Efficient Single Image Dehazing Using Filtered Non-Local Processing

Rajni Nagar[1], Prof. Damodar Tiwari[2]

[1]MTech. Scholar, [2]Research Guide

Deprtment of Computer Science and Engg, Bansal Institute of Science and Technology, Bhopal

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 mean filtered nonlocal means algorithm. The optimum values of both the parameters are shown in the simulation results section which is better than the previous results.

Keywords - Haze, Non-Local, Weiner Filtering, Recursive Filtering.

I. INTRODUCTION

Nowadays, outdoor applications of media such as broadcasting winter sport events, camera monitoring, and driver assistance systems are often exposed to bad weather due to the presence of atmospheric particles causing fog or haze. At the same time, fog or haze could have some benefits in the artistic domain through simulation or painting for instance. Often contain an atmospheric perspective - known also as aerial perspective - of a background scene, where further scene points were painted brighter and bluer. The term aerial perspective was first employed by Leonardo Da Vinci in his Treatise on Painting, in which he wrote: "Colours become weaker in proportion to their distance from the person who is looking at them.". Also called atmospheric perspective, aerial perspective is a method of creating the illusion of depth, or recession, in a painting or drawing by modulating color to simulate changes effected by the atmosphere on the colour of objects viewed from farther away. It is evident, then, that if painters use haze or fog to give the depth impression on their canvas, haze is quite important for one to perceive a scene as natural.

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.

A widely used model for haze formation is:

$$I(x) = R(x)t(x) + a_{\infty}(1 - t(x)) \ldots\ldots\ldots (1.1)$$

where x is a pixel location, I is the observed image, R is the underlying scene radiance, a_∞ 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_∞ 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.

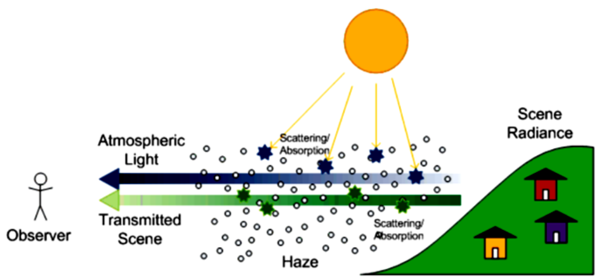

Figure: 1.1 Haze Model.

Due to the presence of haze particles, the quality of our daily photographs and videos is easily undermined. The haze particles not only scatter and attenuate the reflected radiance of the scene, but also scatter and add atmospheric light from the hazy medium to the camera sensor. The scattered atmospheric light, called airlight, veils the reflected radiance of the scene and leads to colour shifts in hazed images and videos. Therefore, haze in images and videos signify a combination of two scattering effects: direct attenuation of the scene radiance and undesired airlight.

$$Haze = Attenuation + Airlight \ldots\ldots\ldots\ldots (1.2)$$

II. SYSTEM MODEL

The evaluation of the haze model and dehazing algorithms is a major challenge for ensuring the quality of processed images. The perceived color shift between original and recovered colors represents a crucial element in such evaluation. There is a need to identify the cause of this effect: the amount of haze as physical limiting factor or the spectral dependence of the haze effects.

The striking similarity is the blue hue that the three have in common, this is the typical blueness of small haze particles as described. This can only be eliminated with model based techniques. These are just a few examples; there are actually many contrast manipulation algorithms available, mostly known from photography. It is considered humans have a minimum contrast threshold that is needed for object separation. Luckily, this contrast threshold can be raised in images using simple mathematical concepts like the gamma correction, unsharp masking or histogram equalisation. These were not developed to dehaze images, can however improve visibility for the human eye, hence they can also be used to further improve an already dehazed image. Thus for this purpose, they should not be used exclusively, but in combination with a dehazer.

The local smoothing methods and the frequency domain filter aim at a noise reduction and at a reconstruction of the main geometrical configurations. Due to the regularity assumptions on the original image of previous methods, details, texture and fine structures are smoothed out because they behave in all functional aspects as noise.

NL-means algorithm, whose aim is to remove the noise while keeping all these meaningful information. For this purpose, the NL-means algorithm tries to take advantage of the redundancy and self similarity of the image.

Denoising can also be performed by computing the average color of these most resembling pixels. The resemblance is much more reliable if it is evaluated by comparing a whole window around each pixel, not just the color of the pixel itself. These most resembling pixels to a given pixel may be far away. Think of the periodic patterns, or of the elongated edges which appear in most images. Thus, the spatial distance of the resembling pixels to the current pixel doesn't matter anymore.

The NL-means algorithm replaces the noisy value by a weighted average of all the pixels of the image. The weight of a pixel is significant only if a Gaussian window around it looks like the corresponding Gaussian window around the reference pixel. Thus the non-local means algorithm uses image self-similarity to reduce the noise by averaging similar pixels. This average preserves the integrity of the image but reduces its small fluctuations, which are essentially due to noise.

The NL-means algorithm is not only able to restore periodic or texture images. Natural images also have enough redundancy to be restored. For example, in a flat zone, one can find many pixels lying in the same region and with similar configurations. In a straight or curved edge a complete line of pixels with a similar configuration is found. In addition, the redundancy of natural images allows us to find many similar configurations in far away pixels.

Non local averaging

The most similar pixels to a given pixel have no reason to be close to it. Think of periodic patterns, or of the elongated edges which appear in most images. This algorithm scans a vast portion of the image in search of all the pixels that resemble the pixel in restoration. The resemblance is evaluated by comparing.

III. PROPOSED METHODOLOGY

At present, most open air image and video-surveillance systems, driver-assistance system and optical remote detecting frameworks have been intended to work under good visibility and climate conditions. Low visibility regularly happens in foggy or hazy weather conditions and can unequivocally impact the accuracy or even the general functionality of such vision frameworks.

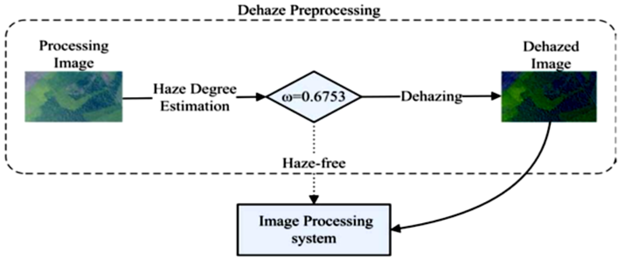

Fig.3.1 Sample dehazing flows by haze degree estimation, where ω is a haze factor defined.

Subsequently, it is imperative to import real time weather condition data to the appropriate processing mode. As of late, noteworthy advancement has been made in haze removal from a single image. Based on the hazy weather condition, specific methodologies, for example, a dehazing procedure can be utilized to enhance recognition. Fig.3.1 demonstrates an example processing stream of proposed dehazing approach. Despite its remarkable quality, determining weather data from an image has not been completely examined. Traditional algorithms are intended for specific applications or require human intervention. Weather acknowledgment frameworks for vehicles which rely upon vehicle-specific priors, have been examined.

Against this background, the fundamental goal of the proposed work is to build up an approach of stable algorithms for the recognizing foggy images and labeling the fog level of images by utilizing a factor with general applications. In research work, a haze degree estimation function to naturally recognize foggy images and label images with their corresponding haze degrees to remove haze from image. Effective single image dehazing utilizing filtered non-local processing methodology is proposed in this work. It depended on the atmospheric scattering model analysis and statistics derived from different outside images with the end goal to build up the estimation work. Fig. 3.2 demonstrates the block representation of proposed work.

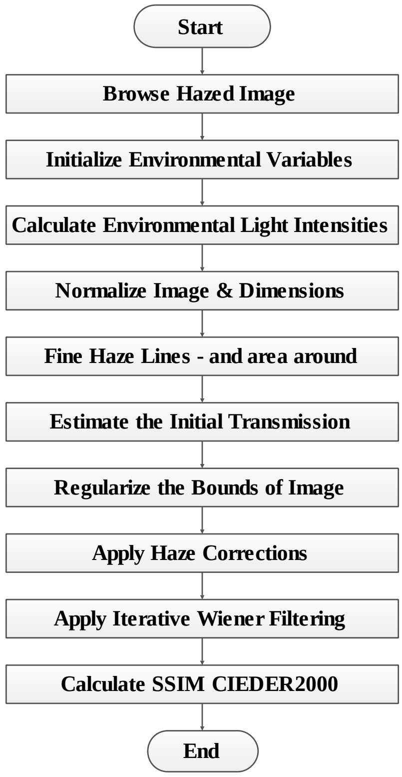

Fig. 3.3 Flow of proposed algorithm.

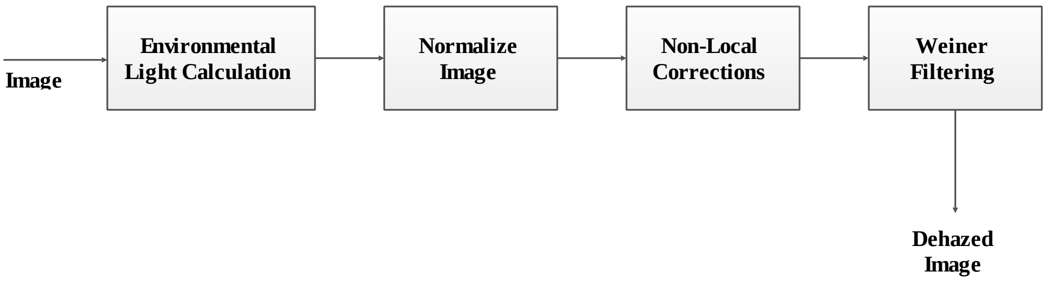

Fig.3.2 Block representation of proposed work.

The implementation execution and simulation of proposed algorithm has been completed in MATLAB image processing environment. Fig. 3.3 shows the process flow of proposed work in MATLAB simulation environment. To achieve optimum quality of hazy image a fine wiener filtering approach is used.

IV. EXPERIMENTAL RESULTS

The NL-implies algorithm chooses for every pixel an different average configuration adjusted to the image. As clarified in the system model, for a given pixel, consider the similarity between the neighborhood arrangement of pixels and every one of the pixels of the image. The similarity among pixels is estimated as a demising function of the Euclidean distance of the similarity windows. Because of the fast decay of the exponential part, substantial Euclidean separations lead to about zero weights, going about as a automatic threshold. The decay of the exponential function, and therefore the decay of the weights, is controlled by the parameter. Software simulation examination shows that one can take a similarity window of color images with little noise. These window sizes have appeared to be sufficiently expansive to be strong to noise and in the meantime to have the function to deal with the subtle elements and fine structure. Smaller windows are not sufficiently hearty to noise. In the limit case, one can take the window decreased to a single pixel and in this way return to the wiener neighborhood filter. Fig. 4.1 shows Hazzy and Experimental Dehazed Images of church, couch, flower1 and lawn1 respectively.

For computational aspects, in the following experiments the average is not performed with the pixels of the whole image. Because of the concept of the algorithm, the most useful case for the NL-algorithm implies is the periodic case. In this situation, for every pixel of the image one can find a large set of samples with a very similar configuration, prompting a noise optimization and a conservation of the original image. The performance of proposed image dehazing algorithm has been examined based on SSIM and CIEDEF2000 calculation and compared this parameters with previous base work algorithm outcomes for the same hazy test image. Table 1 shows the Comparison of SSIM and CIEDEF2000. It is examined that proposed algorithm has better performance in terms of visual quality of image along with SSIM and CIEDEF2000.

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

Graphical representation of SSIM for church couch, flower1, lawn1 image with corresponding base work outcomes are shown in Fig.4.2 SSIM Bar Chart Comparison and Graphical representation of CIEDEF2000 for church couch, flower1, lawn1 image with corresponding base work outcomes are shown in Fig.4.3 CIEDEF2000 Bar Chart Comparison.

Table 1: Comparison of SSIM and CIEDEF2000

Image	***SSIM***		***CIEDEF2000***	
	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

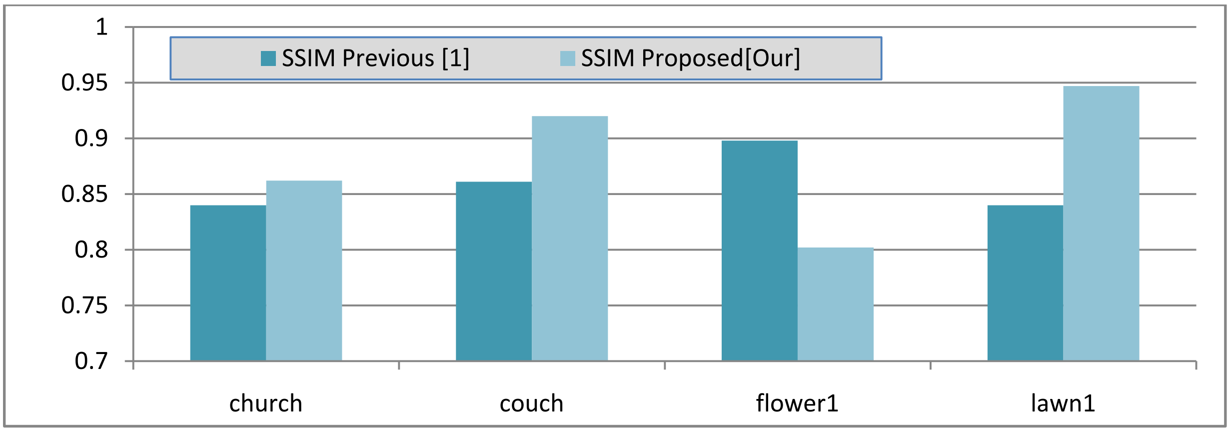

Fig.4.2 SSIM Bar Chart Comparison.

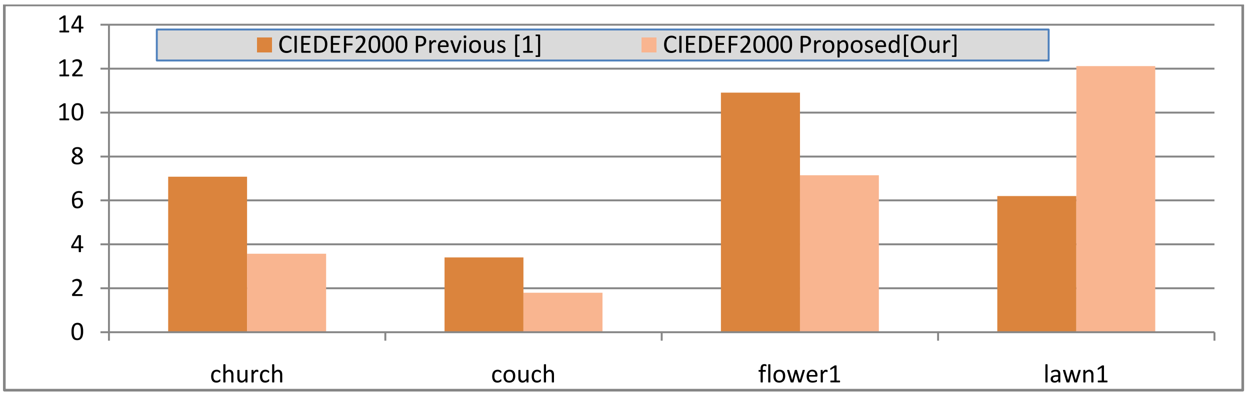

Fig.4.3 CIEDEF2000 Bar Chart Comparison.

V. CONCLUSION AND FUTURE SCOPES

In this research work, the haze removal problems and related issues have been studied and examined. A dehazing method has presented. Unlike existing single image dehazing methods, proposed approach focuses on the airlight component in the hazy image formation model rather than relying upon scene radiance priors. an efficient single image dehazing using filtered non-local processing is proposed in this research work and simulated in MATLAB image processing environment. Even though regularization is an essential process in dehazing, traditional regularization methods often fail with isolation artifacts when there is an abrupt change in depth, of which information is missing in single-image dehazing. A novel non-local regularization method that utilizes NNFs searched in a hazy image to infer depth cues to obtain more reliable smoothness penalty for handling the isolation problem. The validation of robust performance of proposed algorithm with extensive test images and compared it with the base work in terms of SSIM and CIEDEF2000.

In the future, there is a plan to study the problem under more general haze imaging situations, e.g., spatially variant atmospheric light or channel-dependent transmission. The problem becomes more ill-posed and new priors are needed. Also in future we may apply the fast guided filter in more computer vision problems. On the human vision study, It is expect to build a model to quantitatively explain the haze perception.

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