IMAGE ENHANCEMENT USING WAVELET DECOMPOSITION, SUPER RESOLUTION ALGORITHM & LUM FILTERS

K. Tejasri[1], Mrs. K. Rani Rudrama [2]

[1] P.G. Student, Department of Electronics & Communication Engg., Lakireddy Balireddy College of Engg., Andhra Pradesh, India
[2] Associate Professor, Department of Electronics & Communication Engg., Lakireddy Balireddy College of Engg., Andhra Pradesh, India

---***---

Abstract - ***Image processing is used in different areas like face recognition, gaming and medical fields. Image enhancement is a technique used to improve the quality of the image which suffers from poor contrast in bad weather conditions as fog whitens the captured image and decreases the visibility leading to the decline of image contrast, providing a foggy look to the images. Therefore, it is necessary to enhance the image captured in a bad weather or the foggy image. In this paper different techniques for enhancing the image quality like Wavelet transforms, LUM Filters and Super resolution algorithms are applied. Discrete Wavelet Transform (DWT) is applied to the image to divide the image into low frequency and high frequency components. The low frequency components are considered to improve the contrast of foggy image. In LUM filter the image is divided into windows and sub-windows. The sharpening techniques are applied to sub-windowed image resulting in the foggy image enhancement. In super resolution algorithm the intensity of the image is improved by adjusting the higher limits of the individual elements of the image. Finally all the techniques are compared by using entropy, peak signal to noise ratio, mean square error and standard deviation.***

Key words: *wavelet transformation, LUM (Lower Upper and Middle) Filter, Super resolution algorithm, entropy, PSNR, standard deviation and mean square error.*

1. INTRODUCTION

Weather conditions play very important role in outdoor image acquisition. As one of the most common weather conditions, rain, sunlight, fog has whitening effect on the scenery thus drops the atmospheric visibility by declining the contrast of the image.[1]. The image acquainted in the foggy weather may not be clear. The data acquired from the image can be seen that the low gray value is strengthened and the high gray value is weakened, leading to the over-concentrated distribution of pixel gray value which is an obvious contrast degradation problem [2]. Therefore the foggy images restoration [1] is also regarded as the image contrast enhancement problem. There by we can divide the enhancement technology into two methods: first one based on the time domain and the second one is based on the frequency domain.

Image resolution enhancement in the wavelet domain provides many new algorithms. Discrete wavelet transform (DWT) [5] is one of the recent wavelet transforms used in image processing. DWT decomposes an image into different sub band images, namely low-low (LL), low-high (LH), high-low (HL), and high-high (HH). Another recent wavelet transform which has been used in several image processing applications is stationary wavelet transform (SWT) [6]. In short, SWT is similar to DWT but it does not use down-sampling, hence the sub bands will have the same size as the input image.

The image enhancement algorithm can improve image's contrast and enhance image's detail. It is also enhancing the noise in the image, making the effect not very good. In order to achieved good results to enhance the foggy image in the wavelet domain LUM Filters [3] are used. The enhancement is inadequate thus the block effect is obvious due to the LUM filter's smoothing parameter and sharpening parameter [4] are fixed in some local areas.

In super resolution algorithm the inner intensity of the image is increased by considering luminance (intensity) and cromadisity (resolution) components of the NTSC values of the image.

In this paper different techniques for improving the image quality like Wavelet transforms, LUM Filters and Super resolution algorithms are discussed. In wavelet transform we used Discrete Wavelet Transform (DWT) by dividing the image into its low frequency and high frequency components. In LUM filter the image is divided into windows and sub-windows then by using sharpening technique the quality of the image is improved. In super resolution algorithm the intensity of the image is improved by adjusting the lower and higher limits of the individual elements of the image.

2. WAVELET DECOMPOSITION

In image resolution enhancement smoothing caused by using interpolation, the main loss is on its high frequency components (i.e., edges). In order to increase the quality of the super resolved image, preserving the edges is important. In this paper, DWT has been employed in order to preserve the high frequency components of the image.
Here, one level DWT is used to decompose an input image into different subband images. Three high frequency subbands (LH, HL, and HH) contain the high frequency components of the input image. In the proposed technique, bicubic interpolation is applied to high frequency subband images. Down sampling each of the DWT sub bands (LL, LH, HL, and HH) causes information loss in the respective subbands. Therefore, SWT is employed to minimize the information loss.

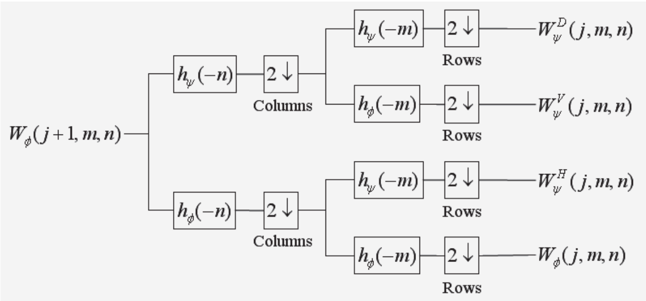

Fig-1: single level wavelet decomposition.

The SWT high frequency sub bands and the interpolated high frequency sub bands have the same size which means they can be added with each other. The new corrected high frequency sub bands are interpolated further for further enlargement. Also it is known that in the wavelet domain, the low resolution image is obtained by lowpass filtering of the high resolution image [16]. In other words, low frequency subband is the low resolution of the original image. Therefore, instead of using low frequency subband, which contains less information than the original high resolution image, we are using the input image for the interpolation of low frequency subband image. Using input image instead of low frequency subband increases the quality of the output image. Fig. 1 illustrates the block diagram of the proposed image resolution enhancement technique.

3. LUM FILTER

The usual output value from a median filter is denoted as m(k) at location k in a filter window of size N as follows:

$$m(k) = \mathrm{MED}\, w\{k\} = \mathrm{MED}\{x_1(k), .., x_n(k), x_{n+1}(k), ..., x_N(k)\} \quad (1)$$

Where MED is the median operation. The centre weighted median (CWM) filter with a variable centre weight w0 is an extension of the median filter. For example, the output y(k) of the CWM filter is given as:

$$y(k) = \mathrm{MED}\{x_1(k), .., x_n(k), \underbrace{x_{n+1}(k) \ldots x_{n+1}(k), ...}_{w_0 \text{ times}}, x_N(k)\} \quad (2)$$

Where w_0 denotes the non-negative integer weight. According to Equation (2), MED is determined from 2n + w_0 pixel values. Thus, when w_0 = 1; the CWM filter degenerates into a standard median filter; however, when w_0 is equal to or larger than the filter window of size N, the CWM filter becomes the identity filter, which outputs the original pixel value. Based on these observations, the performance of the CWM filter with a smaller centre weight is superior to that with a larger centre weight in terms of noise suppression, but inferior in terms of detail preservation.

3.1. LUM smoother

The output of the LUM smoother with parameter k is given by

$$y^* = \mathrm{med}\{x_{(k)}, x^*, x_{(N-k+1)}\}$$

where $1 \leq k \leq (N+1)/2$
Thus, the output of the LUM smoother is $x_{(k)}$ if $x^* < x_{(k)}$. If $x^* > x_{(N-k+1)}$, then the output of the LUM smoother is $x_{(N-k+1)}$. Otherwise the output of the LUM smoother is simply x*.
The reasoning behind comparing the middle sample x* to the lower- and upper-order statistics is that these order statistics form a range of "normal"-valued samples. If x* lies in this range it is not modified. If x* lies outside this range it is replaced by a sample that lies closer to the median. This creates a smoothing function. For example, if x* is an impulse it is likely to fall outside the range of the upper- and lower-order statistics. It would then be replaced with a value closer to that of the median, and the outlier would be removed.

3.2. LUM sharpener:

The LUM smoother and other rank-order smoothers obtain smoothing characteristics by shifting samples toward the median. To obtain sharpening characteristics, samples must be moved away from the median to more extreme order statistics. This is how the LUM sharpener operates. Before defining the LUM sharpener, let us first define a value centered between the lower- and upper-order statistics, $x_{(l)}$ and $x_{(N-l+1)}$. This midpoint or average, denoted t_l, is given by

$$t_l = (x_{(l)} + x_{(N-l+1)})/2$$

The LUM Sharpener is defined as the output of the LUM sharpener with the parameter l is given by

$$y^* = \begin{cases} x_{(l)}, & \text{if } x_{(l)} < x^* \leq t_l \\ x_{(N-l+1)}, & \text{if } t_l < x^* < x_{(N-l+1)} \\ x^*, & \text{otherwise} \end{cases}$$

Thus, if $x_{(l)} < x^* < x_{(N-l+1)}$, then x* is shifted outward to $x_{(l)}$ or $x_{(N-l+1)}$ according to which is closest to x*. Otherwise the sample x* is unmodified. The reasoning behind this sharpening operation is that if $x_{(l)} < x^* < x_{(N-l+1)}$ then x* is interpreted as being a transition sample in a slope region. By shifting it to an extreme-order statistic we are removing the transition points and creating a steeper slope and in many cases an ideal step edge.

4. METHODOLOGY

Super-resolution is based on the idea that a combination of low resolution (noisy) sequence of images of a scene can be used to generate a high resolution image or image sequence. Thus it attempts to reconstruct the original scene image with high resolution given a set of observed images at lower resolution.

The general approach considers the low resolution images as resulting from resampling of a high resolution image. The goal is then to recover the high resolution image which when resample based on the input images and the imaging model, will produce the low resolution observed images. Thus the accuracy of imaging model is vital for super-resolution and an incorrect modeling, say of motion, can actually degrade the image further.

The observed images could be taken from one or multiple cameras or could be frames of a video sequence. These images need to be mapped to a common reference frame. This process is registration. The super-resolution procedure can then be applied to a region of interest in the aligned composite image. The key to successful super-resolution consists of accurate alignment i.e. registration and formulation of an appropriate forward image model. The figure below shows the stages in super-resolution process.

Resolution and localization True resolution involves the distinction of whether a target, e.g. a star or a spectral line, is single or double, ordinarily requiring separable peaks in the image. When a target is known to be single, its location can be determined with higher precision than the image width by finding the centroid (center of gravity) of its image light distribution.

NTSC image components:

a) Luminance (Y): Black and white television came first. A black and white image only contains white, black and shades of grey. All these values could (and still can) be obtained merely by varying brightness.

In scientific terms, the brightness of light is measured in terms of Luminance. The word 'Luminance' is directly defined by CIE in relation to human vision. It is represented by the letter Y as far as video is concerned.

b) Chrominance (C): Chrominance is the part of a video signal which carries information about the attributes of the colors being displayed. The development of a technique for transmitting information about color paved the way to color television, a move which revolutionized the television industry.

As most object surfaces consist of a uniform material or a uniform composite of materials, the two chrominance channels of a color image ought to be piecewise constant. Because natural image statistics exhibit much less variability in a 2D chrominance space than in a combined luminance-chrominance space, we explore the chrominance space in search for useful image priors.

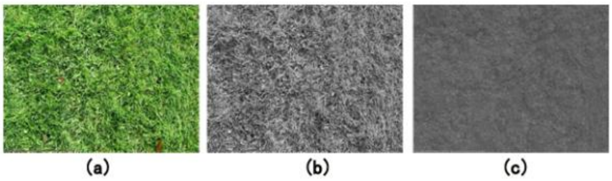

Fig-2 : Example of natural scene in YCbCr space; (a) original RGB image; (b) Y luminance channel; (c) Cb chromiance channel.

In this paper the internal luminance (intensity) 'Y' and the chrominance (Resolution) 'C' of the image are changed by using the MATLAB coding.

5. RESULTS AND DISCUSSION

Below figures show that super resolved image of foggy images using proposed super resolution technique is much better than the low resolution image as in original image, second image is by using the LUM Filter, and third image is by using wavelet decomposition. In order to show the effectiveness of the proposed method over the conventional and state-of-art image resolution enhancement techniques, four foggy test images with different features are used for comparison. Tables compare the MSE, PSNR, Entropy, Mean and Standard deviation performance of the proposed technique using super resolution for the given image. The results in Table I indicate that the proposed technique over-performs the aforementioned conventional and state-of-art image resolution enhancement techniques. Tables also indicate that the proposed technique over-performs the aforementioned conventional and state-of-art image resolution enhancement techniques.

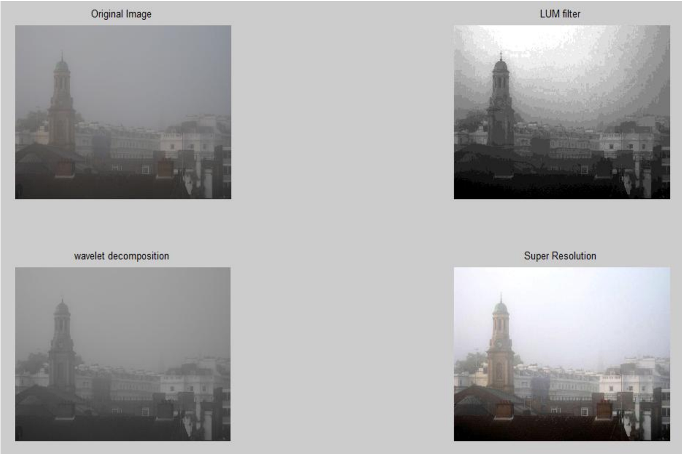

Fig-3: (a) Original low resolution foggy1 image. (b) LUM Filter output Image. (c) Wavelet decomposition output. (d) Proposed super resolution technique.

TABLE- I: MSE, PSNR, Entropy, Mean, Standard deviation results for foggy1 image

Image Type	MSE	PSNR	Entropy	Mean	Standard Deviation
Original	0.00	22.68	7.46	122.35	37.12
LUM Filter	0.03	13.44	7.28	127.48	75.25
Wavelet decomposition	0.00	33.40	6.67	122.31	37.20
Super resolution	**1.34**	**49.86**	**8.66**	**430.06**	**203.22**

.

Fig-4 (a) Original low resolution forest image. (b) LUM Filter output Image. (c) Wavelet decomposition output. (d) Proposed super resolution technique.

TABLE- II: MSE, PSNR, Entropy, Mean, Standard deviation results for forest image.

Image Type	MSE	PSNR	Entropy	Mean	Standard Deviation
Original	0.00	14.19	5.89	125.92	12.95
LUM Filter	0.06	10.12	8.06	128.12	72.98
Wavelet decomposition	0.00	26.50	6.00	125.79	15.53
Super resolution	**0.34**	**55.81**	**8.15**	**216.53**	**99.30**

6. CONCLUSION

This work proposed an image resolution enhancement techniques based on the wavelet decomposition, LUM Filter and the Super resolution Algorithm using the luminance and the chrominance components of the original image. In this paper DWT is used to decompose an image into different subbands, and then the high frequency subband images have been interpolated. The interpolated high frequency subband coefficients have been corrected by using the high frequency subbands achieved by SWT of the input image. An original image is interpolated with half of the interpolation factor used for interpolation the high frequency subbands.

The LUM filter algorithm can be used to choose the upper and lower limit of smoothing and sharpening parameter in order to retain the details of the image. This technique can be implemented in Moving Vehicles, especially during foggy days where the Vehicle driver would obtain an enhanced view of the road on the screen.

In super resolution algorithm the inner intensity of the image is increased by considering luminance (intensity) and cromadisity (resolution) components of the NTSC values of the image.

In wavelet decomposition the quality of the foggy image can be further enhanced by using multi-level decomposition. In LUM filtering technique by varying the window and sub-windowing size the quality of the image can be improved further. In super resolution technique in addition to Luminance and cromadisity, the in-phase (I) and quadrature (Q) components can also be considered to further enhance the image quality.

REFERENCES

[1] Sermsak Jaruwatanadilok, Akiram Ishimaru, Yasuo Kuga. "Optical Imaging through Clouds and Fog [J]", IEEE Transcations on Geosciences and remote sensing. 2003,41(8):1834~1843.

[2] Srinivasa G. Narasimhan, Shree K. Nayar, "Contrast Restoration of Weather Degraded Images [J]", IEEE Transcations on Pattern Analysis and Machine Intelligence, vol.25, No.6, June 2003.Nidhal k.Al abbadi, Nizar Saadi Dahir and Zaid Abd Alkareem,"Skin Texture Recognition Using Neural Networks".

[3] Yan Feng, Mingyi He, Weihua Liu, "A New Method Foggy Image Enhancement," Industrial Electronics and Applications,2009,ICIEA 2009.

[4] Hardic R C, Boncelet C G, "LUM filters: a class rank order based filters for smoothing and sharpening [J]", IEEE Trans. Signal Processing, 1993,41(3): 1061-1076.

[5] S. Mallat, A Wavelet Tour of Signal Processing, 2nd ed. New York: Academic, 1999.

[6] J. E. Fowler, "The redundant discrete wavelet transform and additive noise,"Mississippi State ERC, Mississippi State University, Tech. Rep. MSSU-COE-ERC-04-04, Mar. 2004.

[7] Hasan Demirel and Gholamreza Anbarjafari, "IMAGE Resolution Enhancement by Using Discrete and Stationary Wavelet Decomposition" IEEE TRANSACTIONS ON IMAGE PROCESSING, VOL. 20, NO. 5, MAY 2011

[8] Vigneswaran T, Vijay Krishna T and Sairam G, "Image Enhancement Using Wavelet Decomposition,Quadratic Thresholding and Auto-Adaptive LUM Filter".

[9] Tzu-Chao Lin; and Chao-Ming Lin, "DECISION-BASED ADAPTIVE LOW-UPPER-MIDDLE FILTER FOR IMAGE PROCESSING" International Journal of Innovative Computing, Information and Control ICIC International© 2011 ISSN 1349-4198 Volume 7, Number 10, October 2011

[10] Russell C. Hardie, Member, IEEE, and Charles G. Boncelet, Member, IEEE, "LUM Filters: A Class of Rank-Order-Based Filters for Smoothing and Sharpening".

BIOGRAPHIES

K.Tejasri has received her B.Tech from JNTU Kakinada with Electronics & Communications Engineering Specialization and at present she is pursuing M.Tech from JNTU Kakinada University, AP,India in the area of Systems and Signal Processing .She has actively involving in college level activities and technical symposiums.

Mrs. K. Rani Rudrama has received her Master's Degree from JNTUH in the Discipline of Digital System Design.She is pursuing her Ph.D in ECE.She has been actively involved in teaching and research for the past 16Years and she is working as Assoc Professor, in the Dept of ECE,Lakireddy Balireddy College Of Engineering, Mylavaram. AP, India