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Visibility Enhancement of Hazy Images using Depth Estimation Concept

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Abstract - *Image Enhancement is used to improve the contrast of the image having luminance. Image enhancement process removes the distortion from the image and improves the quality of the image. The image is captured in the outdoor scene are highly despoiled due to the reduced lighting situation or due to the soil particles. So, due to these particles the irradiation coming from the object is scattered and absorbed and hence the phenomenon of haze and fog occurs. Most of the researchers of the previous decade have proposed various methodologies to improve the visibility of the hazy images under the atmospheric conditions. This work proposes a methodology using depth estimation concept to improve the visibility of hazed images due to atmospheric troubles. The proposed methodology concentrated only on the depth estimation of the surface of the scene to camera lens and gamma correction factor has been applied at the final stage in order to obtain the output image as perfect as visible for the human eyes.*

***Key Words*: Image enhancement, Haze, Depth estimation, Gamma correction, weight maps, visibility restoration.**

1. INTRODUCTION

The main purpose of image processing is to identify, understand, interpret and investigate the data from the image pattern. Outdoor images taken in bad weather (e.g., foggy or hazy) usually lose contrast and fidelity, resulting from the fact that light is absorbed and scattered by the turbid medium such as particles and water droplets in the atmosphere during the process of propagation. Haze and fog are an atmospheric effect, but they are different: haze is thin and translucent effect while fog is thick and opaque. The haze is formed in the atmosphere due to the airlight and attenuation process. The concept of haze formation has illustrated in Figure1.

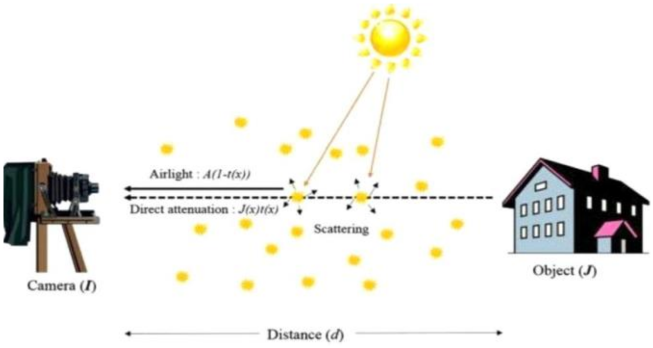

Fig -1: Haze formation concept

Moreover, most automatic systems, which strongly depend on the definition of the input images, failed to work normally caused by the degraded images. Therefore, improving the technique of image haze removal will benefit many image understanding and computer vision applications such as aerial, imagery, image classification, image/video retrieval, remote sensing and video analysis and recognition [1-5].

Haze removal (Dehazing) is highly desired in consumer/computational photography and computer vision applications. The process of removing haze can significantly increase the visibility of scene and correct the color shift caused by the airlight. In general, the haze-free image is more visually pleasing. Majority of the computer vision algorithms, from low-level image analysis to high-level object recognition, usually assume that the input image (after radio metric calibration) is scene radiance. The performance of many vision algorithms (e.g. feature detection, filtering, and photometric analysis) will inevitably suffer from the biased and low-contrast scene radiance. Finally haze removal can provide depth information and benefit many vision algorithms and advanced image editing. Haze or fog can be a useful depth clue for scene understanding.

Visibility restoration refers to different methods that aim to enhance the visibility of an image. The degradation may be due to various factors like relative object camera motion, blur due to camera misfocus, relative atmospheric turbulence and others. The image quality of outdoor screen in the fog and haze weather condition is usually degraded by the scattering of a light before reaching the camera due to large quantities of suspended particles (e.g., fog, haze, smoke, impurities) in the atmosphere. The quality of the outdoor image is purely depends up on the depth estimate from the camera lens to the object. This phenomenon affects the normal work of automatic monitoring system, outdoor recognition system and intelligent transportation system. Scattering is caused by to fundamental phenomena such as attenuation and air light.by the usage of effective haze removal of image the stability and robustness of the visual system can be improved haze removal is a tough task because fog depends on the unknown scene depth information. Fog effect is the function of distance between camera object. Hence removal of fog requires the estimation of air light map or depth map [6]. Since concentration of the haze is different from place to place and it is hard to detect in a hazy image, image dehazing is thus a challenging task. Early researchers use the traditional techniques of image processing to remove the haze from a single image (for instance, histogram-based dehazing methods [7-9]). However, the dehazing effect is limited, because a single hazy image can hardly provide much information. Later, researchers try to improve the dehazing performance with multiple images.

2. LITERATURE SURVEY

Image dehazing is a very challenging problem and most of the researchers have proposed various methodologies, strategies, models, and algorithms to improve the visibility of the images. Yoav Y. Schechaner et al [10] presented an approach for improving the visibility of hazy images based on the fact that usually airlight scattered by atmospheric particles is partially polarized. Their methodology using polarization works instantly, without relying on the weather conditions and they have presented the experimental results of completed dehazing in far from ideal conditions for polarization filtering. Recent researches in the field of visibility restoration of hazy images described that the images can be compensated for haze, and even yield a depth map of the scene. In order to recover the effected scene air light subtraction is necessary.

Generally the recovery requires the parameters of the airlight. An approach for blindly recovering the parameters required for separating the airlight from the measurement was proposed by S. Shwartz et al [11]. Srinivasa G. Narasimhan and Shree K. Nayer introduced a geometric framework for analyzing the chromatic effects. These authors studied a simple color model for atmospheric scattering and verify it for fog and haze and also derived several constraints on scene color changes based on the physics of scattering caused by various atmospheric conditions. Finally they have proposed an algorithm [12] for computing fog or haze color, depth segmentation, extracting 3 dimensional structures, and recovering the scene color from two or more images taken under different but unknown weather conditions using chromatic constraints. The vision systems are designed to perform only in perfect weather conditions but the real time applications essentially have the vision systems, which are performed in the outdoor bad weather conditions. Ultimately, the computer vision systems must include mechanism that enable them to function (even if somewhat less reliability) in the presence of fog, haze, rain, hail and snow. The authors of [12] have observed that the atmosphere modulates the information carried from a scene point to the observer; it can be viewed as a mechanism of visual information coding. Based on this observation they have developed models and methods [13] for recovering pertinent scene properties such as three dimensional structures from images taken under poor atmospheric conditions. From last two decades, a significant progress has been made in single image dehazing based on the physical model. Under the assumption that the local contrast of the haze-free image is much higher than that in the hazy image, Tan [14] proposes a novel haze removal method by maximizing the local contrast of the image based on Markov Random Field (MRF). Although tan's approach is able to achieve impressive results, it tends to produce over-saturated images.

Fattal [15] proposes to remove the haze from color images based on Independent Component Analysis (ICA), but the approach is time consuming and cannot be used for gray scale image dehazing, furthermore, it has some difficulties to deal with dense haze images. Inspired by the widely used dark-object subtraction technique [16] and based on a large number of experiments on haze-free images, He et al discover the dark channel prior (DCP) that, in most of the non-sky patches, at least one color channel has some pixels whose intensities are very low and close to zero. With this prior, they estimate the thickness of haze, and restore the haze–free image by the atmospheric scattering model [17]. The nighttime haze removal techniques are important and necessary procedure to avoid ill-condition visibility of human eyes. S. –C. Pei and T. –Y. Lee proposed a method that can be properly applied nighttime haze images even they have some ill-properties of low overall contrast, low overall brightness, refined Dark channel prior and bilateral filter in local contrast correction. Tremendous amount of research work has been done to improve the visibility of the hazy images under atmospheric conditions. This work aims to develop a methodology using depth estimation concept to improve the visibility of the hazy images.

The reminder of this work as organized as follows: section 3 describes the methodology to improve the visibility of haze images using depth estimation concept. Section 4 deals with experimental results. Section 5 concludes with a summary of the work presented.

3. METHDOLOGY

The basic concept of the proposed method as illustrated in figure 2. The images which are captured in the outdoor scenes are subjected to atmospheric troubles such as haze, fog and rain etc. In the proposed method input image is a hazy image.

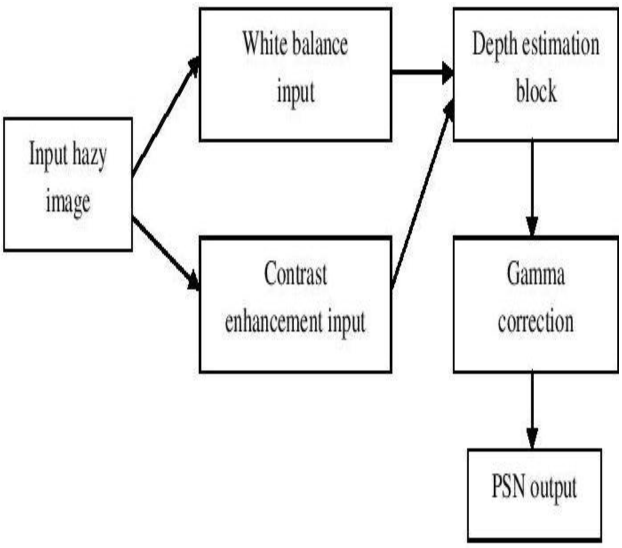

Fig -2: Basic concept of proposed methodology

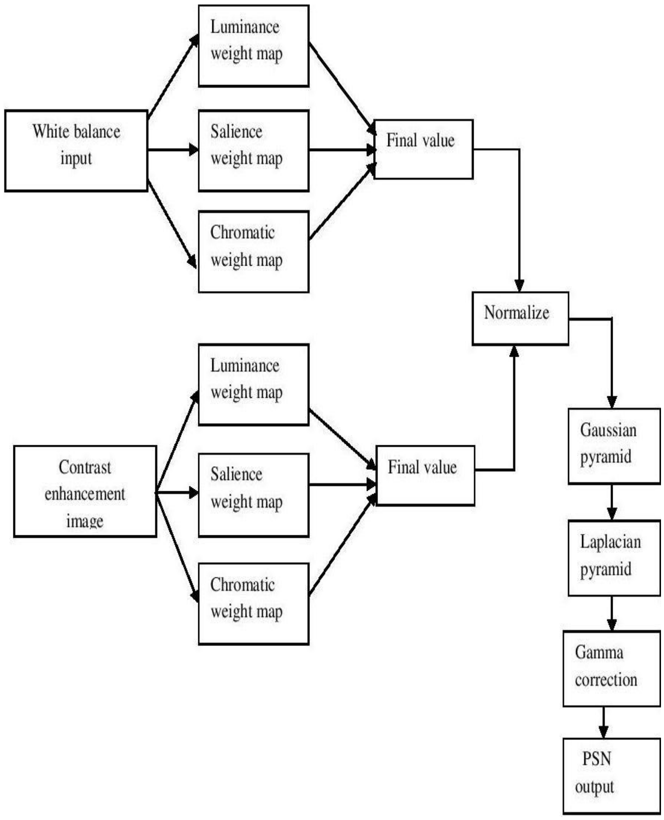

Fig -3: Depth estimation process

In order to identify the color temperature and the contrast levels the input image is converted into two individual inputs such as white balance input and contrast enhancement image. These two individual images are then applied to depth estimation block to identify the unknown depth information of the image from the camera scene for the visibility enhancement of the hazy images. A gamma correction factor has been applied to the output of the depth estimation process in order to improvising the visibility, which is perfect scene to human eyes. Finally PSNR has been calculated for both depth estimation output and final output after gamma correction. The depth estimation process involve in various segments such as finding the weight maps of individual images (for both white baleen and contrast enhancement), normalization of weigh maps and application of pyramids. The depth estimation process has been illustrated in figure 3.

The absorption and scattering effects in the atmosphere causes serious degradation in the images, especially in the form of noise, blur etc. sometimes images may have distortion due to the motion blur and refraction. Reconstruction of images from these atmospheric disturbances we have implemented min max filters for image restoration. Generally a distorted image tends to become flat in final result where we are controlling its luminance gain. It defines the standard deviation between luminance L and every R, G, and B color channels while preserving each input region. This map enhances degraded input but it may reduce the color and image contrast. For this reduced color and contrast we have defined other weights as Chroma (color) and saliency (global contrast). Chromatic weight map controls the saturation gain in the image and the saliency weight map defines the quality which contributes to degree of conspicuousness with respect to the neighborhood regions (see figures 7 & 8).

The outputs of each weight maps are normalized (changes the range of pixel intensity values) and then applied to Gaussian pyramid of length five. The image pyramid is a data structure designed to support efficient scaled convolution through reduced image representation. It consists of a sequence of copies of an original image in which both sample density and resolution are decreased in regular steps. These reduced resolution levels of the pyramid are themselves obtained through a highly efficient iterative algorithm. A five-tap filter was used to generate the Pyramid construction is equivalent to convolving the original image with a set of Gaussian-like weighting functions. These equivalent weighting functions for three successive pyramid levels. Note that the functions double in width with each level. The convolution acts as a low pass filter with the band limit reduced correspondingly by one octave with each level. Because of this resemblance to the Gaussian density function we refer to the pyramid of low pass images as the Gaussian pyramid. The Laplacian pyramid has been described as a data structure composed of band pass copies of an image that is well suited for scaled-image analysis. But the pyramid may also be viewed as an image transformation, or code. The pyramid nodes are then considered code elements, and the equivalent weighting functions are sampling functions that give node values when convolved with the image. A gamma correction has been performed to improvising the visibility for human eyes. Finally PSNR for depth estimated image and gamma corrected images are calculated.

4. EXPERIMENTAL RESULTS

The input hazy image has been dehazing using depth estimation concept as shown in figure 4. We can observe from the figures 5&6 the topmost region of the image is visible for human eyes when compare to figure 4. Then the weight maps for white balance and contrast enhanced images are performed and illustrated in figures 7 & 8 respectively. After the weigh maps the normalized output of weight maps has applied to the Gaussian and laplacian pyramids, where the unknown depth from camera lenses to object has been estimated and image visibility has been enhanced (see figure 9). A gamma correction factor was applied to the depth estimation output in order to improve the visibility for human eyes (see figure 10). The PSNR values of both depth estimated image and the gamma correction image has evaluated. We have observed that the gamma correction image is more attractive in visibility for human eyes when compared to depth estimation image. Table 1 illustrated the PSNR values of depth estimation and gamma corrected images.

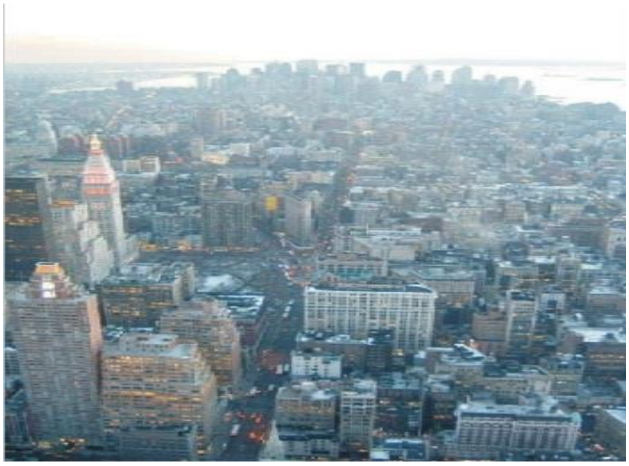

Fig -4: Input hazy image

Fig -5: White balance input

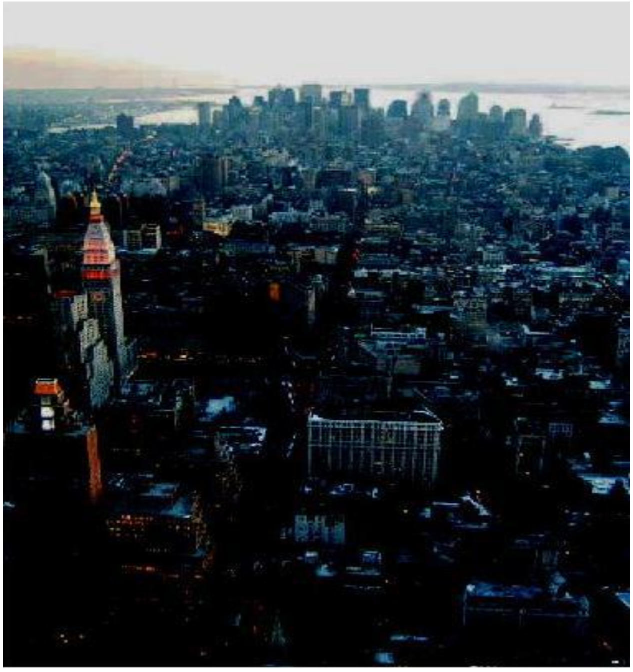

Fig -6: Contrast enhancement image

Fig -7: Luminance, salience and chromatic weight maps of white balance input from left to right

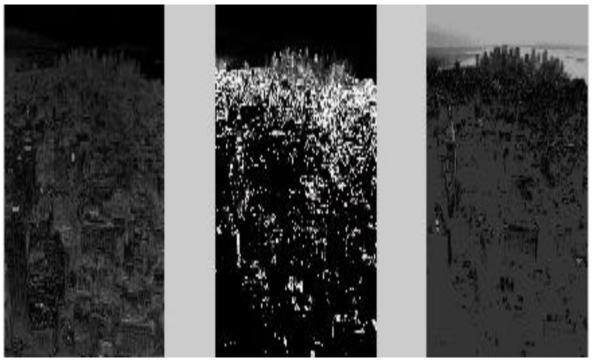

Fig -8: Luminance, salience and chromatic weight maps of contrast enhanced input from left to right

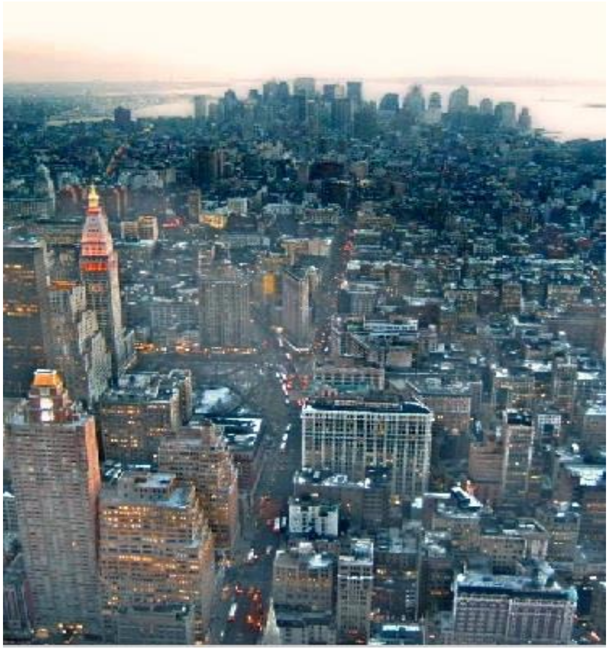

Fig -9: Depth estimation output

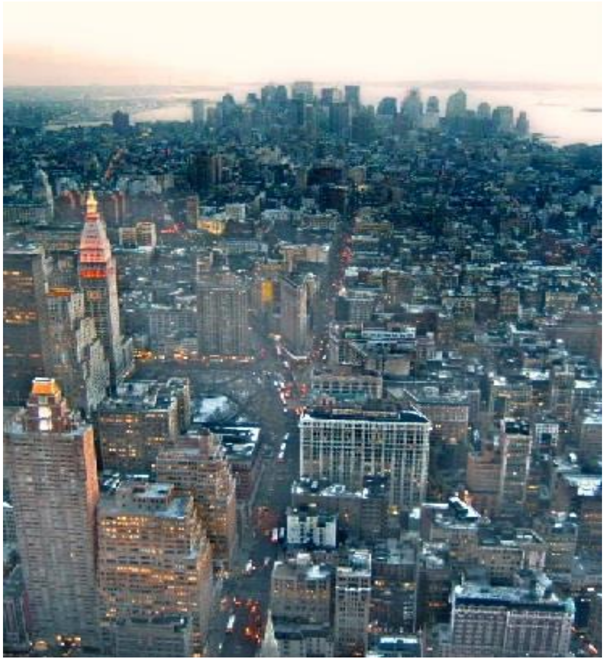

Fig -10: Output image after Gamma correction

Table -1: PSNR values of depth estimation and gamma correction outputs

Peak Signal-to-Noise Ratio(PSNR)	
Depth estimation output	Gamma corrected output
54.27	38.03

5. CONCLUSION

In this work we proposed a methodology that improves the visibility of hazy images. The methodology uses the depth estimation concept to restore the fine details of the degraded image. A gamma correction factor has been applied to the depth estimation output in order to enhance the visible clarity of the image. The PSNR values of both depth estimation and gamma correction images are evaluated. Gamma correction enhances the contrast levels of the image and we have showed that even in the high atmospheric troubles we get an visually perfect image. The PSNR value of gamma correction image is less than depth estimation image but the visibility is clear for human eyes.

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