Image Dehazing

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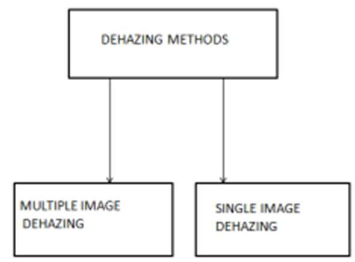
***Abstract*— Images captured in dense, hazy, foggy atmospheric conditions or in a surrounding filled with impurities, are exposed to deterioration of the captured image which reduces the contrast, changes the color, and makes the object features difficult to identify by human vision and by some outdoor computer vision systems too. This paper analyses the enhancement in the visibility of a single degraded image. The single image is processed to give two or more images of different characteristics and features. The information from these images is used to generate a solitary image with more accurate information of the scene than the original images. To maintain the important features and information of the image for good visibility regions, three parameters are used as filters; namely Luminance, Chromaticity and Saliency. The resultant images are then normalized and weighed to reduce the unwanted attributes followed by Laplacian and Gaussian Pyramid Representation. The resultant image eventually is improved as compared to the resource images.**

Keywords*— *Multi-Scale Fusion, Image Dehazing, Gaussian Pyramid, Laplacian Pyramid, MATLAB.

I. Introduction

Images which are of inferior quality or have deteriorated due to bad atmospheric conditions are very difficult for human as well computer vision and processing. Images may loose their quality due to bad atmospheric conditions, foggy weather or haziness. Haze is an atmospheric phenomenon in which dust, smoke, and other dry particulates obscure the clarity of the sky. Most of the impurities in air ranges below 1000m. Haziness constitutes of "Airlight" and "Direct Attenuation". Images which are captured outside or under the influence of sunlight in poor atmospheric conditions are prone to unwanted radiance. This unwanted radiance in addition to the unwanted light coming from all directions is call Airlight. This adds unwanted whiteness to the image. Direct Attenuation is the gradual loss of intensity in the image which causes decay in the color of the image. Haze leads to failure of many computer vision/graphics applications as it diminishes the scene visibility. Apart from that, many automated systems mostly relied on the definition of the input images, fail to work efficiently due to degradation of images. To improve these images and correct the inconsistencies of the image, Image Dehazing is used. Haze removal or Dehazing is highly required in computer vision applications and in computational photography. Removing the haze layer from the input hazy image can significantly increase the visibility of the scene. The haze-free image is also pleasing to view. Image Dehazing also plays a dominant role in many image processing applications. Image Dehazing is mainly of two types, i.e. Single Image Dehazing and Multiple Image Dehazing.



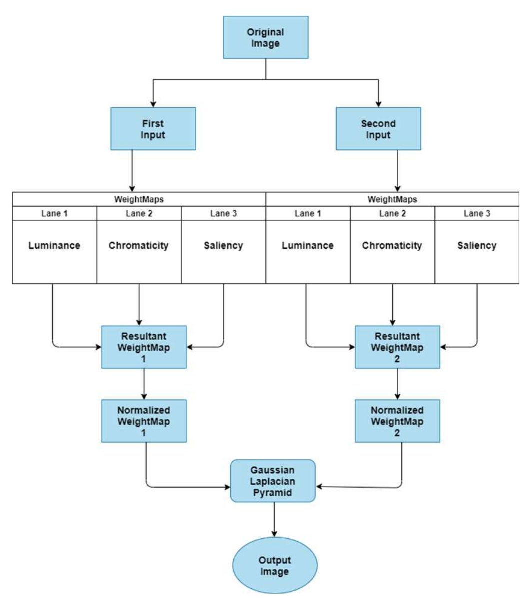
In Single Image Dehazing, a Single Image of the scene is taken while in Multiple Image Dehazing two or more Images of a scene are taken. Here, Single Image Dehazing is explored.

Two distinct foggy images are obtained from a single image with the use of white balance and contrast enhancing procedure. These images are then used to derive a fusion-based strategy to obtain an image of amended quality.

Here we explore a single-image based strategy that is capable to precisely dehaze images using only the unique degraded information in MATLAB R2018b. MATLAB is an amazing software for image processing and dehazing owing to it's ease of use and amazing functionalities.

II. Procedure

The Procedure is divided into mainly 6 steps:



A. Converting Single Image to two Images:

There are two main complications in the original image, color cast and lack of visibility. Color cast is a tint of a particular color, usually unwanted, that evenly affects a photographic image in whole or in a part. It can be introduced due to the influence of airlight. The lack of visibility into unwanted regions due to dust and dilution is the second complication.

The first input is obtained by correcting the white balance of the original image which helps in improving the color cast complication. This is achieved using the Gray World Assumption for color balancing. Gray World is among the simplest estimation methods. The main premise behind it is that in a normal well color-balanced image, the average of all the colors is a neutral gray. As a result, we can estimate the illuminant color cast by looking at the average color and comparing it to gray. Considering the RGB color system consisting of three colors or components i.e. Red, Green and Blue, each component has a specific integer value between 0 to 255 which makes 1,67,77,216 colors possible. The average of these values is taken and compared to the values neutral of neutral gray.

The second input is obtained by correcting the contrast of the image which significantly helps in obtaining a better-quality global visibility mainly in cloudy or foggy regions. This is done by using the RGB to Luma conversion formula which gives the standard Luminance of an image.

However these inputs taken alone still suffer from poor visibility. Therefore, to effectively blend the information and features of the derived inputs, we filter their key features in a per-pixel manner by calculating their weight maps.

B. Calculating Weightmaps:

Weight maps are properties of point clusters on geometric objects. They associate each point in a cluster with a weight value. Each cluster can have different weight maps so, you can modulate different parameters on different operators in different ways. In this project, the derived inputs are weighed by three normalized weight maps namely Luminance, Chromaticity and Saliency. Luminance is the apparent brightness of an object that appears to the human eye. In simple words, luminance is the intensity of the emitted light from a surface per unit area in a particular direction that can be considered for its definition. It provides the amount of light that passes through, is reflected, and falls within a given solid angle. Chromaticity is an objective specification of the quality of a color regardless of its luminance. Chromaticity consists of two independent parameters, often specified as hue and colorfulness, where the latter is also called saturation, chroma, intensity, or excitation purity. Saliency of an image is the prominent features of the image. A Saliency map is an image that shows each pixel's unique quality. Using these properties, the three wight maps of the two derived inputs are obtained.

- Equations:

Luminance measures the visibility at each pixel by assigning low values to regions with low visibility and high values to regions with good visibility. This weight map is given by the following equation:

$$W_L^k = \sqrt{1/3[(R^k - L^k)^2 + (G^k - l^k)^2 + (B^k - L^k)^2]}$$

Here, k indexes the derived inputs, R, G and B represent the color channels of the derived inputs and L represent the luminance.

Chromaticity is the weight map assigned to control the saturation gain in the output image and thus increase its colorfulness. It is given by the equation:

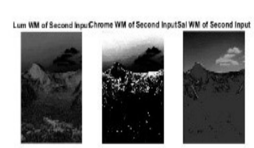
$$W_C^k(x) = \exp\left(-\frac{(S^k(x) - S_{max}^k)^2}{2\sigma^2}\right)$$

Here, default value of σ (i.e. standard deviation) is 0.3, S is the saturation value of the derived input and Smax is the maximum of the saturation range (equal to 1 for higher saturated pixels).

Visual Saliency is that quality of an image which highlights the presence of an object, or rather a pixel with respect to its surrounding, thus grasping our attention. Here, the saliency algorithm of Achanta et al. is used for saliency computation. The equation for the same is given as:

$$W_S^k(x)\left\|I_k^{\omega_{hc}}(x) - I_k^{\mu}\right\|$$

Where I_k^{μ} represents the arithmetic mean pixel value of the input and $I_k^{\omega_{hc}}$ is the input image's blurred version to exclude the high frequency components



C. Calculating Resultant Weight Map:

The resultant of the three weight maps of each input is calculated with the help of vector multiplication. Hence, we get two resultant weight maps i.e. resultant weight map 1 and resultant weight map 2.

D. Normalizing the Resultant Weight Maps:

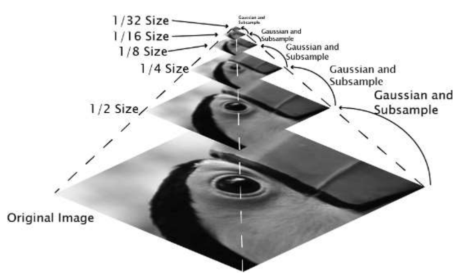
In Image Processing Normalization is a process that changes the range of pixel intensity values. The purpose of dynamic range expansion in the various applications is usually to bring the image, or other type of signal, into a range that is more familiar or normal to the senses, hence the term normalization. Often, the motivation is to achieve consistency in dynamic range for an image. After Normalizing the two resultant weight maps, we obtain two normalized weight maps.

E. Gaussian Laplacian Pyramid:

A haze-free image is obtained with multi-scale fusion using Laplacian Pyramid representation of inputs merged with the Gaussian representation of the normal weights is applied.

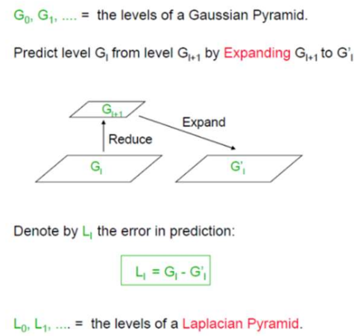
1) Gaussian Pyramid:

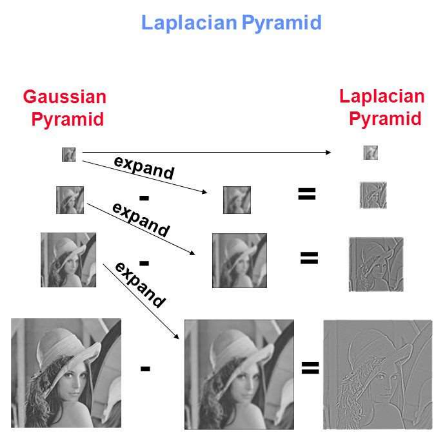
The main objective of Gaussian Pyramid is to decompose the images in order to obtain the information at multiple scales, to extract characteristics or structures of interest, to attenuate noise. The Gaussian Pyramid consists of the first layer as the original image. As the number of layers increases, the resolution of the image is reduced by applying a Gaussian Blur. This as a result forms a pyramid. The bottom layer of the Pyramid consists of the image with the highest resolution while the top layer comprises of an image with the lowest resolution.

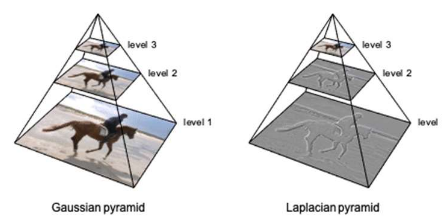


2) Laplacian Pyramid:

Consider G_i, G_{i+1}, … as the levels of the Gaussian Pyramid. The G_{i+1} level is expanded and the difference between the original G_i level and the expanded G_{i+1} level is calculated. This difference is the L_i level of a Laplacian Pyramid. The Laplacian filter provides a good framework for image detail enhancement and manipulation.







F. Output:

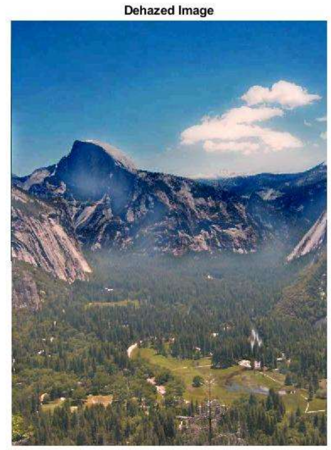
The Gaussian and Laplacian pyramid are then fused together using vector multiplication. The image pyramid is then expanded and reconstructed to obtain the dehazed image. This image is completely dehazed and can be used for various computer systems.

III. RESULT

The dehazing of an image using multi-scale image fusion takes two images as an input. These images are obtained from the original image. For obtaining the first input, the white balance of the original image is corrected using Gray World Assumption which discards unwanted color casts because of numerous illuminations. This also helps in improving image appearance. The second input is obtained by correcting the contrast of the original image for increasing the visibility as only correcting white balance doesn't prove enough. This enhances the contrast of the regions that undergo on the account of airlight influence. The regions with good visibility are then preserved using weight maps. This is very useful for feature extraction. A pyramidal representation is then used for elimination of unwanted features. Per-pixel manipulation is performed by strategic scheme. The outcomes of the experiment shows that the obtained image is dehazed and efficient for various application of computer vision and many more.

IV. CONCLUSION

This paper has successfully shown that images deteriorated due to haziness and cloudy atmosphere or fog can be successfully improved and enriched to a great extent using manipulating fusion-based strategy. These images have considerably enriched visibility and distinct features. They can now be efficiently used in many computer vision systems. Image dehazing has an extensive use in the field satellite imagery. It has also proved helpful in enriching images of various geographical terrains which have undergone extensive deterioration due to haze.



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