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EFFICIENT METHOD FOR HAZE REMOVAL FROM IMAGE CAPUTERED IN FOGGY ENVIRONMENT

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***Abstract*— Images are very important parts of dat to day life. They plays very important role in analyzing traffic on roadways, railways and airways.Sometimes due to bad weather effect the analysis through these images becomes difficult. As weather effect degrade the quality of images and those images suffer low contrast, color alteration and shrink the resolution of the captured object in open-air. The reason behind this problem is that the light capture by the lens of the capturing device get spread by the atmosphere. So it was found that conventional techniques used for enhancing the images are not sufficient for removing foggy effect or any other weather effect from the captured images. In this work, we have analyzed the hand techniques employed for image processing. And through that analysis we propose a technique which is efficient technique for enhancing the quality of degraded images. This technique consists of two phases, the first phase is used to remove fog from an image using a Fog removal prior knowledge of image. And after that Second phase is to enhance the quality of image for high visibility using FFT (Fast Fourier Transformation). This method is works for weather conditions like rains, smog, fog etc.**

***Index Terms*— Weater effect, Fog, Image processing, FFT, Image enhancement, Fog removal method.**

I. INTRODUCTION

An image captured in natural light or in open area totally depends on the atmospheric conditions. Some atmospheric conditions like fog, smog, rains, cloud may blur the image or may degrade the quality of an image. There are condensed visibility trace in awful weather condition due to the widespread amount of atmospheric particles that have a large volume and distribution in the causative medium. While capturing a photograph the light reflected by any object is absorbed or scattered by the particles of rain, fog or cloud which causes the problem of low image quality. This results in getting very less details of the object which is intended to be captured . Therefore fog proves to be the reason for low image quality and information such images contain a low gray value is strengthened whereas high gray value becomes weaken, that causes over-concentrated division of pixel gray value hence the contrast also degrades [1].

High visibility is achieved when the rays of light travel from air to the object and then to the camera. And atmosphere plays a very important role in the quality of image captured. The main reason which affects the visibility in an image captured are fog, mist, smoke, cloud etc and when these conditions occurs in any image background or foreground area the it also gets affected by small water droplets present in these conditions.[2]

Decrease in quality of an image is caused by a scattering and deflection of light rays by water droplets and gases in the atmosphere.Visibility is mostly decreased by spreading particles between image capturing device 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.

The seasons of rain and winters are most harmful weather conditions for image capturing because of low visibility and low contrast the color information also get destroyed, which results in making an image less analyzable and less recognizable. Pollution is also one of the major problem during good wheather . Because the particles present in air can also degrade the quality of image.and seems to be like foggy weather.

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

When an image processing or image recognition system is designed they are intended to be used in normal weather and normal atmospheric conditions. So if we manage to remove atmospheric effect from our captured foggy image then we can get a clear good quality image. Figure 1 gives a demonstration of foggy image that how bad weather effect the visiblity. In figure it can easily be observed how the fog can degrade the quality of the image. In these conditions the driver may not be able to see the road or other vehicles and may cause accidents.

It also decreases the user visibility on the road and increases the possibility of road accidents. If the effect of weather is reduced from the image the possibility of accidents can also be minimized.

The conventional schemes for pictures captured in poor conditions are retained by victimization many sorts of low filters to get rid of the results of noise, however they're not applicable for the foggy surrounding image. A foggy weather has many vaporizer atoms within the surroundings, these atoms break the trail of sunshine, additionaly influence the distribution of the sunshine unfold, thus it affects the feature of the image, and also the distinction of the image fall per raise the space of objects from camera. Several researchers are now targeting on fog removal, image enhancement and working on various techniques to remove weather affect from the picture.

II. Related work

As the fog affects quality of image, details and color balance are affected hence many researchers try to remove bad weather effects from the images. As work in [2] states 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 [3,4], 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 [5] 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 [6] 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 [7] a physical model to improve the degradation of bad visual image.

Paper [8] 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 [9] 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 [10] 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. FREQUENCY TECHNIQUES FOR IMAGE ENHANCEMENT

Author	Year	Model	Processing techniques	Application
Guang Deng [11]	2012	HE based Logarithmic Transform LTHS	The log reduction zonal magnitude technique; Logarithmic transform histogram shifting	Traffic monitoring Security Surveillance
Hao Hu [12]	2010	Content adaptive video processing model	Content classification and adaptive	Processing Computer vision
Tarik Arici [13]	2009	HE based modification	Histogram modification framework, content adaptive algorithm	LCD display device; Low quality video
Ali, M.A [14]	2012	Dynamic range compression	Discrete Cosine transform (DCT); Retinex theory	Image/video compressing
Viet Anhnguyen [15]	2009	Cauchy distribution model; AC transform coefficient	Video reconstructed from multiple compressed copies of video content	Compression video
R.C. Gonzalez [16]	2008	HE	Global Histogram Equalization	Image/ Video Security Surveillance
Xuan Dong [17]	2010	Image Inverting Model	Inverting the input low lighting video; dehaze algorithm	Traffic monitoring; Medical imaging
Shan Du [18]	2010	ARHE model	Adaptive Region based Method	Face Recognition
Iwanami, T. [19]	2012	Dynamic Histogram equalization	Dynamic Histogram Equalization technique	Medical Image, Low quality video
Boudra a A.O [20]	2008	2DTKEO model	2D Teager- Kaiser Energy Operator	Medical image; Satellite image
David Menotti [21]	2007	MHE model	Multi histogram equalization methods	Image processing
Sara Hashem [22]	2010	Improve HE	Genetic algorithms	Compute high dynamic range image processing
Naidu V.P.S. [23]	2011	Fast Fourier Transform (MFFT)	Multi-resolution image analysis	well suited for real time applications
Tzimiropoulo	2009	Gradient-based	FFT-based correlation	Images from popular

Author	Year	Model	Processing techniques	Application
s, G. [24]		methods		database

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

III. 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).

A. *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

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

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*ε *{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.

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

B. *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 [25].

The calculation of the DFT is very expensive and hence to decrease the cost, the FFT came into existance. 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 components 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 of an image is expressed by the equation:

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

Where $0 \le m \le M-1$ and $0 \le n \le N-1$

And 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.

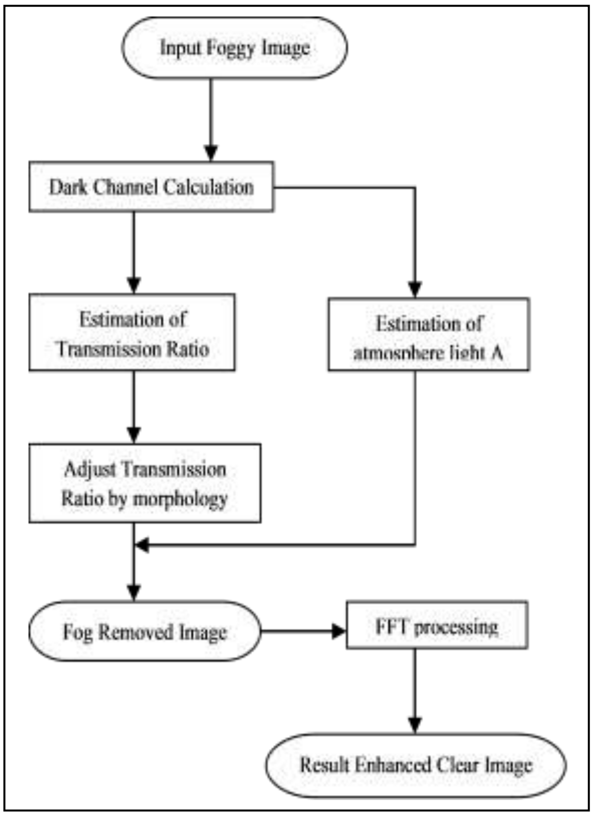


Fig. 2. Proposed work architecture

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.

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

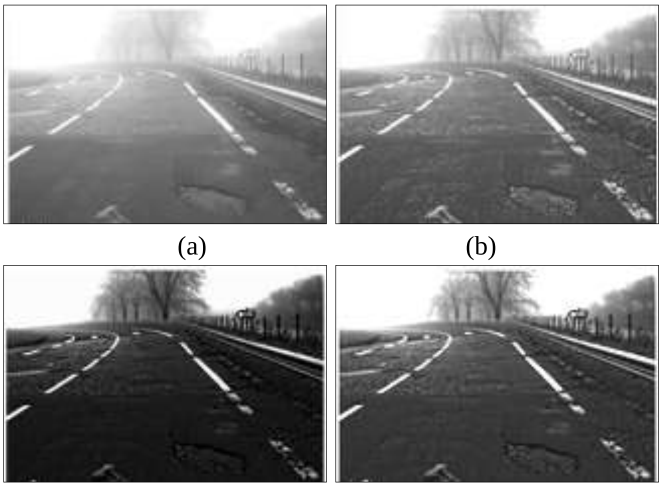
$$sf(m,n) = \frac{1}{MN}\sum_{m=0}^{M-1}\sum_{n=0}^{N-1} F(x,y)\, e^{j2\pi(x\frac{m}{M}+y\frac{n}{N})} \quad (8)$$

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 [25]. The results obtained from FFT are though clear along with that some more parameter for image enhancemet are adjusted to make it more clearer.

IV. Simulation and Results

Proposed work has been implemented in Matlab version 7.10.0 on hardware plateform of Pentium(R) Dual-Core CPU @3.20 GHz, 2-GB cache with windows 7 operating system. This work is applied on 300 × 200 resolution test images and compared with exiting methods [26, 9] for different outdoor environments. In this experimental parameter patch size L = 25 is set for estimation of outdoor light.



(a) (b) (c) (d)

Fig. 3. Visual comparison of the dehazing results of these methods for a misty gray image. These methods are [26, 9] and the proposed algorithm using image filtering approach. (a) Foggy image, (b) [26], (c) [9] (d) the proposed algorithm.

(a) (b)

(c) (d)

Fig. 4. Visual comparison of the dehazing results of these methods for a foggy color image. These methods are [26, 9] and the proposed algorithm using image filtering approach. (a) Foggy image, (b) [26], (c) [9] (d) the proposed algorithm.

Figure 3 compares results of existing fog removal methods [26, 9] with the proposed method [27] for visibility enhancement from a single foggy image in gray scale format. Table 2 gives detailed comparision of proposed work with existing [26] , [9] on basis of various parameters like fog content in image.

(a) (b) (c) (d)

Fig. 5. Visual comparison of the dehazing results of these methods for a heavy foggy color image. These methods are [26, 9] and the proposed algorithm using image filtering approach. (a) Foggy image, (b) [26], (c) [9] (d) the proposed algorithm.

Some other experiments are done to show effectiveness in different conditions and light. Such as trees, vehicles, highways, house and garde are demonstrated in figure 4 and 5. Where results of proposed method is compared with existing methods. Image captured in high dense environment in Figure 6 is compared results of proposed methods with existing methods. [26, 9].

Table II. Result Comparision with Existing methods on defferent Parameters

Output Image	(a)	(b)	(c)	(d)
Parameters	Input foggy image	Output image by [26]	Output image by [9]	Proposed method
Fog content	High	Medium	Low	Low
Brightness	Poor	Poor	Poor	Good
Contrast	Poor	Poor	Average	Good
Sharpness	Poor	Poor	Average	Good
Total Visibility	Very poor	poor	Good	Good

Parameters on which comparision is done are fog content in image, brightness of image, contrast of image, sharpness and overall visibility of object in picture. We have found that image given as input has high fog content therefore visibility of object in image was very poor. When method [26] is applied on input image the output obtained is a bit clear image with poor brightness, low contrast and poor sharpness hence total visibility was found not very clear. Same input image was proccesed with [9] result found preety good on the parameter of contrast, sharpness hence total visibility. Proposed method[27] show good results on above parameters in various outdoor environment such as road, garden and heavy fog.

V. Conclusion

This research paper provides an analysis and comparision of conventional image enhacement techniques with proposed technique. Also the recent trends and research going on in the field of image enhancement is highlighted through this paper. This paper proposes a fast fog removal method with a quality enhancement technique which can be used for next generation traffic and railway image processing to remove the weather effect from image. This technique can be used for better visibility and image processing of images which are degraded by weather effect. As the result shows proposed technique has been found more effective than other existing technique in the terms of quality and clarity. In this work we have compared the results of various image enhancement techniques on different grounds like on the images of a building, highway,trees and open area, which are very important aspects for traffic analysis during foggy weather. This work has given an effective and fast foggy image enhancement technique for better visibility in image or video in real world images.

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