BI-ORTHOGONAL WAVELET TRANSFORM BASED SINGLE IMAGE VISIBILITY ON HAZY SCENES

[1]P. Madhuri, [2]B. Swathi
[1]Assistant Professor, [2]PG Scholar
Department of Electronics and Communication Engineering
G. Narayanamma Institute of Technology and Science (for women), Hyderabad, India

Abstract: Digital Images having a prominent role in applications of our daily life like magnetic resonance imaging, computer tomography, satellite television and in department of research and technology. This paper represents Single Image Visibility Restoration of Hazy Scenes using Bi-Orthogonal Wavelet Transformation technique. The outdoor images which are captured in poor weather like fog and haze are referred as hazy images and these images reduces the contrast. The visibility of digital images will be poor due to presence of different atmospheric substances which absorb and results in light scattering between captured object and digital camera. Image Dehazing techniques are categorized into three approaches and those are additional information approach, multiple images approach and single image approach. Here, Single Image Approach is preferred because of its low cost and flexibility. Image dehazing model is proposed with utilization of adaptive gamma correction technique, median filtering and dark channel prior technique. Dark channel prior method [5] is used to estimate scene depth in single image and to estimate one color channel with low intensity. This restoration technique uses difference in color values and enhanced transmission to achieve a scene with better quality and haze free. Simulation results will show good haze free images with better contrast under different weather conditions. The goal of restoration from hazy image is achieved by using a software tool MATLAB.

Index Terms – Image, Image Denoising, Hazy Image, Image Dehazing, Bi-Orthogonal Wavelet Transform

I. INTRODUCTION

The important issue in images is presence of noise which is introduced because of compression and transmission errors. Mostly, natural images assumed to have additive random noise modelled as gaussian. To remove such noise from a noisy image, a method employed named as Image Denoising. The method which removes noise and preserves useful information of an image is referred as Image Denoising. The removal of noise from noisy image is one of the challenging task in Digital Image Processing. The challenging task in Image Processing is Image Dehazing. Three-dimensional image in real is converted to two-dimensional image by photo cells in camera which is used for capturing. To remove such haziness, Image Dehazing is employed.

The method of retrieving a clean image from a hazy image without any ambiguities is defined as Image Dehazing. The aim of image dehazing is to improve the effects of visuality of a hazy image and to remove effects of weather factors. Based on differences in principles of dehazing, Image dehazing methods [8] classified into three methods like Image Enhancement based methods, Image Fusion based methods and Image Restoration based methods. Image Enhancement based methods improves the quality of image in perception of human eye and directly enhances the contrast of an image. This Enhancement methods do not solve the physical model of degraded image. Image Fusion based methods increases extraction of information to have more detailed information from each channel. These methods collect related information from multiple source channels. Image Restoration based methods analyze the purposes of degradation of scenes. By analyzing reasons, appropriate restoration model is employed. Most of the researchers uses the general restoration model.

Single image visibility restoration method is one of the method of haze removal. This method is employed by applying Bi-Orthogonal Wavelet Transform. An Optical Imaging model is established to determine the factors of degraded scenes. This method removes the scattering of light due to atmospheric particles. Wavelet Transform is employed to determine the noise dominant regions in an image.

A Foggy Image Processing method is employed for haze removal. There are two methods i.e., non-model based image algorithms and model based algorithms. Non-model based algorithm highlights the details of foggy images, improves the level of contrast of foggy images and enhances the vision of foggy images. Consistence of adjacent images for video frames is guaranteed by nan-model based algorithms. Model based algorithms compensates the degradation n foggy images.

II. RELATED WORK

Earlier, **Bissonnette [9]** worked greatly to acquire more quality from images which are captured during rainy and foggy conditions. Recovering the image contrast by maximizing the local contrasts of hazy image is proposed by Tan. **Tarel and Hautiere [9]** employed non-linear filters to estimate air light scattering for easy haze removal.

Markov [9] established the adjustment of transmission map i.e., Gaussian Markov Random Field (GMRF). **Kratz et al [9]** used MRF algorithm to determine depth of information and scene albedo by assuming scene albedo is statistically independent.

Kaiming He, Jian Sun and Xiaoou Tang [5] proposed a new method of haze removal i.e., Haze removal using dark channel. Determination of transmission map, Soft Matting, restoring radiance of scene and atmospheric light estimation are the steps followed in Haze removal using dark channel prior.

Wencheng Wang and Xiaohui Yuan [8] proposed various removal of haze methods which are Image Enhancement based methods, Image Fusion based methods and Image Restoration based methods. Internally these methods had many different strategies.

K. Tan and J. P. Oakley [6] worked on enhancing the color of hazy images in poor weather conditions. This method is to determine the enhanced edges of scenes in turbid mediums.

S. C. Huang, Chen and Y. J. Cheng [3] explained an algorithm for haze removal. When driver keeps the lights of their vehicles in active and street lights are in activations which results in light scattered images. Algorithm helps to remove the haziness of images captured by ITS when drivers driving the vehicles in very fog and haze conditions.

III. PROPOSED METHODOLOGY

The entire method of Haze Removal involves the following strategies.

1. Optical Imaging Model of Foggy Weather
2. Foggy Image Enhancement Algorithm

3.1 Optical Imaging Model of Foggy Weather

The captured object which is in three dimensional is converted to two-dimensional by photo electric cells present in digital cameras. The sensors in cameras senses the atmospheric substances while capturing a foggy image which is combined form of Forward scattering (E_f), Backward scattering (E_b) and Direct transmission (E_d).

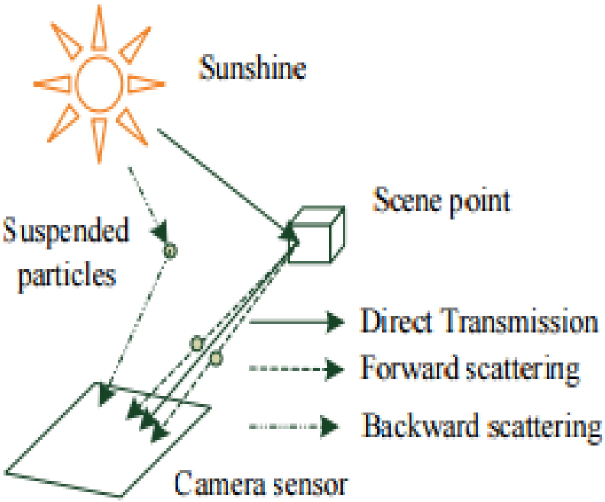

Figure 3.1: Optical Imaging Model

This model solves the problems facing when capturing a foggy image by optical devices such as cameras, lenses, microscopes, telescopes etc.

3.2 Foggy Image Enhancement Algorithm

The main objective of Foggy Image Enhancement algorithm is to remove the scattered light effect in medium regions of foggy image and to enhance the details of an image shown in Fig.3.2. This algorithm involves four major steps explained as follows:

1. **Color space transformation and wavelet transform:**
   The original foggy image in RGB (Red-Green-Blue) color format is transformed to the YUV color space that comprises of a luminance component (Y) and two chrominance components (U, V). Apply wavelet decomposition to the luminance component Y to get a low-frequency sub band (LL), and multiple high-frequency sub bands LH, HL and HH. Here LL, LH, HL and HH stands for low-low, low-high, high-low and high-high sub bands respectively.
2. In the low-frequency sub band of wavelet domain, the medium scattered light component of a foggy image is estimated and removed and the image is enhanced.
3. In the high-frequency sub bands of wavelet domain, adaptive enhancement of a foggy image is conducted.
4. Apply inverse wavelet transform to the enhanced wavelet image and obtain the enhanced luminance component. Y′ and UV components are reconstructed to form a clearer YUV image, and this YUV image is converted back to an RGB colored image.

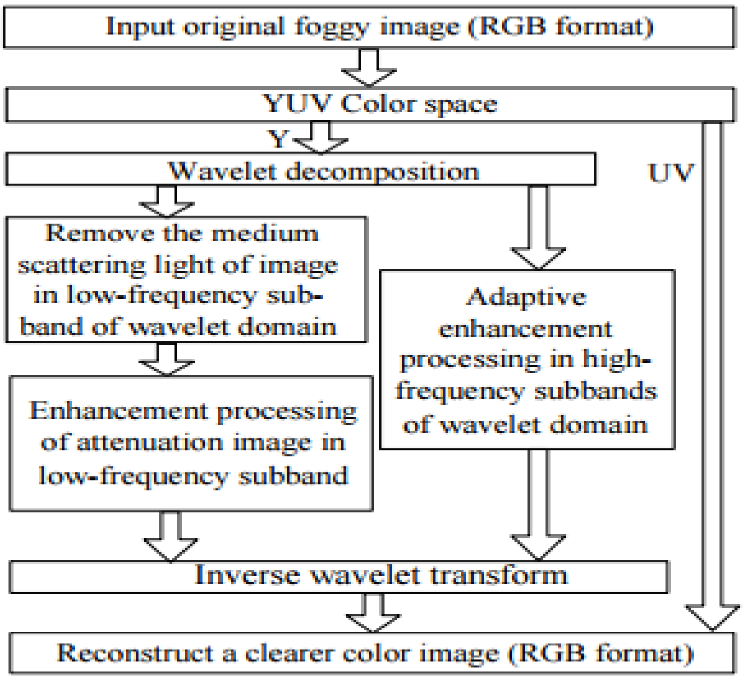

Figure 3.2: Foggy Image Enhancement Algorithm

In this algorithm, the image transform to YUV space separates the luminance component(Y) from the chrominance components. The wavelet transform decomposes Y further into a low-frequency sub band and several high-frequencies.

3.2.1 Bi-Orthogonal Wavelet Transform

Bi-Orthogonal Wavelet Transform is employed to determine the level of noise in different frequency bands. Wavelet Transform separates the image into four frequency sub-bands i.e., LL, LH, HL and HH as shown in Fig.3.3.

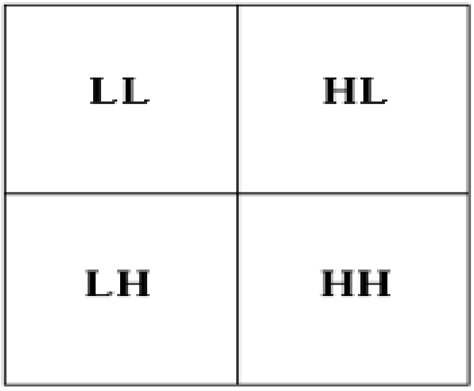

Figure 3.3: Four Sub-bands of Foggy Image

Where LL, LH, HL and HH represents Low to Low frequency, Low to High frequency, High to Low frequency and High to High frequency.

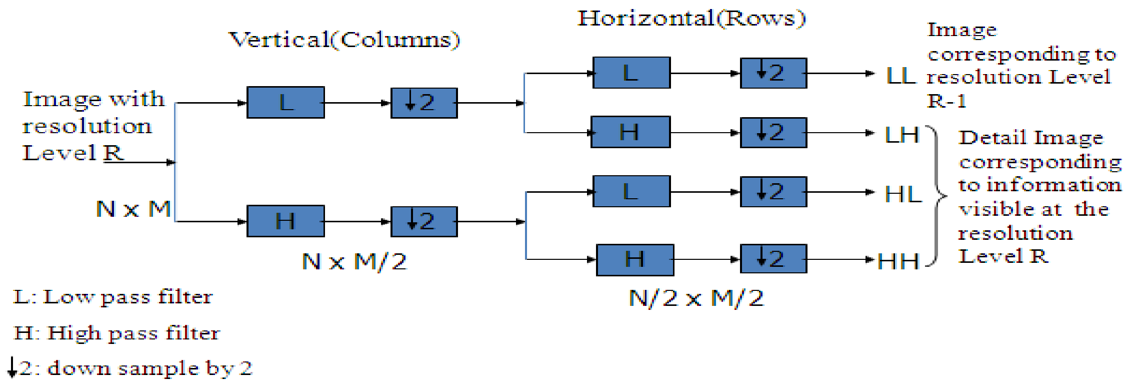

Figure 3.4: Flow Process of Wavelet Transform

There are three saturation level components like Luminance, Chrominance and Chromatic. Generally, Gray level is a measure of intensity and it is determined by energy but Luminance or brightness is determined by the perception of color. Chrominance convey the information of picture and chrominance components are digital sample values. Chromatic component is an objective specification of quality of a color regardless of luminance. Chromaticity consists of two independent parameters i.e., Hue and Colorfulness.

IV. RESULTS AND DISCUSSIONS

Simulation results of different hazy images Haze removal using Bi-Orthogonal Wavelet Transform based Single Image Visibility are shown from Fig.4.1 to Fig.4.16. Results of an original image namely "Nature with Girl" is shown from Fig.4.1 to Fig.4.8.

Figure 4.1: Original Image

Figure 4.2: YC_bC_r Conversion of an Original Image

Figure 4.3: Separation of YC_bC_r Converted Image into Three Components (Luminance, Chrominance and Chromatic)

Figure 4.4: Bi-Orthogonal Wavelet Transform of Luminance Component Image

Figure 4.5: Canny Edge Detection of Transformed Image in LL Band

Figure 4.6: Edge Enhancement of Canny Edge Detected Image

Figure 4.7: Inverse Bi-Orthogonal Transform of Edge Enhanced Image

Figure 4.8: Dehazed Image of an Original Image shown in Fig.4.1

The results of another image named as "Forest" is shown from Fig.4.9 to Fig.4.16.

Figure 4.1: Original Image

Figure 4.2: YC_bC_r Conversion of an Original Image

Figure 4.3: Separation of YC_bC_r Converted Image into Three Components (Luminance, Chrominance and Chromatic)

Figure 4.4: Bi-Orthogonal Wavelet Transform of Luminance Component Image

Figure 4.5: Canny Edge Detection of Transformed Image in LL Band

Figure 4.6: Edge Enhancement of Canny Edge Detected Image

Figure 4.7: Inverse Bi-Orthogonal Transform of Edge Enhanced Image

Figure 4.16: Dehazed Image of an Original Image shown in Fig.4.8

Table 4.1 gives the values of Peak Signal to Noise Ratio (PSNR) and Mean Square Error (MSE) of different types of input original images.

Table 4.1 PSNR and MSE values of above results

Name of an Image	PSNR	MSE
Nature with Girl	130.4961	0.1399
Forest	122.2977	0.3175
Canon1	86.9060	10.9345
Coins	92.9811	5.9561
Light House	169.1604	0.0029
Cameraman	123.9951	0.2679
Peppers	125.8975	0.2215
Rice	125.5485	0.2294

Similarly, for database of more images are simulated and their values of PSNR and MSE are calculated and listed in Table 4.1.

V. CONCLUSION

It is observed that the Single Hazy Image visibility restoration gives best results for removing the haziness from hazy or foggy image which is flexible and low-cost method using best software tool MATLAB. The usage of Wavelet Transform helped in determining the dominance of noise in different frequencies of an image so that the haziness can be removed easily. Bi-Orthogonal Wavelet Transform plays a unique role in this proposed method when compared to other methods employed by different researchers.

The values of Peak Signal to Noise Ratio (PSNR) shows the quantity of image details which are extracted by using Bi-Orthogonal Wavelet Transform based single image restoration without any haziness in a foggy image. Apart from this proposed implementation, many other different methods can be established in future for haze removal.

REFERENCES

[1] Fumitaka Hosotani, YuvaInuzuka, Masaya Hasegawa Shigeki Hirobhayashi and Tadanobhu Misawa. 2015. Image Denoising With Edge-Preserving and Segmentation Based on Mask NHA. IEEE Transactions on Image Processing, 24(12): 1-9.

[2] K. Tan and J. P. Oakley. 2000. Enhancement of color images in poor visibility conditions. IEEE ICIP, 2: 788-791.

[3] S. C. Huang, B. H. Chen and Y. J. Cheng. 2014. An efficient visibility enhancement algorithm for road scenes captured by intelligent transportation systems. IEEE Trans. Intell. Transp. Syst., 15(5): 2321-2332.

[4] J-P Tarel. 2012. Vision enhancement in homogeneous and heterogeneous fog**.** IEEE Trans. Intell. Transp. Syst. Mag, 4(2)**:** 6-20

[5] K. M. He, J. Sun and Xiaung Tang. 2011. Single image haze removal using dark channel prior**.** IEEE Trans. Pattern Anal. Mach. Intell., 33(12): 2341-2353.

[6] K.Tan and J. P. Oakley. 2000. Enhancement of color images in poor visibility conditions. Proc. IEEE ICIP, 2: 788-791.

[7] S. G. Narsimham and S. K. Nayar. 2003. Interactive (De) weathering of an image using physical models. Proc. ICCV Workshop Color Photometr. Methods Comput.: 1387-1394

[8] Wencheng Wang and Xiaohui Yuan. 2017. Recent Advances in Image Dehazing. IEEE, 4(3): 410-436

[9] Pucheng Zhou and Yuan Zhou. 2014. Single Image Haze Removal Using Dark Channel Prior and Fields of Experts Model. 11th International Conference on Fuzzy Systems and Knowledge Discovery. IEEE, : 820-824

[10] https://en.wikipedia.org/wiki/Edge-preserving_smoothing

[11] https://www.ijsr.net/archieve/v3i2/MDEwMjE0MDE=.pdf

[12] https://en.wikipedia.org/wiki/Kernel_(image_processing)

[13] https://courses.cs.washington.edu/courses/cse576/book/ch5.pdf