Removal of the Fog from the Image Using Filters and Colour Model

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Abstract: **Images captured in poor weather conditions is often get degraded due to suffering from poor contrast and loss of color characteristics. Poor visibility becomes a major problem for most outdoor vision applications. Visibility enhancement in bad weather is important in many applications. To restore both contrast and color we propose following methods 1) Low pass and High pass filters; 2) Hue Intensity Saturation (HIS) Model; 3) Homomorphic filter; 4) Masking with histogram equalization. Fog removal algoritham has a wide application in tracking and navigation, entertainment industries, and consumer electronics.**

Keywords- fog removal; image enhancement; HSI model; low pass filter; high pass filter; homomorphic filter; masking; histogram equalization

I. INTRODUCTION

Bad weather caused by atmospheric particles, such as fog, haze, mist etc may significantly reduce the visibility and distorts the colors of the scene [4]. The degree of degradation increases exponentially with the distance of scene points from the sensor. The low quality images are a nuisance for object detection algorithms. They generally fail to correctly detect objects due to low visibility. Thus it is very essential to make these vision algorithms robust to weather changes. Foggy conditions drop atmospheric visibility and brings whitening effect on the images causing poor contrast that is called as air light [6]. Hence basic challenge is to nullify the whitening effect thereby improving the contrast of the degraded image. However, fog removal is a challenging problem because the fog is dependent on the unknown depth information.

Depth based methods require the rough depth information either from the user inputs or from known 3D models. Recently, single image fog removal has made significant progresses. The success of these methods lies in using a stronger prior or assumption. Tan observes that the fog-free image must have higher contrast compared with the input fog image and he removes the fog by maximizing the local contrast of the restored image. The results are visually compelling but may not be physically valid. Fattal estimates the scene and then infers the medium transmission, under the assumption [1][7][8][9].

II. FOG, MIST AND HAZE

From the atmospheric point of view, weather conditions differ mainly in the types and sizes of the particles present in the space. A great effort has gone into measuring the size of these particles [3].

Table 1: Weather conditions and associated particle types and sizes.

Condition	Particle type	Radius (μm)
Air	Molecule	10^{-4}
Haze	Aerosol	$10^{-2} – 1$
Fog	Water droplet	1-10
Cloud	Water droplet	1-10
Rain	Water droplet	10^{2} - 10^{4}

Based on the type of visual effects, bad weather conditions are broadly classified into two categories: steady and daynamic. In steady bad weather, constituent droplets are very small (1-10 micrometer) and steady in air. Fog, mist and haze are example of steady weather. In daynamic bad weather, constituent droplets are 1000 times large (0.1-10 mm) than those of the steady weather. Rain and snow represent dynamic weather conditions [3][10][11].

The only difference between mist and fog is visibility. This phenomenon is called fog if the visibility is one kilometre (1,100 yards) or less otherwise it is known as mist. Fog is much thicker than mist. This is because the amount of water droplets in fog is more than that which forms mist. Fog is defined as cloud which reduces visibility to less than 1 km, whereas mist is that which reduces visibility to less than 2 km. Haze is traditionally an atmospheric phenomenon where dust, smoke and other dry particles obscure the clarity of the sky.

In fog degradation in visibility is caused by attenuation and airlight. A light beam travels from a scene point through the atmosphere, gets attenuated due to the atmospheric particles, this phenomena is called attenuation which reduces the contrast in the scene. Light coming from the source is scattered by fog and part of it travels towards the camera. This phenomena is called airlight. Airlight adds whiteness into the scene [6].

III. LOW PASS AND HIGH PASS FILTER

[A] LOW PASS FILER[12]

Low pass filters only pass the low frequencies, drop the high frequencies. It cut off all high frequency components that are a specified distance D_0 from the origin of the transform. Smoothing is fundamentally a low pass operation in the frequency domain.

Table 2: Equations of all standard forms of low pass filter

Ideal filters	$H(u,v)=\begin{cases}1 & \text{if } D(u,v)\le D_0\\ 0 & \text{if } D(u,v)>D_0\end{cases}$
Butterworth Lowpass	$H(u,v)=\dfrac{1}{1+[D(u,v)/D_0]^{2n}}$
Gaussian lowpass	$H(u,v)=e^{-D^2(u,v)/2D_0^2}$

[B] HIGH PASS FILTERS[12]

High pass filters – only pass the high frequencies, drop the low ones. High pass frequencies are precisely the reverse of low pass filters.

$$\mathbf{H_{hp}(u,v) = 1 - H_{lp}(u,v)} \qquad \mathbf{(1)}$$

Table 3: Equations of all high pass filters

Ideal filters	$H(u,v)=\begin{cases}0, & if\ D(u,v)\le D_0\\ 1, & if\ D(u,v)>D_0\end{cases}$
Butterworth highpass	$H(u,v)=\dfrac{1}{1+[D_0/D(u,v)]^{2n}}$
Gaussian highpass	$H(u,v)=1-e^{-D^2(u,v)/2D_0^2}$

[C] RESULT OF LOW PASS

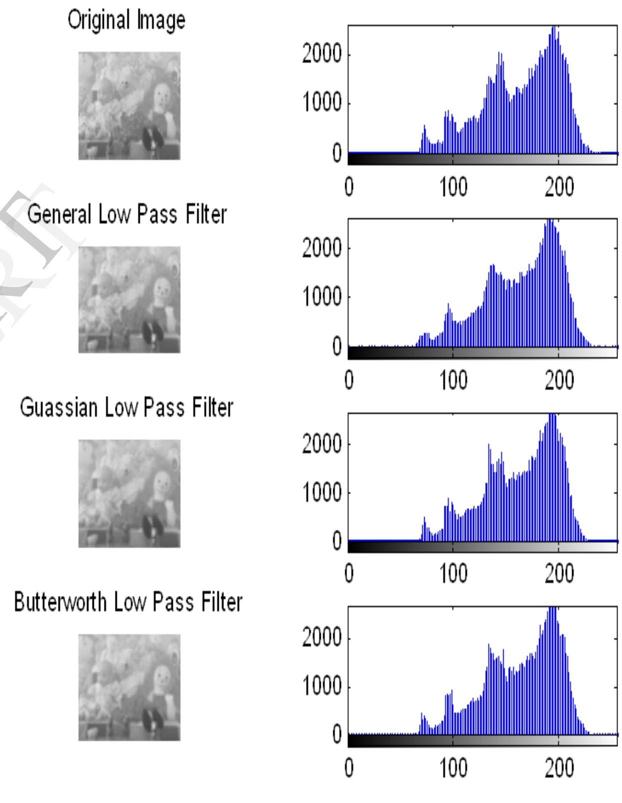

Figure 1: Fog removal using low pass filter

From the fig-1 of fog removal using low pass filters we can conclude that low pass filter can only pass low frequency component and hence no fog can be removed. Low pass filters can allow the frequencies with the given cutoff range. Here we apply different cutoff range and the order of the filter but no effect of fog removal is measured using histogram output.

[D] RESULT OF HIGHPASS

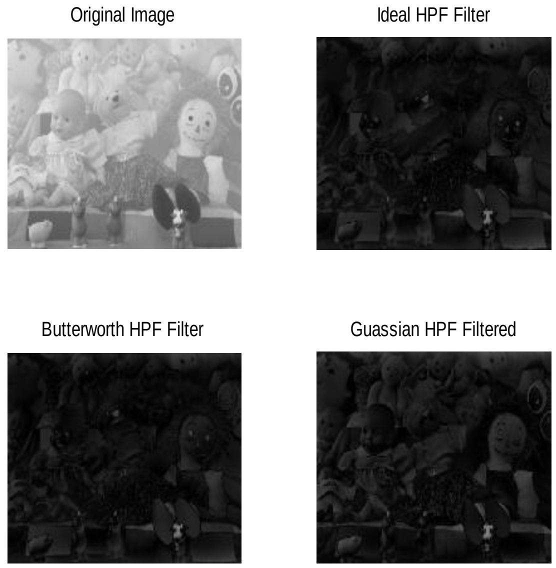

Figure 2: Fog removal using high pass filter

From the above outputs of fig-2 we can conclude the high pass filters can pass only high frequency components. High pass filters can do sharpening of the images. High pass filter can sharp the edges. In the foggy images no need to use sharpening so fog cannot be removed using high pass filter.

IV. HOMOMORPHIC FILTER

[A] PROPOSED WORK

Homomorphic filtering technique is one of the important ways used for digital image enhancement, especially when the input image is suffers from poor illumination conditions. This filtering technique has been used in many different imaging applications, including biometric, medical, and robotic vision. Homomorphic filtering works in frequency domain, by applying a high-pass type filter to reduce the significance of low frequency components.

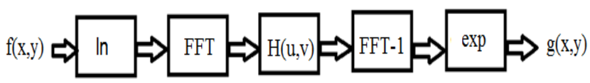

Figure 3: Homomorphic filter

[B] RESULT

Homomorphic filtering technique is one of the important ways used for digital image enhancement, especially when the input image is suffers from poor illumination conditions. Homomorphic filtering works in frequency domain, by applying a high-pass type filter to reduce the significance of low frequency components. By reducing the effect of the dominant illumination components, it became possible for the dynamic range of the display to allow lower intensities to become much more visible[12]. Similarly, because the high frequencies are enhanced by homomoephic filtering, the reflectance components are enhanced by this filter. From the fig-4 we can also see that by increasing the value of radius the result become poor in quality.

Figure 4: Fog removal using Homomorphic Filter

V. HUE SATURATION AND INTENCITY (HIS) MODEL

[A] PROPOSED WORK

Human vision system is more sensitive to brightness, so we propose to apply enhancement algorithm on I component. For this RGB component of the input image is first converted into HSI space to get brightness component. Because of scene depth varies differently over whole image, global enhancement methods does not reflect depth change. So to take care of local scene depth changes, we process the image on a block by block basis, assuming that the pixels in the block are now of same seen depth. We enhance the block according to pixel intensities in it. Basically this mean that if the given image has many objects with varying seen depth, global enhancement techniques are expected to do average kind of enhancement of various object. On the other hand, processing on a block-by-block basis will enhance the object effectively.

The process is described as follow: If we observe that a given block has only high intensity values we declare the block as High Region (HR) block. Pixels of this block are stretched from the minimum intensity value of the block to 255.However if we would have stretch it from 0 to 255 there would have been many black and white spots appearing as salt-peeper noise. On the other hand if a block has mix intensity, i.e. consisting of almost all the intensity values we applied linear contrast stretching method from 0 to 255 to improve contrast level of the block. However, since foggy images are very less likely to have blocks with very low intensity values we were not required to control salt-peeper type of noise in this case[2].

A brief introduction of algorithm is as follows:

Step 1: Let input degraded foggy image $I(x, y)$ be of size M X N. Convert this input image to HSI space. Take Intensity component as $I1(x, y)$ .Take pixels in a Block $B(x, y)$ l (mask) of size m X n.

Step 2: Find the pixel of highest gray level in the I component.

P = max($I1(x, y)$) **(2)**

xÎ[1.......M], yÎ[1......N]

Step 3: Get the Higher region of the image

HR = P –TH **(3)**

Where *TH* = Threshold

The criterion of selecting the threshold is as follows:

If* 220 < *P* < 255 *, then TH = 25

***elseif* 150 < *P* £ 220 *,then TH* =15** **(4)**

else TH = 10

These thresholds were arrived at after extensive Experimentation with a large set of test images.

Step4: Get a block of pixels l B , with x = A and y = B from the image $I1(x, y)$.

Step 5: Find the minimum intensity value in the block.

L min($B(x, y)$) **(5)**

Step 6: Based on L identify the block and apply contrast enhancement accordingly.

if L>= HR ; //All pixels are in Higher region

Apply contrast enhancement on image from L to 255.

***else* // Mix intensity block** **(6)**

Apply contrast enhancement on image from 0 to 255

Step 7: Move the block now in raster order (Left to Right and top to bottom) to cover whole image.

if(*B* < *N*)

B = B + stepsize ;

***Goto* Step 5;**

***elseif* (*A* < *M*)** **(7)**

***A = A+ Stepsize*; *B* =1;**

***Goto* Step 5;**

***else END*;**

For *Stepsize* >1, the complexity of the algorithm is reduced without any significant loss in the enhancement of the visibility. But increasing it more produces blocking effects.

[B] OUTPUT

Figure 5: Fog removal using HSI Model

We adjusted the color of S component by iteratively changing the value of λ and found it to be fairly constant value (0.8 produce a perceptually good quality for foggy images). This is encouraging in view of the computational requirement for finding value of λ. However, to ensure enhancement of color component of the image, we could have used histogram equalization or linear stretching.

VI. MASKING

Here histogram equalization is used that spread the intensities in the full range. After that convolution with the special mask is done and there is a visible difference is shown in foggy and defoggy images.

Figure 6: Fog removal using Masking output-1

Figure 7: Fog removal using Masking Output-2

VII. CONCLUSION

We conclude that low pass and high pass filters cannot remove the fog from any types of foggy images. In HSI model fog is removal is done by gamma correction method but it is very time consuming method and result is not satisfactory. Homomorphic filter and masking method with histogram equalization can remove the fog that can be seen in results.

VIII. FUTURE WORK

In Future , YCBCR model and HSI model will be used with Discrete Wavelet Transform and will get the better results with the comparison of the outputs with its performance quality.

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