Al-Furat Journal of Innovations in Electronics and Computer Engineering (FJIECE)
ISSN -2708-3985

Image Haze Removal Via Thresholding Method

Essam Haider Majeed [1*]

[1*] Al-Furat Al-Awsat Technical University, Higher Institute for Nanotechnology, Iraq, E-mail: essam.mageed.cku@atu.edu.iq

Article's Information

Received: 02.9.2026
Accepted: 17.10.2026
Published: 3.11.2026

Keywords:
Haze Image
DeHaze Image
Otsu's method
Dark Channel
Transmission map

Abstract

For many image processing and computer vision researchers, removing image haze is a significant difficulty. In order to eliminate haze from the images, this study suggests a novel technique that mainly uses a type filter (Otsu). The basic idea underlying Otsu thresholding is to test various threshold (T) values, calculate the between – class variance for each value, and then select the value that yields the highest between – class variance. Using edgeThreshold of 0.2, which indicates the lowest intensity amplitude of strong edges to preserve, Edge-aware local contrast adjustment is used. Images with fog (haze) were used to test this improvement, and the findings were found to be improved. The core of the proposed method is the Otsu but the presence of anisotropic diffusion filter serves to improve image quality because it renders uniform areas smoother and clearer.

https://doi.org/10.46649/fjiece.v5.2.5a.3.11.2026
*Corresponding author: essam.majeed.cku@atu.edu.iq

1. INTRODUCTION

The presence of aerosols, fog, smoke, dust, and water droplets in the environment can cause image haze, a typical meteorological phenomenon that lowers the clarity of outdoor photos. Reduced visibility, low contrast, color distortion, and loss of detail are the results of these particles' scattering and absorption of light as it travels from scene objects to the camera. Both visual perception and the functionality of computer vision systems used in real-world settings are greatly impacted by haze [1].

In general, atmospheric scattering theory explains how haze forms. Scattered light known as airlight is introduced by atmospheric particles during image acquisition, whereas light reflected from scene objects is attenuated. Distant things appear faded and less discernible as a result of the combined effect. Atmospheric scattering is a key element in algorithms for removing haze from rel world images [2].

Researchers have developed image restoration mathods that rely primirly on manual amd preestablished data to avoid the draw back of traditional enhancement techniques. These methods adress atmospheric effects on image by leveraging prior information such as the dark channel , color attenuation, and non local data, while they may not always provide an ideal solution , they are considered satisfactory[3].

Removing haze from real-world images poses a significant technological challenge despite the existence of methods that approach perfection, primarily due to the difficulty of handing tje non uniform distribution of haze , which is influenced by factors such as lighting and atmospheric conditions. These methods encounter difficulities when trained on syhnthetic dada and subsequently tested on real world data [4].

Without delving into the details of fogforms, images enhancements techniques such as gamma corretion and histogram based methods can assist in the fog reemoval process. However, in some instance, these methods cause color distortion and fail to restore the scenns vibrancy [5].

2.RELATED WORK

A single-image dehazing method has been proposed that integrates the dark channel and the bright channel. This method has yielded effecrive results particulary for images containing sky regions by isolating the sky area from other regions and subsequently estimating the atmospheric light the key element in this process [6].

A method based on ectended dark channel wich relies on calculating expected dark channel values rather than indivisual pixel values to create en extended representation, reduce the apperance of distortion (unwated atrifacts) and enhance haze removal effiecincy [7].

A hybrid model is proposed that integrates the Dark Channel Prior with [DCP] using a genetic-based, adaptive algorithm designed to facilitate the transmission map calculation; this model addresses the issue of images characterized by extensive dark regions [8].

Using light and dark values to remove haze from images by accurately estimating transmission map through the combination of known charactristics of light and darkness [9].

A new proposal utilize the dark channel within a self supervised dehazing network , moving a way from reliance on pretrained or traditional dark channel methods alone. This model eliminates the need for paired training data , as it employs the dark channel solely to estimate atmospheric illumination [10].

A new approach based on featues ectraction using Generative Transformer Model (GTM) and guided transmission map, in regions of dense haze the transmission map facilitates the recovery of image visibility for optimal restoration [11].

A new infrared based framework enhance the transmission maps by utilizing edges and conrast derived from thermal images, this method improve the ccurecacy of trasmission estimation in mages with dense fog [12].

An enhanced dark channel filtering method was employed by calculating atmospheric light values, when compared with conventional methods , the rsult demonstrated improvement in signal ratio and structural similarity [13].

The saturation line based dehazing technique operates by determining and utlizing pixel values, this method been shown to improve the dehazing process while preserving image detail [14].

A poeposed algorithm based on dark channel , haze scattering, and key region segmentation operating in conjuction to reduce color distortion in image and improve the estimation of he haze scattering coeffieint in the region [15].

3. HAZE MODEL

The atmospheric scattering model develop by Koschmieder's law for the field of atmospheric optics is the most widely used version, it illustrate how light is scattered and attenuated as it passes throgh a foggy medium. The model looks like this:

Al-Furat Journal of Innovations in Electronics and Computer Engineering (FJIECE)
ISSN -2708-3985

$$I_x = J_x \cdot t_x + (1 - t_x) \cdot A \qquad (1)$$

This formula indicates that two physical components constitute the observed hazy image. Direct transmission is represented by the first term, $J_x \ and \ t_x$, indicating that the medium attenuates yet partially preserves the radiance of the actual scene, J(x). Airlight the diffuse ambient light that casts a white veil over the image is represented by the second term, A(1−t(x)). Also, $t_x \in [0, 1]$ is the transmission of the light reflected by the object. Since the light traveling a longer distance is more attenuated, we have

$$t_x = e^{-\beta d_x} \qquad (2)$$

Where $J_x \ and \ t_x$, denote the original color and the observed color at pixel position x, A is the airlight that represents the ambient light in the atmosphere. and β is the air scattering coefficient and d_x is the scene depth from the camera. Thus, the reflected object color J_x is attenuated by t_x, whereas the air light A is weighted by $(1-t_x)$ and plays a more important role if the object is farther from the camera [16].

He et al. (2009, 2011) made a significant contribution to practical picture dehazing with the Dark Channel Prior (DCP) technique. They noted that at least one color channel in a local area had extremely low intensity (near zero) in the majority of haze-free outdoor photos. They retrieved the clear picture by using this assumption to estimate the atmospheric light and transmission map from a single photograph [17].

Fattal (2008) is another significant study that use color-line statistics to distinguish haze from structure under the assumption that transmission and surface shading are locally uncorrelated [18].

4. METHODOLOGY

In this paper, a new method is proposed to remove haze from the image using the following steps:

4.1 Filtering Images (ADF).
4.2 Otsu's approach for multilevel image thresholds.
4.3 Determine the dark channel.
4.4 Calculating the values of transmission map.
4.5 Restoring a de-hazed image
4.6 Making the local contrast better.

To explain the proposed method, use the image in (Fig. 1) to implement all the previous steps on it.



Fig. 2. An image with Haze

ATU-FJIECE, Volume: 5, Issue: 2, 11, 3, 2026, © 2020 FJIECE, All Rights Reserved

Al-Furat Journal of Innovations in Electronics and Computer Engineering (FJIECE)
ISSN -2708-3985

4.1 Filtering Images (ADF)

One method for improving or changing a picture's visual look is image filtering. In this step, Anisotropic Diffusion Filters (ADF) are used, which can perform better than isotropic ones in some situations, such as denoising severely damaged edges or improving coherent flow-like pictures by sealing interrupted one-dimensional structures. Smoothing with simultaneous edge-enhancing and smoothing with augmentation of coherent flow-like textures are the two distinct goals of anisotropic diffusion filtering. The smoothing outcome for applying a filter to the Red, Green, and Blue channels is displayed in (Fig. 2) [19].



Fig. 2. Image after applying Anisotropic diffusion filters.

4.2 Otsu's approach for multilevel image thresholds

Otsu's approach is a histogram-based thresholding technology that automatically selects threshold values by maximizing the distance between picture classes. While the original Otsu approach only identifies one threshold (binary segmentation), multilevel Otsu thresholding discovers several thresholds that split an image into many intensity zones [20]-[22].

4.2.1 Otsu thresholding a several levels

By identifying many thresholds that optimize the between-class variance of histogram classes, multilevel Otsu thresholding expands upon the original Otsu technique. The algorithm:

1. Calculates the histogram of the image.
2. Tests every possible combination of thresholds.
3. Computes means and class probabilities.
4. Maximizes the variation across classes.
5. Divides the picture into many intensity areas using the ideal thresholds.

4.2.2 Algorithm (Brute Force)

This algorithm displays every Multilevel Otsu thresholding requirement, including:

Input: A grayscale picture with K thresholds

Output: Ideal thresholds $t_1 , t_2 , \dots , t_K$

Step.1 Make a histogram.
Step.2 Make the histogram normal.
Step.3 Determine the global mean intensity.
Step.4 Create every feasible combination of thresholds.
Step.5 For every combination:
Step5.1 Determine the probability of each class.
Step5.2 Calculate class mean.
Step5.3 Calculate the variation between classes.

ATU-FJIECE, Volume: 5, Issue: 2, 11, 3, 2026, © 2020 FJIECE, All Rights Reserved

Al-Furat Journal of Innovations in Electronics and Computer Engineering (FJIECE)
ISSN -2708-3985

Step.6 Maintain criteria that allow for maximum volatility.
Step.7 Use those thresholds to segment the picture.

4.3 Determine the dark channel prior

This method looks at the Red, Green, and Blue intensities of every pixel in the RGB picture. For every pixel, the algorithm basically selects the smallest value from the three channels. The resultant image, referred to as the dark channel, has just the lowest intensity value from each pixel's RGB components. The mathematical definition of the dark channel as follows:

$$D(x) = \min_{c\in\{R.G.B\}}(\underset{i\in\Omega(x)}{average}(D^c(i))) \quad (3)$$

Where D is a dark channel, D^c is an intensity of color channels R, G and B in image result from step 2, x is a center of a local patch Ω(x), the size of the local patch is 5*5. Dark channel is displayed in (Fig.3) [23]



Fig. 3. Dark channel Image after Multilevel image thresholds using Otsu's method.

4.4 Calculating the Transmission value

After the multilevel thresholding process using Otsu's method produces the dark channel picture, the transmission value is calculated using the following formula:

$$D(x) = 1 - W * \min_{c\in\{R.G.B\}}(\underset{i\in\Omega(x)}{average}(\frac{D^c(i)}{A^c})) \qquad (4)$$

The value of w is application based. In our proposed method set it to 0.85 for all result appear in this paper (was selected empirically) is the weighting factor that establishes the amount of assumed haze in the image , the transmission map determines how much scene illumination reaches the camera without being dispersed by air particles. (**Fig. 4)** illustrates this.

Al-Furat Journal of Innovations in Electronics and Computer Engineering (FJIECE)
ISSN -2708-3985

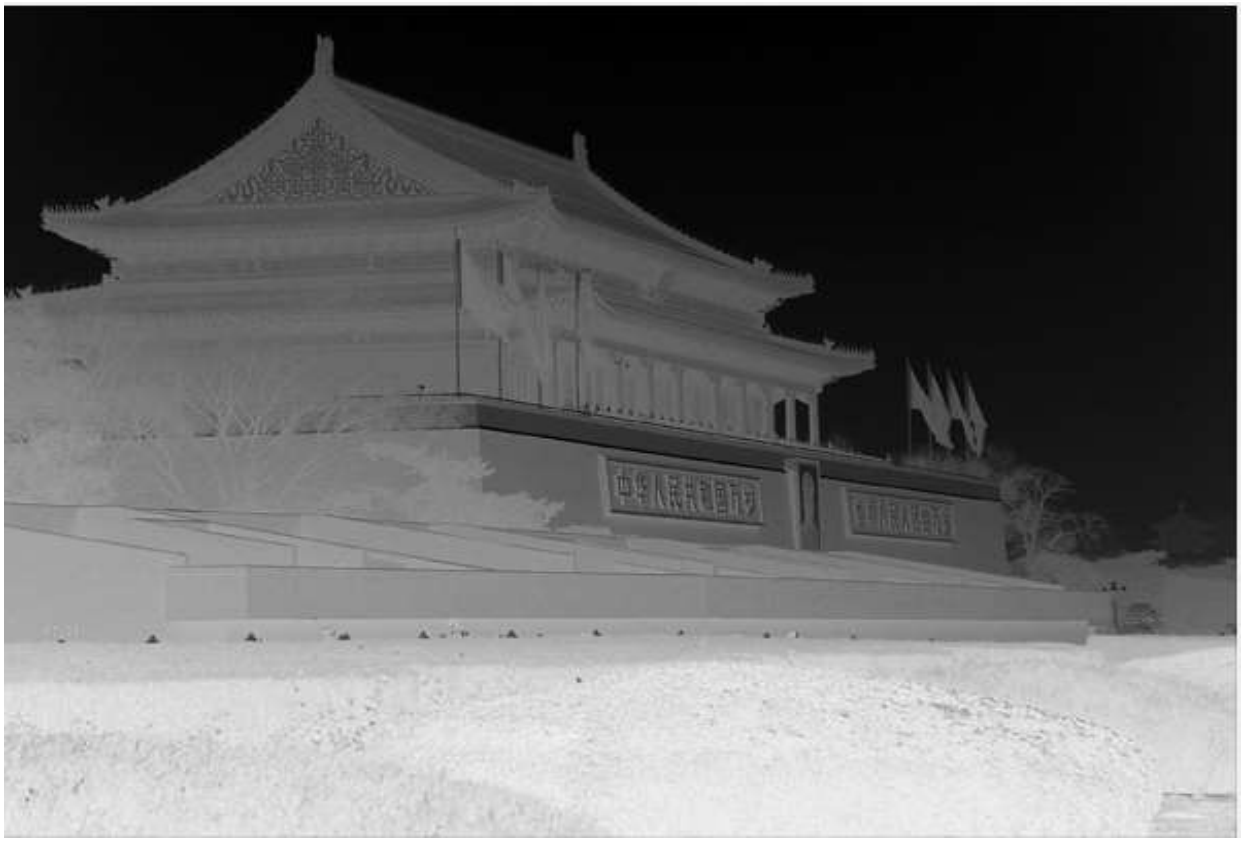


Fig. 4. The Transmission Map.

4.5 Restoring a de-hazed image

The penultimate step in the recommended process is to obtain a clear picture. This step uses the atmospheric scattering model to integrate the transmission map, atmospheric light, and hazy image to produce a haze-free image. First, a tiny constant Teps(t_0) = 0.001 is specified to prevent division by zero or extremely small transmission values that might cause numerical instability. After that, a haze-free output picture is created in double precision to allow for accurate calculation. Each RGB channel's Dehazing formula is:

$$J(x) = \frac{I(x)-A}{\max(t(x).\ t_0)} + A \qquad (5)$$

Where t_0 is the lower bound for transmission map used it to prevent dense haze regions , airlight A is removed, divided by the transmission map, and then added back. The function max (Transmission Map (t(x)), Teps(t_0)) ensures that the transmission values do not fall below the threshold to prevent excessive noise amplification in highly foggy areas, (Fig. 5) illustrates this.

Al-Furat Journal of Innovations in Electronics and Computer Engineering (FJIECE)
ISSN -2708-3985

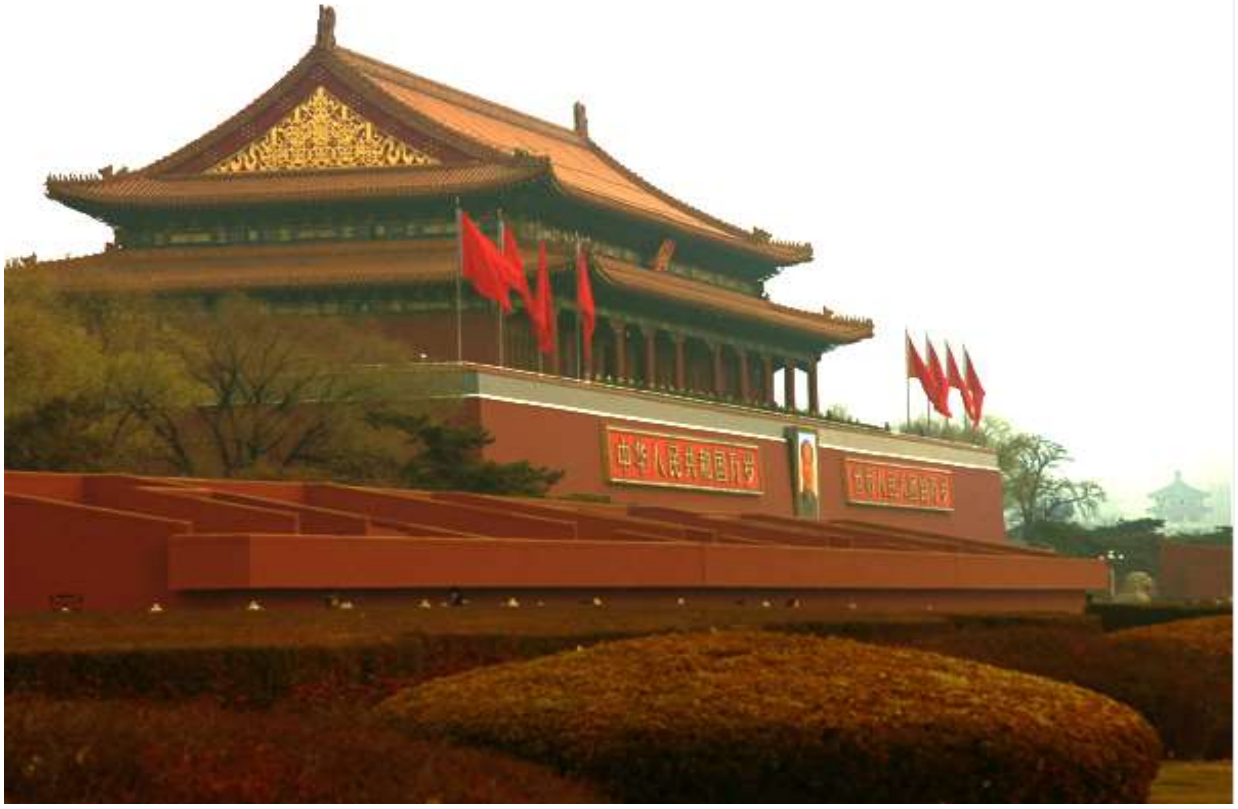


Fig. 5. The Recover image (With Out Haze).

4.6 Making the local contrast better

Additionally, an additional step known as contrast enhancement is necessary if the source image is very hazed. By removing the foggy density, this enhances the output. is the same as giving an input picture (result from previous step) a local contrast enhancement operator. The following is a mathematical expression for the idea of local contrast enhancement:

$$C(x\,.\,y\,) = \frac{b(x.y) - \mu_w(x.y)}{\sigma_w(x.y) + \epsilon} \qquad (6)$$

Where b(x,y) is the initial image intensity at pixel (x,y), $\mu_w(x.y)$is the local mean intensity calculated across a neighbourhood window around (x,y), $\sigma_w(x.y)$is the local standard deviation in that same window , and ϵ is a tiny constant to prevent division by zero.

In the function notation:

$$\text{R=local contrast(J(x), } k_1,k_2) \qquad (7)$$

The parameters $k_1 = 0.2. k_2 = 0.2$ usually serve as scaling or strength controls, controlling the degree to which the local mean and local variance affect the normalization process by weighting the contribution of μ_w and σ_w , $J(x)$ from equation(5), and (Fig. 6) illustrates this.

Al-Furat Journal of Innovations in Electronics and Computer Engineering (FJIECE)
ISSN -2708-3985

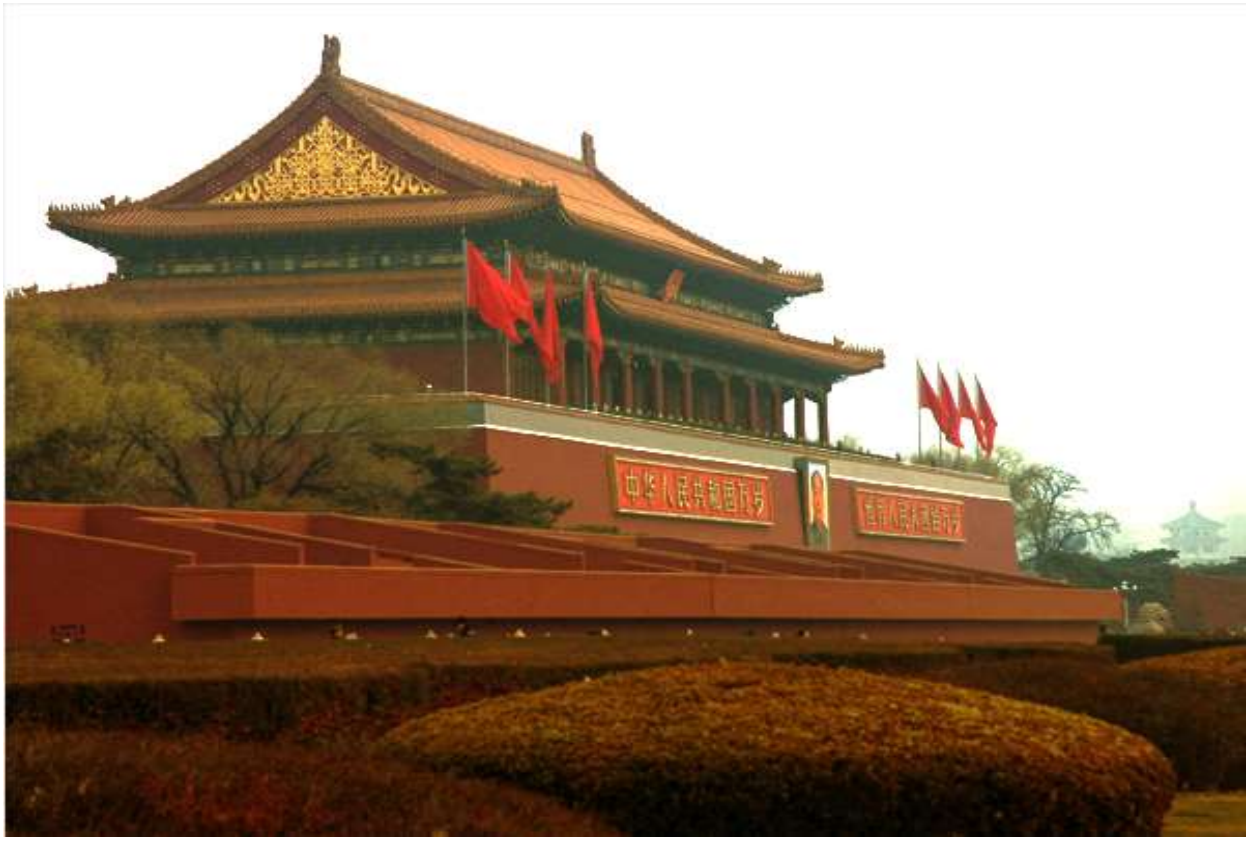


Fig. 6. The Recover Image after enhancement the Contrast.

5. The result

Two main themes will be covered in this section of the paper: first, how the performance of the recommended technique may be measured, and second, the results obtained from the presentation of the first part.

5.1 Image Quality Metrics (IQM)

In this section, we will cover all methods for measuring image quality, including blind approaches [24] (e , σ ,r)

1. **e-Descriptor:** This indicates the number of edges that can be identified following Dehazing.
2. **r_ Describer:** This is quite similar to E-Descriptor in principle, but it concentrates on improving contrast through changes in edge visibility.
3. **σ_ Descriptor:** After Dehazing, it counts the number of pixels that reach full saturation (0 or 255).
4. **Contrast to Noise Ratio (CNR):** This measure is frequently used to assess how well a picture maintains meaningful contrast in relation to noise, particularly in enhancement tasks like Dehazing [25].

Al-Furat Journal of Innovations in Electronics and Computer Engineering (FJIECE)
ISSN -2708-3985

5.2 The Proposed Method Result

This section will detail the results of applying the Image Quality Metrics (IQM) to the images from which the hazing was removed, (Table 1) presents these findings. Finally, the proposed method was used to 12 images that were deemed to be among the hardest to eliminate haze. The next figures (depict the haze and the ensuing picture without hazing. These images are extremely well-known in papers dealing with haze removal. The best CNR value is 140.81, because a higher contrast-to-noise ratio generally indicates better contrast and lower relative noise. The proposed method was compared with earlier, traditional methods for the following reason, the proposed method operates within the framework of traditional techniques rather than deep learning or machine learning, therefore the comparison had to be conducted within the same category.

Table 2. Comparing The Proposed Method with Other De-Hazing Method by Using the Quality Measurements.

IQM / Methods	E-Descriptor	σ_ Descriptor	r_ Describer	CNR
	Maximum	**Minimum**	**Maximum**	**Minimum**
[26]	-0.092431605	0	1.158966796	54.41668
[23]	-0.017266118	0.673232323	1.18807771	62.89127
[18]	0.079988425	0.032323232	2.01237241	81.00537
[27]	0.0408713	0.088383838	2.350912329	108.8879
[19]	0.047349193	0.214141414	2.72991737	120.4646
[28]	0.077154949	0.452525253	1.321442097	74.06283
[29]	0.087632782	0.456060606	1.969242627	89.53748
The proposed method	**0.1147**	**0**	**5.2880366104**	**140.81**

ATU-FJIECE, Volume: 5, Issue: 2, 11, 3, 2026, © 2020 FJIECE, All Rights Reserved

Al-Furat Journal of Innovations in Electronics and Computer Engineering (FJIECE)
ISSN -2708-3985



Fig. 7. The Recover Image for critical images (left image : haze image , and the right image : image without haze) for first six images.



Fig. 8. The Recover Image for critical images (left image : haze image , and the right image : image without haze) for second six images.

6. CONCLUSIONS

We present a new method for removing image haze in this paper. The application of a filter type that has never been employed to eliminate haze is the contribution of this work. The trial results were quite promising based on performance metrics for existing haze reduction methods. The proposed technique performed more efficiently than other methods in a number of cases. One of the most significant developments in this article is the removal of thick haze. The proposed filter was adopted as a unique strategy when it was found to be very successful in removing (haze) through testing and implementation, despite the fact that it is believed to be fairly simple in computer image and vision processing.

REFERENCES

[1] G. Li et al., "Delving Deeper Into Image Dehazing: A Survey," IEEE Access, vol. 11, pp. 131759–131774, 2023.
[2] X. Qin, Z. Wang, and Y. Li, "Atmospheric Scattering Models for Image Restoration: Recent Advances and Challenges," IEEE Access, 2023.
[3] J. Gui et al., "A Comprehensive Review of Image Dehazing Models and Methods," IEEE Transactions on Neural Networks and Learning Systems, 2023.
[4] L. Wang et al., "Real-World Image Dehazing: Challenges, Datasets, and Evaluation," IEEE Access, 2024.
[5] M. Akram et al., "Recent Advances in Image Dehazing: Formal Analysis to Automated Approaches," Information Fusion, vol. 101, 2024.
[6] Li, C., et al., "Single-Image Dehazing Based on Improved Bright Channel Prior and Dark Channel Prior," Electronics, vol. 12, no. 2, 2023.
[7] Saha, S. et al., "Single Image Dehazing Using Extended Local Dark Channel Prior," Image and Vision Computing, vol. 136, 2023.
[8] Wu, L. et al., "Hybrid Dark Channel Prior for Image Dehazing Based on Transmittance Estimation by Variant Genetic Algorithm," Applied Sciences, 2023.
[9] Ning, J. et al., "Single Remote Sensing Image Dehazing Using Robust Light-Dark Prior," Remote Sensing, vol. 15, 2023.
[10] Xiao, X. et al., "Self-supervised Zero-shot Dehazing Network Based on Dark Channel Prior," Frontiers of Optoelectronics, 2023.
[11] Li, H. et al., "GTMNet: A Vision Transformer with Guided Transmission Map for Single Remote Sensing Image Dehazing," Scientific Reports, 2023.
[12] Xie, J., and Jin, X., "Thermal Infrared Guided Color Image Dehazing," IEEE ICIP 2023.
[13] Wang, X. et al., "Optimization Research on Single Image Dehazing Algorithm Based on Improved Dark Channel Prior," Artificial Intelligence and Machine Learning Review, 2023.
[14] Ling, P. et al., "Single Image Dehazing Using Saturation Line Prior," IEEE Transactions on Image Processing, vol. 32, pp. 3238–3253, 2023.
[15] Cui, G. et al., "Image Dehazing Algorithm Based on Optimized Dark Channel and Haze-Line Priors of Adaptive Sky Segmentation," Journal of the Optical Society of America A, vol. 40, no. 6, pp. 1165–1182, 2023.
[16] Jin-Hwan Kim, Jae-Young Sim, Chang-Su Kim, "Single image dehazing based on contrast enhancement", Acoustics, Speech and Signal Processing (ICASSP), 2011 IEEE International Conference on, DOI:10.1109/ICASSP.2011.5946643.
[17] He, K., Sun, J., & Tang, X. (2009). Single image haze removal using dark channel prior. In 2009 IEEE Conference on Computer Vision and Pattern Recognition (pp. 1956–1963). IEEE. He, K., Sun, J., &

Tang, X. (2011). Single image haze removal using dark channel prior. IEEE Transactions on Pattern Analysis and Machine Intelligence, 33(12), 2341–2353.

[18] Fattal, R. (2014). "Dehazing using color-lines". ACM Transactions on Graphics, 34(1), Article 13, 1–14.

[19] Hajiaboli, M. R. (2011). An anisotropic fourth-order diffusion filter for image noise removal. International Journal of Computer Vision, 92, 177–191.

[20] Otsu, N., "A Threshold Selection Method from Gray-Level Histograms," *IEEE Transactions on Systems, Man, and Cybernetics*, Vol. 9, No. 1, 1979, pp. 62-66.

[21] P. S. Liao, T. S. Chen, and P. C. Chung, "A Fast Algorithm for Multilevel Thresholding," Journal of Information Science and Engineering, vol. 17, no. 5, pp. 713–727, 2001.

[22] E. H. Houssein, G. M. Mohamed, I. A. Ibrahim, and Y. M. Wazery, "An Efficient Multilevel Image Thresholding Method Based on Improved Heap-Based Optimizer," Scientific Reports, vol. 13, Art. no. 9094, 2023, doi: 10.1038/s41598-023-36066-8.

[23] Cai B, Xu X, Jia K, Qing C, Tao D. DehazeNet: An end-to-end system for single image haze removal. IEEE Trans Image Process, Volume. 25, Issue 11, 2016, PP 5187-5198.

[24] Hautire, N. and Tarel, J.-P. and Aubert, D. and Dumont E. "Blind Contrast Enhancement Assessment By Gradient Ratioing At Visible Edges". Image Analysis & Stereology, Volume 27 , Issue 2,pp . 87–95, 2008.

[25] M. Welvaert, Y. Rosseel, and E. Yacoub, "On the Definition of Signal-To-Noise Ratio and Contrast-To-Noise Ratio for fMRI Data," PLOS ONE, vol. 8, no. 11, e77089, 2013, doi: 10.1371/journal.pone.0077089.

[26] Gu Z, Ju M, Zhang D. A Single Image Dehazing Method Using Average Saturation Prior. Hindawi , Mathematical Problems in Engineering , 2017, pp 1–17.

[27] Codruta O. Ancuti, Cosmin Ancuti, Chris Hermans, Philippe Bekaert, "A Fast Semi-inverse Approach to Detect and Remove the Haze from a Single Image", Asian Conference on Computer Vision: Computer Vision – ACCV 2010 pp 501- 514, DOI: 10.1007/978-3-642-19309-5_39.

[28] Jean-Philippe Tarel, Nicolas Hautière, "Fast visibility restoration from a single color or gray level image", Computer Vision, 2009 IEEE 12th International Conference on, DOI: 10.1109/ICCV.2009.5459251.

[29] Kristofor B. Gibson, Truong Q. Nguyen, "Fast single image fog removal using the adaptive Wiener filter", Image Processing (ICIP), 2013 20th IEEE International Conference on, DOI: 10.1109/ICIP.2013.6738147.

ATU-FJIECE, Volume: 5, Issue: 2, 11, 3, 2026, © 2020 FJIECE, All Rights Reserved