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HAZE REMOVAL TECHNIQUES-A COMPREHENSIVE SURVEY

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Abstract: This paper presents a review on the different haze removal techniques. Haze is formed due to the two fundamental phenomena that are attenuation and the air light. Attenuation reduces the contrast and air light increases the whiteness in the scene. Haze removal techniques recover the color and contrast of the scene. Haze is an important phenomenon that significantly degrades the visibility of outdoor scenes, and it is due to the atmospheric particles that absorb and scatter the light which makes it very difficult to quickly detect and track moving objects in intelligent transportation systems. Recently, haze removal through single image attracted much interest and made significant progresses due to its broad applications such as image processing, computational photography and computer vision applications. The overall objective of this paper is to explore the various methods for efficiently removing the haze from digital images and also the short comings of the existing methods.

Keywords : Dehazing, Edge preserving, Filtering, Haze, Single image haze removal.

1. INTRODUCTION

Images of outdoor scenes are usually degraded by the turbid medium (*e.g.*, particles, water-droplets) in the atmosphere. Haze, fog, and smoke are such phenomena due to atmospheric absorption and scattering. The irradiance received by the camera from the scene point is attenuated along the line of sight. Furthermore, the incoming light is blended with the air light (ambient light reflected into the line of sight by atmospheric particles). The degraded images lose the contrast and color fidelity, as shown in Figure 1(a). Since the amount of scattering depends on the distances of the scene points from the camera, the degradation is spatial-variant. The haze removal techniques can be classified into two categories: Image enhancement and Image restoration. Image enhancement doesn't include the reason why haze degrades image quality. This technique enhances the contrast of haze image but it leads to loss of information in image.

Image restoration studies the physical procedure of imaging in haze. After observing degradation style of haze, image will undoubtedly be established. At last, the degradation process is used to produce the haze free image. Haze removal (or dehazing) is highly desired in both consumer/computational photography and computer vision applications. First, removing haze can significantly increase the visibility of the scene and correct the color shift caused by the air light. In general, the haze-free image is more visually pleasuring. Second, most computer vision algorithms, from low-level image analysis to high-level object recognition, usually assume that the input image (after radiometric calibration) is the scene radiance. The performance of vision algorithms (*e.g.*, feature detection, filtering, and photometric analysis) will inevitably suffers from the biased, low- contrast scene radiance. Last, the haze removal can produce depth information and benefit many vision algorithms and advanced image editing. Haze or fog can be a useful depth clue for scene understanding. The bad haze image can be put to good use as shown in fig 1(b).

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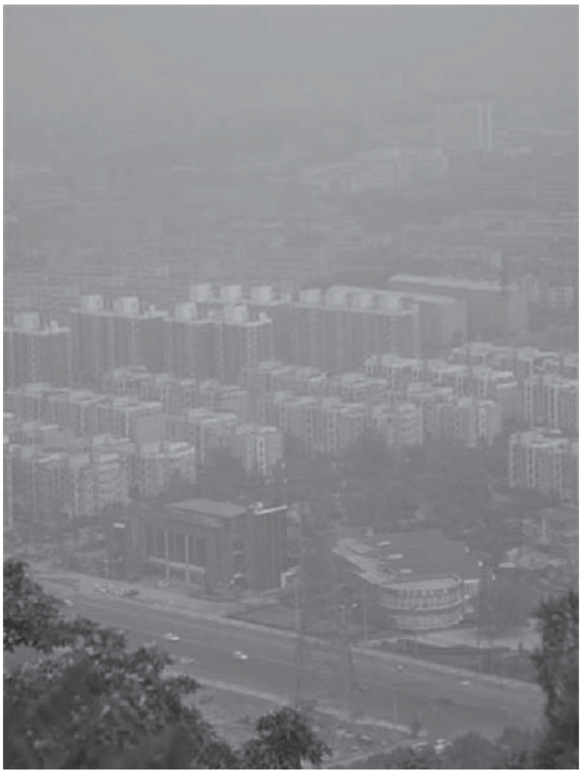

Figure 1. (a) Haze image

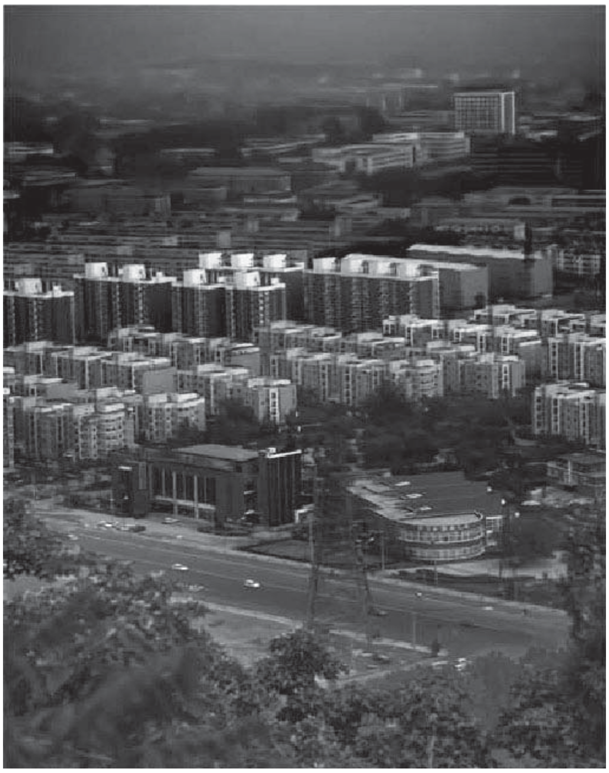

Figure 1. (b) Dehazed image

This paper is organized as follows section II describes about various survey papers related to haze removal, section III describes the comparative analysis table, section IV discusses the gaps in literature survey, section V describes about the edge preserving techniques, section VI explains about various filters used in noise removal and section VII ends with conclusion of the paper.

2. LITERATURE SURVEY

C.Tomasi et.al (1998) [1] proposed bilateral filtering which smooth's images while preserving edges, by means of a nonlinear combination of nearby image values. This method was non iterative, local, and simple. They combined gray levels or colors based on both their geometric closeness and their photometric similarity. They used a bilateral filter which smooth colors and preserved edges in a way that was tuned to human perception. Finally they obtained results with no phantom colors along edges in color images, and reduced phantom colors in the original image.

S.G.Narasimhan et.al (2000) [2] developed a general chromatic framework for the analysis of images taken under poor weather conditions. They begun by describing the key mechanisms of scattering. Next, they analyzed the dichromatic model and experimentally verify it for fog and haze. Then, they derived several useful geometric constraints on scene color changes due to different but unknown atmospheric conditions. Finally, they developed algorithms to compute fog or haze color, to construct depth maps of arbitrary scenes, and to recover scene colors as they would appear on a clear day. All that methods only required images of the scene taken under two or more poor weather conditions, and not a clear day image of the scene.

F.Durand et.al (2002) [3] proposed a new technique for the display of high-dynamic-range images, which reduces the contrast while preserving detail. It was based on a two scale decomposition of the image into a base layer, encoding large-scale variations, and a detail layer. The base layer has its contrast reduced, thereby preserving detail. They first obtained the base layer using an edge preserving filter called the bilateral filter. This was a non-linear filter, where the weight of each pixel was computed using a Gaussian in the spatial domain multiplied by an influence function in the intensity domain that decreases the weight of pixels with large intensity differences. Finally they used bilateral filtering in the framework with robust statistics and also it relates with anisotropic diffusion. They obtained the results with fast and high speed-up of two orders of magnitude.

S.G.Narasimhan et.al (2003) [4] addressed the problem of restoring the contrast of atmospherically degraded images. They presented methods to locate depth discontinuities and to compute structure of a scene, from two images captured under different weather conditions. Using either depth segmentation (regions within closed contours of depth edges) or scene structure (scaled depths), they showed how to restore contrast from any image of the scene taken in bad weather. The entire analysis was presented for monochrome images.

S.Shwartz et.al (2006) [5] proposed a method based on polarization techniques. Here two images taken with different degrees of polarization and then the scene depth was measured from the difference between the two images. They derived an approach for blindly recovering the parameter needed for separating the air light from the measurements, thus recovering contrast, with neither user interaction nor existence of the sky in the frame. They used this interaction and conditions needed for image dehazing, which also requires compensation for attenuation.

Robby T. Tan (2008) [6] has introduced an automatedmethod that only required a single input image. Two observations was made based on this method, first, clear day images have more contrast than images afflicted by bad weather and second, air light whose variant mostly depends on the distance of objects to the observer tends to be smooth. Tan developed a cost function in the framework of Markov random fields based on these two observations. Finally he obtained the results which has larger saturation values and also it contain halos at depth discontinuities.

R. Fattal (2008) [7] proposed a method such that a haze image is interpreted through a refined image formation model that accounts for both surface shading and scene transmission. He used an assumption that the transmission and the surface shading are locally uncorrelated, and so the air-light-albedo ambiguity was resolved. It sounds reasonable from the physical point of view and it can also produced impressive results. However, this algorithm was failed in presence of heavy haze. Finally he estimated the transmission map based on an lack-of correlation assumption between the transmission and shading functions to obtain a reliable transmission estimate.

Z.Farbman et.al (2008) [8] introduced a new way to construct edge-preserving multi-scale image decompositions. They first showed that current base detail decomposition techniques, based on the bilateral filter, to extract detail at arbitrary scales. Instead, they advocate the use of an alternative edge-preserving smoothing operator, based on the weighted least squares optimization framework, which was particularly well suited for progressive coarsening of images and for multi-scale detail extraction. After that they used it to construct edge-preserving multi-scale decompositions, and compared it with the bilateral filter, as well as to other schemes. Finally, they demonstrated the effectiveness of edge-preserving decomposition in the context of LDR and HDR tone mapping, detail enhancement, and other applications.

J.P.Tarel et.al (2009) [9] proposed a novel algorithm and variants of visibility restoration from a single image based on median filter to remove fog or haze. It was also used for both color images and gray scale images. Its main advantage was its speed since its complexity is only a linear function of the input image size. They used this high speed visibility restoration method for real-time processing applications such as sign, lane-marking and obstacle detection from an in-vehicle camera. They have also proposed a new filter which preserves edges and corners with obtuse angle as an alternative to the median filter.

K.He et al. (2011) [10] have proposed a simple but effective image prior called as dark channel prior to remove haze from a single input image. First they used the dark channel prior as a type of statistics for outdoor haze-free images where most of the non-sky patches, in which at least one color channel (RGB) has very low intensity at some pixels (called dark pixels).These dark pixels provide the estimation of haze transmission and they directly evaluated the thickness of the haze using this prior. Finally they used this haze imaging model and got a high-quality haze-free image but the dark channel prior does not work efficiently if the surface object is similar to the atmospheric light.

J.Pang et.al (2011) [11] have proposed elaborate single image dehazing by combining dark channel prior and guided image filtering. First they studied study several aspects through experiments and analyses, and proposed an effective scheme to adapt the patch size of dark channel and the filtering radius of guided filter. They used guided filter to refine the transmission map which has low computational cost, and it has similarities to soft matting. Finally they obtained comparable dehazed results when compared to other papers. But this method fails if the input image contains abrupt depth changes. They used this method on many hazy images, and obtained O(N) time complexity which made it appealing for many applications.

Y.Q.Zhang et.al (2012) [12] have proposed a novel effective algorithm for visibility enhancement from a single gray or color image. They considered that the haze mainly concentrates in one component of the multilayer image and then the haze-free image was reconstructed through haze layer estimation based on the image filtering approach. They used the Monte Carlo simulation for the coarse atmospheric veil by using the median filter, and refined smooth haze layer was acquired with both less texture and retained depth changes. Finally they used the dark channel prior to obtained the normalized transmission coefficient to restore fogless image. This algorithm was simpler and efficient method for clarity improvement and contrast enhancement for a single foggy image.

C.Xiao et.al (2012) [13] proposed a new fast haze removal method from single image based on filtering. The basic idea was to compute an accurate atmosphere veil that is not only smoother, but it also has depth information of the underlying image. Initially they obtained an atmosphere scattering light through median filtering, and then refined it by guided joint bilateral filtering to generate a new atmosphere veil which removes the abundant texture information and recovers the depth edge information. Finally, they solved the scene radiance using the atmosphere attenuation model and obtained a better haze removal effect for distant scene and places where depth changes abruptly in the number of pixels of the input image. This method was also performed in parallel using GPU, which made their method applicable for real-time requirement.

C.Ancuti et.al (2012) [14] described a novel strategy to enhance under- water videos and images. They used the fusion principle strategy which derives the inputs and the weight measures only from the degraded version of the image. In order to over- come the limitations of the underwater medium they defined two inputs that represent color corrected and contrast enhanced versions of the original underwater image and also four weight maps that aim to increase the visibility of the distant objects degraded due to the medium scattering and absorption. They used this strategy for single image approach which does not require specialized hardware or knowledge about the underwater conditions or scene structure. This fusion method also supports temporal coherence between adjacent frames by performing an effective edge preserving noise reduction strategy. They obtained the enhanced images and videos which have reduced noise level, better exposedness of the dark regions, improved global contrast and also the finest details and edges are enhanced significantly.

Y.S.Lai et.al (2012) [15] described a novel approach to remove haze in single image. They included a transmission heuristic method and formulated image dehazing as an optimization problem with global minimization solution. Based on the model, they derived the optimal transmission map and successfully recovered the haze-free image. They obtained the experimental results in which both transmission map and dehazed results are superior when compared to other previous work.

J.H.Kim et.al (2013) [16] developed a fast and optimized dehazing algorithm for hazy images and videos. They considered that a hazy image exhibits low contrast, so they restored the hazy image by enhancing its contrast .But the overcompensation of the degraded contrast has truncated pixel values and caused information loss. Therefore, they formulated a cost function that consists of the contrast term and the information loss term. By minimizing the cost function, they enhanced the contrast and preserved the information optimally. Moreover, they extended the static image dehazing algorithm for real-time video dehazing and reduced flickering artifacts in a dehazed video sequence which was used sufficiently fast for real-time dehazing applications.

K.He et. al (2013) [17] proposed a method to remove haze by using a novel type of explicit image filter guided filter with dark channel prior. They derived it from a local linear model where the guided filter generates the filtering output by considering the content of a guidance image, which can be the input image itself or another different image. The guided filter can perform as an edge-preserving smoothing operator like the popular bilateral filter, but has better behavior near the edges and it can better utilize the structures in the guidance image. Moreover, the guided filter has a fast and non-approximate linear-time algorithm, whose computational complexity is independent of the filtering kernel size. They demonstrated that the guided filter is both effective and efficient in a great variety of computer vision and computer graphics applications including noise reduction, detail smoothing/enhancement, HDR compression etc.

C.O.Ancuti et.al (2013) [18] have proposed a novel single image approach that enhances the visibility of degraded images. First they used a fusion-based strategy which was derived from two original hazy image inputs by applying a white balance and a contrast enhancing procedure. Then they blend effectively the information of the derived inputs and preserved the regions with good visibility and computed three parameters luminance, chromaticity, and saliency. They minimized the artifacts introduced by the weight maps by using a multiscale fashion Laplacian pyramid representation. Finally they demonstrated the utility and effectiveness of a fusion-based technique for dehazing a single degraded image which was used for real-time applications.

P.Drews et.al (2013) [19] introduced a methodology to find the transmission map for underwater environments. Initially they used adaptation of the Dark Channel Prior (DCP), a statistical prior based to obtain the outdoor natural scenes. They developed a method called as Underwater DCP (UDCP), which basically considered that the blue and green color channels are the underwater visual information source, which enables a significant improvement over existing methods based on DCP. Finally they presented a detailed analysis technique which was used for real time and simulated scenes.

R.Fattal (2014) [20] proposed a new method for single-image dehazing that relies on a generic regularity in natural images where pixels of small image patches typically exhibit a one-dimensional distribution in RGB color space, called as color-lines. He derived a local formation model for color lines in the hazy scenes and used it for recovering the scene transmission from the origin. The lack of a dominant color-line inside a patch or its lack of consistency with the formation model was used by him to identify and avoid false predictions. Finally he described a Markov random field model which was dedicated for producing complete and regularized transmission maps in noisy and scattered estimates. Unlike traditional field models that consist of local coupling, this method was augmented with long-range connections between pixels of similar attributes. He obtained results over different types of images with consistent improvement in the accuracy of the estimated scene transmission and haze-free radiances.

S.C.Huang et.al (2014) [21] have proposed a novel visibility restoration method that uses a combination of three major modules: a depth estimation module, a color analysis module, and a visibility restoration module. First they used the depth estimation module with median filter technique and adaptive gamma correction technique to reduce the halo effects in images and effective transmission map estimation was obtained. They then used the color analysis module was based on the gray world assumption and analyzed the color characteristics of the input hazy image. Finally they used the visibility restoration module and obtained the transmission map which was captured during inclement weather conditions. The result obtained was superior to other haze removal methods.

Y.Wang et.al (2014) [22] have proposed a multi-scale depth fusion (MDF) method for defogging a single image. They used a linear model representing residual of nonlinear filtering and multiscale filtering results are probabilistically blended into a fused depth map. Then they formulated an energy minimization problem along with inhomogeneous Laplacian–Markov random field for the multiscale fusion with smoothing and edge-preserving constraints. Finally they used a non convex potential adaptive truncated Laplacian to account for spatially variant characteristics such as edge and depth discontinuities and defog was solved. Then the MDF method was experimentally verified for real-world fog images including cluttered-depth scene. The fog-free images are restored with improved contrast and vivid colors but without over-saturation and also the estimation of depth map by this method preserved edges with sharp details.

H.Lu et.al (2014) [23] described a novel method to enhance underwater optical images by dehazing. They considered that scattering and color change are two major problems of distortion for underwater images. Scattering was caused by large suspended particles, like fog or turbid water which contains abundant particles, plankton etc. Color change corresponds to the varying degrees of attenuation encountered by light travelling in the water with different wavelengths, dominated by a bluish tone. They developed a fast image and video dehazing algorithm, to compensate the attenuation discrepancy along the propagation path, under the presence of an artificial lighting source. Finally they obtained images which has reduced noised level, better exposedness in the dark regions, improved global contrast and also the finest details and edges are enhanced significantly.

Z.Li et.al (2015) [24] first introduced, a weighted guided image filter (WGIF) by incorporating an edge-aware weighting into an existing guided image filter (GIF) to addressed the problem. They used WGIF which inherits advantages of both global and local smoothing filters and has a complexity of $O(N)$ for an image with N pixels, which was same as the GIF. They applied the WGIF to avoid halo artifacts like the existing global smoothing filters for single image detail enhancement, single image haze removal, and fusion of differently exposed images. They showed that the resultant produced images with better visual quality and at the same time halo artifacts was reduced/avoided in the final images with negligible increment on running times.

Y.H.Lai et.al (2015) [25] have proposed the significance of accurate transmission estimation and derived the optimal transmission map directly from the haze model under two scene priors. They introduced theoretic and heuristic bounds of scene transmission to guide the optimum and to justify the well-known dark channel prior of haze-free images. Then they incorporated two scene priors, including locally consistent scene radiance and context-aware scene transmission and formulated a constrained minimization problem and solved it by quadratic programming. They obtained results with global optimality and the accuracy of the transmission map successfully captured fine grained depth boundaries.

3. COMPARITIVE ANALYSIS TABLE

Table I shows the comparison of various haze removal techniques.

Table 1.
Comparison of Various Haze Removal Techniques

S. No	*Authors*	*Techniques*	*Features*	*Parameters*		
				PSNR	*MSE*	*Running Time*
1	F. Durand and J. Dorsey-2002	Fast Bilateral filtering	Effective in preserving edges	-	-	0.31sec
2	Robby T. Tan -2008	Optical model with Markov random field	Used for both grey and color images	-	-	5min
3	Raanan Fattal -2008	Refined image formation model	Single image dehazing		0.07	35sec
4	J.P.Tarel and N. Hautiere -2009	Fast visibility restoration using median filter	Used for both single grey or color image	-	-	0.17sec
5	K. He, J. Sun, and X. Tang -2011	Dark channel prior	High quality single de-hazed image	-	-	10-20sec
6	J.Pang, O.C. Au, and Z. Guo -2011	Dark channel prior and Guided image filter	Dehazed image with low computation time	-	-	4 sec
7	Y.Q. Zhang, Y. Ding, J.-S. Xiao, J. Liu, and Z. Guo -2012	Dark channel prior and image filter (Median)	Low computation complexity	-	-	3 sec
8	C. Xiao and J. Gan -2012	Guided joint bilateral filter	Fast and better dehazing	-	-	1.32 sec
9	C. Ancuti, C. O. Ancuti, T. Haber, and P. Bekaert -2012	Fusion principle for under water images and videos	Reduced noise, improved global contrast	-	-	2 sec
10	K. He, J. Sun, and X. Tang -2013	Guided image filtering	Edge preserving and fast linear time algorithm	-	0.05	0.1sec
11	C. O. Ancuti and C. Ancuti-2013	Multiscale fusion with Laplacian pyramid	Fast and accurate results	-	-	2-300msec
12	R. Fattal -2014	Dehazing using color lines	Consistent improvement in accuracy	-	-	0.55 sec
13	H. Lu, Y. Li, L. Zhang, A. Yamawaki, S. Yang, and S. Serikawa -2014	Guided Trigonometric Bilateral filtering for under water images	Reduced noise, high quality output image	-	-	4.42 sec
14	Y.-H. Lai, Y.-L. Chen, C.-J. Chiou -2015	Optimal transmission map with scene priors	Accurate transmission and realistic haze free images	-	0.10	5 min
15	Z. Li, J. Zheng, Z. Zhu, W. Yao -2015	Weighted Guided image filtering	Halo artifacts is reduced	-	-	sec

4. GAPS IN LITERATURE SURVEY

Haze removal algorithms become more beneficial for numerous image processing and vision applications. From the above survey results it has been observed that the most of the existing research work has mistreated numerous subjects.

4.1 Median filter

The median filter is normally used to reduce noise in an image i.e salt and pepper noise, approximately like the mean filter. However, it often does a better job than the mean filter of preserving useful detail in the image. These filters Following are the various research gaps concluded using the literature survey:

1. The above presented methods have neglected the techniques to reduce the noise issue which is presented in the output images of the existing haze removal algorithms.
2. Haze degree and estimation of haze level was not accurate. It degrades the performance of haze removal algorithm.
3. Not much effort has focused on the integrated approach of the Adaptive histogram equalization and Dark channel prior.
4. Noise present in the output video sequence after dehazing has been neglected in the above methods.
5. Not much effort has focused in calculating PSNR and MSE values.

5. EDGE PRESERVING TECHNIQUE

Classical smoothers have limited usefulness in image processing, because sharp edges tend to be blurred. So edge preserving smoothers was used. Edge preserving smoothing is an image processing technique that smooth's away textures while retaining sharp edges. In human visual perception, edges provide an effective and expressive stimulation that is vital for neural interpretation of a scene. Larger weights are thus assigned to pixels at edges than pixels in flat areas. The most widely used edge preserving smoothers are Bilateral filter, Guided image filter and Anisotropic diffusion.

6. TYPES OF FILTERS

Filtering in image processing is a process that cleans up appearances and allows for selective highlighting of specific information. A number of techniques are available and the best options can depend on the image and how it will be used. Both analog and digital image processing may require filtering to yield a usable and attractive end result. In image processing filters are mainly used to suppress either the higher frequencies in the image or the low frequencies edges in the image. The two basic types of filters are a) Linear filters and b) Non linear filters. The various types of filters are given below:

1. ***Mean filter:*** The mean filter is a simple method of denoising images by reducing the amount of intensity variation between one pixel and the next. The basic idea is to replace each pixel value in an image with the mean value of its neighbors pixel together with itself thus removing the unwanted pixel which is considered as noise. It is the optimal linear filter for the Gaussian noise. The main drawback is this filter blurs the edges, remove the lines and other image details. belong to that class of filters which are used as edge preserving smoothing filters which are non-linear filters. It also has some disadvantages. The median filter removes both the noise and the fine detail since it can't tell the difference between the two.
2. ***Adaptive Median filter:*** Adaptive Median Filter does not disrupt away edges or other small structure of the image. This filter performs spatial processing to determine which pixels in an image have been affected by impulse noise. The Adaptive Median Filter classifies pixels as noise by comparing each pixel in the image to its surrounding neighbor pixels. The size of the neighborhood is adjustable, as well as the threshold for the comparison. This filter is used to remove impulse noise, smoothing of other noise, reduce distortion, like excessive thinning or thickening of object boundaries.
3. ***Wiener filter:*** Wiener filtering is based on dark channel prior, it is used to counter the issues such as color distortion while using dark channel prior when the images with large white area is processed. So, median filtering is employed to estimate the media function, so that edges can be preserved. After making the median function more accurate it's along with wiener filtering so that the image restoration problem is transformed into optimization problem. This filter gives minimal mean square error for the dehazed image.

4. ***Gaussian filter:*** Gaussian smoothing is very effective for removing Gaussian noise. They are linear low pass filters. The weights are computed according to a Gaussian function where the weights give higher significance to pixels near the edges so that it reduces edge blurring. This filter is rotationally symmetric and computationally efficient.

5. ***Bilateral filter:*** Bilateral filtering smooth images and it also preserves edges, with nonlinear combination of nearby image values. Bilateral is non iterative, local, and simple. Gray levels or colors are combined by the bilateral filter based on both their geometric closeness and their photometric similar, and prefers close values to distant values in both domain and range. Bilateral filter smooth edges towards piecewise constant solutions. Bilateral filter does not provide stronger noise reduction. The bilateral filter (BF) is widely used due to its simplicity. However, the BF could suffer from "gradient reversal" a artifact which refers to the artifacts of unwanted sharpening of edges despite its popularity, and the results may exhibit undesired profiles around edges, usually observed in detail enhancement of conventional low dynamic range images or tone mapping of high dynamic range images.

6. ***Trilateral filter:*** Trilateral filtering smooth's images without influencing edges, by means of a non-linear combination of nearby image values. In this filter replaces each pixel by weighted averages of its neighbor's pixel. The weight allotted to each neighbor pixel decreases with both the distance in the image plane and the distance on the intensity axis. This filter helps us to get result faster as compare to other. While using trilateral filter we use pre-processing and post processing steps for better results. Histogram stretching is used as post-processing and histogram equalization as a pre processing. Trilateral filter provides stronger noise reduction.

7. ***Guided Joint Bilateral filter:*** Guided joint bilateral filtering is used to generate a new atmosphere veil which removes the abundant texture information and recovers the depth edge information. It is used to filter atmosphere veil to receive more accurate atmosphere veil. The joint bilateral filter is particular favored when the input image is not reliable to provide edge information, e.g., when it is very noisy or is an intermediate result in image processing. Joint bilateral filter can enforce the edge information of the filtered image to be similar to the reference image.

8. ***Guided Image filter:*** The guided filter generates the filtering output by considering the content of a guidance image, which can be the input image itself or another different image. The guided filter can perform as an edge-preserving smoothing operator like the popular bilateral filter but has better behavior near the edges. It also has a theoretical connection with the matting Laplacian matrix, so is a more generic concept than a smoothing operator and can better utilize the structures in the guidance image. Moreover, the guided filter has a fast and non-approximate linear-time algorithm, whose computational complexity is independent of the filtering kernel size. The guided filter is both effective and efficient in a great variety of computer vision and computer graphics applications including noise reduction, detail smoothing/enhancement, HDR compression, image matting/feathering, haze removal, and joint up sampling .But this filter produces halo artifacts near some edges.

9. ***Guided Trigonometric Bilateral filter:*** Guided trigonometric filter is used instead of the matting Laplacian or guided filters to solve the alpha mattes more efficiently. First this proposed filter can perform as an edge-preserving smoothing operator like the popular bilateral filter, but has better behavior near the edges. Second, the novel guided filter has a fast and non-approximate constant-time algorithm, whose computational complexity is independent of the filtering kernel size.

10. ***Weighted Guided Image filter:*** Weighted guided image filter (WGIF) is introduced by incorporating an edge-aware weighting into an existing guided image filter (GIF) to address the problem. The WGIF inherits advantages of both global and local smoothing filters by decreasing the complexity

of the WGIF is *O(N)* for an image with *N* pixels, which is same as the GIF and the WGIF can avoid halo artifacts like the existing global smoothing filters. The WGIF is applied for single image detail enhancement, single image haze removal and fusion of differently exposed images. It produces images with better visual quality and at the same time halo artifacts can be reduced.

7. CONCLUSION

Haze removal algorithms become more useful for many image processing and computer vision applications. It is found that most of the existing research papers have neglected many issues; i.e. no technique is accurate for different kind of circumstances. The literature survey has shown that the presented methods have neglected the techniques to reduce the noise issue which is presented in the output images of the existing haze removal algorithms. The problem of uneven and over illumination is also an issue for dehazing methods. So it is required to modify the existing methods in such a way that modified technique will work better and to produce an accurate results. In future to overcome the problems of existing research methods a new integrated algorithm along with enhanced filtering will be proposed.

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