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Implementation of Image Dehazing Technique Using Image Fusion

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ABSTRACT

One of the main difficulties in image processing is to recover the images degraded by different types of degradations such as haze and fog. Images of outside scenes may suffer from atmospheric degradation due to impurities present in the atmospheric medium. Light may be absorbed or scattered due to these particles. From an artistic stand point, although this effect may be advantageous but for better visibility one may need to recover an image degraded by these effects, the process of removing these effects is called haze removal. In this paper we represent an improved haze removal technique based on image fusion which merges two images obtained from the original image. This technique is simple because it requires only original image for haze removal.

Keywords: Airlight, Image Fusion, PSNR

1. INTRODUCTION

Haze is the synthesis of two components Airlight and Direct attenuation. Scattering of light due to atmospheric particles is called airlight and gradual loss in intensity is called attenuation. Haze is an atmospheric phenomenon which degrades the quality of images due to presence of aerosols such as fumes, mist and dust. This phenomenon is mainly occurred in large populated areas. When we capture the images in bad weather conditions, the radiance obtained at camera is characterized by faded colours and decreased contrast. Climate conditions fluctuate mainly in the nature and dimension of the impurities involved and their density in atmosphere. Many computer perception algorithms depend on the presumption that the input image is accurately the scene radiance, i.e. there is no degradation from haze. When this perception is disobeyed, algorithmic faults can be miserable. One could simply observe how a car direction-finding system that did not consider this effect could have hazardous results. For that reason, finding efficient techniques for haze removal is an unending area of interest in the computer vision fields and image processing. This is important in numerous outside applications such as underwater imaging, intelligent vehicles, remote sensing and many more.

This paper focus on improved haze removal technique using image fusion. Image fusion is a process that integrates complementary information from differently exposed images such that the new images are more suitable for human visual perception and processing [1]. In last two decades researchers have proposed many methods of image fusion in spatial domain as well as in transform domain. In this paper, we deal only in spatial domain.

The reason of using image fusion in dehazing technique is to merge images obtained from corrupt image. Two images are obtained by applying white balance and contrast enhancement techniques on original corrupted image. This differentiates the visibility in hazy and haze free section of image and also removes impractical color shed appeared due to atmospheric color. With fusion technique the resultant inputs are

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scaled by three types of weight maps i.e. chromatic, luminance and saliency weight maps [2]. These weight maps help to preserve areas with good visibility. The objects introduced by weight maps can be removed by fusing the images obtained by Laplacian and Gaussian pyramid technique. The final images is the dehaze version of original corrupted image.

2. HAZY IMAGE MODEL

In navigation system, underwater imaging and remote sensing the appearance of image depends on atmospheric conditions such as smoke, fog and haze. Haze model is mainly used in image processing and computer vision. This model is preferred for the development of images in the bad weather conditions. The quality of image is corrupted due to the existence of substantial elements in the atmosphere which have considerable size between 1-10 ìm. The radiance coming from a camera is scattered and absorbed by these atmospheric elements.

Consider that this haze model is a linear model. By the definition of linearity, in this model only the position of pixel is changed. Fog is the mixture of Direct attenuation and Airlight. This problem is mainly due to two fundamental events: Airlight and Direct attenuation. And it is illustrate as follow:

$$I(x) = \text{Direct attenuation (A)} + \text{Airlight (A)}$$

$$I(x) = J(x)*t(x) + A*[1-t(x)]$$

where I(x) is the intensity of the xth pixel, J(x) is the picture radiance vector (the real color that we want to recuperate), A is the light of atmospheric, and t is the transmission medium containing the part of the light that is not dispersed and reaches direct to the camera. First term of the equation, J(x)*t(x) is the direct attenuation; the second term, A*(1-t(x)) is Airlight. This model is directly applied to each RGB element of a color image.

3. DIFFERENT DEHAZING METHODS

Methods of haze removing can be classified into two categories that are single image haze removing methods and multiple image haze removing methods.

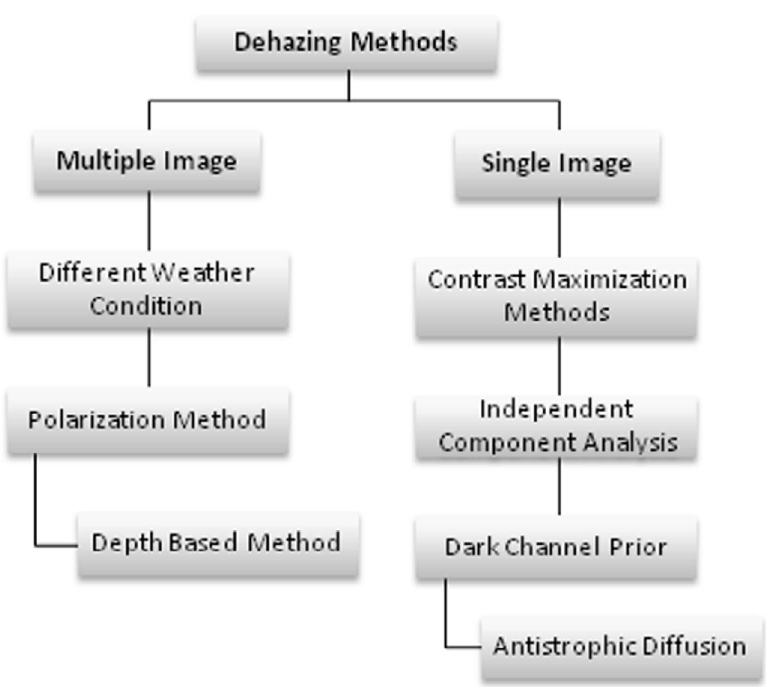


Figure1: Different Dehazing Methods

3.1. Single Image Dehazing Method

Single Image method requires only a single input image. This method is based upon statistical postulations and on the characteristics of the scene and regain the scene information on the basis of previous information from a single image. The methods under this category are described as follows.

3.1.1. Contrast Maximization Method

Haze reduces the quality of image like contrast. Haze can be removed by enhancing the contrast of the image. Contrast maximization improves the contrast under the limitation. But, the resulting images have large saturated pixel values since this method does not actually enhance the intensity or deepness but somewhat just improve the visibility. Furthermore, the result restrains halo effects at depth discontinuities.

3.1.2. Independent Component Analysis (ICA)

Independent Component Analysis is a arithmetical method to detach two additive constituents from a signal image. Fattal [4] applies this method and considers that the transmission and outside shading are statistically not related in local space. This method is physically applicable and can generate good results, but may be changeable since it does not perform well for heavily hazed images.

3.1.3. Dark Channel Prior

This method [6] is based on the information of outdoor haze-free images. In nearly all of the non-sky patches, as a minimum one color channel (RGB) has extremely poor intensity at a few pixels. These pixels

Figure: 2. Contrast Maximization Method [3]

Figure: 3. Independent component analysis [5]

(a) Hazy Image **(b) Recovered Depth map** **(c) Haze-free image**

Figure 4: Dark channel prior [7]

are called dark pixels. These dark pixels give the information of haze transmission. This method is also physically applicable and performs well for heavily hazed images. When the entities are analogous to the air light then it is not applicable.

3.1.4. Antistrophic Diffusion

It [8] is a technique that removes haze without removing the parts of the image such as lines, edges or other features that are necessary for the image. Flexibility of this method allows combining the properties with qualities of image enhancement. Tripathi [8] give an algorithm that uses anisotropic diffusion for cleansing air light map from DCP (dark channel prior). This method is used to balance the airlight map. It works well in case of dense fog.

3.2. Multiple Images Dehazing Method

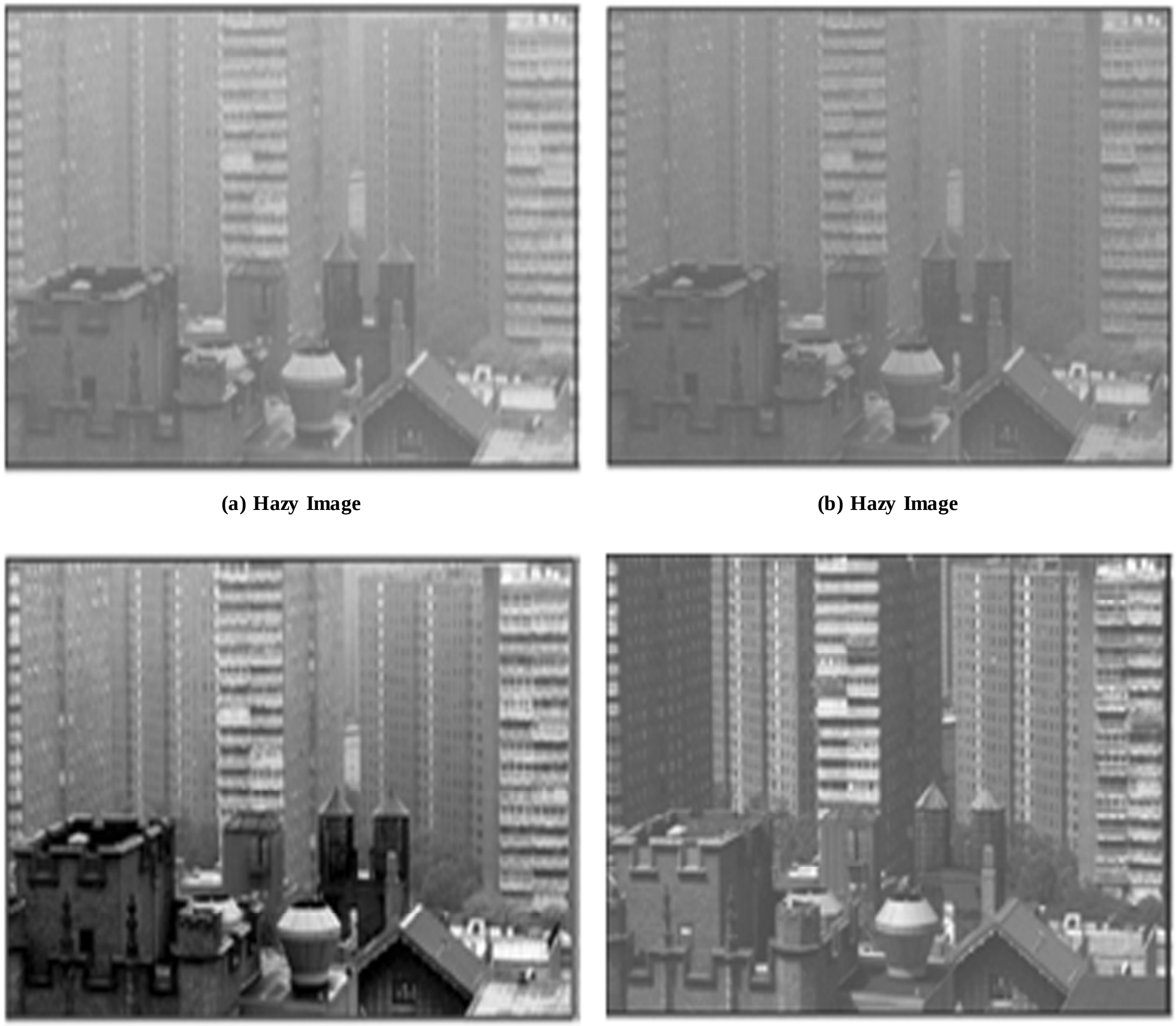
In multiple images dehazing, two or more images [9, 10, 11, 12] of the same view are taken. This method uses known variables and ignores the unknowns. The methods under this class are described as follows.

3.2.1. Method Based On Different Weather Condition

In this method multiple images [9, 11, 13] taken under different weather condition are used. The basic idea is to take the variations of two or more images of the same scene. Each image has different properties of the contributing medium. This method can considerably improve visibility, but its drawback is to wait until the

(a) Hazy image **(b) Haze-free image**

Figure 5: Antistrophic diffusion [8]



(a) Hazy Image **(b) Hazy Image**

(c) Dehazed Image **(d) Clear Weather Image**

Figure 6: Multiple Image dehazing [14]

characteristics of the medium change. So, this method is not capable to give the results instantaneously for scenes that have never been taken. Furthermore, this method also cannot handle vibrant scenes.

3.2.2. Methods Based On Polarization

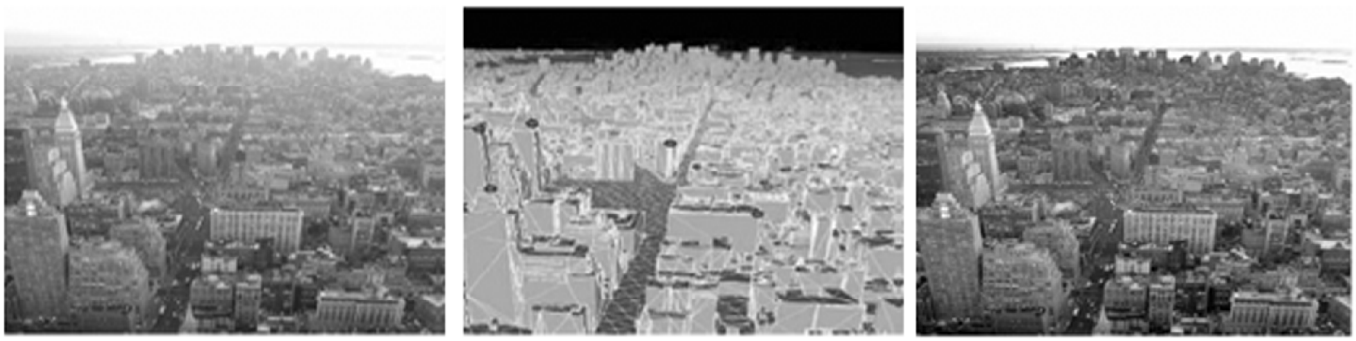
In this technique two or more images of the identical scene are acquired with different polarization filters [10, 15]. The basic idea is to capture multiple images of the similar scene having different degrees of polarization, which are captured by turning a polarizing filter connected to the camera, but the healing effect of vibrant scene is not very good. The deficiency of this method is that it cannot be used for dynamic scenes for which the variations are quicker than the filter revolution and involve special apparatus like polarizers and not essentially produce better results.

3.2.3. Depth Map Based Method

This technique uses a single image and presumes that 3D geometrical model [11, 16, 17] of the scene is offered by some databases for example from Google Maps and also considers the consistency of the scene

(a) Best Polarization State **(b) Worst Polarization State** **(c) Dehazed Image**

Figure 7: Image dehazing using polarizing filters [10]



(a) Hazy image **(b) 3D structural model** **(c) Dehazed Image**

Figure8: Depth map based method [17]

is given. This 3D model then line up with hazy image and give the scene depth [18]. This technique needs user interaction to line up 3D model [17] with the scene and it gives precise results. This technique does not need special apparatus's. Its limitation is that it is not automatic, it requires user interactions. This scheme is to use the some degree of interactive treatment to dehaze the image, but it requires an assessment of more parameters, and the supplementary information difficult to obtain.

4. DEHAZING BASED ON FUSION

This section describes the fusion technique that uses only the inputs and weights obtained from the original hazy image. The basic idea is to merge multiple input images (guided by weight maps) of the same scene into single image, keeping only the most important features of them. This method executes following three steps with the aim to remove haze from corrupted image.

Step1: Obtaining two input images from the original image.

Step2: For the obtained images define different weight measures.

Step 3: Calculate the mean value of the images

Step4: Comparison of mean value to pixels of images

Step5: Fusion of images.

5. EXPERMENTAL RESULTS

To estimate the performance of fusion based dehazing technique, we apply this method to improve the quality of numerous hazy images and evaluate this method with the two existing single image based methods of Tarel [19] and Fattal [4]. In [4], an albedo estimation-based method was projected while method used in

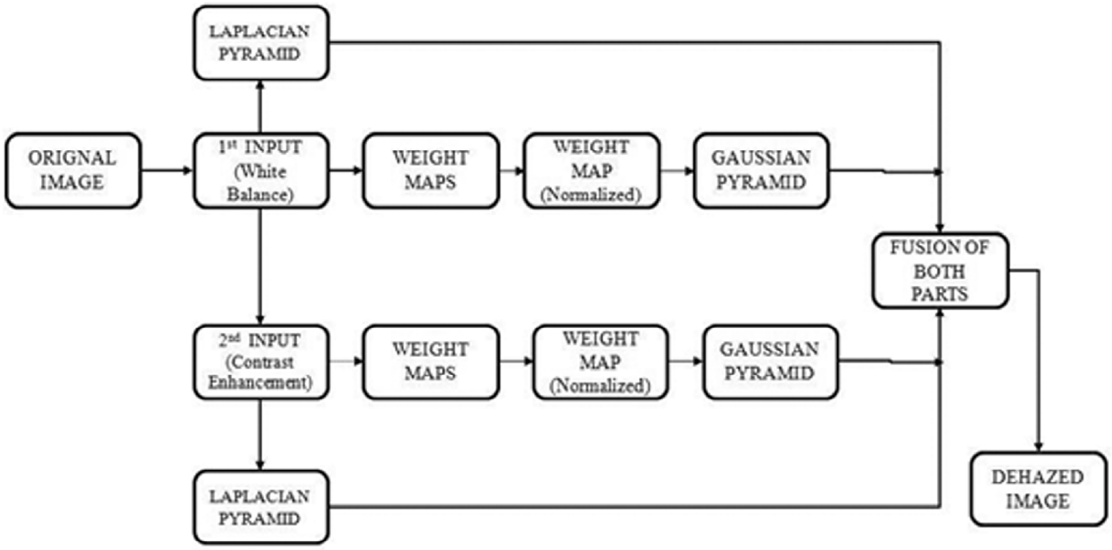


Figure 9: Flow chart of fusion based dehazing approach

Original Hazy **Image Fattal [4]** **Tarel [19]** **Fusion Based Dehazing [2]**

Figure 10: Comparison of Fattal [4] and Tarel [19] techniques with Fusion based dehazing

Table 1
Comparison of PSNR

Images	*Fattal [4]*	*Tarel [19]*	*Fusion based approach [2]*
Img1	6.6947	5.6432	5.6126
Img2	10.829	5.484	5.3151
Img3	11.772	7.9193	7.3812
Img4	9.8758	4.7542	4.6475
Img5	8.8142	5.5801	5.7584

[19] was based on contrast enhancement. In our experimentation, we execute the method introduced in section 4 using MATLAB 16 on PC with a 3 GHz Intel Pentium Dual Core CPU. Figure 7 demonstrates the comparative analysis of three approaches. In order to ensure the robustness of fusion based approach PSNR (Peak signal to noise ratio) and MSE (Mean square error) is calculated and it has been monitored that this

Table 2
Comparison of MSE

Images	*Fattal [4]*	*Tarel [19]*	*Fusion based approach [2]*
Img1	13342	18381	18268
Img2	4753.6	23751	24576
Img3	2598.7	15854	15906
Img4	8506.1	29443	29653
Img5	7890.6	22560	22956

Table 3
Comparison of computation time

Images	*Fattal [4]*	*Tarel [19]*	*Fusion based approach [2]*
Img1	159.67 sec	99.91 sec	29 sec
Img2	132.30 sec	103.82 sec	31 sec
Img3	124.56 sec	108.48 sec	30 sec
Img4	48 sec	38 sec	22 sec
Img5	73 sec	65 sec	23 sec

method do better than the other two single image based dehazing methods in [4],[19] as shown in table 1 and table 2.

The main benefit of this technique is that it does not essential to approximate depth map, which decreases the complexity to a great extent. Furthermore it has been examined that final output achieved is more satisfying than any other methods. Moreover, compared with most of the existing methods, a significant advantage of fusion based dehazing is that it needed less computation time. This technique is able to process a 600×800 image in just about 29-31 seconds as shown in table 3.

6. CONCLUSION AND FUTURE SCOPE

The fusion based dehazing approach presented in this paper can efficiently renovate image color balance and eliminate haze and fogg. This technique is based on assortment of appropriate weight maps and inputs, a fusion method can be used to attain dehazed version of hazy images. Furthermore, it has been monitored that this technique does better than the other single image based dehazing techniques. The approach is faster than existing single image dehazing methods and yields precise results. In future work we would like to verify this method on images from intelligent vehicles and underwater images.

REFERENCES

[1] P. J. Burt, K. Hanna, and R. J. Kolczynski, “Enhanced image capture through fusion,” in *Proc. IEEE Int. Conf. Comput. Vis.*, May 1993, pp. 173–182.

[2] C.O Ancuti and C. Ancuti, “Single image dehazing by multi-scale fusion,” *IEEE Trans. Image Processing*, Aug.2013, vol.22, pp. 3271-3282.

[3] Tan, Robby T, “Visibility in bad weather from a single image” IEEE Conference on Computer Vision and Pattern Recognition, CVPR, pp. 1-8, Year 2008.

[4] Fattal, Raanan. “Single image dehazing.” In ACM Transactions on Graphics (TOG), vol. 27, no. 3, p. 72, 2008.

[5] Xu, Zhiyuan, Xiaoming Liu and Na Ji, “Fog removal from color images using contrast limited adaptive histogram equalization”, 2nd International Congress on Image and Signal Processing (CISP), pp. 1-5, 2009.

[6] Fang, Faming, Fang Li, Xiaomei Yang, Chaomin Shen and Guixu Zhang, “Single image dehazing and denoising with variational method”, IEEE International Conference on Image Analysis and Signal Processing (IASP), pp. 219-222, 2010.

[7] He, Kaiming, Jian Sun and Xiaoou Tang, "Single image haze removal using dark channel prior.", IEEE Transactions on Pattern Analysis and Machine Intelligence, vol.33, no. 12, pp. 2341-2353, 2011.

[8] Tripathi, and S. Mukhopadhyay, "Single image fog removal using anisotropic diffusion.", Image Processing, Vol. 6, no. 7, pp. 966-975,2012.

[9] Nayar, Shree K. and Srinivasa G. Narasimhan, "Vision in bad weather", The Proceedings of the Seventh IEEE International Conference on Computer Vision, vol. 2, pp. 820-827, 1999.

[10] Schechner, Yoav Y., Srinivasa G. Narasimhan and Shree K. Nayar, "Instant dehazing of images using polarization", The Proceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR), vol. 1, pp. I-325, 2001.

[11] Narasimhan, Srinivasa G. and Shree K. Nayar, "Contrast restoration of weather degraded images", IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 25, no. 6,pp. 713-724, 2003.

[12] Tao, Zhang and Shao Changyan, "Atmospheric scattering-based multiple images fog removal", 4th IEEE International Congress on Image and Signal Processing (CISP), vol.1, pp. 108-112, Year 2011.

[13] Narasimhan, Srinivasa G. and Shree K. Nayar, "Chromatic framework for vision in bad weather", The Proceedings of IEEE Conference on Computer Vision and Pattern Recognition, vol. 1, pp. 598- 605, 2000.

[14] Narasimhan, Srinivasa G., and Shree K. Nayar. "Vision and the atmosphere" International Journal of Computer Vision 48, no. 3 (2002): 233-254.

[15] Shwartz, Sarit, Einav Namer and Yoav Y. Schechner, "Blind haze separation", IEEE Computer Society Conference on Computer Vision and Pattern Recognition, vol. 2, pp. 1984-1991, 2006.

[16] Narasimhan, Srinivasa G. and Shree K. Nayar, "Interactive (de) weathering of an image using physical models", IEEE Workshop on Color and Photometric Methods in Computer Vision, vol. 6, no. 6.4, p. 1., France, 2003.

[17] Kopf, Johannes, Boris Neubert, Billy Chen, Michael Cohen, Daniel Cohen-Or, Oliver Deussen, Matt Uyttendaele, and Dani Lischinski. "Deep photo: Model-based photograph enhancement and viewing." In ACM Transactions on Graphics (TOG), vol. 27, no. 5, p. 116, 2008.

[18] Hautière, Nicolas, J-P. Tarel and Didier Aubert, "Towards fog-free in-vehicle vision systems through contrast restoration", IEEE Conference on Computer Vision and Pattern Recognition, (CVPR), pp. 1-8, 2007.

[19] J.-P. Tarel and N. Hautiere, "Fast visibility restoration from a single color or gray level image," in *Proc. IEEE Int. Conf. Comput. Vis.*,Sep.–Oct. 2009, pp. 2201–2208.