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# Review on Various Haze Removal Methods for Image De-Hazing

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| ARTICLE INFO | ABSTRACT |
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| Corresponding Author: **Karuna Khatter** M. Tech Student Dept. ECE, Geeta Engineering College (Naultha) India | Haze is an atmospheric effect in which turbid media like fog, dust particles, smoke, haze, snow abs truces the captured image resulting in reduction in scene visibility, increase in color fading thus reducing the color contrast causing trouble in pattern analysis, image processing, computer vision applications etc. Haze not only attenuates the scene reflected light but also blends it with the atmospheric light. Thus the Image quality is degraded. Hence, haze removal from images is considered an important and widely challenging topic in computer vision and computer graphics areas. In this paper, various visibility restoration techniques for Image De-hazing are presented/compared to remove the degradation occurred in the digital image captured to be utilized for applications such as satellite system, aircrafts system, video surveillance. |

**KEYWORDS:** ***Visibility restoration, Airlight, Dark Channel prior, Light Channel prior, Guided Filter, Bilateral Filter, Trilateral Filter.***

## I. INTRODUCTION

Hazeforms due to the scattering effect i.e. air light and attenuation. Airlight results in blurness of the captured imagewhereas attenuation decreases the image color contrast degrading the picture quality. Moreover the image also gets distorted with atmospheric turbulents, poor climatic conditions, large distance between the capturer and the image to be captured etc. The aim ford hazing the captured digital image is to recover the refined imagei.e. recover the reflected light that is mixed with the blended light.

Visibility/ Image restoration includes the techniquesfor refining the input haze image and receiving a clarified dehazed image as the output.

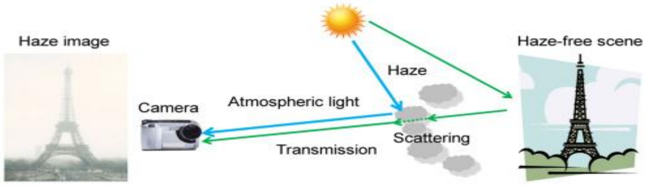


**Fig1**. Formation of Haze

Haze removal is always a challenging topic in image processing. This paper represents some of the haze removal methods for de-hazing the captured image. The two main techniques for single image haze-removal include Dark channel prior and Light channel prior. The Dark channel prior is based on the assumption that most local regions have some dark pixels that have much low intensity for least one color channel(RGB), whereas Light channel prior is based on the assumption that most local regions have some bright pixels that have muchhigh intensity for least one color channel (RGB).Guided filter smoothens the edge detection of the image thus a more refined output image. Bilateral filter further refines the image by replacing every pixel with its neighboring pixel corresponding weighted average. In a similar fashion,more methods are detailedfor refining the input hazy images and obtain refined haze-free output image.

**Fig 2**(a) Input hazy image (b) Output haze-free image

## II.HAZE REMOVAL METHODS

Typical techniques used for single image haze removal are listed as under:

### *Schechner and etal method*

This method is based on the assumption that the scattering phenomenon is generally caused by airlight and attenuation. The scattered light due to these atmospheric particles is partially polarized in nature. Thus, only a polarization filter doesn'trefine the captured hazy image effectively. Thus the image formation here mainly occurs by the polarization effect and hence this process is inverted to gethaze free output image. Schechner and etal considers thetwo basic input image component as: 1. scene radiance and 2. airlight. Thus the two independent images are required to obtain the haze-free output image.

### *Tan method*

This method utilizes the atmospheric optical model. This model contains two values. First term symbolizes direct attenuation whereas the second term symbolizes airlight. Tanfurther dictated image processing in terms of light chromaticity including the color vector (RGB). The light chromaticity approach reveals that the clear images have high color contrast value than the hazy images which are degraded due to atmospheric disturbances. With this assumption, Tan proposed the algorithm to remove the haze by maximizing the imagelocal color contrast.

### *Fattal method*

Fattal's method uses the theory of ICA (Independent component analysis). Itdiscusses the optical transmission for the foggy images. His method of single image haze removal producing an output of haze free image with the input foggy image introduceda refined image model that consists of two terms - surface shading and transmission function. His approach grouped the pixelsthat belongto same surface that have the same value for reflection factor and same value for surface albedo. His another new method is based upon ICA approach (Independent Component Analysis) to calculate the values for surface shading along with the transmission factor. This aims to refine the airlight albedo factor with the assumption that the above two factors i.e. surface shading and transmission factor of the scene are totally un correlated. With this assumption, the lightscatteredneeds to get removed so as to increase the image scene visibility and hence remove the haze so as to get the increased value for image color contrast. In this approach, visibility restoration depends on the color information. The main disadvantage of this method is that it doesn't hold good for the gray scale and the dense fogimages.


**Fig 3** Independent Component Analysis

### *He and etal method*

He-etal's method uses the theory of dark channel prior to remove the haze from a single image. The dark channel prior is generally used to get the statistics for any input hazy image to get the output refined image. The theory for this method lies in the assumption that some pixels possess very low intensity for a color channel for the regions that do not cover the sky. These pixels are generally called as the dark pixels. For the hazed images, it is assumed that the intensity for such dark pixels is generally attributed by airlight. The value computed for these dark pixels estimated by dark channel prior is used to obtain thealue forhaze transmission. The novel idea of this method is to recover the output image i.e. fog free with the estimated value of t transmission map.

***Kopfetal method***

The basis for this technique is the three dimensional model foran outdoor image/ scene. The main advantage for this method is that it does not need multiple images for the same image/ scene taken with different values for polarization degree. On the other hand, the main disadvantageof this method is that the real world structure is variedsignificantly. Also, this technique depends only upon the application with an expert interaction.

***Tareletal method***

Tareletal proposed a visibility restoration technique that assumes that the factor airlight varies in a percentage value of local standard deviation with the local value for mean whiteness. This method uses the concept of depth map forsmoothening the corners. Also this method depends on the linear operations requiring many adjustmentparameters.

***Fang etalmethod***

This method is based on graph based segmentation. The graph based approach for image segmentation is applied to a particular segment of the input hazy image. Using dark channel prior, an initial value for the transmission map is calculated. Furthermore, a bilateral filter is applied to get a refined value for transmission map. For this inputhazy image, the segmentation choice for the control parameters is difficult.

***Dark Channel Prior (based on Guided filter)***

The Dark Channel Prior technique for the large grey region for the input hazy image is same as the atmospheric light factor. Guided filter is appliedto obtain a more refined output image. The guided filter gives more accurate result.


***Histogram specification***

Histogram specification after Dark channel prior rebuilds the image histogram with the changed value for color contrast and the resultant image intensity. Advantages of this method include reduced value for image contrast and thick haze removal. Disadvantage includes that it increases thehaze thickness, if haze in the image does not removes clearly.

***Light Channel Prior***

Light Channel Prior technique is based on the artifact that the atmospheric light component for a light pixel should not have the same value for a dark pixel. Hence it takes the atmospheric light component a variable for x denoted by $A(x)$ where x represents the pixel intensity.

***CLAHE***

CLAHE stand for Contrast limited adaptive histogram equalization. This method is mainly used for low color contrast pictures/ scene enhancement. The advantage of this method is that it does not require the weather information prediction beforehand for the input hazy image processing to refined image. It works on the basis of color space conversion (the captured input image under the foggy weather conditions is first converted into HSV (hue, saturation and value) color space from RGB (red, green and blue) color


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space. The main reason behind the image conversion is that the human eye senses the scene colors in the same way as HSV predicts colors.Also the value component gets evaluatedwith this process with the advantage that the values for hue and saturation doesn't get altered. This method uses the histogram equalization concept. The histograms obtained via the equalization process are cropped first and further these cropped pixels are redefined for the gray-level. Finally, as an output the image is converted to RGB color space.

***MIX – CLAHE***

MIX – CLAHE stands for mixture Contrast Limited Adaptive Histogram Equalization. The main advantage of this method is that it not only improves the underwater scenes visibility but also gives the output with lower Mean Square Error and better PSNR values.

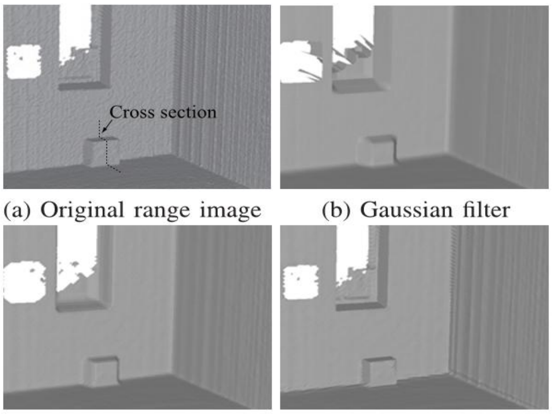
***Weighted haze removal method***

The weighted method for haze removal is one of the efficient method for removing of haze from an input hazy image. In this method, weighted atmospheric light and the factor t i.e. transmission of a picture is estimated. The reason for calculating the weighted value for transmission is that the normal value for atmospheric light and the corresponding factor of transmission results in long execution time. Thus its weighted value is computed so as to balance the picture illumination with the weighted value for transmission to mitigate this artifact.

***Bilateral and Trilateral Filtering***

Filters in image processing smoothens the images and also maintain the edges, with the nonlinear combination for close image pixel values. Bilateral filters are generally non iterative in nature, with simple construction and local behavior. Gray levels in scenes are occupied with bilateral filter with both the attributes i.e.their geometric closeness and the photometric similarity between different pixels of the scene. The disadvantage of bilateral filter is that it does not reducesthe noise power, thus degrading the PSNR value of output image.

Trilateral filtering enhances the image smoothness using the concept of non-linear combination for the image pixels. Here every pixel is replaced by the weighted average of the neighbor pixels. Weight allocated depends on the distance in the image plane with the distance measured on intensity axis. Main advantage is the faster results with this filter.




(a) Original range image (b) Gaussian filter (c) Bilateral filter (d) Trilateral filter

***Image Fusion with Laplacian Pyramid***

Image Fusion with Laplacian Pyramidinvolves a pattern selective technique. This method decomposes the source image in a pyramid fashion and later onrebuilds the output image using an inverse pyramid transform methodology. Advantages of this technique involves improved resolution, better S/N ratio etc.Images formed using fusion with Laplacian Pyramid are more beneficial for humanperception, and other image-processing tasks likeremote sensing, satellite imaging etc.Using this fusion methodthe fused image is retrievedwith this fused pyramid.

## III. CONCLUSION

Visibility Restoration/ Haze Removal algorithms are used to get the undistorted good quality output image. This paper describes various visibility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restoration techniquesthat are used for image processing to be used in satellite, radar systems etc. using Light/ Dark Channel prior and other proposed techniques in this regards.

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