PERFORMANCE EVALUATION OF VIDEO DEHAZING BY USING IDCP WITH GUIDED FILTER AND CLAHE

Sapna Goel, Navneet kaur, Twinkle Jaswal, Jasdeep Kaur
Electronics & Communication Engineering
Amritsar, India

Abstract: When processed the outdoor video in the presence of haze, noise, fog or smoke which degrades the quality of video through decreasing the contrast then many complications occurs. This paper use approaches neglected issues like noise reduction and improve contrast gain which will be presented in the output image of the previous existing haze removal algorithms. Firstly the video is break into frames, then proposed video dehazing algorithm is applied on individual frame. In this paper we proposed a new haze removal technique in which input hazy image noise reduction and edge smoothening is performed by guided filter and to remove haze, dark channel prior is integrate with contrast limited adaptive histogram equalization and adaptive gamma correction to remove the haze from color video.

Index Terms **-Guided filter, CLAHE, Adaptive gamma correction, DCP.**

I. INTRODUCTION

Road accidents increased in hazy weather because vision of objects is blurry and misty so the requirement of new ideas in the field of dehazing is needed that provide better contrast and remove noise along with better visual quality in real time applications. **Tarel et al.** [1-4] introduced a contrast based enhancement algorithm, in which he assumed that atmospheric veil function changed with local area, so median filtering and pre-treatment has been used to evaluate the transmission coefficient of medium.

S Shrestha [5] provided the comparison between denoising techniques of the image and for removing the impulse noise proposed a technique i.e. decision based approach. Mostly previous techniques for denoising of image have some noise density but in this approach firstly save the image details and then analysis is done by using Matlab.

Liu Qian et al. [6] explained that due to fog or haze, image has low contrast through which difficulties occur to find the interest points and edge in hazy image, so they proposed a depth based contrast stretching transform (DCST) method to increase the contrast of the single hazy gray image to obtain the good visibility. **Vishal Kahar and Bhailal Limbasiya** [7] recommended an algorithm on the basis of DCP for Hazy Image that has very low contrast using Detection. They mainly pay attention on difficulties that happen during awful climate, which includes halo artifacts, noise and low resolution.

Bo-Hao Chen and Shih-Chia Huang [8] introduced an Edge Collapse-Based Dehazing Algorithm through which dynamically repaired the transmission map to achieve Visibility Restoration in Real Scenes. **Sajna M. Iqbal et al.** [9] proposed a method for removing haze on remote sensing images by using two filters (Gaussian and weight guided image filter).WGIF provides better visual effects by increasing not only sharpness but also increase naturalness of the image.

Wencheng Wang and Xiaohui Yuan [10] reviewed the techniques which gave good results of image dehazing as image enhancement, image fusion methods and image restoration methods.

II. RELATED WOK

In this part we depicted the guided filter, contrast adaptive histogram equalization method and adaptive gamma correction along with their characteristics.

2.1 GUIDED FILTER

It is derivative from a linear model so it is also known as explicit filter. In this filter a guidance image is needed for the filtering and this guidance image may be same as input image or may be a different image. In an image processing some important characteristics of guided filter is described below:

Conservation of edge**-** after corrosion, images has base layer and detail layers in image processing. When the filter is applied on the image, then variations in image is occurred which described through base layer. Detail layer defines the difference between input image and base layer. The processing of layers may be done according to the application necessity. For conservation as well as smoothening of edges guided filter is best and for this guidance image should be same as input image.

Image Noise removal filter – Noise in images may be occurring at the time of capturing or may be at the time of transmission. High frequency details of image are considered as noise which does not have any useful information. When noise is removed through guided filter then guidance image at lower frequency stabilize the high frequency components of noisy image and also provides preservation of edge with smoothening.

Transference of structure – A linear equation is used to relate the guidance image and output image which indicate the presence of edge in the guidance image that can be transferred to output image. Feathering and matting of image can be done by using this property which differentiate foreground and background. In this method guidance image or input image may be same or different.

2.2 CONTRAST LIMITED ADAPTIVE HISTOGRAM EQUALIZATION (CLAHE)

This method is an improved version of adaptive histogram equalization (AHE), in which a number of histograms can be computed with different image sector through with redistribution of values of image luminosity becomes easy. This AHE method enhances each region of image but has one drawback of over amplification of noise. This drawback is recovered in CLAHE method through bounding the amplification.

Xu et al. [11] has concludes that degraded images has poor contrast, to overcome this problem he has defined a method i.e. contrast limited adaptive histogram equalization (CLAHE) method. In this method firstly the RGB color image that is captured by the camera was converted to his color space after that by using CLAHE the intensity component of the image processed and a new HSI image is achieved, which has hue and saturation same as in old HSI image. CLAHE method bound the amplification through clipping the histogram and then reallocated clipped pixels on each gray level. According to user the intensity of each pixel can be abbreviated to maxima. And in last again RGB color is received by converting this new HSI image.

Contrast limited adaptive histogram equalization has some characteristics which are given below:

- ❖ Prior knowledge about weather is not required.
- ❖ Enhancement of image details is very good.
- ❖ It effectively bound the enhancement of noise.
- ❖ This method is simple and faster for image enhancement.

2.3 ADAPTIVE GAMMA CORRECTION

It is nonlinear operation through which luminance intensity of a captured image is amplified by applying on each pixel. Power law expression is used to explain the gamma correction which is given as-

$$B_{out} = A.(B_{in})^{\wedge} \gamma \qquad (2.1)$$

Where B_{in}, B_{out} represents the levels of brightness before and after apply gamma correction respectively and A is a constant. If value of gamma is less than 1 ($\gamma < 1$), known as gamma encoding and the encoding along with power law expression known as gamma compression, but if the value of gamma is more than 1($\gamma > 1$) then it is known as gamma decoding and the decoding along with power law expression known as gamma expansion.

III. PROPOSED WORK

In our work we integrate the guided filter, dark channel prior (DCP) [12-14], CLAHE techniques and adaptive gamma correction to achieve better visual quality along with remove bad vision, noise and improve contrast gain as compare to the previous methods. The process of our work is clearly explained in the next section through algorithm.

3.1 ALGORITHM FOR PROPOSED METHOD

The process of our work for video dehazing is described systematically through the given flow chart which is explained in following steps as:

1. To study the performance of de-hazing techniques applied on an image and video.
2. Upload a capture video from camera for de-hazing in MATLAB®2014.
3. Break the video in frames through MATLAB®2014.
4. Apply de-hazing algorithm to the individual frame, some steps are given below-
    - ❖ Input image has noise and haze, firstly guided filter is used to remove noise and for edge preservation smoothening.
    - ❖ Apply contrast limited adaptive histogram equalization (CLAHE) over lab colors to enhance the contrast.
    - ❖ Apply basic DCP algorithm [15] in which Dark channel of the image is calculated, then transmission map and atmospheric light and after that refine the transmission map using filter.
    - ❖ Adaptive gamma correction is applied to adjust the luminance of dehazed image.
5. Now create a dehaze video by Combining the de-hazed frames along with frames per second (fps) specification.
6. Compute the mathematical factors such as PSNR, CG, MSE and SSIM and then plot these factors for knowing about our proposed dehazing amount in graphical form.

3.2 FLOW CHART OF PROPOSED METHOD

Above steps explained in algorithm 3.1and flow chart in fig 3.1 clearly explains the process of our work. Further quality measurement and results are evaluated and discussed in next section by imposing this proposed algorithm on the sample video.

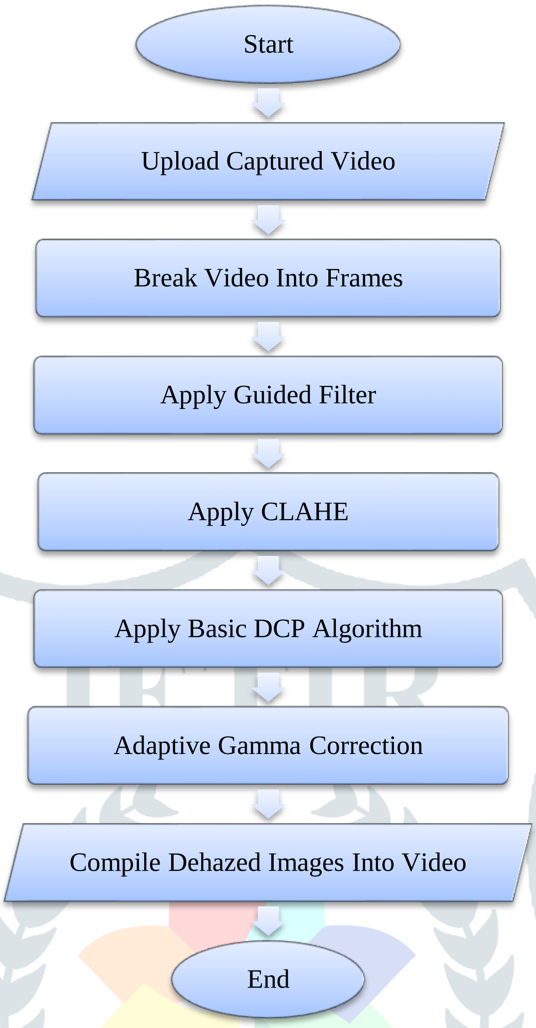

Fig 3.1 flow chart for process of proposed work

IV. QUALITY MEASUREMENT AND RESULTS

This section firstly discusses about parameters and then experimental results of video dehazing techniques of previous work and our work. The parameters that will be discussed in this section illustrate how much proposed method is successful. All the parameters are computed on DCP, IDCP and on proposed method and then comparison of different methods on the basis of parameters will be done through graphs and tables.

4.1 PARAMETERS

4.1.1 Mean square error Mean square error (MSE) – MSE is average of squared of errors. The value implied by hazy mage is differs from dehazed image which is the amount of error. The difference between the original hazy image and reconstructed haze free image is described through this MSE parameter. A lesser amount of MSE provides reconstructed haze free images with good quality.

$$MSE \frac{1}{P*Q} \sum_{m=1}^{P} \sum_{n=1}^{Q} (I[m,n] - J[m,n])^2 \qquad (4.1)$$

Where P*Q are dimensions of an image and I is the original hazy image and J is the haze free reconstructed image.

4.1.2 Peak signal to noise ratio (PSNR) – Peak signal to noise ratio is a term for the evaluation of ratio between the maximum signal power and the power of corrupting noise that affects the fidelity of its representation [16]. Generally various signals have a very wide dynamic range, so PSNR is usually expressed in terms of the logarithmic decibel scale. Basically PSNR is used to measure the quality of reconstruction of loss compression codec. The reconstruction of image is of higher quality with higher PSNR generally means PSNR is directly proportional to the quality of dehazed image and inversely proportional to mean square error.

$$PSNR=10*10 \log_{10}(MAX_I^{\wedge 2}/MSE) \qquad (4.2)$$

Where MAX_I is referred as maximum value of image pixel and MSE is the mean square error. If the observer is human, then PSNR between the two images equals to or more than 40db cannot be observed.

4.1.3 Standard deviation –It illustrate that how much dispersion or variation exists from mean value and it is symbolized by sigma which is a Greek letter. If the value of standard deviation is low, its means data points have a tendency to be very close to the value that is expected and if the value of standard deviation is high its means data points spread out over large range of values.

4.1.4 Contrast gain - It is the difference of mean contrast of hazy image and mean contrast of haze free reconstructed image. For good performance of haze removal methods, the value of contrast gain should be high which indicates the recovered image is noise free image. Mathematically it can be explained as:

$$CG = C_{I\ dehaze} - C_{I\ hazy} \quad (4.3)$$

Where CG is contrast gain, $C_{Idehaze}$ is contrast mean of dehazed image and $C_{I\ hazy}$ is the contrast mean of hazy image.

4.1.5 Structural similarity index (SSIM) - To assess the similarity between two images, SSIM is used which is also consider as visibility metric value. Estimation of image quality is done with the help of dehazed image. SSIM is further consistent and accurate than PSNR and MSE values. Luminance distortion, loss of correlation and contrast distortion are the three factors used in image distortion modeling which plays important in evaluating SSIM [17].

4.2 Experimental results

Sample video contains 89 frames but we take some frames to show result because neighboring frames have almost same results if we consider it parametrically. This sample video is of the traffic on the road taken in foggy day. Frames of video that are taken for comparisons in table or graph are randomly as frame 1, 6,12,18,24,30,36,42, and 48. This video consist not only low contrast but also it is less colorful, improvement is done through proposed method.

4.2.1 Visual and Parametric Comparison between Techniques for frame

Results of frame 1 ,18 ,30 and 48 out of 89 frames shown in Fig 4.1, 4.2, 4.3 and 4.4 respectively in which (a) is original hazy image (b) shows the result of proposed method in which head lights of car and white strip on the road can be seen clearly.

Figure 4.1 frame 1(a) original image (b) dehaze image with proposed method

Figure 4.2 frame 18(a) original image (b) dehaze image with proposed method

Figure 4.3frame 30 (a) original image (b) dehaze image with proposed method

Figure 4.4 frame 48 (a) original image (b) dehaze image with proposed method

4.3 COMPARISONS BETWEEN MEAN SQUARE ERRORS (MSE) OF EXISTING AND PROPOSED METHODS

Table 4.1 and fig 4.5 shows that proposed method for dehaze the sample video gives least MSE as compare to previous method.

Table 4.1comparison of MSE values of sample video frames with different techniques

Frame of video	MSE with DCP	MSE with IDCP	MSE with proposed method
1	48828	39089	19833
6	48579	39723	18928
12	48579	42826	19768
18	53511	50231	26178
24	53084	48456	28241
30	53799	52383	30221
36	54381	45287	25364
42	57122	51969	29681
48	56032	51560	34302

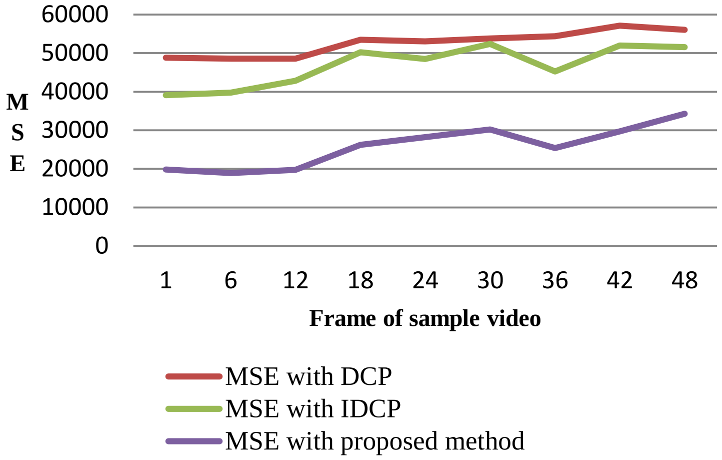

Figure 4.5 graphical comparisons of mse values for sample video frames using DCP, IDCP and proposed method

4.4 Comparisons between PEAK SIGNAL TO NOISE RATIOS (PSNR) of Existing and Proposed Methods

Table 4.2 and graphical results in fig 4.6 shows that proposed method for dehaze the sample video gives improved PSNR as compare to previous method.

Table 4.2 comparison of PSNR values of sample video frames with different techniques

Frame of video	PSNR with DCP	PSNR with IDCP	PSNR with proposed method
1	8.5312	8.7107	9.3080
6	8.5352	8.6974	9.3521
12	8.5352	8.6361	9.3110
18	8.4594	8.5089	9.0540
24	8.4657	8.5373	8.9814
30	8.4553	8.4760	8.9279
36	8.4469	8.5911	9.0822
42	8.4090	8.4822	8.9436
48	8.4238	8.4884	8.8197

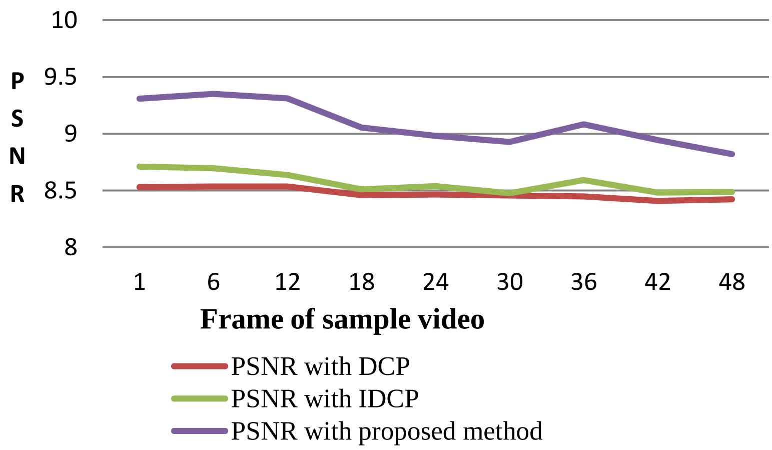

Figure 4.6 graphical comparisons of PSNR values for sample video frames using DCP, IDCP and proposed method

4.5 Comparisons between STANDARD DEVIATIONS of Existing and Proposed Methods

Table 4.3 shows the Comparison of standard deviation between exiting and proposed methods. Value of SD should be reduced for better result.

Table 4.3: comparison of SD values of sample video frames with different techniques

Frame of video	SD with DCP	SD with IDCP	SD with proposed method
1	.0098	.0098	.0098
6	.0098	.0098	.0097
12	.0098	.0098	.0098
18	.0098	.0098	.0098
24	.0098	.0098	.0098
30	.0098	.0098	.0098
36	.0098	.0098	.0098
42	.0099	.0098	.0098
48	.0098	.0098	.0098

Quantitative analysis of SD between DCP, IDCP and proposed method as shown in fig 4.7 in which SD values is same almost for most of the frames of sample video.

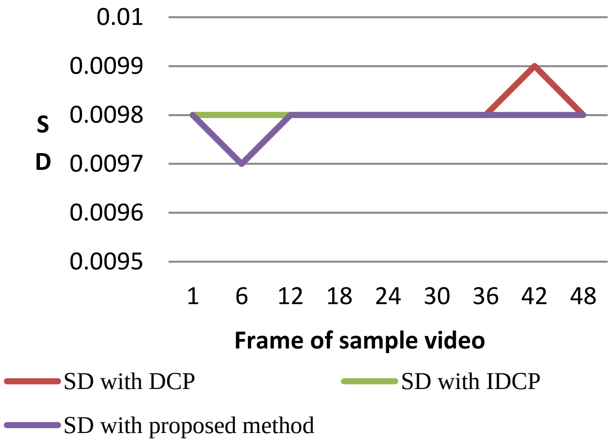

Figure 4.7 graphical comparisons of SD values for sample video frames using DCP, IDCP and proposed method

4.6 Comparisons between CONTRAST GAIN of Existing and Proposed Method

For good performance of haze removal methods, the value of contrast gain should be high which indicates the recovered image is noise free image.

Table 4.4 comparison of CG values of sample video frames with different techniques

Frame of video	CG with DCP	CG with IDCP	CG with proposed method
1	.8041	.8969	1.2481
6	.8063	.8896	1.2755
12	.7769	.8575	1.2489

18	.7695	.7938	1.0926
24	.7727	.8083	1.0492
30	.7678	.7780	1.0190
36	.7637	.8356	1.1095
42	.7454	.7812	1.0288
48	.7530	.7847	.9584

Table 4.4 and graphic representation for CG in fig 4.8 shows the results of all method's contrast gain for sample video which illustrate that our method is perform well for this parameter.

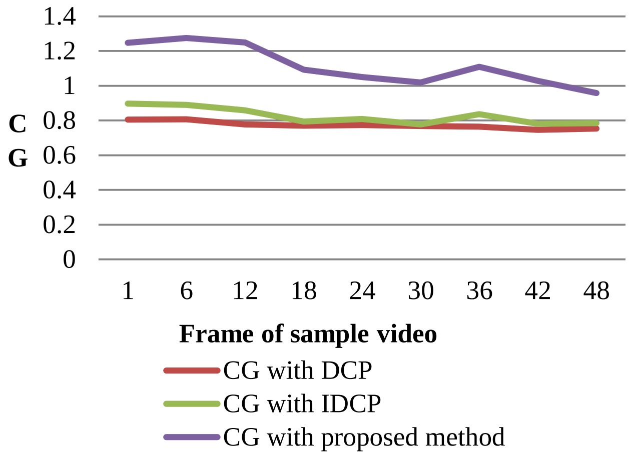

Figure 4.8 graphical comparisons of CG values for sample video frames using DCP,IDCP and proposed method

4.8 Comparisons between SSIM of Existing and Proposed Methods

Through DCP method highest values of SSIM is achieved so this method attains accuracy of dehazing which has output image closet to the original image. But our method also provides good result.

Table 4.5 comparison of SSIM values of sample video frames with different techniques

Frame of video	SSIM with DCP	SSIM with IDCP	SSIM with proposed method
1	.9375	.8787	.8519
6	.9150	.8065	.8814
12	.9231	.8068	.8512
18	.9304	.8445	.8449
24	.9256	.8414	.8482
30	.9253	.8074	.8154
36	.9443	.8869	.8184
42	.9684	.8049	.8473
48	.9668	.9072	.8847

Table 4.5 and graphic representation for SSIM in Fig 4.9 shows the results of all method's SSIM for sample video.

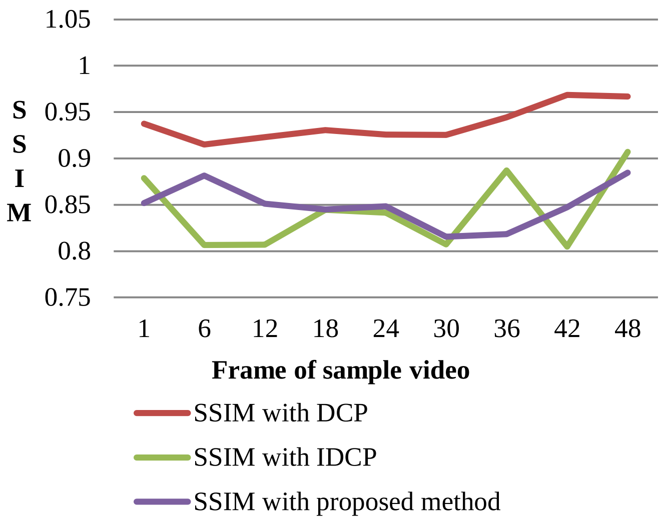

Figure 4.9 graphical comparisons of SSIM values for sample video frames using DCP, IDCP and proposed method

V. CONCLUSIONS

Final conclusion leads that our proposed technique is gain better enhancement along with sharpness as compare to DCP and IDCP for hazy images but sometimes for more dense haze images it gives little less improved result as comparison IDCP. It removes bad vision, noise and improves contrast gain. Lesser amount of MSE and increased values of PSNR and CG provide reconstructed haze free images with good quality.

Guided filter is very effective filter and time taken by this filter is very less as compare to other filter, so in our method we using this filter because our main motive is to process our method for real time applications.

VI. FUTURE WORK

In future, our motive is to implement our method for dehaze a video in real time. When drive in a hazy weather device like spectacles to be worn or a display on wind shield of the car that must be directly connected to receive dehazed signals. So, lesser number of accidents will be happened in future due to better view on road. During wars time night vision and bad weather become major problems, but this situation can be handled in future by hybridization of proposed technique. Development for dehazing, fulfil the purpose that can save life of both mankind and animals.

REFERENCES

[1] L. Caraffa and J. P. Tarel.2013. Markov random field model for single image defogging. Proceeding 2013 IEEE Intelligent Vehicles Symposium, Gold Coast, QLD, Australia: pp. 994-999.

[2] L. Caraffa and J. P. Tarel.2013.Stereo reconstruction and contrast restoration in daytime fog. Proceeding 11th Asia Conference on Computer Vision, Daejeon, Korea: 13-25.

[3] L. Caraffa and J. P. Tarel,.2013.Markov random field model for single image defogging. Proceeding 2013 IEEE Intelligent Vehicles Symposium, Gold Coast, QLD, Australia: pp. 994-999.

[4] J. P. Tarel and N. Hautiere.2009. Fast visibility restoration from a single color or gray level image. Proceeding IEEE 12th International Conference on Computer Vision, Kyoto, Japan: pp. 2201-2208.

[5] Suman Shrestha.2014. Image denoising using new adaptive based median filter. Signal & Image Processing : An International Journal (SIPIJ) Vol.5, No.4.

[6] LIU Qian, CHEN Mao Yin & ZHOU Dong Hua.2014. Single image haze removal via depth-based contrast stretching transform. Department of Automation, T singhua National Laboratory for Information Science and Technology, Tsinghua University, Beijing 100084, China.

[7] Vishal Kahar and Bhailal Limbasiya.2015.An Improved algorithm for Low Contrast Hazy Image Detection using DCP. International Journal of Advance Engineering and Research Development, vol.2, Issue 5.

[8] B. H. Chen and S. C. Huang.2016. Edge Collapse-Based Dehazing Algorithm for Visibility Restoration in Real Scenes. Journal of Display Technology, vol. 12, no. 9: pp. 964-970.

[9] Sajna M.Iqbal, Muhammed Nizar B K, and Athira Abraham.2016. Weighted guided Gaussian single image dehazing. Procedia Technology25: pp. 293-301.

[10] Wencheng Wang and Xiaohui Yuan.2017.Recent Advances in Image Dehazing. IEEE/CAA JOURNAL OF AUTOMATICA SINICA, VOL. 4, NO. 3.

[11] Haoran Xu, Jianming Guo, Qing Liu and Lingli Ye.2012.Fast image dehazing using improved dark channel prior. International Conference on Information Science and Technology: pp. 663-667.

[12] S. C. Pei and T. Y. Lee.2012.Night time haze removal using color transfer pre-processing and dark channel prior. In Proceeding 19th IEEE International Conference of Image Processing, Orlando, FL, USA: pp. 957-960.
[13] J. Zhang, Y. Cao, and Z. F. Wang.2014.Night time haze removal based on anew imaging model. In Proceeding 2014 IEEE International Conference on Image Processing, Paris, France: pp. 4557-4561.
[14] X. S. Jiang, H. X. Yao, S. P. Zhang, X. S. Lu, and W. Zeng.2013.Night video enhancement using improved dark channel prior. In Proceeding 20th IEEE International Conference on Image Processing, Melbourne, VIC, Australian: pp. 553-557.
[15] Sapna Goel And Jasdeep Kaur.2018.An In –Depth Analysis Of Dark Channel Prior Based Image Dehazing. International Journal Of Creative Research Thoughts, volume 6, Issue 1: 1037-1044.
[16] Jiawan Zhang, Liang Li, Yi Zhang, Guoqiang Yang , Xiaochun Ca, Jizhou Sun.2011.Video dehazing with spatial and temporal coherence. Published online: 20 April 2011© Springer-Verlag.
[17] Alian hore and Djemel ziou.2010.Image quality matrix: PSNR Vs SSIM. International conference on pattern recognition: 1051-4651/10.