Hardware Implementation of Combining Image Enhancement and ROI Extraction for Night Time Images

R. Nivedha
PG Student / ECE
Kings College of Engineering, Punalkulam
Thanjavur, Tamil Nadu
Email:nivedharaj15@gmail.com
W. Newton David Raj M.Tech.,
Assistant Professor / ECE
Kings College of Engineering, Punalkulam
Thanjavur, Tamil Nadu
Email: newton.davidraj1@gmail.com

ABSTRACT

In nighttime images, vehicle detection is a tricky task because of low contrast and luminosity. To enhance those images by normal MSR gives the apparent data loss because it uses a logarithmic function. To minimize the data loss, the proposed Multi-Scale Retinex Color Restoration (MSRCR) is used. It uses customized sigmoid function which result in preserve areas with normal lighting and suppress noise speckles in very low light areas and also it increases the Peak Signal to Noise Ratio (PSNR) of the image. In this paper, we combine a nighttime image enhancement approach based on Multi-Scale Retinex Color Restoration (MSRCR) and a novel region of interest (ROI) extraction approach that fuses object proposals and vehicle light detection together to enhance images and to extract accurate ROIs for accurate nighttime vehicle detection. Since Field Programmable Gate Array (FPGA) performs the high speed processing required for more accurate detection, FPGA technology will be used for the implementation of Artificial Neural Network (ANN) classifier. Our proposed method can detect blurred and partly occluded vehicles, as well as vehicles in a variety of sizes, locations and backgrounds.

I. INTRODUCTION

Night time image is more challenging than the Day time image due to the low contrast, environmental conditions(snow, rain etc.,) and poor illumination condition. To achieve color dynamic range compression and constancy, Retinex is an efficient theory aiming at simulating Human Visual System (HVS). Since Retinex is a combination of Retina + Cortex, it improves the visual rendering of an image even at the low lightening condition. Single-Scale Retinex (SSR) and Multi-Scale Retinex (MSR) uses a logarithmic function which makes the principal results of these Retinex processes can have too high or too low range of value. One method now normally use is proposed in involving a gain-offset method that clips those pixels with too high or too low lightness which leads to little information is lost. So this gain-offset method is not suitable for the Night time images. Inorder to maintain the ordinary color

of an image, we came up with a proposed technique i.e. Multi-Scale Retinex color restoration (MSRCR) which is at the root of the Retinex filter. MSRCR uses a sigmoid function instead of logarithm function. One of the main advantages of the sigmoid function is producing a positive range of output. Rather than clipping, this output is determined by compressing the 'extreme' pixels .So this proposed Multi-Scale Retinex doesn't require the gain-offset method which involves the clipping and result in information loss. This proposed technique increases the Peak Signal to Noise Ratio (PSNR) of the image.

II. ORIGINAL MSR

Compared to how these days camera perform, retinex theory is fine at adapting to variation of lighting state. Suffering from uneven lighting state, Multi-Scale Retinex is suitable to attain dynamic range compression on daytime images. Nighttime images behave more extremely but share the same uniqueness. The normal MSR can be written as

$$\mathrm{F_i(x;y)} = \sum_{n=1}^{N} \mathrm{W_n f}\{\log[\mathrm{S_i(x;y)}]\log[\mathrm{S_i(x;y)} * \mathrm{M_n(x;y)}]\}\mathrm{g} \quad (1)$$

Where N denote the number of scales of retinex computed, F represents the result we get from MSR operation, the subscripts $i \in R; G; B$ represents the three color channels, and W_n are the weighting factors of each scale. $S_i(x; y)$ is the ith channel two dimensional matrix of the original image, is the convolution operator, and the $M_n(x; y)$ are the surround functions given by

$$M_n(x;y) = K_n exp[(x^2 + y^2) = n^2] \quad (2)$$

Where K_n is to insure$M_n(x;y)$dxdy $= 1$. Single-Scale Retinex is represented in each one of the expressions inside the summation in Eq. 1. This expression of SSR can be written as

$$\log\left[\frac{S_i(x;y)}{S_i(x;y)M_n(x;y)}\right] \quad (3)$$

Where the Eq.3 can be naturally professed as a comparison between the weighted surrounding pixels and its current pixel. Shaping the scales of the surrounding neighborhood are done by the standard deviations of the Gaussian distribution is represented by *'n'*. More color constancy are produced by larger scales and more dynamic range compression are produced by smaller scales.

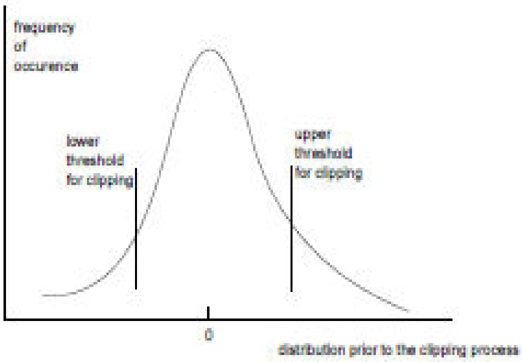


Fig. 1. The clipping method after initial retinex operation illustrated on histogram.

A characteristic form for the resulting histogram (shown in Fig.1) obtained after the initial retinex process accomplished by Eq.1. In spite of the various scenes, region of zero is distributed by the data and has a form of a Gaussian distribution. Clipping together the highest and lowest data and use gain-offset method to produce the final image is a common technique to show the result as an image.

This clipping step's higher and lower threshold can be determined by

$$T_H = M + \alpha \cdot \mathrm{d} \quad (4)$$

$$T_L = \mathrm{M} - \alpha \cdot \mathrm{d} \quad (5)$$

where d and I is the standard deviation and average lightness of the whole image, respectively. How much variation of the lightness to keep is determined by the factor α means. The Large keeps more lightness information but has poor visual effect since the lightness distribution will be closely around the average value and little lightness variation can be perceived. Lower will lead to better lightness distribution but also greater information loss since it has lower T_H and higher T_L. So, between more information for highlight/lowlight pixels and more nature visual effect are the trade-off

III. PROPOSED METHOD

The original MSR may manifest the following defects, when directly used on nighttime images. The clipping method prior to display can lead to data loss mainly in areas highlighted or non-lighted. This kind of areas are very ordinary in nighttime images unlike those took in normal daytime. (2) Retinex's nature tends to enlarge the lightness difference between pixels to improve clarity in nighttime images where noise is quite common, can extensively increase the noise effect. The proposed Multi-Scale Retinexcolor Restoration (MSRCR) is replace the logarithm function with a customized sigmoid function. The sigmoid function is projected to act as the logarithm one except that it's well bounded and only to compress the lightness near to its bound. Thus no clipping is needed and no apparent data loss obtained. It is a monotonic growing function and its form can be easily manipulated, i.e. the lower bound and the upper bound and the derivative at a certain point. We implemented a simple method to suppress the noise based on the cause of the magnified noise effect. Finally, we apply a parallel method to also preserve areas with good illumination.

(A) Sigmoid function

An easy form for a sigmoid function is

$$\mathrm{sig(x)} = \frac{1}{1 + \mathrm{e^x}} \quad (6)$$

And it's corresponding shape is sown in Fig.2

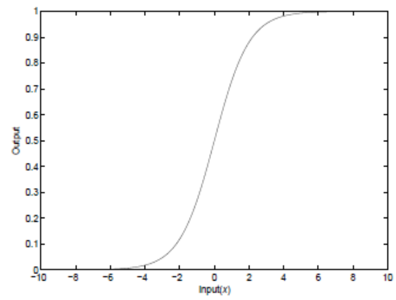


Fig. 2. Shape of a original sigmoid function

Like logarithm the function is bounded and is monotonically increasing. It has the output range between 0 and 1, suitable derivative and function value when x = 1, and a like form to the logarithm function when it is modified. In Eq.3, to replace the logarithm function with sigmoid, we have

$$\mathrm{Sig}\left[\frac{S_i(x;y)}{S_i(x;y)M_n(x;y)}\right] \quad (7)$$

A ratio between two images can be considered as the input of the Sig() function can meaning it is forever larger than 0. So the function with a domain on the right side of 0 has to consider. The weighted average one of the nearby pixels is alike as the lightness of the current pixel when the input equals to 1 and the result can be considered as the medium lightness of the image when the result must be near to 0.5.

The sigmoid function we choose is

$$\mathrm{Sig(x)} = \frac{1}{1+e^{-kx+c}+c} \cdot \frac{1}{c+1} \quad (8)$$

Where k is a factor to find out general steepness of the sig() function. b and c are parameters to make certain sigmoid goes through point (0*;* 0) and (1*;* 0*:*5), and ends at (+*1;* 1). The larger k gives more sensitive retinex. The corresponding curves with different k are shown in Fig.3. This curve shown in Fig.3 is similar to logarithmic, except it reaches 0 when x comes to 0, 0.5 when 1 and it slowly approaches 1 when x goes beyond 1 and further.

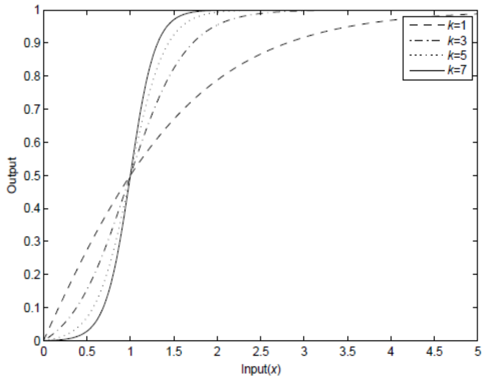


Fig. 3. Sigmoid curves with different ks

(B) Noise suppression

After the original retinex operation noise can be unique in dark area. It is due to that in nighttime view where light coming into the camera is partial, high ISO is used and can incur more noise, at first. Retinex operation's nature is to magnify difference between nearby pixels, and noise can be magnified, at second. Retinex operation's division part (like can be seen in Eq. 3) contains dividing one pixel's lightness by it's nearby pixels' averaged lightness, at third. In dark area, the averaged value is frequently close to 0 and a noise pixel whose lightness is even slightly larger can be extensively magnified after the division (See Fig. 4). In this section based on the third cause of the retinex noise,we propose an approach to limit the noise effect specially in dark area.

Fig. 4. (a) Original MSR tends to maginfy noise speckles (b) Original image

The denoising can be time consuming and it affects the naturalness of the image but an effective method is to suppress the noise first before applying retinex operation. When the surrounding lightness is extreme low, the information can be exploited from this area is quite l imited since it's full of noise pixel and often damaged by the compression algorithm used in storing images/videos. So, the retinex operation should only produce small effect when in a certain area where the lightness is very low We use a weight factor W^1 to achieve this

$$I_i(x;\ y) = F_i(x;\ y)W_i^1\ (x;\ y) + Si(x;\ y)\left(1\ \ W_i^1(x;\ y)\right) \quad (9)$$

Where *I* means final image we get, *i* is the certain color band of the image, *F* means primary retinex result, and *S* is original image. W^1 means weight factor determining how much of the retinex result we will use to frame the final image. In very low-light area the retinex result can be basically not exploitable, the W^1 should be near zero and W^1 should be near to 1 in other areas.

The weight factor we use is

$$W_i^1(x;\ y) = 1\ \left(1\ \ Li(x;\ y)\right)^{20} \quad (10)$$

$$Li(x;\ y) = Si(x;\ y)\ Mn(x;\ y) \quad (11)$$

Where the Eq.11 indicating the surrounding pixel lightness at *i*th color band. Thus W^l is determined correspondingly in each color band. This is for the reason that the division takes place separately in each color band.

(C) High-light preserving

Using the above operation we have suitable results from most night-time images. Although in nighttime images on occasion we come across areas which have moderately normal illumination. Due to the division step of retinex, a few areas are previously acceptable to person eyes and so the retinex operation may damage the 'good' areas. The division step will make the 'good quality' pixel close to medium lightness and direct to lightness reduction due to the overall lightness is high in normal lighting area. As a matter of fact, the retinex operation tends to redistribute them around the medium value, 0.5 and move overall pixel lightness. This 'grayish' effect can have not-nice on normal lighting areas and good on low-light areas and So, to distinguish poor lighted areas and normal ones, we use

$$H_i(x;\ y) = max_{i=1;\ 2;\ 3}\ L_i(x;\ y) \quad (12)$$

to determine the lighting degree of the current pixel. All lightness levels of the three color bands will be very low, in bad lighting areas. To indicate the lighting level of this area, we only need to utilize the greatest lightness level over the 3 bands

To implement the lighting level we generate another weight factor

$$W_i^2(x;\ y) = 1\ H_i(x;\ y)^{0.5} \quad (13)$$

Finally we get the overall weight through trouble-free multiplication

$$W_i(x;y) = W_i^1(x;\ y)W_i^2(x;\ y) \quad (14)$$

and the final equation for our proposed MSR

$$I_i(x;y) = F_i(x;y)\ W_i(x;y) + S_i(x;y)\ \left(1W_i(x;y)\right) \quad (15)$$

Where $I_i(\ x;y)$ is given by,

$$I_i\ (\ x;y) = \left(\sum_{n=1}^{N} W_n \cdot \{Sig(Si\cdot(x;y))Sig(Si(x;y) * M_n(x;y))\}\right)$$

(16)

(D) Flow of MSRCR

Before applying the MSRCR to the original image, some pre-processing steps are needed they are RGB (Red-Green-Blue) to HSV (Hue Saturation Value) conversion, localized Overlapping based luminance enhancement, HSV to RGB conversion

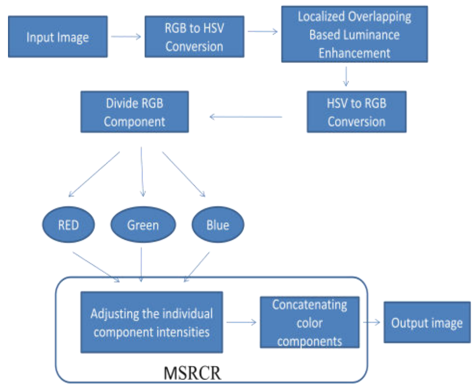


Fig. 5. Flow of MSRCR

IV. REGION OF INTEREST (ROI)

ROI is created by using special algorithm with the help of masking functions to mask the unnecessary part of the frame. The algorithm returns an image sub-region is defined as a binary image the same size as the original. There are two major steps in ROI. In first steps, the captured frames are masked to create the ROI. In second step, a region of ROI within an image is an image sub-region over which localized image processing operations can be performed. The advantages are

- It reduces the complexity in searching for vehicle candidates.
- It also decreases the false positive detection rate.

The region of interest is that part of the image which catches our attention immediately than the other parts of the image. For example, here our region of interest is vehicle light is shown in Fig. 6.

Fig. 6. Intensity image with region of interest

(A) Bright object segmentation

In order to detect bright objects and to measure some geometric parameters over them, the images are thresholded by using a threshold. Some essential aspects are considered for choosing a correct threshold value such as: road illumination conditions, nuisance light sources camera parameters and vehicle's lights appearance. To segment out the edges of light objects canny method is used. The main motive of using this method is the edges occurring in images are not missed and that there is no reaction where edges do not exist. Also dual threshold is an significant feature of canny. The segmented light objects are filled by white pixels that are holes. The above thresholding generate the binary image *b(x, y)* from an intensity image *I(x, y)* according to following,

$$b(x,y) = \begin{cases} 1 & \text{if } I(x,y) > T \\ 0 & \text{otherwise} \end{cases} \quad (17)$$

Where T means the thresholding level. Thresholding is obtained on region of interest i. e. masked intensity image which is done by special masking algorithm as shown in Fig. 6. The image histogram of masked image is shown in Fig. 7.

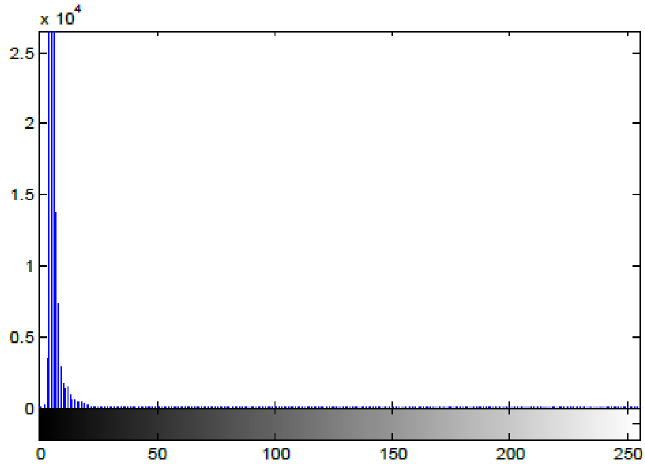


Fig. 7. Histogram of masked mage

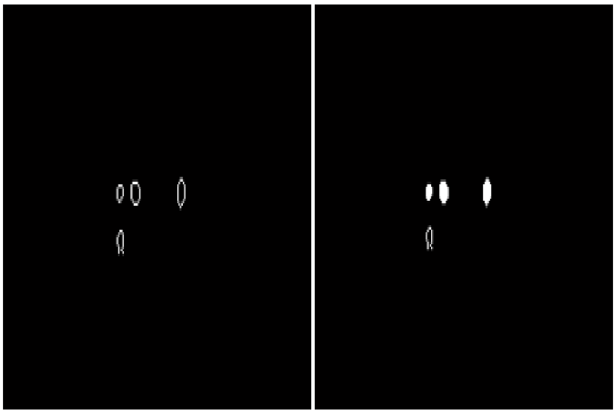
The x-axis shows the range of values within 0-255 and y-axis represents the number of times each value actually occurs within the image. The threshold value is selected to detach the foreground of the image and vehicle's light using the thresholding. Fig. 8(a) shows the segmented image after canny method and bright object after filling of holes in segmented object is shown in Fig. 8(b).

(B)Morphological filtering

By using morphological functions, the non objects that are detected in frames are eliminated. These functions are useful to eliminate objects from binary images that have fewer than 'P' pixels, producing another binary image.This operation is identified as an area opening. The default connectivity is 8 for two dimensional images and opening is the name given to morphological operation of erosion followed by dilation with the same structuring element. We denote the opening of A by structuring element B as

$$A \cdot B = (A \ominus B) \oplus B \quad (18)$$

Where $\ominus$ and $\oplus$ denote erosion and dilation, respectively. Opening eliminates small objects from the foreground (usually taken as the dark pixels) of an image, insertion them in the background. Fig. 8(a) shows the image after thresholding and segmentation, which includes two head lights and some fake lights. After elimination of fake lights Fig. 8(b) shows totally clear image which consists only two blobs of head light.



(a) (b)

Fig. 8. (a) Edge detected image (b) Segmented bright lights

(C)Clustering and labeling

The aim of this process is to cluster the detected blobs in the earlier step and attach a label to each observation or data point in a set which are near to each other. It extracts the connected components and leads to new image. Sequential assigned with integer values for new image with connected group of pixels like 0 for dark background, 1 for first detected object, 2 for second detected object and so on. Once the objects that are detected in frame & get labelled as in Fig.9 then we can estimate the feature of object according to shape of head light, tail light, road reflection, vehicle bumper reflections etc. The features like area, bounding box are revealed in table 1 as per clustered object. For example the area of object number 2 and 3 is approximately equal i.e. 12 and 11 respectively as compared to object number 1.

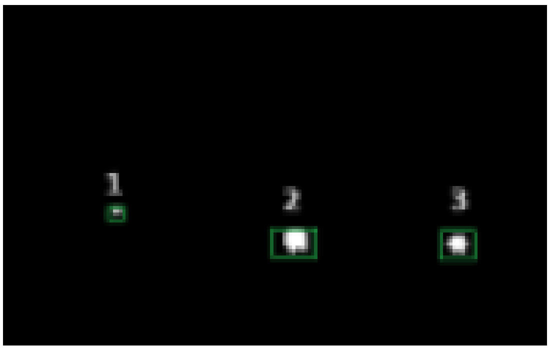


Fig.9. Labeled image

The luminance graph is shown between the intensity and the position of the pixel as shown in Fig. 10 tells the intensity variation between the original image (blue color) and the enhanced image (red color). The enhanced image increases the Peak Signal to Noise Ratio (65.9157) and decreases the mean square error (0.0167847). Then the Enhanced output image is given to the Region of Interest (ROI). The ROI is created by masking the unnecessary part of the frame. Here, our Region of Interest is vehicle light and then the lightening part of an image is extracted as shown in Fig. 10. After extracting the lightening part, the centroid of the light of the lightening part is found. By using this centroid, the vehicle can be detected by the Artificial Neural Network (ANN) classifier in the phase II.

These features are important for classification of vehicle's light and nuisance light because there is a large variation between them.

Table 1: Area and Bounding box

Clustered object	Area	Bounding Box Parameters
1	02	X=300, Y=230, W=02, H= 01
2	12	X=392, Y=240, W=06, H=06
3	11	X=442, Y=241, W=06, H=06

V. SIMULATION RESULT

The Nighttime images has distinct characteristics so based on this, we propose an Multi-Scale Retinex Color Restoration Retinex which uses customized sigmoid function and it is further suitable for nighttime image. After loading the color Night time image from the Data Base, this proposed MSRCR able to preserve and avoid the 'good' areas under normal lightings and intensifying noise effect in very dark areas respectively. And also the proposed technology increases the Peak Signal to Noise Ratio (PSNR) for the loaded image as shown in Fig. 10.

Fig.10. Simulation Output

VI. CONCLUSION

In this paper, we propose the MSRCR approach for color image contrast enhancement. From the experimental results, we can see that MSRCR can prevent from over-enhancement of the noises contained in the smooth dark/bright regions and also it enhance the contrast of edge regions. Thus, by using this improved MSR, we can get a fused image having high contrast and proper tonal rendition in the whole image. The nighttime images has distinct characteristics so based on this, we propose an Multi-Scale Retinex Color Restoration Retinex which uses customized sigmoid function and it is further suitable for nighttime image. It is able to avoid intensifying noise effect in very dark areas and to protect the 'good' areas under normal lightings. And also the proposed technology increases the Peak Signal to Noise Ratio (PSNR) of the image. Then the Enhanced output image is given to the Region of Interest (ROI) where the lightening part of an image is extracted. The Region of Interest is extracted by masking the unnecessary part of frame. There are two steps involved ROI. First step is, captured frames are masked to create the ROI. And the second step is, region of ROI within an image is an image sub-region over which localized image processing operations can be performed. The advantages of ROI are, it reduces the complexity in searching for vehicle candidates and also it decreases the false positive detection rate.

VII. FUTURE WORK

This project combines the Night time image Enhancement using MSRCR and Region of Interest Extraction. Further, Field Programmable Gate Array (FPGA) technique will be used for the implementation of Artificial Neural Network classifier. The application of FPGA has a large impact on image processing. FPGA performs the high speed processing required for more accurate detection and classification. It provides scalable system platforms with significant increases in image processing performance, yet in smaller, more available and portable equipment. FPGAs are more flexible systems with the ability to continually update features and algorithms over the equipment's lifetime. FPGAs enable flexible algorithm deployment and modality fusion. FPGA implementation renders many useful real time applications.

References

[1] Alexe B. (2012), "Measuring the Objectness of Image Windows," IEEE Trans. PatternAnalysis and Machine Intelligence, vol.34, no. 11, pp. 2189–2202.

[2] Chang-Hsing L., Cheng-Chang L. and Chin-Chuan H. (2014), "Color Image Enhancement Using MSR And Image Fusion Technique", World Academy of Science, Engineering and Technology International Journal of Computer, Electrical, Automation, Control and Information Engineering Vol.8, No.10.

[3] Dalal N. and Triggs B. (2005), "Histograms of Oriented Gradients for HumanDetection," IEEE Conf. Computer Vision and Pattern Recognition,vol.1,no.12, pp. 886–893.

[4] Dollar P. and Zitnick C.L. (2015), "Fast Edge Detection Using structured Forests,"IEEE Trans. Pattern Analysis and Machine Intelligence, Vol.37, no.1, p.1

[5] Felzenszwalb P.F. (2010), "Object Detection with Discriminatively Trained Part-Based Models," IEEE Trans. Pattern Analysis and Machine Intelligence, Vol.32, no.9, pp.1627-1645.

[6] Jang C.Y., Hyun J., Cho S., Kim H.S. and Kim Y.H (2010), "Adaptive selection of weights in multi-scale retinex using illumination and object edges".

[7] Jang C.Y., Lim J.H. and Kim Y.H. (2012), "A fast multi-scale retinex algorithm using dominant ssr in weights selection", in: SoC Design Conference (ISOCC), International, IEEE, vol.12, pp. 37–40

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

[9] Jang I.S., Park K.H. and Ha Y.H. (2009), "Color correction by estimation of dominant chromaticity in multi-scaled Retinex", Journal of Imaging Science and Technology, vol.53, no.5, pp.50502–11.

[10] Jobson D.J., Rahman Z.U. and Woodell G.A. (1997), "Properties and performance of a center/surround retinex, Image Processing", IEEE Transactions on vol.6, no.3 pp.451–462.

[11] Land E.H. (1986), "An alternative technique for the computation of the designator in the retinex theory of color vision", Proceedings of the National Academy of Sciences, vol. 83, no.10. pp. 3078–3080.

[12] Lin H. and Shi Z. (2014), "Multi-scale Retinex Improvement for Nighttime Image Enhancement" Int'l J. Light and Electron Optics, vol. 125, no. 24, pp.7143–7148.

[13] Rahman Z.U. (1996), "Multi-scale Retinex for Color Image Enhancement,"IEEE Intelligence Conference Image Processing, pp. 1003–1006.

[14] Rahman Z.U., Jobson D.J. and Woodell G.A. (2011), "Investigating the relationship between image enhancement and image compression in the context, of the multi-scale retinex", Journal of Visual Communication and Image Representation, vol.22, no.3, pp.237–250.

[15] Razavian A.S. (2014), "CNN Features Off-the-Shelf: An Astounding Baseline for Recognition," Proc.

IEEE Conf. Computer Vision and Pattern Recognition Workshops, pp. 512–519.

[16] Robinson P., Roodt Y. and Nel A. (2012), "Adaptive multi-scale retinex algorithm for contrast enhancement of real world scenes", in: the Proceedings of Twenty-Third Annual Symposium of the Pattern Recognition Association of South Africa, Pretoria, South Africa, Edited by Alta de Waal.

[17] Toufique A.S., Abdul S.S, Shafiullah S., Syed Abid Ali S. and Assadullah Khuhawar T. (2015)," Enhancement of Color Fundus Images by using Single and Multi-Scale Retinex " Bahria University Journal of Information & Communication Technologies Vol. 8, Iss.1.

[18] Wang W., Li B., Zheng J., Xian S. and Wang J. (2008), "A fast multi-scale retinex algorithm for color image enhancement", in: Wavelet Analysis and Pattern Recognition, ICWAPR'08. International Conference on, IEEE, vol. 1, pp. 80–85.

[19] Yee Ming C. and Jen-Hong C. (2010), "Face Recognition Using Combined Multiple Feature Extraction Based on Fourier- Mellin Approach for Single Example Image per Person," Pattern Recognition Letters, vol. 31, no. 13, pp.1833–1841.