International Journal of Enhanced Research in Science Technology & Engineering, ISSN: 2319-7463
Vol. 3 Issue 1, January-2014, pp: (137-145), Impact Factor: 1.252, Available online at: www.erpublications.com

An Analytical Approach For Enhancement Techniques Over Multiple Foggy Images

Ashish K Saxena[1], Dr. Rajiv Srivastava[2]
[1]M. Tech Scholar, SIRT, Bhopal
[2]Professor & Director, SIRT, Bhopal

Abstract: Images plays a very important role in human being's life. They are very useful in all the problems we came across day by day. Such as, satellite images are used for traffic analysis or in developed cities traffic analysis is also done through the CCTV cameras. But images which are captured under bad weather conditions suffer low contrast so as their quality also degrade with the changes in atmosphere. The main reason behind this problem is that, the light capture by the lens is spread by the atmosphere. Many techniques since long time are being applied on these images but are not enough to remove weather affect from these images. The hazy, foggy or atmospheric conditions result as image color degradation and disturb the resolution and the contrast of the captured image under these weather conditions. In this work, we analyzed some existing methods used in image processing to remove hazy, cloudy or foggy affect. As the result of this analysis some efficient fog clearance techniques came across and this paper hence proposes an efficient fog removal technique with quality improvement. The proposed method is performed under two steps one is to remove fog from the image using prior dark channel information, and other is to enhance the quality of that image using fast Fourier transform. This technique covers the clearance of images captured in hazy, cloudy and foggy weather. The proposed algorithm can be employed on any type of color or gray scale images

Keywords: Foggy images, Fast Fourier Transform, Fog clearance, Image processing, Image enhancement.

Introduction

Any image captured in outside totally depends on atmospheric conditions if the weather is good image quality is good if the weather is bad quality of the image also decrease as conditions. One most universal weather environment is fog that has blurred or dim effect on the landscape, fall the atmospheric visibility that causes to the refuse of image contrast and generates vagueness to the image. There are reduced visibility record in awful weather condition due to the extensive occurrence of atmospheric particles that have a large volume and distribution in the contributing medium. Light from the atmosphere and light return of an object are absorbed and scattered by those particles, causes degradation in the visibility of the scene. Due to these abstractions it very difficult to extract information from image outdoor monitoring applications, object extraction and object tracking. Fog is responsible for degrade image quality and information such images contain a low gray value is strengthened whereas high gray value becomes weaken, that causes over-concentrated distribution of pixel gray value hence the contrast poverty problem .

Visibility is capable to travel light from the air to see objects in the presence of sunlight or any other light. If the air is clean and clear visibility is better in comparison to impure air with sand particle or water droplets. There are various reason influence visibility, including rain, fog, mist, haze, smoke, and in coastal regions sea spray, and they are usually composed mostly water droplets or the particles whose size cannot be ignored for the wavelength. The difference between fog, mist, and haze can be measured as the visibility distance [1]. Fall in visibility is caused by a deflection and scattering of light by particles and gases in the environment. Visibility is mostly decreased by spreading particles between an camera and object. Particles scatter light coming from the sun and reflected by an object to capture device lens, and the rest of the sky during the line of sight of the spectator, thereby reducing the contrast between the object and the background.

As a great improvement in the field of digital image processing this technique is used in vast applications such as image and video processing in traffic management or satellite image processing. The quality of image capture at outdoor totally depend on current weather conditions if the weather is clear image is so good but it could be worst if weather is bad. As the seasons foggy and rainy weather is most harmful weather for image obtain good quality image because of low contrast and visibility also color information of the image is lost, it results image less analysis and recognition capability. Weather condition becomes worst during good weather also out area seems like foggy due to pollution present in the air. Almost all image recognition and processing systems are developed for normal weather images, so restoration of foggy image is from the foggy image to remove the weather effect is very needful to improve image quality that has more applicable value. Figure 1 gives a demonstration of foggy image that how bad weather effect image in compares if it has been captured in normal clear weather. In figure 1 left side images are captured from a vehicle during clear weather and right side images are captured by same vehicle when fog is present in the air. It can easily observe how the fog effect quality of the image, hence image processing is not possible for these types of image for any application or recognition.

It also decreased user visibility on the road and increases possibility of road accidents. If any good fog is removed method is applied efficiently to these image users could have great visibility during bad weathers to minimize accident possibility also any technique easily apply The conventional schemes for picture dreadful conditions are using every type of low filters to remove the effects of noise, but they are not appropriate for the foggy environment image. A foggy weather has plenty of vaporizer atoms in the environment, these atoms break the path of light, also influence the distribution of the light spread, so it affects the feature of the image, and the contrast of the image fall according to raise the distance of objects from camera. Many researchers till now are focused on the foggy removal image enhancement and proposed many methods for foggy degrading images.

Fig. 1: Effect of fog during bad weather condition on road traffic

International Journal of Enhanced Research in Science Technology & Engineering, ISSN: 2319-7463
Vol. 3 Issue 1, January-2014, pp: (137-145), Impact Factor: 1.252, Available online at: **www.erpublications.com**

Related Work

As a fog effect reduces quality of image, information and color are blurring hence many works try to clear bad weather images. As mentioned in [1] based on ambiance light model to compute the light and the depth of the scene. This method can evaluate the scene correctly and need no additional information, so the restoration effect is fine, but the significant shortcoming is the computation time is very long and not suitable for real-time image processing.

To remove weather effect using histogram equalization [2,3], there are two main methods for histogram equalization first one is global histogram equalization and second is local histogram equalization. The global histogram equalization technique is very easy and fast, but the result of image is also poor, on other hand local histogram equalization scheme involves massive calculation costs. So lots of researchers have given several better algorithms extended version of histogram equalization, the method of paper [4] is using an area segmentation process to remove a flat area from the image, the local histogram equalization method is used in the non-flat area. Author in [4] mentioned an successful technique to correct the ruined image by subtracting the estimated airlight map from the degraded image. The airlight map is generated using multiple linear regression, which shows the relationship between local airlight and the image pixel's coordinate. Assumption of airlight can be done using a cost function that relies on human visual model, where eye is more insensitive to changes of the luminance in bright area than in dark area. For this purpose, the luminance image is used in airlight estimation. The luminance image is generated by an suitable fusion of the R, G, and B components. Another method states [5] a physical model to improve the degradation of bad visual image.

All image processing techniques presented for image related problem solving or recognitions can get correct results in clear weather. For some images taken in a tremendous environmental situation like foggy or cloudy sky proposed image processing schemes are hard to recognize the horizon correctly. Paper [6] contributes a strong, vision-based horizon discovery method good in such type situation. This method supports a dark channel prior, which illustrate the depth of fog naturally. The horizon can be effortlessly determined in dark channel. This method good and robust for heavy foggy weather conditions in synthetic vision system.

Paper [7] states a valuable method for visibility improvement from a single gray or color image to identify and eliminate haze. Haze focus in one factor of the multilayer image, the haze-free image recreates through haze layer evaluation based on the image filtering method by low-rank and the overlap averaging scheme. This method uses dark channel prior information and normalized transmission coefficient is evaluated to recreate the image without fog. This method is easier and well-organized method for clarity enhancement and contrast enrichment for a solo foggy image.

The depth information of the foggy image is extracted according to the foggy image model and the prior knowledge. Secondly, the transmission ratio of the atmosphere light is estimated and adjusted, and the atmosphere light A is also estimated. At last, the gamma adjustment is used to get the final enhancement image. Comparing with the other method, the speed is faster than the one in reference. Seen from the experimental results the method seen in the paper [8] is suitable for the application need fast computation. Comparing with retinex method, the deblurring effect of the algorithm stated in this paper is better than the one obtained from retinex method.

TABLE I. TABLE I. FREQUENCY TECHNIQUES FOR IMAGE ENHANCEMENT

Author	Year	Model	Processing techniques	Application
Guang Deng [9]	2012	HE based Logarithmic Transform LTHS	The log reduction zonal magnitude technique; Logarithmic transform histogram shifting	Traffic monitoring Security Surveillance
Hao Hu [10]	2010	Content adaptive video processing model	Content classification and adaptive	Processing Computer vision
Tarik Arici [11]	2009	HE based modification	Histogram modification framework, content adaptive algorithm	LCD display device; Low quality video
Ali, M.A [12]	2012	Dynamic range compression	Discrete Cosine transform (DCT); Retinex theory	Image/video compressing
Viet Anhnguyen [13]	2009	Cauchy distribution model; AC transform coefficient	Video reconstructed from multiple compressed copies of video content	Compression video
R.C. Gonzalez [14]	2008	HE	Global Histogram Equalization	Image/ Video Security Surveillance
Xuan Dong [15]	2010	Image Inverting Model	Inverting the input low lighting video; dehaze algorithm	Traffic monitoring; Medical imaging
Shan Du [16]	2010	ARHE model	Adaptive Region based Method	Face Recognition

Author	Year	Model	Processing techniques	Application
Iwanami, T. [17]	2012	Dynamic Histogram equalization	Dynamic Histogram Equalization technique	Medical Image, Low quality video
Boudraa A.O [18]	2008	2DTKEO model	2D Teager- Kaiser Energy Operator	Medical image; Satellite image
David Menotti [19]	2007	MHE model	Multi histogram equalization methods	Image processing
Sara Hashem [20]	2010	Improve HE	Genetic algorithms	Compute high dynamic range image processing
George D [21]	2009	Improve HS and HE	Histogram based image enhancement	Image processing
Naidu V.P.S. [22]	2011	Fast Fourier Transform (MFFT)	Multi-resolution image analysis	well suited for real time applications
Jing Wang [23]	2010	FFT	2-D FFT removal	Removing strain image artifacts
Tzimiropoulos, G. [24]	2009	Gradient-based methods	FFT-based correlation	Images from popular database

All other techniques comparison based on frequency filtering or frequency domain for image enhancement is given in Table I

I. Discrete Fractional Transforms

The entire entity going into part as fractions of it signify major theoretical increase. We can express 34 = 3×3×3×3, but still it cannot be deduced that how 33.5 can be defined. It is somehow timeconsuming to deduce 33.5 = 37/2 = √ 37. The first and second derivative of the function f (x) is commonly denoted by df (x)/dx and d2f(x)/dx = d/dx[df(x)/dx] = d[df(x)/dx]/dx = (d/dx)2f(x) respectively. Similarly higher order derivatives are defined. The 2.5-th derivative of a function is not defined from here. Let F (μ) denote the FT of f (x). The FT of the n-th derivative of f(x) ie dnf(x)/dxn is known to be given by (j2πμ)nF(μ) for any positive integer n. Now let us generalize this property by replacing n with the real order a and take it as the a -th derivative of f(x). Thus to find daf(x)/dxa , the a-th derivative of f(x), find the inverse Fourier transform of (j2πμ)aF(μ). These two above examples deals with the fractions of an operation applied on an entity, but not on fractions of the entity. The function [f (x)]0.5 is the square root of the function f(x). But d0.5f(x)/dx0.5 is the 0.5-th derived part of f(x), with (df(x)/dx)0.5 being the square root of the derived part operator d/dx.

The method of getting whole of an entity from fractions of it causes several of the more important conceptual developments. For an instance the fuzzy logic, where the binary 1 and 0 are substituted by continuous values representing faith or improbability of a proposition. The fractional Fourier transform (FrFT) was came into existance in 1980 by Victor Namias and it was recognized in the same time period that the other transforms could also be fractionalized. Its enhancement and mathematical meaning were explored by McBride and Keer in 1987.

II. Discrete Fractional Fourier Transform

Firstly three requirements are satisfied by itself when the fractional transform is defined by a spectral development. Assuming $P_k[n]$ to be an random orthonormal eigenvector set of $N \times N$ the DFT matrix and λ_x to be the related eigenvalues, the discrete analog is

$$F^a[m,n] = \sum_{k=0}^{N-1} p_k\,[m](\lambda_k)^a p_k[n]$$

Which contains a description of the discrete fractional Fourier transform matrix . since the transform matrix is unitary ,the eigen values $\lambda_k = \exp(-j\pi k/2)$ of the DFT matrix have unit size [31]. Reduction to the DFT when α=1 follows from the fact that when , above equation reduces to the spectral expansion of the ordinary DFT matrix.

III. Discrete Fractional Cosine Transform

Discrete fractional cosine transform (DFrCT) is completed by discrete Fourier transform (DFrFT). DFrCT is also a common form of the discrete cosine transform (DCT), which has a related connection with that between DFrFT and the discrete Fourier transform (DFT).

The DFrCT and DCT have many similar features, and it has a free parameter, its part. When the part is zero, we get the cosine modified version of the input signal [29]. When it is unity, we get the conventional DCT. The DCT of a sequence $\{x[n],\ 0 \le n \le N-1\}$ is defined by:

$$X(k) = \alpha(k)\sum_{n=0}^{N-1} x[n]cos\left[\frac{(2n+1)\pi k}{2N}\right], 0 \le k \le N-1$$

Where

$$\alpha(k) = \begin{cases} \frac{1}{\sqrt{N}} for\ k = 0 \\ \sqrt{\frac{2}{N}}\ \ for\ 1 \le k \le N-1 \end{cases}$$

The contents of single dimensional DCT kernel matrix are expressed as

$$E_{DTC}(k,n) = \begin{cases} \frac{1}{\sqrt{N}}, k = 0; 0 \le n \le N-1 \\ \sqrt{\frac{2}{N}}\cos\left[\frac{(2n+1)\pi k}{2N}\right]; \\ 1 \le k \le N-1; 0 \le n \le N-1 \end{cases}$$

As the sequence is orthogonal, the inverse DCT (IDCT) can be gained by

$$x[n] = \sum_{k=0}^{N-1} \alpha(k)X(k)\cos\left[\frac{(2n+1)\pi k}{2N}\right], 0 \le n \le N-1$$

IV. Haze Removal Techniques

Fast fog removal Method and Image Enhancement:

A faster method of foggy image enhancement is given in this section. Firstly, the depth information of the foggy image is extracted according to the foggy image model and the prior knowledge. Secondly, the transmission ratio of the atmosphere light is estimated and adjusted, and the atmosphere light A is also estimated. At last, the Gama adjustment is used to get the final enhancement image. Comparing with the other method, the speed is faster than the one in reference [8].

The model of the foggy image

In computation visual the model of foggy image is shown as follows,

$$I(x) = J(x)T(x) + A\big(1 - t(x)\big) \qquad (1)$$

where I(x) is the foggy image, J(x) the image without fog, A the atmosphere light, t(x) the ratio of transmission. The object of remove fog is to recover J(x), A and t(x). The first item in the right hand side of equation (1) J(x)t(x) is called direct attenuation, and the second item A(l -t(x)) is called air light component. The direct attenuation describes the scene radiance and its decay in the medium, while air light results from the scattered light previously and will lead to the color shift of the scene. Because the atmosphere is homogenous, the ratio of transmission is expressed as,

$$t(x) = e^{-\beta d(x)} \qquad (2)$$

Where β is the scattering coefficient of the atmosphere. It indicates that the scene radiance is attenuated exponentially with the scene depth d.

According to equation (1), it can be obtained,

$$t(x) = \frac{\|A - I(x)\|}{\|A - J(x)\|} = \frac{A^C - I^C(x)}{A^C - J^C(x)} \quad (3)$$

Where *Cε {r, g, b}*, is the color channel index.

V. The prior knowledge of dark channel

The prior knowledge of dark channel is obtained from the observation of the image without fog in outdoor condition. In most non-sky area, some pixels always have very low values in a channel at least, namely that the min value of the light strength in the area is a very small number. For an image J(x) , we define,

Jdark (x) = min(min(JC (y))) (4)

Where f denotes a color channel of J(x), Ω(x) a square area centered at x. Except of sky area, the strength of Jdark is very low and tends to zero if J(x) is fog-free. So Jdark is called dark channel of J(x).

Haze Removal Based on Luminance

Paper [25] contributes a easy but valuable technique for visibility re-establishment from an image. The major benefit of this method is no user interface is needed, due to which this algorithms can be applied on realtime applications, such as surveillance, intelligent vehicle, etc. Another benefit is its rapidity, transmission map can be obtained with a very less cost by employing Retinex algorithm on luminance part. A comparative analysis and quantitative valuations are projected with the recent methods which exhibit that similar or better feature results are gained.

Retinex theory deals with compensation for illumination effects in images. The main aim is to convert a given image S into two different images, the reflectance image R, and the illumination image L, such that, at each point (x, y) in the image domain, $S(x, y) = R(x, y) * L(x, y)$. The Retinex methodology was motivated by the Land's landmark research of the human visual system [28]. The main advantage of such decomposition is the chance of removing illumination effects, improved image edge quality, and correcting the colors in images by eliminating illumination induced color shifts.

Our unique technique relies on the process of gaining transmission map. In accordance with this method, the transmission map is in fact an alpha map with a sharp edge outline and the intense layer of the scene objects, which is used to calculate the width of the haze layer. MSR algorithm combines the properties of multi-scale by fixing the scale parameters, the method synthesizes the benefits of the dynamic range compression, edge detail improvement of the small scale, and the balance of the color of the medium and large scale. So image sharpness, dynamic range compression of gray level, contrast enhancement and color balance can be realized at the same time. Applying MSR to the luminance component of the hazy image in YCbCr color space, then does linear transformations and median filter operation, the transmission map of our approach can be obtained, so it gives the automatic and fast attainment of transmission map.

Proposed Work

Our proposed work computes image enhancement in two phases. The first phase is used to remove fog from an image. Second phase enhance quality of image for improved visibility and noise reduction using FFT (Fast Fourier Transformation).

I. Fog removal based on prior knowledge

A fast method of foggy image enhancement is given in this section. Firstly, the depth information of the foggy image is extracted according to the foggy image model and the prior knowledge. Secondly, the transmission ratio of the atmosphere light is estimated and adjusted, and the atmosphere light A is also estimated. At last, the Gama adjustment is used to get the final enhancement image. Comparing with other method, the speed is faster than traditional methods.

The model of the foggy image In computation visual the model of foggy image is shown as following, As fast fog removal Method and Image Enhancement

$$I(x) = J(x)T(x) + A(1 - t(x))$$

The atmosphere is homogenous, the ratio of transmission is expressed as,

$$t(x) = e^{-\beta d(x)}$$

According to the equation, it can be obtained,

$$t(x) = \frac{\|A - I(x)\|}{\|A - J(x)\|} = \frac{A^C - I^C(x)}{A^C - J^C(x)}$$

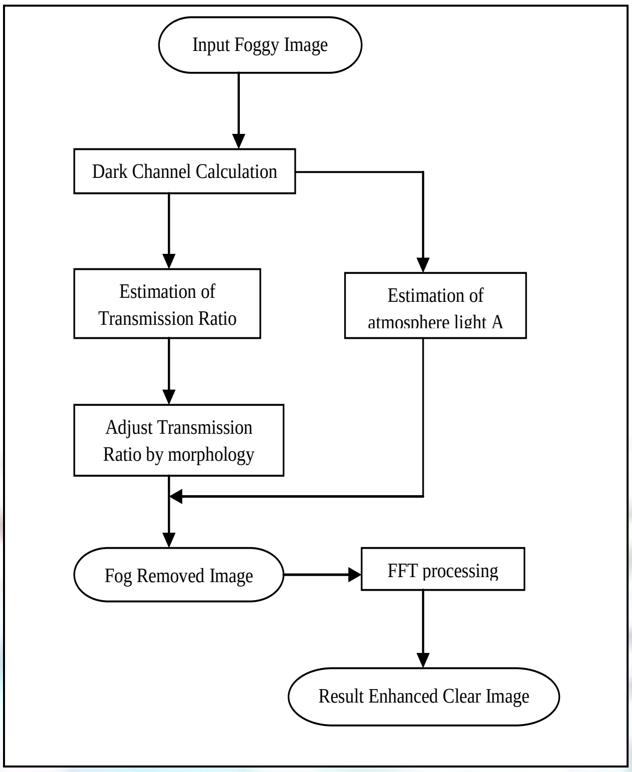
Where $C\varepsilon \{r, g, b\}$, is the color channel index.
The prior knowledge of the dark channel for an image J (x) , we define,

Jdark (x) = min(min(JC (y)))

Except of sky area, the strength of Jdark is very low and tends to zero if *J(x)* is fog-free. So Jdark is called dark channel of *J(x)*.

The scheme of fog removal based on prior knowledge overall algorithm given in fig 2 in detail.

Estimation of transmission Ratio.
The Adjustment of Transmission Ratio by morphological operation.
Recovering Source Image J (x).
Estimation atmosphere light A.



Proposed work architecture

II. Quality Enhancement of Fog removal Image

The FFT is an efficient implementation of DFT and is used in digital image processing. It is used to convert any picture from its spatial domain to its frequency. As it is faster to perform any computation or to apply any filter in frequency domain rather than spatial domain [27].

The calculation of the DFT is very expensive and hence to decrease the cost, the FFT came into existence. With the use of FFT the computational complications are decreased from N^2 to $\log_2 N$. For example, for an picture of size 256×256 pixels the processing time required is about two minutes on a general purpose computer. The same machine would take 30 times longer (60 minutes) to compute the DFT of the same image of size 256×256.

Fourier Transform converts an image into its actual and imaginary components which is a depiction of the image in the frequency domain. Suppose we are giving an image in the form of input signal then the number of frequencies in the frequency domain is same as the number of pixels in the image or spatial domain. To convert the image into its spatial domain inverse transform is applied. The FFT and its inverse of a 2D image are expressed by the equations:

$$F(x) = \sum_{n=0}^{N-1} f(n) e^{-j2\pi(x\frac{n}{N})} \quad (5)$$

$$f(n) = \frac{1}{N} \sum_{n=0}^{N-1} F(x) e^{j2\pi(x\frac{n}{N})} \quad (6)$$

Where the pixel at coordinates (m, n)are given by f(m,n), the value of the image in the frequency domain corresponding to the coordinates x and y is F(x,y), M and N are the proportions of the image.

As equation states, execution of this algorithm is very costly. But the benefit of FFT is that it is autonomous, namely, the 2D transform is converted into two 1D transforms as given in equation(shown only in the horizontal direction) - one in the horizontal direction followed by the other in the vertical direction on the consequence of the horizontal transform. The final result is counterpart of performing the 2D transform in the frequency space.

$$F(x,y) = \sum_{m=0}^{M-1} \sum_{n=0}^{N-1} f(m,n) e^{-j2\pi(x\frac{m}{M}+y\frac{n}{N})} \quad (7)$$

$$f(m,n) = \frac{1}{MN} \sum_{m=0}^{M-1} \sum_{n=0}^{N-1} F(x,y)\, e^{j2\pi(x\frac{m}{M}+y\frac{n}{N})} \quad (8)$$

The FFT that is employed on the application here needs that image dimensions are represented in two's power. One more advantage of FFT is transformation of N points could express as total of N/2 transforms by divide and conquer technique. It is a good property for reduce calculation effectiveness also take lesser time compare to others.

Fourier Transformation generates results as complex number and this numbers have greater range than spatial domain. Hence accuracy represent these values are stored as floats. Also range of coefficient generated by Fourier transformation is too large to displayed on the screen so these values are converted to another formatted as dimension values height*width for decrease the range and make able to displayed on screen [27].

Conclusion

This work gives an analytical approach for various image enhancement techniques. This work shows an exhaustive analysis on various image enhancement techniques and also propose a noble technique for fog clearance and quality enhancement. This analysis could play a important role to decide an algorithm for image clearance applications. This work also states the recent trends of image processing in the field of foggy image and point out hopeful instructions on research for image enhancement for future research. This paper is also proposing a fog removal with a quality enhancement technique which can be used for next generation traffic and railway image processing. This algorithm can be used to reduce the atmospheric effect from image to obtain better visibility of an image.

References

[1]. Srinivasa G. Narasimhan and Shree K. Nayar, "Removing Weather Effects from Monochrome Images", CVPR 2001. IEEE Computer Society Conference on Computer Vision and Pattern Recognition, vol.2, pages 186-193, IEEE 2001.
[2]. Jia MingQiao. "Method on Image Clearness Technique in Fog Weather." Xian University o/Technology, 2006.
[3]. Zhang RuiPing. "Research on Restoration of Image in Foggy Weather." TianJin University, 2007.
[4]. Kaijun Zhu, Van Zhou, Zusong Lan. "Enhancement Algorithm of Misty Image Based on Region Segmentation." Computer Measurement & Control, vol. 14, no. 5, pp. 661-663,2006.
[5]. Celebi, A.T. ; Gullu, M.K. ; Erturk, S., "Enhancement of fog degraded images using empirical mode decomposition", Conference Signal Processing and Communications Applications, Page(s): 1 – 4, IEEE, 2013.
[6]. Hong-Zhao Yuan, Xiu-Qiong Zhang; Zi-Liang Feng," Horizon detection in foggy aerial image", International Conference on Image Analysis and Signal Processing (IASP), Page(s): 191 – 194, 2010 IEEE.
[7]. Yong-Qin Zhang, Yu Ding, Jin-Sheng Xiao, Jiaying Liu, Zongming Guo, "Visibility enhancement using an image filtering approach", EURASIP Journal on Advances in Signal Processing 2012, Springer.
[8]. Rong Wang, XiaoGang Yang, "A Fast Method of Foggy Image Enhancement", International Conference on Measurement, Information and Control (MIC), 2012 IEEE
[9]. Guang Deng , "A Generalized Logarithmic Image Processing Model Based on the Gigavision Sensor Model", Image Processing, IEEE Transactions on Image Processing, Volume: 21 , Issue: 3, Page(s): 1406 – 1414, IEEE, 2012 ,
[10]. H. Hu, "Video enhancement: content classification and model selection", Ph. D. Thesis, Technique Universities Eindhoven, Eindhoven, Netherlands, 2010.
[11]. Arici T., Dikbas S., Altunbasak Y., "A Histogram Modification Framework and Its Application for Image Contrast Enhancement", IEEE Transactions on Image Processing, Volume:18 , Issue: 9, 1921 – 1935, IEEE, 2009
[12]. Ali, M.A., Mann, S,."Comparametric image compositing: Computationally efficient high dynamic range imaging", International Conference on Acoustics, Speech and Signal Processing (ICASSP), Page(s): 913 – 916, IEEE, 2012.
[13]. V. A. Nguyen, Y. P. Tan and Z. H. Chen, On the method of multicopy video enhancement in transform domain", Proc. of the 16th IEEE International Conference on Image Processing, pp. 2777- 2780, 2009
[14]. R. C. Gonzalez and R. E. Woods, Digital Image Processing, Prentice Hall, New Jersey, 2008.
[15]. X. Dong, Y. Pang and J.Wen, "Fast efficient algorithm for enhancement of low lighting video", Proc. Of the 37th International Conference and Exhibition on Computer Graphics and Interactive Techniques, 2010.
[16]. Shan Du, Ward R.K., "Adaptive Region-Based Image Enhancement Method for Robust Face Recognition Under Variable Illumination Conditions" IEEE Transactions on Circuits and Systems for Video Technology, Volume: 20 , Issue: 9, Page(s): 1165 – 1175, IEEE, 2010.
[17]. Iwanami, T. ; Goto, T. ; Hirano, S. ; Sakurai, M., "An adaptive contrast enhancement using regional dynamic histogram equalization", International Conference on Consumer Electronics (ICCE), Page(s): 719 – 722, IEEE, 2012
[18]. A. O. Boudraa and E. H. S. Diop, "Image contrast enhancement based on 2D teager-kaiser operator", Proc. of the IEEE International Conference on Image Processing , pp. 3180-3183, 2008.
[19]. Menotti, D. ; Najman, L. ; Facon, J. ; de Araujo, A.A., "Multi-Histogram Equalization Methods for Contrast Enhancement and Brightness Preserving", IEEE Transactions on Consumer Electronics, Volume: 53 , Issue: 3, Page(s): 1186 – 1194, IEEE, 2007.

[20]. S. Hashemi, S. Kiani, N. Noroozi and M. E. Moghaddam, “An image contrast enhancement method based on genetic algorithm”, Pattern Recognition Letters, vol. 31, no. 13, pp. 1816-1824, 2010.
[21]. I. Jafar and H. Ying, A new method for image contrast enhancement based on automatic specification of local histograms, International Journal of Computer Science and Network Security , vol. 7, no. 7, pp. 1-10, 2007.
[22]. Naidu V.P.S., “Multi-resolution image fusion by FFT”, International Conference on Image Information Processing (ICIIP), Page: 1 – 6, IEEE, 2011.
[23]. Jing Wang ; Liu, D.C., “2-D FFT for Periodic Noise Removal on Strain Image” 4th International Conference on Bioinformatics and Biomedical Engineering (iCBBE), Page(s): 1 – 4, IEEE, 2010.
[24]. Tzimiropoulos, G. ; Argyriou, V. ; Stathaki, T., “FFT-based estimation of large motions in images: A robust gradient-based approach”, International Conference on Acoustics, Speech and Signal Processing, ICASSP, Page(s): 969 – 972, IEEE, 2009.
[25]. Fan Guo Zixing Cai Bin Xie Jin Tang, “Automatic Image Haze Removal Based on Luminance Component”, IEEE, 2010
[26]. E. H. Land, “The Retinex Theory of Color Vision”, Sci. Amer., Vol. 237, pages 108-128, 1977.
[27]. Yi Wan ; Wah Chiu, “A transform method for fast generalized image registration”, IEEE International Conference on Acoustics, Speech, and Signal Processing, (ICASSP '04) Proceedings vol.3, Page(s): 501-504, IEEE, 2004.
[28]. Soo-Chang Pei ; Wen-Liang Hsue, “Random Discrete Fractional Fourier Transform”, Volume: 16 , Issue: 12, Page: 1015-1018, IEEE, 2009.
[29]. Lin Zhang ; Jianhua Wu ; Nanrun Zhou, “Image Encryption with Discrete Fractional Cosine Transform and Chaos”, International Conference on Information Assurance and Security, IAS '09 Volume: 2, Page(s): 61 – 64, IEEE, 2009.