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Improved Trilateral Filter Based Dark Channel Prior For Haze Removal

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Abstract: Fog is just a mixture of two components airlight and direct attenuation, it reduces the image quality and creates large amount of problems in video surveillance, tracking and navigation. Thus, to eliminate it from a picture, several defogging methods have been proposed in literature. Defogging can be achieved utilizing various images and single image fog removal strategy. Fog removal algorithms are most utilized for a lot of vision applications. It has been found that nearly all the existing scientific study has neglected many issues; i.e. no strategy is perfect for diverse circumstances. In this paper, a new technique of fog removal has been presented. This technique combines Dark Channel Prior and CLAHE based fog removal algorithm with trilateral filter. The algorithm has been designed and implemented and in MATLAB. Experiments shows that the proposed algorithm has better results as compared to previous algorithms on the basis of various parameters.

Keywords: Fog Removal, Visibility Restoration

I. INTRODUCTION

Visibility restoration refers to various ways that has objective to decrease or eliminate the degradation that have occurred while the digital image was being obtained. The deprivation might be due to several factors like relative object-camera motion, blur due to camera misfocus, relative atmospheric turbulence and others. Fog is often distinguished from the more generic term "cloud" for the reason that fog is low-lying, and the moisture content in the fog is often generated locally. So to overcome the degradation in the image, visibility restoration strategies are applied to the image so as to get a better quality of image [1]. The image quality of outdoor screen in the fog and haze weather condition is generally degraded by the scattering of a light prior reaching the camera because of all these large quantities of suspended contaminants (e.g. fog, haze, smoke, impurities) in the atmosphere. This phenomenon influences the normal work connected with automatic monitoring system, outdoor recognition system and intelligent transportation system.

Scattering is caused by two essential phenomena like attenuation and airlight. By the simply using effective haze removal of image one is able to enhance the stability and robustness of the visual system[2]. So to eliminate this color shift in the image, several haze removal methods are utilized to enhance the quality of the image. Haze removal is a difficult task as fog depends on the unknown scene depth information. Fog effect is the function of distance between camera and also the object. Hence removal of fog needs the estimation of airlight map or depth map.

II. LITERTURE SURVEY

Desai et al. (2009) [3] examined that de-weathering a haze corrupted picture is just a poorly postured issue and existing methods are of high trouble and adaptability. Desai et al gave a guide fluffy rationale based system, to de-climate haze debased pictures. Exceptionally, air-light judgment is completed utilizing fluffy rationale conveyed by shade amendment for enhanced perceivability. Because of its low many-sided quality contrasted with progressive physical science based results, this strategy makes continuous usage conceivable on a versatile stage which will be basic from the block security perspective. Chao et al (2010) [4] has proposed a substance versatile method for single picture dehazing. As the corruption level harmed by dimness is joined with the profundity of the scene and pixels atlanta divorce attorneys particular little the picture, (for example, trees, structures or different articles) will likely have comparable profundity to the Polaroid. It is expected that the corruption level influenced by fog of every locale is the same in a way that the transmission atlanta divorce attorneys district should really be comparable too.

Considering these circumstances, each of these data picture is partitioned into diverse locales and transmission is assessed for each and every single district emulated by change by delicate tangling and the murky pictures could be effectively recuperated. Wang, et al. (2010) [5] has explored that haze removal from the image depend upon the unknown depth information. This algorithm is on the cornerstone of the atmospheric scattering physics-based model. In this on selected region a dark channel prior is wear obtain estimation of atmospheric light. This model is predicated on some observation on haze free outdoor image. In non-sky patches, a the least one color channel has suprisingly low intensity at some pixels.

The reduced intensity for the reason that region is a link between shadows, colorful objects, dark objects etc. Jing Yu et al (2011) [6] suggests that imaging in poor weather is normally strictly corrupted by dispersion consequently of floating particles in the atmosphere such as as an example as an example haze and fog. A book fast defogging approach is proposed from one image of a scene on the cornerstone of the atmospheric spreading model. In the deduction means of the atmospheric mask, the coarser approximation is advanced utilizing a quick edge-preserving smoothing approach. The complication of the proposed method is simply a linear function of the total quantity of image pixels and this thus allows a very quickly implementation. Results on several outdoor foggy images |demonstrate that the proposed method achieves good restoration for contrast and color loyalty, making a great enhancement in image visibility. Kaiming He et al (2011) [7] has proposed a straightforward but effective image prior dark channel just before eradicate haze from only one input image. The dark channel prior is some sort of data of outdoor haze-free images. It's dependant on a vital inspection that a lot of local patches in outdoor haze-free images include some pixels whose power is suprisingly lower in a minumum of only one color channel. Applying this prior with the haze imaging representation, the thickness of the haze is approximated and improve high-quality haze-free image. Results on numerous cloudy images demonstrate that the capability of the proposed prior. Moreover, a supreme quality intensity map are often obtained as a offshoot of fog removal. Yu, et al.

(2011) [8] has proposed a story fast defogging method from only one image on the basis of the scattering model. A white balancing will become necessary ahead of the scattering model went for visibility restoration. Then an edge-preserving smoothing approach based upon weighted least squares (WLS) optimization framework to smooth the sides of image. Eventually inverse scene albedo is went for recovery process. This process doesn't involve prior information. Houssam Halmaoui et al (2011) [9] has observed that driver assistance systems specialized in camera are strongly experiencing the clear presence of foggy weather. The restoration of the images, as pre-processing, would improve the end result of such systems. A technique is proposed to boost the image contrast of foggy road scenes joining an actual approach, specialized in Koschmieder model and a signals approach, specialized in local histogram equalization. Odds are they analyzed the parameters of the strategy employing a simulated annealing.

Shuai, et al. (2012) [10] discussed problems regarding the dark channel prior of color distortion problem |for many light white bright area in image. An algorithm to estimate the media function in using median filtering on the foundation of the dark channel was proposed. After making media function more accurate a wiener filtering is applied. By this fog restoration problem is became an optimization problem and by minimizing mean square error a clearer, finally fog free image is obtained. Cheng, et al. (2012) [11] has proposed a lowest channel prior for image fog removal. This algorithm is simplified from dark channel prior. It's dependant on a vital undeniable proven proven fact that fog-free intensity in a shade image is generally a least value of trichromatic channels. In dark channel just before estimate the transmission model it performs because the absolute minimum filter for lowest intensity.

This filter results in halo artefacts, specifically in the neighbourhood of edge pixels. In this algorithm rather than minimum filter they utilises exact O(1) bilateral filter on the foundation of the raised cosines function to the weight value of neighbour to acquire fog-free image. Sahu, et al. (2012) [12] has proposed an algorithm of fog removal from the colour image and also useful in hue preserving contrast enhancement of color images. In this method firstly, the very first image is converted from RGB to YCbCr(a method of encoding RGB information). Y′ may be the luma component and C_B and C_R would be the blue-difference and red-difference chroma components. Secondly, the intensity element of the converted image and the main element observation of all the pixels of image are computed. Xu, et al. (2012) [13] has recommended a design on the foundation of the physical way of imaging in foggy weather. In this model a quick haze removal algorithm which may be dependent on a quick bilateral filtering with dark colors prior is explained. Firstly, the atmospheric scattering model is employed for to spell it out the forming of haze image. Then an estimated transmission map is formed using dark channel prior. Then it's coupled with gray scale to extract the refined transmission map by utilizing fast bilateral filter instead of soft matting. The important thing reasoned explanations why the image is dim after using dark channel prior is observed and a better transmission map formula is proposed to effectively restore the colour and contrast of the image, resulting in improvement in the visual ramifications of image.

Matlin, et al. (2012) [14] has discussed in this paper a technique through which noise is within the image model for haze formation. All images contain some number of noise because of measurement error. A specific denoising algorithm referred to as Block matching and 3D filtering that's used a block matching and collaborative Wiener filtering scheme for removal of noise is used. After pre-processing step this algorithm is divided directly into two steps a haze estimation step and haze restoration step. Dark channel prior is employed for haze estimation. Finally image is restored in last step. In a few instances when first faltering step of denoising isn't successful then your Simultaneous Denoising and Dehazing via Iterative Kernel Regression is used.

Hitam et al. (2013) [15] has discussed that the within the past decades, improving the caliber of an underwater image has received considerable attention due to poor visibility of the image which may be attributable to physical properties of the water medium. They've presented a fresh method called mixture Contrast Limited Adaptive Histogram Equalization(CLAHE) color models that specifically developed for underwater image enhancement. The technique operates CLAHE on RGB and HSV color models and both email address details are combined together using Euclidean norm.

E. Ullah et al. (2013) [16] evaluated that environmental conditions such as as an example for example haze, fog or rain noticeably affects the visibility. The water droplets existing in the atmosphere produce mist, fog and haze results because of dispersion of light since it circulates through these particles. These chromatic ramifications of image dispersion |may be reversed for recovery of image knowledge. Someone image dehazing technique using dark channel prior has been broaden. The suggested model considers both chromatic and achromatic top options that include the image to define the Dark Channel. Foremost application elements of realtime single image dehazing involve tracking system, electronics and entertainment industry.

Zubaidy Yaseen et al (2013) [17] examined that the perceivability of a scene is defiled by climate sensation, like, downpour shower, haze and dimness. The rottenness of picture scene is expected the broad vicinity of particles in the environmental surroundings that diffuse and ingest light. As the light spreads from item to the spectator, the shade and quality is changed by the environmental particles. Another technique is proposed to unequivocally locate airlight and gauge the environmental cover from picture that caught in terrible climate. The after effectation of proposed techniques is utilized as part of dissipating air model to uproot environmental particles specifically, downpour sprinkle, mist and fog from the solitary picture. Accordingly a greater perceivability picture will undoubtedly be created.

Shiau et al. (2014) [18] proposed an efficient approach to get rid of haze from a signal image on the building blocks of the atmospheric scattering model and dark channel prior. Additionally they applied a heavy technique that automatically finds the possible atmospheric lights, and mixes these candidates to refine the atmospheric light. Then, difference prior, a tale prior processing method, has been employed for the estimation of the transmission that mitigates the halo artifact over the sharp edges. It requires a low computational cost and is fantastic for real-time applications. The experimental results demonstrate that the proposed approach obtains the significant results as in comparison to previous methods.

III. PROPOSED METHODLOGY

The detailed algorithm for the proposed approach is given below:

Step1: First of all images which are foggy in nature are passed to the system.

Step 2: Then we apply trilateral filter that removes the random noise from the input images. This noise removal is done as:

a. Gaussian distance weights are calculated as

$$[X, Y] = MESHGRID(-w{:}w, -w{:}w);$$

$$g = e^{-\frac{x^2+y^2}{2*\sigma^2}} \quad (3.1)$$

b. The local region extraction is done by using equations as below

$$imin = max\ (i - w, 1) \quad (3.2)$$

$$imax = min\ (i + w, dim\ (1)) \quad (3.3)$$

$$jmin = max\ (j - w, 1) \quad (3.4)$$

$$jmax = min(j + w, dim(2)) \quad (3.5)$$

c. Gaussian intensity weights are calculated using equation as h $= e^{-(I-A(i,j))^2/2*\sigma_r^2}$ (3.6)

d. Trilateral filter response is calculated as

$$f = h * g((imin{:}imax) - i + w + 1, (jmin{:}jmax) - j + w + 1) \quad (3.7)$$

Step 3: Now apply the dark channel prior to the image

(a) For applying the dark channel first of all the input image I is doubled in size according to the equation:

$$I = double(I)/255 \quad (3.8)$$

(b) Then the dimensions of the image are set

$$[h, w, c] = size(I) \quad (3.9)$$

Now the array of all ones are created for the dark channel original with the help of the given equation:

$$dco = ones(h, w) \quad (3.10)$$

Where dco is dark channel original

(c) Once the array for original dark channel is created, the dark channel is extended

$$dce = ones(h + 8, w + 8) \quad (3.11)$$

Where dce is dark channel extend and then the mask is set

$$mask = 4 \quad (3.12)$$

Now the minimum value of the extended dark channel is calculated for the input image.

$$dce(i + mask, j + mask) = min\ (I(i, j, :)) \quad (3.13)$$

Where dce is dark channel extended

(d) Now the atmospheric map and the weighted map is initialized using the following equations:

$$A = \frac{220}{255} \quad (3.14)$$

$$W = 0.90 \quad (3.15)$$

Here A is the atmospheric light, W is the weighted map. Now the array of all ones is created for the transmission map t

$$t = ones(w, h) \quad (3.16)$$

And then the input depth is calculated using the equation

$$t = 1 - W * \frac{dco}{A} \quad (3.17)$$

Where t is transmission map, W is the weighted map, Dco is dark channel original, A is the atmospheric light.

$$t = max(min(t, 1), 0) \quad (3.18)$$

(h) Now the input depth of dark channel for the original is measured using the equation given below:

$$dco1 = min(min(min(I(:, :, :)))); \quad (3.19)$$

$$dcm1 = zeros(w, , h) \quad (3.20)$$

Then the input depth is filtered according to the given equation:

$$t1(i, j) = (dcmax - dco) * (A - min(I(i, j, :))) \quad (3.21)$$

$$t2(i, j) = (dcmax - dco) * A - (min(I(i, j, :)) - dco) * min\ (I(i, j, :)) \quad (3.22)$$

$$t(i, j) = \frac{t1(i,j)}{t2(i,j)} \quad (3.23)$$

Where dcmax is dark channel maximum, dco is dark channel original, A is atmospheric light.

(e) Fog removed image is restored using below equation

$$op(j, l, i) = \frac{I(j,l,i) - A}{max(t(j,1), t0)} + A \quad (3.24)$$

Where op is output image.

Step 3: Once the dark channel prior is applied to the image, then contrast limited adaptive histogram equalization is applied to it according to the equation:

$$fop(:, :, 1) = adapthisteq\ (op, NUMTILES, [3\ 3], CLIPLIMIT, 0.001) \quad (3.25)$$

Where NUMTILES is the positive integer specifying the number of tiles of rows and columns [M,N], CLIPLIMIT is s real scalar value that specifies the contrast enhancement limit. The higher number of clip limit means more contrast.

IV. RESULTS AND DISCUSSIONS

Figure above has shown the input images for experimental analysis. In this section we will compare the results of the images by the existing and the proposed approaches. The images of the existing and the proposed approaches are shown as under.

Figure: 4.1 a) Results of the Existing Technique b) Results of the Proposed Technique

Fig.4.1 (a) is showing the restored image by the existing approach and fig.4.1 (b) is showing the restored image by the proposed method. The figure 4.2(b) gives the better results as compared to the figure4.1(a).

A. Performance Evaluation:

The proposed algorithm is tested on various images. The algorithm is applied using various performance indices Bit error Rate (BER), Average Difference(AD) and Root Mean Square Error (RMSE). In order to implement the proposed algorithm, design and implementation has been done in MATLAB using image processing toolbox. The developed approach is compared against a well-known image dehazing technique available in literature that is Dark Channel Prior. We are comparing proposed approach using some performance metrics. Result shows that our proposed approach gives better results than the existing technique.

a. Bit Error Rate:

Table 4.1 is showing the comparative analysis of the Bit Error Rate. As Bit Error Rate needs to be minimized; so the main objective is to reduce the Bit Error Rate as much as possible.

Table 4.1 has clearly shown that Bit Error Rate is less in our case therefore the proposed algorithm has shown significant results over the available algorithm

Table 4.1 Bit Error Rate Evaluation

Image name	Existing algorithm	Proposed algorithm
image 1	0.0158	0.0154
image 2	0.0161	0.0158
image3	0.0157	0.0152
image4	0.0148	0.0142
image5	0.0144	0.0138
image6	0.0154	0.0149
image7	0.0144	0.0139
image8	0.0146	0.0140
image9	0.0152	0.0148
image10	0.0137	0.0134
image11	0.0155	0.0152
image12	0.0154	0.0147
image13	0.0155	0.0151
image14	0.0161	0.0157
image15	0.0141	0.0136

Figure 4.1 has shown the quantized analysis of the Bit Error Rate of different images It is very clear from the plot that there is decrease in BER value of images with the use of proposed method over existing method. This decrease represents improvement in the objective quality of the image.

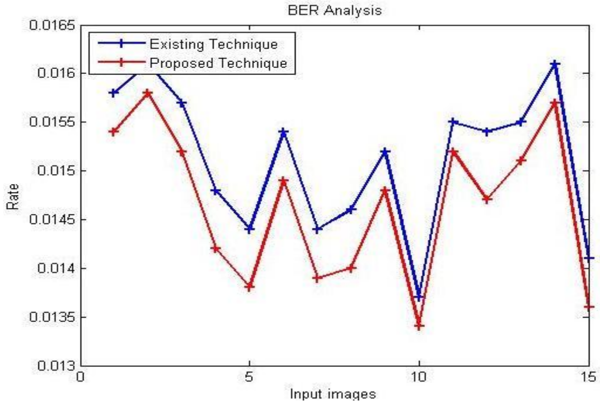

Figure 4.1: BER of Existing Approach & Proposed Approach

b. Root Mean Square Error:

Table 4.2 is showing the comparative analysis of the root mean square error. Table 4.2 has clearly shown that is less in our case therefore the proposed algorithm has shown significant results over the available algorithm.

Table 4.2 Root Mean Square Error Evaluation

Image name	Existing algorithm	Proposed algorithm
image 1	0.3623	0.3385
image 2	0.3186	0.2657
image3	0.1559	0.1270
image4	0.2738	0.2487
image5	0.3459	0.2251
image6	0.1187	0.1037
image7	0.1210	0.1016
image8	0.2589	0.2492
image9	0.2053	0.1784
image10	0.3022	0.2466
image11	0.3584	0.2941
image12	0.2891	0.2322
image13	0.3458	0.2846
image14	0.0824	0.0026
image15	0.1119	0.1003

Figure 4.2 has shown the quantized analysis of the Root mean squared Error of different images. It is very clear from the plot that there is decrease in RMSE value of images with the use of proposed method over existing method. This decrease represents improvement in the objective quality of the image.

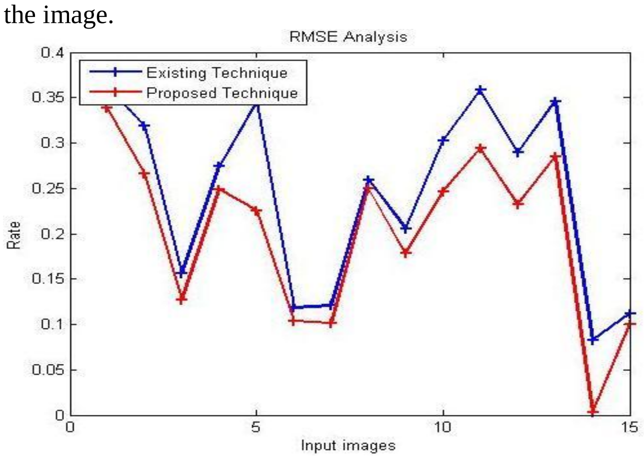

Figure 4.2: RMSE for Existing Approach & Proposed Approach

c. Average Difference:

Table 5.3 is showing the comparative analysis of the Average Difference. As Average Difference needs to be minimized; so the main objective is to reduce the Average Difference as much as possible. Table 5.3 has clearly shown that Average Difference is less in our case therefore the proposed algorithm has shown significant results over the available algorithm.

Table 5.3 Average Difference Evaluation

Image name	Existing algorithm	Proposed algorithm
image 1	0.1514	0.1234
image 2	0.2497	0.1644
image3	0.2659	0.2329
image4	0.1683	0.1263
image5	0.1208	0.1126
image6	0.2256	0.1674
image7	0.1136	0.1022
image8	0.1256	0.1137
image9	0.2199	0.1748
image10	0.0873	0.0509
image11	0.2524	0.2001
image12	0.2275	0.1829
image13	0.1012	0.0796
image14	0.1782	0.1560
image15	0.1532	0.1282

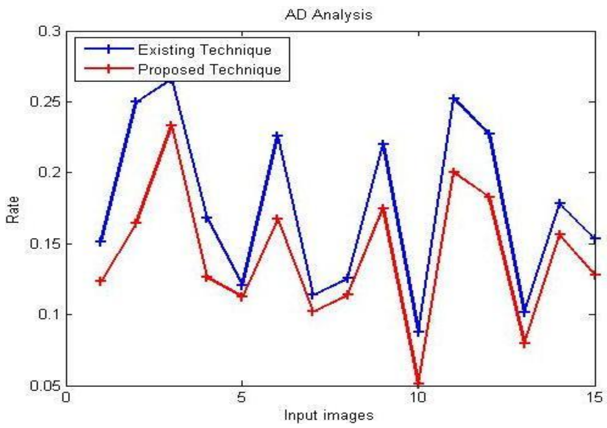

Figure 4.3: Average Difference of Existing Approach & Proposed Approach

Figure 4.3 has shown the quantized analysis of the Average Difference. It is very clear from the plot that there is decrease in AD value of images with the use of proposed method over existing method. This decrease represents improvement in the objective quality of the image.

V. CONCLUSION AND FUTURE SCOPE

In this paper, a new technique of fog removal has been presented which combines Dark Channel Prior and CLAHE based fog removal algorithm. Fog removal algorithms are most utilized for a lot of vision applications. Basic reason of new technique proposal is that nearly all the existing scientific study has neglected many issues like no strategy is perfect for diverse circumstances. The algorithm has been implemented and designed in MATLAB. Results have shown the better performance of the proposed algorithm as compared to existing one. In near future, we will use negative selection algorithm to enhance the results further.

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