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EVALUATION OF VARIOUS DIGITAL IMAGE FOG REMOVAL ALGORITHMS

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Abstract: This paper is a review on the various fog removal algorithms. Fog removal otherwise called visibility restoration refers to diverse systems that suppose to lessen or evacuate the degradation that have happened while the digital picture was being acquired. In this paper, various fog removal techniques have been analysed. It has been shown that each fog removal technique has its own features and drawbacks. The presented methods have neglected the techniques to reduce the noise issue, which is presented in the output images of the existing fog removal algorithms. Not much effort has focused on the integrated approach of the CLAHE and Dark channel prior. The problem of the uneven illuminate has also neglected by the most of the researchers.

Index terms: Fog removal, image enhancement, visibility restoration.

1. INTRODUCTION

Diverse weather situations such as haze, fog, smoke, rain, or snow will cause multifaceted visual effects of spatial or temporal domains in images or videos [1–3]. Such artifacts may appreciably humiliate the performances of outdoor vision systems relying on image/video feature extraction [4] or visual attention modeling [5–7], such as event detection, object detection, tracking, and recognition, scene analysis and classification, image indexing and retrieval [8].Images or video bear from lack of quality taken under such conditions, unless the hazy appearance is needed for artistic reasons. Visibility restoration [9] refers to different methods that seek to reduce or remove the degradation that have occurred while the digital image was being obtained. The reasons of the degradation can be factors like blurring due to camera misfocus, relative object-camera motion, relative atmospheric turbulence and various others. In this paper, we discuss the degradations due to bad weather like fog, haze, rain and snow in an image. The key reason of degradation of picture quality of outside screen in the mist and fog climate condition is for the most part the diffusing of a light before arriving at the camera because of these extensive amounts of suspended particles (e.g. haze, dimness, smoke, impurities) in the weather. This influences the typical working of automatic monitoring system, outdoor recognition system and intelligent transportation system. By the use of haze removal methods of picture we can improve the stability and strength of the visual framework.

Fig 1.1:(a) Original image (b) Processed image

Haze is acase of the opaque medium (*e.g.*, particles and water droplets) in the atmosphere, which will humiliate outdoor images due to atmospheric absorption and scattering[8].Its removal is an excessive undertaking as fog relies on upon the unknown scene depth data. Fog effect is the function of distance between camera and object. The haze removal approach might be divided into two classifications: image enhancement and image restoration. Image enhancement classification excludes the reasons of haze humiliating picture quality. This method loses a portion of the data in regards to image additionally enhance the contrast of fog picture. Image restoration firstly studies the physical process of image imaging in foggy climate [9].Several algorithms have been anticipated to boost the quality of images taken under foggy environment, focusing for instance on visibility.

2. VISIBILITY RESTORATION TECHNIQUE

For removing haze, fog, mist from the image various procedures are used. Typical procedures of image restoration to the fog are:

A. Dark channel prior:Dark channel prior [10] is an effectual image prior. It was projected to banish cloudiness from a single image, where the key perception is that most local patchesin outside fog free images hold a few pixels whose intensity is low in no less than one shade channel. In light of this former with the fog optical model, one can distinctively assess the thickness of the dimness and renovate a great fog free image. Then, the dark channel prior was also engaged in [11-12] for single image dehazing.This method is for the most part utilized for non-sky patches, as no less than one shade channel has low intensity at a few pixels. The low intensity oblivious channel are readily due to three segments:-Colorful things or surfaces(green grass, tree, blossoms etc) , shadows(shadows of auto, structures and so forth), dim things or surfaces(dark tree trunk, stone).

As the outdoor pictures are often full of shadows and colorful, the dark channels of these pictures will be really dark. Due to fog (airlight), a haze picture is brighter than its picture without haze [22]. So we can say dim channel of haze image will have higher intensity in area with higher haze. In this way, visually the intensity of dull channel is a unkind close estimation of the thickness of cloudiness. In dark channel prior we equally utilize pre and post processing steps for showing signs of progress results. In post processing steps we utilize soft matting or bilateral filtering etc. Let J(x) is input picture, I(x) is foggy picture, t(x) is the transmission of the medium. The attenuation of picture due to fog can be expressed as:

$$I_{att}(x) = J(x)f(x) \ldots\ldots\ldots\ldots (1)$$

the result of fog is Airlight effect and it is expressed as:

$$I_{airlig\,ht}(x) = A\big(1-t(x)\big) \ldots\ldots.. (2)$$

Dark channel for an arbitrary picture J, expressed as J dark is defined as:

$$J^{dark}(x) = \frac{min}{y \in \Omega(x)} (\min J^C(Y) \ldots\ldots (3)$$

In this Jc is color image involving REG segments, represents a local patch which has its origin at x. The low intensity of dark channels is accredited for the most part because of shadows in pictures, saturated color items and dark objects in images.

After dark channel prior, we have to estimate transmission t(x) for succeeding further with the result. An alternate assumption required is that let Atmospheric light An is additionally known. We standardize (4) by partitioning both sides by A:

$$\frac{I^c}{A^c}(x) = t(x)\frac{J^c}{A^c}(x) + 1 - t(x) \ldots\ldots (4)$$

Figure 1: a)Input Imagesb)Haze removal results.

B. CLAHE

The CLAHE method [13] applies histogram equalization to sub-images. Every pixel of original image is in the focal point of the sub- image. The first histogram of the sub-picture is cut and the cut pixels are redistributed to each gray level. The new histogram is not quite the same as the first histogram on the grounds that the intensity of every pixel is inhibited to a client determined maximum. Consequently, CLAHE can lessen the enhancement of noise.

The various steps of CLAHE method are divided as follows[13]:

Step 1: The original picture should be divided into sub-pictureses which are continuous and non-overlapping. The size of each sub-picture is M×N.

Step 2: The histograms of the sub-pictures are calculated.

Step 3: The histograms of the sub-pictures are clipped.

The number of pixels in the sub-picture is uniformly distributed to each gray level. Then the average number of pixels in each gray level is given as

$$N_{avg} = \frac{N_{SI-XP} * N_{SI-YP}}{N_{graylevel}} \ldots\ldots (5)$$

where N_{avg} is the average number of pixels,

$N_{graylevel}$ is the number of the gray levels in the sub-picture.

N_{SI-XP} is the number of pixels in the x dimension of the sub-picture.

N_{SI-YP} is the number of pixels in the y dimension of the sub-picture.

Based on the Eq. (5), the actual clip-limit is calculated as

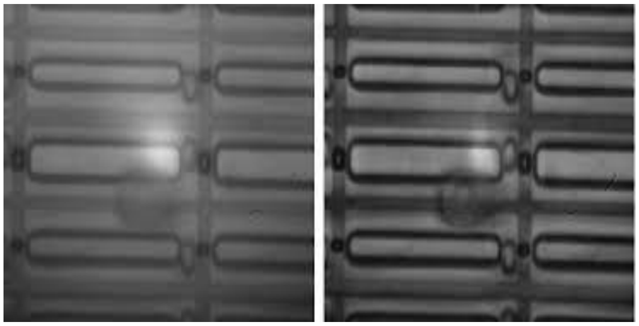

Figure 2: (a) input image b) haze removed

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$$N_{C-L} = N_c * N_{avg} \ldots\ldots(6)$$

where$N_{C-L}$is actual clip-limit.

$N_c$is the maximum multiple of average pixels in eachgray level of the sub-image.

In the original histogram, if the number of pixels is more than N_c then the pixels will be clipped. The number of pixels scattered averagely into each gray level $N_d$is defined by the total number of clipped pixels NTC as

$$N_d = \frac{N_{TC}}{N_{grayscale}} \ldots\ldots(7)$$

$$If\ H_{SI} > N_{C-L} \ldots\ldots(8)$$

At the end of the above distribution, the lasting number of clipped pixels is expressed as NRP.

C. Wiener filtering

Wiener filtering is based on dark channel prior: Wiener filtering [14] is used to respond to the problems such as color distortion while utilizing dark channel prior.The approximation of media function is rough which make halo effect in final image. Thus, median filtering is utilized to approximate the media function, so edges might be preserved. In the wake of making the median function more correct it is united with wiener filtering so the image restoration problem is transformed into optimization problem. Blurring is because of straight movement in a photo is the result of poor sampling. Every pixel in a digital representation of the photo ought to represent the intensity of a single stationary point in front of the camera. If the shutter speed is extremely moderate and the camera is in movement, a given pixel will be an amalgram of intensities from point along the line of the camera movement. This is a two-dimensional analogy to

$$G(u,v) = F(u,v).H(u,v) \ldots.(9)$$

where F is the fourier transform of an "ideal" version of a given image, and H is the blurring function. In this case H is a sinc function: if three pixels in a line contain info from the same point on an image, the digital image will seem to have been convolved with a three-point boxcar in the time domain. Ideally one could reverse-engineer a Fest, or F estimate, if G and H are known. This technique is inverse filtering.

In this present reality, in any case, there are two issues with this system. To start with, H is not known correctly. Engineers can hypothesize the blurring function for a given situation, however determination of a great blurring function requires heaps of experimentation. Second, inverse filtering comes up short in a few conditions in light of the fact that the sinc function goes to 0 at a few estimations of x and y. Real pictures contain noise which gets opened up to the point of decimating all endeavors at remaking of a Fest.

The best method to solve the second problem is to use Wiener filtering. This tool solves an estimate for F according to the following equation:

$$Fest(u,v) = |H(u,v)|^2.\frac{G(u,v)}{|H(u,v)|^2.H(u,v) + K(u,v)} \ldots..(10)$$

K is a constant chosen to optimize the estimate. This equation is derivative from a least squares method

This algorithm is useful to recuperate the contrast of a large white area for image. The running time of image algorithm is also less.

Figure 3: (a) Original foggy image (b) Weiner defogged image

D. Bilateral filtering

This filtering [15] smooths images without effecting edges, by means of a non-linear grouping of nearby image values. In this, filter replaces every pixel by weighted average of its neighbor's pixel. The weight assigned out to each one neighbor pixel diminishes withboth the distance in the picture plane and the distance on the intensity axis. This filter helps us to get come about quicker as contrast with other. While utilizing bilateral filter we utilize pre-processing and post transforming steps for better comes about. Histogram equalization is utilized as preprocessing and histogram stretching as a post preparing. These both steps help to manufacture the contrast of image previously, then after the fact utilization of two-sided channel. This algorithm is autonomous of density of fog so can also be applied to the images taken in dense fog. It doesn't require user interference. It has a broad application in tracking and navigation, consumer electronics and entertainment industries.

A bilateral filter is a non-linear, edge-preserving and noise-rdeducing smoothing denoising technique for pictures. The intensity value at each pixel in a picture is transferred by a weighted average of intensity values from nearby pixels. This weight can be based on a Gaussian distribution. significantly, the weights rely not only on Euclidean distance of pixels, but also on the radiometric differences (e.g. range differences, such as color intensity, depth distance, etc.). This conserves sharp edges by methodically looping through each pixel and adjusting weights to the adjacent pixels accordingly.

The bilateral filter is defined as

$$I^{filtered}(x) = \frac{1}{W_p}\sum_{x_i \in} I(x_i) f_r(||I(x_i) - I(x)||) g_s(||x_i - x||) \dots (11)$$

where the normalization term

$$W_p = \sum_{x_i \in} f_r(||I(x_i) - I(x)||) g_s(||x_i - x||) \dots\dots (12)$$

ensures that the filter conserves image energy and$I^{filtered}$ is the filtered image;I is the original input image to be filtered;x are the coordinates of the current pixel to be filtered;is the window centered in x;$f_r$is the domain kernel for smoothing differences in intensities. This function can be a Gaussian function;$g_s$is the spatial kernel for smoothing differences in coordinates. This function can be a Gaussian function;

As mentioned above, the weight$W_p$is assigned using the spatial closeness and the intensity difference. Consider a pixel located at (I,j) which needs to be denoised in image using its neighbouring pixels and one of its neighbouring pixels is located at (k,l). Then, the weight assigned for pixel (k,l) to de-noise the pixel (i,j) is given by:

$$w(i,j,k,l) = \in^{\left(-\frac{(i-k)^2+(j-l)^2}{2\sigma_d^2} - \frac{||I(i,j)-I(k,l)||^2}{2\sigma_r^2}\right)} \dots\dots\dots (13)$$

where σ_d and σ_r are smoothing parameters and I(i, j) and I(k, l) are the intensity of pixels (i,j) and (k,l) respectively. After calculating the weights, normalize them.

$$I_D(i,j) = \frac{\sum_{k,l} I(k,l) * w(i,j,k,l)}{\sum_{k,l} w(i,j,k,l)}$$

where $I_D$is the denoised intensity of pixel (i,j).

Figure 4: (a) original foggy image, (b) Restored image using bilateral filtering

3. GAPS IN LITERATURE

Fog removal algorithms become more beneficial for numerous vision applications. It has been originated that the most of the existing research have mistreated numerous subjects. Following are the various research gaps concluded using the literature survey:-

1. The presented methods have neglected the techniques to reduce the noise issue, which is presented in the output images of the existing fog removal algorithms.
2. Not much effort has focused on the integrated approach of the CLAHE and Dark channel prior.
3. The problem of the uneven illuminate is also neglected by the most of the researchers.

4. CONCLUSION AND FUTURE WORK

Haze removal methods have become more helpful for vision applications. It is discovered that the majority of the researchers have disregarded numerous issues; i.e. no method is correct for diverse sort of circumstances. The current strategies have dismissed the utilization of uneven illuminate problem. To overcome the issues of existing research another noble algorithm will be proposed in near future. New methods will incorporate the dark channel prior and CLAHE to enhance the results further.

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