IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
PP 25-31

Image Processing for Hazy Weather Conditions

Swapnil Kothari, Atanu Roy, Kaustubh Chakkarwar, Dr. Prof. T. S. Chaware
Department of Electronics and Telecommunication, MAEER's MIT College of Engineering, Savitribai Phule Pune University, India

Abstract: *Accidents due to the hazy vision in adverse atmospheric conditions is not an issue limited to a region. It is observed worldwide that even after developing the road safety knowledge the accidents in hazy atmosphere are not reduced. These are due to some constraints like blurred vision in hazy conditions in which human eyes cannot detect vehicles or other objects coming in front of vehicle. To overcome this issue there should be some interface between the driver and the objects coming in front of vehicle. The issue occurs while driving in hazy environment and can be avoided by providing an interface which will store the video in form of frames at a speed specified by the camera module used on the front panel of the vehicle. The video stored in format of frames will be processed through the Raspberry Pi which is a series of small single board computer. There will be a provision for the driver to turn on the system whenever it is necessary by pressing a button and then there will be a TFT display provided inside the vehicle to visualize the objects coming in front of the vehicle in advance to the driver.*

Keywords: *Single image haze removal, gamma correction, low visibility conditions, contrast enhancement*

I. Introduction

Nowadays low visibility conditions are a frequent occurrence. Due to fog and haze, visibility is impaired. Poor visibility causes flight delay, diversion, cancellation as well as automobile accidents. Driving at night in case of fog forms a challenging condition which may lead to an accident. We have seen a change in the environmental condition. Also pollution has increased the problem in driving and proving to be fatal. This issue is on a larger scale in the industrial region but with the increasing development and industrialization, it won't take long to spread across the countries. Thus, the problem is to deal with such situations in which human performance is limited by low visibility. The resolution of the human eye is 324 to 576 megapixels depending upon the angle of vision, but in the case of fog or other weather haze, the visibility is disturbed. With the advancement in every field of image processing and computer vision from last few decades it is possible to visualize even in bad weather. The performance of many computer vision applications, such as object detection and tracking, video surveillance, FVES and target identification may fail due to degraded images. Therefore improving visibility through fog removal is an inevitable task. Research is still going on to implement such a system so that it will assist the driver in any weather condition.

With the advancement of technology, many single image fog removal methods [7] [8] [9] [10] have been proposed. R.Fattal [7] has proposed a method which solves a non-linear inverse problem and its performance is greatly dependant on quality of input data. If insufficient signal to noise ratio or the absence of multiplicative variation are seen on insignificant portion of the image then there may be a chance of proposed method failure. R. Tan [10] proposed a method in which they first estimate the atmospheric light, from which they obtain the light chromaticity. Based on the estimated air-light, they compute the direct attenuation that represents the scene with enhanced visibility. Since the actual value of air-light is unknown the output tends to have larger saturation values than those in actual clear day images. To solve these problems, we have introduced a method that only requires a single input image that neither requires geometrical information of the input image nor it is dependent on quality of input image.

In this paper a different approach for fog removal technique is proposed and partially implemented. It produces a more enhanced edge preserving image using preprocessing technique like histogram. Proposed algorithm uses color correction at initial stage followed by gamma correction for contrast adjustment and to visualize the fine details within in an image. Contrast enhancement is applied to the gamma corrected image which is preprocessed using histogram equalization. A Wiener filter is used to diminish ringing effect while de-blurring images in presence of noise.

This paper is organized into five sections. In the section II of this paper we explain in detail the proposed fog removal algorithm which consists of color correction, gamma correction, contrast enhancement and histogram equalization. In section III, contrast manipulation with preserving fine details using Wiener filter is discussed. Further in section IV, simulation and results has been discussed. The remaining of this paper gives conclusion and future scope.

II. A. Algorithm for grayscale image

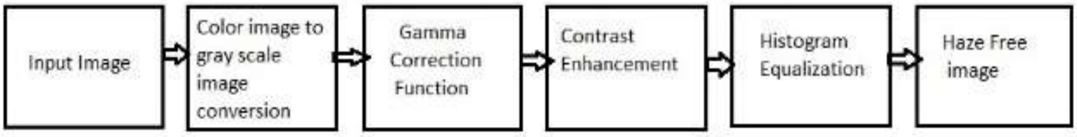

Fig.1

Fig. 1 shows the detailed algorithm of the proposed method. An input image is acquired in the step I of the algorithm. This image is then converted from color space to gray-scale using color conversion in step 2 of algorithm. Uneven luminance is compensated or corrected in step 3 by using gamma correction. Step 4 deals with the contrast enhancement of the gamma corrected image. Histogram equalization is then applied to equalize the brightness and contrast of the image respectively [14].

A. Input Image:

Input image is the hazy image. In this proposed algorithm we have taken a random hazy image from the internet.

B. Color image to grayscale image conversion:

RGB image contains lots of data which are not required for the processing. When an image is converted into grayscale, lots of information is discarded which are irrelevant to processing. In case of a RGB scale image, for each of the components i.e. R, G, B, image holds different intensity labels. RGB color model, a color image can be represented by the intensity function.

$I\text{-}_{RGB} = (F_{R,} F_{G,} F_B)$

Where, $F_R(x,y)$ is the intensity of the pixel (x,y) in the red channel, $F_G(x,y)$ is the intensity of the pixel(x,y) in the green channel and $F_B(x,y)$ is the intensity of the pixel (x,y) in the blue channel.

Each of the R, G and B component consist of 8 bits. If only the brightness information is needed, color images can be transformed to gray-scale image. The transformation can be made using proposed equation [11].

$I_y=0.333F_R+0.5F_G+0.1666F_B$

Where, F_R, F_G and F_B are the intensity of R, G and B component respectively and I_y is the intensity of equivalent gray level image of RGB image.

C. Gamma correction:

Gamma correction, the second step in this flow is a function which maps the uneven luminance in the image and compensates or syncs that according to the human eye perspective. This is because the video recorders or cameras do not correctly capture the images with proper luminance. The gamma correction actually plots a graph of voltage on x-axis versus the levels brightness of an image on y-axis. It plots an inverse curve to that of original image which is gamma correction function and a resultant gamma function corrected curve which describes the voltage and brightness level of gamma correction of an image. Fig.2 describes the related theory of gamma correction in an easy way.

$C(x,y) =A(x,y)^{\alpha}$

Equation 1: Gamma correction function

Where,

$A(x,y)$ =Input foggy image with (x,y) pixels

$C(x,y)$ =Output or required image

α =gamma correction factor.

- Solid red curve is of voltage and brightness ratio.
- The dash red curve is its inverse function i.e. gamma correction function.
- The gray dotted line is the corrected result.

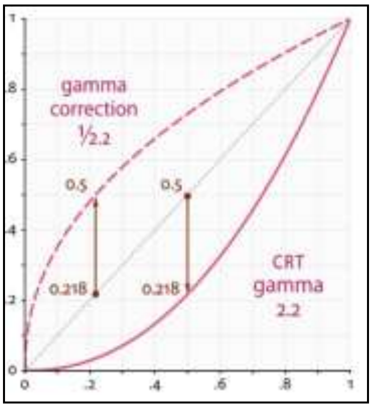

Fig.2 Gamma correction function graph

D. Contrast Enhancement:

Contrast enhancement is a process that makes the image features stand out more clearly by making optimal use of the colors between the ranges of gray color levels.

E. Histogram Equalization:

Histogram equalization is one of the techniques for contrast enhancement. In histogram equalization a graph between the values of gray level on x-axis versus the frequency of occurrence of gray colors on y-axis is plotted. After that the graph is analyzed and the frequency of specific values of gray levels is equalized throughout the range of gray-scale.

Implementation:

Consider the discrete grayscale input Image $X = x(i,j)$, with the L discrete levels, where $x(i,j)$ represents the intensity levels of the image at the spatial domain (i,j) Let histogram of Image X is $H(X)$. Now the probability density function $pdf(X)$ can be defined as-

$Pdf(X_k)$ or $p(X_k) = n_k/N$

Equation 2: Probability density function (PDF)

Where, $0 \le k \le (L - 1)$

L is the total number of gray level in the image

N is the Total number of pixels in the image,

n_k is the total number of pixels with same intensity level k.

From the $pdf(X)$ (1) the cumulative distribution function $cdf(X_i)$ is defined as

$Cdf(X_i)$or $c(X_i)= \sum^{k}_{i=0} p(X_i)$

Equation 3: Cumulative distribution function (CDF)

Note that $cdf(X_{L-1})=1$ from equation (2) and (3)

Fig.3 (a) input image having low contrast (b) histogram of input image (c) shows histogram equalized image and (d) shows histogram of processed image.

Histogram equalization is a scheme that maps the input image into the entire dynamic range $[X_o, X_{L-1}]$ by using the cumulative distribution function as a transform function. Let's define the transform function f(X) using $cdf(X_i)$ as:-

$f(X)=X_o+(X_{L-1}-X_o) \times cdf(X_i)$

Then the output image of histogram equalization, Y=y(i,j) can be expressed as

$Y =\{f(x(i,j))| \ x(i,j) \ X\}$

Above shown results in Fig. 3 consists of four images. Fig. 3(a) is the original image with haze and as it can be observed objects in that image are not easily detectable. Fig. 3(b) shows the plot of histogram for original image. After histogram equalization the results are shown in Fig. 3(c) with clearer vision of objects and Fig. 3(d) is the equalized plot of resultant histogram equalized image.

F. Haze Free Image:

This improved algorithm will produce an image which will be haze free. However in the obtained image effects like blurring and ringing are seen, which are not expected and need to be removed with the post-processing techniques.

II. B. Algorithm for color image

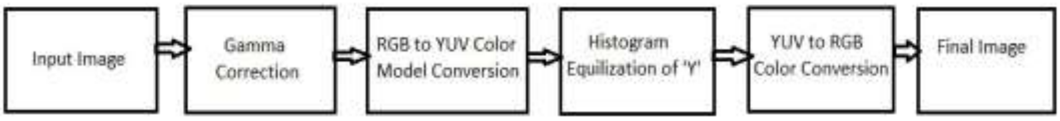

Fig.7
(Algorithm to remove haze from color image)

A. Input Image:
Input image is the hazy image. In this proposed algorithm we have taken a random hazy image from the internet.

B. Gamma Correction:
This step is similar to the Gamma Correction step of gray scale image algorithm.

C. RGB to YUV Color Conversion:
Formulas for conversion of RGB into YUV are as follows:
$Y= 0.299R + 0.587G + 0.114B$
$U= -0.147R - 0.289G + 0.436B$
$V= 0.651R - 0.515G - 0.100B$

D. Histogram Equalization of Y:
From the three components Y, U&V, Y is the brightness information. After equalization of Y, the brightness of the image gets equalized.

E. YUV to RGB Color Conversion:
The generation of R, G&B from Y, U&V are as follows:
$R= Y + 1.140V$
$G= Y – 0.395U – 0581V$
$B= Y + 2.032U$

F. Final Image:
The Proposed algorithm will produce an image which will be haze free.

III. Simulation Results

A. For grayscale hazy images

To demonstrate the effectiveness of our method, we have used real images of outdoor scenes in out experiment. The computational time for the 600x400 image using MATLAB software with processor of i3 generation is approximately 15-20 seconds.

Fig. 4(a) and Fig. 4(a) shows a road scene partially covered by haze. The distant objects in the images are quite not visible. Fig. 4(b) and Fig. 4(b) shows our result for proposed method. In the result, one can easily observe that the objects which are at far distance are easily visible as compared to original image and even the contrast and brightness is enhanced in our result.

(A) **(B)**

Fig. 4A) Original Image B) Haze free Image

(A) **(B)**

Fig.5 Haze removal result A) Original Image B) Haze free Image

(A) **(B)** **(C)** **(D)**

(E) **(F)** **(G)** **(H)**

Fig. 6 shows different outputs of gamma correction function. Image A), B), C) and D) are the outputs of gamma correction function at the values of α = 2, 3, 4 and 5 respectively. And the images E), F), G) and H) are the final output images. Fig. 6(A) shows gamma corrected image for gamma value α=2. The corresponding output for the gamma corrected image can be seen in Fig. 6(E). Fig. 6(B), (C) and (D) shows different gamma corrected images for different gamma values. It can be observed that with increase in value of gamma correction the luminance in the resultant images get properly mapped such that the objects in the image get easily detected.

B. For color images

Fig.8A) Original image

Fig.8B) Output image

Fig.9A) Original image

Fig.9 B) Output image

Fig.10 A) Original image

Fig.10 B) Output image

Above images are the original hazy and the resultant haze removed images.

IV. Conclusion

In this paper, we presented a framework able to detect and clear the fog. We have successfully removed the fog from randomly selected foggy images. The proposed system can be implemented for various applications like computer vision system for object tracking, night vision surveillance. The proposed method is an efficient single image fog removal method which is used for gray-scale images and color images. As shown in the simulation results the obtained fog free image is clearer than the original image. As the proposed system can be used as a versatile tool in driving assistance, object detection and it can be implemented further on color images or videos.

References

[1]. N. Hautiere, R. Labayrade, D. Aubert, "Detection of visibility conditions through use of onboard cameras," Intelligent Vehicles Symposium, Proceedings, IEEE, pp.193-198, 6-8 June 2005.

[2]. Nicolas Hautiere, RaphaëlLabayrade, and Didier Aubert. "Estimation of the Visibility Distance by Stereovision: A Generic Approach", IEICE - Trans. Inf. Syst. E89-D, 7 (July 2006)

[3]. Hautiere, N.; Labayrade, R.; Aubert, D., "Real-time disparity contrast combination for onboard estimation of the visibility distance", IEEE Transactions on Intelligent Transportation Systems, vol.7, no.2, pp. 201- 212, June 2006

[4]. Pomerleau, D., "Visibility estimation from a moving vehicle using the RALPH vision system", IEEE Conference on Intelligent Transportation System, 1997. ITSC '97, pp. 906-911, 9-12 Nov 1997

[5]. N. Hautiere, D. Aubert, "Contrast restoration of foggy images through use of an onboard camera," Intelligent Transportation Systems, 2005.Proceedings.2005 IEEE, pp.601-606, 13-15 Sept. 2005.

[6]. Mori, K.; Kato, T.; Takahashi, T.; Ide, I.; Murase, H.; Miyahara, T.; Tamatsu, Y., "Visibility Estimation in Foggy Conditions by In-Vehicle Camera and Radar," Innovative Computing, Information and Control, 2006. ICICIC '06.First International Conference on, vol.2, no., pp.548- 551, Aug. 30 2006-Sept. 1 2006.

[7]. S. G. Narasimhan, S. K. Nayar, "Shedding light on the weather. In Proceedings of the 2003 IEEE computer society conference on Computer vision and pattern recognition (CVPR'03). IEEE Computer Society, Washington, DC, USA, pp. 665-672.

[8]. R. Fattal, Single image dehazing. In SIGGRAPH, pages 1-9, 2008.

[9]. S. G. Narsimhan and S. K. Nayar. Contrast restoration of weather degraded images. PAMI, 25:713-724, 2003.

[10]. R. Tan. Visibility in bad weather from a single image.CVPR, 2008.

[11]. Tarun Kumar and Karun Verma, A Theory based on Conversion of RGB image to gray image, International journal of computer application(0975-8887), Vol. 7- No. 2, Sept 2010.

[12]. [12]Omprakash Patel, Yogendra P. S. Maravi and Sanjeev Sharma, A Comparative Study Of Histogram Equalization based image enhancement techniques for brightness preservation and contrast enhancement, An International Journal (SIPIJ), Vol-4, N0. 5, Oct. 2013

[13]. Rafael C. Gonzalez, Richard E. Woods, Digital Image Processing, third edition, Pearson publication.

[14]. Atanu Roy, Swapnil Kothari, Kaustubh Chakkarwar, "Image processing for Hazy Weather"(pp.53-58), Proceedings, ICISCN,22-23 Feb 2019.