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Improved Modified Dark Channel Prior to Fog From Color Images

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Abstract: Fog formation is because of attenuation and airlight. Attenuation degrades the contrast and airlight enhances the whiteness in the scene. Atmospheric conditions created by suspended particles, such as fog and haze, severely degrade image quality. Fog removal from a single image is a difficult task, because the fog is dependent on the unknown depth information. This paper has proposed a new fog removal technique IDCP which will integrate dark channel prior with CLAHE to remove the fog from digital images. Fog in image reduces the visibility of the digital images. A number of factors such as fog, mist and haze formed by the water droplets in the air leads to poor visibility. The proposed algorithm is designed and implemented in MATLAB using image processing toolbox. The comparison among dark channel prior and the proposed algorithm is also drawn based upon certain performance parameters. The comparison analysis has shown that the proposed algorithm has shown quite effective results.

Index terms: Visibility restoration, Airlight map, Fog removal and Haze.

I. INTRODUCTION

Fog is a collection of liquid water droplets or ice particles hanging in the air. Fog is low-lying, and the humidity in the fog is often created locally (such as from a close by remains of water, like a lake or the ocean, or from nearby moist ground or marshes)[1].When there is fog, smog, rain and other bad weather conditions, a number of deterioration will occur in the image obtained by the camera, which reduces the purpose of the outdoor monitoring system and causes difficulty for the extraction of image features [2].

Reduced visibility degrades the quality of the image and the performance of the computer vision algorithms such as observation, object detection, tracking and segmentation. Reduced visibility in bad climate such as fog, smog and cloudare caused due to the water particles present in the air. These droplets are very small and gradually float in the air. Due to these droplets in the air when the images are captured in such condition the light gets spread before reaching the camera which reduces the quality of the image.

A light beam travelling from a source point through the atmosphere is distributed by the atmospheric particles, this phenomenon is called attenuation which reduces the contrast in the scene. Light that is coming from the source is scattered by fog and part of it also travels towards the camera [3]. Air-light increases with the distance from the object. The current fog removal method can be divided into two categories: image enhancement and image restoration. Image enhancement excludes the reasons of fog corrupting the image quality. This method is applicable to a broader scope; it can improve the contrast of haze image, but can also lead to the loss of information in the image. On the other hand, imagerestoration first studied the physical features of the image and the model for the degradation of the fog is applied to it.In computer vision, the optical model, this is widely used to approximate the image formation in bad weather.

II. LITERATURE SURVEY

Fog removal methods are used in image processing systems. Various fog removal methods have been proposed in the literature to reduce fog effects. These methods enhance the quality of image by removing the fog and the quality of the image is improved. A CLAHE [4] based method creates a maximum assessment to clip the histogram and redefines the clipped pixels equally to each gray-level. The image contrast is enhances and the noise is also reduced in the image. It converts the original image from RGB to HIS and then the intensity component of the HIS image is redefined by CLAHE. Finally, the modified image in HIS is reverted back to RGB image. Houssam Halmaoui et al [5]proposed a method to improve the image contrast of foggy road scenes joining a physical method based on Koschmieders model and a other method based on local histogram equalization. Then they analyzed the parameters of the method using a simulated annealing ZhiyuanXu and Xiaoming Liu [6] has modified a foggy image contrast enhancement method based on Bilinear Interpolation Dynamic Histogram Equalization. First,the original foggy image is divided into same size sub-images. Then the histogram of each sub-image is divided into sub-histograms without command and then new active values are allocated for all such sub-histograms. Finally, HE and Bilinear Interpolation methods are applied to the image respectively.

Kaiming He et al [7] has proposed a efficient image prior dark channel prior to eliminate fog from a single input image. It is based on a key inspection that most of the local areas in outdoor fog free images have some pixels which have low power in one of the color channel. Using this prior with the fog imaging depiction, a the thickness of the haze is approximated and get better high-quality haze-free image. Cheng et al[8] has reported that the lowest level channel prior for image fog removal. The use of the lowest level channel is cut down from the dark channel prior. It is based on a key inspection that fog-free strength in a colour image is usually the minimum value of trichromatic channels. To approximate the transmission model, the dark channel prior then performs as a min filter for the lowest concentration. However, the min filter results in halo artefacts, specifically for neighbours of edge pixels. Li Peng et al [9] have proposed a novel atmospheric model–based defogging method from single image, for the image corrupted by spreading due to atmospheric particles. They estimated that the transmission using local extreme standard and bilateral filter that a high class depth map can be obtained. Experiments on a variety of outdoor haze images exhibit that this method can repair well colors and contrast of the experimental objects, progress the visibility of image and keep away from the Halo and jamming effects effectively.

Yanjuan Shuai et al [10] presented an image haze deduction of wiener filtering based on dark channel prior. The algorithm is mostly to approximate the median function in the use of the media filtering method based on the dark channel, to make the media function more exact and unite with the wiener filtering closer. So that the fog image restoration problem is altered into an optimization problem, and by minimizing mean-square error a clearer, fog free image is finally obtained. A. K .Tripathi and S.Mukhopadhya[11] have proposed a novel and efficient fog removal algorithm which uses anisotropic diffusion to improve scene contrast. Proposed algorithm is independent of the thickness of fog and does not need user interference.

It can hold colour as well as grey images. Along with the RGB (red, blue and green) colour model, it can work for HSI (hue, saturation and intensity) model which further reduces the calculation. Proposed algorithm has a wide function in tracking and navigation, consumer electronics and entertainment industries.Jacky S-C. Yuk and Kwan-Yee K. Wong[12] presented a novel adaptive background defogging method that shows that background segmentation can be improved significantly with background-defogged video frames. With the foreground map, the defogging of background regions is completed by 1) foreground transmission judgment by fusion, and 2) transmission revision by the proposed foreground incremental preconditioned conjugate gradient (FIPCG) The proposed method can successfully improve the revelation quality of observation videos under heavy fog.Yan Wang and Bo Wu [13]introduced an improved single image de hazing method which is based on the atmospheric scattering physics-based models. Yan Wang and BoWu applied the local dark channel prior on selected region to estimate the atmospheric light, and obtain more accurate result. Saxena et al [14] On the basis of analysis done by Saxena et al an efficient technique for more visibility from a grayscale and color images and proposed an resourceful and fast fog removal technique with quality enhancement. This method involves two phases. The first phase is used to remove fog from an image for which a Fog removal technique based on previous knowledge. Second phase enhance quality of image for improved visibility and noise reduction using FFT (Fast Fourier Transformation). This method is proficient under a wide range of weather conditions including cloud, smog, fog etc. This method can be applied to any type of images like RGB Color, gray scale.

III. GAPS IN LITERATURE SURVEY

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

a. 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.
b. Not much effort has focused on the integrated approach of the Adaptive gamma correction.
c. The problem of the uneven illuminate is also neglected by the most of the researchers.

IV. PROPOSED ALGORITHM

We develop a method which combines the two existing methods of fog removal and the gamma correction is applied to it. It is found that the proposed method is more suitable for obtaining the better quality of the image than the most of the existing methods. The results produced by the existing dark channel prior method have less PSNR value and more Mean square error. Therefore the overall objective is to improve the results by combining CLAHE with Dark channel prior method and gamma correction. The proposed algorithm is designed and implemented in MATLAB using image processing toolbox.

A. Steps of proposed approach:

The details of proposed algorithm are given as given below along with their detail. Each step used in the proposed algorithm is mentioned below. All the steps are explained in detail in this section.

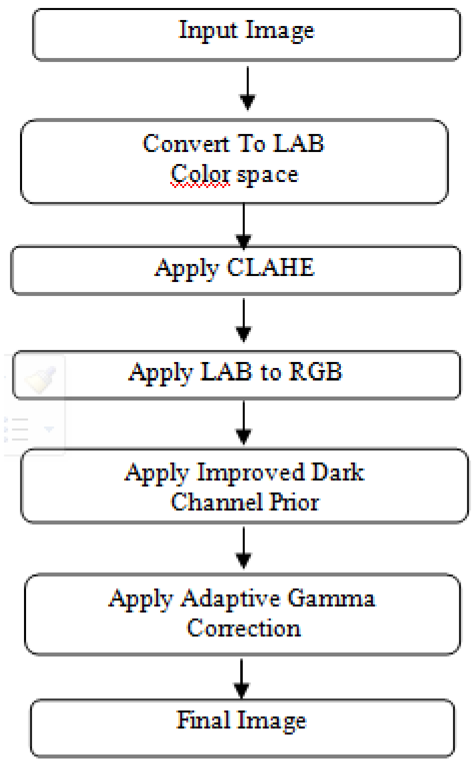

Figure: 1

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

Step 2: Apply LAB to convert given image in the LAB color space. The image is converted to the LAB color space because this color space senses the colors in the similar manner as the human eyes.

Step 3: Now contrast limited histogram evaluation (CLAHE) is applied to the image. In this method only the intensity component of the image is changed without effecting the hue and saturation. Histogram equalization is carried out in this. The original histogram is clipped and the clipped histogram is applied to each pixel of the image. In this each pixel intensity is shortened to maxima of user selectable.

Step 4: Apply LAB to RGB color space. After the CLAHE is applied to the image the image is converted back to the RGB color space.

Step 5: Apply improved dark channel prior method.The channel which has the minimum values of RGB is named as Dark Channel (DC). Then the transmission map is estimated for the image. As the edge information is lost in the transmission map so the refined transmission map is obtained in order to improve the accuracy of the method. With the help of the transmission map scene radiance is recovered.

Step 6: Apply the adaptive gamma correction. The gamma correction is applied on R G B separately.

Step 7: Final image is obtained which is visibly restored.

V. PERFORMANCE METRICS

The quality of an image is examined by objective evaluation as well as subjective evaluation. For subjective evaluation, the image has to be observed by a human expert.Therefore, in addition to objective evaluation, the image must be observed by a human expert to judge its quality. There are various metrics used for objective evaluation of an image. Some of them are Mean squared error (MSE) andPeak signal to noise ratio (PSNR)

A. *Mean Square Error (MSE):*

Mean square error is a measure quality index of the image. The larger the value of mean square error the poorer is the quality of the image.

$$MSE = \frac{1}{mn} \sum_{i=1}^{m} \sum_{j=1}^{n} \left(A_{ij} - B_{ij}\right)^2$$

B. *Peak Signal to Noise Ratio (PSNR):*

The PSNR calculates the peak signal to noise ratio of the image. It is the ratio of signal to noise ratio between the original image and the restored image and is used as the quality measurement. The higher is the value to peak signal to noise ratio the better is the quality of the image. The PSNR can be calculated using the following equation:

$$PSNR = 10\log_{10}\left(\frac{255}{MSE}\right)^2$$

VI. EXPERIMENTAL SET-UPS

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 the existing dark channel prior method available in the literature.Result shows that our proposed approach gives better results than the existing methods.Table is showing the various images which are used in this research work. Images are given along with their formats. All the given images given images passed the proposed algorithm.

Table 6.1: Images Taken For Experimental Analysis

Image name	Format	Size in (K.Bs)
image 1	.jpg	78.0
image 2	.png	331
image3	.png	349
image4	.jpg	53.8
image5	.jpg	73.0
image6	.jpg	23.2
image7	.png	611
image8	.png	173
image9	.png	903
image10	.jpg	51.1
image11	.jpg	44.1
image12	.jpg	75.1
image13	.jpg	4.99
image14	.jpg	5.59
image15	.jpg	489

A. *Experimental results:*

Figure has shown the input images for experimental analysis. The overall objective is to implement the existing method and the proposed technique to the input image and to get the better quality image.

Figure:2 Input Foggy Image

Figure: 3 restored Image by Existing Method

Figure 5.2 has shown the output image taken by Dark channel prior method.The output image is the restored image by the dark channel prior method but the gamma correction which would help to overcome the noise effect in the image.

Figure: 4 Final Restored Image by the Proposed Method

Figure 5.5 has shown the output image taken by the proposed method. The quality of output image is quite good with our proposed method with respect to existing methods discussed.

VII. PERFORMANCE ANALYSIS

This section contains the cross validation between existing and proposed techniques. Some well-known image performance parameters for digital images have been selected to prove that the performance of the proposed algorithm is quite better than the existing methods.

A. Mean Square Error Evaluation

Table 7.1 is showing the analysis of the mean square error. As mean square error should be less so the proposed algorithm is showing the betterresults than the available methods as mean square error is less in every case.

Table: 2 Mean Square Error Evaluation

Image name	Existing algorithm	Proposed algorithm
image 1	0.0513	0.0295
image 2	0.0552	0.0188
image3	0.0743	0.0243
image4	0.0406	0.0306
image5	0.1423	0.0372
image6	0.0891	0.0337
image7	0.0336	0.0207
image8	0.0379	0.0358
image9	0.0619	0.0346
image10	0.0619	0.0176
image11	0.0389	0.0318
image12	0.2053	0.0068
image13	0.1361	0.0458
image14	0.0707	0.0502
image15	0.1456	0.0471

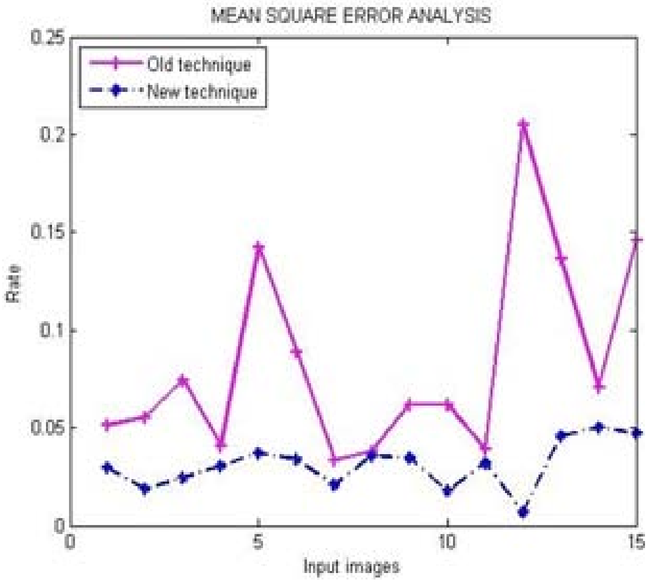

Figure7.1 MSE of existing and proposed method

Figure 7.1 has shown the mean square error for the existing and the proposed method.It is very clear from the plot that there is decrease in MSE value of images with the use of proposed method. The blue color in the plot is showing the response of proposed method which has less value of mse than the pink color plot having the larger value.

B. Peak Signal to Noise Ratio Evaluation:

The table 7.2 shows comparative analysis of the Peak Signal to Noise Ratio (PSNR). As PSNR should to be maximum, so the main target is to increase the PSNR as much as possible.Table 7.2 has clearly shown that the PSNR is maximum in the case of the proposed algorithm therefore proposed algorithm is providing better results than the existing method.

Table7.2: Peak Signal To Noise Ratio Evaluation

Image name	Existing algorithm	Proposed algorithm
image 1	61.0322	63.4264
image 2	60.7104	65.3953
image3	59.4213	64.2781
image4	62.0459	63.2687
image5	56.5984	62.4234
image6	58.6316	62.8594
image7	62.8617	64.9648
image8	62.3424	62.5926
image9	60.2135	62.7457
image10	60.2109	65.6780
image11	62.2676	63.1069
image12	55.0079	69.7744
image13	56.7929	61.5189
image14	59.6343	61.1244
image15	56.5002	61.4049

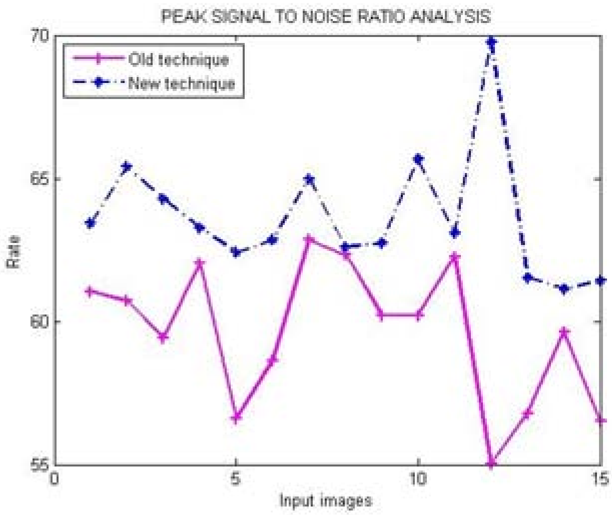

Figure 7.2 PSNR for the existing and the proposed method

Figure 7.2 is showing the analysis of the peak signal to noise ratio of different images using existing dark channel prior method(pink color) and the proposed method(blue Color).It is very clear from the plot that there is increase in PSNR value of images with the use of proposed method over other methods.

VIII. CONCLUSION

Fog removal algorithms are more helpful for many vision applications. It is found that most of the presented researchers have mistreated many issues; i.e. no technique is better for different kind of conditions. The existing methods have ignored the use of gamma correction and histogram stretching to diminish the noise problem which will be presented in the output image of the offered fog removal algorithms. To decrease the short comings of existing literature a new integrated algorithm has been proposed that has integrated the dark channel prior with CLAHE to enhance the results further. The proposed algorithm is designed and implemented in MATLAB using image processing toolbox. Different kinds of images are taken for experimental purpose. The comparison among dark channel prior and the proposed algorithm is also drawn based upon certain performance parameters. The comparison analysis has shown that the proposed algorithm has shown quite effective results.

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