Industrial Engineering Journal
ISSN: 0970-2555
Volume: 52, Issue 3, March: 2023

DIGITAL IMAGE HAZE REMOVAL USING ENHANCED PRIOR ALGORITHM'S

[1]**Dr. G. Nagaraju,** [2]**P. Udaya Bhanu,** Assistant Professor,
[3]**S. Bhanu Rekha,** [3]**N. Rupa,** [3]**P. Prem kanth,** [3]**N.S.H. Viswa Karthik,** B. Tech Students
[1,3]Department of ECE, S.R.K.R. ENGINEERING COLLEGE (A), BHIMAVARAM, Andhra Pradesh, India.
[2]Department of EEE, S.R.K.R. ENGINEERING COLLEGE (A), BHIMAVARAM, Andhra Pradesh, India.
Corresponding author: [1]bhanu.raj.nikhil@gmail.com, +91 9010133466

Abstract — **In this article, we suggest a straightforward but efficient technique for removing haze from a single input image. This approach is both light and previously on a dark channel. A new haze removal method is put forth by Dr. He in [7] and is based on dark channel prior (DCP). It is gaining popularity due to its dark channel statistics of outdoor haze-free photos. However, there are two issues with the plan put forward: the high cost of computing the transmission map using soft mapping and the overexposure of ambient light when a bright location is visible in photos. This study suggests a brand-new dehazing method with a dark channel and a light channel, with the light channel serving as a sort of statistics for photographs taken outdoors in haze. Additionally, the guided filter is utilized in this research to enhance both the light and dark channels. The suggested dehazing algorithm's (PDA) goal is to reduce or eliminate these issues in [7]. Several examples are provided in this work to demonstrate the PDA and contrast it with the DCP system. The findings indicate that the PDA is about 25 times faster than the DCP due to the average avoidance of soft matting and the superior visual quality of the PDA without overexposure issues. With these upgrades, the suggested technique can be used for remote sensing, intelligent transportation systems, and video monitoring.**

***Keywords**:* Dehaze, dark channel prior, light channel prior, image restoration, guided filter.

I. INTRODUCTION

Bad weather, such as fog and haze, can drastically affect images of outdoor situations [7]. As a result of the countless air particulates that scatter and absorb atmospheric aerosols, this has happened. Image dehazing is a useful technique for boosting contrast, enhancing the visual impact, and removing the negative effects of adverse weather on the image quality. For dehazing or removing haze from a single image, numerous approaches based on the atmospheric scattering model (ASM) have recently been reported. It is difficult to accurately and effectively estimate the ASM parameters, such as the atmospheric light and transmission map.

To lessen or eliminate the undesirable effect from captured photographs and restore the true textures and colours of natural scenes, use image haze removal software. Single scale retinex (SSR) and multi-scale retinex (MSR) algorithms based on human perception and Gaussian Blur were proposed by Rahman [11, 14], This approach was dropped for image hazy removal because it uses a lot of floating-point calculations and leaves the hazy image looking quite noisy after dehazing, Narasimhan [12] proposed a dehazing technique that is computationally efficient and incorporates the unknown depth information. Multiple images or other information are required to estimate the unknown depth information. The single image algorithms have been researched to address the flaw [2, 7, 16]. Stronger priors or assumptions have advanced significantly. [2] Fattal calculated the scene's albedo and deduced the medium transmission. However, this method struggles with photos that are heavily hazy and may fail, demonstrating that the assumption is incorrect. According to Tan's observation, a haze-free image must have more contrast than the hazy input image. Tan then removes haze by maximising the local contrast of the restored image. Tan's algorithm unfortunately frequently overstretches contrast and creates halo effects. Dr. He [7] and his team presented a well-liked method for removing single picture haze that is based on DCP. However, when a bright area is visible in photographs utilising the DCP-based approach, ambient light is overexposed and the cost of computing the transmission map using soft mapping is considerable. Numerous DCP-based algorithms have been developed in recent years, including the system. In research, a guided filter is put forth that has the appealing quality of edge preserving smoothing, can be computed quickly, and has an algorithm with non-approximate linear time. Due to its ability to transmit the guiding image's structural information to the filtering output, new filtering applications including dehazing and guided feathering, it is introduced by many dehazing algorithms.

This research proposes a brand-new haze reduction technique based on Dr. He's DCP scheme. We suggest a novel light channel prior for removing haze from a single image that is similar to DCP. The light channel prior is based on data from hazy photographs taken outside. We discover that some pixels, referred to as light pixels, frequently exhibit extremely high intensities in at least one colour (R, G, B) channel in the majority of the local regions. In his paper, Dr. He identifies some pixels (referred to as dark pixels) that are often very dim in at least one colour (R, G, B) channel in the majority of the local regions that do not cover the sky. The atmospheric light image (also known as global atmospheric light) is estimated by Dr. He, not the atmospheric light in each individual pixel. We believe that air light in hazy photos is mostly responsible for the intensity of these light pixels in that channel. As a result, using these light pixels, we can estimate the atmospheric light image properly. We can estimate the haze transmission by Dr. He's dark pixels and our atmospheric light image by combining Dr. He's DCP technique. After that, by fusing Dr. He's guided filter method with the haze imaging model, we can recover a high-quality haze-free image.

II. DCP SCHEME AND GUIDED IMAGE FILTERING

Currently, the equation (1)'s model:

$$I(x) = J(x)\ t(x) + A\ (1- t(x)), \tag{1}$$

Is frequently employed to explain how a fuzzy image form. (1), where *I(x)* is the image with haze, *J(x)* is the image without haze, *t(x)* is the transmission map, and A is the ambient light i.e., the atmospheric light.

Dehazing objective is to restore *J(x)*, yet the only known condition is *I (x)*. As a result, it is first necessary to estimate *t(x)* and *A*. As a result, haze removal is more difficult. In (1), the second term *A (1- t(x))* is known as air light [6, 15], while the first term *J(x)t(x)* is known as direct attenuation [6, 15]. The term "atmospheric light" refers to light that has been scattered or diffused in the air by fog, haze, or other atmospheric phenomena. The direct attenuation characterises the scene brilliance and its degradation in the medium.

A. DCP Scheme

A noval dehazing algorithm based on the dark channel prior is suggested by Dr. He in [6]. The DCP is predicated on the idea that most non-sky regions in an outdoor haze free image contain some pixels with very low brightness in at least one colour channel. The dark channel $J^{dark}(x)$ for every given image *J* is determined by,

$$J^{\text{dark}}\,(x) = \min_{x\in\Omega(\mathrm{x})}\left(\min_{c\in(R,G,B)} J^{c}(x)\right) \tag{2}$$

Where *Ω(x)* is a local patch centred at *x* and J^c is a colour channel of *J*. When *J* is an outdoor, haze-free image, the intensity of the dark channel is often low and tends to be nil, except for the bright region:

$$J^{dark}(x) \rightarrow 0 \tag{3}$$

Combining Equation (3) and Equation (1), Dr.He derived the transmission t~ simply by the following Equation:

$$t{\sim}(x) = 1 - \min_{x\in\Omega(x)}\left(\min_{c\in(R,G,B)} \frac{I^{c}(x)}{A^{c}}\right) \tag{4}$$

To compute the transmission t~, a constant parameter ω(0<ω<1) is introduced since if the haze is completely removed, the image would appear strange:

$$t{\sim}(x) = 1 - \omega * min\left(\min_{x\in\Omega(x)} \frac{I^{c}(x)}{A^{c}}\right) \tag{5}$$

Dr. He provided a straightforward way to calculate the global atmospheric light *A* based on DCP: 1) Select the top 0.1 percent of the dark channel's brightest pixels. 2) The input image *I's* pixel with the highest intensity out of all of these is chosen as the atmosphere light. Recover the illumination of the scene using Equation (6):

$$J(x) = A + \frac{I(x)-A}{max(t(x),t_0)} \tag{6}$$

Where *t0* is a user-defined lower bound of *t(x)*, and a typical value is 0.1.

The DCP scheme's process is depicted in Fig. 1. In general, the DCP technique can produce satisfactory dehazing results. However, there are two issues with the plan: atmospheric light overexposes when a bright location is visible in photos, and computing the transmission map using soft mapping is expensive.

B. Guided Image Filtering

Dr. He suggests a brand-new explicit picture filter with broad applications in computer vision and graphics. This filter is termed the guided filter.

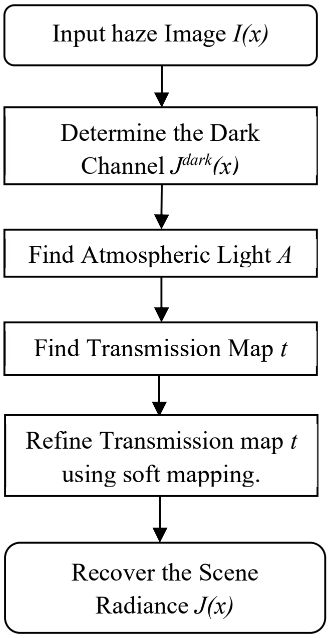

Fig. 1: Flow Chart of Dark Channel Prior

To estimate the filter output q using the guided image I and the filter input p is a straightforward concept. Naturally, it can be applied to improve the transmission t. A local linear relationship between the guidance *I* and the filter output *q* is the guided filter's main presumption. In a window centred on pixel $w_{k,\,q}$ is a linear transform of *I*

$$q_i = a_k * I_k + b_k \forall i \in \omega_k \tag{7}$$

If $(a_k,\ b_k)$ are some linear coefficients in a window of length *k* that are thought to be constant. Setting some constraint conditions from the assumptions that will be made about the linear coefficients $(a_k,\ b_k)$ can help. p input is filtered. As well as minimising the difference between q and p while retaining the linear model in Equation (7), the output q should take certain undesirable components n, such as noise or textures, from the input p. Consequently, in the window k, we should minimise the costs associated with:

$$\mathrm{E}(a_k, b_k) = \sum_{i\in\omega_k} \left((a_k * I_i + b_k - p_i)^2 + \varepsilon a_k^2\right) \tag{8}$$

Where ε is a regularization parameter penalizing large a_k. The Equation (8) is the linear regression model mentioned. And its solution is shown in Equation (9), (10):

$$a_k = \frac{\frac{1}{\mathrm{M}}\sum_{i\in\omega_k} I_i * p_i - \mu_k * \bar{p_k}}{\sigma_k^2 + \varepsilon} \tag{9}$$

$$b_k = \bar{p_k} - a_k * \mu_k \tag{10}$$

Where μ_k and are the mean and variance of I in ωk, M is the number of pixels in ω_k, p_k is the mean of p in ω_k.

$$\bar{p_k} = \frac{1}{\mathrm{M}}\sum_{i\in\omega_k} p_i \tag{11}$$

After computing (a_k, b_k) for all windows ω_k in the input image I, we can get the filter output image q:

We can rewrite equation (11) by:

$$q_i = \frac{1}{\mathrm{M}} \sum_{k|i\in\omega_k} (a_k * I_k + b_k) \tag{12}$$

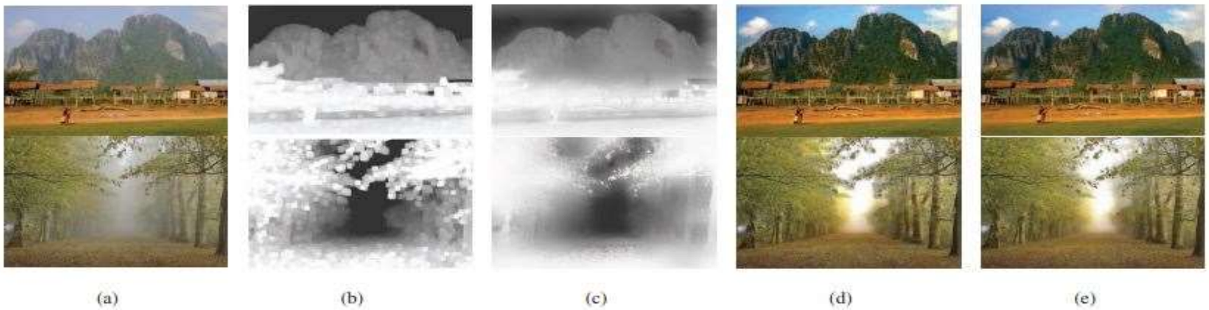

Fig. 2. Haze removal. (a) Input hazy images. (b) Estimated transmission maps before guided filtering. (c) Refined transmission maps after guided filtering. (d), (e) Recovered images using (b) and (c), respectively.

Dr. He uses up sampling and subsampling to enhance guided picture filtering. Both theory and practice demonstrate that a fast guided filter will significantly speed up processing without sacrificing filter quality. Using Equation, Fig.2b displays the expected transmission maps (12). The comparable restored images are displayed in Fig.2d.

Using Fig. 2b as the constraint; Fig. 2c displays the refined results. The recovered images that match to Fig. 2c are shown in Fig. 2e. We can observe that the block and halo effects have been somewhat muted. The transmission map successfully captures the object's shape and any fine, abrupt sharp edges.

III. PROPOSED APPROACH

Nearly all hazy removal algorithms consider atmospheric light A to be the global atmospheric light, meaning that the atmospheric light in each pixel is the same. However, as demonstrated in Fig.3, we cannot infer from the image that the ambient light in a light pixel is same to that in a dark pixel:

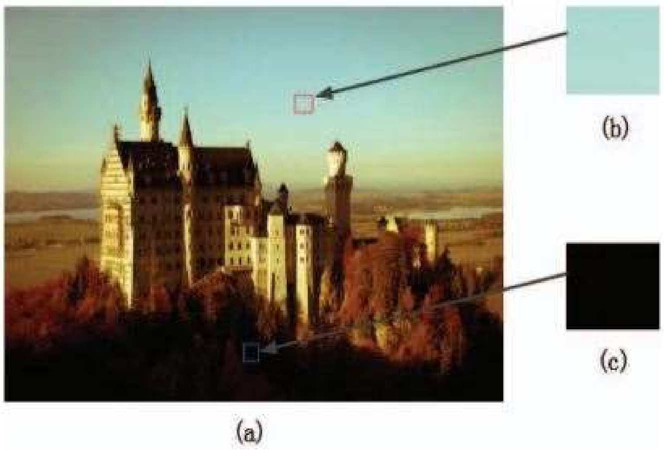

Fig. 3. The contrast of the atmospheric light at different pixel

The atmospheric light in Fig. 3 is obviously not comparable to the atmospheric light. Consequently, the atmosphere light should be recorded as an atmospheric light image (x). And the following should replace Equation (1):

$$I(x) = J(x)\, t(x) + A\,(1 - t(x)) \tag{14}$$

We suggest a novel prior-light channel prior for removing haze from a single image that is like DCP. The light channel prior is based on data from hazy photographs taken outside. The light channel prior is predicated on the notion that at least some of the pixels in the foggiest image patches have very bright intensities in at least one of the colour channels. A random image I's light channel, I_{light} (x), is displayed:

$$I^{\text{light}}(x) = \max_{x \in \Omega(x)} \left(\max_{c \in (R,G,B)} I^c(x) \right) \tag{15}$$

Where I^c is a color channel of I and Ω (x) is a local patch centered at x. In the case of light channel prior

$$J^{\text{light}}(x) \rightarrow A^{\text{light}}(x) \tag{16}$$

It indicates that given a clear image, the brightness of the light channel at pixel x tends to be equal to the brightness of the ambient light. Equation (17) is produced by combining Equation (14), Equation (15), and Equation (16):

$$\mathrm{A}(x) = \max_{x\in\Omega(\mathrm{x})}\left(\max_{c\in(R,G,B)} I^c(x)\right) \tag{17}$$

Equation (17) means that the atmospheric light of a hazy image can be estimated by its light channel image. Because there is J(x) ≤ A(x) in haze image, we need to correct the A˜ (x) calculated by Equation (18).

$$A(x) = \alpha \tilde{A}(\mathrm{x}) + \beta A_0 \tag{18}$$

Where A_0 is determined by Dr. He, and are adjustment coefficients, and + 1.0 is a restriction. Fig.5 displays multiple photos of hazy outdoor scenes along with the corresponding light channels. The dark channels of these photos are computed using a patch size of 15 * 15 and enlarged so that the width is 600 pixels. According to equation (17), the light channel picture of a hazy image can be used to estimate the ambient light. We must fix the A (x) obtained by Equation because there is J(x) A(x) in the haze image (18).

The transmission map t(x) can be recalled as follows if the ambient light refined by guided filtering is written for A (x) and the dark channel refined by guided filtering is written for $I^{\mathrm{dark\_Guided}}$:

$$\mathrm{t(x)} = 1 - \omega * \frac{I^{\mathrm{dark\_Guided}}(x)}{A(x)} \tag{19}$$

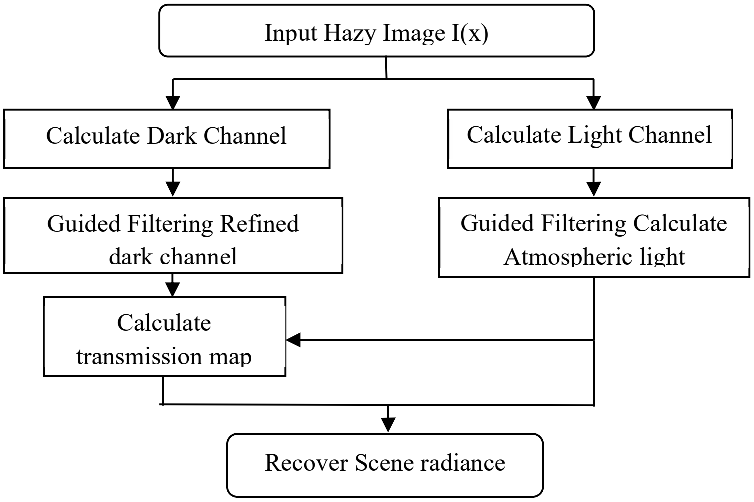

Fig4. Flow Chart of Proposed scheme

And the image will be recovered after dehazing by:

$$\mathrm{J(x)} = \mathrm{A(x)} + \frac{I(x)-A(x)}{max(t(x),t_0)} \tag{20}$$

As illustrated in Figure 5, the light channel picture of the hazy image generated using Equation (17) is more confusing and contains the same block effect as the original dark channel image. By using guided filtering to optimize the dark channel image, we can do the same for the brilliant channel.

The proposed algorithm's flow chart is shown in Fig. 4. Due to the independence of the light channel and dark channel, our method processes both simultaneously before generating the transmission map. Additionally, by doing it this manner, we considerably save some time. The results of Fig.5 are further refined in Fig.6. As we can see, the halo and block effects are reduced, and each pixel has a unique atmospheric light.

IV EXPERIMENT RESULT

In our studies, van Herk's fast approach, whose complexity is linear to the image size, is used to compute the minimal filter and the maximum filter. For quick guided filtering that will save additional time, we employ subsampling and up sampling. Figure 7 displays the transmission map, the atmospheric light image, the hazy image, the results of our approach, Dr. He's result, and Rahman's MSR algorithm. Although Dr. He's result is superior to Rahman's, it is obvious that our approach has a good effect on the hazy removal and does not need to take the effect of the brighter region into consideration. Using Dr. He's method as a comparison, we can see that our dehazing result is superior to his in the visual sensor. The ambient light is primarily responsible for this since it is an image made up of several values rather than a single value.

Fig.5.The Light channel of hazy image. From up to down is: (a) Outdoor hazy images. (b) The light channel

Fig.6. The atmospheric light image

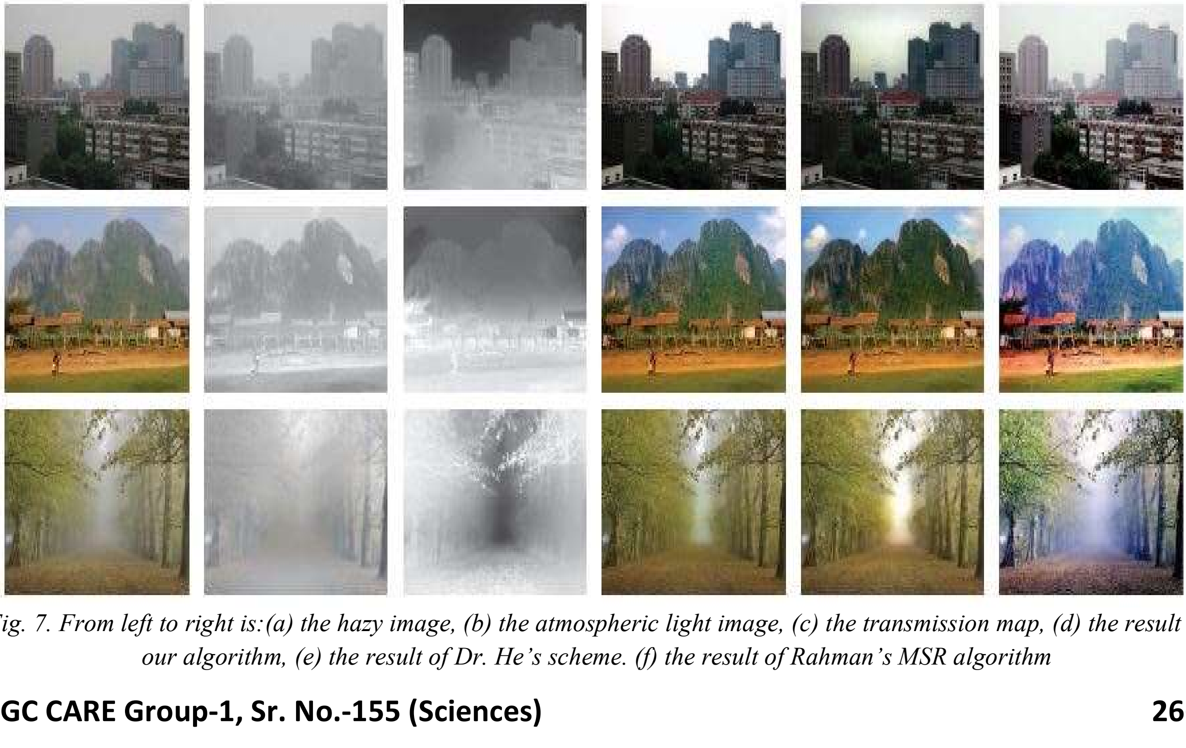

Fig. 7. From left to right is:(a) the hazy image, (b) the atmospheric light image, (c) the transmission map, (d) the result of our algorithm, (e) the result of Dr. He's scheme. (f) the result of Rahman's MSR algorithm

V CONCLUSION

In this study, we propose the light channel prior based on dark channel prior, a novel and potent prior for single image haze removal. The light channel prior is based on data from hazy photographs taken outside. We propose a novel idea: the atmospheric light is an image of the atmospheric light. Single image haze removal becomes easier and more efficient when the light channel prior, our novel atmospheric light image, and Dr. He's dark channel prior are combined with the haze imaging model. Because bright channel and dark channel are both forms of fuzzy estimate, guided filtering is used to accurately tune both. According to experimental findings, the suggested method can remove haze effectively and restore images accurately. The proposed approach can be improved and used for remote sensing, intelligent traffic systems, and video surveillance.

REFERENCES

[1] Norman Richard Draper, Harry Smith, and Elizabeth Pownell. Applied regression analysis, volume 3. Wiley New York, 1966.
[2] Raanan Fattal. Single image dehazing. In ACM transactions on graphics (TOG), volume 27, page 72. ACM, 2008.
[3] Jerome Friedman, Trevor Hastie, and Robert Tibshirani. The elements of statistical learning, volume 1. Springer series in statistics Springer, Berlin, 2001.
[4] G. Nagaraju, Dr. P. V. Ramaraju, A.Nandini, G.P.P.S. Viswanadh Varma, K.P.M. Mounika, Md.Akram Baig, Segmentation of MRI Image for the Detection of Brain Tumour, International Journal of Electrical and Electronics Research, volume 3, Issue 2, 2015.
[5] Kaiming He and Jian Sun. Fast guided filter. arXiv preprint arXiv:1505.00996, 2015.
[6] Kaiming He, Jian Sun, and Xiaoou Tang. Guided image filtering. In Computer Vision–ECCV 2010, pages 1–14. Springer, 2010.
[7] Kaiming He, Jian Sun, and Xiaoou Tang. Single image haze removal using dark channel prior. Pattern Analysis and Machine Intelligence, IEEE Transactions on, 33(12):2341–2353, 2011.
[8] G. Naga Raju, Dr.P V Rama Raju, Ch.Ramya Priya, G.Padmini Devi, I.Ajay Kanth, A.H.V.Kiran Kumar, Analysis of Deforestation images f a region by colour image segmentation .International Journal for Innovative Engineering and Management Research, Volume 7, issue 5, 2018.
[9] Cheng-Hsiung Hsieh, Yu-Sheng Lin, and Chih-Hui Chang. Haze removal without transmission map refinement based on dual dark channels. In Machine Learning and Cybernetics (ICMLC), 2014 International Conference on, volume 2, pages 512–516. IEEE, 2014.
[10] Kaiming He, Jian Sun, and Xiaoou Tang. Guided image filtering. Pattern Analysis and Machine Intelligence, IEEE Transactions on, 35(6):1397–1409, 2013.
[11] Daniel J Jobson, Zia-ur Rahman, and Glenn A Woodell. A multiscale retinex for bridging the gap. between color images and the human observation of scenes. Image Processing, IEEE Transactions on, 6(7):965–976, 1997.
[12] Srinivasa G Narasimhan and Shree K Nayar. Vision and the atmosphere. International Journal of Computer Vision, 48(3):233–254, 2002.
[13] Soo-Chang Pei and Tzu-Yen Lee. Effective image haze removal using dark channel prior and post-processing. In Circuits and Systems (ISCAS), 2012 IEEE International Symposium on, pages 2777–2780. IEEE, 2012.
[14] Zia-ur Rahman, Daniel J Jobson, and Glenn A Woodell. Multiscale retinex for color image enhancement. In Image Processing, 1996. Proceedings., International Conference on, volume 3, pages 1003–1006. IEEE, 1996.
[15] Yingchao Song, Haibo Luo, Bing Hui, and Zheng Chang. An improved image dehazing and enhancing method using dark channel prior. In Control and Decision Conference (CCDC), 2015 27th Chinese, pages 5840–5845. IEEE, 2015.
[16] Robby T Tan. Visibility in bad weather from a single image. In Computer Vision and Pattern Recognition, 2008. CVPR 2008. IEEE Conference on, pages 1–8. IEEE, 2008.
[17] Ehsan Ullah, R Nawaz, and Jamshed Iqbal. Single image haze removal using improved dark channel prior. In Modelling, Identification & Control (ICMIC), 2013 Proceedings of International Conference on, pages 245–248. IEEE, 2013.
[18] Dr. P V Rama Raju, G. Naga Raju, B. Bhavya Saisri, Ch. Midhun Kumar, D. Siva Sankar, D. Anji Nayak, Oral Cancer Detection by Image Processing Using MATLAB, International Journal of Future Generation Communication and Networking, Volume 13, 2020.