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Comparison of Image Dehazing Using Dark Channel Prior With Edge Preserving Filters

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ABSTRACT: Haze, fog, dust particles and water droplets degraded the standard of an image taken by the camera. In numerous PC vision applications for example-video surveillance system, a navigation application, remote sensing, there is a need for high visibility pictures as contribution to further processing. Fog and haze can influence the outside pictures as far as low complexity, poor visibility and lessen the color contents of an image. In this paper we discussed about various filtering operation for refining the transmission map for image restoration of foggy picture and compare the restore results with parameters used for quality measurement of an picture. Dark channel prior method is used for image defogging with different filters- guided filter, average filter and median filter.

KEYWORDS: Haze formation model, Image Dehazing, Dark Channel Prior, Filter.

I. INTRODUCTION

In numerous PC vision applications, for example, intelligent transportation framework, self-driving vehicles, mist and fog deleting is essential capacity from a foggy picture. In the air, there are different sorts of pollutant substances, mist, water beads, fog and brown haze that degrade the standard of a picture as far as poor visibility , absence of shading, low brightening and experience the ill effects of poor contrast which is because of the absorption and scattering.

Degraded image is not suitable for computer vision application- video surveillance system and the intelligent transport system.

In a ongoing study, there are a great deal of strategies to re-establish the corrupted hazy image. Image dehazing based on two classification (a) image enhancement (b) image rebuilding. In image enhancement [1] retinex algorithm [2] and histogram equalization are very popular methods. In [3], polarization is used for image dehazing, air-light scattered by atmospheric particles and gets polarized it follows the reverse process to image dehazing.

The image restoration method further divided based on Multiple images and a single image. Multiple images method [3], in it two polarization images are taken through different orientations such as parallel and perpendicular polarization.

Multiple image methods face an issue of the accessibility of an alternate picture of similar scenes in online applications. To overcome these difficulties single image methods [4] comes in picture.

On the further most significant technique dependent upon prior knowledge and assumption , He [5] initiated a new procedure built on dark pixels called as Dark Channel Prior which can be helpful in many new dehazing algorithms [6]. In [7] define a specific region on an image for an approximation of atmospheric light and use local dark channel prior.

II. HISTORICAL BACKGROUND

Haze Image Developing Model

From [8] haze image developing model described by this mathematically equation.

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

In the above given equation I is represented as hazy picture, J is represented as the original picture, x is the represented as picture element spot, A is the atmospheric air light. J (x) and I (x) treated as magnitude of the pixel spot in haze free and hazy images, t is the transmission medium that relate the section of lights that is not disperse and stick out the image caption source. Transmission map can defined as

$$t(x) = e^{-\beta d(x)} \qquad (2)$$

Where scene depth denoted as d and scattering coefficients denoted as β, in transparent weather condition β becomes zero I is approximately equal to J but in poor weather conditions β has non zero value which can form

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hazy image. Dehazing is phenomenon is recovered J from I after estimation of transmission map $t(x)$ and atmospheric light A.

$$J(x) = \frac{I(x) - A}{t(x)} + A \qquad (3)$$

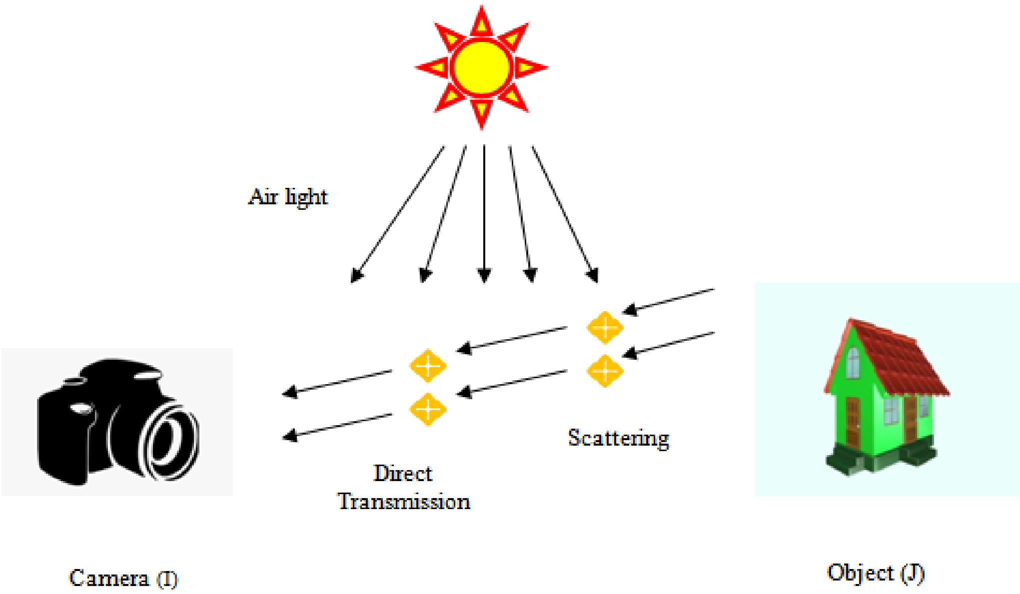

Fig 1.Haze Formation Model

III. RELATED WORK

The dark channel prior [5] is build on a genre of data of open air image, it is built on the subsequent survey on mist-free open air pictures. In almost all region without sky area having spot with low pixel value in the color channel of an image.

$$J^{dark}(x) = min_{C\in\{r,g,b\}}(min_{y\in\Omega(x)}(J^C(y)))$$
(4)

In the above equation $\Omega(x)$ is a neighbourhood dot focus at x and J^C is a color channel of *J*. inspection carried out, some region without a sky area having; low intensities pixel value and approximate become zero

Firstly take an assumption atmospheric light is given, after it calculation of transmission map and assume local patch $\Omega(x)$ is constant. Fog extraction method pointed that to restore an original picture which suffers from truncated contrast and distinctness. Foggy image are typically depicted as equation (1)

Normally β is thought to be consistent consequently thus it is contrarily correlated to d(x). Accepted that A has been accurately evaluated subsequently model can be rearranged as

$$\frac{I(x)}{A} = \frac{J(x)}{A} t(x) + [1 - t(x)]$$
(5)

$$I_w(x) = J_w(x)t(x) + [1 - t(x)] \qquad (6)$$

Where,

$$I_w(x) = \frac{I(x)}{A}$$

$$J_w(x) = \frac{J(x)}{A},$$

$$t(x) = e^{-\beta d(x)}$$

$J(x)t(x)$ is direct attenuation and $A(1 - t(x))$ is air light, scene radiance related by direct attenuation its degraded in the medium,

Put the min operation in the neighbourhood fix on the fog imaging condition (3),

$$\min_{y\epsilon\Omega(x)} I_w(y) = t(x)\min_{y\epsilon\Omega(x)} J_w(y) + (1 - t(x))$$
(7)

Apply minimum operation in all colour channels

$$\min_{y\epsilon\Omega(x)}(min(I_w^c(y))) = t(x)\min_{y\epsilon\Omega(x)}(min(J^c(y)) + 1 - t(x) \qquad (8)$$

based on the dark channel prior

$$J^{dark}(x) = \min_c(\min(J^c(y))) = 0 \qquad (9)$$

put the eq.9 into eq.8 then the transmission can be expressed as

$$\min_{y\epsilon\Omega(x)}(\min I_w^c(y)) = 1 - t(x) \qquad (10)$$

This method assumes that transmission is matching in each Ω symbolize as $\tilde{t}$, so

$$\min_{y\epsilon\Omega(x)}(\min I_w^c(y)) = 1 - \tilde{t}(x) \qquad (11)$$

$$\tilde{t}(x) = 1 - \min_{y\epsilon\Omega(x)}(\min I_w^c(y)) \qquad (12)$$

Scene radiance recovery

After the estimation of transmission map by equation (12) scene radiance is restored by the subsequent using equation (3)

$$J(x) = \frac{I(x)-A}{t(x)} + A \qquad (13)$$

Edge preserving filter

Image smoothing filters are the same as image blurring filter, which aim to smooth a region by replacing pixel values by some linear or non-linear function of neighbourhood values. In this paper use different filter to refine the estimated transmission map

1. Guided filter

The guided filter [6] channel conduct edge-saving smoothing on a picture, utilizing the substance of a subsequent picture, known as a direction picture, to impact the separating. The direction picture can be simply the picture, an alternate variant of the picture, or a totally extraordinary picture.

Neighbourhood action used in guided image filtering, as other filtering actions, however considers the insights of an area in the relating spatial neighbourhood in the guidance picture while figuring the estimation of the yield pixel.

In the guide filter initially characterize a general straight interpretation variation separating process, which includes a direction picture I, an info picture p, and a yield picture q. Both I and p are given in advance as indicated by the application, and they can be indistinguishable. The sifting output at a pixel I is communicated as a weighted average.

$$q_i = \sum_j W_{ij}(I)p_j \qquad (14)$$

Where i and j are pixels dot. The filter bit W_{ij} is treated as an element of the guidance picture I and free of p. This is a linear filter direct as p.

Presently characterize the guided channel and its part. The key supposition of the guided channel is a local straight model linking the direction I and the channel yield q. We expect that q is a straight change in I in a window ω_k centered at the pixel k

$$q_i = a_k I_k + b_k \quad , \quad \forall_i \in \omega_k \qquad (15)$$

a_k and b_k are constant in ω_k and are determined by the following function

$$E(a_k, b_k) = \sum_{i\in\omega_k}((a_k I_i + b_k - p_i)^2 + \varepsilon {a_k}^2) \qquad (16)$$

Where ε is a regularization parameter keeping a_k from being excessively enormous. Solution of (a_k, b_k) can be get by

$$a_k = \frac{\frac{1}{|\omega|}\sum_{i\in\omega_k} I_i p_i - \mu_k \bar{p}_k}{{\sigma_k}^2 + \varepsilon} \qquad (17)$$

$$b_k = \bar{p}_k - a_k \mu_k \qquad (18)$$

μ_k is the mean and ${\sigma_k}^2$ is the variance in ω_k

Refined transmission map using guided filter with regularization parameter ε = 0.04 and local window size r = 16.

2. Average filter

The averaging filter act as low-pass filters normalizing image pixel intensity variations. As a result, the edges (which consist of sharp intensity variations across them) in an image also get blurred which is not desired.

Mean filter, or average filter is windowed channel of direct class, that smoothes signal (picture). The channel fills in as low-pass one. The fundamental thought behind channel is for any component of the sign (picture) take a normal over its neighborhood.

For the refining of transmission map use 5×5 average filter.

3. Median filter

The median filter used the method of non linear filtering for eradication of noise from image.

The Median Filter is categorized under non-linear digital sifting strategy, frequently used to expel noise from a picture or signal. So noise cutting is a common pre-handling venture to upgrade the consequences of later processing (for instance,

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edge recognition on a picture). Median filter is broadly utilized in digitalized image processing because of under specific situations, it has a quality of preserving edges at the stage of expelling noise, additionally having applications in signal processing [12]

It is extremely efficient at evacuating impulse noise, the "salt and pepper" noise, in the picture. The guideline of the median filter is to supplant the gray level of every pixel by the middle of the gray levels in an area of the pixels, rather than utilizing the normal activity. For median filtering, indicate the piece size, list the pixel esteems, secured by the portion, and furthermore decide the median level. In the event that the bit covers a significantly number of pixels, the average of two median values is utilized. [13]

For the refining of transmission map use 9×9 median filter

Block Diagram

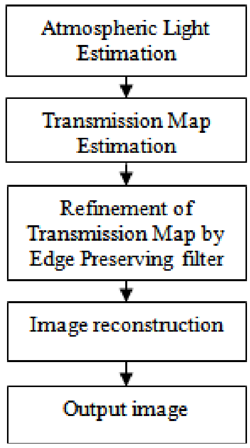


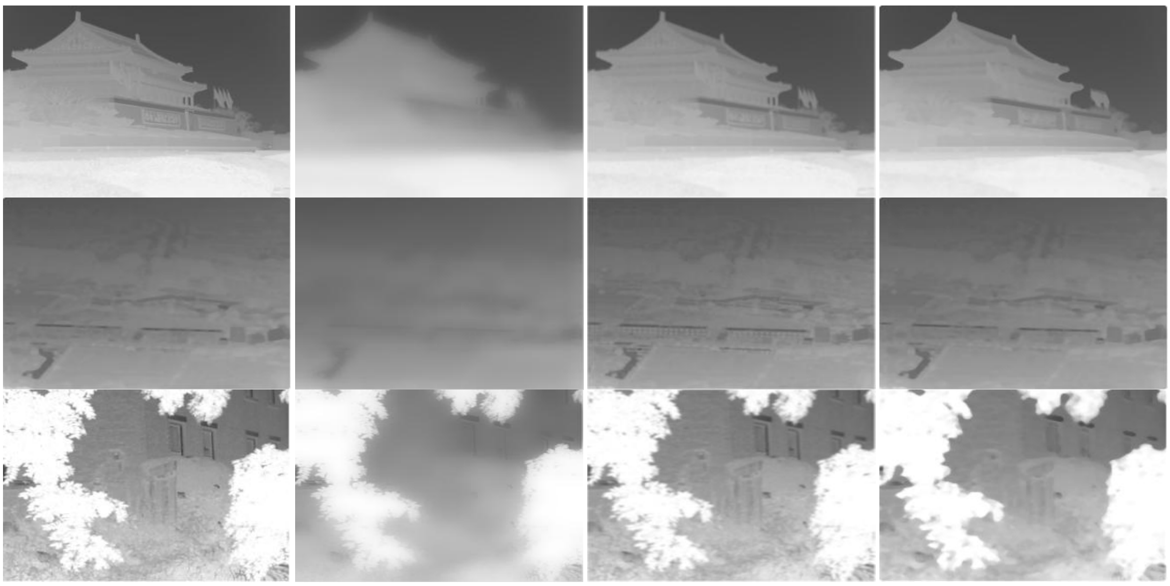
Figure 2- Work Flow of Method

Table 1- Quantitative Comparison of image defogging in figure-3

Hazy Image	Performance Parameter	DCP [6]	DCP With Guided [7]	DCP With Average	DCP With Median
Temple	PSNR	28.9329	28.8518	29.0767	29.0969
	MSE	83.1344	84.7029	80.4281	80.0551
	SSIM	0.9014	0.8985	0.9092	0.9082
	IE	7.4605	7.4295	7.4834	7.4907
	CEIQ	3.4152	3.4202	3.4237	3.4388
City	PSNR	28.8684	28.9705	28.8450	28.9928
	MSE	84.3801	82.4182	84.8360	81.9971
	SSIM	0.7747	0.8787	0.7872	0.8818
	IE	6.4478	6.9561	6.5025	6.9344
	CEIQ	2.8177	3.2042	2.8796	3.1661
House	PSNR	30.3736	29.8795	30.4146	30.6219
	MSE	59.6637	66.8541	59.1046	56.3491
	SSIM	0.8414	0.9083	0.9139	0.9117
	IE	6.9828	7.1410	7.1743	7.1623
	CEIQ	3.1361	3.2369	3.2532	3.2437
Forest	PSNR	28.8758	28.8492	28.8758	28.8871
	MSE	84.2355	84.7525	84.2356	84.0167
	SSIM	0.8071	0.8255	0.8071	0.8082
	IE	6.8949	6.9990	6.8949	6.9162
	CEIQ	3.0830	3.1383	3.0830	3.0945

(i) (ii) (iii) (iv) (v)

Figure-3 Defogging results with various filter used (i) original fog free picture (ii) DCP (iii) DCP with guided filter (iv) DCP with average filter (v) DCP with median filter



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(i) (ii) (iii) (iv)

Figure-4 Transmission map of foggy picture (i)DCP (ii) DCP with guided filter (iii) DCP with average filter (iv) DCP with median filter

IV. RESULTS

In this paper we compare the image defogging with DCP method. In additionally use different filters with DCP to restore the foggy picture. At the time of results inspection, for the quality measurement we compare the PSNR (peak signal to noise ratio) value. For the better defogging result it should have greater value. PSNR value is achieved higher in median filtering. The lesser the value of MSE the image has better quality.MSE value is achieved low in Median filter method. SSIM structural similarity used to compare the defogging result with original picture. Information entropy (IE) used to evaluate information content in picture higher the value of IE the image has more information. CEIQ (Contrast changed image quality) used to measure the contrast of an image higher the value of CEIQ better the contrast in restored output. It is clearly shown in Table-1

V. CONCLUSION

Based on quantitative analysis of the hazy images median filter gives better outcomes.MSE value is lower when median filter is used with Dark Channel Prior to estimate transmission map. PSNR value is higher than other filters and SSIM value gives stronger dehazing result from hazy images. IE and CEIQ have higher value than other filters when used median filter.

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