

$$I_i \approx \frac{2}{E[G]} a_i = \emptyset a_i$$

Since, $f_i(x,y) = G(x,y) R_i(x,y) I_i$ output value is given by

$$o_i\,(x,y) = \frac{f_i(x,y)}{I_i} = \frac{f_i(x,y)}{\emptyset a_i}$$

B. White Patch Algorithm

The White Patch Retinex method is greatly based on the Retinex theory. It is based on the assumption that anywhere in the scene is a white patch, which reflects maximum and canonically. White-Patch or Max-RGB technique evaluates the illuminance color from the highest reaction of the numerous color channels. Thus, the light source color can be straightway obtained from the brightest pixel. In general, we consider the maximum reaction of every color channel individually, potentially from various pixels. It is susceptible to noise because only bright pixel results in to a poor estimate. The method can be enhanced by calculating histograms ω for each

And every color channel. Another possible way is to choose a value, where only a little percentage, e.g. 1%, of the pixels has a greater intensity. The maximum intensity in each channel is calculated [7] by

$$I_{imax} = \max\{f_i\ (x,y)\}$$

C. Gamut Mapping

The gamut mapping technique [12] of color constancy is, so far one of the successful solution to this color constancy problem. In this method the group of mappings taking the image colors recorded under an unfamiliar illuminant to the gamut of all colors seen under a ordinary illuminant is characterized. Then, at a second stage, a single mapping is selected from this possible set. Gamut mapping is approach which is based on the hypothesis, that for a known light source in real-world images, just restricted amount of colors can be seen. For that reason, deviation in color of illuminance leads to unexpected deviations in the colors of scene. The name known as canonical gamut is well-read from a training set known as limited group of colors that begins under a given light source. Trained group consists of many numbers of images. Then initial gamut can be created for any given image that can be used as group of colors falling on the illuminant color to capture the given image. Group of mappings are mainly measured by making use of achromatic gamut and the given gamut that plots the given gamut entirely within the achromatic gamut. Out of the possible manifold mappings, one of the mappings has to be chosen as the estimated light source. In conclusion, the resultant image is generated by chosen mapping is used to create the resultant output image.

D. Diagonal Model

In order to eradicate the superfluous illumination from given image [37], a variety of color constancy methods has been used .The color constancy in the diagonal method is obtained by following step, written as follows:

$$\begin{pmatrix} f'_R \\ f'_G \\ f'_B \end{pmatrix} = \begin{pmatrix} S_R & 0 & 0 \\ 0 & S_G & 0 \\ 0 & 0 & S_B \end{pmatrix} \begin{pmatrix} f_R \\ f_G \\ f_B \end{pmatrix}$$

Where f'_R, f'_G, f'_B and f_R, f_G, f_B are final transformed and initial values of RGB. Whereas S_R, S_G, S_B map the colors of initial image Captured under unfamiliar light source to the analogous colors under the achromatic light (white light).

E. Gamma Correction

Gamma Correction (GC) can be thought of as the process [5] of counterbalancing the nonlinearity in order to obtain accurate reproduction of relative luminance. The luminance nonlinearity presented by numerous imaging devices is described with the process of the form

$$g[f_i(x,y)] = f(x,y)^{\gamma}$$

Where $f_i(x,y) \in [0,1]$ denotes the image intensity in the component i. If the value of γ is known, then the inverse process is trivial.

$$g^{-1}[f_i(x,y)] = f(x,y)^{\frac{1}{\gamma}}$$

F. Gray Edge Hypothesis

Gray edge hypothesis is used for the purpose of color correction. It gives better results than all other existing methods. The illumination falling on the image is estimated and then normalized.

$$\int \frac{|f_x(x)|dx}{\int dx} = \frac{1}{\int dx} \iint_{\omega} e(\lambda)|s_x(\lambda,x)|c(\lambda)d\lambda dx$$

$$=\int_{\omega} e(\lambda)\left(\frac{\int s_x(\lambda,x)|dx}{\int dx}\right)c(\lambda)\, d\lambda$$

$$= K\int_{\omega} e(\lambda)c(\lambda)d\lambda = Ke$$

Where $|f_x(x)| = (|R_x(x)|,|G_x(x)|,|B_x(x)|)^T$

$f = (R,G,B)^T$ For a Lambertian surface,

(λ) is light source,

c (λ) camera sensitivity functions, c (λ) = R (λ),G (λ),B (λ) ,

s (λ) the surface reflectance,

λ ¸ is the wavelength,

ω is the visible spectrum

IV. PROPOSED ALGROITHM

This section explains the various steps of the proposed algorithm. Subsequent section has shown that the proposed algorithm works in several stages named as step.

Step 1: Initially color image will be converted into digital image and then we will find the size of image using the equation

$$[M,N,\sim] = size(I) \text{ ..... (1)}$$

Where m represents row, n represents column, ~ represents any channel i.e. red, green or blue and I represents image.

Step 2: Afterwards saturation color pixels are eliminated i.e the colors that are greatly influenced by the illumination; by using following equations

(a) Firstly all three color channels will be measured by using the following equation

$$T_R = \sum\sum(I_R) \text{..... (2)}$$

$$T_G = \sum\sum(I_G) \text{..... (3)}$$

$$T_B = \sum\sum(I_B) \text{..... (4)}$$

Where T_R,T_B represents total red, T_G represents green and T_B represents blue color and I_R,I_G,I_B represent red, green and blue image.

(b) After calculating R,G,B Channel, mean of all 3 color channels will be calculated by using the following equation

$$gm = \sum(r_m g_m\ b_{m)}/3 \text{...... (5)}$$

Where gm represent global mean and r_m g_m b_m represent mean of all individual color channels.

(c) After calculating the mean we will remove the saturation points by applying color aggregation using the following equation

$$a_r = gm/r_m \text{ .... (6)}$$

$$a_g = gm/r_g \text{ .... (7)}$$

$$a_b = gm/r_b \text{ .... (8)}$$

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

(d) After removing the saturation points new images will be acquired by using the following equation

$$ni(red) = a_r * I_R \text{..... (9)}$$
$$ni(green) = a_g * I_g \text{..... (10)}$$
$$ni(blue) = a_b * I_b \text{..... (11)}$$

Where ni represents new image.

Step 3: In this step the effect of light is removed using edge based 2nd order derivation by using the following equation

(a) Firstly illuminance value will be estimated to represent the gray edge hypothesis by using the following equation

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

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

Step 4: After estimating the illumination, normalization will be performed to equalize the impact of degraded light.

(a) Firstly effect of red, green and blue channel will be calculated by using the following equations

$$wr = wr/ew \text{ ..... (13)}$$
$$wg = wg/ew \text{..... (14)}$$
$$wb = wb/ew \text{..... (15)}$$

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

(b) Now all three channels i.e red, green and blue will be normalized individually.

$$OI_R = \left(\frac{OI_R}{wr*\sqrt{3}}\right) \text{ .... (16)}$$
$$OI_G = \left(\frac{OI_G}{wg*\sqrt{3}}\right) \text{.... (17)}$$
$$OI_B = \left(\frac{OI_B}{wb*\sqrt{3}}\right) \text{.... (18)}$$

Step 5: Now we will find the image gradients using image gradient formula for given image:

The image gradient is represented by the formula :

$$\nabla f = \frac{\partial f}{\partial x}\hat{x} + \frac{\partial f}{\partial y}\hat{y}$$

Where $\frac{\partial f}{\partial x}$ and $\frac{\partial f}{\partial y}$ are gradients in the x and y direction.

The gradient direction is represented by formula:

$$\theta = atan2\left(\frac{\partial f}{\partial y}, \frac{\partial f}{\partial x}\right)$$

Step 6: Now CLAHE will come in action to enhance the output of proposed algorithm. The CLAHE method can be divided into steps to achieve.

$$N_{aver} = \frac{N_{CR-xp} \times N_{CR-Yp}}{N_{gray}} \qquad (1)$$

Where: N_{aver} is the aggregated amount of pixel; N_{gray} Is the amount of gray level pixels in the contextual area; N_{CR-Xp} and N_{CR-Yp} are the number of pixels in x and y dimension of the contextual area. Based on the Eq.(1), the N_{CL} can be computed using the equation:

$$N_{CL} = N_{clip} \times N_{aver}$$

Where N_{CL} is definite clip-limit, N_{clip} is the highest number of mean pixels in each and every gray level of contextual area.

V. EXPERIMENTAL RESULTS

This section contains the outcomes of the proposed techniques and some of the existing techniques. Fig.3 has shown the input image. It has been clearly shown that the image has been affected by the red light. Therefore input Image needs color constancy to become an color corrected image.

Fig.3 Input image

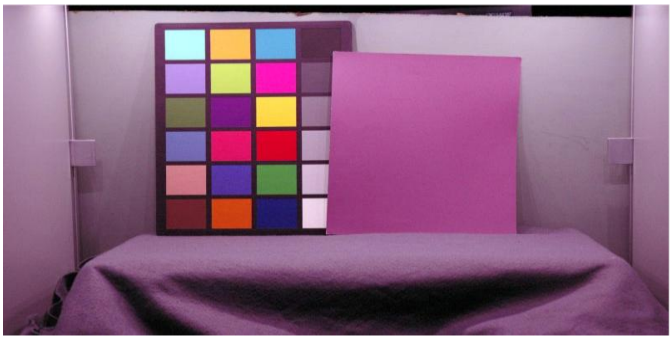

Fig.4 CLAHE output

Fig.4 has shown the output of the CLAHE algorithm. It has been clearly shown that the output image has reduced the effect of the illumination alot but it has lost its brightness.

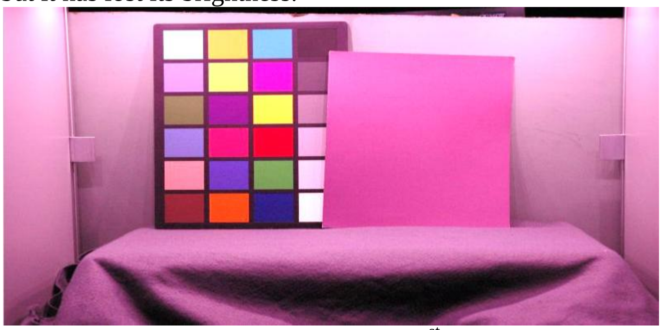

Fig.5 Edge based using 1st order

Fig.5 clearly shows the results of the Edge based using 1st order. It has been clearly shown that the output of the figure 3 much better than the CLAHE (figure 2). But still some improvement is required.

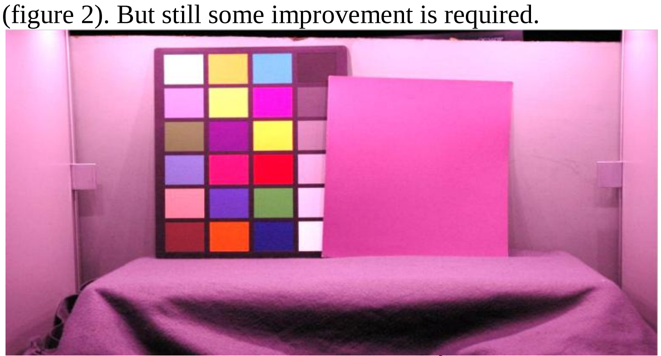

Fig.6 Edge based using 2nd order

Fig.6 clearly shows the results of the Edge based using 2nd order. It has been clearly shown that the output of the figure 4 much better than the CLAHE (fig.4) and also Edge based using 1st order (fig.5). But still some improvement is required.

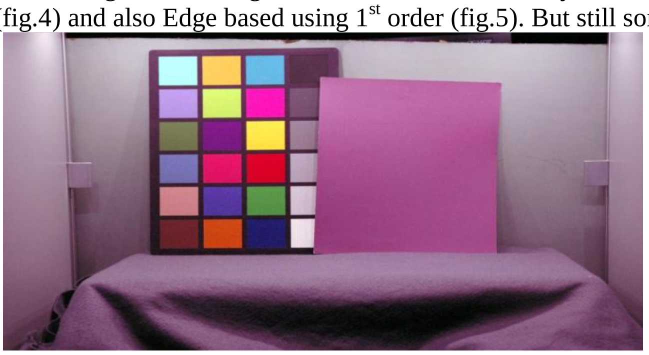

Fig.7 Proposed output

Fig.7 has shown the results of the proposed technique. It has been clearly shown that the output of the figure 5 much better than the CLAHE (fig.4), Edge based using 1st order (fig.5) and also Edge based using 2nd order (fig.6). The image is rich in its colors as well as the brightness. Therefore it has shown significant results.

VI. PERFORMANCE EVALAUATION

This section contains the comparative analysis between the proposed and other techniques. 15 different images are taken for comparative analysis.

Table1: Mean Square Error

Image Name	Edge based- 1st order	Edge based - 2nd order	Proposed
Image1	0.0301	0.0284	0.0094
Image2	0.0215	0.0205	0.0017
Image3	0.0482	0.0460	0.0094
Image4	0.0348	0.0326	0.0218
Image5	0.0452	0.0419	0.0036
Image6	0.0558	0.0518	0.0115
Image7	0.0358	0.0343	0.0036
Image8	0.0387	0.0361	0.0024
Image9	0.0576	0.0546	0.0014
Image10	0.0226	0.0196	0.0077

Table 1 shows the study of the mean square error. MSE needs to be less for the proposed algorithm for obtaining enhanced results than existing techniques. As shown in the table the results for proposed algorithm are less in every case. This shows the efficiency of proposed algorithm.

Table2: Root Means Square Error

Image Name	Edge based- 1st order	Edge based - 2nd order	Proposed
Image1	0.1735	0.1685	0.0969
Image2	0.1467	0.1432	0.0414
Image3	0.2195	0.2146	0.0968
Image4	0.1867	0.1804	0.1476
Image5	0.2125	0.2048	0.0603
Image6	0.2363	0.2277	0.1071
Image7	0.1893	0.1852	0.0602
Image8	0.1968	0.1901	0.0493
Image9	0.2400	0.2337	0.0375
Image10	0.1505	0.1401	0.0880

Table 2 has shown the survey of the Root mean square error. Root Mean Square Error needs to be less for the proposed algorithm for obtaining enhanced results than existing techniques. As shown in the table the results for proposed algorithm are less in every case. This shows the efficiency of proposed algorithm.

Table3: PSNR

Image Name	Edge based- 1st order	Edge based - 2nd order	Proposed
Image1	63.3425	63.5981	68.4017
Image2	64.8019	65.0119	75.7997
Image3	61.3018	61.4988	68.4120
Image4	62.7101	63.0046	64.7507
Image5	61.5833	61.9052	72.5257
Image6	60.660	60.9838	67.5384
Image7	62.5879	62.7769	72.5445
Image8	62.2483	62.5523	74.2762
Image9	60.5250	60.7570	76.6538
Image10	64.5818	65.2015	69.2450

Table 3 has shown the comparable analysis of the Peak Signal to Noise Ratio (PSNR). PSNR needs to maximum for the proposed algorithm than existing techniques. As shown in the table the results for proposed algorithm are maximum in every case. Therefore proposed algorithm is providing better results than existing techniques.

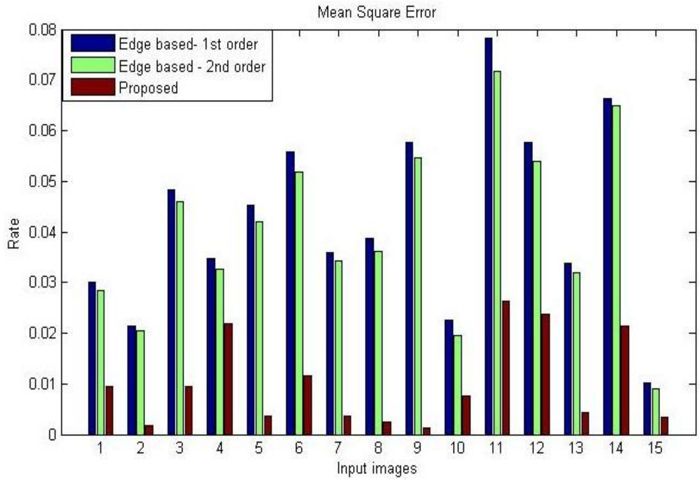

Fig.8 Mean Square Error

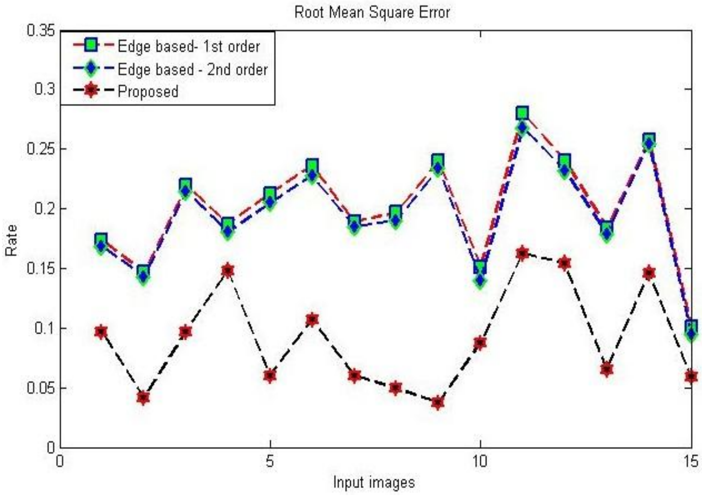

Fig.9 Root Mean Square Error

Fig.8 has shown the study of the mean square error. Mean Square Error needs to be less for the proposed algorithm for obtaining better results than existing techniques. As shown in the table the results for proposed algorithm are less in every case. This shows the efficiency of proposed algorithm.

Fig.9 has shown the comparable analysis of the Root mean square error. Root Mean Square Error needs to be less for the proposed algorithm for obtaining better results than existing techniques. As shown in the table the results for proposed algorithm are less in every case. This shows the efficiency of proposed algorithm.

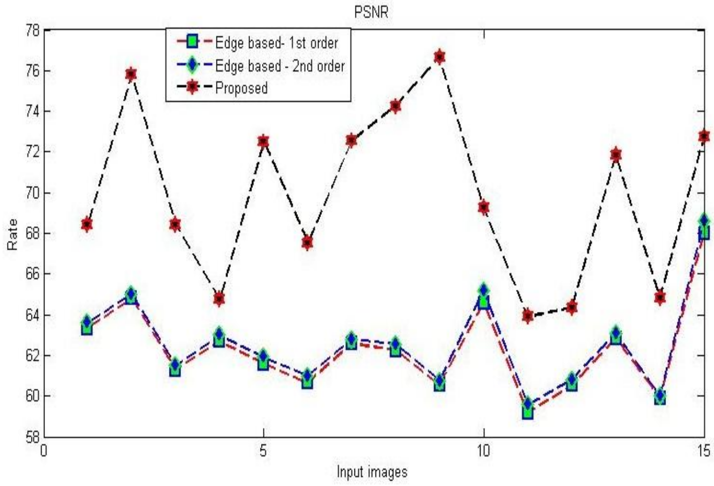

Fig.10 Peak Signal to Noise Ratio

Fig.10 has shown the comparable analysis of PSNR. Peak Signal to Noise Ratio (PSNR) needs to maximum for the proposed algorithm than existing techniques. As shown in the table the results for proposed algorithm are maxium in every case. As a result proposed algorithm is providing improved results than existing techniques.

VII. CONCLUSION

The color constancy is a procedure that measures the influence of different light sources on a digital image. The image captured by a camera depends on following factors: physical content of an image, light source on the scene, and features of a camera. The goal of the computational color constancy is to account for the effect of the illuminate. Many traditional methods such as Grey-world method, Max RGB and learning-based method were used to measure the color constancy of digital images affected by light source. All these methods have an obvious disadvantage that the illumination covering the scene is spectrally consistent. This hypothesis is often despoiled due to the presence of multiple light sources illuminating the scene. For example, indoor scenes could be affected by both indoor and outdoor light sources, each having different spectral power distributions. The research work has proposed Improved Edge Based Color Constancy using CLAHE and Edge preserving using gradients methods. The problem is seem to be justifiable and will have great impact on vision application because as edge based color constancy will reduce the impact of the light but it also reduces the sharpness of the image and also may result in poor brightness and also may lost its edges; so to remove this problem an integrated effort of the edge based color constancy along with CLAHE and Edge preserving using gradients has been implemented for efficient results. In order to validate the performance of the proposed algorithm has been designed and implemented in MATLAB by making use of image processing toolbox. The comparison among state of art techniques has also been drawn by considering the well-known image processing performance metrics. The comparative analysis has shown the significant improvement of the proposed technique over the available methods.

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