RESTORATION OF COLOR AFFECTED IMAGES USING SOFT COMPUTING TECHNIQUES

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Abstract: Color constancy is a technique to compute effect of different light sources on an obtained image. The obtained image generally contains actual scene radiance, illumination if scene, and the characteristics of the visual camera. However, it is found that the images obtained under different light sources do not provide true scene radiance. That means there is a great effect of light source on the obtained image. Therefore, the primary objective of color constancy is to restore actual image. Many methods have been proposed so far to handle this issue. Existing techniques have an obvious disadvantage of which the lighting supply along the field will be spectrally uniform. This specific presumption is sometimes broken since there is much more than one lighting supply lighting the actual scene. In this paper, to handle these issues, a fourth order partial differential equations-based weighting factor based color constancy technique is proposed. Thereafter, soft computing based image enhancement-based image enhancement technique is also designed and implemented to enhance the results. Ultimately, the effectiveness in the planned technique is evaluated by using benchmark images. Extensive experiments have been considered to evaluate the effectiveness of the planned technique. It is found that the proposed technique outperforms the competitive color constancy techniques.

keyword: Color Constancy, Grey World, Grey, Edge Hypothesis, White Patch Retinex, Gamut Mapping.

1 INTRODUCTION

Color Constancy is a standard problem in computer programming.[2] Color Constancy is the capability to evaluate the true colors of objects independent of the light source color.. Color Constancy is very important for recapture of image, categorization of image, identification of object, and tracking of object. [1] Human can recognize the intrinsic object color with the help of color constancy.[3] This adjustment of color constancy requires some presumptions as a way to estimate the scene regarding illuminant. The existing color constancy procedures can deteriorate the performance of an image under uniform illuminant [4].

Statistics type color constancy techniques including MAX algorithm, Grey world are usually speedier and also extensively used. Max RGB calculate the max value of different color channels.

The image values $P = (P_{r,}P_{g,}P_b)^t$ for a Lambertian surface depend on the color of light source $S(\lambda)$, the surface reflectance $R(y,\lambda)$, and also the digital camera sensitivity function $f(\lambda) = (f_r(\lambda), f_g(\lambda), f_b(\lambda))^t$, where λ is definitely the wavelength of the light and also y is definitely the spatial coordinate

$$P_c(y) = s(y)\int_\omega S(\lambda)f_c(\lambda)R(y,\lambda)d\lambda \quad \text{..... (1)}$$

where ω is the noticeable spectrum, $s(y)$ is Lambertian treatment, and $c\{r,g,b\}$. The observed color of the source of light L depends upon color of souce of light $S(\lambda)$ and camera sensitivity function under uniform illuminant. $f(\lambda)$

$$L = \begin{pmatrix} L_r \\ L_g \\ L_b \end{pmatrix} = \int_\omega I(\lambda)f(\lambda)d\lambda. \quad \text{.....(2)}$$

color constancy can easily be observed through calculating light source L, presented image valuations connected with P

$$P_{t=} \quad D_{u,t}\ P_u \quad \text{..... (3)}$$

where P_u is the image used within good source of light which is not known, P_t is the same image transformed, and $D_{u,t}$ is a diagonal metrix which maps colors that are utilized under light source u which is not known.

1.1 COLOR CONSTANCY TYPES:

Color Constancy is divided into various color constancy methods where every method possesses its own amazing benefits along with limitations.

A. White Patch Retinex: It is a color constancy technique working under individual source of light. It is dependent on retinex theory that gives the presumption that the max value of each color channel as white representation of image [8]. There is a abrupt enhancements made on reflectance model which produce changes in chromaticity. The illuminant varies throughout the picture and doesn't reveal any change among close by locations [7]. This algorithm gives the presumption that the highest values of color components of an image tend to be the same It can be often known as MAX-RGB algorithm.

B. Grey World : It is a color constancy technique is depending on the presumption that the standard reflectance connected with surfaces is colorless that means the scene is neutral Grey. We can also say Grey world as white balance method. Grey world method gives the assumption that the average Grey value of three color components are achromatic. The supposition is applied under uniform illuminant scene.[8] Grey World algorithm is applying to the different image parts rather than applying to the whole image. The results of different image parts collectively gives the better accuracy.

C. Grey Edge Hypothesis: Grey Edge Hypothesis depending on the presumption that this standard edge variation within the scene is usually achromatic.[1] This technique can be according to the observation that the allocation of types of colors indicates the greatest variance inside way of light source The Minkowski norm of these types is utilized to estimate the light source path. This process can be additionally more expanded and also include more significant higher order derivatives.

D. Gamut Mapping: This algorithm based on presumption under given illuminant, in real world images, merely a reduced variety of color will be observed. However, this algorithm focuses on the pixel values, the additional information present in image is ignored[19]. The colors which could seen within presented illuminant are canonical gamut. The algorithm is made up of 3 significant measures:

1.Approximation of gamut with uncertain source of light.

2.Determine the wide range of uncertain mappings.

3.Utilize an estimator to choose particular maps with the quantity of unstable mappings.

E. Physics-Based Methods: This method use data about the physical interface amongst the source of light and an object in the scene. The presumption in RGB color space is actually that each pixel surface falls on the plane[22].The interface between the different planes are employed to determine the light source color.

F. Learning based Method: Learning based methods estimate the illuminant using training data with the help of model.[22] Correlation matrix is performed under the illuminant with higher probability.This method gives good results with the help of training data.[6]

2. RELATED WORK:

Bing Li et al () [2] presents a Weibull parameterisation can be used to recognize the texture characteristics regarding color images. In accordance with the surface similarity, the best colour constancy procedure (or most effective blend of methods) is chosen out there for unique image. A experiments had been accomplished on a massive details collection along with the outcomes demonstrate that this brand-new tactic outperforms present-day state-of-the-art solitary algorithms, in addition to many put together algorithms.

Nikola Banić et al [7] presents an improved white patch color constancy method for accurate results. The superior way is subjected to testing upon many benchmark data source and it's proven to outperform the actual base line whitened fix strategy concerning accuracy. Within the benchmark repository additionally, it outperforms a lot of the other techniques and it is terrific rendering swiftness makes it suited to computer hardware implementation

Sang-Ho Lee et al [3] offered a new two-step multi-illuminant criteria intended for color constency within outdoor scenes. They choose distinct color constancy strategies both for key along with additional illuminations. Around the first step, a good input image is definitely white-balanced solely applying the previous single-illuminant colouring constancy method. Upcoming, people create the actual extra lighting location, that ordinarily corresponds to a shady location in outside scenes. Lastly, the actual shady location is definitely corrected because of the assistance of the Planckian locus theory. This consist of algorithm criteria is capable of doing smaller angular miscalculation in comparison with typical multi-illuminant approaches though colouring artifact is definitely alleviated.

Arjan Gijsenij et al (2011) [9] paper reveals an assessment for a great deal of advancements and also state-of-the-art methods. . A classification of pre-existing techniques tend to be segregated inside several communities: static strategies, gamut-based strategies, and learning-based strategies which usually are evaluated with a couple of datasets.

A Galdran et al (2018) [26] give theoretical proof that Retinex theory on inverted intensities will be a strategy to the look dehazing problem. Complete qualitative in addition to quantitative results indicate of which a number of established in addition to contemporary implementations with Retinex is usually become fighting picture dehazing algorithms undertaking upon set together with more complicated errors removal methods which enable it to overcome a few of the main challenges involving this specific problem.

WA Mustafa et al (2018) [20] suggested Grey World method by presuming the average of the surface reflectance associated with a regular picture is some pre-specified value. The effectiveness of the Grey Word method and normal Grey strategy seemed to be determined through the use of MSE and PSNR. The Grey World achieved the highest PSNR plus cheapest MSE turned out to be which the image top quality has been improved.

S Mahajan et al (2018) [21] proposed development in the pre- existing weighted grey-edge (GE) for color constancy employing vector filteration process. A received images are generally denoised by means of vector selection then, a two-step color correction practice is performed. Inside the 1st step, the actual grey edge way is employed for costing the worldwide illuminant and also accomplish the initial a higher level color correction. This kind of computed illuminant and also the initial repaired impression are widely-used within the the next step, which usually employs the weighted grey edge approach to iteratively determine a final illuminant pertaining to receiving the remaining color repaired image. This offered formula reduced this mean angular error by somewhere around 67.85% when compared to the current calculated grey edge method.

Seoung Wug Oh et al (2017) [24] choose a deep learning solution to a illumination estimation problem. The particular planned method works within the presumption with standard illumination in the scene. the convolutional neural network will be trained to resolve the problem through casting the color constancy challenge as being an light category problem. That they made the actual deep learning structure so the output of the actual network is usually right utilized for computing along with of the illumination.

E Lakehal et al (2017) [25] offer just one as well as a various illuminant approximation physics-based criteria to increase the trade-off involving accuracy and reliability (illuminant approximation error) along with computational complexity. Both equally algorithms are in accordance with the necessarily mean predictions maximization supposition along with un-centered element analysis.

3. Gaps in literature

The review shows that the color constancy algorithms suffer from various issues such as:-

1. The use of illumination normalization has been neglected by the majority of the existing literature to reduce the color artefacts that are presented in an output image.
2. The use of soft computing techniques is also ignored in the existing literature to enhance the results further.
3. The use of various post processing techniques such as filters and image enhancement techniques are also ignored.

4. PERFORMANCE ANALYSIS

The results of pre-existing techniques are shown in the figures. Fig 1 indicates the input image which is impacted by the actual light. For that reason color constancy is necessary to get an color repaired image.

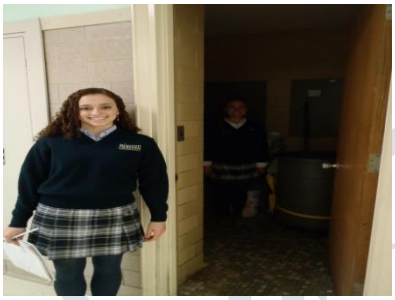


Fig 1: Initial Image

Fig 2: Edge based 1

Figure 2 reveals the results of the Eb1. It is usually undoubtedly revealed that the consequence of the fig 2 can be greater than the fig 1. Though quite a few advancement is required

Fig 3: Edge based 2

Figure 3 reveals the results of theEb2. It is usually undoubtedly revealed that the consequence of the fig 3 can be greater than the input image and Edge based first order (fig 2). Though quite a few advancement is required.

4.1 PERFORMANCE EVALUATION

1 Mean Angular Error

The angular error $\in$ is defined as the angular distance between the algorithm's estimate of the source of light(ee)and the true illuminant vector (el) in normalized $\in = \cos^{-1}(ee.el)$. Mean angular error is the mean of computed angular error. It contains the comparison investigation concerning the current techniques. 15 different photographs are usually obtained with regard to comparison analysis.

Table1: Mean Angular Error

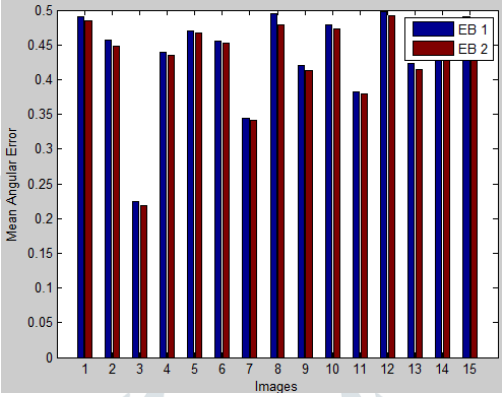
Image	Eb1	Eb2
1	0.4900	0.4851
2	0.4567	0.4478
3	0.2247	0.2191
4	0.4396	0.4349
5	0.4701	0.4668
6	0.4555	0.4519
7	0.3444	0.3418
8	0.4945	0.4787
9	0.4205	0.4127
10	0.4785	0.4725
11	0.3825	0.3799

12	0.4985	0.4919
13	0.4232	0,4152
14	0.4693	0.4606
15	0.4912	0.4795

Table 1 shows the study of the necessarily mean angular error. Mean Angular Error should be a smaller amount for that Edge based-second order for getting improved results as compared to Edge based first order. As shown in the table the outcomes for Edge based-second order are significantly a lesser amount of in every case. That reveals the effectiveness of algorithm.

Figure shows the examination of the actual mean angular error. Mean Angular Error should really be a smaller amount for that Edge based-second order for getting improved results .

Graph 1: Mean Angular Error



2. Root Mean Square Error

The Root Mean Square Error (RMSE) is utilized to discover the difference between values predicted by means of a model as well as the real values noticed from the surroundings and that is remaining modeled.

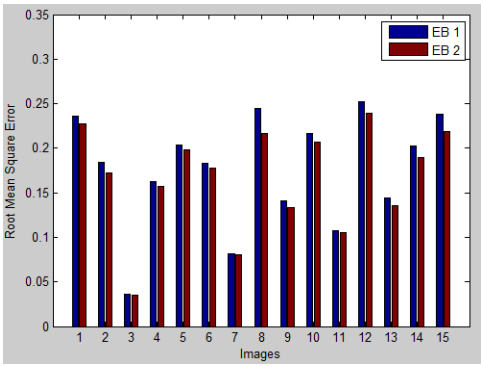
Table 2 indicates the actual examination of the Root mean square error. RMSE should really be a smaller amount to the Edge based-2nd order for getting improved results . As shown in the table the outcomes for Edge based-2nd order are significantly less in every case. This reveals the effectiveness of algorithm.

Table2: Root Means Square Error

Image	**Eb1**	**Eb2**
1	0.2363	0.2277
2	0.1842	0.1724
3	0.0360	0.0346
4	0.1624	0.1569
5	0.2035	0.1985
6	0.1826	0.1777
7	0.0820	0.0805
8	0.2446	0.2170
9	0.1412	0.1335
10	0.2167	0.2072
11	0.1074	0.1054
12	0.2521	0.2398
13	0.1440	0.1359
14	0.2024	0.1895
15	0.2386	0.2183

Figure shows the analysis of the Root mean square error. Root Mean Square Error should be a smaller amount less for that Edge based-2nd order for getting improved results than Edge based-1st order. As shown in the table the outcomes for Edge based second order are significantly a lesser amount of in every case. That reveals the effectiveness of algorithm.

Graph 2: Root Mean Square Error



3. Median Angular Error

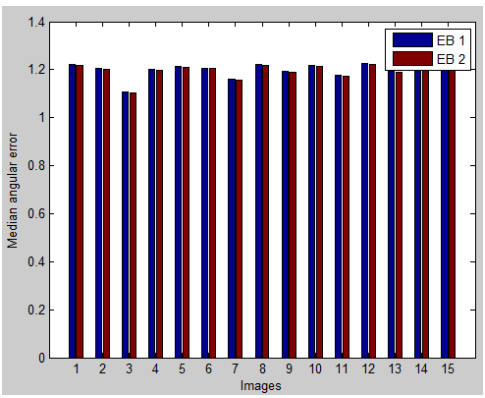
Table 3 shows the analysis of the median of an angular error. Median Angular Error should be less for the Edge based-2nd order for getting improved results than Edge based first order.

Table 3: Median Angular Error

Image	Eb1	Eb2
1	1.2206	1.2186
2	1.2069	1.2032
3	1.1067	1.1041
4	1.1999	1.1979
5	1.2125	1.2111
6	1.2065	1.2049
7	1.1595	1.1584
8.	1.2225	1.2160
9	1.1918	1.1886
10	1.2159	1.2135
11	1.1758	1.1747
12	1.2241	1.2214
13	1.1930	1.1896
14	1.2122	1.2085
15	1.2212	1.2163

Figure shows the analysis of the Median Angular Error. Median Angular Error should really be a smaller amount to the Edge based second order for getting improved results than Edge based first order. The table shows the outcomes for Edge. based second order are significantly a lesser amount of in every case. That reveals the effectiveness of algorithm

Graph 3: Median Angular Error



4. PEAK SIGNAL TO NOISE RATIO:

Peak signal to noise ratio is the ratio between the max achievable value of a signal and the power of noise which distorts the signal is affecting the quality of the representation.

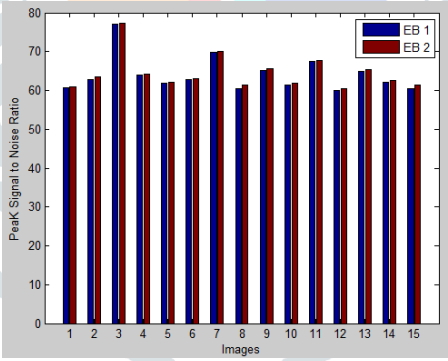
Table 4 shows the analysis of the Peak Signal to Noise Ratio (PSNR). PSNR should be max for the Edge based- 2nd order tas compared to Edge based first order. As shown in the table the outcomes for Edge based-2nd order are max in each and every case. Thus Edge based second offers improved outcomes compared to Edge based first order.

Table 4: PSNR

Image	Eb1	Eb2
1	60.6606	60.9838
2	62.8244	63.3984
3	77.0134	77.3417
4	63.9186	64.2185
5	61.9596	62.1748
6	62.9011	63.1369
7	69.8555	70.0140
8	60.3632	61.4001
9	65.1345	65.6229
10	61.4154	61.8038
11	67.5100	67.6746
12	60.1010	60.5323
13	64.9614	65.4668
14	62.0085	62.5773
15	60.5791	61.3499

Figure indicates the comparable analysis of the Peak Signal to Noise Ratio . Peak Signal to Noise Ratio really should be max for any Edge based second order for getting improved results than Edge based first order. The table shows the outcomes for Edge based second order are maximum in every case. This reveals the effectiveness of algorithm.

Graph 4: Peak Signal to Noise Ratio



Conclusion

The review on existing color constancy techniques has shown that also significantly development will be needed in along with color constancy algorithms. It is discovered that the color normalization has been neglected to balance the color artefacts which is presented in the image produced by the color constancy algorithms; as the modification is done in the image according to measured lumination source. The issue of Human visual system is also ignored. Because the alteration done by the color constancy is based upon the measured light source and this can be effective a while or could develop bad results about selected cases. Therefore, in this paper, to handle these issues, fourth order partial differential equations-based weighting factor based color constancy technique has been designed and implemented. Soft Computing based image enhancement technique is then utilized to enhance the results of proposed technique further. The problem is seemed to be sensible and has great impact on vision application because as Gray world based color constancy lessens the impression of the light. However, furthermore, it decreases the sharpness of the image and also may result in poor brightness. Therefore, to remove this problem an improved soft Computing based image enhancement technique has been used. So as to establish the performance on the proposed algorithm design and implementation has been done in MATLAB using image processing toolbox. The actual comparison among the state of art techniques has also been drawn by considering the well-known image processing performance metrics. Experimental outcomes reveal that the proposed approach outperforms the previous techniques.

Future work:

Subsequent section describes future directions for the proposed work:

1. In near future other meta-heuristic techniques such as Gray wolf optimization, artificial bee colony etc. approaches will be considered to tune the hyper parameters of the proposed approach to enhance the results further.
2. Also, in near future proposed technique will be applied on other fields such as remote sensing images, underwater images, etc. to estimate the performance of the proposed technique for other applications.
3. Also, in near future multi-objective fitness function will also be considered to enhance the color constancy results further.

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