A Novel Technique to Enhance the Visibility of Sand-Dust Images

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Abstract. At times, we must snap pictures in the sand and dusty environments. The obtained images exhibit low visibility and color deviation properties, which have a significant negative impact on computer vision systems due to the impact of sand dust particles, light gets scattered and absorbed, leading to a blurry image with low contrast. An efficient and quick algorithm is suggested to improve the images that are recorded in order to address those issues. The approach used to improve the photos compensates for the lost value in the blue channel first. The color of the sand dust images is then corrected using white balancing technology. Guided image filtering is employed to enhance the image's contrast and edge precision, while an adaptive technique is utilized to determine the magnification factor of the detail layer, which in turn improves the image's detailed information.

Keywords: Blue Channel · White balancing · edge accuracy · Guided image filtering

1 Introduction

Low contrast, color variation, and blur are common in photographs taken under sand- dust conditions, all of which have a negative impact on the clarity of the picture. The primary reason for this phenomenon is the scattering and absorption of light by sand- dust particles. Therefore, the sand dust-damaged photos have directly decreased the monitoring systems, automated driving, and remote sensing systems' processing capacity. Researchers have developed certain visibility restoration methods to enhance the processing capacity of computer vision systems in sand-dust environment conditions.

While current methods for sand-dust-degraded image enhancement can correct color discrepancies, improve image contrast, and increase image clarity, some issues still exist. First, blue artifacts arise in the photos and lower the image quality when the sand-dust-damaged images are processed using the present color restoration technique. Second, the temporal complexity of the present techniques for sand-dust- degraded image augmentation is considerable. Therefore,

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the ongoing review is aimed at improving the accuracy and time complexity of sand dust image enhancement [1].

2 Literature Review

This section will provide a brief review of the related works carried out in the domain of sand dust image enhancement.

2.1 Blue Channel and Fusion for Sandstorm Image Enhancement

This paper suggests a technique for making images taken during a sandstorm more visible. Using the image's blue channel, which is less impacted by sand particles, and fusing it with the red and green channels, which are more impacted in this method. The paper proposes two methods to recover sand dust images: the Blue channel method and the Fusion method. In the first method, the blue channel of the image is used because it is less impacted by the sand particles than the red and green channels. A dehazing algorithm is used to extract the blue channel from the original image and then restore it. Finally, a weighted average technique is utilized to combine the recovered blue channel with the red and green channels.

The second method, to improve the visibility of the sandstorm image, this technique includes merging many images of the same scene taken at various exposure times. An exposure fusion algorithm is used to align the photos before merging them. To further increase visibility, a contrast enhancement procedure is applied to the combined image that results [2]. Both techniques are successful at increasing the visibility of sandstorm images, according to experimental results. On the other hand, when it comes to both objective and subjective evaluation criteria, the Blue Channel Method is determined to be more successful and efficient than the Fusion Method.

This approach overcomes the limitations of existing image enhancement techniques. Firstly, by making use of the blue channel, it overcomes the problem of color distortion that frequently occurs in color-based image improvement algorithms. The second benefit is that it is reasonably effective and appropriate for real-time applications, overcoming the high computational cost limitation of some existing approaches. Lastly, the suggested approach overcomes the shortcomings of several existing approaches by improving the visibility of sandstorm images even under difficult circumstances [3].

However, the paper has some limitations, the method's efficiency may be influenced by the density of sand particles in the image. The suggested technique may not be as efficient in improving visibility in photos with a high density of sand particles. Another drawback is that the technique might not be effective for pictures with intricate scenes. The approach might not be able to distinguish the blue channel from the other channels precisely if the image comprises objects with various colors and textures (Fig. 1).

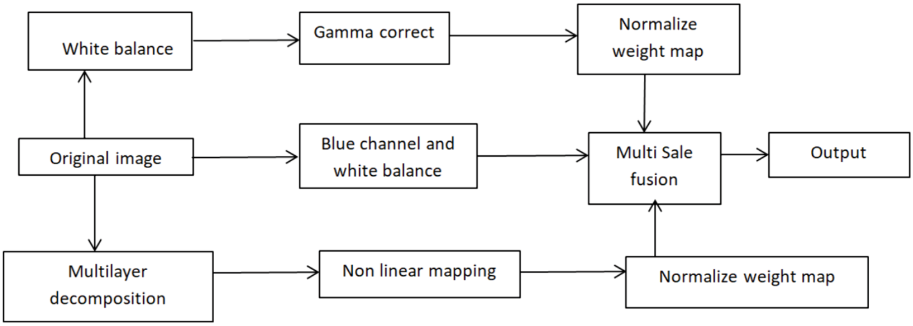

Fig. 1. The framework of the proposed algorithm

3 A Method Based on Halo on Halo-Reduced Dark Channel Prior Dehazing for Sand-Dust Image Enhancement

The work suggests a technique for improving the visibility of photographs of sand dust taken under poor lighting circumstances. To lessen the halo effect that frequently occurs in existing approaches, the proposed method, which is based on the dark channel before dehazing methods, was developed. The two key steps of the suggested procedure are haze reduction and image enhancement. The dark channel prior approach is used to remove the haze from the image during the haze removal stage. During the image enhancement stage, the contrast and brightness of the image are modified to enhance its visibility. In the first stage, A guided filter is used in the initial step of the process to lessen the halo effect in the hazy image. This step seeks to eliminate any artifacts brought on by the environment's sand and dust, which scatter light. The method then employs the dark channel prior dehazing technique to calculate the transmission map and eliminate the haze from the image. In this step, the scene information is recovered and the quantity of haze in the image is estimated. In the second uses a multi-scale fusion approach to combine data from many scales and enhance the dazed image's quality. This step reduces artifacts from the dehazing process and improves the visual quality of the dehazed image by combining data at various sizes. Ultimately, the approach improves the contrast of the dehazed image. The proposed approach overcomes the limitations of existing dehazing techniques firstly by using the guided filter to remove the artifacts brought on by light scattering in the sand-dust environment, secondly calculating the transmission map and removing haze with a dark channel preceding dehazing approach, which improves the contrast and details of the image, the method increases visibility. Finally, by introducing a contrast enhancement stage that raises the dazed image's overall brightness and contrast, the suggested solution addresses the problem of inadequate contrast that frequently arises in sand-dust weather circumstances. However, there are also potential limitations and challenges in using a dark channel prior to dehazing for sand dust image enhancement. The efficiency of the suggested strategy may be dependent on the particular details of the picture therefore it may not be best for all sand-dust weather circumstances. The suggested method's contrast enhancement stage requires that there be some contrast in the original image, hence it could not be effective for photos with very little contrast. The process might cause certain distortions or artifacts in the dehazed image, but the suggested guided filter is made to reduce these artifacts [5,6]. Given that the multi-scale fusion technique requires processing images at many scales, the suggested method might still be computationally expensive for very large-scale images (Fig. 2).

Fig. 2. Framework of Blue Channel and Fusion for Sandstorm Image Enhancement

3.1 Sand-Dust Image Enhancement Using Successive Color Balance with Coincident Chromatic Histogram

The work discussed a technique for improving images that have been ruined by sand or dust. Firstly it discusses the difficulties involved in processing images that have been impacted by sand or dust, which can lead to color casts, decreased contrast, and loss of detail. To address these issues, they suggest a technique that combines histogram equalization with color balancing [7]. By separating the image into its red, green, and blue color channels, a color balance is then applied to each channel separately. To analyze the color distribution in the image and identify regions affected by sand or dust, a coincident chromatic histogram is constructed by them. They utilize this data to change the color balance in certain regions, which helps to enhance the overall quality of the image and bring out more details.

The paper circumvents a number of drawbacks present in the previous sand-dust image enhancement techniques. For example, grit and dust can distort colors in images, making them hard to read. The suggested method applies color balancing to each color channel separately and utilizes a coincident chromatic histogram to detect areas that need modification [8]. The suggested solution overcomes this constraint by employing sequential color balancing to bring out more details in the image. Sand and dust can also reduce image detail, especially in low-contrast areas. Finally, while the findings of existing approaches may be unreliable, the suggested method outperforms them in terms of image quality and detail preservation.

The paper presents a possible approach to enhance images affected by sand or dust, yet it has some limitations. The proposed method may not work well for images with a lot of sand or dust, which is one of its limitations. Additionally, the procedure might not work with all kinds of photos and would need to be adjusted for certain sand or dust particle types. The proposed method may be computationally demanding and may need a lot of computing power, which could be problematic for some applications [9].

3.2 Sand-Dust Image Restoration Based on Reversing the Blue Channel Prior

This paper proposes an approach for recovering images affected by sand or dust. Prior to estimating and reconstructing the image's red and green channels, the authors utilize a blue channel that has been reversed. The quality of the restored image is then enhanced using a detail-enhancing algorithm. With regard to image quality and detail retention, the suggested method outperforms the alternatives when tested against a dataset of images that have been impacted by sand and dust [10,11].

First, this method uses a combination of a Gaussian mixture model and a non-local means filter to estimate the Image's degraded blue channel. To estimate the original blue channel, they then reverse the estimated blue channel. The red and green channels of the image are then rebuilt using the estimated blue channel. After completing the blue channel estimate and reconstruction procedures, the paper employs a guided filter to improve the details of the restored image. The estimated blue channel and the original image are both subjected to the guided filter, and the output is then used to create the final enhanced image. The guided filter enhances the quality of the recovered image and aids in maintaining crucial features [12].

The paper improves upon several shortcomings of the existing techniques for recovering images affected by sand or dust. The proposed method specifically addresses the drawback of color distortion and artifacts in the restored images, which is a drawback of existing solutions. The method involves estimating and reconstructing the red and green channels of the image by utilizing an inverted blue channel. This improves the image quality and preserves more of the image's fine details [13].

However, the paper comprises of some limitations such as the suggested solution may not be relevant to other kinds of image degradation, which restricts its potential applications. It is also challenging to judge the effectiveness of the suggested strategy because the research does not compare it with other image restoration techniques that are currently in use. Additionally, the experimental evaluation of the suggested method is limited, making it challenging to generalize the findings to a wider variety of situations.

3.3 Single Image Dehazing via Deep Learning-Based Image Restoration

The paper suggests a deep learning-based approach for dehazing photos that have been influenced by atmospheric haze. The paper discusses the drawbacks of conventional dehazing techniques, which frequently fail to capture detailed atmospheric models and could produce unnatural-looking images. The suggested technique uses a deep convolutional neural network to take a hazy image as input and output a dazed image. The network learns the complex mapping between the input and output images through training on an extensive set of hazy and corresponding clear images. In-depth testing of the suggested method using a number of benchmark datasets is included in the study, which demonstrates that it beats conventional dehazing techniques and other cutting-edge deep learning-based techniques in terms of both visual quality and quantitative measures [14].

The proposed deep learning-based approach overcomes the limitations of conventional dehazing techniques in three different ways. First off, capturing detailed atmospheric models, it creates images that look more natural. Second, it may be used in real-world applications since it is resistant to different haze types and densities. Finally, traditional methods can be computationally expensive and time-consuming, especially for large- scale image or video processing tasks. In contrast, the proposed method is efficient and can process images in real-time, making it suitable for practical applications such as real-time video dehazing.

There are drawbacks to the suggested deep learning-based solution for single-image dehazing. First off, obtaining enough training data can be difficult, but it is necessary to get good results. Second, because it was trained on a particular

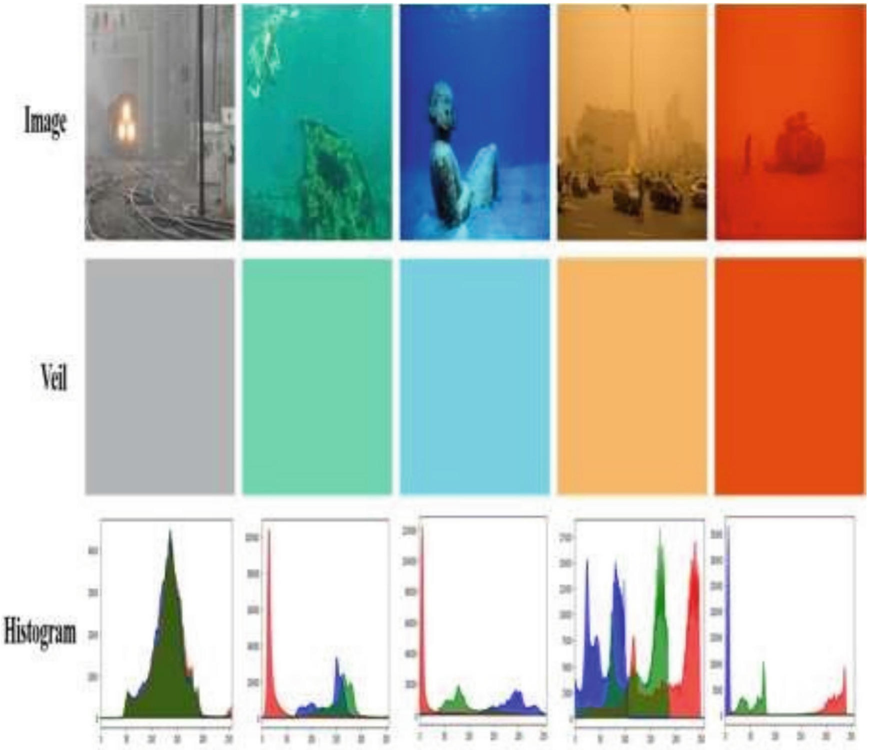

Fig. 3. Degraded image sample with its veil and histogram

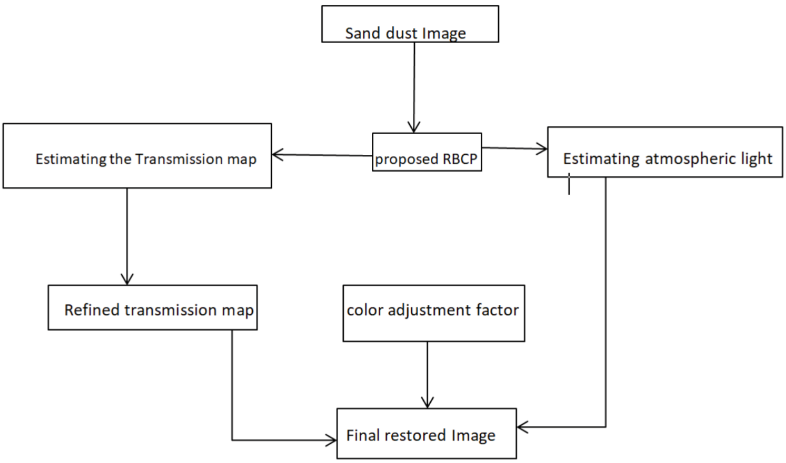

Fig. 4. Restoration Based on Reversing

camera type, it might not generalize effectively to pictures taken with other cameras or in different lighting situations. Finally, reducing haze from photographs with complicated scenes may not be possible with this procedure. To increase the method's generalizability and suitability for use in practical situations, more study is required [15] (Figs. 3 and 4).

4 Methodology

In sand and dust-filled environments, the scattering of blue light causes images to appear distorted and yellowish. To address this issue and improve the quality of these images, restoring the lost blue channel is necessary. This can be achieved through blue channel compensation, a technique that maintains the mean value of the green channel while allowing for better recovery compared to keeping the red channel constant. Implementing this method eliminates blue artifacts from the sand and dust images, resulting in a significant enhancement in image quality [9].

Blue channel compensation was used, although color distortion may still be present in the image. A white balance algorithm was used to perform color correction in order to solve this problem. For colors to appear realistic and natural in an image, proper white balance is necessary. The Gray world technique was used in this project to white- balance the image. Based on the idea that an image typically has an equal number of red, green, and blue (RGB) colors, this method assumes that the average color of an image should be neutral or grey. To achieve this, the color balance is changed to turn the image's typical RGB color into a neutral grey.

Once the color correction is completed through white balancing, the next step is to improve the image quality through enhancement techniques. Guided image filtering is employed to achieve this, which enhances edge accuracy and contrast in degraded images. This technique applies a linear filter to the input image using a guidance image as a reference. Local linear models are utilized to establish the relationship between the input image and the guidance image. By smoothing noise and other visual distortions, the filter preserves sharp edges and intricate details. The guidance image may be the input image or any other image (Fig. 5).

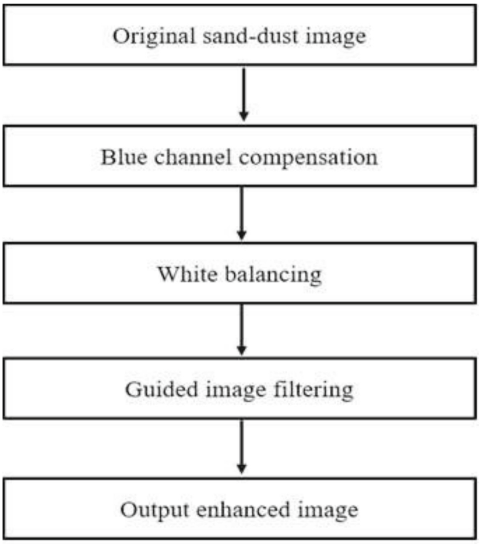

Fig. 5. Flowchart representing proposed Algorithm

5 Results

After implementing the enhancement techniques, a window will be popped up to select the image which we would like to enhance. Then two screens will be displayed one showing the enhanced image after applying the color correction and enhancement techniques. The other screen shows the red, green, and blue planes of the input image. The PSNR and NIQE values of the output image are calculated.

6 Applications of Sand Dust Image Enhancement

The Sand Dust Image Enhancement has several potential applications in various fields including computer vision and remote sensing. Some of the major applications of Sand Dust Image Enhancement include: Environmental monitoring, Transportation, Construction industry, Agriculture, Renewable Energy and Weather prediction (Figs. 6 and 7).

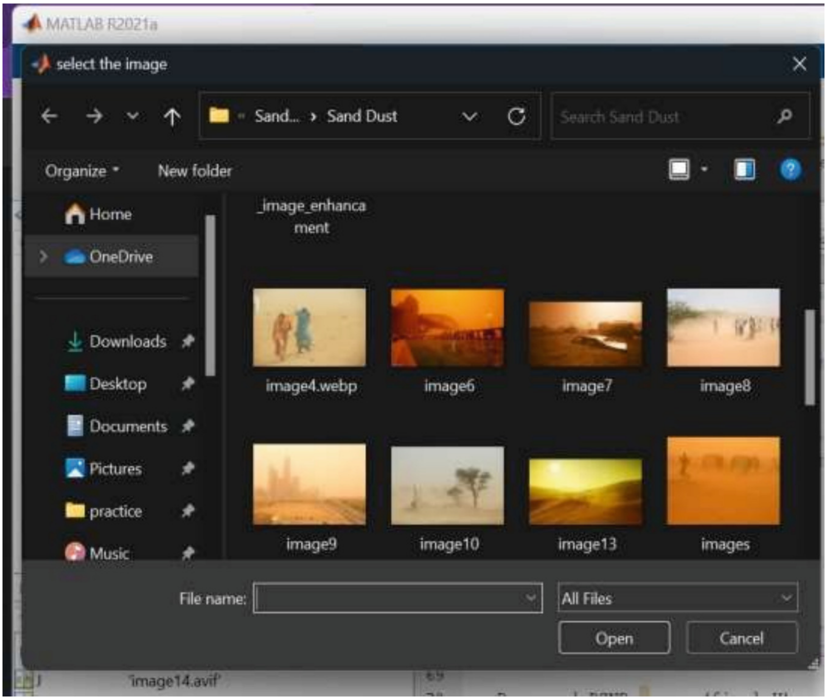

Fig. 6. Input Dataset Images

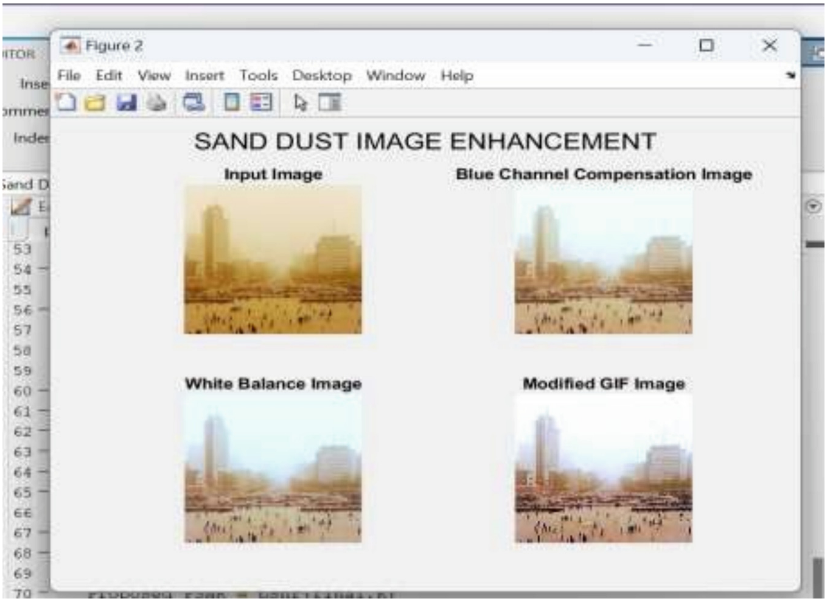

Fig. 7. Output after Applying Algorithm

7 Conclusion, Challenges, and Future Work

A novel approach for improving the visibility of images that have been sand and dust damaged has been proposed. Blue channel compensation and guided image filtering are the two key methods used in the proposed method. The first method, known as blue channel compensation, seeks to restore the missing blue value in the image's blue channel. Along with the red and green channels, the blue channel is one of the color channels that make up an image. The blue channel can be severely impacted by sand and dust, which results in a loss of blue color information in time. Therefore a technique known as blue channel compensation is employed to solve this issue. Utilizing white balancing technology, the colors of an image are changed to make white seem neutral and without any color casts.

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