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Quality Improved Image Dehazing using Photometric Bound Processing

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Abstract- These days' images are the integral part of everybody's life in this world and the every mobile has the personal camera with them. These cameras are not having that much image enhancement the professional camera or other professional imaging device has. The images are captured are random and affected by environmental conditions like fog, moisture, dust particles and light intensities which can be reduced up to certain level during post processing of images. In this work an image defogging algorithm is proposed and analyzed with respect to its structural similarity and color difference. The proposed defogging algorithm is based on recursive wiener filtered photometric bound corrections. The optimum values of both the parameters are shown in the simulation results section which is better than the previous results.

Keywords - Haze, photometric bound, Weiner Filtering, Recursive Filtering.

I. INTRODUCTION

Digital images are subject to many potentially corrosive processes that introduce artifacts, deviations, and distortions in the course of image capture, compression, transmission and reproduction. Human observers can easily identify distortions, and can classify deviations that lead to images that appear unnatural (and thus degrade the quality of the image) separately from those that are natural (and do not degrade the quality of the image, or even improve it). For many years, the field of image quality assessment (IQA) has been structured around studying the set of distortions that are encountered in the processing of digital images, and human sensitivity to them. The goal of this field has been to build a metric, or model, that quantifies the visibility of different types of image distortions, which can be utilized to benchmark algorithms for all of the above processes in the image capture and display.

Images captured in bad weather have poor contrast and colors. The first step in removing the effects of bad weather is to understand the physical processes that cause these effects. As light propagates from a scene point to a sensor, its key characteristics (intensity, color, polarization, coherence) are altered due to scattering by atmospheric particles. Scattering of light by physical media has been one of the main topics of research in the atmospheric optics and astronomy communities. In general, the exact nature of scattering is highly complex and depends on the types, orientations, sizes and distributions of particles constituting the media, as well as wavelengths, polarization states and directions of the incident light [17; 47]. Depending on the sensor type (grayscale, RGB color) or the imaging cue used (contrast, color and polarization), we combine these two models in three different ways to describe image formation in bad weather. These 5 models together form the basis of a set of algorithms we develop in subsequent chapters for scene interpretation in bad weather. We also describe the validity of the models under different weather and illumination conditions.

Haze is constituted of aerosol which is a dispersed system of small particles suspended in gas. Haze has a diverse set of sources including volcanic ashes, foliage exudation, combustion products and sea salt (see [45]). The particles produced by these sources respond quickly to changes in relative humidity and act as nuclei (centers) of small water droplets when the humidity is high. Haze particles are larger than air molecules but smaller than fog droplets. Haze tends to produce a distinctive gray or bluish hue and is certain to effect visibility. In contrast to a haze-free image, a hazy image contains an additive component due to the atmospheric light contribution, and since haze is typically close to white, this component is present in all color channels.

Restoration algorithms are based on statistical priors for generating the depth map. In such prior based algorithms, as the problem is ill-poised, we presume certain statistical assumptions beforehand. Generally, the major limitation of such methods is, if the part of the image component resembles the whiteness of image, dehazing becomes a difficult task. The second major problem with this statistical prior based method is selection criteria of atmospheric light value and choice of filter for refinement of transmission map using edge-preserving smoothing filters.

To achieve the goal of haze removal and visibility improvement, several ways can lead to decent results. The methods can basically be divided into two groups, those methods that only need one single image for dehazing and those methods using 2 or more input images for one dehazed image. Also, there are model based methods and those trying to enhance the contrast of an image using simpler computer vision techniques such as gamma correction, unsharp masking or histogram equalisation. The model based methods usually produce a depth map of the scene as a byproduct; the variety of applications that could make use of the depth information seems to be endless. This examination proposed a quality improved image dehazing using photometric bound processing.

II. HAZE MODEL

Images of outdoor scenes often contain haze, fog, or other types of atmospheric degradation caused by particles in the atmospheric medium absorbing and scattering light as it travels from the source to the observer. While this effect may be desirable in an artistic setting, it is sometimes necessary to undo this degradation. For example, many computer vision algorithms rely on the assumption that the input image is exactly the scene radiance, i.e. there is no disturbance from haze. When this assumption is violated, algorithmic errors can be catastrophic. One could easily see how a car navigation system that did not take this effect into account could have dangerous consequences. Accordingly, finding effective methods for haze removal is an ongoing area of interest in the image processing and computer vision fields.

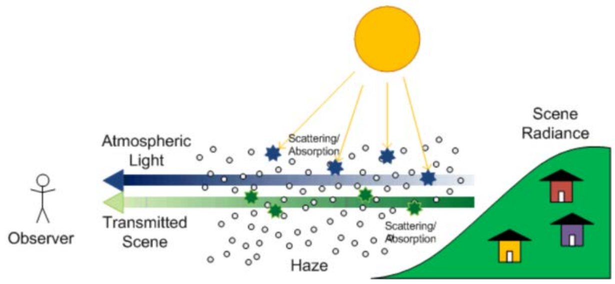

Fig. Haze Model.

A widely used model for haze formation is:

$$I(x) = R(x)t(x) + a\_\infty (1 - t(x) \dots\dots\dots\dots.(1)$$

where x is a pixel location, I is the observed image, R is the underlying scene radiance, $a\infty$ is the atmospheric light (or airlight), and t is the transmission coefficient. Intuitively, the image received by the observer is the convex combination of an attenuated version of the underlying scene with an additive haze layer, where the atmospheric light represents the color of the haze (figure 1.1). The ultimate goal of haze removal is to find R, which also requires knowledge of $a\infty$ and t . From this model, it is apparent that haze removal is an under-constrained problem. In a grayscale image, for each pixel there is only 1 constraint but 3 unknowns; for an RGB color image, there are 3 constraints but 7 unknowns (assuming t is the same for each color channel). Essentially, one must resolve the ambiguous question of whether an object's color is a result of it being far away and mixed with haze, or if the object is close to the observer and simply the correct color.

In order to make the problem easier, the atmosphere is generally assumed to be homogeneous. This has two simplifying consequences: the atmospheric light is constant throughout the image meaning it only has to be estimated once, and trans- mission follows the Beer-Lambert law:

$$t(x) = exp(-\beta d(x)) \dots\dots\dots\dots..(2)$$

Where β is the scattering coefficient of the atmosphere, and d is the scene depth. This allows recovery of the scaled scene depth if transmission is known and vice-versa.

Haze is an atmospheric phenomenon where turbid media obscure the scenes. Haze brings troubles to many computer vision/graphics applications. It reduces the visibility of the scenes and lowers the reliability of outdoor surveillance systems; it reduces the clarity of the satellite images; it also changes the colors and decreases the contrast of daily photos, which is an annoying problem to photographers. Therefore, removing haze from images is an important.

III. PROPOSED METHODOLOGY

In this examination, an effective method for image dehazing has proposed implemented and simulated in MATLAB image processing environment. The proposed optimized image dehazing method can generate visually compelling results. Moreover, our robust atmospheric light estimation method can produce better results than those presented in recent researches, which either assume a homogenous atmosphere or apply a difficult threshold to select the area part of the image. The proposed method can also avoid color distortion successfully.

When considering the effects of noise in the scene radiance recovery process, an important simplifying assumption is that the atmospheric light and transmission map are perfectly known. Although this is not generally the case, the conclusions drawn are still valid. Errors in the atmospheric light component will lead to some color biasing in the final image, which can be solved by performing white balancing as a post-processing step. Underestimating the transmission map results in some haze left in the image, while overestimating the transmission map leads to over-saturation. These effects can be suppressed by re-performing the dehazing process to remove additional haze, and by color post processing to reduce saturation. Fig. 3.1 shows the block diagram of proposed work. The proposed algorithm has the following essential blocks which are described as follows.

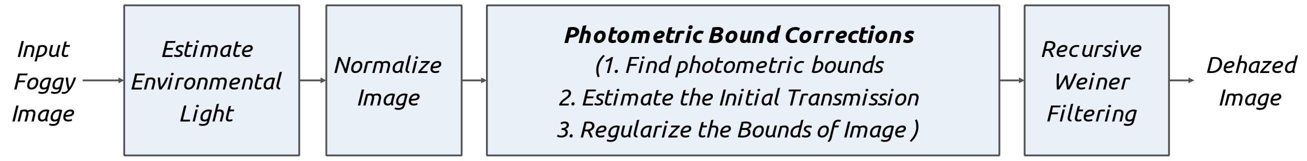

Fig.3.1 Block Diagram of Proposed Dehazing System

1. Environmental Light Estimation

The color of the most haze-opaque (smallest t) regions is considered as A. However, the detection of the “most haze-opaque” regions is not trivial, because the estimation of t is often after the estimation of A. So we cannot find such regions by the criterion of “smallest t”. Some methods require the user to mark such regions. But in most applications automatic methods are required. Unfortunately, the atmospheric light is rarely the sole illumination source. If the weather is not cloudy or overcast, the sunlight may go through the atmosphere and illuminate the scene objects. The light reflected or radiated by the clouds can also be another illumination source in hazy weather.

The light scattering of haze particles obeys Mie scattering that is all wavelengths of visible light scatter approximately identically. Therefore, the haze presented in the image has a whitish appearance. Based on this fact, it is common in existing image dehazing studies, for the atmospheric light constants ac, c = 1, 2, 3, to be estimated in the most haze-opaque region.

2. Normalize Image

The basic idea of image geometric normalization is to transform a given image into a standard form where this normalized form is independent of any possible geometric distortions applied on the image. Given an input image, geometric normalization systems designed to geometrically transform this image into a standard form such that the normalized image is invariant to geometric distortions. In addition, a robust normalization system should be able to perfectly normalize images, regardless of any additional image degradation such as noise contamination, cropping, etc. In general, the geometric distortions considered in geometric normalization systems are rotation, scaling and translation.

3. Photometric Bound Corrections

The photometric is the measure of intensity and brightness of image. The second method assumes that the observed source is constant in intensity and should only display Poisson fluctuations in the count rate in spectral regions free of airglow lines. The photometric bound correction has carried out in three steps. First find the photometric bound in sample image then estimate the initial transmission and regularize the bounds of image.

4. Recursive Weiner Filtering

The reverse filtering is a restoration strategy for deconvolution, i.e., when the image is degraded by a known lowpass filter, it is conceivable to recover the image by inverse filtering or summed up inverse filtering. However, inverse filtering is sensitive to added additive clamor. The methodology of decreasing one corruption at a time enables to build up a restoration algorithm for each sort of degradation and basically combine them. The Wiener filter executes an ideal tradeoff between inverse filtering and commotion smoothing. It expels the additive commotion and inverts the blurring at the same time. Recursive filtering rely upon the information values and past values of the yields too, thus the name recursive. The Recursive Weiner Filtering is applied on image filtering to get desired result. Process flow of proposed approach in MATLAB image processing has shown in Fig. 3.2.

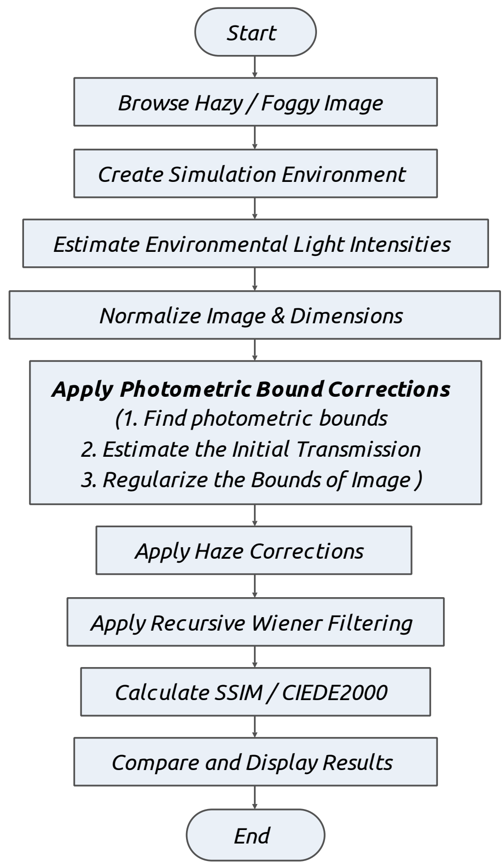

Fig.3.2 Algorithmic Execution Flow of Proposed Dehazing System

IV. EXPERIMENTAL RESULTS

The performance of proposed algorithm has been verified based on the simulation in MATLAB image processing tool. A large set of hazed images church, couch, flower1 and lawn1, were tested to evaluate the performance of our proposed algorithm, in comparison with the previous base work algorithms. Unlike other computer graphics problems, e.g. denoising, there is no direct quantitative assessment technique for the image dehazing results for the lack of reference images for benchmarking. It has been suggested that dehazing performance can be compared between images of a scene with and without haze. The quality of image can be examined based on visual observation as well as SSIM (Structural Similarity Index). The formula for calculation of SSIM is given in equation (3). Fig. 4.1 shows the simulation out come of dehazing of image using proposed algorithm. There are three Hazy image aye used to verify the performance of proposed algorithm. In Fig. 4.1 shows the Hazzy and Experimental Dehazed Images of church, couch, flower1 and lawn1 test images respectively. At the left hand side of Fig. 4.1 is a Hazy image and at the right hand side of the Fig. its corresponding dehazed image. The visual quality of image is clearly visible that dehazed images has more information as compared hazy image.

Fig. 4.1 Hazzy and Experimental Dehazed Images of *church*, *couch, flower1* and *lawn1* respectively.

The numerically characteristic of test image in terms of SSIM is plotted in table 1. In table SSIM and CIEDE2000 numeric value of proposed work and previous base work are given. The diffrence between proposed values and previous values are clearly visible and can be say that proposed algorithm has better haze removal capability as compared to previous work.

The Structural Similarity (SSIM) Index quality assessment index is based on the computation of three terms, namely the luminance term, the contrast term and the structural term.

$$SSIM(x,y) = [l(x,y)]^{\alpha}.[c(x,y)]^{\beta}.[s(x,y)]^{\gamma} \ldots\ldots(3)$$

To further demonstrate the performance of the proposed dehazing algorithm, the mean Structural Similarity (SSIM) and CIEDE2000 between the sample (input test image) image and the dehazed images of proposed algorithm, are listed in Table 1. It is easily observed that proposed algorithm yields the least best SSIM and CIEDE2000.

Table 1: Comparison of SSIM and CIEDE2000

Image	*SSIM*		*CIEDE2000*	
	Previous [1]	*Proposed[Our]*	*Previous [1]*	*Proposed[Our]*
church	0.84	0.862	7.077	3.576
couch	0.861	0.920	3.404	1.800
flower1	0.898	0.802	10.911	7.145
lawn1	0.84	0.947	6.196	12.116

The graphical representation of comparative analysis of proposed algorithm with previous algorithm in terms of SSIM is shown in Fig. 4.2.

The graphical representation of comparative analysis of proposed algorithm with previous algorithm in terms of CIEDEF2000 is shown in Fig. 4.3

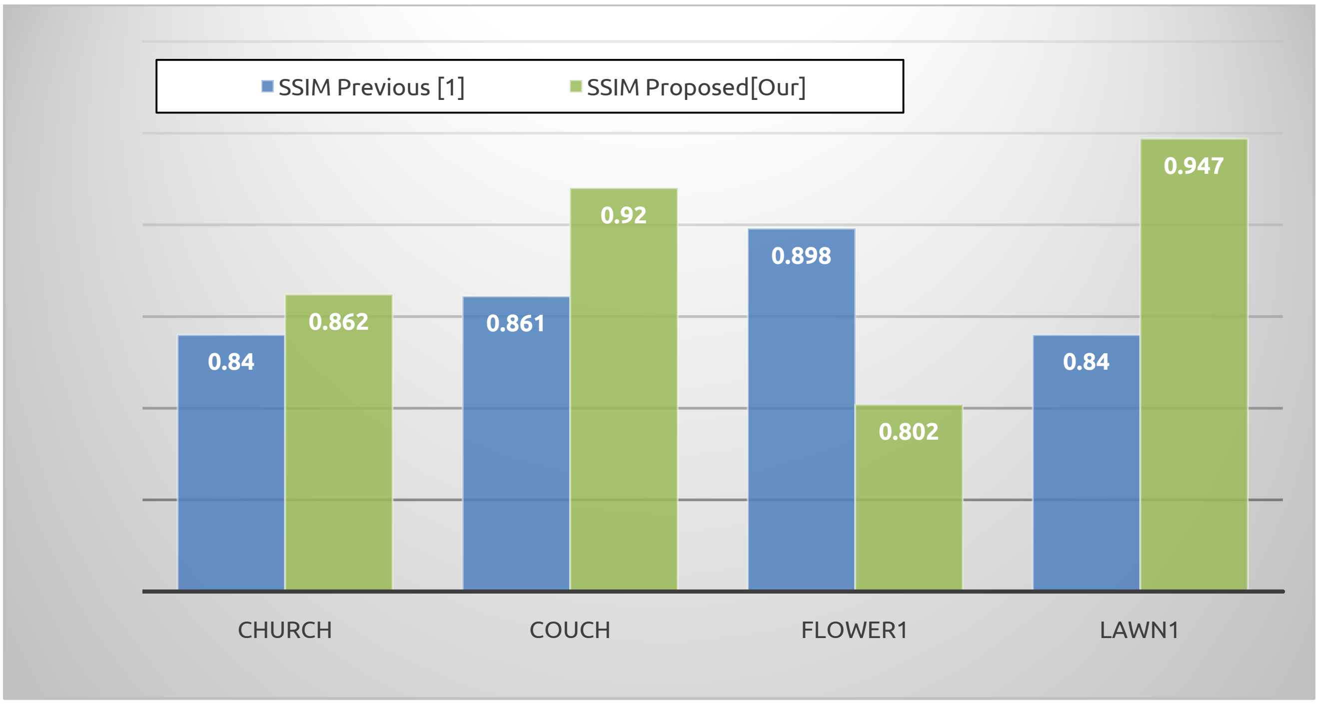

Fig.4.2 Comparison of SSIM

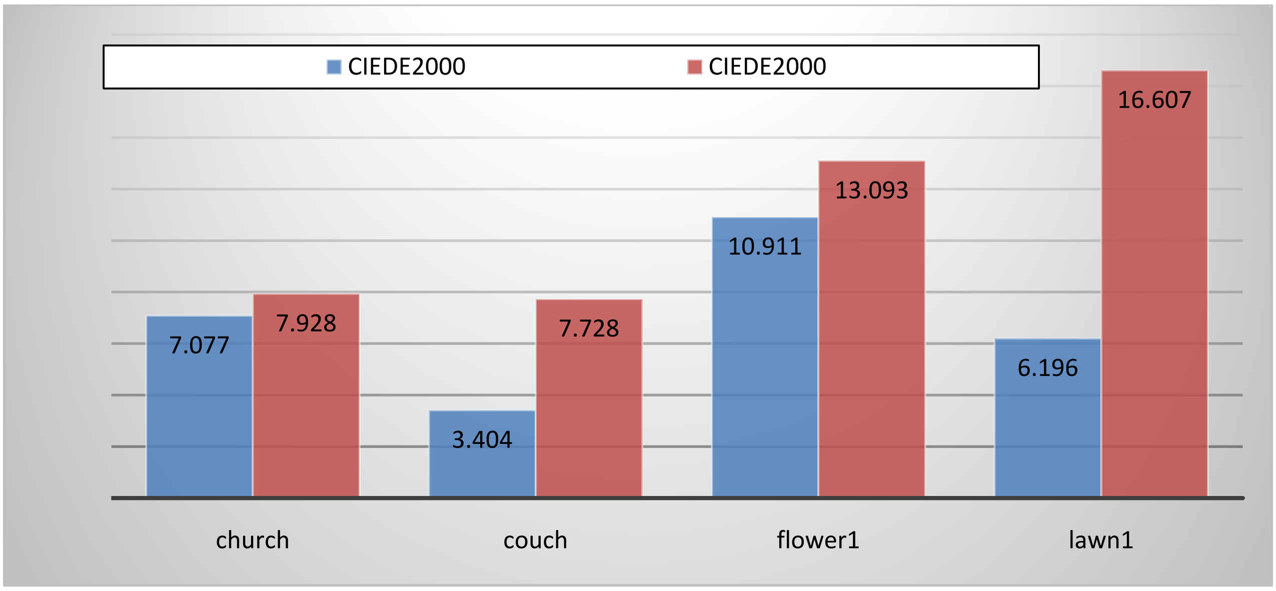

Fig.4.3 Comparison of CIEDEF2000

V. CONCLUSION AND FUTURE SCOPES

This examination addresses the problem of recovering the underlying scene radiance of a hazy image. The main contributions are as follows. Images and videos captured in hazy weather often yield low contrast and offer limited visibility due to the presence of haze in the atmosphere. Hazed images and videos, which suffer from biased colour contrast and poor visibility, unavoidably degrade the performance of various computer vision applications that require robust detection of image and video features, such as photometric analysis, object recognition and target tracking. Dehazing is used to restore the true appearance, i.e. recovering what the scene should have looked like on a clear day, by enhancing the colour contrast and sharpening the details in this examination using MATLAB. The performance of proposed algorithm has verified based on simulation. The proposed dehazed image have better visual quality as well as SSIM and CIEDEF2000 as compared to previous work.

Beyond the work presented in research exploration, there are several areas that deserve further research. Parameter Estimation: There are a number of parameters that must be chosen throughout the dehazing process. Improved Dehazing Algorithm: For this thesis, we used the dark channel prior for haze estimation, and al- though this method provides good results for colorful images, it tends to over-estimate the haze content in images containing many gray or white objects. Video: Another potential topic of research is expanding the presented haze removal and denoising process to video

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