

Visibility Improvement in Foggy Images using POSHE Algorithm

G Srikanth, and G Manoj Kumar

Abstract-- Bad weather, such as fog and haze, can significantly degrade the visibility of a scene. Optically, this is due to the substantial presence of particles in the atmosphere that absorb and scatter light. In order to deal with the information of fog image, a method for improving image definition based on image segmentation and image improvement technologies is presented. First of all, in accordance with the characteristics of the grayscale distribution of image, the method finds the non-sky region using regional growth method, and then only in this region POSHE algorithm is used to improve the definition of scene in fog image. The experimental results show that the method can effectively improve the image of degradation in fog and improve image definition.

Keywords-- Image segmentation, regional growth, POSHE algorithm, image degradation, image definition.

I. INTRODUCTION

CURRENT vision systems are designed to perform in clear weather. Needless to say, in any outdoor application, there is no escape from bad weather. Most outdoor vision applications such as surveillance, terrain classification and autonomous navigation require robust detection of image features. Under bad weather conditions, however, the contrasts and colors of images are drastically altered or degraded and it is imperative to include mechanisms that overcome weather effects from images in order to make vision systems more reliable.

At present, there are two methods of foggy image processing. One method is based on the method of atmospheric degeneration physical model[1][2]. The method combines the modeling analysis of atmospheric scattering and image restoration techniques to achieve the restoring effect on the image. Degeneration model is $Y = HX + N$ (here X is the original image, Y is the degraded image, H is the point spread function of Y , N is the additive noise).

It is hoped that the original image X can be obtained through the degraded image Y , but this method's premise is that the spread function H needs to be known.

Advanced models are required to describe complicated phenomena, such as the sun's influence on the sky region, and the bluish hue near the horizon. Most physics-based haze removal methods are limited by the conditions under which the model is valid. The image pollution process and the mechanism created by fog weather are very complex, so it is difficult to express the different fog weather processes by the unified spot proliferation model. Generally, the point spread function of degeneration image is not known in advance, which limits the practical application of this method. Also these methods are not suitable for general outdoor surveillance videos that present heavy fog or rain conditions, and low quality of images with noise and compression artifacts. Under these conditions, it is very hard to get a valid imaging model.

Another one is a variety of enhancing methods based on filtering technologies. According to the different space, the commonly used enhancement technology can be divided into two methods: Histogram modification based and based on the frequency domain.

Histogram processing (global and local histogram equalization and specification)[4] is the second approach to enhance image contrast. For images which contain local regions of low contrast bright or dark regions, histogram equalization does not work effectively. Applying histogram equalization globally to such an image has the disadvantage that bright and dark regions of the image are treated equally. This may cause the contrast in very bright or dark regions to remain bad or even to deteriorate.

Local histogram equalization methods like adaptive histogram equalization provide better performance than global method by revealing more image local details and giving stronger image enhancement performance. Adaptive histogram equalization (AHE)[7] is a modification of histogram equalization. Adaptive histogram equalization transforms each pixel by considering only small regions and based on their local cumulative density function, performs contrast enhancement of those regions. As a consequence, contrast is enhanced locally, with physically separated bright and dark regions

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treated independently. The downside of AHE from a quality perspective is that it can over amplify noise: when the neighborhood lies completely within a nearly homogeneous region, a very small range of values is mapped to the whole output range. So Partially overlapped sub block histogram equalization is proposed in this paper.

Frequency domain based methods make use of wavelets. Multilevel wavelet decomposition to the foggy image is carried out to obtain low and high frequency components of the image which are then processed separately to bring out details.

II. SEGMENTATION OF SKY REGION

The image usually consists of objects, building, roads, vehicle, people and sky region which usually does not carry much relevant information. So this sky region can be separated out from the image as a non processing region thereby reducing the computational steps.

As a result of light scattering in fog, the image of the sky region has higher gray value, and presents a more prominent peak as shown in Figure 1. For this reason, we can firstly determine the gray threshold of sky region, and then through the image segmentation techniques the regions being consistent with the scope of the threshold will be separated.

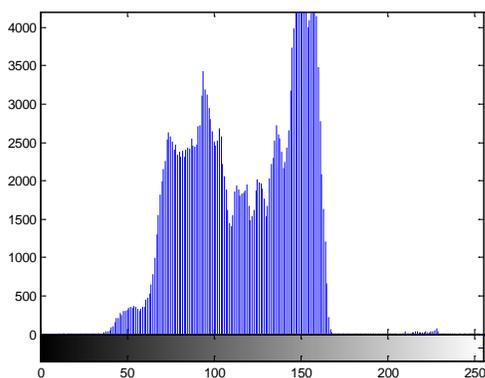


Fig. 1 A fog image and its histogram

A. Determination of the threshold of sky region

Through the histogram analysis of numbers of fog images, it is found that the histogram of these images do not necessarily show double-peaks form, and sometimes the peak which corresponding sky region in the histogram is submerged in the

summit of the gentle slope next to the other peak, so the histogram basically become a single-peak form. In this case, we can determine an appropriate threshold to separate the image through analyzing the concavo-convex distributing of histogram. The basic algorithm is as follows.

The histogram of image can be seen as a region in the plane. The convex hull and its maximum convex deficiency can be calculated to this region. As a result of the maximum convex deficiency often appears in the shoulder of the histogram peak, we can use the corresponding gray value of maximum convex deficiency as a threshold to split the image.

As shown in Figure 2, a 2-D plane is enclosed by the histogram's envelope and the corresponding left edge, right edge and bottom edge. A threshold T which is used to separate the image can be calculated by detecting the maximum convex deficiency of hull of this region. This threshold still depends on pixels.

Once the threshold is obtained, the sky region is identified in the image and is separated out. The rest of the image is processed to extract the information of the scene.

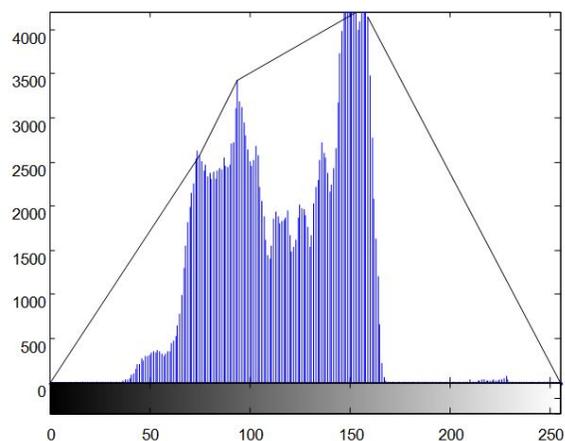


Fig. 2 Convex hull and its maximum convex deficiency

B. Untying sky region using regional growth method

The sky region often appears in the top of the image, and considering the possible shielding objects, therefore the location will be decided necessarily before selecting the seed. In addition, the growth stops until the region is non-continuous according to the connectivity of sky region.

The algorithm steps are as follows:

The image size is 512×512 , and the threshold determined is T , starting from the pixel (x_0, y_0) at left corner of the image, in accordance with the sequence from left to right, top to bottom. Consider the 3×3 neighborhood of each pixel. Check for the intensity values of each of the 9 pixels and count for the ones greater than T . Count the number of pixel out of nine for intensity values greater than T , if number is greater than five then set $Flag(x_0, y_0) = 1$ else $Flag(x_0, y_0) = 0$.

Thus the sky region is having the flag value of ‘1’ and non sky region has flag value of ‘0’. Thus the image is the binary output of the operation.

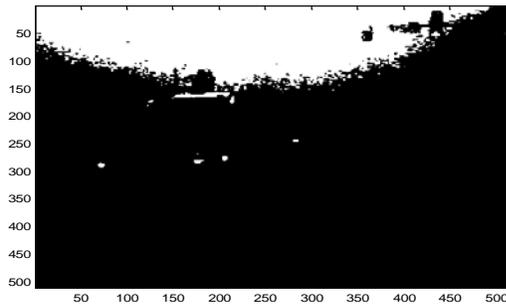


Fig. 3 The separated sky region

III. DEFINITIONS OF IMAGES OF THE SCENE

In order to improve the image contrast in fog, the method of histogram equalization can be adopted. Histogram equalization is that a given image histogram distribution is changed into an even histogram distribution in order to achieve image contrast enhancement.

A. Partially overlapped sub-block histogram equalization (POSHE) algorithm

The size of the input image is 512×512 , so the output image is also defined with dimensions 512×512 . The input of size of sub-block and overlap ratio are taken from the user. According the sub-block size and step size gets adjusted and the operation is performed on the image.

If ignore the border case, the algorithm steps are described as follows:

Step1: Initialize the output image to zero, and set the number of computing *count* as well as the cycle variables *i, j* as zero

Step 2: Determine whether (*i, j*) belong to the sky region, if so, then the pixel will be unchanged, if not, then enter step 3

Step 3: Set (*i, j*) as the vertex, from the input image *f* the corresponding sub-block f_B was taken out

Step 4: Perform the histogram equalization of the sub-block f_B , and add the result to the output image, and record the number of operation of each pixel:

$$g_B = g_B + T_{HE}(f_B), \text{count}(x, y) = \text{count}(x, y) + 1$$

Where *x, y* is the coordinates of pixel

Step 5: Move the sub-block horizontally by the step *hstep*, namely: set $j = j + hstep$, repeat Step 4; Otherwise, enter the next step

Step 6: Move the sub-block vertically by the step *vstep*, namely: set $i = i + vstep$, repeat steps (4); Otherwise, enter the next step;

At the intermediate step count of one fourth, half and three-fourth of the total step count, the image processed thus far is obtained and is compared with the input image using the function PSNR

Step 7: After the above steps are completed, the gray value of each pixel of the output image divided by the number of computing, the output image $g(x, y)$ will be got:

$$g(x, y) = g(x, y) / \text{count}(x, y)$$

For the border region, the effective pixels of the sub-block can be calculated as the above algorithm.

B. Smoothing algorithm of blocking effect

The image obtained has visible boundaries, which make the image look discontinuous. Following filters are used to smoothen out the blocking effect. Different results are obtained as a result of application of different filters.

The filters applied are:

Weighted filter with the definition of:

$$[1 \ 1 \ 1 \ 1 \ 1; 1 \ 3 \ 3 \ 3 \ 1; 1 \ 3 \ 10 \ 3 \ 1; 1 \ 3 \ 3 \ 3 \ 1; 1 \ 1 \ 1 \ 1 \ 1]$$

- Average filter
- Gaussian Filter
- Disk Filter
- Unsharp Filter

The results of these filter application are then compared with the input image.

IV. EXPERIMENTAL RESULTS AND ANALYSIS

The Comparison results of the fog image through the above method showed in figure 4 and the images after applying the filters like Gaussian, disk, Unsharp, Weighted average filter are shown in figure 5.

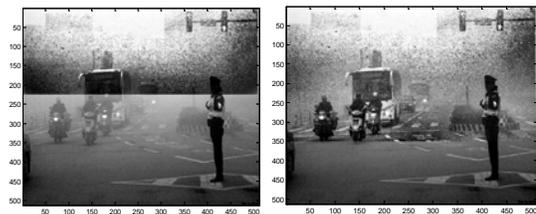


Fig 4(a),(b): Images after one-fourth and half of the processing steps.

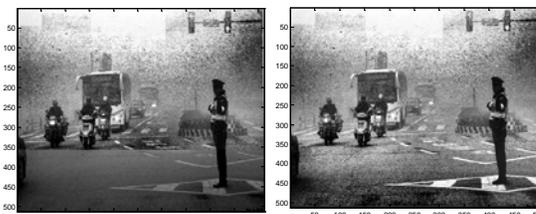


Fig 4(c),(d): Images after three-fourth and end of the processing steps.

TABLE I
COMPARISON OF PSNR VALUES FOR DIFFERENT TECHNIQUES

Technique	PSNR value(db)
Histogram Equalization	15.294
Bi-histogram Equalization	15.261
POSHE	13.931

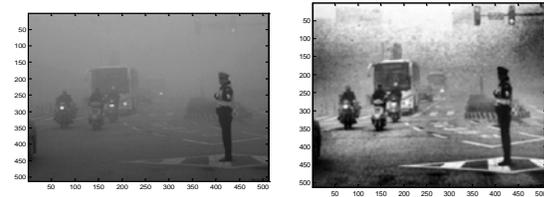


Fig 5(a),(b): Input Image and after applying average filter.

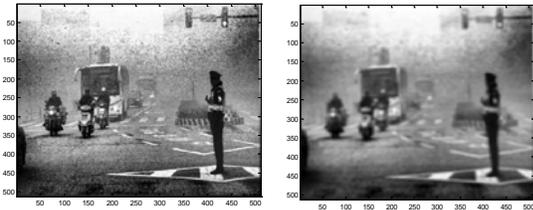


Fig 5(c),(d): Images after applying Gaussian and disk filter.

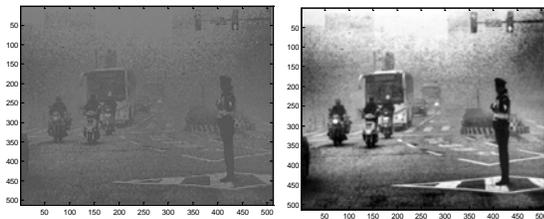


Fig 5(e),(f): Images after applying Unsharp and Weighted average filter.

TABLE II

COMPARISON OF PSNR VALUES FOR SUB-BLOCK SIZE=100

Type of filter	Overlapping fraction=0.1	Overlapping fraction=0.2	Overlapping fraction=0.3
Average Filter	15.971	16.053	16.027
Gaussian Filter	15.752	15.838	15.822
Disk Filter	16.160	16.247	16.219
Unsharp Filter	12.612	12.706	12.759
Weighted average Filter	-28.762	-28.822	-28.927

V. CONCLUSION

In order to adapt to the different degradation of the target in the multi-depth scenes in fog, in this work a comprehensive definition method of images is presented. First of all, the sky region and the non-sky region are separated. Since we are interested in the roads, buildings and objects, therefore in the non-sky region, Partially Overlapped sub-block Histogram Equalization is performed through the moving sub-block.

Different filters have been used to smoothen out the irregularities in final images. The images thus obtained are carrying relevant information and the final smoothening filter to be used depends on the application of the fog image. The above work has been done for the gray scale image. It can further be explored for the color images where the color image enhancement can directly be done, therefore also carrying the color information.

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