Image Defogging by Contrast Enhancement and Fusion Based Transmission Estimation

Darsana V
M.Tech student - Applied Electronics and Communication System
Nehru College of Engineering and Research Centre
Thrissur, India

Rahul M Nair
Asst. Professor–Department of Electronics and communication Engineering
Nehru College of Engineering and Research Centre
Thrissur, India

Abstract—*Image contrast enhancement and defogging is an important area in image processing. It is common in poor weather conditions that the moisture or pollutant particles suspending in air result in attenuation, absorption and scattering. This effect often degrades image quality by low contrast and faded colors, and thereby impacts negatively on the accuracy of the subsequent procedures such as object detection, recognition and analysis. Thus, we develop asingle image defogging or dehazing algorithms for the restoration of image quality along with contrast enhancement. In this project intrinsic image decomposition priors into decomposition for contrast enhancement, Gaussian based dark channel technique and fusion based transmission estimation is used for efficient defogging.*

Keywords—*defogging, contrast enhancement, fusion based transmission estimation, intrinsic image decomposition, Gaussian based dark channel technique.*

I. Introduction

Degrading of images acquired by camera, in terms of visibility is often introduced to images captured in poor weather conditions, such as fog or haze. To overcome this problem, existing approaches focus mainly on the enhancement of the overall image contrast. However, the usage of enhancement schemes which destroy the naturalness of the image, it is often difficult to achieve quality results. In this paper, along with improved contrast enhancement scheme based on intrinsic image decomposition, a fusion-based transmission estimation method is introduced to adaptively combine two different transmission models. Specifically, the new contrast enhancement scheme, fusion weighting scheme and the atmospheric light computed from the Gaussian-based dark channel method improve the estimation of the locations of the light sources.

II. Literature survey

The research on image defogging has been done by many research institutions and has got different variety of results depending on the defoggingalgorithm .Each applications may require different algorithms or an efficient algorithm might be enough for majority of the applications.The defogging algorithms are created because of the degradation of image quality due to haze in the form of low contrast and faded colors which impacts negatively on the accuracy of the subsequent procedures such as object detection, recognition and analysis[5]. The existing algorithms can be classified into two groups of single and multiple image based techniques, in terms of the number of input images [8] focused on the restoration of scene contrast and colors through user interactions and has a good restoration capability. However, due to the requirement of images as input the computation complexity increases and is not feasible for practical applications. In this paper we use single image defogging algorithm which reduces complexity. He et al. [9] used the dark channel prior information to estimate the depth of the scene and the atmospheric light. The transmission map is then refined by closed form alpha matting technique but this increases computation complexity and processing time which need to be considered in practical applications.Zhu et al. [10] considered the scene depth as weighted sum of brightness, saturation and error and a learning strategy was applied to estimate the coefficients in depth model to remove the haze but this was limited due to insufficient information for mathematical models and complexity in computations. The contrast enhancing methods can be classified as histogram and Retinex based. Histogram based methods by modifyinghistogram distributions enhance the contrast of an image. However, this method change the brightness of the image and may result in over enhancement. Therefore, many constraints were introduced including brightness preservation [12], contrastlimitation [14], weightedadjustment [13] to overcome the drawback of histogram equalization method. Retinex based method assumes human’s eye sees scene as a product of reflectance and illumination layers [11]. Earlier days Retinex based enhancement methods usually utilize the enhanced reflectance layer as enhanced output [15][16][17]but this might destroy the naturalness of the images. To overcome this problem instead of enhancing the reflectance layer illumination layer can be adjusted. This also solves the problem of over and under enhancement of images. The intrinsic image decomposition was first proposed by [18] which separates reflectance and illumination layers. The illumination value represent the amount of reached light and the reflectance values, invariant to illumination conditions, depict the intrinsic color of the material.

In this paper, an efficient and effective single image defogging method is introduced. This algorithm determines the atmospheric light with high accuracy using Gaussian based dark channel technique. We combined the fusion based defogging techniques and improved contrast enhancement based on intrinsic image decomposition to reach the effective detailed outcome

III. OPTICAL SCATTERING MODEL

A. Model description

According to optical scattering model proposed by Koschmieder [3], the formulation of the hazy image can be written in the form of

$$I(X) = J(X)T(X)+A(1-T(X)), \quad (1)$$

Where I(x) is captured hazy image, J(x) is haze-free image, T(x) is the transparency function between the scene objects and the lens of the camera, term A denotes the atmospheric light. The first term J(X)T(X) is a multiplicative mapping process which represents the attenuation during the propagation through the hazy medium. The second term A(1-T(x)) denotes the light pattern, resultant from propagation loss and scattering. If the propagation medium is homogeneous then the transparency function T(X) can be modeled as

$$T(X) = e{-}\beta d(X)\,, \quad (2)$$

Where β is the scattering coefficient, d(X) is the scene depth.

B. Objective

Objective of the formulation is to restore the Haze free image J(X) from the captured fog containing image I(x) through the estimation of the transparency function T(x) and atmospheric light A.

IV. PROPOSED METHOD

The proposed image defogging by contrast enhancement and fusion based defogging will be presented in this section. First, the overview of the proposed method is illustrated. Then, the main modules: Gaussian based dark channel technique, intrinsic image decomposition for contrast enhancement, fusion based transmission estimation will be presented in details.

A. Overview

The framework of the proposed method is depicted in Fig. 1. Given an input hazy image, I(X). Based on

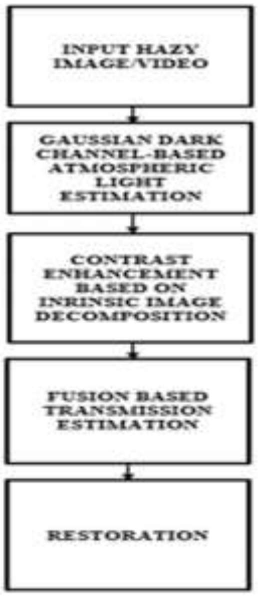

Fig 1:The frame work of proposed model

the optical scattering model, we first estimate the atmospheric light with Gaussian based dark channel technique (while avoiding the color fading problems). Then to enhance the low contrast or detail part while prevent from the over enhancing with similar pixel value we impose a contrast enhancement technique. Then the transparency function is estimated using theFusion weighting function. And finally the haze free image, J(x) is restored from hazy image, I(X).

B. Gaussian based dark channel technique.

This technique is used to estimate the atmospheric light, A in equation (1). Traditionally, A is considered as the brightest pixel in the input image (assuming there are no saturated pixels). But this is not so in all practical cases. According to He's [9] method, the atmospheric light can be correctly obtained through the selection of part of brightness pixels in the dark channel of the normalized input.

$$I_{dark}(X) = \min_{Y\in\Omega(x)} \min_{C\in\{r,g,b\}} \frac{I^c(Y)}{A^c} \quad (3)$$

Where A^c is the atmospheric light of color channel, C and I^c is the input hazy image of color channel, C. Local path is denoted by $\Omega(x)$ and I_{dark} is the channel of image, I. But for complicated scenes two min operators seems computationally expensive and might degrades the accuracy. To overcome this deficiency, a Gaussian based dark channel I_{Gdark} is introduced

$$I_{Gdark}(X) = W(X)*M(X) \quad (4)$$

Where M is the minimum component of I and W(X) is the Gaussian function.

$M(X) = \min_{c\in\{r,g,b\}} I^c(5)W(X) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{X^2}{2^{2K}}}$ (6)

$K=\max(\text{size}(I^c(y)))$ (7)

In Gaussian each pixel is substituted by the Gaussian average value instead of the minimum in the local patch to reduce sensitivity. Moreover, according to its physical properties the Gaussian based dark channel should also be subject to the constraint

$I_{Mdark}(X) = \min(I_{Gdark}(X), M(X))$

Here, we calculate atmospheric light and the fusion process A (1-T(X)) will be calculated on the basis of transparency function, T(X).

C. Contrast enhancement

The proposed contrast enhancement method is described as follow. Given an input color image I, we first convert this image into HSV representation. Then, the value (V) channel image is decomposed into illumination (L) and reflectance (R) layers using the intrinsic decomposition model [1].Now, L layer is adjusted by Gamma mapping function, producing an adjusted L layer, denoted by L_a. Then, the adjusted L_a is multiplied by the reflectance layer R to generate the enhanced V channel image denoted by V_e. Since the mapping function is performed globally, we adopt the contrast limited adaptive histogram equalization (CLAHE) [14] to further enhance the local contrast of V_e. The enhanced result is denoted as$\widehat{V}_e$. Finally, the enhanced HSV image is transformed to RGB space, which yields the final result I_e. The two main modules are intrinsic decomposition [4] and illumination adjustment [1].

D. Fusion weighting function

One key element of restoration procedure other than atmosphere the existing methods are not effective in the estimation of the transparency function.The existing methods are not effective in the estimation of the transparency function while maintaining the input image's natural appearance. Thus, a new approach is introduced for the improvement of the estimation procedure by combining the information from both the strong and weak enhancement levels according to the fusion weighting function. The estimation of the transparency function is to calculate the degradation component contributed by haze or fog.At strong end of the range in terms of scene radiance high contrast, a transparency function can be formed. Then, based on the boundary conditions on the scene radiance [2], the patch wise transparency functions $T_S(x)$ can be formulated as

$T_S(X) = \underset{X\in W_X}{\text{closing}} T_b(X)$(8)

$T_b(X)=\min(1,\max_{c\in\{r,g,b\}}(\frac{I^c(X)-A^c}{C^c_{low}-A^c},\frac{I^c(X)-A^c}{C^c_{high}-A^c}))$(9)

Where the closing is the morphological closing operation and the kernel set to 9×9; C^c_{low} and C^c_{high} are the lower and upper bounds, respectively; and $T_b(X)$ is the resultant transparency function.

$C_{low} \leq J(X) \leq C_{high}$

The transparency function $T_S(x)$ is considered as the one with strong enhancement level. The transparency function $T_W(x)$, in terms of the weak enhancement level of scene radiance and with more natural scene appearance. , we assume that A = 1 when calculating the transparency function $T_W(x)$. In general, for an image of size 640 x 480, the patch size is set to 19 x 19 for $T_W(x)$, and C^c_{low} and C^c_{high} are set at 10 and 255, respectively [2].

The hazy images can be divided into two regions, onewith heavy haze with extremely limited visibility and the other with less haze with faded colors and lower contrast. To conduct effective defogging the fusion weighting scheme is applied [2] assigning a greater weighting to $T_W(x)$ for heavy haze portion and $T_S(X)$ for less haze portion. The canny edge detection and the dilating morphological operation are imposed to the input image sequentially to identify and partition he images into the two types of region.

$I_{edge}(X) = \text{dilate}(\text{edge}(I_{grey}(X),\alpha), \beta)$, (10)

Where α is the parameter of the sensitivity for edge detection and β is the number of dilating iterations.The formulation of the weighting scheme for optimal performance is

$T(X) = (1-W(X) T_W(X) +W(X) T_S(X)$ (11)

Where $W(X) = GF(I_{edge}(X), I(X))$, (12)

The guided filteris used for the purpose of refinement, noise reduction and edge preservation [19][6][7]. It can be seen that the final T(X) is heavily influenced by $T_S(X)$ for a greater value of W(X). Similarly, T(X) is approaching $T_W(X)$ if the weighting of W(X) is low. The distribution of subjects, which is spread over the lower half of the image, will be the region for effective dehazing and the sky region, the top portion of the image, is relatively prone to over enhancement. This technique facilitates different weighting coefficients to be appropriately distributed to $T_W(X)$ and $T_S(X)$. Assigning a larger weighting to $T_S(X)$ on the bottom portion of the image effectively restores the original scene, while assigning a greater weighting to $T_W(X)$ onto the top part preserves the natural appearance. And finally, the guided filter is applied to T(X) for further refinement.

V. EXPERIMENT RESULT AND DISCUSSION

The proposed method is evaluated on different set of Images.One among those images is shown in fig. 2.

The experiment result shows that the output images

Fig 2: comparison of results proceeding from left to right, the hazy input image, Jing- Mingguo [2] method, and our proposed method.

were enhanced in terms of contrast enhancement and removal of fog content.

VI. CONCLUSION

We proposed a method to defog images more effectively. The new combination of contrast enhancement scheme, fusion weighting scheme, and atmospheric light computed from Gaussian based dark channel method has been used in the proposed method. We use intrinsic image decomposition for contrast enhancement to enhance images by estimating illumination and reflectance layers. After decomposition, we perform correction on the illumination layer to boost the details globally. Then we adopt CLAHE to further enhance local details. Experimental results can demonstrate that our decomposition model outperforms existing image decomposition models in terms of image enhancement, and our enhancement method provides quality for a wide variety of images. We use the fusion based transmission estimation scheme and the atmospheric light computed from the Gaussian-based dark channel as defogging procedures with contrast enhancement to get the improved and efficient model.

Acknowledgment

The authors would like to thank Prof. Dr.S.RajKumar for the support and guidance given for the successful completion of writing this paper.

References

[1] Huanjing Yue,Xiaoyan Sun,Feng Wu, Chunping Hou,"Contrast Enhancement Based on Intrinsic Image Decomposition", IEEE Transactions on Image Processing, Volume: 26, Issue: 8,PP. 3981 - 3994 Aug. 2017

[2] Jing-Ming Guo,Jin-yu Syue,Hua Lee,"An Efficient Fusion-Based Defogging",IEEE Transaction on Image Processing,Volume: 26, Issue: 9, PP4217 - 4228.Sept. 2017

[3] H. Koschmider, "Theorie der horizontalen Sichtweite," in Proc. Beiträgezur Phys. der Freien Atmos., 1924, pp. 171–181.

[4] Pierre-Yves Laffont,Jean-Charles Bazin,"Intrinsic Decomposition of Image Sequences from Local Temporal Variations", Computer Vision (ICCV),IEEE International Conference ,pp. 433-441, Dec 2015

[5] A. Almagambetov, S. Velipasalar and M. Casares, "Robust and Computationally Lightweight Autonomous Tracking of Vehicle Taillights and Signal Detection by Embedded Smart Cameras", IEEE Trans. Ind. Electron., vol. 62, no. 6, pp. 3732-3741, 2015.

[6] X. Kang, S. Li, and J. A. Benediktsson, "Spectral–Spatial Hyperspectral Image Classification with Edge-Preserving Filtering," IEEE Trans. Geosci. Remote Sens., vol. 52, no. 5, pp. 2666–2677, May 2014.

[7] C. T. Shen, H. H. Liu, M. H. Yang, Y. P. Hung and S. C. Pei, "ViewingDistance Aware Super-Resolution for High-Definition Display", IEEE Transactions on Image Processing, vol. 24, no. 1, pp. 403-418, 2015.

[8] S. G. Narasimhan and S. K. Nayar, "Interactive (De)Weathering of an Image Using Physical Models," in Proc. IEEE Workshop Color Photometric Methods Comput. Vis., vol. 6. France, 2003, p. 1.

[9] K. He, J. Sun, and X. Tang, "Single Image Haze Removal Using Dark Channel Prior," IEEE Trans. Pattern Anal. Mach. Intell., vol. 33, no. 12, pp. 2341–2353, Dec. 2011.

[10] Q. Zhu, J. Mai and L. Shao, "A Fast Single Image Haze Removal Algorithm Using Color Attenuation Prior," Image Processing, IEEE Transactions on, On page(s): 3522 - 3533 Volume: 24, Issue: 11, Nov. 2015.

[11] E. H. Land and J. J. McCann, "Lightness and retinex theory," JOSA, vol. 61, no. 1, pp. 1–11, 1971.

[12] C. Wang and Z. Ye, "Brightness preserving histogram equalization with maximum entropy: a variational perspective," IEEE Transactions on Consumer Electronics, vol. 51, no. 4, pp. 1326–1334, 2005

[13] S.-H. Yun, J. H. Kim, and S. Kim, "Contrast enhancement using a weighted histogram equalization," in Consumer Electronics (ICCE), 2011 IEEE International Conference on. IEEE, 2011, pp. 203–204.

[14] A. M. Reza, "Realization of the contrast limited adaptive histogram equalization (clahe) for real-time image enhancement," Journal of VLSI signal processing systems for signal, image and video technology, vol. 38, no. 1, pp. 35–44, 2004.

[15] D. J. Jobson, Z.-u. Rahman, and G. A. Woodell, "Properties and performance of a center/surround retinex," IEEE transactions on image processing, vol. 6, no. 3, pp. 451–462, 1997.

[16] M. Herscovitz and O. Yadid-Pecht, "A modified multi scale retinex algorithm with an improved global impression of brightness for wide dynamic range pictures," Machine Vision and Applications, vol. 15, no. 4, pp. 220–228, 2004.

[17] Z. Rahman, D. J. Jobson, and G. A. Woodell, "Retinex processing for automatic image enhancement," Journal of Electronic Imaging, vol. 13, no. 1, pp. 100–110, 2004.

[18] H. Barrow and J. Tenenbaum, "Recovering intrinsic scene characteristics," Comput. Vis. Syst., A Hanson & E. Riseman (Eds.), pp. 3–26, 1978.

[19] X. Chen, S. B. Kang, J. Yang, and J. Yu, "Fast Edge-Aware Denoising by Approximated Patch Geodesic Paths", IEEE Trans. Circuits Syst. Video Technol., vol. 25, no. 6, pp. 897-909, 2015