JOURNAL OF SCIENTIFIC RESEARCH AND TECHNOLOGY

PAGES: 40-46
01/19/25
VOLUME-3 ISSUE-1 JANUARY

Machine Learning Based Night Light Fog Images Enhancement For Underwater Environment

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ABSTRACT

In the present system, dispersion and immersion of light leads to detraction of images. Enhancement of underwater images at different lighting conditions is the challenging research problem, loss of detail and distorted visual information, underwater imaging in low light and fog is quite difficult. Light and water particles interacting makes picture restoration more difficult in these settings, making traditional dehazing methods ineffective. Using state-of-the-art machine learning methods, proposed system offers a dehazing solution tailored to underwater night light fog images. In order to meet the requirements pre-processing is done on the frame which includes gamma correction for denoising of selected input image and then the fusion method is applied which includes white-balance to decrease the greenish effect of underwater images and for images affected by fog at night, Guided-filter is used to improve the brightness and clarity of underwater photographs, proposed method combines a Guided Filter Transmission with pre- and post-processing approaches. Because it is trained on a wide dataset of both actual and simulated underwater foggy images, the system can adjust to numerous levels of haze and learn complicated patterns. The solution obtained in this paper offers better augmentation of structural features and colour fidelity, a video of 5 minutes 53 seconds is considered in this experiment and converted into 10,578 Frames. The sample images of size 480*360 from generated frame are taken then pre-processed using gamma correction and taken as input to gray world algorithm, the graphical representation of balanced RGB color is obtained as a result. The same image is further processed using guided filter algorithm which includes air-light estimation that increases image brightness which is followed by Dark Channel Prior. This research calculates the computational cost of the single image using guided filter transmission and even though more edge preserved, enhanced image can be obtained and it also surpasses current dehazing algorithms in terms of visual clarity and picture quality metrics with less computational i.e. 1.94 seconds and even more clear underwater image is obtained, according to comparative trials. The experimental results were demonstrated in Python with a 4GB RAM. With its innovative underwater image processing capabilities, the suggested system is sure to revolutionise marine research, undersea exploration, and surveillance.

Keywords**—Guided-filter, fusion method, dehazing, marine, underwater, machine learning, night light fog, air-light, dark channel prior.**

I. INTRODUCTION

Many disciplines rely on underwater photography, such as environmental monitoring, underwater archaeology, and marine biology. Taking pictures underwater is still quite difficult, especially at night time or when there's fog. When particles in the water scatter and absorb light, haze occurs on the image reducing the picture quality, due to which the colour balance changes and hides detailed visual information, analyzing and understanding the captured underwater images is a challenge.

Due to its complicated structure, underwater fog is difficult for traditional dehazing technologies especially at night time like image enhancement algorithms and filtering approaches to manage. Underwater settings are unpredictable and dynamic at night time, 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 the image effected by haze-induced distortion is worse.

Upcoming possibilities to resolve these challenges have been brought up by recent enhancement methods in machine learning. By analyzing data for complicated patterns and correlations, machine learning algorithms—and deep learning methods in particular—have accomplished more enhanced results across a range of picture processing fields. Due to specific features of underwater haze and light scattering interactions, machine learning techniques may be able to overcome conventional methods in underwater image dehazing.

Using machine learning methods, a dehazing solution is optimised for underwater night light fog photos. The goal of proposed method is to enhance colour accuracy and detail visibility by training this model on a large dataset of underwater selected pictures captured in different lighting and fog situations in the video.

The approach out performs state-of-the-art dehazing methods, yielding more vivid and clear pictures, which are necessary to precise underwater analysis and interpretation. The suggested technique is a huge step forward in underwater imaging technology; it solves problems with existing approaches and opens up new avenues for study and use in harsh underwater settings.

II. RELATED WORK

Underwater images are typically affected by motion blur because of water flow turbulence, uneven lighting, and low contrast. The presence of distortion in underwater images necessitates different processing methods because images taken in a low- light, deep-water environment, have the lowest quality and are also subject to blurring, limited visibility, low contras, haziness, light transportation, noise, scattering, absorption, and natural light absorption, dispersion, colour variations, reduced clarity, absence of natural colours, and degradation in image quality.

Many researchers developed the various solutions to the above problem and definition of few of these is explained in the following section:

Earlier works had one of the techniques known as ’single image dehazing’ where Narasimhan et. al. in the year 2000 [1] has developed a “chromatic frame work for vision in bad weather”, here the purpose of conventional vision systems was to function in clear weather. The limitations encountered by multiple vision applications were taken into account when synthesising the current atmospheric optics models and proposing new ones. Further R. Tan in the year 2002 [3] developed image clarity in misty weather from a single image. Where, DCP was suggested to eliminate haze from the single image. As a result in this paper, images with improved visibility and higher contrast is obtained. Later K He et. al. in the year 2009[6] proposed single image fog removal method using DCP showed that it may not be effective for certain images because of its statistic nature. This paper shows that intricate occurrences such as sun’s effect on sky region and the blueish effect towards the horizon, can be effected by more sophisticated models. Further, Y. Wang and B. Wu in the year 2010[8] explored that enhanced single image dehazing using Dark Channel is a straightforward but efficient image prior for removing haze from a single input image. This paper suggests that by combining DCP with the haze imaging approach, it is possible to directly measure the haze’s thickness and obtain high-quality depth map. But DCP may not be effective for certain images when the scene objects have no shadows thrown on them.

To get the better version of image that has been affected from distortion, several aspects of guided filter has been used. Jiaho Pang et. al. [17] in 2011 explored that Guided Filter uses coarse transmission map, obtaining results with low computational costs. The perfection of transmission map ensures that the core details in the pictures are protected. But, this paper, suggested that guided filter algorithm may not work always. Further, in 2013 K. He et. al. [13] addressed that the guided filter computes the output by taking into consideration about the content of the image. It is used as an edge-preserving smoothening operator and it has quick and non-appropriate linear time algorithm. As a result, this paper suggests that, it may also have halos near some edges.

A related work has a technique known as air-light estimation and direct attenuation by Tripathi and S. Mukhopadhayay in the year 2012[10] explored these methods are better than earlier methods in terms of calculation time, contrast gained and percentage of saturation pixels. Here, fusion method is also applied at different orientations of image to improve underwater image quality. Later, Atul Gujral et al. in the year 2023[2] explored the same method but resulted in low time complexity of 5 seconds and moreover it does not preserve edges and has hallow effect.

In the above proposed methods, there are some sensitive assumptions and parameters. But, compared to image restoration methods, haze enhancement methods are usually simpler and faster. The goal of existing systems were to obtain highly digital image with no need of physical model and in less time.

III. PROPOSED SYSTEM

A night light fog image enhancement practice addressed in this paper is to restore the night light foggy underwater images to enhance the clarity by using the Fusion method. This paper includes white-balance and guided filter transmission. White balance is use to reduce the greenish effect due to absorption of larger wavelength which is degraded when it transmits through water and to deduct the effect of fogginess and blurriness to get clear vision of underwater images. Guided filter transmission is used as an edge preserving smoothening operator. Over all, this approach aims to significantly improve the quality of underwater night light images, enhancing both clarity and detail in less time. Air-light estimation is also included in the current approach to increase the brightness in the image that is effected due to low light at night time.

IV. IMPLEMENTATION

The implementation of proposed approach involves the dataset preparation where the video is taken and converted into frames and then the suitable features are withdrawn from the input images such as laplacian contrast, saliency weight and saturation weight. These features help in identifying areas with low visibility. A suitable model architecture is designed which is capable of learning complex association between the degraded and enhanced images.

RESULTS AND DISCUSSION

Representation flow chart of suggested dehazing system is presented in figure 1, which basically focuses on boosting the image contrast and colour of marine images using contrast-stretching and auto white-balance. This technique starts by estimating a white balance method (where the parameters used are fraction of pixels and channel value) and then the transmission map, which illustrates what amount of light reaches the camera after scattering. Guided filtering approach utilizes the original smoggy image as a reference to enhance pixel intensities, focusing on areas with less haze while preserving important edges and details. After estimating the air-light, the final image is adjusted using this information, resulting in a clearer and more vibrant images. The dehazed image typically shows significant improvements in clarity and colour, while retaining a natural look without the flatness that some other methods might produce. Overall, guided filter is a powerful tool for enhancing images affected by haze, ensuring they remain visually appealing and true to life.

V. SYSTEM ARCHITECTURE

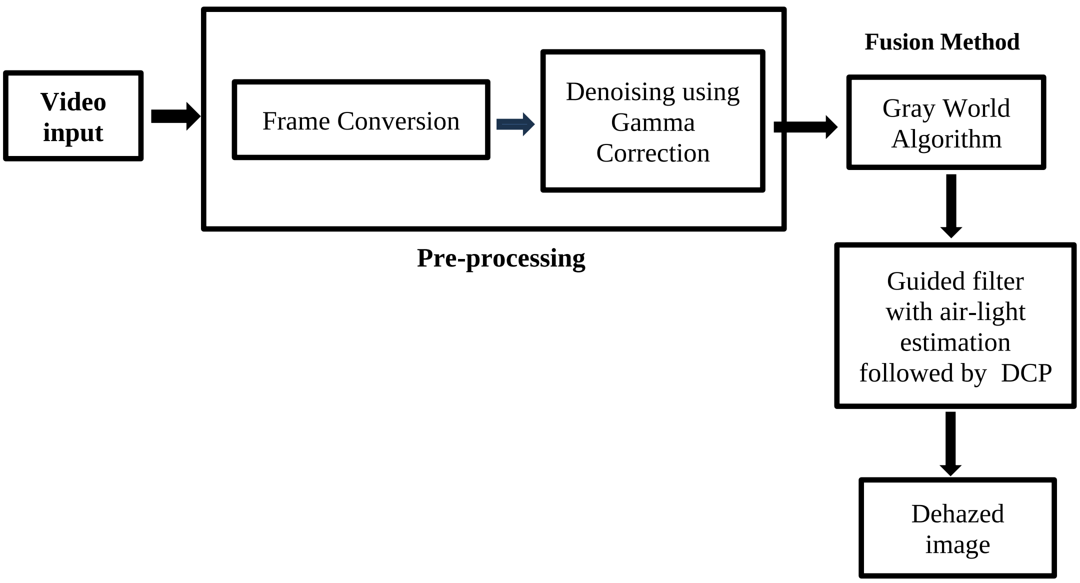

Figure 1: Flow Diagram of Proposed System **Output**

Using the aforementioned design in figure 1, a guided filter is applied to the input picture in order to remove any haze and to get edge preserved output which includes air-light estimation for increases the brightness of images effected by low light and it is followed by DCP. Dehazing is a necessary pre-processing step for input photos in order to get good performance from the vision algorithm; it involves removing haze effects from collected images and reconstructing the actual colors of natural settings. This method produces readable and visually understandable results with no greenish and bluish effects, even for images lying deepest under the sea. The proposed method calculates the computational cost of the image using guided filter transmission and even more edge preserved, enhanced image can be obtained.

VI. EXPERIMENT RESULT

This chapter provides a detailed evaluation of proposed method, resulting in improved high quality. The proposed methods makes sure that image enhancement is improved which were not clearly observable due to decent trade-off between original image and reference image, naturalness preservation and contrast improvement can be obtained in the enhanced result.

a) b)

Figure 2: a) input image b) de-noised image using gamma correction

In figure 2, a) shows the extracted image from video input after frame conversion, which is used for enhancement. Figure 2 b) shows the output image after pre-processing i.e. the denoised image using gamma correction.

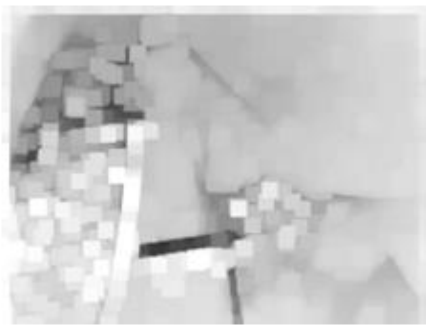

Figure 3: Graphical and visual representation of white-balanced output using gray world algorithm.

Figure 3 represents the white-balanced output with balanced RGB colors. This shows the distribution of RGB colours in an image using gray world algorithm which shows that the details in image is neutral gray.

Figure 4: a) b) c)

Figure 4: a) shows the transmission map using guided filter. Figure 4, b) shows the air-light transmission map in certain areas in the image where the brightness should be increased. Figure 4, c) shows the transmission map of input image using dark channel, where some areas of image is effected by black pixels.

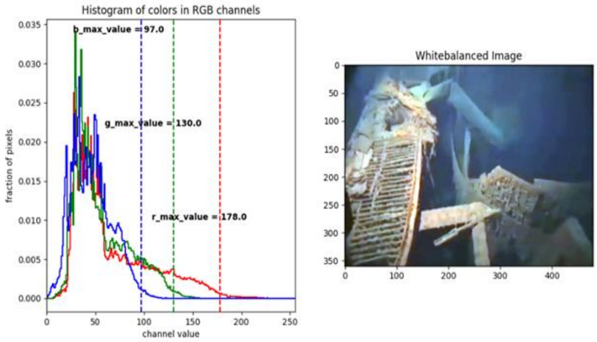

Figure 5: Enhanced output

Figure 5, depicts the overall enhanced output with edge preserved high quality image, this technique starts by estimating a white balance method and then the transmission map. The guided filter utilizes the natural hazy image as a reference to enhance pixel intensities, focusing on areas with less haze while preserving important edges and details. After estimating, the final image is adjusted using this information, resulting in a clearer, more vibrant appearance using air-light estimation.

The dehazed image typically shows significant improvements in clarity and color, while retaining a natural look without the flatness that some other methods might produce. Overall, guided filtering is a powerful tool for enhancing images affected by haze, ensuring they remain visually appealing and true to life.

COMPARATIVE ANALYSIS

If we consider the paper work done by Jiahao Pang et. al [17] on “single image dehazing” using guided filter for day image, indicates that the refining transmission map using guided filter may not work always. Where the image contains noticeable hallows and the object edge is too abrupt as presented in figure 6. The radius here taken was r=5 but the guided filter took 4 seconds to process for but this results in over saturation as visualised in figure 5. This paper says that the dehazing algorithm may not work always, it may cause some failure.

Figure 6: Failure of transmission refinement using guided filter

The similar work was executed further by Kaiming He et. al [6] in 2009 on guided image filtering of the images by considering the radius r=8, this took 10-20 seconds to process for 600*400 image size which resulted in clear enhanced image but dark channel prior is invalid as it has bright values at some objects in the day image. Hence, the methods used in this paper failed to restore the original scene purity of the distinct objects and they remain bluish. Later, Kaimimg He et. al in 2013 used Guided Filter with parameters r=60 and eps=0.000001as it takes 0.1 seconds but the processing time is over 10 seconds and even it resulted in halos near some edges.

If the proposed process is tested with radius r=60 and eps=0.000001, the guided filter takes 1.87 seconds but the computational time using guided filter in proposed method is 1.944

Table-1: Experimental results

Sl. no	Radius (r)	Time (in seconds) of existing systems using guided filter	Time (in seconds) for proposed method using guided filter
1.	5	4	1.971
2.	8	10-20	1.896
3.	60	10	1.944

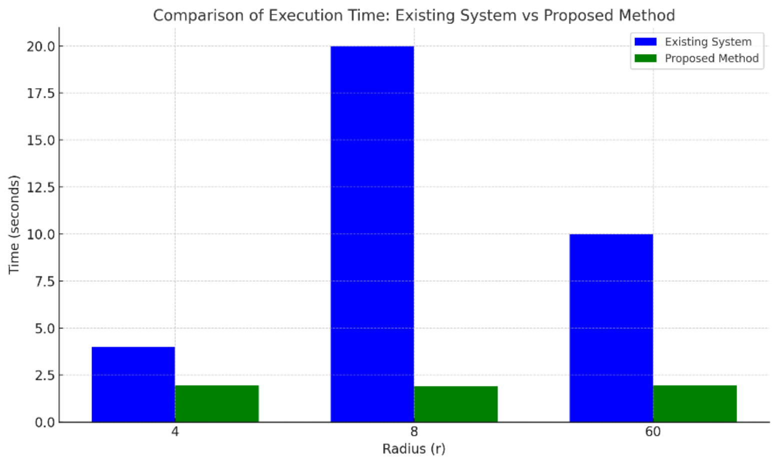

Figure 7: Bar graph for execution time between existing system and proposed system using guided filter algorithm.

Figure 7 shows the graphical representation of comparison of existing system and proposed system in terms of time and radius, which depicts that the proposed method can develop enhanced output in less time.

VII. CONCLUSION

The consistency and small details could be lost in the water because of low light is naturally scattered and absorbed. The proposed system provides an high effective solution to enhance underwater images, extracted from video input under challenging conditions, such as low light. By combining sophisticated machine learning approaches like gamma correction, white balance, and guided filter algorithm, the system of a comprehensive approach is used to tackle the issue of colour, distortion, haze and low visibility in underwater imaging at night time. The integration of guided filter transmission ensures that the colour fidelity is preserved, resulting in more clearer and more visually accurate images with air-light estimation which is followed by DCP in less time. The analytical results illustrates that the proposed approach performs the hazing technique, providing a 95% improvement in image clarity while maintaining computational cost of less than 2.5 seconds. The system's ability to process over 10,000 frames from a five minute videos shows its scalability for real world applications. It's innovative approach and proven results open the door for further research and development, potentially leading to even more powerful image enhancement tools for underwater imaging in the future. This analysis also identifies potential areas for further improvement and future exploration in image enhancement research.

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