Chapter 11
Image Enhancement:
Application of Dehazing and Color Correction for Enhancement of Nighttime Low Illumination Image

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ABSTRACT

This chapter describes a novel method to enhance degraded nighttime images by dehazing and color correction method. In the first part of this chapter, the authors focus on filtering process for low illumination images. Secondly, they propose an efficient dehazing model for removing haziness Thirdly, a color correction method proposed for color consistency approach. Removing nighttime haze technique is an important and necessary procedure to avoid ill-condition visibility of human eyes. Scattering and color distortion are two major problems of distortion in case of hazy image. To increase the visibility of the scene, the authors compute the preprocessing using WLS filter. Then the airlight component for the non-uniform illumination presents in nighttime scenes is improved by using a modified well-known dark-channel prior algorithm for removing nighttime haze, and then it uses α-automatic color equalization as post-processing for color correction over the entire image for getting a better enhanced output image free from haze with improved color constancy.

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INTRODUCTION

Main degradation of outdoor images occurs due to bad atmospheric phenomena such as hazy or foggy weather effect. Scattering of atmospheric particles reduces the visibility in terms of color variation contrast and makes difficult to recognize the object's prominent features to be identified by human and computer vision systems. So haze process yield pour visibility in day as well as night time or on low dim light effect. In the past few years images taken from worst weather situations and restoring them has made greater impact and progress. These image restorations are vital in various outdoor applications like surveillance, intelligent vehicles, object recognition, and remote sensing. Due to the ambiguity between the unknown depth of haze and the object underlying scene haze removal is very difficult. Another major issue related to haze images is perceivability degradation due to lag of missing information in terms of color effect due to effect of low illumination.

Considering into account of the illumination characteristics of night-time imaging, a modified algorithm for image enhancement is proposed in this chapter. In the first phase of proposed method Weighted Least-Squares (WLS) is used for filtering application to visualize the fine detail within an image respectively by Perona et. al (1900). WLS is an edge preserving filter which computes detail layers and recombines them with approximate pixel intensity value. The dehazing method based on Prior method is adopted as the key parameters of dehazing method using the local patch process Tarel et. al (2009) to obtain the better conditions of nighttime imaging. The illumination level of nighttime hazy image can be artificially enhanced through flexibly selecting the color correction method. In contrast to the classical model of color transfer with the strategy of overall to overall transfer, the modified model focuses on the different characteristics of various regions in the original image, and it works well even though the nighttime image is interfered by various artificial light sources. Various preprocessing methods are providing in terms of histogram, bilateral histogram, spatial filtering, Homo-morphic filtering. But in this chapter, the application of edge preserving application is done for better result. Similarly, for dehazing Presented by Perona et. al (1900) in order to use for haze removal methods are based on a) Image Enhancement b) Image Fusion c) Image restoration. The main object of haze removal algorithms is to enhance and restore the exact information of the scene from hazy image. In a haze removal model, primarily a haze density distribution map of hazy image is created. It enables to segment the hazy image into scenes according to generated density distribution function improving the scene with proper brightness, contrast and information contest of image. Here in, we focus to find methods to enhance and restore the dehazed images. Visibility restoration plays an important role in image processing applications.

Based on restoration methods for dehazing many methods are open to new avenues for the image degradation and scrutinize the imaging procedure, then recover the scene by an inverse transformation. Due to the use of better assumptions and priors single image dehazing has made progress efficiently. With the progression of innovation, numerous single image Haze removal strategies have been proposed based on Additional information, multiple images methods, and prior knowledge. Various models as described further are taken as reference in our method. Fattal (2014) strategy was based on Independent Component Analysis. Tarel et. al (2009) presented visibility restoration strategy depending on linear operations computed by numerous parameters for alteration. Kaiming et. al (2011) proposed an image dehazing method using cloudiness combined with Dark and re-estimated by soft matting. Tripathi et. al (2012) presented a novel effective mist expulsion algorithm with a pre-processing step as histogram equalization individually. Multi-scale fusion approach is deployed for dehazing Ancuti et. al (2013) and Wang et. al (2014) in terms of white adjustment, and a differentiate upgrading utilizing two original hazed pictures. Farbman et. al (2008) once more proposed a modern haze removal method for a picture employing a neighborhood color-line demonstrate that exhibit a one-dimensional conveyance of pixels of little picture patches. He employed a 'Gamma variable' adjustment to re-establish the color images with tall high precision at lower commotion levels as it were, but the picture limits the execution of color-line dehazing algorithm like other strategies in sky region. Color distortion corresponds to the varying degrees of attenuation encountered by light traveling in different medium. This means that the colour correction is not a linear transformation Economopoulos et. al (2010). Many underwater image enhancement techniques are embedded with colour correction algorithms. But some authors are only confined to colour correction techniques, which are discussed here. Hou et. al (2007) enhanced the colour of the underwater image using Markov Random Field (MRF). The algorithm used training image patches to colour correct the images. It has training image patches which are both bluish and original colored image patches. For each input image patch closest patches are selected. The color value of center of each estimated maximum probability patch is assigned to the corresponding pixel in output image. Farbman et. al (2008) presented algorithm which is based on the modeling of the color modification by the water. Backscattered component is not considered in this algorithm. All the discussed method is time consuming, so it is improved by new approach for image colorization very fast, named αACE presented by Imatiyaz et. al (2017) are also taken care in this chapter.

BACKGROUND OF RELATED WORK

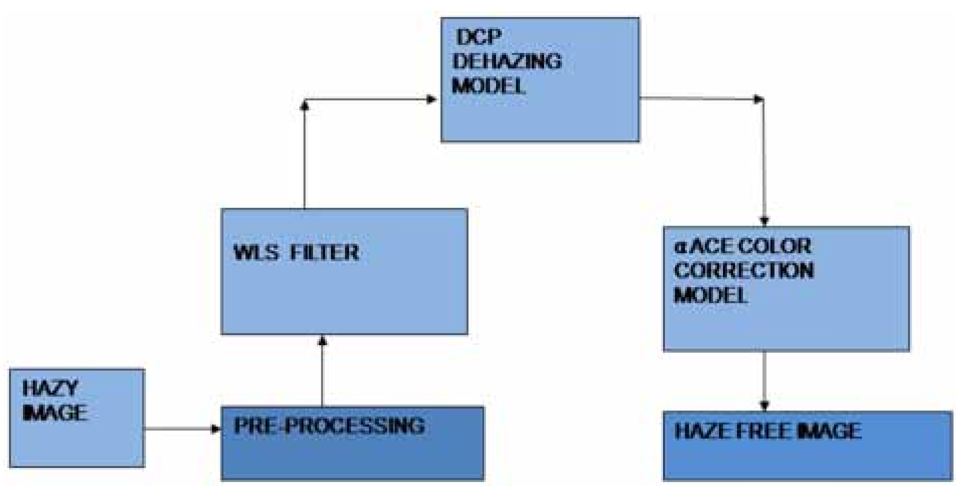
Various preprocessing methods provide in terms of histogram, bilateral histogram, spatial filtering, Homo-morphic filtering. But in this chapter application of edge preserving application is done for better result. Similarly, for dehazing by Perona et. al (1900) that are used for haze removal methods are based on a) Image Enhancement b) Image Fusion c) Image restoration. The main object of haze removal algorithms is to enhance and restore the exact information of the scene from hazy image. In a haze removal model, primarily a haze density distribution map of hazy image is created. It enables to segment the hazy image into scenes according to generated density distribution function improving the scene with proper brightness, contrast and information contest of image. Here in, we focus to find methods to enhance and restore the dehazed images. Visibility restoration plays an important role in image processing applications.

Based on restoration methods for dehazing many methods are open to new avenues for the image degradation and scrutinize the imaging procedure, then recover the scene by an inverse transformation. Due to the use of better assumptions and priors single image dehazing has made progress efficiently. With the progression of innovation, numerous single image Haze removal strategies have been proposed based on Additional information, multiple images methods, and prior knowledge. Various models as described further are taken as reference in our method. Fattal (2014) strategy was based on Independent Component Analysis. Tarel et. al (2009) presented visibility restoration strategy depending on linear operations computed by numerous parameters for alteration. Kaiming et. al (2011) proposed an image dehazing method using cloudiness combined with Dark and re-estimated by soft matting. Tripathi et. al (2012) presented a novel effective mist expulsion algorithm with a pre-processing step as histogram equalization individually. Multi-scale fusion approach is deployed for dehazing Ancuti et. al (2013) and Wang et. al (2014) in terms of white adjustment, and a differentiate upgrading utilizing two original hazed pictures. Farbman et. al (2008) once more proposed a modern haze removal method for a picture employing a neighborhood color-line demonstrate that exhibit a one-dimensional conveyance of pixels of little picture patches. He employed a 'Gamma variable' adjustment to re-establish the color images with tall high precision at lower commotion levels as it were, but the picture limits the execution of color-line dehazing algorithm like other strategies in sky region. Color distortion corresponds to the varying degrees of attenuation encountered by light traveling in different medium. This means that the colour correction is not a linear transformation Economopoulos et. al (2010). Many underwater image enhancement techniques are embedded with colour correction algorithms. But some authors are only confined to colour correction techniques, which are discussed here. Hou et. al (2007) enhanced the colour of the underwater image using Markov Random Field (MRF). The algorithm used training image patches to colour correct the images. It has training image patches which are both bluish and original colored image patches .For each input image patch closest patches are selected. The color value of center of each estimated maximum probability patch is assigned to the corresponding pixel in output image. Farbman et. al (2008) presented algorithm which is based on the modeling of the color modification by the water. Backscattered component is not considered in this algorithm.

HAZE REMOVAL MODEL FOR IMAGE RESTORATION

In this chapter a fusion process of filter application, haze removal algorithm and improvement of color restoration is applied to obtain an image free from haze and restoration of color components is achieved by αACE represented in Figure 1. The details discussion can be made in several sub-chapters in subsequent section. Apart from this the algorithm has used as color correction in the proposed model.

Figure 1. Model for image dehazing



PROPOSED METHOD

The primary focus of this chapter is the development of a fast and robust exposure fusion approach based on local texture features computed from edge-preserving filter. W**LS** filter is used as a preprocessing technique that produces a composite image without blurring or loss of detail.

In WLS pre-processing is done. Edge preserving filters have received considerable attention in computational photography over the last decade. From the literature we have observed that the both techniques presented by both Ancuti et. al (2012) and Hou et. al (2007) are the most popular edge-preserving operators. Standard BLT uses distances of neighboring pixels in space and range. The space varying weighting function is computed at a space of higher dimensionality than the signal being filtered. As a result, such filters have high computational speed by Liu et. al (2017). The motivation behind weight map computation by Wang et. al (2017) is to yield nonlinear adaptive function for controlling the contribution of pixels from base layers and detail layers computed across all input exposures. Then the filtered image is dehazed by DCP (Dark channel prior) model and processed according to the steps given below

THEORETICAL CONCEPT OF DCP

According to his law, the impact of haze or fog is presented as:

$I(i,j)=I_{an}(i,j)+A_{airlight}(i,j)$ (1).

On, the right-hand side value, attenuation, and air-light are the function of distance from capturing devices of the scene in form of:

$$I_{an}\left(I,j\right)=I_{o}\left(I,j\right)e^{-\beta l\left(I,j\right)} \text{ (2).}$$

$$A_{airlight}\left(i,j\right)=I_{pS}\left(1-e^{-\beta l\left(i,j\right)}\right) \tag{3}$$

Combining all the parameters of Attenuated image component and Airlight image component the Haze model can be entitled as:

Algorithm 1: Implementation procedure for dehazing model

- Read a low light mist or fog picture taken from output of WLS filter
- The shade of the air light - An is near the shade of the sky so simply pick the initial couple of pixels that are nearest to in Dark and take the normal pick top 0.01% brightest pixels oblivious channel
- Accommodate a vector of pixels in Dark of picture
- Sort the vector and need the last couple of pixels on the grounds that those are nearest to 1 named as A
- Re Estimate RT – reclassified Transmission utilizing A
- Get Radiance utilizing picture, 'T' transmission and Atmospheric light 'An' acquiring dehazed yield picture
- Get Radiance utilizing picture, 'RT' transmission and Atmospheric light 'A' acquiring Redefined dehazed yield picture
- Enhance the dehazed yield picture with boosting the picture pixels of shading data RGB
- utilizing local inclination methods
- Apply the dehazed output for color correction

Finally color correction is consider for color distortion corresponds to the varying degrees of attenuation encountered by light traveling in different medium with different wavelengths, rendering ambient environments dominated by a bluish tone. The algorithm has been implemented in following the ways. The first stage accounts for chromatic spatial adjustment and models two important mechanisms: bilateral inhibition and global/local adaptation by Imtiyaz et. al (2017). These two mechanisms form the basis of the appearance computation of each area in the image, taking into account their neighboring and dimensional relationship. Then, the second stage maximizes the image dynamic, normalizing the white at a global level and performing a global gray world behavior. The proposed αACE-improved the degraded images by color correction method with different color vision well than the state-of-the-art methods, also with little computation time. The proposed methods are suitable for real-time computing in night time also. This method also contains some problems such as the influence of the possible presence of an artificial lighting source is not considered.

RESULTS AND DISCUSSION

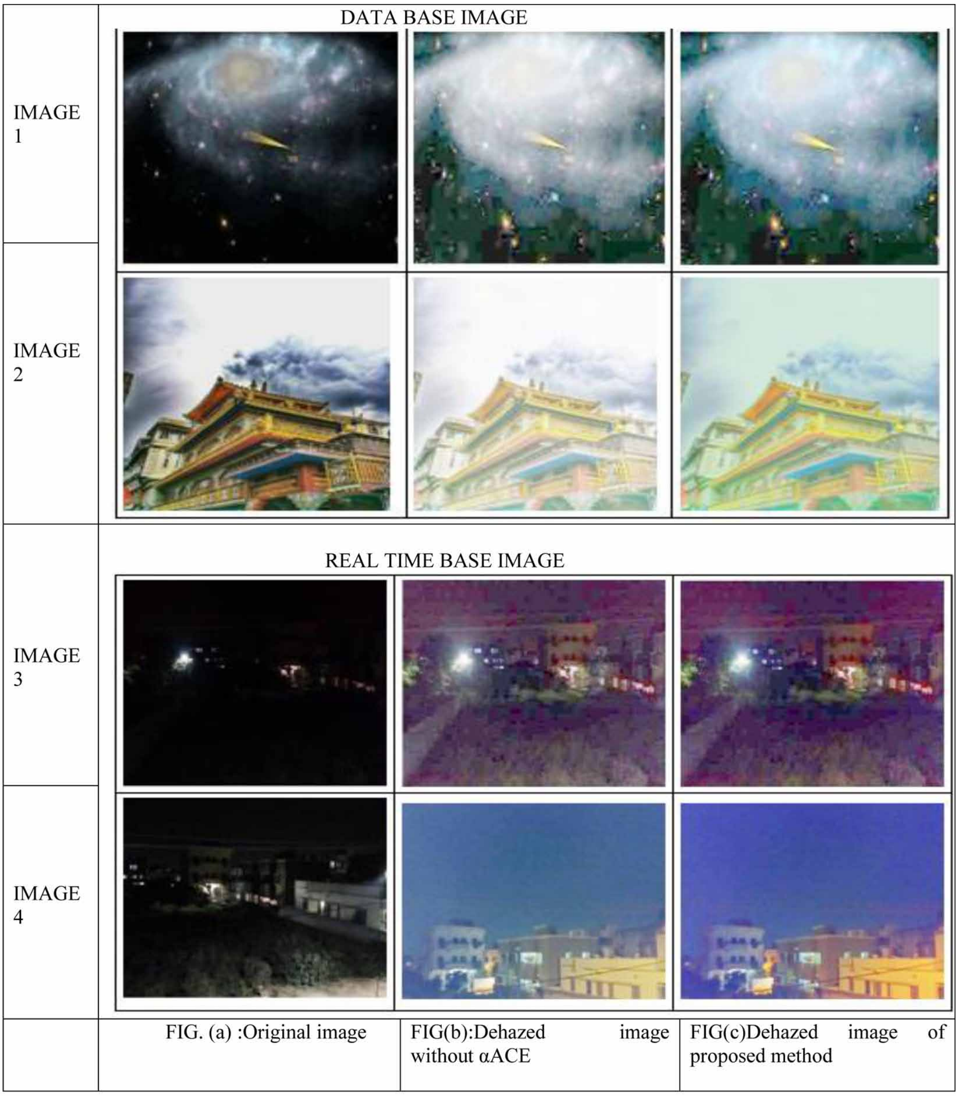
Subjective Analysis of Enhancement Results Considering Data Base Image and Real Time Image

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 DCP and combining DCP with color correction factor .Since these images have low intensity value they appear lighter as shown in Figure (2) and the corresponding quality assessment is shown in Table 1. The images 3 and 4 which are taken at night time from different mobiles the output carrying information and clarity is different in for both the algorithm as presented in Table 1. The proposed algorithms enhance the contrast of the input image of low as well as images taken from mobiles at same instant as in Figure 2(b), 2(c). The simulation results clearly show that the improved output images have more clarity than the output images processed with only DCP. The Image quality assessment (IQA) measure the image quality consistently with subjective evaluations The parameters such as PSNR SNR SSIM(structural-similarity index), MSSIM(multi-scale 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 (2) and objective analysis as shown in Table 1.

PROBLEMS

The model proposed in this chapter presents a good result for images taken at proper illumination condition. It is better than previous method where enhancement is done by applying Dehazing model as shown in Figure 2a with respect to Figure 2b for real time images also. In the proposed algorithm involves three step which consumes more time than the previous method. In this paper images are captured from different capturing devices which indicates for correction of illumination is also considerable factor. But the overall result analysis is good from subjective point of view

Figure 2. Result analysis of proposed scheme



SOLUTIONS AND RECOMMENDATIONS

As hazy image is considered here so better illumination condition is difficult to provide as it depends on natural resources in some cases. So developing a more improved algorithm is necessary where filtering process that can be made adaptive in nature, the dehazing model can be performed by clearly getting depth and the improvement of contrast after haze removal process.

Table 1. Quality index assessment comparison between DCP Image and Dehazed image with αAce

SL N0		PSNR	SSIM	MSSIM	FSIM	FSIMc
IMAGE 1	WITH DCP	64.535	0.678	0.766	0.711	0.704
	WITH DCP & αACE	66.535	0.786	0.811	0.716	0.737
IMAGE 2	WITH DCP	62.534	0.567	0.678	0.714	0.697
	WITH DCP & αACE	65.533	0.768	0.798	0.756	0.735
IMAGE 3	WITH DCP	65.411	0.611	0.490	0.647	0.646
	WITH DCP & αACE	66.961	0.721	0.664	0.741	0.739
IMAGE 4	WITH DCP	61.011	0.430	0.572	0.865	0.841
	WITH DCP & αACE	66.313	0.623	0.752	0.863	0.842

FUTURE RESEARCH DIRECTIONS

As discussed in previous section we have considered the natural images which have some references data base and result is good .If this proposed method can be implemented in case where there is no reference image as shown in Figure 2a, 2b, and 2c and out can be further increased .Hence there should be more improved in the process to get more better quality image in output when it is consider as a non-reference image.

CONCLUSION AND FUTURE SCOPE

In this chapter we have adopted a new direction of restoration of hazy image based on both preprocessing and post processing in terms of WLS filter and color correction. In this chapter the proposal method is applied for images at different haze depth. But it can be extend to medical image processing confined to collect for information from color component and nuclear medical detection process. Developed in image acquisition process is also required as one of the major problem. Apart from its various invented machine learning approaches such as regression model can be applied to such problem domain. Further, other techniques are to be explored for betterdehazing process with proper image clarity.

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NOTE: *In this chapter we presented an algorithm for color correction in dehazing process. The weighted least squares (WLS) filter is a well-known edge preserving smoothing technique, but its weights highly depend on the image gradients. It helps to calculate the smoothing weights for pixels based on both their isotropy and gradients.*

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KEY TERMS AND DEFINITIONS

Color Correction: Color distortion corresponds to the varying degrees of attenuation encountered by light traveling in medium with different wavelengths, rendering ambient hazy, low light environments dominated by a bluish tone. Color correction model used to compensate the attenuation discrepancy along the propagation path in various medium, automatic color enhancement algorithm enhanced images by reducing noised level, better exposedness of the dark regions, improved global contrast while the finest details and edges are enhanced significantly.

Dehazing Model: Images obtained under adverse weather conditions, such as haze or fog, typically exhibit low contrast and faded colors, which may severely limit the visibility within the scene. Restoring the image structure under the haze layer and recovering vivid colors out of a single image is known as dehazing process. Various models such as DCP and CAP are used as prior based dehazed model.

WLS Filter: The weighted least squares (WLS) filter is a well-known edge preserving smoothing technique, but its weights highly depend on the image gradients. It helps to calculate the smoothing weights for pixels based on both their isotropy and gradients.