



An Innovative Fog Removal and Enhancement using DCP and ACCLAHE with Gamma Transformation

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Abstract— Outdoor scenes images taken in bad climate gone through poor contrast. Under bad climate environments, reaching the light a camera is severely scattered through the environment, that is why the image received is extremely degraded because of additive light. Additive light from light scattering through fog particles. Additive light is created through mixing visible light means emitted from various light sources. Fog elimination also called as visibility restoration refers to numerous approaches that goal to decrease or eliminate the degradation that have occurred while the digital image was being obtained. The reason is the adverse climate situations like the heavy rain or presence fog, digital images are simply subjected to an extensive variety of disturbances during acquisition, which may decrease the visual effect and image post-processing affect. In this research, presents an innovative fog removal and enhancement applying dark channel prior (DCP) model and Adaptively clipped contrast limited adaptive histogram equalization (ACCLAHE) with gamma transformation. The proposed work is implemented in MATLAB R2012a using an image processing toolbox. The comparison among DCP and gamma transformation with median filtering and the proposed algorithm is measured various kinds of performance, namely, gain contrast (GC), entropy and execution time. The experimental results have composed of different types of fog images and it has shown better results as compared to previous methods.

Keywords— Fog Removal; DCP; ACCLAHE; Gamma Transformation; Entropy.

I. INTRODUCTION

The outdoor scenic images are debased by several reasons, but one of the source reasons is presence of bad weather conditions. Fog is caused by the droplets of water in the environment. The outdoor surveillance systems effect is limited by fog. In foggy weather situations, the images contrast and color are extremely degraded. This degradation level improved with distance from camera to object. In the fog degradation and fog invisibility is produced through two different fundamental phenomena airlight and attenuation. Light beam approaching from a point of scene, becomes attenuated scattering because of through atmospheric particles. This phenomenon is known as attenuation, which reduce contrast in any scene. Light coming from scattered sources towards adding whiteness and camera in the scene. This phenomenon is termed as airlight [1].

The modern defogging approaches [2] to single images defog through imposing various constraints upon either the albedo or depth, or on both. Tan imposes a nearby constant constraint on airlift as an image maximize function depth local contrast. However, the results tend to have higher saturation values because this technique does not physically recover depth or albedo but rather just improve the visibility. Besides, the outcome contains effects of halo along depth discontinuities. Fattal imposes an adjacent consistent requirement on the albedo together with decorrelation of the transmission in a nearby fix under the suspicion that shading surface and transmission are locally measurably uncorrelated.. This method requires sufficient color information and significant variation, for its performance greatly depends on the statistics of the input data. He et al. Impose constraints on the structure of depth induced through an empirical observation that within a local patch the scene albedo is assumed to tend to zero in at least one color channel. Kratz et al. impose natural statistics priors on both values of the albedo and depth and jointly estimation the depth and albedo by a recognized formulation of probabilistic. It is a tedious task to define scene-specific albedo priors and empirically set these parameters, resulting in not appropriate for practical required. Tarel et al. impose constraints on the depth variation with the maximizing atmospheric veil assuming that it must smooth in largest time.

Contrast enhancement is often required for video and image capture applications probably because of lens configurations, fog, or haze. Consider possible scenarios where contrast improvements are required for a vehicle driving down a foggy road or a surveillance camera viewing through a fog layer near the ocean. To find higher contrast imagery nearly, all images or frames from a video stream (un-compressed) is required to be enhanced in near-real time. A primary step to providing a solution to this problem would be to perform Histogram Equalization (HE), a statistical contrast enhancement method where the probability distribution function (PDF) of the image is transformed to be more uniform. Another similar approach is to enforce Gray-Level-Grouping [3] which also achieves spreading the original PDF while preserving dark and/or light pixels. A common problem with fog in scenes is that the amount of contrast degradation is spatially varying. This can be seen in everyday life by observing the amount of haze present in front of two distant

mountains. The farthest mountain would appear more hazy. This effect has been an important technique by artists for conveying scene depth on a two dimensional canvas.

A reasonable approach to improving the spatially varying contrast is to design the contrast enhancement to be spatially varying as well. A few examples are the Adaptive HE, Contrast Limited Adaptive HE, Adaptive GLG. The statistical methods attempt to achieve a desired PDF structure of an image without knowledge of the scene's physical parameters. If there is prior knowledge of the scene, then it makes sense to take advantage of this knowledge.

II. LITERATURE SURVEY

Zhengguo Li (2015) et al, present that outdoor scenes images could be degraded by fog, haze, and smoke in the environment. Here, propose a new single image haze elimination algorithm by introducing a minimal color channel and a sky region compensation term. A simplified dark channel is computed via the minimal color channel. The transmission map is first estimated by using the simplified dark channel. To avoid increasing noise in the sky, a non-negative sky region compensation term is proposed to adjust the transmission map in the sky. The map is then refined via a content adaptive guided image filter and is finally applied to recover the haze image. Experimental outcomes on images of outdoor scene with haze and without haze demonstrate that the proposed algorithm outperforms existing algorithms [4].

Pucheng Zhou (2014) et al present that images quality taken outdoors will be impaired severely in bad weather conditions, such as haze, mist, fog or rain. Here increase the visibility with only the single hazy image, algorithm of haze elimination type is proposed. Firstly, the transmission map of raw atmospheric is estimated by use of the dark channel prior. And then, Experts model is accepted to amend the raw atmosphere transmission map. As a final point, scene albedo is restored based on the atmosphere scattering model. Experiments on a variety of outdoor hazy images verify the feasibility and validity of our algorithm [5].

Garima Yadav (2014) et al present that for enhancing visibility level four levels are used. The first level is the acquisition process of foggy images. Second level is the estimation procedure (estimate scattering phenomena, visibility level). Third level is an enhancement process (improve visibility level, reduce fog or noise level). Last step is restoration process (restore enhanced image). The main goal is to review state-of-art enhancement of image and restoration approaches for enhancing the image level visibility and quality which provides clear image in the worst climate situation. Also compare prevalent methods in this area through implementation of the methods keeping parameters common for critical analysis. In the end provide the future scope for working directions in this area for the readers [6].

Di Wu (2014) et al present that Image haze removal has become an essential researching direction in computer vision because of the increasing demand of computer vision systems. Images acquired in bad climate condition, for example fog and haze, are extremely degraded through atmosphere scattering, which creates the gray color image, decreases the contrast and make the object features difficult to identify. The bad climate condition not only lead to the variation of the image visual effect, but also to disadvantage of the post processing to the image, as well as the inconvenience of each instruments types which rely on optical imaging, for example satellite remote sensing system, aerial photo system, system of outdoor monitoring and system of object identification. That's the aim why they required restoration and enhancement for the enhancement of the visual effects and post processing convenience. This paper sums up elimination of image haze approaches status. After that, qualitative evaluations and quantitative of these methods are presented and the present haze elimination technique challenges are summarized. Finally, proposed some expectations to the future research in the image haze elimination field [7].

Kristofor B (2014) et al present that An imaging usual problem in the environment is atmospheric turbulence and fog. Over the years, numerous researchers have providing insight into turbulence and fog physics but not these two. Most presently, researchers have proposed approaches to eliminate fog in images real-time processing fast enough. Additionally, approaches have been proposed through different researchers that address the atmospheric turbulence issue. In this paper, provide an analysis that incorporates both of physics: 1) fog and 2) turbulence. Observe how contrast enhancements (fog elimination) can influence image alignment and image averaging. Presented in this paper, a novel joint contrast enhancement and turbulence mitigation (CETM) technique that uses estimates from the algorithm of the contrast enhancement to increase the turbulence elimination algorithm. Provide a new turbulent mitigation object metric that measures temporal consistency. Finally, CETM design to be efficiently such that it can function in the second fractions for close to the real-time applications [8].

Shih-Chia Huang (2014) et al present a new visibility restoration technique that uses a combination of three major modules: a depth estimation module, a color analysis module, and a visibility restoration module. The proposed depth estimation module takes median filter technique benefit and adopts our adaptive gamma correction technique. By performing this, halo effects can be avoided in the images with complex structures and efficient transmission map estimate can be done. The proposed color analysis module is based on the gray world assumption and analyzes the color characteristics of the input hazy image. Subsequently, the visibility restoration module uses the adjusted map of transmission and the color-correlated information to repair the color distortion in variable scenes captured at the time of inclement climate situations. The experimental results demonstrate that our proposed technique provides haze elimination in comparison to preceding state-of-the-art technique by quantitative evaluations and qualitative of different scenes captured during various weather conditions [9].

Wei-Jheng Wang (2013) et al present that perceivability of outdoor images caught in nasty climate will get to be corrupted because of the nearness of murkiness, mist, fog, etc. Poor visibility caused through the climatic phenomenon in turn failure causes in applications of computer vision, for example systems of outdoor object recognition, obstacle

detection systems, video surveillance systems, and intelligent transportation systems. In order to solve this problem, visibility restoration approaches have been developed and perform a significant role in numerous computer vision applications. However, complete haze elimination from a single image with a complex structure is difficult for visibility restoration methods to achieve. This paper proposes a new visibility restoration technique which uses a median filter operation and the dark channel prior combination in order to achieve effective haze elimination in a single image with a complex structure. The experimental outcomes establish that the suggested technique provides superior haze elimination in the comparison to the previous state-of-the-art technique through visual evaluation of different scenes [10].

Yanjuan Shuai (2012) et al present that usage image haze elimination of dark channel prior, prone to color distortion phenomenon for some large white bright image area. Focusing at these problems, this paper displays an image fog elimination of wiener filtering based on dark channel prior. The algorithm is essential to estimation the median function of the media filtering technique usage dark channel based, to generate the function of media extra accurate and combine with wiener filtering closer. So that the fog image restoration issue is transformed into an optimization problem, and through minimizing mean-square error a clearer, without fog image is finally obtained. Experimental outcomes present that proposed algorithm can create the image extra detailed, the contour smoother and the whole image clearer. In specific, this algorithm can recover the contrast of a huge white area fog image. The algorithm not only adjust for the dark channel prior algorithm lack, additionally expands the dark channel prior algorithm application and abbreviates the image algorithm running time [11].

III. PROPOSED WORK

This paper deals with the defogging of images by using DCP and ACCLAHE with gamma transformation for fog removal. In this study, we worked on color image. First of all, in the case of the color image, convert an RGB image into Red, Green and Blue format. Convert image into a double value for dark channel (DC). Now produce matrix for DC foggy image with zeros. Extend the matrix size of DC using eqn.3. Estimate the atmospheric light applying the minimum filter. Calculating the transmission map for visibility of an image. The value of transmission map is less than 1 with varying weighted map. After that refine the transmission map for smoothing the image using gamma transformation. Apply edge preserving method for protecting the image edges using ACCLAHE enhancement method. The upgrade method viably improves the mist scene image perceivability. After that, GC, entropy and execution time calculated.

A. Read Foggy Image is indicated as I and resize the image with 512*512 dimension

B. Then the dimensions of the image are set

$$[r, c, ch] = size(I)$$

Where r,c is the row and column of foggy image and ch is the number of dimension

C. Now the array of all zeros is obtained for the dark channel foggy with the help of the given equation:

$$output_R = zeros(r, c, 1)$$

$$output_G = zeros(r, c, 2)$$

$$output_B = zeros(r, c, 3)$$

Where output is a dark channel foggy image

D. Estimate the atmospheric light 'A' using a maximum filter for Red ' A_R ', Green ' A_G ' and Blue ' A_B '.

E. Calculate weighted map 'w' can be found through solving equation:

$$w_R = output_R((m - floor(\frac{p}{2})) : (m + floor(\frac{p}{2})), (n - floor(\frac{p}{2})) : n + floor(\frac{p}{2})), 1)$$

$$w_G = output_G((m - floor(\frac{p}{2})) : (m + floor(\frac{p}{2})), (n - floor(\frac{p}{2})) : n + floor(\frac{p}{2})))$$

$$w_B = output_B((m - floor(\frac{p}{2})) : (m + floor(\frac{p}{2})), (n - floor(\frac{p}{2})) : n + floor(\frac{p}{2})))$$

Where w_R is a weighted map for the red component, w_G is a weighted map for the green component, w_B is a weighted map for blue component, [m, n] is row and column and p is local patch value which is initialized to 2

F. Calculate transmission map 't' using below formula:

$$t = 1 - \min \times \left(\frac{(\min(w_R))}{A_R}, \frac{(\min(w_G))}{A_G}, \frac{(\min(w_B))}{A_B} \right)$$

G. Refine transmission map and gamma transformation can be obtained by the equation, where γ is gamma value and c is constant

$$t = c \times (t)^\gamma$$

H. Estimate the scene radiance can found with the help of this formula:

$$output(i, j, ch) = \frac{output_R(i, j, ch) - A_R(i, j, ch)}{\min(\max(\frac{K^2}{\sum(\sum(w_R - A_R)^2)}, 1) \times \max(t, t_0), 1)} + A_R(i, j, ch)$$

$$output(i, j, ch) = \frac{output_G(i, j, ch) - A_G(i, j, ch)}{\min(\max(\frac{K^2}{\sum(\sum(w_G - A_G)^2)}, 1) \times \max(t, t_0), 1)} + A_G(i, j, ch)$$

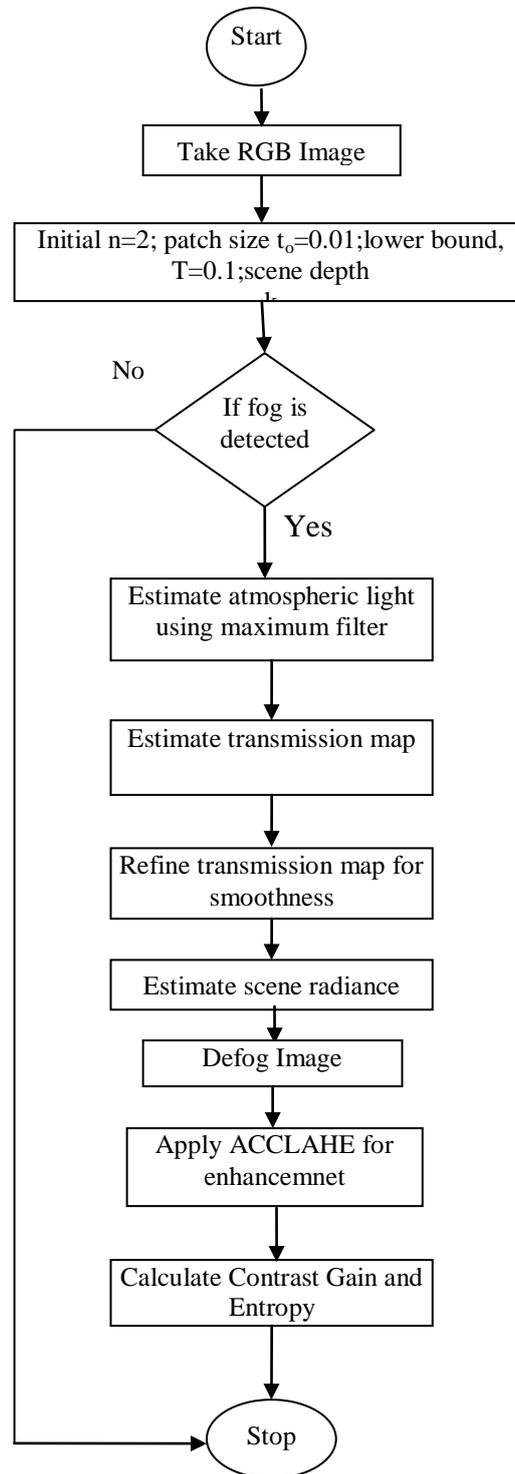
$$output(i, j, ch) = \frac{output_B(i, j, ch) - A_B(i, j, ch)}{\min(\max(\frac{K^2}{\sum(\sum(w_B - A_B)^2)}, 1) \times \max(t, t_0), 1)} + A_B(i, j, ch)$$

Where $t_0=0.01$, it denotes lower bound and K is scene depth

- I. Convert defog image into gray scale image if it is color image.
- J. For each sub-image do the following:
 - a) Compute the sub-image histogram.
 - b) Compute the sub-image value of high peak.
 - c) Calculate the nominal level of clipping, P from 0 to high peak using the binary search.
 - d) For all gray level bin in the histogram do the following:
 - i. If the histogram bin is greater than the nominal clip level P , clip the histogram to the nominal clip level P
 - ii. Collect the various pixels in the sub-image that caused histogram bin to exceed the nominal clip level (P).
 - a) Distribute the clipped pixels uniformly in all histogram bins to obtain the renormalized clipped histogram.
 - b) Equalize the above histogram to obtain the clipped HE mapping for the sub-image
- K. For each pixel in the input image, do the following :
 - i. If pixel belongs to an internal region (IR), then
 - ii. Compute four different weights, one for all of four nearest sub-images, based on pixel proximity to the four nearest sub-images centers (nearer the center of the sub-image, larger the weight).
 - iii. Calculate the output pixel mapping as the weighted sum of the clipped HE mappings for the four nearest sub-images applying the weights computed above.
- If the pixel belongs to an border region (BR), then
 - i. Calculate two different weights, one for each of the two nearest sub-images, based on the pixel proximity to the two nearest sub-images centers.
 - ii. Calculate the output mapping for the pixel as the clipped HE mappings weighted sum for the two nearest sub-images applying the weights computed above.
- If the pixel belongs to a corner region (CR), the pixel output mapping is the clipped HE mapping for the sub-image that contains the pixel.
- L. Apply the output mapping obtained to each of the pixels in the input image to obtain the image enhanced by ACCLAHE.
- M. Experimental Data



Fig 2. Image Dataset



N. Calculate entropy of an image:

$$ent = \sum_{i=0}^{N-1} p(xi) \log p(xi)$$

Where ent: Entropy

N: Maximum gray level value

p(xi): Probability of occurrence of xi

Entropy is a randomness measure or disorder of an object in this case the difference image between the foggy image and the defog image. Entropy gives the information about the loss of features in the noise free image during the filtering process by finding the power spectrum of the difference image. The lower entropy is better.

O. Calculate Mean Square Error (MSE) between defog image and fog image.

$$MSE = \frac{1}{M * N} ||y - s^{\wedge}||^2 = \frac{1}{MN} \sum_{i=1}^{MN} (y - s)^2$$

where M, N is size of foggy image, y is original foggy image and s is defog image

P. Calculate Contrast Gain between defog image and fog image.

$$Gain = \log_{10} \frac{\max Value(size(y))}{\sqrt{mean(mean(MSE))}}$$

Where y is fog image, MSE is mean contrast

IV. SIMULATION RESULT

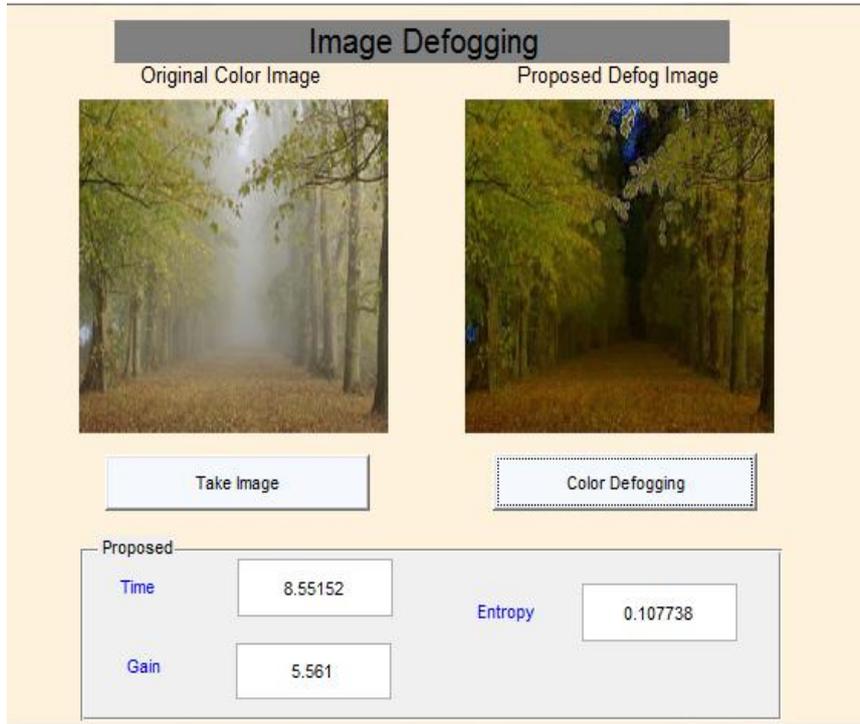


Fig 3. Show Results on Trees Image using Proposed System

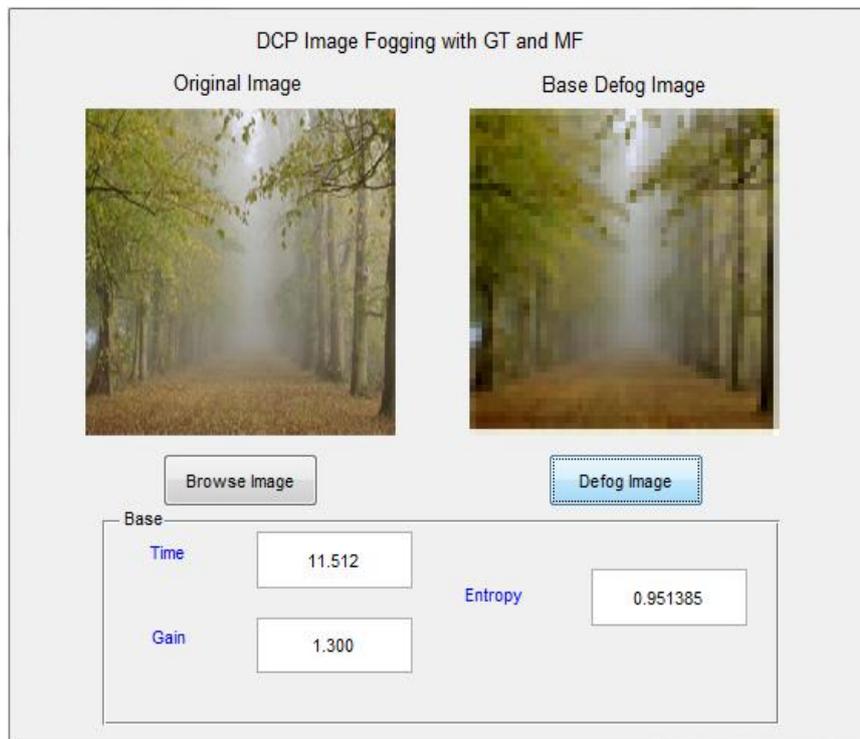


Fig 4. Show Results on Trees Image using Base System

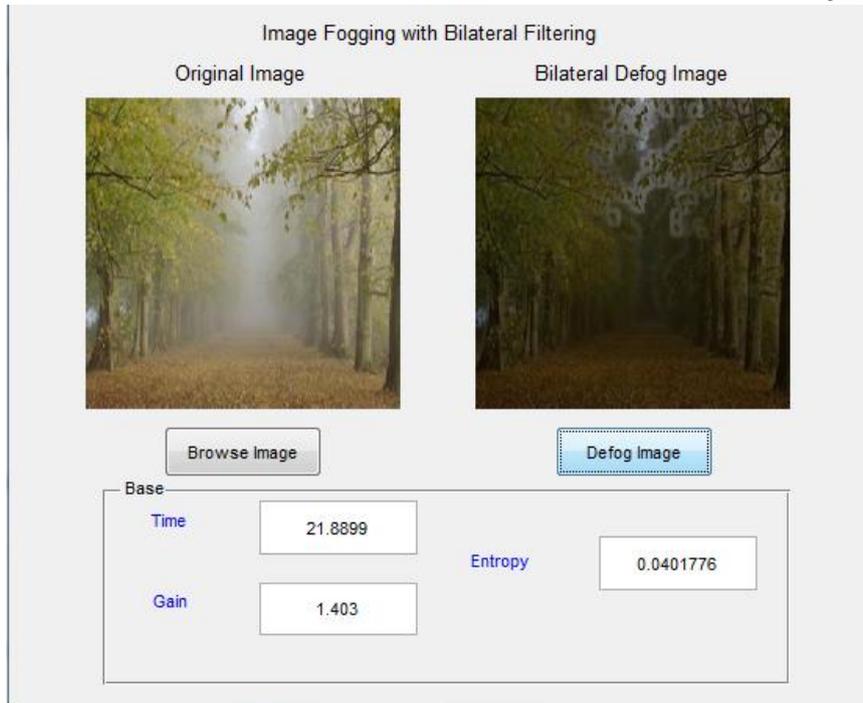


Fig 5. Show Results on Trees Image using Bilateral Filtering

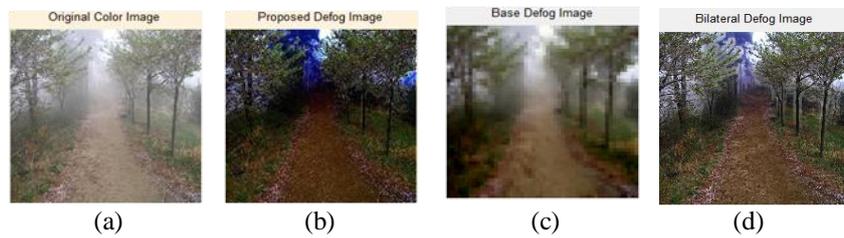


Fig 6. (a) Original Image (b) Defog using Proposed System (c) Defog using Base System (d) Defog using Bilateral Filtering

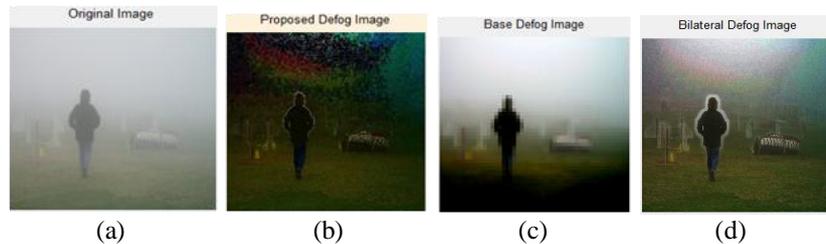


Fig 7. (a) Original Image (b) Defog using Proposed System (c) Defog using Base System (d) Defog using Bilateral Filtering

Table I . CG and Time Comparison of Proposed System with Bilateral Filter [12] Base System

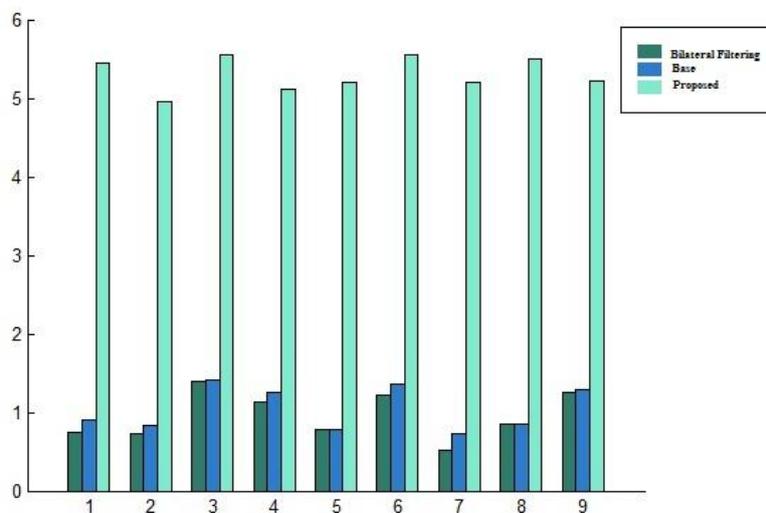
Image No.	Image	Bilateral CG	Base CG	Proposed CG	Bilateral Time	Base Time	Proposed Time
1	Toys	0.744	0.897	5.453	22.129	12.1744	8.753
2	Fog -1	0.729	0.830	4.954	21.660	11.8018	8.922
3	Tress	1.403	1.412	5.561	21.775	11.5983	8.671
4	Cones	1.137	1.257	5.112	22.015	11.3922	8.520
5	Canon	0.772	0.780	5.207	21.425	11.4593	8.514
6	Banya_San_Nonsan	1.226	1.361	5.555	21.456	11.7264	8.742
7	Foggy- 5	0.526	0.721	5.205	21.570	11.7715	8.582
8	Fog- 13	0.845	0.850	5.506	22.098	12.0266	8.531
9	610228-Foggy	1.254	1.298	5.216	21.732	11.5016	8.951

Table1. is demonstrating the similar investigation of the time As Time should be minimized; so the primary target is to lessen the Time, however much as could reasonably be expected. Table1. has obviously demonstrated that time is less for our situation in this manner the proposed calculation has indicated critical results over the accessible calculation.

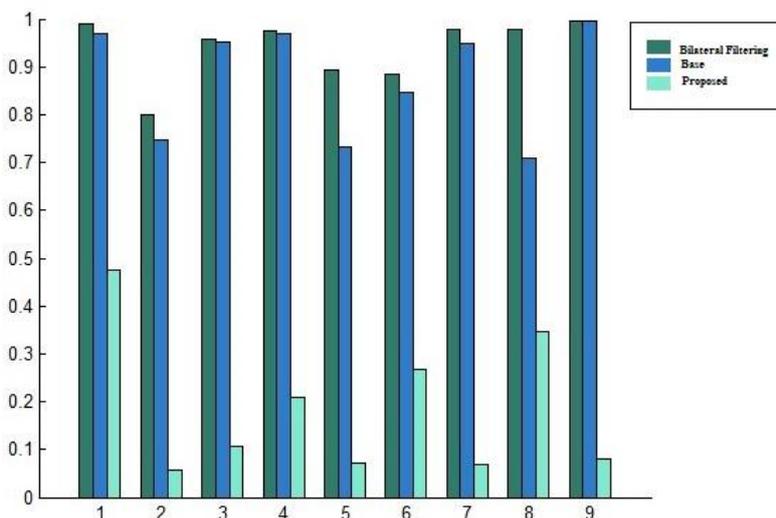
Table II. entropy Comparison of Proposed System with Bilateral Filtering [12] And Base System

Image No.	Image	Bilateral Entropy	Base Entropy	Proposed Entropy
1	Toys	0.9901	0.9703	0.4745
2	Fog1	0.7995	0.7481	0.0581
3	Trees	0.9582	0.9513	0.1077
4	Cones	0.9743	0.9698	0.2101
5	Canon	0.8921	0.7311	0.0704
6	Banya_San_Nonsan	0.8853	0.8468	0.2671
7	Foggy-5	0.9769	0.9501	0.0686
8	Fog13	0.9786	0.7093	0.3472
9	610228-foggy	0.9953	0.9953	0.0799

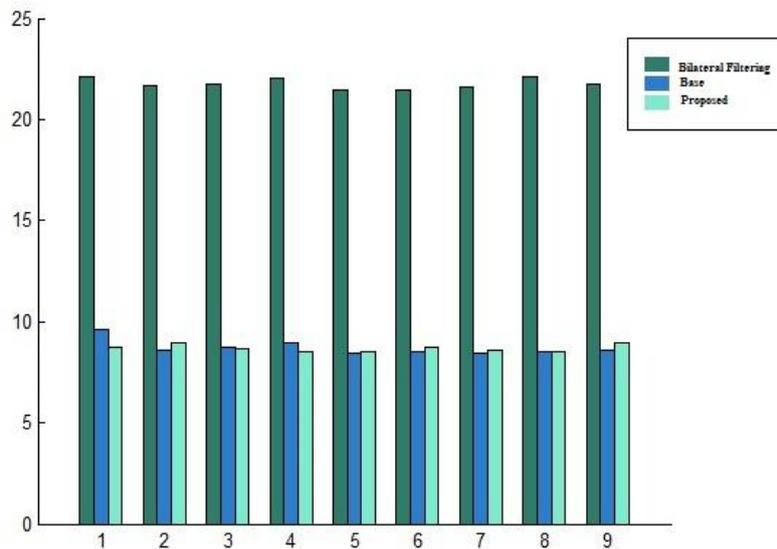
Table II. is demonstrating the similar investigation of the Entropy. As Entropy (Ent.) should be minimized; so the primary target is to lessen the Ent, however much as could reasonably be expected. Table2. has obviously demonstrated that Ent is less for our situation in this manner the proposed calculation has indicated critical results over the accessible calculation.



Graph 1. CG Comparison of Proposed System with Bilateral Filter[12] and Base System[1]



Graph 2. Entropy Comparison of Proposed System with Bilateral Filter[12] and Base System[1]



Graph 3. Processing Time Comparison of Proposed System with Bilateral Filter[12] and Base System[1]

The above graphs demonstrates the quantized examination of the CG, Entropy and Processing Time of various pictures utilizing Bilateral Filter (Dark green color), Base framework (blue color) and by Proposed Approach (Aqua Blue color). It is clear from the graphs that there is an increase in CG, decrease in Entropy and Processing time estimation of pictures with the utilization of the proposed strategy over existing systems. This diminishing speaks to change in the target nature of the picture.

V. CONCLUSION

In this study, the proposed method presents that innovative fog removal using DCP and ACCLAHE with gamma transformation. Using ACCLAHE, enhance the final defog image for preserving edges. With the use of gamma transformation, refine the transmission map for visibility of an image. The experimental result proved that the DCP channel prior based fog removal and edge-preserving smoothing approach has provided quite promising results over the presented methods. This work has not considered underwater images furthermore remote sensing images so in future we will approve the proposed strategy on the underwater images and satellite images. Likewise the use of the filtering techniques will also be considered to uproot the noise related issue in this research work.

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