# Enhanced Mist Elimination using Dark Channel Prior and Gaussian Domain based Adaptive Gamma Correction

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## ABSTRACT
Removal of fog from a digital image of a climatic corrupted scene has assessed to be a complicated task since the fog is dependent on the unidentified intensity data. Mist removal techniques have in recent times shown a great role in a variety of vision applications. It has been shown in existing research that the most of the existing techniques have many problems. To conquer the limitations of the prior work; a novel techniques has been proposed in this paper. The proposed method has enhanced dark channel prior by using the Gaussian domain based adaptive gamma correction. The proposed algorithm is composed and actualized 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 verified that the proposed algorithm has shown truly effective results.

## Keywords
Fog, Dark Channel, Adapative Gamma Correction, Gaussian Filter

## 1. INTRODUCTION
Images of outdoor scenes often contain Mist, fog, or other types of atmospheric degradation caused by particles in the atmospheric medium absorbing and scattering light as it travels from the source to the observer. While this effect may be desirable in an artistic setting, it is sometimes necessary to undo this degradation. For example, many computer vision algorithms rely on the assumption that the input image is exactly the scene radiance, i.e. there is no disturbance from Mist. When this assumption is violated, algorithmic errors can be catastrophic. One could easily see how a car navigation system relying on visual inputs from the scene ahead, which did not take this effect into account could have dangerous consequences. Visibility restoration refers to different methods that aim to reduce or remove the degradation that have occurred while the digital image was being obtained. The degradation may be due to various factors like relative object-camera motion, blur due to camera misfocus, relative atmospheric turbulence and others. In this we will be discussing about the degradations due to bad weather such as fog, Mist, rain and snow in an image. The term "fog" is typically distinguished from the more generic term "cloud" in that fog is low-lying, and the moisture in the fog is often generated locally [1]. In order to overcome the degradation in the image, visibility restoration methods are applied to the image so as to obtain a better quality of image. The image quality of outdoor screen in the fog and Mist weather condition is usually degraded by the scattering of a light before reaching the camera due to these large quantities of suspended particles (e.g. fog, Mist, smoke, impurities) in the atmosphere. This phenomenon affects the normal work of automatic monitoring system, outdoor recognition system and intelligent transportation system. Scattering is caused by two fundamental phenomena such as attenuation and airlight. By the usage of effective Mist removal of image we can improve the stability and robustness of the visual system. So in order to remove this color shift in the image various Mist removal methods are used in order to improve the quality of the image [2]. Mist removal is a tough task because fog depends on the unknown scene depth information. Fog effect is the function of distance between camera and object [3]. Hence removal of fog requires the estimation of airlight map or depth map.

## 2. LITERATURE REVIEW
This section represents the literature survey done on the various fog removal techniques. The literature review represents the work done by the various researchers and scholars in this direction which serves as an introduction to research further on various steps of fog removal. Following are the various research papers which have been referred during this research work. Mengyang et al (2009) [3] has studied that bad weather, such as fog and Mist can considerably degrade the perceptibility of a scene. To surmount it, some methods have been proposed. A novel defogging principle just based on a single image using dark channel prior as basics of principle. After experimental analysis about the dark channel prior Mist removal, they found that although dark channel prior reacts well in most situations, it also results in larger diffusion values in some specific situations. Targeting on these situations, they proposed an iterative principle to alter the color distortion effected by higher diffusion. This kind of global or local modification can be achieved by relatively ideal compromise between natural color and image definition. Jing et al (2010) [8] discussed that imaging in poor weather is often harshly degraded by scattering due to floating particles in the atmosphere such as Mist, fog and mist. Poor perceptibility becomes main problem for most outdoor vision applications. Jing et al proposed a novel fast defogging technique from a single image of a scene based on a fast bilateral filtering method. The difficulty of this method is only a linear function of the number of input image pixels and this thus allows a very fast implementation. Guo Fan et al (2010) [9] developed a simple but effective method for visibility restoration from a single image. The main benefit of the planned method is no user interaction is needed, this allows our algorithm to be applied for practical applications, such as surveillance, intelligent vehicle, etc. Another advantage is its speed, since the cost of obtaining transmission map is really cut down by using Retinex technique on luminance component. Nishino et al (2010) [12] studied that atmospheric conditions induced by suspended particles, such as fog and Mist, severely alter the scene appearance. They introduce a novel Bayesian probabilistic method that jointly predicts the scene albedo and depth from a single foggy image by fully leveraging their latent statistical structures. The idea is to model the image with a factorial Markov random field in which the scene albedo and

depth are two statistically independent latent layers and to jointly estimate them. Nishino et al showed that exploited natural image and depth statistics as priors on these hidden layers and estimate the scene albedo and depth with a canonical expectation maximization algorithm with alternating minimization. Jing Yu et al (2011) [14] has shown that imaging in poor weather is often strictly corrupted by dispersion due to floating particles in the atmosphere such as Mist and fog. A novel fast defogging approach is proposed from a single image of a scene based on the atmospheric spreading model. In the deduction process of the atmospheric mask, the coarser approximation is advanced using a fast edge-preserving smoothing approach. The complication of the proposed method is only a linear function of the number of image pixels and this thus allows a very fast implementation. Results on a variety of outdoor foggy images reveal that the proposed method achieves good restoration for contrast and color loyalty, resulting in a great enhancement in image visibility. Kaiming He et al (2011) [15] has proposed a simple but effective image prior dark channel prior to eliminate Mist from a single input image. The dark channel prior is a kind of data of outdoor Mist-free images. It is based on a key inspection that most local patches in outdoor Mist-free images include some pixels whose power is very low in at least one color channel. Using this prior with the Mist imaging representation, the thickness of the Mist is approximated and get better high-quality Mist-free image. Results on a variety of cloudy images reveal that the power of the proposed prior. Moreover, a high-quality intensity map can also be obtained as a offshoot of fog removal. A.K. Tripathi el al (2012) [17] have studied that fog formation is due to attenuation and airlight. Attenuation reduces the contrast and airlight increases the whiteness in the scene. Proposed method uses bilateral filter for the judgment of airlight and improve scene contrast. Proposed method is independent on the density of fog and does not need user interference. Yanjuan Shuai et al (2012) [18] studied that if we use the image Mist elimination of dark channel prior prone to color distortion occurrence for some large white bright area in the image. They presented an image Mist 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. Experimental results show that the proposed algorithm can make the image more detailed, the contour smoother and the whole image clearer. In particular, this algorithm can recover the contrast of a large white area fog image. Cheng et al (2012) [20] 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 that performs as a min filter for the lowest concentration. However, the min filter results in halo artefacts, specifically for neighbours of edge pixels. Robby et al (2012) [21] described that bad weather particularly fog and Mist, commonly hinder drivers from observing road conditions. This could often lead to a number of road accidents. To avoid the problem, automatic methods have been proposed to enhance visibility in bad weather. Methods that work on visible wavelengths, based on the type of their input, can be divided into two approaches using polarizing filters and images taken from different fog densities. Wang et al (2013) [23] developed a defogging algorithm on the basis of in depth analysis on degradation. They developed a algorithm which first divides the foggy image in sky and non sky region and then the co efficient of the two regions are estimated separately. Then the two regions are combined using the refining step. Zubaidy Yaseen et al (2013) [24] studied that the visibility of a scene is corrupted by weather phenomenon such as rain drizzle, fog and Mist. The filth of image scene is due the extensive presence of particles in the atmosphere that scatter and absorb light. As the light spreads from object to the observer, the color and strength is changed by the atmospheric particles.

# 3. PROPOSED METHODOLOGY

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: Global white balancing:-Color balance is the global adjustment of the intensities of the colors (typically red, green, and blue primary colors). An important goal of this adjustment is to render specific colors particularly neutral colors. Hence, the general method is sometimes called gray balance, neutral balance, or white balance. Color balance changes the overall mixture of colors in an image and is used for color correction. Generalized versions of color balance are used to get colors other than neutrals to also appear correct or pleasing.

Step 2: Then we apply Gaussian domain based adaptive gamma filtering that removes the random noise from the input images. This noise removal is done as:

(a) Gaussian distance weights are calculated as

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

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

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

$$\boldsymbol{imin} = \boldsymbol{max}(\boldsymbol{i}-\boldsymbol{w},\boldsymbol{1}) \qquad (3.2)$$

$$\boldsymbol{imax} = min(i+w, dim(1)) \qquad (3.3)$$

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

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

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

(d) Gamma response is calculated as

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

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:

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

(b) Then the dimensions of the image are set

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

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

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

Where dco is dark channel original

(d) 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

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

(e) 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

(f) 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

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

(g) And then the input depth is calculated using the equation

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

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

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

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

$$\mathrm{dco1 = min\big(min\big(min(I(:, :, ;))\big)\big);} \quad (3.19)$$

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

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

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

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

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

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

Fog removed image is restored using below equation

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

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:

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

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.

## 4. 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.

**Fig: 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).

The proposed algorithm is tested on various images. The algorithm is applied using various performance indices peak signal to noise ratio (PSNR), Mean squared error (MSE), 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.

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 | 0.0168 | 0.0164 |
| image 2 | 0.0171 | 0.0168 |
| image3 | 0.0167 | 0.0164 |
| image4 | 0.0158 | 0.0155 |
| image5 | 0.0154 | 0.0151 |
| image6 | 0.0164 | 0.0160 |
| image7 | 0.0154 | 0.0152 |
| image8 | 0.0156 | 0.0154 |
| image9 | 0.0162 | 0.0158 |
| image10 | 0.0147 | 0.0144 |
| image11 | 0.0165 | 0.0161 |
| image12 | 0.0164 | 0.0163 |
| image13 | 0.0161 | 0.0159 |
| image14 | 0.0159 | 0.0156 |
| image15 | 0.0151 | 0.0146 |

Figure 4.2 has shown the quantized analysis of the Bit Error Rate of different images using Dark Channel prior (yellow color) and by Proposed Approach (green color). 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

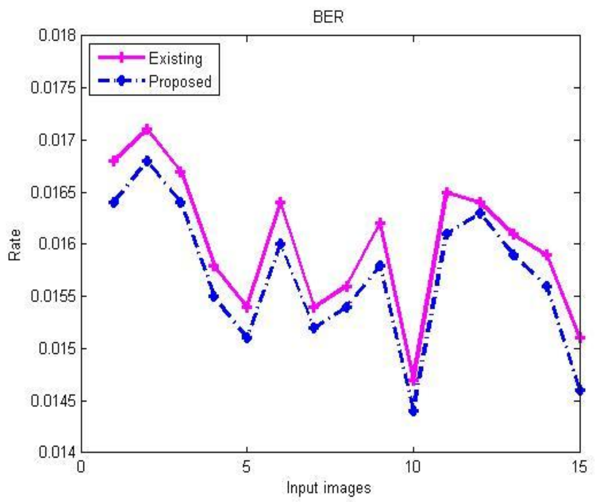


**Fig 4.2: BER of Existing Approach and Proposed Approach**

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 | 0.2643 | 0.2285 |
| image 2 | 0.2986 | 0.2657 |
| image3 | 0.2559 | 0.2270 |
| image4 | 0.1738 | 0.1487 |
| image5 | 0.1459 | 0.1251 |
| image6 | 0.2287 | 0.1937 |
| image7 | 0.1410 | 0.1306 |
| image8 | 0.1589 | 0.1492 |
| image9 | 0.2053 | 0.1784 |
| image10 | 0.1022 | 0.0866 |
| image11 | 0.2384 | 0.2041 |
| image12 | 0.2291 | 0.2162 |
| image13 | 0.1968 | 0.1846 |
| image14 | 0.1824 | 0.1626 |
| image15 | 0.1219 | 0.0983 |

Figure 4.3 has shown the quantized analysis of the Root mean squared Error of different images using existing method (yellow color) and the proposed method (green color). 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.

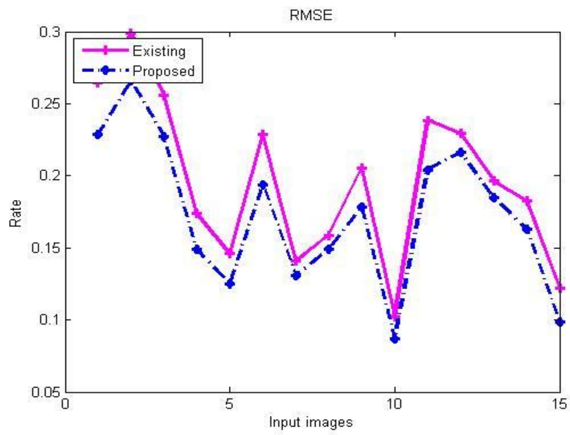


**Fig 4.3: RMSE for Existing Approach and Proposed Approach**

## 5. CONCLUSION

Fog removal of a digital image of a atmospheric corrupted scene has assessed to be a complicated task since the fog is dependent on the unidentified intensity data. Mist removal methods have recently exposed an enormous role in a variety of vision applications. It has been shown in existing research that the most of the existing techniques have many problems. To overcome the limitations of the earlier work; a new techniques has been proposed in this research paper. The proposed technique has improved dark channel prior by usage of the Gaussian domain based adaptive gamma correction. 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 revealed that the proposed algorithm has shown effective results.

This work has not considered underwater images furthermore remote sensing images so in future we will approve the proposed strategy on the remote sensing and underwater images. Likewise the use of the filtering techniques will also be considered to uproot the noise related issue in this research work.

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