Fusion of and bilateral histogram with Retinex Algorithm for Enhancement

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Abstract-The MSR algorithms, for the most part, have defined weights in spite of image properties. So it generates the genuine artifact, less clear image. Most of the dehazing strategy use retinex algorithm. We proposed an algorithm that adopts the nonillumination and protects edges to estimate the clarity of the image. Here the optimal weights are adopted based on the level of haze in the image. Gradually the image artifacts are diminished more by expanding color constancy, local dynamic range by adjusting the local contrast adaptively depending on the depth of image details. So images under variable illumination conditions such as lightness and sensitive to distortion created by cameras produce a photo in dim light are considered as input to our proposed method. MSRCR can achieve the picture color constancy, neighborhood range of pixel, compression, color enhancement good under all above circumstances. But the enhancement is improved by fusing Bilateral histogram equalization method as a pre-preocessing and MSRCR is used as ppst processing. In this paper, various quality metrics are calculated among the contrast enhancement and fusion retinex processed images taken under low illumination effect with a different cell phone
Keywords-Retinex theory, Multiscale retinex with color restoration method, Bilateral histogram equalizationImage quality metrics.

I. INTRODUCTION

1.1 As a rule

There are contrasts between a recorded color picture and the coordinate perception of the same scene. One of the huge contrasts is the truth that the human visual framework is able to recognize points of interest and distinctive colors in shadows and in scenes that contain illuminate shifts. In this manner moved forward devotion of color pictures to human perception requests a computation that artificially combines energetic extend compression, color consistency, and color / delicacy interpretation, or wide energetic extend color imaging frameworks. So color consistency is an imperative include of the human color recognition framework. It is the property by which the color seen by human remains nearly consistent when the brightening condition changes[1] At afternoon an orange shows up orange in color in people when the most illumination is white additionally at nightfall when the most brightening is ruddy. This appears the color constancy of , and color/ lightness rendition, or wide dynamic range color imaging systems. So color constancy is an important feature of the human color perception system. It is the property by which the color perceived by human remains almost constant when the illumination condition changes [1]. At afternoon an orange appears orange in color in humans, when the main illumination is white and also at sunset, when the main illumination is red. This shows the color constancy of human vision. To enhance the quality of an image, various contrast enhancement techniques have already been proposed such as Histogram Equalization (HE) (Kang, 1977), Brightness Preserving Bi- Histogram Equalization (BBHE) (Kim, 1997), Dualistic Sub-Image Histogram Equalization (DSIHE) (Wang, 1991), Recursively Separated and Weighted Histogram Equalization (RSWHE) (Kim, 2008), Adaptive
Gamma Correction with Weighting Distribution (AGCWD) (Huang, 2013), Weighted Adaptive Histogram Equalization (WAHE) (Arici, 2009), Layered Difference Representation (LDR) (Lee, 2013)Similarly Retinex algorithm is used for enhancement.The Retinex algorithms give this color constancy along with dynamic range compression and color rendition. In Retinex theory, the perceived image intensity is assumed to be the product of scene reflectance and illumination. Jobson et al. proposed single scale Retinex (SSR) algorithm [2] where the illumination of an input image is estimated as a Gaussian filtered image. Due to the smoothing effect of Gaussian filtering process, it results in enhanced images that yield color shifting artifacts as well as halo artifacts in the vicinity of edges. Work from Jang [3,4] focuses on better color correction for retinex algorithm. Robinson et al. [5] improve MSR by reducing halo artifacts and gray-ing effect. Rahman et al. [6] investigate the relationship between retinex and image compression. Jang [7] improves the MSR with respect to weights of different scales of retinex and papers [8] both propose to accelerate the implementation of MSR and MSRCR. In remote sensing images reduces the interpretation precision due to brightness, non-uniformity caused by vignetting effects, viewing, and illumination angels so multi-resolution variation Retinex scheme is proposed for efficiently correct the non-uniform brightness in airborne remote sensing images. This variational Retinex model is non-linear, constrained by the grey-world

assumption and the total variation regularization. In this paper bilateral histogram is used as a pre-processing step then combined with MSRCR for better result.

1.2. Bilateral histogram equalization:

To obtain the better result in case of low dim effect result Bilateral Histogram Equalization is used for contrast enhancement (BHE) which uses Harmonic mean of the image to divide the histogram is introduced. BHE creates less artifacts on several standard images than other existing state-of-the-art image enhancement techniques. Bilateral Filter [2] was first proposed by C. Tomasi, R. Manduchi in the year 1998. It is basically a non-linear, edge-preserving and Gaussian noise reducing filter used for gray and color images. It tries to smoothens the image and at the same time preserves edges of the image. As we know that color images have three bands i.e. red, green and blue. If these three bands are filtered separately, the smoothness of the image at the edges will be different. Separate smoothing disturbs the balance of colors and unexpected color combinations may appear. Therefore, bilateral filters operate on three bands of color at once and can tell which colors are similar so that they can be averaged together. The basic idea of bilateral filtering [3] is that it makes a nonlinear combination of similar pixel values. It filters the image using range and domain filter. For domain filtering, values chosen show the desired amount of combination of pixels, while the range filtering chooses values based on the desired amount of low pass filtering. A low pass domain filter on image

mathematically at a pixel location (x,y) the output I(x,y) of the bilateral filter is calculated as follows

$$I'(x,y)=\sum_{y \in N(x)} e^{\frac{-\|y-x\|^2}{2\sigma_d^2}} e^{\frac{-\|I(y)-I(x)\|^2}{2\sigma_r^2}} I(x,y) \quad (1)$$

Where σd and σr are parameters controlling the fall-off of weights in spatial and intensity domains, respectively. N(x) is a spatial neighborhood of pixel I(x). σd is the geometric spread parameter that is to be chosen based on the amount of the low pass filtering required. A large value of σd means it combines values from more distance in an image. Similarly σr is the parametric spread that is set to achieve the desired amount of combination of pixel values

1.3 Retinex-Based Contrast Enhancement

Retinex theory [1] assumes that an image intensity I is represented by the product of scene reflectance R and illumination L, given by

$$I(x,y) = R(x, y) \cdot L(x,y) \quad (1b)$$

where R(x, y) is the reflectance and L(x, y) is the illumination

In SSR algorithm [2], the illumination is estimated by convolving a Gaussian filter with an input image, and the resulting scene reflectance R_{SSR} is obtained in log-scale.

$$R_i(x,y)=\log_i(x,y)\log[F(x,y)*I_i(x,y)] \quad (2)$$

where F(x; y) is a normalized Gaussian surround function [2], given by

$$F(x,y)=K*\exp(-r^2/c^2) \quad (3)$$

where c is the Gaussian surround space constant and K is selected such that

$$\iint F(x,y)dxdy = 1 \quad (4)$$

K is a normalization parameter satisfying and when the values for ‘c ‘is the Gaussian surround space constant The Retinex enhancement algorithm has a better dynamic range and color reproduction characteristics, therefore resulting ina better visual effect.

When c becomes large, halo artifact becomes severe around high-intensity pixels. To reduce halo artifact of SSR algorithm, multi-scale Retinex (MSR) algorithm [3] was proposed, which yield scene reflectance RMSR as a weighted sum of SSR results at multiple image scales

The MSR output is then simply a weighted sum of the outputs of several different SSR outputs.

$$\hat{R}_{MSR_i} = \sum_{n=1}^{N} w_n \hat{R}_{n,i} \quad (5)$$

where N is the number of scales, $\hat{R}_{n,i}$ the i'th component of the n’th scale, $\hat{R}_{MSR_i}$ the i'th spectral component of the MSR output, and w_n the weight associated with the n’th scale. The only difference between $\hat{R}(x,y)$ and

$\hat{R}_n(x, y)$ is that the surround function is now given by

$$F_n(x, y) = K_n e^{-r^2/c_n^2} \quad (6)$$

The color restoration method for the MSR is given by

$$C_i(x, y) = \log[\alpha I_i(x, y)] - \log\left[\sum_{i=1}^{S} I_i(x, y)\right] \quad (7)$$

where α is a constant parameter of the color restoration function taken as 15, 80,250 for better dynamic range and color reproduction characteristics, therefore resulting in a better visual effect.
where N is the number of image scales, and w_n and RSSR;n denote a weighting parameter and the scene reflectance obtained by SSR at the n-th scale, respectively. Moreover, to alleviate color shifting artifact of MSR algorithm, MSR color restoration (MSRCR) algorithm [4] was also proposed. The output reflectance RMSRCR is obtained by performing color restoration function to the resulting reflectance of MSR, given by
The MSRCR is given by

$$\hat{R}_{MSRCRi}(x, y) = C_i(x, y)\hat{R}_{MSRi}(x, y) \quad (8)$$

Where $C_i(x; y)$ is a color restoration function.

The final version of MSRCR can be written as

$$\hat{R}_{MSRCRi}(x, y) = G[C_i(x, y)\sum_{n=1}^{N}\{\log I_i(x, y) - \log[I_i(x, y) * F_n(x, y)]\} + b] \quad (9)$$

where G and b are the final gain and offset values respectively.

1.4.Multiscale Retinex Algorithm

The MSR is an extended single-scale retinex (SSR) withthemultiple kernel windows of the different sizes. The outputofMSR of i-th color spectral band is a weighted sum ofseveraldifferent SSR outputs of i-th color spectral band. TheMSRoutput of i-th color spectral band for a singlespectralcomponentcanrepresentas

$$\hat{R}_{MSR_i} = \sum_{n=1}^{N} w_n \hat{R}_{n,i}$$

MSR retinex theory was brought up by Edwin Land [1] to simulate human Visual System which, when capturing images, is surprisingly good at adapting to the variation of lighting condition, compared to how now adays cameras perform. This paper mainly bases itself on one of retinex's successful formulation from Rahman's work[4]. Its MSR proves to be able to achieve dynamic range compression on daytime images suffering from uneven lighting condition. Night time images share the same characteristics but behave more extremely. The MSR is composed of three SSR functions with small(c=80), intermediate (c=120) and large (c=250) scale-constants. This combination allows the MSR to synthesize dynamic range compression, color consistency, and tonal rendition, except for scenes that contain a violation of the gray-world assumption.
The Original MSR can be written as

$R^{(i)}(x,y)$ □□log$I^{(i)}$ (x, y)□□log[F_n(x, y)□□$I^{(i)}$(x,y)]

Here $I^{(i)}(x,y)$is the input image in the i-th color spectral band, "*" denotes the convolution operation, Fn(x,y) is the surround function with n-th scale. Note that a weight on is set to satisfy the condition of

$$\sum_{n=1}^{N} Wn = 1$$

MSR serves a subset of the following five image processing goals, depending on the circumstances:
1) Compensating for uncalibrated devices (gamma correction)
2) Colour constancy processing
3) Local dynamic range compression
4) Global dynamic range compression
5) Colour enhancement

The MSR is very efficient at improving the image details and enhancing the contrast of the shaded region in the image [3]. However, the resulting image cannot be successfully compressed if weights are in appropriately determined in the MSR. To appropriately reproduce the image, the degree of shade can be an important parameter.So to solve the problem of color distortion and to improve the disadvantages of a slowly time-consuming arithmetic in the course of image enhancement which is based on the multi-scale retinex algorithm is done by color restoration function of the chromaticity.

1.5 Multi-Scale Retinex With Color Restoration (Msrcr)

To reduce the computational effort the two-dimensional filtering between surround function and the image function is performed in the frequency domain by finding the product of spectra of both the functions.[18] The drawback of MSR with regard to color restoration, where weights are introduced for three color channels depending on the relative intensity of the three channels in the original images[18]. The multi-scale retinex with color restoration (MSRCR) was developed as a general-purpose image enhancement algorithm that provides simultaneous dynamic range compression, local lightness/contrast enhancement, and good color rendition, and has been successfully used for a wide variety of imagery from diverse fields. While the MSRCR performs good enhancement in most images, the output image can sometimes be further visually optimized during our experiments. The original image of poor quality is read in RGB color space. The color channels are separated followed bythe estimation of Gaussian surround function using Equation (3). Single Scale Retinex (SSR) is obtained for each channel using Equation (2). Further, Multi-Scale Retinex (MSR) operation is carried out by using Equation (4). In the proposed approach, the color restoration block is modified in such a way that the number of operations is reduced. In order to get the image pixel values in the standard unsigned range of 0 to 255.It reduces the color constancy problem. Color constancy refers to computational approaches to recover the actual color of surface objects independent of the color of light source. Color is important in many applications such as human-computer interaction, color feature extraction and color appearance models. Color constancy helps to identify objects notwithstanding large differences in illumination. The goal of computational color constancy is to estimate the actual color of an object in an acquired scene disregarding its illuminant.Color constancy processing involves estimating the color of the illuminant and then to correct the image to a canonicalillumination using the diagonal model[19].So the color restoration method can be described as,

$$\hat{R}_{MSRCRi}(x,y) = C_i(x,y)\hat{R}_{MSRi}(x,y) \quad (8)$$

Where by multiplying it by a color restoration function of the chromaticity. So the first move is to compute the chromaticity coordinates

$$X = \frac{X}{X+Y+Z}(9) \quad , \quad Y = \frac{Y}{X+Y+Z}(9)$$

If we assume that the region's reproduced chromaticity X', Y', matches the region's scene chromaticity XY, then it follows immediately that, equation (16).

$$X' = KX, Y' = KY, Z' = K--(10), where \; K = \frac{X'+Y'+Z'}{X+Y+Z} \quad (11)$$

Similarly, scaling the reproduction X', Y', Z' by a constant K preserves chromaticity. Thus to preserve chromaticity we can manipulate K on a region-by-region basis, normally it is deal with intermediate variables such as camera RGB. In order to be confident that a good approximation of scene chromaticity is being reproduced. MSRCR is represented in form of frequency domain to have better performance [9]. The following points in case of MSRCR such as gain factor, illumination effects, color constancy are also discussed.

II. PROPOSED ALGORITHM

2.1The paper represents a combine method to obtained an enhanced image . This paper proposes Bilateral Histogram Equalization (BHE) where histogram is divided in an accurate manner, and then histogram equalization is performed separately in each part. Pre-processing techniques are applied to extract image details and to make image visually smoothing. The pre-processing image is applied as input to MSRCR unit where color constancy is good enough as shown in figure 1.

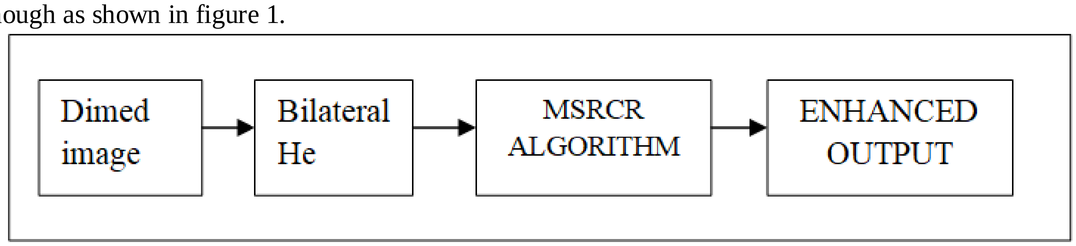


Figure 1.WORK FLOW OF PROPOSED METHOD

2.2 Gain/Offset Of Msrcr

In this original work [20] where the center/surround version of retinex is introduced, Land does not propose any solution for the treatment of the retinex output. Since the result of the above process can yield negative and positive RGB values with arbitrary bounds, the range of values has to be transformed into the display domain, [0, 255]. In a posterior work, Moore et al. [13] proposed an automatic treatment of the retinex output prior to display, where each color channel is adjusted by the absolute minimum and maximum of the three color bands. The choice of scale is application dependent but for most of the applications three scales are required. The multiscale retinex with color restoration is computed by using Equation (8). The result of the above processing will have both negative and positive RGB values and the histogram will typically have large tails. A gain $G = 30$ and an offset $b = -6$ produces decent results on most images. Nevertheless, for others, it has been observed to have better by changing the values of the gain/offset. Thus a final gain-offset is applied to get an enhanced image. The gain and offset value of different value used for enhancement processing are used.

2.3 Illumination Effects On Image Enhancement

It is difficult to get clear information from the low illumination images. In recent progress research of the low illumination, image enhancement has become a most demanding in image processing and computer vision. The Retinex algorithm is one of the most popular methods in the field and uniform illumination is necessary to enhance low illumination image quality by using this algorithm. However, for the different areas of an image with contrast brightness differences, the illumination image is not smooth and causes halo artifacts so that it cannot retain the detail information of the original images. To overcome the problem, we generalize the multi-scale Retinex algorithm and multi-scale Retinex with color restoration enhancement method for the low illumination images based on the microarray camera. The proposed method can well make up for the deficiency of imbalanced illumination and significantly inhibit the halo artifacts as well. This method also includes that it can significantly inhibit the halo artifacts and thus retains the details of the original images; it can improve the brightness and contrast of the image as well. This developed method has application potential to the images captured by cell phone of different specifications in the low illumination environment

2.4 Color Constancy

Color constancy methods use the information provided by image pixels to perform illumination estimation. These pixels contain both spatial and color information. [12]. It is to maintain the hue of an image during the processing so that the change of saturation can be minimized by applying color restoration factor. The original image was first multiplied by a scale parameter obtained by the adaptive quadratic function to enhance the luminance, and then the edge details were restored by a shifting parameter.

2.5 Image Quality Assessment

Image quality assessment (IQA) used as computational models to measure the image quality consistently with subjective evaluations. Digital images are subjected to a variety of distortions or degradations at the time of acquisition, restoration, enhancement, compression and transmission. Removal of such degradations is very important for successive processing or analysis of images. Image enhancement is used to improve the image quality for better vision. It is defined as the impression of its merit of excellence, as perceived by an observer. Contrast, brightness and sharpness are the three basic parameters that control the quality of an image. Image Quality Assessment(IQA) [20] techniques can be categorized into subjective assessment, involving humans to evaluate the image quality and objective assessment, that measures the image quality automatically. Subjective quality evaluation is a reliable method since human beings are the ultimate users in most of the image processing applications. Objective quality evaluation is to obtain a quantitative measure which gives the quality of the image in a manner consistent with human perception and subjective analysis should match with objective assessment values. According to the availability of a reference image, objective evaluation techniques are classified as Full-Reference(FR), no or Blind-Reference(BR) and Reduced-Reference(RR) image quality metrics. In this paper various quality metrics are used to compare between various images which is being processed by using multicsale retinex algorithm and multi-scale Retinex with color restoration. The comparison is done considering raw images taken at different time by different devices at different illumination condition. So different quality assessment such as MSE, PSNR,SSIM,MSSIM,FSIM, FSIMc are calculated considering input database.

2,.6 Result Analysis Of Contrast Enhancement With Proposed Algorithm By Subjective And Objective Analysis

(a)

Table 1(a): Quality index assessment comparison between input and contrast adjustment output Images for figure2(a)

PSNR	SSIM	MSSIM	FSIM	FSIMc
46.675	.861	.866	.891	.899

(b)

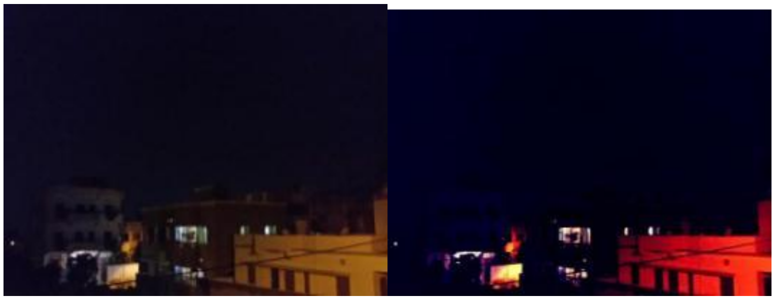
Table 1(b): Quality index assessment comparison between input and contrast adjustment output Images for figure2(b)

PSNR	SSIM	MSSIM	FSIM	FSIMc
45.315	.811	.838	.875	.878

(c)

Table 1(c): Quality index assessment comparison between input and contrast adjustment output Images for figure2(c)

PSNR	SSIM	MSSIM	FSIM	FSIMc
44.343	.801	.821	.897	.898



(d)

FIGURE 2(a)(b)(c)(d) : Left image is original and Right image is output image by Contrast adjustment,

Table 1(d): Quality index assessment comparison between input and contrast adjustment output Images for figure2(d)

PSNR	SSIM	MSSIM	FSIM	FSIMc
45.535	.802	.823	.896	.899

(a)

table 2:Quality index assessment comparison between MSRCR and FUSION Images

table 2(a): Quality index assessment comparison between MSRCR and FUSION Images for figure1(a)

PSNR	SSIM	MSSIM	FSIM	FSIMc
64.535	.678	.766	0.711	0.704
66.535	.786	.811	0.716	0.737

(b)

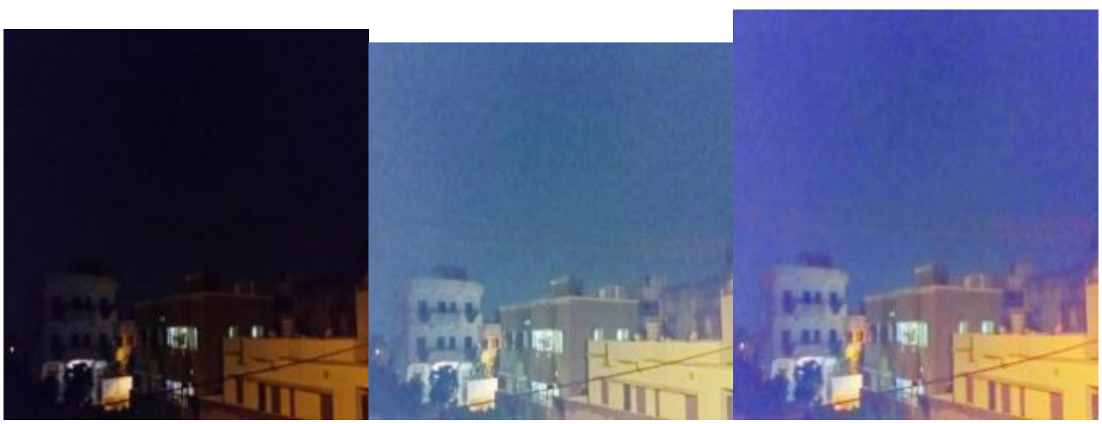
Table 2(b): Quality index assessment comparison between MSRCR and FUSION Images for figure1(b)

PSNR	SSIM	MSSIM	FSIM	FSIMc
62.534	.567	.678	0.714	0.697
65.533	.768	.798	0.756	0.735

(c)

Table 2(c): Quality index assessment comparison between MSRCR and FUSION Images for figure1(c)

PSNR	SSIM	MSSIM	FSIM	FSIMc
65.41132	0.311	0.490	0.647	0.646
67.961736	0.729	0.664	0.741	0.739



(d)

Figure 3(a)(b)(c)(d) : Left image is original, Center image is MSRCR and Right image is fusion image

Table 2(d): Quality index assessment comparison between MSRCR and FUSION Images for figure1(d)

PSNR	SSIM	MSSIM	FSIM	FSIMc
61.01112	0.340	0.572	0.8654	0.8413
66.31993	0.723	0.752	0.8638	0.8402

III. RESULT ANALYSIS

It is observed from the table that quality index varies because of low illumination effect and devices standard parameter while capturing images .It is good for images taken from high quality devices. The images are taken from Samsung and Asus phone but at different illumination effect so there SSIM, MSSIM, FSIM, FSIMc varies a lot . The software simulation tool used is MATLAB R2014. Two reference images one low contrast , one high illumination image along with two other real images are taken from Samsung and Asus phone but at different illumination effect .Two methods are used for comparison of image clarity and visibility such as Retinex algorithm and contrast image enhancement and corresponding quality performance is calculated for enhancement process .Since these images have low intensity value they appear lighter as shown in figure 1(a) and the corresponding quality assessment is shown in Table 2 the images which are taken at night time from different mobiles the output carrying information and clarity is different in for both the algorithm as shown in figure 2(b),(c),(d). The MSR , MSRCR and contrast image enhancement algorithms are applied on this four images. These algorithms enhance the contrast of the input image of low as well as images taken from mobiles at same instant as in figure 1(a),1(b) . The simulation results clearly show that the Improved MSRCR output images have more clarity than the MSR and contrast image output image. The Image quality assessment (IQA) measure the image quality consistently with subjective evaluations The parameters such as PSNR SNR SSIM(structural-similarity index), MSSIM(multiscale SSIM index) FSIM(feature-similarity index) ,FSIMc (feature-similarity index with chromatic) are calculated as an objective quality assessment .So both subjective analysis as shown in figure (1) and figure (2) and objective analysis as shown in Table (1) and Table (2)

IV. CONCLUSION

The experiments were conducted by considering a number of poor quality test images taken by various cell phones such as Samsung, Asus at different illumination condition. The images enhanced bymult-iscale method are better in quality but certain areas of the image get whitened due to incompetent colour restoration .So the processed method imphasis MSRCR method .Various image quality metrics are calculated among the original image and the MSRCR and Fused image .Overall result analysis shows that all images and its quality metrics indicates variation on structural similarity and feature similarity which depend on illumination and capturing of image . So in future illumination effect and image capture and calibration in color space for devices can be improved for better image quality assessment .

V. REFERENCES

[1] E. H. Land. The retinex theory of color vision. Scientific America., 1977.

[2] C. Tomasi and R. Manduchi, “Bilateral filtering for gray and color images’’, in the proceedings of 6th IEEE International conference on computer vision, (1998), pp. 834-846.

[3] I.-S. Jang, T.-H. Lee, H.-G. Ha, Y.-H. Ha, Adaptive color enhancement based on multi-scaled retinex using local contrast of the input image, in: International Symposium on Opto mechatronic Technologies (ISOT), IEEE, 2010, pp. 1–6.

[4] I.-S. Jang, K.-H. Park, Y.-H. Ha, Color correction by estimation of dominantchromaticity in multi-scaled retinex, J. Imaging Sci. Technol. 53 (5) (2009)50502–50511.

[5] P. Robinson, Y. Roodt, A. Nel, Adaptive multi-scale retinex algorithm for contrastenhancement of real world scenes, in: A. de Waal (Ed.), The Proceedings ofTwenty-Third Annual Symposium of the Pattern Recognition Association ofSouth Africa, Pretoria, South Africa, 2012.

[6] Z.-u. Rahman, D.J. Jobson, G.A. Woodell, Investigating the relationship betweenimage enhancement and image compression in the context of the multi-scaleretinex, J. Vis. Commun. Image Represent. 22 (3) (2011) 237–250.

[7] C.Y. Jang, J. Hyun, S. Cho, H.-S. Kim, Y.H. Kim, Adaptive selection of weights In multi-scale retinex using illumination and object edges, IPCV (2012).

[8] C.Y. Jang, J.H. Lim, Y.H. Kim, A fast multi-scale retinex algorithm using dominantSSR in weights selection, in: International SoC Design Conference (ISOCC), IEEE,2012, pp. 37–40.

[9] Z. Rahman, G. A. Woodell, and D. J. Jobson, "AComparison of the Multiscale Retinex With Other ImageEnhancement Techniques," Proceedings of the IS&T 50^{th}Anniversary Conference, May 1997.

[10] Hanumantharaju MC, Ravishankar M, Rameshbabu DR, Ramachandran S. Proc EAIT. 2011:93–99.

[11] A. C. Hurlbert,“The computation of color,” Ph.D. dissertation, Mass.Inst. Technol., Cambridge, Sept. 1989.

[12] “Formal connections between lightness algorithms,” J. Opt. Soc. Amer. A, vol. 3, pp. 1684–1693, 1986.

[13] A. Moore, J. Allman, and R. M. Goodman, “A real-time neural system for color constancy,” IEEE Trans. Neural Networks, vol. 2, pp. 237–247, Mar. 1991.

[14] A. Rizzi, C. Gatta, "From Retinex to Automatic Color Equalization: issues in developing a new algorithm for unsupervised color equalization", Journal of Electronic Imaging, 2004.

[15] X. Fu, Y. Sun, M. LiWang, Y. Huang, X.-P. Zhang, "A novel retinex based approach for image for enhancement with illumination adjusment", IEEE International Conference on Acoustic Speech and Signal Processing, pp. 1199-1203, 2014.

[16] Hongqing Hu and Guoqiang Ni, “The improved algorithm for the defect of the Retinex Image Enhancement”, Proceedings of International Conference on Anti-Counterfeiting Security and Identification in Communication (ASID), pp. 257-260, July, 2010.

[17] Xinghao Ding, Xinxin Wang, Quan Xiao, “Color Image Enhancement with a Human Visual System based Adaptive Filter”, Proceedings of International Conference on Image Analysis and Signal Processing, April, 2010.

[18] Siddesha K, Kavitha Narayan B M. Frequency Domain Based MSRCR Method for Color Image Enhancement. IJREAT International Journal of Research in Engineering & Advanced Technology, Volume 2, Issue 4, Aug-Sept, 2014, Dept., Dr.AIT, Bangalore, India

[19] G. Finlayson, M. Drew, and B. Funt, “Color constancy: diagonal transforms suffice,” in Int. Conf. on Comp. Vis., 1993, pp. 164–171

[20] E. Land, Recent advances in retinex theory, Vision Research, 26 (1986), pp. 7–29.Z. Wang and A. C. Bovik. Modern image quality assessment, chapter Introduction, pages 1–15. Morgan and Claypool, New York, 2006