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An Integrated CEA Approach for Color Light Source Estimation

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Abstract—Color constancy is an element of human vision framework which guarantees that the apparent color of items under fluctuating light conditions generally remains constant. It is fundamentally used to eliminate the color cast in the picture. Color Cat is a quick and precise learning-based methodology for accomplishing computational color constancy. However, despite everything it confronts a few limitations like poor brightness due to normalization used. Furthermore it doesn't promise edge preservation. So to overcome these issues a CEA strategy has been proposed which is a hybrid model based on Color Cat, Edge preservation filter and Adaptive histogram Equalization. As Adaptive histogram Equalization is exceptionally valuable for contrast improvement and edges are protected by edge preservation filter. Experimental results show that the proposed CEA approach outperforms over existing techniques.

Index Terms—Color constancy, illuminant estimation, performance evaluation, Adaptive histogram Equalization, Edge preservation filter, CLAHE(Contrast Limited Adaptive Histogram Equalization)

I. Introduction

In Image Processing Color Constancy is the capability to see color of articles regardless of the shade of the light source [1]. Fortunately, individuals have the limit of color steadiness, they see the same shade of a thing independent of extensive contrasts in enlightenment. A similar shading unfaltering quality limit is imperative for various PC vision assignments, for instance, object affirmation, video recuperation and scene classification. The shade of a light source sways object tints in the scene. These changed color qualities may show undesirable effects in electronic pictures. Other than it may conversely impact the execution of PC vision systems for different applications [2].The purpose of shading consistent quality is to conform the consequence of the illuminant shading, either by enlisting invariant components or by changing the information picture such that the consequences of the shade of the light source are cleared [3]. Color Constancy techniques are isolated into three ways: low-level statistics based strategies, gamut based mapping and learning based strategies. The first kinds of calculations are strategies that are connected to any picture without the requirement for training. Before the illuminant can be evaluated, a model should be prepared for second and third sort of calculations. [4].Low level measurements based techniques incorporate *White Patch Retinex*: It is one among the essential shading consistency approaches considering single light source and ventures the things that are truly white i.e. the lightest patch within the scene. It expect that sudden change in reflectance model causes the conformity in chromaticity [4]. *Gray World* depends on assumption that the ordinary reflectance of surfaces is color less and by applying Color balancing algorithms picture it is expected to have uniform scene brightening [5]. In *Gray Edge Hypothesis*, As contrasted with 4-associated, there is accessibility of more points of interest for picture rectification in 8-associated. It is not considered as productive on the grounds that each pixel is considering its 4-neighboring pixels just for the assessment [6]. *Color Rabbit* is extremely successful Retinex-based strategy for brightening estimation. Both precision and calculation expense can just be controlled by a few parameters and the technique's exactness is appeared to be powerful to change of parameter qualities [7].Learning based calculations incorporate *Gamut mapping* calculation, that is a basic, quick calculation for figuring the arrangement of conceivable lights steady with a given picture. The yield of array mapping is an arrangement of 2-D practical chromaticity maps[8].Other learning-based algorithms include *color-by correlation* is variant of gamut mapping where correlation matrix replaces the canonical gamut.Calculation of correlation matrix is performed for considered illuminations and the illumination with the highest probability is selected [9].This approach needs large amount of training data and can provide good results when trained correctly. *Bayesian formulation based method* models the variability of reflectance and light source as irregular variables and illumination estimation from the posterior distribution on the image intensity have also been proposed. It has been demonstrated the need for precise priors for reflectance and illumination [10].In *Exemplar-*

based learning approach, test image figures nearest neighbor models for each surface and enlightenment estimation is done taking into account looking at the statistics of pixels [11]. *Color constancy using saturation weighting* use distinctive approaches in accordance to saturation values from many observations and ultimately incorporated a saturation weighting function into the already present techniques [12].By using *Sparse Coding for Enlightenment Estimation*, the photo's scene content information is joined with its shading dissemination to perform perfect light estimation [13]. *3D geometry models* are utilized to review which color consistency technique is suitable to use for the particular geometrical districts in pictures [14].*Object shading models from multi-view confinements* can misuse picture correspondences acquired by different arrangement systems, and it has indicated cases taking into account coordinating close-by area highlights [15]. *Color Cat* is speedy and exact learning-based procedure to achieve computational shading consistency. Color Cat is quick and precise learning-based technique to accomplish computational color consistency. Relationship between regularity in the desirable illumination colors and modified color histograms is used in color cat. The principle step in accomplishing computational color consistency is the illumination estimation of color light source that is further used to eliminate the color cast effect. It performs illumination estimation by using information provided by image pixels and adjust the distinctive histograms. It compares the illumination estimation with the truth ground values [16].

This paper is structured as follows: Section2 presents the related work in the field of color constancy methods. Section 3 defines the proposed work which includes the steps of proposed methodology and Section 4 includes the parameters on the basis of which experimental results are drawn. Section 5 includes the experimental set up consisting the results in the form of tables and bar graphs of existing and proposed method and finally conclusions are provided in section 6.

II. Related Work

Choudhury, et al.(2010) [21] have explained Color Constancy systems as disengaged in three ways: low-level statistics based methodologies, gamut based mapping and learning based techniques. Authors have proposed another strategy to accomplish color constancy taking into account the measurements of pictures with color cast. Pictures with color cast have standard deviation of one color channel essentially not quite the same as that of other color channel and it is likewise appropriate to nearby fixes of pictures and proportion of the greatest and least standard deviation of color channels.

Gijsenij, et al. (2011)[2] have demonstrated Color Constancy methodology by utilizing Natural picture statistics and scene semantics. Natural picture statistics are utilized to analyze the best significant properties of color pictures. On the basis of these properties, the color constancy methodology is selected for a particular picture. Weibull parameterization is used for acquiring picture properties. Experiment has shown that on a data set involving more than 11,000 images, There can be an increment of 20% in color constancy performance in terms of median angular error.

Gijsenij et al.(2012)[1] have amplified the current calculations by applying color constancy locally to picture patches, instead of the whole picture. After the estimation of neighborhood illuminant, these estimates are joined into more vigorous estimations, Experiments has shown that the proposed method results in reduction of the influence of two light sources concurrently present in one picture. In the event that the chromatic distinction between two illuminants is more than 1 °, It outperforms from the algorithms based on the uniform light-source assumption .Otherwise, when the chromatic difference is less than 1 ° and the scene considered to contain single uniform light source, the performance of the proposed methodology is similar to global color constancy techniques.

Chakrabarti, et al.(2012)[20] have presented Color Constancy with Spatio-Spectral Statistics. They acquainted the model to eliminate the color cast produced by the spectral distribution of the dominating scene illuminant from a picture. They built up a model for spatial distribution of colors in white balanced images and after that by utilizing this model ,illumination parameters are figured. Exploratory evaluation on standard information sets proposes that the proposed methodology outperforms than traditional methods.

Gijsenij, et al.(2012)[19] have enhanced Color Constancy by Photometric Edge Weighting. This methodology make utilization of picture derivatives for illumination estimation. They have demonstrated an execution assessment of edge-based color constancy utilizing distinctive edge types. This execution assessment determined that specular and shadow edge sorts are more important than material edges for the illuminant estimation. Thus, the iterative weighted Gray-Edge calculation is schemed . This iterative weighted Gray-Edge calculation lowers the median angular error with around 25 percent and when contrasted with edge based Color Constancy it has indicated upgrades in angular error up to 11 percent.

Vazquez, et al.(2012)[9] have shown Color Constancy by Category Correlation. They have proposed perceptual limitations that are processed on the corrected pictures. They have characterized the category hypothesis that weights the arrangement of practical illuminants to outline the corrected picture onto particular colors and also proposed a quick implementation that permits the testing of a large arrangement of illuminants. Test results have demonstrated that this strategy rivals current state-of-art execution without the requirement for training algorithmic framework. Furthermore, the strategy can be utilized as a system to embed top-down data from different sources.

Vaezi , et al.(2012) [22] have characterized the White Patch Gamut as another augmentation to the Gamut Mapping Color Constancy strategy, containing the

brilliant pixels of the picture and this strategy beats array mapping techniques.

Rezagholizadeh et al. (2013) [18] have proposed Edge-Based and powerful Chromaticity Spatio-spectral Models for Color Constancy. They explained that quick and exact estimation of the conversion forced by the illuminant to the color of a picture taken under that illuminant is of great significance in real-time computational color constancy operations. They exhibited evaluation of the performance of the proposed technique on a synthetic color picture database.

Marin-Franch et al. (2013)[17] have evaluated data from color of picture with two goals. Firstly ,to determine estimators of the accessible data and the data recovered under various illuminations from the color values at every point in pictures of a scene. Secondly, applying these estimators to simulations of pictures acquired with five arrangements of sensors utilized in computerized cameras and with the cone photoreceptors of the human eye.

Banic et al.(2014)[7] have clarified low-level statistics based color constancy calculation for illumination estimation and tried. They consolidated numerous local illumination estimations by utilizing a new methodology into a global one. The proposed calculation is tried on a few accessible databases and it performs very well than all other color constancy strategies as far as execution pace and exactness are concerned.

Joze, etal.(2014) [11] have analyzed Color Constancy and Multiple Illumination as the model based learning. They dissected that as opposed to focusing on surfaces in the picture and addressing the color constancy issue by unsupervised learning for every training surface in training pictures. They proposed closest neighbor models for every surface in a test picture and estimate its illumination on the basis of comparing the measurements of pixels related to closest neighbor surfaces and the target surface. They have demonstrated a strategy to beat the various illuminant situation and test is conducted utilizing a numerous illuminant color constancy on pictures with two different sources of illumination.

Banic et al. (2015)[16] have proposed the Color Cat (CC), a very fast and best learning-based technique to accomplish computational color constancy. This method utilizes the relationship between transformed color histograms and the regularity in the possible illumination colors. The proposed method outperformed from the other color constancy methods in a way accuracy and computation cost is concerned.

Banic, et al. (2015)[23] have exhibited how a current technique can be simplified by utilizing effective elements for color constancy taking into account the red chromaticity.

Sahani, et al. (2015) [24] have planned an installed framework with changed contrast limited adaptive histogram equalization technique for real-time image enhancement and this framework has shown remarkable results than existing methodologies.

Muniyappan, et al. (2013) [26] Authors have characterized new methodology for picture enhancement by utilizing CLAHE technique that results in a better contrast pictures.

Khan, et al.(2013)[27]Creators have executed Balanced CLAHE for Adaptive Dynamic Range Compression (ADRC) of real time medical pictures and this proposed methodology has demonstrated better outcomes as far as latency and perceptibility parameters are concerned.

Iwanami, et al.(2012) [28] Authors have used the DRSHE technique to the part of the picture so as to enhance the regional picture contrast in short computational time.

Lidong, et al.(2015) [29] have displayed a novel picture upgrade strategy, named CLAHE-discrete wavelet change (DWT), which joins the CLAHE with DWT.

Kaur, et al.(2015)[31] have proposed Biorthogonal Wavelet Transform by Utilizing Bilateral Filter and Adaptive Histogram Equalization and by the use of this methodology, experimental results has shown improvement in fusion quality by the reduction in loss of important data available in separate pictures

Hameed, et al.(2011) [30] have characterized the strategy that includes two stages. The initial step is to perform AHE to enhance the signal contrast in a discriminative way and then the histogram of the input picture is taken into consideration. After that recognition of irregularity of image intensity is performed and on recognition it is eliminated by utilizing a CLAHE technique.

Begill et al. (2016) [25] have planned an installed framework with changed contrast limited adaptive histogram equalization technique for real-time image enhancement and this framework has shown remarkable results than existing methodologies.

III. Proposed Work

A New CEA algorithm has been proposed which provides the complete information about Color light Source estimation by using Color Cat and edge preservation filter which presents superior results than existing Color Cat technique. The implementation process of proposed algorithm has been demonstrated in Fig. 1 and Steps of algorithm are clarified below:

Step1: Take the image and construction of the histogram of the input image is done.

Step2: After obtaining the histogram of selected image, mean values of red, green and blue channel are evaluated.

Step 3: Evaluate the global mean value from the mean values of red, green and blue channel obtained in previous step.

Step 4: Restore red, green and blue using global mean value with the help of Color Cat algorithm.

Step 5: Application of Edge preservation filter on the selected image is performed.

Step 6: After the application of edge preservation filter Contrast limited adaptive histogram equalization (CLAHE) is performed on the input image.

Step 7: Finally Evaluation of parameters is performed and restored image is returned.

Step 8: Final image is acquired with improved quality and preserved edges as the output of this proposed methodology.

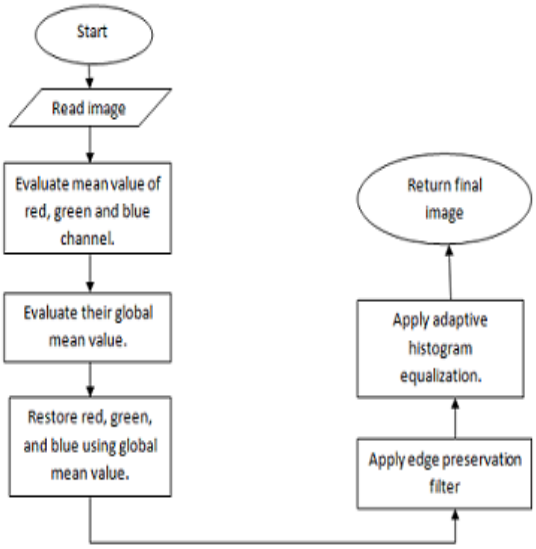

Fig.1. Flowchart of proposed algorithm

IV. Performance Metrices

The investigation of picture quality is finished by subjective assessment alongside target assessment. For subjective assessment, it is elusive distinction in the middle of proposed and existing technique. Along these lines, execution measurements have been utilized to dissect the execution of color pictures. Performance metrices are MSE, RMSE, PSNR and BER. It has demonstrated that the execution of the arranged calculation is superior than the existing techniques.

A. Mean Square Error (MSE)

Mean square error is utilized to assess picture quality list. High estimation of mean square shows that nature of picture is poor.

$$\text{MSE} = \frac{1}{IR}\sum_{i=1}^{I}\sum_{r=1}^{R}[P(i,r) - Q(i,r)]^2 \qquad (1)$$

Where P(i,r) is value of pixel of input image.

Q(i,r) is value of pixel of reconstructed image.

B. Root Mean Square Error (RMS)

Substantial estimation of root mean square error demonstrates that nature of picture is unfavorable. As RMSE must be maximized, therefore the key goal would be to decrease the RMSE around possible. It is computed as:

$$\text{RMSE}=\sqrt{\frac{1}{IR}\sum_{i=1}^{I}\sum_{r=1}^{R}[P(i,r) - Q(i,r)]^2} \qquad (2)$$

C. Peak Signal to Noise Ratio (PSNR)

PSNR is basically the ratio that is used as a performance metric between input image and reconstructed image. It is computed as:

$$\text{PSNR} = 10\log_{10}\left(\frac{255}{MSE}\right)^2 \qquad (3)$$

D. Bit Error Rate (BER)

Bit error rate is used in accessing systems that transfer digital data from one place to another and is defined as the number of bit errors divided by the total number of transferred bits during a specific time interval.

V. Experimental Setup

The proposed CEA algorithm has been tested on ten color images and the results are evaluated. Different parameters like MSE, RMSE, PSNR, BER are used for evaluating the performance of these methods. Ten experimental images are considered and their improved values of parameters are shown below and Results of applying proposed CEA method over the existing Color Cat technique has clearly shown in the form of images in Fig.6(a) and Fig.6(b).These includes ten input images along with their results. Fig. 6(a) and Fig. 6(b) are placed at the end of REFERENCES section.

Table 1. Mean Square Error

Input images	Existing Color Cat Algorithm	Proposed CEA Algorithm
1	463.7641	9.8412
2	777.5763	44.6547
3	525.0034	55.7444
4	377.1125	116.0597
5	224.4842	125.4587
6	108.5944	94.9016
7	20.3155	15.1895
8	340.0370	47.2816
9	159.8068	139.1771
10	639.2008	28.0047

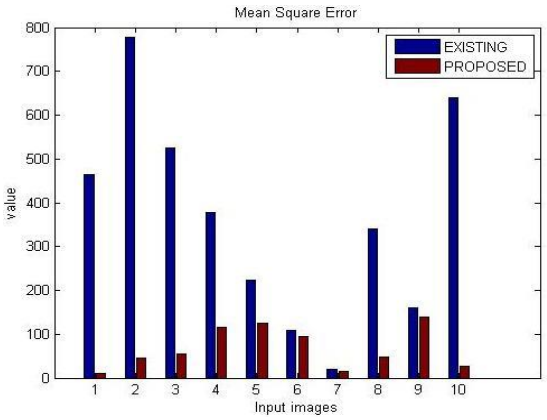

Fig.2. Mean Square Error

As mean square error has been decreased which means proposed CEA algorithm is featuring the better benefits compared to the existing color cat technique as mean square error is less in all the samples (as shown in Table 1)

Fig. 2 is representing a bar graph of mean square values of ten images that are considered as a sample. Blue colored bar shows the MSE values of existing method while red colored bar shows values of proposed CEA technique. It is clearly shown that mean square error is less in all the samples by using proposed technique. Hence, the results are better than existing method.

Table 2. Root mean Square Error

Input images	Existing Color CAT Algorithm	Proposed CEA Algorithm
1	21.5352	3.1371
2	27.8492	6.6824
3	22.9130	7.4662
4	19.4194	10.7731
5	14.9828	11.2008
6	10.4209	9.7422
7	4.5073	3.8974
8	18.4401	6.8762
9	12.6415	11.7973
10	25.2824	5.2919

Table 2 has clearly shown that the RMSE is minimal in case of the proposed method. Thus proposed CEA algorithm is providing better effects compared to the existing technique. Root Mean squared error between the reference image and the final image is as shown in Fig. 3.

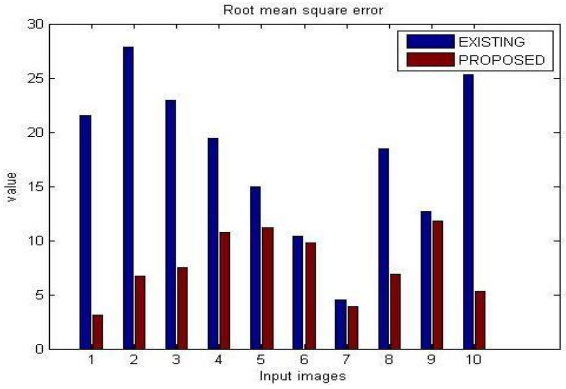

Fig.3. Root Mean Square Error

Fig. 3 is representing a bar graph of root mean square values of ten images that are considered as a sample. Blue colored bar shows the RMSE values of existing method while red colored bar shows values of proposed CEA technique. It is clearly shown that the root mean square error is less in all the samples by using proposed technique. Hence, results are better than existing method.

Table 3. Peak Signal Noise Ratio

Input images	Existing Color CAT Algorithm	Proposed CEA Algorithm
1	21.4678	38.2003
2	19.2346	31.6321
3	20.9292	30.6688
4	22.3661	27.4840
5	24.6189	27.1458
6	27.7727	28.3577
7	35.0525	36.3154
8	22.8154	31.3839
9	26.0949	26.6951
10	20.0744	33.6585

Higher value of PSNR leads to high quality of reconstructed image and Table 3 shows that value of PSNR is high in proposed technique and as shown in Fig. 4.

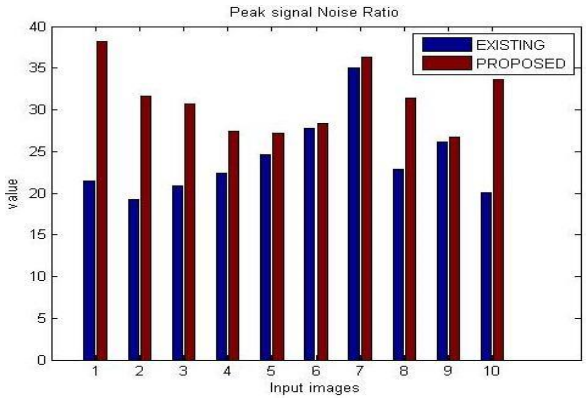

Fig.4. Peak Signal Noise Ratio

Table 4. Bit Error Rate

Input images	Existing Color CAT Algorithm	Proposed CEA Algorithm
1	0.0466	0.0262
2	0.0520	0.0316
3	0.0478	0.0326
4	0.0447	0.0364
5	0.0406	0.0368
6	0.0360	0.0353
7	0.0285	0.0275
8	0.0438	0.0319
9	0.0383	0.0375
10	0.0498	0.0297

Fig. 4 is representing a bar graph of peak signal to noise ratio of ten images that are considered as a sample. Blue colored bar shows the PSNR values of existing method while red colored bar shows values of proposed CEA technique. It is clearly shown that PSNR is more in all the samples by using proposed technique.

As shown in Table 4, the value for BER is lower by using proposed technique than the existing method. Thus proposed methodology is showing better performance.

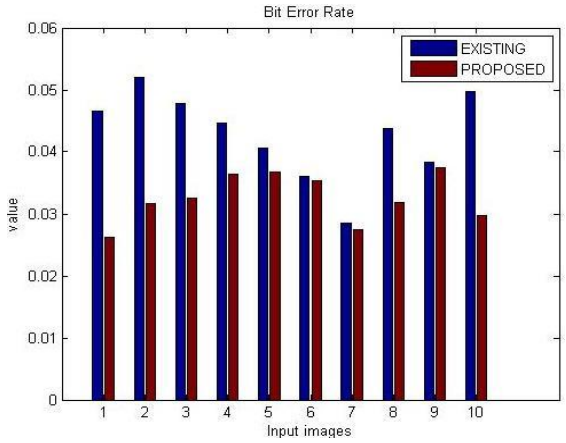

Fig.5. Bit Error Rate

Fig. 5 is representing a bar graph of bit error rate values of ten images that are considered as a sample. Blue colored bar shows the BER values of existing method while red colored bar shows values of proposed CEA technique. As it has been clearly shown that as BER is less in all the samples by using proposed technique. Hence, results shows greater improvement than existing technique.

VI. Conclusion and Future Work

The proposed CEA strategy is an integrated approach which is based on Color Cat, Adaptive histogram equalization and Edge preservation filter so as to overcome the restrictions of existing technique. Experimental results shows that parameter BER value has been decreased to 0.01026, parameter MSE value decreased to 295.9609, RMSE value decreased to 10.11272 and PSNR value increased to 7.11151 by using proposed technique. Hence the proposed CEA algorithm is better than existing technique in terms of evaluated parameters. This work has not been considered for the use of fuzzy based enhancement. So in near future, one can utilize fuzzy membership functions to enhance the quality of picture.

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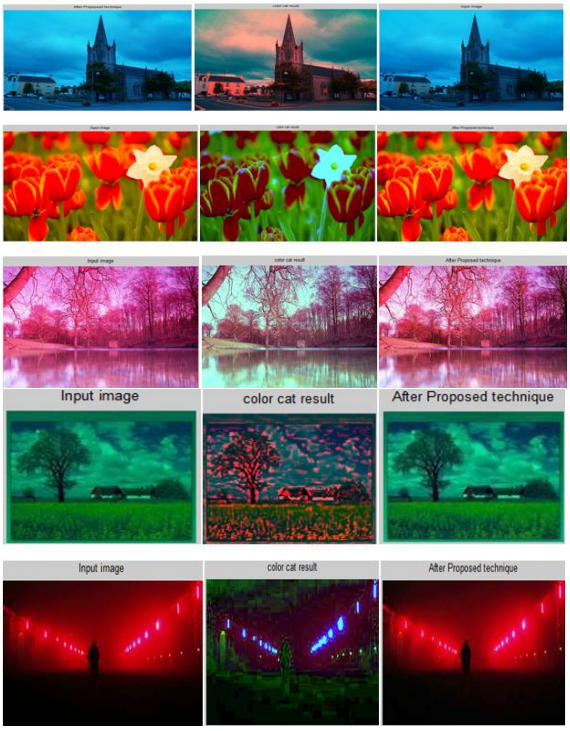

Fig.6.(a): Results obtained after applying proposed CEA technique and Color cat on the sample of images

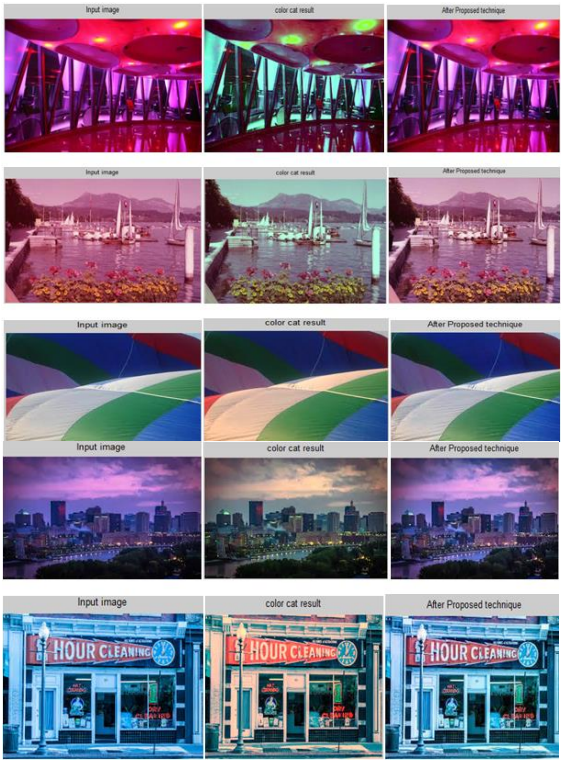

Fig.6.(b): Results obtained after applying proposed CEA technique and Color cat on the sample of ten images

Authors' Profiles

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