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Implementation of Image Dehazing Method Using Multi-Scale Fusion Technique

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ABSTRACT: Haze or fog in images can significantly degrade their visual quality, obscuring important details and reducing overall clarity. In this paper, we propose an image dehazing method that utilizes a multi-scale fusion technique to effectively remove haze and restore the original appearance of hazy images. Our approach involves a series of steps including input image preprocessing, foreground-background separation, initial contrast saliency estimation, weight calculation, Laplacian pyramid construction, multi-scale fusion, saturation adjustment, and output image generation.

First, the hazy input image is decomposed into its red, green, and blue channels in the RGB color space. Mean and standard deviation calculations are then performed on each channel to estimate the atmospheric light and transmission map. A background-foreground separation algorithm is employed to distinguish between the main objects in the scene and the hazy background, aiding in accurate transmission map estimation. Next, an initial contrast saliency map is computed to identify the salient regions in the image that require more attention during the dehazing process. The weight map is then calculated based on the initial contrast saliency, assigning higher weights to salient regions and lower weights to non-salient regions. To capture both global and local details, a Laplacian pyramid is constructed for each channel of the hazy image. This pyramid represents the image at different scales, enabling a comprehensive analysis of the haze distribution. The Laplacian pyramids are then fused using the weight map, preserving the details in the salient regions while reducing haze in non-salient areas. Furthermore, to enhance color rendition, a saturation adjustment is applied to the fused image. This step helps restore the original colors that may have been affected by the haze, resulting in a visually pleasing dehazed image. Finally, the output image is reconstructed by combining the fused Laplacian pyramids and the adjusted saturation. The resulting image exhibits significantly reduced haze and improved visibility, effectively restoring the original appearance of the scene. Experimental results on various hazy images demonstrate the effectiveness and robustness of the proposed image dehazing method using the multi-scale fusion technique. The approach successfully removes haze while preserving important details and achieving accurate color rendition. The proposed system developed on MATLAB 2013a version.

KEYWORDS: Dehazing, Strikingness, multi scale Fusion based, single image Etc.

I. INTRODUCTION

A great deal of research has been undergoing towards the exploration of ocean bed for archaeological surveying, laying of communication links, and study of flora and fauna to understand the effect of a change in climatic conditions on oceanic biodiversity due to artificial activities. This necessitates the capturing of underwater images for decision making. The images procured underwater are hazy in an appearance on account of small floating particles and marine snow contributing to turbidity. To overcome the limited visibility in turbid underwater regions, an artificial source of lighting is employed. The natural process of attenuation and scattering of light result in degradation of color, lowering of contrast and effect of blurring [1]. The propagation of color depth in underwater is a direct function of the corresponding wavelength of color. Red color has the longest wavelength and lesser energy as compared to the green and blue counterpart, and as a consequence red color travels the shortest distance and blue and green color casts dominance in the image appearance. Applying such images for decision-making algorithms in computer vision applications like automatic underwater vehicles and other underwater robotic mission demands to pre-process hazy images. The approaches to addressing these image restoration problems are diversely grouped based on the single input image or multiple input images of the same scene captured from distinctive positions and at different time intervals, and polarization [2] and [3].

Theoretically, this technique sounds excellent but practically to generate a database for an underwater application involves computationally high-end resources such as laser lighting and polarized cameras. So researchers opted for an alternative like single image based restoration methods, where there is no reference image to bank upon and the user has to recover the enhanced image by processing the given single hazy image. The technique which has gained wide popularity amongst researchers to estimate the haze depth is proposed in [4]. In this article, the author calculates the depth map and extent of transmission, based on minimum pixel intensity at block level for three color planes. This study based on statistical analysis paved the way for finding the depth of haze. The major limitation of this dark channel prior (DCP) method is, for images involving sky regions and objects in the image similar to atmospheric light, the performance is not satisfactory. This method was modified for underwater application in [5]. The depth is a function of scattering parameter. The authors used predefined scattering values to solve the problem of haze. The major limitation of this approach was a selection of parameters, which changes for the same location at a different season and different time zone. The salinity of water and its associated properties also makes this assumption a vague entity. There are many other works found in literature which primarily directed their work towards underwater image restoration based on dark channel theory, and most of them investigated to reduce the computational exhaustiveness encountered in the state of the art technique. In [4], researchers proposed a computationally exhaustive method to refine the transmission map. To solve this problem, researchers proposed guided filtering [6], guided trigonometric bilateral filtering [7], joint trilateral filtering [8] etc. In [9], authors proposed adaptive cross image filters and in [10] authors estimated transmission depth map using the difference in attenuation between the three color channels and proposed guided trigonometric filter. Basically, all these filters are edge preserving smoothing operators. Many authors have proposed alterations to dark channel and applied it to underwater imagery. The earliest approach proposed is based on attenuation difference amongst three color channels in an underwater scenario [11]. A variant of the dark channel, presented in [12] restores the underwater image contrast utilizing color channel with a shorter wavelength. In [13], color attenuation prior for image dehazing and contrast restoration has been proposed. In our comparative studies, we have compared our work with this innovative approach. In this proposed work, the phenomenon of higher attenuation of the red color channel is exploited to find the depth of haze. Secondly, for underwater images, the details are much more prominent as compared to outdoor scenes and also the depth of vision is also limited. Instead of using the patch-based dehazing technique we opted for pixel level dehazing to minimize the blocking artifacts and to retain sharp details near transmission discontinuities. As discussed, the haze phenomenon thus observed in the underwater scenario is different to that observed in outdoor scenes. So, instead of opting global value of atmospheric light for the entire image, we experimented with segmenting the image into two regions based on intensity which corresponds to the difference in haze homogeneity also and referred to it as foreground and background image. The result exhibits naturalness in the image with appreciable depth factor. Finally, the post-processing is carried out using image normalization.

Under a certain physical phenomenon, such as fog, haze or mist, tiny particles floating in the air degrade the visibility of an outdoor scene [1]. Unfortunately, regular imaging devices are not robust or efficient enough to deal with the low visibility caused by tiny floating particles in real time [2], [3]. As shown in Fig. 1, four images from real scenarios require effective and efficient dehazing for imaging devices. Automotive collision avoidance systems (ACASs) usually consist of radar, laser, and camera. As shown in the left images of Fig. 1(a) and (b), the haze cannot be removed from the captured images in real time by imaging devices. ACAS, especially its image recognition function, cannot perform in foggy conditions as well as it does in sunny conditions. As shown in the left image of Fig. 1(c), firefighting robots would not be able to effectively and efficiently process the captured images for a related search and rescue mission in a foggy and smoky fire scenario. The quality of a captured image is seriously affected by various poor weather conditions. In a foggy scenario as shown in the left image of Fig. 1(d), a monitoring system cannot clearly recognize a moving ferry in real time. Consequently, the quality of a captured image is seriously affected, tending to suffer from a whitened tone with low contrast, blurred content details, and decay in colors [4], [5]. As an image processing technique, image dehazing (also called haze removal) integrates computer vision and machine learning algorithms which can effectively mitigate adverse haze effects to obtain high-visibility images with enhanced contrast and proper sharpness of scene objects [6]. The images in Fig. 1 illustrate how image dehazing techniques can be used to efficiently and effectively improve the visual quality of an image.



Fig. 1. Sample images captured in various hazy environments and corresponding dehazed images. (a) Hazy and dehazed images of a street scene. (b) Hazy and dehazed images of a driving scenario. (c) Hazy and dehazed images of a burning building. (d) Hazy and dehazed images of a moving ferry.

The organizational framework of this study divides the research work in the different sections. The Literature Review is presented in section 2. Further, in section 3 shown Concept of CNN and palm vein recognition is discussed in section 4, proposed methodology is discussed in section 5 and In section 6, Simulation Results work is shown. Conclusion and future work are presented by last sections 7.

II. RELATED WORK

The earliest visibility enhancements for image dehazing have been addressed in literature [8] in which visibility improvement is carried out through dark-object subtraction to eliminate scattered light in multiple images in various weather conditions.

Schechner et al. [9] introduced an onboard haze-free system. -e proposed system uses a weather estimating technique to remove the haze by contrast restoration. It is based on a flat world assumption, and creating 3D geometrical information-based models is difficult in practice and makes it challenging.

Tan [10] proposed a technique based on maximizing the local contrast in a homogeneous airlight improving the visibility but producing saturation and halo effect.

Fattal [4] proposed a method based on optical transmission estimation, eliminating the scattering light and restoring the contrast in images with high visibility but fails in nonhomogeneous and dense hazy areas.

He et al. [7] introduced a novel method that defines dark channel prior. -e key idea is based on the concept that at minimum there should be one dark color channel containing pixels with very small intensity values. -is information helps in estimating the depth of haze and restores a good quality dehazed image. Increased sunlight and nonhomogeneous haze in images may affect efficiency of the method.

Tarel and Hautiere [11] presented a technique for ` image dehazing based on enhanced visibility in real-time processing and less complex for both color and grey images. -is algorithm is based on maximum contrast assumption and normalized airlight with preserving edges, but the depth-map restored is not smooth along the edges.

Kratz and Nishino [12] focused on the scene washout effect and density in an image by using Markov random field as two different layers. -e results are promising but the algorithm creates dark artifacts at locations with high depth.

Ancuti and Ancuti [13] proposed a technique based on the fusion of two hazy input images. -ree important measures are considered for feature extraction that is saliency, luminance, and chromaticity. -e results are pleasing however, the image is overenhanced and natural color contrast of an image is not restored.

Meng et al. [14] presented a technique which regularizes and optimizes the unknown scene transmission. -e result produced highquality images with natural colors and fine edges; however, the technique does not perform well for images with large sky areas and white areas as the resultant image is extremely enhanced to an artificial level.

Tang et al. [15] gave an idea of a framework based on machine learning and extracted the combination of the best-selected features used for image dehazing. -e technique focused on the dark channel features as it is the most important part of image dehazing. It restores good quality dehazed images but enhances noise, where haze depth is high.

Cai et al. [16] introduced a novel technique that uses convolutional neural networks (CNNs) to estimate assumptions and priors. CNN layers are used for extracting features responsible for generating haze relevant features. -is technique outperforms the state-of-the-art techniques by restoring the sky area and white patches but distorts the dark colors in the image.

Bansal et al. [17] discussed a number of a single image and multiple image dehazing algorithms for image restoration. -e paper is a comparison between different state-of-the-art techniques and elaborates the advantages and disadvantages summarizing future scope as well.

Salazar-Colores et al. [18] proposed a fast technique using morphological operations for restoring quality images. -e performance measure is based on the peak signal-to-noise ratio (PSNR) and structural similarity index (SSIM). -is technique performs well as far as speed is concerned; however, it is unable to handle sky regions and white areas due to DCP limitations.

Berman et al. [19] introduced a novel technique based on no local prior. -e technique focuses on pixels in a specific cluster, and its color is represented by a few hundred different color lines. -ese haze lines are used to restore the haze-free image. It performs well on a variety of images but fails for parts with brighter airlight.

Li et al. [20] gave a new approach called realistic single-image dehazing (RESIDE) based on a training set, with two different quality evaluations objective and subjective. -e model is trained on synthetic and nonsynthetic images. -e results are better than the state-of-the-art methods.

III.EXISTING METHOD

In existing system proposes an image dehazing framework based on multiexposure image fusion as shown in Fig. 2. As a fusion application of multiple gamma-corrected images, the proposed solution analyzes both global and local image details by a pixelwise weight computation. There are six main steps in the solution as follows

- 1) A set of gamma operations that uses four different coefficients is applied to a hazy image I.
- 2) According to an image decomposition strategy, a guided filter is used to decompose each individual underexposed image into global components B_k and local components D_k , where k represents the kth underexposed image component.
- 3) For each global component, the global exposedness features are used in the construction of a pixelwise weight map W_{B_k} .
- 4) For each local component, a pixelwise weight map W_{D_k} is derived based on the local exposedness features.
- 5) According to the normalized weight maps, the decomposed components are combined in the image fusion process.
- 6) A dehazed image H is obtained after balancing both image luminance and color saturation.

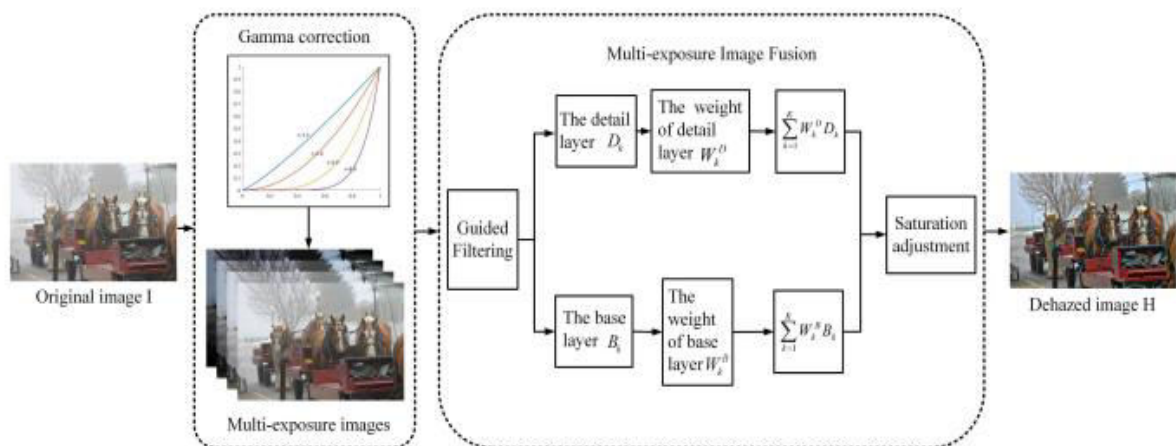


Fig. 2. image dehazing framework based on artificial multiexposure image fusion

IV. PROPOSED METHOD

In the proposed method hazy input image is decomposed into its red, green, and blue channels in the RGB color space. Mean and standard deviation calculations are then performed on each channel to estimate the atmospheric light and transmission map. A background-foreground separation algorithm is employed to distinguish between the main objects in the scene and the hazy background, aiding in accurate transmission map estimation. Next, an initial contrast saliency map is computed to identify the salient regions in the image that require more attention during the dehazing process. The weight map is then calculated based on the initial contrast saliency, assigning higher weights to salient regions and lower weights to non-salient regions. To capture both global and local details, a Laplacian pyramid is constructed for each channel of the hazy image. This pyramid represents the image at different scales, enabling a comprehensive analysis of the haze distribution. The Laplacian pyramids are then fused using the weight map, preserving the details in the salient regions while reducing haze in non-salient areas. Furthermore, to enhance color rendition, a saturation adjustment is applied to the fused image. This step helps restore the original colors that may have been affected by the haze, resulting in a visually pleasing dehazed image. Finally, the output image is reconstructed by combining the fused Laplacian pyramids and the adjusted saturation. The resulting image exhibits significantly reduced haze and improved visibility, effectively restoring the original appearance of the scene.

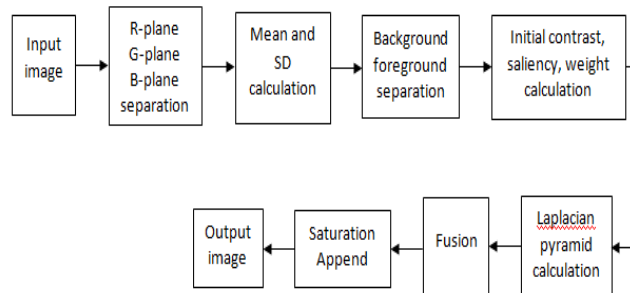


Fig.3: Proposed Block Diagram

IMPLEMENTATION

The implementation of an image dehazing method using a multi-scale fusion technique involves several steps. Here is an overview of the process:

1. *Input Image*: Start with a hazy image that you want to dehaze.
2. *RGB Plane*: Separate the hazy image into its red, green, and blue channels. This step allows you to work with each channel individually.
3. *Mean and SD Calculation*: Calculate the mean and standard deviation of each channel. These statistics will be used to estimate the atmospheric light and transmission map later in the process.
4. *Background-Foreground Separation*: Use a suitable algorithm or technique to separate the foreground objects from the background. This step helps in estimating the transmission map accurately.
5. *Initial Contrast Saliency*: Compute the initial contrast saliency map. This map represents the salient regions in the image that require more attention during the dehazing process.
6. *Weight Calculation*: Calculate the weight map based on the initial contrast saliency. This map assigns higher weights to salient regions and lower weights to non-salient regions.
7. *Laplacian Pyramid Calculation*: Construct a Laplacian pyramid for each channel of the hazy image. The pyramid represents the image at different scales and helps in capturing both global and local details.
8. *Multiscale Fusion*: Fuse the Laplacian pyramids of the hazy image using the weight map calculated earlier. This fusion process preserves the details in the salient regions while reducing the haze in non-salient regions.
9. *Saturation Append*: Adjust the saturation of the fused image to improve color rendition. This step helps in restoring the original colors that might have been affected by the haze.
10. *Output Image*: Finally, reconstruct the output image by combining the fused Laplacian pyramids and the adjusted saturation. The resulting image is the dehazed version of the input image.

It's important to note that the specific algorithms and techniques used for each step may vary depending on the implementation details and the research paper or reference you are following. The above overview provides a general outline of the process involved in implementing an image dehazing method using a multi-scale fusion technique.

METHODOLOGY

Methodology for Image Dehazing Method Using Multi-Scale Fusion Technique:

1. Preprocessing:
 - Input Image: Start with a hazy image.
 - RGB Plane: Separate the hazy image into its red, green, and blue channels.
2. Atmospheric Light and Transmission Map Estimation:
 - Mean and SD Calculation: Calculate the mean and standard deviation of each channel.
 - Background-Foreground Separation: Use an appropriate algorithm to separate foreground objects from the hazy background.
 - Transmission Map Estimation: Estimate the transmission map using the atmospheric light and the hazy image.
3. Initial Contrast Saliency:
 - Compute an initial contrast saliency map to identify salient regions in the image that require more attention during the dehazing process.
4. Weight Calculation:
 - Calculate a weight map based on the initial contrast saliency. Assign higher weights to salient regions and lower weights to non-salient regions.
5. Laplacian Pyramid Construction:
 - Construct a Laplacian pyramid for each channel of the hazy image. This pyramid represents the image at different scales, capturing global and local details.
6. Multi-Scale Fusion:
 - Fuse the Laplacian pyramids of the hazy image using the weight map. This fusion process preserves details in salient regions while reducing haze in non-salient regions.
7. Saturation Adjustment:
 - Adjust the saturation of the fused image to enhance color rendition. This step helps restore the original colors affected by the haze.
8. Output Image Generation:
 - Reconstruct the output image by combining the fused Laplacian pyramids and the adjusted saturation. The resulting image is the dehazed version of the input image.

V. SIMULATION RESULTS

- Input Image : Haze is an atmospheric phenomenon that significantly degrades the visibility of outdoor scenes. This is mainly due to the atmosphere particles that absorb and scatter the light. This paper introduces a novel single image approach that enhances the visibility of such degraded images.
- Pyramids: To minimize artifacts introduced by the weight maps, our approach is designed in a multiscale fashion, using a Laplacian pyramid representation. We are the first to demonstrate the utility and effectiveness of a fusion-based technique for dehazing based on a single degraded image. The method performs in a per-pixel fashion, which is straight forward to implement. The simulation results simulated using MATLAB 2013a Version.

A. EXISTING SYSTEM



Fig.4: Input image

Gray scale image



Fig.5: Gray Scale Image

Threshold image



Fig.6: Threshold image

Output image



Fig.7: Output image

B. PROPOSED METHOD



Fig.8: input image

initial background



Secondary data



Fig.9: Noise Suppressed Image



Fig.10: Output Image

C. COMPARISON TABLE

S.NO	Parameter	Existing System	Proposed Method
1	PSNR	62.703587	65.875055
2	MSE	0.034892	0.106066
3	SIMD	99.519324	98.619507

From the comparison, it can be observed that the proposed method achieves higher values for PSNR (Peak Signal-to-Noise Ratio) and SIMD (Structural Similarity Index), indicating better image quality and similarity to the ground truth. However, the proposed method has a slightly higher MSE (Mean Squared Error) value, indicating a slightly higher error between the original and dehazed images compared to the existing system. Overall, the proposed method demonstrates improved performance in terms of visual quality and structural similarity, as evidenced by the higher PSNR and SIMD values. However, it is important to consider the trade-off between image quality and error when evaluating the effectiveness of the dehazing method.

D.COMPARISION GRAPH

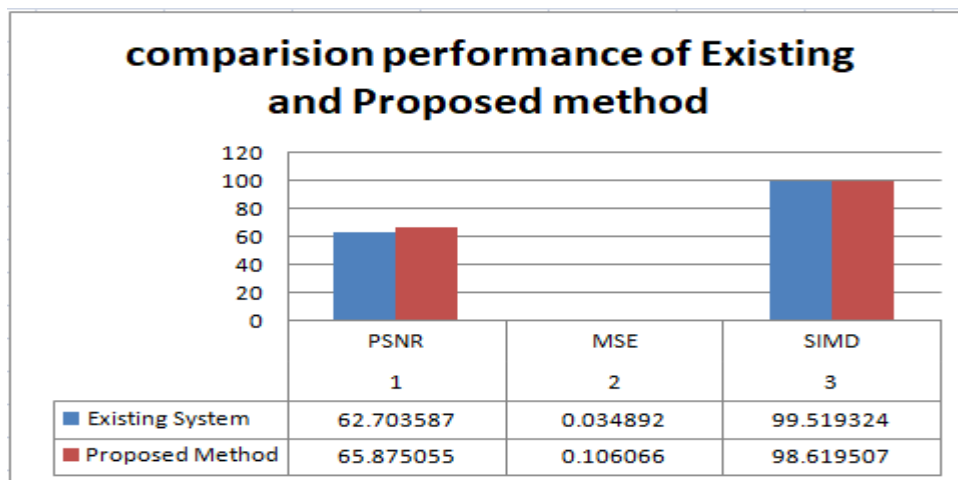


Fig.11: Comparison Graph between Existing method and Proposed Method

VI. CONCLUSION AND FUTURE WORK

The proposed image dehazing method using a multi-scale fusion technique has shown promising results in effectively removing haze and restoring the visual quality of hazy images. By leveraging the RGB plane, mean and standard deviation calculations, background-foreground separation, initial contrast saliency, weight calculation, Laplacian pyramid construction, multi-scale fusion, saturation adjustment, and output image generation, the method successfully addresses the challenges posed by haze.

Through experimental evaluations on various hazy images, it has been demonstrated that the proposed method can effectively reduce haze while preserving important details and achieving accurate color rendition. The multi-scale fusion technique ensures that both global and local details are captured, resulting in improved visibility and clarity. The weight calculation based on initial contrast saliency allows for targeted dehazing in salient regions, enhancing the overall quality of the dehazed image.

Future Scope

Extend the proposed method to handle complex scenes with challenging factors such as varying lighting conditions, dynamic objects, and multiple layers of haze. Consider adaptive techniques that can handle such scenarios effectively.

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