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Model Assisted Multi-Band Image Dehazing by an Artificial Image Fusion

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Abstract
The term "image fusion" refers to the process of collecting all the necessary information from numerous photos and integrating it into fewer, usually single, images. Compared to other images from a single source, this one image is more accurate and informative and has all the necessary information. Image fusion tries to reduce the amount of data while also producing images that are more relevant and understandable for both human and machine perception. There is less information derived from these individual photos. For the purpose of gathering more specific information, each of these photographs has a very low resolution. Multimodal medical image fusion is used to combine various medical images to gain comprehensive and more trustworthy information.This project provides a quick, one-picture update that works in a number of scenarios and pays little attention to deviations. The primary concept of this research is to integrate model-based and combination-based dehazing methods, introducing adjustable picture enhancement while emphasising picture details. The suggested strategy improves both grayscale and shaded images without any prior information. Multi-band degradation is used to extract the base and detail layers for force and Laplacian modules. Restoring the genuine force is successfully accomplished by the power module's proposed complete guiding and gearbox assessment. Due to the flexibility of nonlinear planning, the details on each subsequent layer change. According to our findings, shading improved reproduction performs admirably on many kinds of foggy photographs. The suggested approach is perfectly suitable for regular picture quality inspection. We also provide a preliminary assessment of the geometric (direct odometry) and semantic (segmentation) uses of vision-based robots.

Keywords: Computer Vision for Other Robotic Applications, Localization, Semantic Scene Understanding.

Introduction

This project's primary goal is to clarify obscure photographs using a variety of techniques, although in each of those Only global improvements were made, which meant that the entire image was taken into account. In this project, however, our goal is to apply local improvements to the hazy photographs, which entails applying improvements to each individual pixel in the image. Image fusion is the process of combining two or more images to form a single new image. The finished image will be more educational than the original photos. These images could have been captured using different sensors, at different times, or with different spectral and spatial features.Due to the availability of multi sensor data across several disciplines for a range of applications, image fusion has been receiving more and more interest in research. Image fusion has been widely applied in a variety of domains, including the military, remote sensing, robot vision, medical image processing, and others.

Image fusion is a type of data fusion that involves combining data from two or more source images taken from the same location to create a composite image with enlarged information content. Given the variety of features in the data, the fused image might provide better capabilities for interpretation and more reliable results.

The fusion technique can be applied to a variety of methods. Various decomposition methods are used to split up the source pictures into different sub-bands. These methods are used to split the pictures into lower and higher frequency sub-bands. One technique or a combination of techniques can be used to breakdown the image. Based on a single methodology, a picture can be subdivided into sub images at different levels. Hybrid decomposition technique uses one or more algorithms to decompose an image into several sub-bands and extract more characteristics.

Haze, fog, and smoke are only a few examples of turbid conditions where images frequently suffer greatly. Colour attenuation, haze, and blur are the results of light photons that reflect off of object surfaces scattering and absorbing as they travel in the direction of a camera. An established model [1] depicts the ensuing hazy appearance as a convex mixture of real colour and ambient light. The gearbox level in this model determines the weight of each phrase. Because of this, it is necessary to address two key issues (transmission and ambient light) in order to recover the actual image pixel information. Light at infinite depth is ambient light, and transmission is made up of scene depth and scattering coefficient. A well-known unsolved issue is single image dehazing. Unless more details are given (such scene depth or numerous images), it is difficult to trace the individual colour and transmission of each pixel. Single picture dehazing is a problem that many academics have sought to solve using a variety of techniques that may be divided into three categories: (1) model-based, (2) fusion-based, and (3) learning-based techniques.

When we need to concentrate or highlight certain crucial aspects of an image, we utilise image enhancement. For instance, we might want to sharpen the image to highlight specific characteristics like a car's number plate number or specific regions of an X-ray film. It may be necessary to sharpen the edges or lines in aerial images in order to distinguish between buildings or other things. In photos taken by telescopes or space probes, specific spectral elements of the image may need to be boosted. The contrast may occasionally need to be improved.For some types of enhancement, linear filtering may be sufficient, however the majority of practical enhancement processes are non-linear in nature.

Some known deteriorations in an image are eliminated or reduced during restoration. Geometrical transformations simplify processing in many image processing applications. Examples include picture restoration, in which the degradation process is typically modelled as space-invariant, the calibration of a measurement equipment, or a correction to eliminate a relative movement between an item and a sensor.

The majority of the earlier techniques, including foundational publications [2, 3, 4], utilised model-based single picture dehazing [5, 6, 7]. Each technique used priors [3, 8, 7] or line-based observations [5, 6] to estimate the two key variables (transmission and ambient light). Key discoveries for the algorithm were established by sophisticated analysis of the relationship between specific priors and scene depth.

Literature Review

[2] R. Fattal, present a new method for estimating the optical transmission in hazy scenes given a single input image. A scene's

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visibility is improved and haze-free scene contrasts are recovered by removing dispersed light based on this estimation. With this novel method, we develop a more sophisticated picture creation model that takes surface shading into account in addition to the transmission function. This enables us to address ambiguities in the data by looking for a solution where the resulting colouring and transmission functions are spatially statistically uncorrelated. The estimation of the haze's colour follows a similar logic. Results show that the new approach is effective at removing the haze layer and at estimating the transmission, which may be utilised for other tasks like focussing a picture and creating an entirely new view.

*[4]*J. Tarel and N. Hautiere, One source of difficulties when processing outdoor images is the presence of haze, fog or smoke which fades the colors and reduces the contrast of the observed objects. We present a brand-new method and its versions for sight restoration from a single image. The key benefit of the suggested approach over alternatives is its speed because it simply has a complexity that depends linearly on the quantity of image pixels. This speed enables visibility restoration to be used for the first time in real-time processing applications including sign, lane-marking, and obstacle identification from an in-vehicle camera. Since the ambiguity between the presence of fog and the items with low colour saturation is resolved by assuming only small objects can have low colour saturation, another benefit is the ability to handle both colour images and grey level images. Tone mapping, picture restoration and smoothing, and atmospheric veil inference make up the algorithm, which is only affected by a small number of factors. Other cutting-edge algorithms are compared and quantitatively evaluated in order to show that comparable or superior outcomes can be achieved. In order to demonstrate the usefulness of the method, a use case for lane-marking extraction in grey level photos is shown.

[13] K. Tang, J. Yang, and J. Wang, carried Haze is one of the major factors that degrade outdoor images. Removing haze from a single image is known to be severely ill-posed, and assumptions made in previous methods do not hold in many situations. The goal of this research is to find the ideal feature combination for image dehazing by methodically investigating various haze-relevant properties in a learning framework. From a learning standpoint, we demonstrate that the dark-channel feature is the most instructive one for this task, which confirms He et al.'s [8] discovery. However, other haze-relevant features also considerably contribute in a complimentary manner. Surprisingly, we discover that the artificial hazy image patches we employ for feature exploration work well as training data for actual photos, enabling us to develop particular models for certain applications. Results of the experiments show that the suggested algorithm outperforms cutting-edge techniques on both simulated and real-world datasets.

*[14]*J.-H. Kim, W.-D. Jang, J.-Y. Sim, and C.-S. Kim,[14] experimented an fast and optimized dehazing algorithm for hazy images and videos is proposed in this work. We restore the hazy image by increasing contrast because it is generally observed that a hazy image has low contrast. A pixel value's length may be truncated and information lost due to an overcompensation of the reduced contrast. The contrast term and the information loss term are therefore combined to generate a cost function. The suggested algorithm maximizes contrast while ideally preserving information by minimizing the cost function. We additionally expand the static picture dehazing technique to real-time video dehazing. We do this by making transmission values temporally coherent, which reduces flickering artefacts in a dehazed video sequence. Experimental results show that the proposed algorithm effectively removes haze and is sufficiently fast for real-time dehazing applications.

[9] G. Meng, Y. Wang, J. Duan, S. Xiang, and C. Pan, [8] proposed captured in foggy

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weather conditions often suffer from bad visibility. In this article, we recommend an effective regularization technique to get rid of hazes from a single input image. Exploring the transmission function's built-in boundary constraint is extremely beneficial to our strategy. It is modelled as an optimization problem to estimate the unknown scene transmission using this restriction along with a weighted L1-norm based contextual regularization. Also offered to address the issue is a very effective variable splitting-based solution. The suggested method can recover a high-quality, haze-free image with true colors and minute visual details with only a few general assumptions. This method's usefulness and efficiency are demonstrated by experimental results on a range of hazy photos.

[10]O. Ancuti and C. Ancuti [10] carried out Haze is an atmospheric phenomenon that significantly degrades the visibility of outdoor scenes. This is mostly caused by airborne particles that scatter and absorb light. The new single image technique introduced by this technology improves the visibility of such damaged photos. Our approach is a fusion-based strategy that develops from two initial hazy image inputs by employing a white balance and a contrast increasing technique. We compute three measures (weight maps): brightness, chromaticity, and saliency to filter their key properties in order to properly mix the information of the generated inputs and maintain the regions with good visibility. Our method uses a multiscale design with a Laplacian pyramid representation to reduce artefacts caused by the weight maps. We are the first to show the value and potency of a fusion-based dehazing technique using a single degraded image. The technique operates in a simple-to-implement per-pixel approach. The experimental results show that the method, which has the benefit of being acceptable for real-time applications, produces results comparable to and even better than the more complex state-of-the-art procedures.

[10]K. He, J. Sun, and X. Tang, [16] proposed a novel explicit image filter called guided filter. Derived from a local linear model, the guided filter computes the filtering output by considering the content of a guidance image, which can be the input image itself or another different image. Like the well-known bilateral filter [1], the guided filter can be employed as an edge-preserving smoothing operator, but it behaves better near edges. Beyond smoothing, the guided filter is also a more general notion because it may pass the guiding image's structural information to the filtering output, opening up additional filtering applications like dehazing and guided feathering. Furthermore, the algorithm for the guided filter is fast and roughly linear in time, independent of the kernel size and intensity range. One of the quickest edge-preserving filters available right now. Experiments show that the guided filter is both effective and efficient in a great variety of computer vision and computer graphics applications, including edge-aware smoothing, detail enhancement, HDR compression, image matting/feathering, dehazing, joint up sampling, etc.

METHODOLOGY:

Methodology The genuine force can be restored by conducting thorough guidance and transmission assessments. Due to variable nonlinear planning capabilities, the details of each remaining layer change. Our findings show that employing shading improved reproduction, many sorts of foggy photos perform remarkably well. The suggested approach is entirely appropriate for routine picture quality checking. Furthermore, we provide an assessment of the geometric (direct odometry) and semantic (segmentation) vision-based robotics applications at the application stage.

i. Pre-processing:

Pre-processing steps frequently involve performing picture operations like image augmentation, image normalisation, and noise removal. Image enhancement is the process of adjusting an image to make it better suited for visualisation or deeper study. Examples in further detail include removing noise from the image, sharpening the image, adjusting the intensity of the image, or making object detection (image segmentation) simpler. There are numerous ways to achieve these objectives.

Small items in the image can be eliminated, and uneven background illumination can be corrected, using morphological operators as a filtering technique. Using a structural element with a variable size and shape, the filtering may be carried out. The removal of larger objects is facilitated by larger structural elements as opposed to smaller ones. After removing all objects from the image, the background intensity can be measured and deducted from the original image in order to adjust for non-uniform background lighting. The elimination of noise from photos is one application of median filtering. By tying the output pixel value to the median of the adjacent input pixels, the median filtering method achieves its desired results. Due to their extreme distance from the median value of their nearby pixel values, outliers in the pixel values are eliminated using this method.

A contrast adjustment to the image may be made using histogram equalization, also known as image normalization, to ensure that the image's intensity values cover the whole intensity range. Further, the sharper contrasts between the bright and dark parts are made possible by the wider range of intensity values.

It is also conceivable in the field of picture acquisition to see periodic noise in the photographs, which often results from interference from electrical and/or electromechanical sources that have an impact on image capture. It is required to ascertain the parameters of the periodic noise in order to eliminate it. The Fourier spectrum of the image is often examined to evaluate these. When the frequency spikes from this periodic noise are strong enough to be easily seen, automated analysis can be used to reduce the difficulty of finding the input parameters.

ii. Box Filtering:

Essentially, box filtering is a form of pixel-average image processing. In reality, it is a convolution filter, a type of mathematical operation frequently used for image filtering. One way to multiply two arrays to create a third one is to use a convolution filter. To obtain the filtering result in box filtering, multiply the picture sample by the filter kernel.

As depicted in the accompanying diagram, the filter kernel's minimal standard size is 3x3. No filtering will be applied to the image's four sides since the filter kernel must fit within the sample image's boundaries.

According to the single scattering atmospheric model [1], an image captured in turbid environments can be expressed as $I(x) = J(x)t(x) + A(1 - t(x))$.

A is the overall ambient light, J is the haze-free image (scene radiance), x is a pixel, and indicates the light attenuation caused by the scattering medium. For single picture dehazing research, this is the model that is most frequently used [5, 12, 2, 3, 18]. The scene radiance J is reduced when the optical thickness (d(x)) rises and is displaced by additional ambient light A. Attenuation of individual pixels and deterioration of contrast (detail), which is quantified by the strength of the image gradient, are directly impacted by this process.

iii. Multi-Band decomposition:

Initially, multi-scale guided filters are used to breakdown the input image [16]. Common values were reused in order to increase computational efficiency, and recursively updated parameters for smoothing scales = 1, 2, , n were used. With more subscribers, the smoothing becomes more intense (1 is the smallest scale and n is the greatest scale). A guided filter with an i-smoothing factor is represented by the function F. The filtered and leftover photos of each band are shown as

$$G_i = r_{ei}(I) = a_i I + b_i$$

$$R_i = G_i - G_{i+1} = (a_i - a_{i-1})I + (b_i - b_{i-1})$$

G and R stand for the filtered image and residual image of each layer, respectively. The

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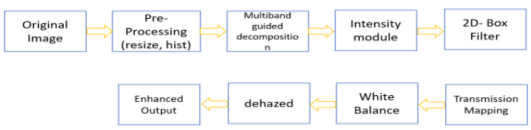
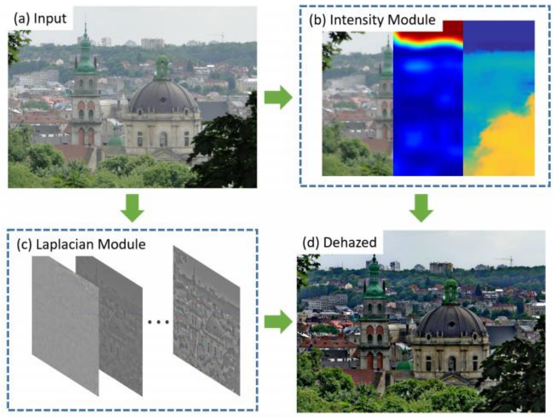
linear and constant maps of the guided filter are a and b [16]. To denote the associated smoothing factor i in this investigation, subscription i is used. According to this strategy, i+1 = 10i is used to determine the relationship between neighbouring smoothing components. It is possible to create multi-band residuals R = R1, R2, , Rn1 using super-positioning since a guided filter is a linear operation on the input image. Additionally, the base layer is chosen as the final filtered picture Gn that has the highest smoothing factor applied to it. The base layer is a low-pass filtered image, and each leftover image can be thought of as a band-pass filtered image. Module B. Intensity The suggested solution uses locally optimised dehazing to restore intensity levels. To quickly estimate ambient light, we first create an ambient map. Each block's initial transmission is optimised while taking information loss considerations into account. Using previously computed guided filter values, the transmission is further adjusted at the pixel level when block-based transmission estimation is finished.

iv Transmission mapping:

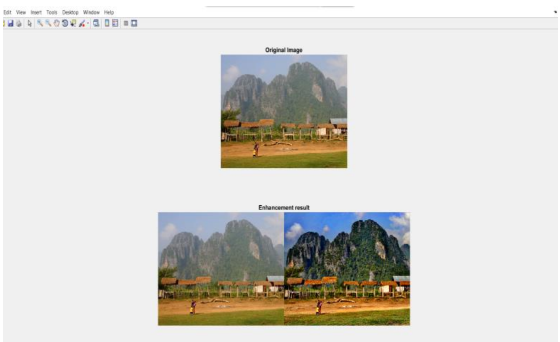
Not only should details be improved, but artefacts should also be suppressed by a mapping function. Halo artefact along a textural border is the main limiting factor for local filters, including bilateral filters and guided filters. By reducing prominent valleys in residual pictures, nonlinear functions aid to reinforce intermediate regions and diminish protruding regions. Reconstruction and correction (D) The reconstruction method is described here. It's feasible to recreate the final enhanced photos after processing the multi-band layers. A color-corrected dehazing method is the first step of the final step.



Proposed Block diagram



Proposed Flow



Original image and Enhancement Result

IV RESULTS

Comparative qualitative and quantitative analysis was used to assess the proposed method. First, the resulting images' single image quality was carefully evaluated against other approaches. In order to do a high-level evaluation, the research approach was put to the test against well-known computer vision algorithms such semantic segmentation and direct visual simultaneous localization and mapping (SLAM). We examined three multi-band layers in the trials with a scale factor of 1 = 0.0001 as the least. We decided on patch size 20 20 since the patch sizes 10 to 30 produced generally satisfactory results. Only three variables were required, and they were determined based on empirical data: smallest scale factor, number of scales, and patch size.

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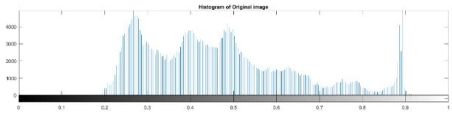
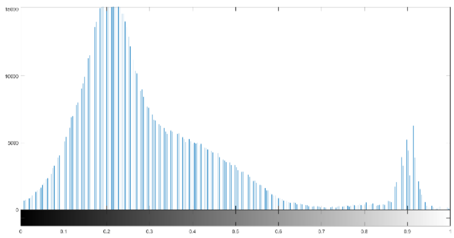


Original Image Histogram

Transmission map result



Dehazed Image Histogram

Original image compared to enhancement result

Input and output parameters for the images before enhanced and after enhanced are represented in this table

PARAMETERS	INPUT PARAMETERS	OUTPUT PARAMETERS
Mean	0.5156	0.3279
Standard Deviation	0.1225	0.2118
Entropy	6.9004	7.3713
RMS	0.5262	0.3775
Variance	0.0114	0.0364
Elapsed Time	1.656854 seconds	1.657029 seconds

V DICUSSION / LIMITATIONS

i. semantic segmentation performance:

By performing semantic segmentation on a popular vision application, the suggested strategy was also assessed. The evaluation's main goal was to determine whether the dehazing approaches' process for enhancing details produced segmentation results that were on par with those of a clear image. The evaluation used artificially created foggy photos created from the publicly accessible CITYSCAPES dataset [24]. Using MONODEPTH [25] for dense depth map estimate, realistic fog was added to clear photos. Foggy photos were produced after the depth map estimation. The network that was put through its paces was PSPNet [22], which achieved the third-best results in the CITYSCAPES benchmarks for the pixel-level semantic labelling job.

ii. Image alignment (Image consistency):

DSO was used to verify the suggested technique utilising the direct image odometry algorithm. Since direct odometry uses pixel intensity and gradient directly, the evaluation findings in this section describe the impact of restoration consistency and details on the image alignment problem. ICL-NUIM, an RGBD dataset [23] with ground truth depth and trajectory, was used to create hazy indoor photos. The evaluation made use of the OFFICE 2 sequence. The proposed method gives comparable intensity and detail levels for each frame, unlike the methods of [8] and [5], which deliver different levels for subsequent frames. The trajectory estimation takes the image consistency into account. The trajectory that was produced using this method was the most accurate. We discovered that the performance of trajectory estimation was considerably impacted by the colour and intensity changes in sequential frames. Additionally, unnatural augmentation of flat sections (such as the circular pattern in [8]) may result in tracking misses or failures. D. Invariance of the Channel The study also aimed to create a channel invariant picture enhancing technique. Images in both colour and grayscale were used to assess channel invariance. Two colour images—Road and Underwater—were chosen for this exam.

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The transmission and dehazing outcomes of the colour photographs were compared with the grayscale versions of the photos. Images in grayscale are comparable to those in colour. Despite the fact that transmission with a grayscale image may be less precise than with a colour image, it should be noted that intensity restoration was accomplished regardless of the image channel with enough relevant mappings.

In MATLAB, the proposed task was developed and put into practise. Work on the project's parameters, such as mean, standard deviation, entropy, RMS, and variance, more precisely will provide further assurance.

VI CONCLUSION

In conclusion, comparative analysis—qualitative and quantitative—was employed to evaluate the suggested methodology. First, the single picture quality of the produced images was carefully compared to that of the existing approaches [10, 5, 11, 6, 3, 14, 8, 7]. For high-level evaluation, the methodology utilised in this work was compared to well-known computer vision methods, such as semantic segmentation and direct visual simultaneous localization and mapping. (SLAM). We examined three multi-band layers with the least scale factor 1 = 0.0001 in the trials. The patch sizes 10 to 30 yielded really good results, so we settled on patch size 20. Patch size, number of scales, and smallest scale factor were the only three necessary and empirically chosen criteria.

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