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A Survey on Improved Dehazing System for Underwater Night Light Fog Images Using Machine Learning Algorithm

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ABSTRACT

The absorption of light in water and scattering leads to degradation of images captured at night under the water. This degradation causes low brightness, diminished colour, and distinguishable objects in the image affected by the night light. Many researchers worked to improve the images under water during day light using contrast stretching and white balance method. Majority of investigation had done using white balance to reduce greenish effect due to absorption of higher wavelength, which is reduced when propagated through water, this survey presents many works like guided filter transmission used as an edge preserving smoothly operator and also "CLAHE" ("contrast limited adaptive histogram equalization") & RGB model. These methods helped to change the intensity of dehazed image and the level of contrast in the image. All these methodologies developed by the previous researchers were on dehazing of day light fog images. Hence, there is a scope for developing an improved dehazing of night light fog images.

Keywords: *Guided-Filter, Convolutional Neural Network, Dehazing, Marine, Underwater, Machine Learning, Night Light Fog*

INTRODUCTION

Many disciplines rely on underwater photography, such as environmental monitoring, underwater archaeology, and marine biology. Nevertheless, taking precise pictures underwater is still quite difficult, especially at night or when there's fog. When particles in the water scatter and absorb light, a phenomenon known as haze occurs, reducing the picture quality. Because the haze changes the colour balance and hides crucial visual information, analysing and understanding the "filmed photos" is challenge.

Due to its complicated structure, underwater fog is notoriously difficult for traditional dehazing technologies like picture enhancement algorithms and filtering approaches to manage. Underwater settings are notoriously unpredictable and dynamic, making it impossible to apply these methodologies' assumptions regarding haze homogeneity and light scattering uniformity. Therefore, these methods aren't very successful, especially in low-light conditions where haze-induced deterioration is worse.

Emerging possibilities for attempting these matters had been opened up by recent developments in machine learning. By analyzing data for intricate patterns and correlations, machine learning algorithms—and deep learning approaches in particular—have accomplished outstanding results across a range of picture processing jobs. Because of the specific features of underwater fog and light interactions, machine learning techniques may be able to surpass conventional methods in underwater picture dehazing.

Using cutting-edge machine learning methods, it is possible to get a dehazing solution that is optimized for underwater night light fog photos. To achieve improved outcomes, a "convolutional neural network" (CNN) in combination with innovative approaches for pre- and post-processing images can be used. The ultimate goal is to enhance colour accuracy and detail visibility by training our model on a huge "dataset of underwater" photographs captured in different lighting and fog situations.

RELATED WORK

The study of existing work on dehazing is an important part of developing novel methods. Following section provides the various solutions developed by many researchers.

i. Narasimhan et al. [1], in 2000 developed "chromatic frame work" for "vision in bad weather'' where the chromatic clear weather was the intended operating environment for traditional vision systems. When it comes to outdoor vision systems, nevertheless, features that ensure adequate performance in "bad weather" are vital. The effect of the atmosphere on the quantity of light that ranges a spectator is well-documented. A geometrical model for the study of atmospheric scattering's chromatic effects is presented in this work. Also shown were three easy algorithms that could restore scene structure from a single or pair of images—all without knowing the weather beforehand. As a outcome, vision systems necessity to be equipped with air scattering models to withstand severe weather conditions and also the proposed method of this paper increased the clarity and quality of images taken in bad weather.

ii. According to Atul Gujural et al. [2] in 2023 proposed "A novel defogging technique for dehazed images." Where the airlight and direct attenuation combine to form fog, which severely impairs image quality and causes several issues with tracking, navigation, and video surveillance. Consequently, several defogging techniques have been suggested in the literature for its removal from images. Both the single-image fog removal approach and the usage of several photos may accomplish defogging. In the field of defogging, Dark Channel Prior (DCP) is among the most well-known strategies. The temporal complexity of this approach is quite high, yet it effectively removes fog from photos. Not to mention the halo effect and the fact that it doesn't maintain edges. So, to get over DCP's drawback while keeping the image quality intact, this research suggests a new method. The recommended method is use in MATLAB-09, and simulation outcomes reveal that recommended approach is quite effective.

iii. According to R. Tan [3] in 2008, explored "'visibility in poor weather from a single image", says that an integral part in this approach is image dehazing. In this article, the researchers suggested a straightforward method for eliminating "haze" from a sole picture using "dark channel". The haze is an atmospheric phenomenon that occurs naturally. Beneath the sea A extensive range of "image processing" and "computer applications" now face the formidable challenge of picture dehazing. The first is that pictures taken in better weather tend to have more contrast than those taken in poor weather; second, airlight, the variation of which is mostly proportional to the distance of objects from the observer, is generally smooth, and these two facts form the basis of this technique. The outcome of this paper explains the physical model utilization which estimated the haze level.

iv. Levin et al. [4] in 2006 presented a closed-form solution for natural image matting, by deriving a cost function that enables high-quality alpha mattes with minimal user input by leveraging local color smoothness assumptions. Methods used in this paper were the alpha channel estimation and a closed-form expression which helped to separate front objects from the background in the images. As a result, these methods improved the accuracy of foreground extraction compared to existing techniques.

v. R. Fattal [5] in 2008 made strides in estimating "optical transmission" in "hazy scenes" by developing a "refined image formation model" that considers surface shading, significantly enhancing scene visibility. The methodologies used in this paper were atmospheric scattering and inverse problem approach where these techniques helped for restoring clarity of hazy image and these methods gave general applicability that can be applied to various scenes of the weather without requiring additional data. As a result these methods helped to remove haze by preserving image details and resulted in clear natural image.

vi. K. He et al. [6] in 2009 further advanced haze removal techniques using Dark Channel Prior, acknowledging that this method may falter in certain conditions, particularly when objects closely match atmospheric light. This method ensured that the output image obtained is of high resolution and also indicates the level of haziness in the image. The output resulted in clearer and natural image

vii. C. "Tomasi and R. Manduchi" [7] in 1998 introduced bilateral filtering, which effectively "smooths images" though "preserving edges", thereby enhancing color images without introducing artifacts. This method was used to remove noise from the image and provide the smooth edges. Further, these methods can also be used for real-time applications in video processing and by developing adaptive bilateral filters the parameters can be adjusted based on image data in future.

viii. Y. "Wang and B. Wu" [8] in 2010 refined the dehazing method with an improved Dark Channel method, focusing on local regions to achieve more accurate atmospheric light estimations. The main objective of this paper is to get a natural image by recovering true colors by the steps of algorithm and mathematical formulations that improved the validations. The method used in this paper can be further combined with other image enhancing methods

ix. Y. "Xiong and H. Yan" [9] in 2013 addressed the Dark Channel Prior's limitations in sky areas by integrating an improved bright channel prior for better parameter estimation. The objective in this paper was to address the limitations in sky area for parameter estimation and also to increase the accuracy of sky detection by using a bright channel prior method. As an outcome the proposed method resulted in improved accuracy in detecting sky region and also the improved parameter estimation. In future the proposed method can be used for other environmental conditions.

x. Tripathi and Mukhopadhyay [10] in 2012 proposed a fog removal algorithm utilizing anisotropic diffusion, demonstrating superior performance compared to existing methods. The main objective in this paper is to remove fog from the images that are deteriorated due the environmental conditions. The methodology used here were anisotropic diffusion and the image processing techniques like estimating atmospheric light and calculating transmission maps. The methods helped in improved visibility of images and the color accuracy gained make them more suitable for further applications. Further, this adaptive isotropic diffusion method can be used to adjust the local image characteristics taken in various weather conditions such as fogginess or rain.

xi. Y-H Shiau et al. [11] in 2013 developed a weighted haze removal method that mitigates halo artifacts and is suitable for real-time applications. The main objective is to remove haze from images that are particularly taken in aerial conditions. This also addresses the halo arti-craft and reduces the halo effect that can occur around arti-craft due to haze. As a outcome, the methods proposed in this paper improves the haze reduction particularly for arti-craft images and also minimizes the halo effects by providing the clear representations of arti-craft in hazy conditions. Further this method can be used when the image captured with landscape photography is degraded due to haze conditions and can also be useful for parameter optimization based on level of haze.

xii. Raimonda and Silvia [12] in 2010 focused on underwater image dehazing, discussing its challenges and proposing solutions using dark channel techniques in order to improve the visibility and quality of underwater images affected due to light scattering. As a result there was a successful restoration of natural colors and the fine data in the image. Further, the dehazing execution can be improved by using machine learning methods.

xiii. Praveen K. Mishra and Maitreyee Dutta [13] in 2015 tackled issues related to halo effects and transmission estimation in night conditions with an enhanced transmission procedure. The methods used here included transmission map calculations and filtering techniques. These methods helped in reducing halo effects in night time and also restoration of image clarity in low-light conditions. As a result the enhanced image quality in low light can be obtained. Further it is useful for real time processing in night time such as navigation.

xiv. Jiaho Pang et al. [14] in 2011 explored the guided filter uses to refine coarse transmission maps, achieving results comparable to state-of-the-art techniques while maintaining low computational costs. The objective of this paper is to improve the accuracy of transmission map and to ensure the fine details in the image are preserved during processing. Further this guided filter approach is used for real time applications both in imaging and video scenarios. This method can be combined with other various machine learning algorithms.

Collectively, these studies highlight a range of methods aimed at enhancing image clarity and visibility under challenging atmospheric conditions, emphasizing both theoretical advancements and practical applications.

Table 1: Survey of dehazing system

Sl.No.	Title of the paper and year	Objectives	Methodology	outcome
1.	Chromatic frame work for vision in bad weather [1] in 2000	Improve out door system visions in bad weather	Developed a chromatic frame work and atmospheric scattering models, introduced restoration algorithms	Vision systems necessity to withstand severe weather conditions.
2.	A novel defogging technique for dehazed image [2] in 2023	Address fog impact on image quality	Dark channel prior and conducted MATLAB simulations	Removes fog from images and gives a enhanced output.
3.	Visibility in bad weather from a single image [3] in 2008	Simplify haze removal from single image	Dark channel prior	The physical model utilization which estimated the haze level.
4.	A closed fdr solution for natural image matting [4] in 2006	Provide high quality image matting	Closed form solution using local colour smoothness assumption	Improved the accuracy of foreground extraction
5.	Optical transmission in hazy scenes [5] in 2008	Enhance visibility in hazy scenes	Estimated optical transmission through a refined image formation model considering surface shading.	Remove haze by preserving image details and resulted in clear natural image.
6.	Haze removal using DCP [6] in 2009	Improve single image haze removal	dark channel prior	High resolution image is produced and the level of haze is estimated.
7.	mage enhancement using bilateral filtering [7] in 1998	"Smooth images" although "preserving edges"	bilateral filtering combining spatial and photometric similarities.	Preserved edges and clear image.
8.	Dehazing method with improved DCP [8] in 2010	Enhance dehazing accuracy	dark channel prior method using local regions for atmospheric light estimation.	Natural image is obtained by retaining trye colors.
9.	DCP's limitations in sky areas by improved bright channel prior [9] in 2013	Address DCP limitations in sky regions	Combined improved bright channel prior with dark channel prior.	Improved accuracy in detecting sky region and also the improved parameter estimation.
10.	Fog removal algorithm using anisotropic diffusion [10] in 2012	To Develop an efficient fog removal algorithm	anisotropic diffusion to recover scene contrast from foggy images.	Improved visibility of images and the color accuracy.
11.	Weighted haze removal method for halo articrafts [11] in 2013	Remove haze while preventing halo effects	Employed a weighted technique for atmospheric "light" assessment and transmission refinement.	Improved haze reduction for articraft images.
12.	Underwater image dehazing [12] in 2010	Address challenges in "underwater image" dehazing	Utilized dark channel techniques to improve clarity in underwater images.	Successful restoration of natural colors and the fine details in the image.
13.	A scheme for increasing visibility of single hazy [13] in 2015	Increase visibility in hazy images at night	Enhanced transmission estimation using adaptive gamma correction to reduce halo effects.	Enhanced image quality in low light is obtained.
14.	Improved single image dehazing using guided filter [14] in 2011	Refine coarse transmission maps for better dehazing	Used guided filters to improve the performance of transmission map refinement.	Improved accuracy of transmission map.

The above table summarizes the objectives, methodologies, and potential future directions of the studies discussed.

CONCLUSION

This survey made on dehazing system of daylight images details on improvement of the foggy images at pixel level. The main focus of this survey is to understand the various methods adopted for dehazing of fog images under water. Some work encourages the single image improvement using fusion method, few work encourages the processing done using “dark channel prior” and some works using guided filter transmission. Most of the work is carried out using fusion technique, but there were few fine details of image that need to be improved. After the detail survey it is found that majority research were on day-light underwater fog images. There is much room for development of the foggy image enhancement in order to reduce computational time and work on night light fog images.

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