Effective Single Image Dehazing by Fusion

03CS6902 Mini Project

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C E R T I F I C A T E

This is to certify that, this report titled ***Effective Single Image Dehazing by Fusion*** is a bonafide record of the work done by

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student, for the course work in **03CS6902 Mini Project**, under our guidance and supervision, in partial fulfillment of the requirements for the award of the degree, M. Tech. Computer Science & Engineering (Image Processing) of **APJ Abdul Kalam Technological University**.

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SHIJJNA T.

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Abstract

This project is an attempt to implement an effective fusion-based technique to enhance both day-time and night-time hazy scenes. The implementation is based on Dark Channel Prior along with a Fusion followed by a local airlight estimation. The outdoor images captured in inclement weather are degraded due to the presence of haze, fog, rain and so on. Images of scenes captured in bad weather have poor contrasts and colors. This may cause difficulty in detecting the objects in the captured hazy images. Due to haze there is a trouble to many computer vision applications as it diminishes the visibility of the scene. In image processing area haze removal is one of the challenging problem or task as because the haze is dependent on unknown depth. For a single input hazy image the haze removal problem is under constrained problem. Therefore many researchers adopted the method in which they have considered multiple images or additional images. There exists some methods for dehazing and these are based on the partial estimation of atmospheric light. Above methods are not worked when the scene objects are inherently similar to the atmospheric light and no shadow is cast on them (such as the Snowy Ground). So in this project I am trying to find a new solution for image dehazing by fusion such that it may give better result for both day and night time hazy scenes.

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Chapter 1

Introduction

1.1 Single Image Dehazing by Fusion

The pictures captured in the presence of haze are often degraded. Haze is caused by scattering of sunlight from various particles present in the air. Therefore Outdoor images often suffer from poor visibility introduced by weather conditions, such as haze or fog, this results in poor visibility of the image which is the common problem in many applications of computer vision.So there is many methods are introduced for haze removal or dehazing.
In earlier or first versions of image dehazing is done by multiple images of the scene and polarization methods. For a single input hazy image the haze removal problem is under constrained problem. More recently, several techniques have introduced solutions that do not require any additional information than the single input hazy image. We required different techniques for dehazing day time hazy scene and night time hazy scene. Thus the effectiveness of these techniques has been extensively demonstrated on daylight hazy scenes, they suffer from important limitations on night-time hazy scenes. This is due to the multiple light sources that cause a strongly non-uniform illumination of the scene in night time, and for day scene the white light presence is more and posses mostly a uniform illumination. We can say that the problem of dehazing of night-time scenes is more challenging.

1.1.1 Problem Statement

Implemention of a single image dehazing technique that work well for both day-time and night-time hazy scenes.

1.1.2 Proposed Solution

Single Image Dehazing Using Multi-Scale Fusion : Multi-scale fusion of the Laplacian with images dehazed using DCP along with a refinement and the corresponding weight maps.

Chapter 2

Report of Preparatory Work

2.1 Literature Survey Report

Image dehazing methods can be divided into three categories based on difference in dehazing principles, that are : image enhancement, image fusion based methods, and image restoration based methods. In image enhancement methods use image processing methods to improve contrast and details, and improve the quality of the degraded image. Image fusion based methods uses takes information from multiple source channel to form a final high quality image. In case image restoration methods are done by forming a image degradation model by the physical mechanisms and degradation process.

Dehazing methods can also divided as multiple images and single image dehazing methods. Earlier methods like using polarization filter are of multiple images and these methods also some additional information like depth. Then methods are turned into using single image input, without any additional information. One of most commonly used single image dehazing algorithm is Dark Channel Prior(DCP).

For a single input hazy image the haze removal problem is under constrained problem. More recently, several techniques have introduced solutions that do not require any additional information than the single input hazy image. While the effectiveness of these techniques has been extensively demonstrated on daylight hazy scenes, they suffer from important limitations on night-time hazy scenes. Obviously, the problem of dehazing of night-time scenes is more challenging. This is mainly due to the multiple light sources that cause a strongly non-uniform illumination of the scene. As a result, the night-time dehazing problem has been addressed only by a limited number of researchers, who introduced methods specific to night-time conditions.

Lets go through various dehazing method by different scholars and researchers.

2.1.1 Day-Time hazy scene condition

Tan uses the contrast maximization techniques to remove haze from an image. He assumes that a dehazed image must have a high contrast. Tan's single image dehazing method is mostly based on two basic observations: On the one hand, the images taken under a clear weather are always with enhanced visibility and high color contrast than those taken under bad visibility like foggy weather. On the other hand, airlight whose variation mainly depends on the distance of objects to the viewer tends to be smooth. Based on these two observations and the assumption that neighboring pixels

suffered from the same degradation, Tan removes the haze by maximizing the local contrast of the restored image. This method does not intend to fully recover the scene's original colors. Its purpose is to only enhance the contrast of an input image. This method only over-saturates the image visibility. Unfortunately this approach is physically invalid and makes Tan's dehazing image lacks color fidelity. Tan's method suffers from color fidelity
Fattal considers that the shading and transmission signals are uncorrelated. Based on this assumption, the airlight-albedo ambiguity can also be resolved. He used Independent Component Analysis (ICA) to estimate the transmission, and then deduct the color of the whole image by Markov Random Field (MRF). The method performs quite well for haze, but declines with scenes involving fog. This method is physically valid and capable to restore the contrasts of complex hazy scene. Moreover, since this method does not assume the haze layer to be smooth, the discontinuities in the scene depth or medium thickness are permitted. This assumption is sometime violated when the shading and transmission signals are correlated and deliver a poor dehazing result.
He in 2009 rely on the blackbody radiation use dark channel prior approach to remove haze from an image. The blackbody theory can be understood as a theoretical object that absorbs 100Namely in this case, such image's pixels are called dark pixel and their value must be very close to zero. In hazy images, the intensity of these dark pixels in that channel is mainly contributed by the air light. These dark pixels can directly provide an accurate estimation of the haze transmission. In the DCP approach soft matting method instead of MRF (Markov Random Field) is used to refine the transmission map. He et al, approach is physically valid and is able to perform with distant objects in heavily hazy images. Like any approach using a strong assumption, their approach also has its own limitation. This assumption sometime cannot perform well when there is no black body in some local patches. In another way, the dark channel prior is invalid when the scene object is intrinsically the same with the air light (e.g. snowy ground or a white wall) over a large local region and no shadow is cast on it. Although their approach works well for most outdoor hazy images, but it fail on some extreme cases. This is a profitable situation because in such situations haze removal is not critical since haze is rarely visible.
Ancuti described that the haze is the atmospheric phenomenon which degrades the visibility of the outdoor images captured under bad weather conditions. This paper describes the dehazing approach for a single input image. This approach is based on the fusion strategy and it has been derived from the original hazy image inputs by applying a white balance and contrast enhancing procedure. The fusion enhancement technique estimates perceptual based qualities known as the weight maps for each pixel in the image. These weight maps control the contribution of each input to the final obtained result. Different weight maps like luminance, chromaticity and saliency are computed and to minimize the artifacts produced during the weight maps, the multiscale approach uses the laplacian pyramid representations combination with Gaussian pyramids of normalized weights. As this approach tries to minimize the artifacts per pixel based has a greater improvement rather than considering a patch based method due to the assumption of contrast airlight in the patch.

2.1.2 Nght-time hazy scene condition

More recently, several techniques have been introduced to dehaze images captured in night-time conditions. Pei and Lee estimate the airlight and the haze thickness by applying a color transfer function, before applying the dark channel prior, refined iteratively by bilateral filtering as a post processing step.

he method of Zhang et al. estimates nonuniform incident illumination and performs color correction before using the dark channel prior. Zhang et al. introduce a prior that is specific to night-time. The paper builds on a nighttime hazy imaging model, which includes a local ambient illumination item. Then, it introduces a simple image prior, called the maximum reflectance prior, called the estimate the varying ambient illumination. In short, the prior assumes that, during night-time, the local maximum intensities of the color channels are mainly contributed by the ambient illumination. Santra and Chanda have proposed to extend the color-line prior introduced in R. Fattal, “Dehazing using color-lines,” to deal both with day and night-time

2.1.3 For both Day and Night hazy scene

Ancuti, C. O. Ancuti, C. DeVleeschouwer, and A. C. Bovik , introduced an effective fusion-based technique to enhance the visibility of hazy scenes both in day or night conditions. The technique presented here builds on their preliminary version, which was specific to night dehazing.In this extended version they generalize this solution to work effectively both on day and night-time hazy scene.

2.2 System Study Report

The images in outdoor scenes are generally degraded by different weather condition. Atmospheric phenomena like fog and haze may degrade the visibility of the scene significantly. We need to restore the image in the absence of the ground truth image, in a computationally inexpensive manner. Here comes the important for generating variety of image dehazing methods. The dehazed images are important role in outdoor video surveillance and the automated driving systems. Haze is one of the major problems at Metropolitan cities like Delhi. If we can easily and inexpensively restore the the degraded image, due to haze like weather condition, then it can use many outdoor image applications. The many of the image dehaze method limited to either day-time hazy scene or night-time hazy scene. Thus we require a effective single image dehazing technique that works wwll in both day and night hazy scene.Image fusion based methods maximize the beneficial information from multiple source channels to finally form a high quality image, without requiring a physical model. So the fusion methods incorporates the other dehazing techniques. By choosing appropriate weight maps and inputs, the fusion strategy can be used to effectively dehaze images.

2.3 Background Theory

Fog/Haze is the combination of Airlight and Direct attenuation. In haze image formation model the light intensity mostly calculated as a sum of direct transmission [D(x)] and airlight [A(x)] and the formation of hazy images is given as: or

$$I(x) = D(x) + A(x)$$

$$I(x) = J(x)T(X) + A_\infty(1 - T(x))$$

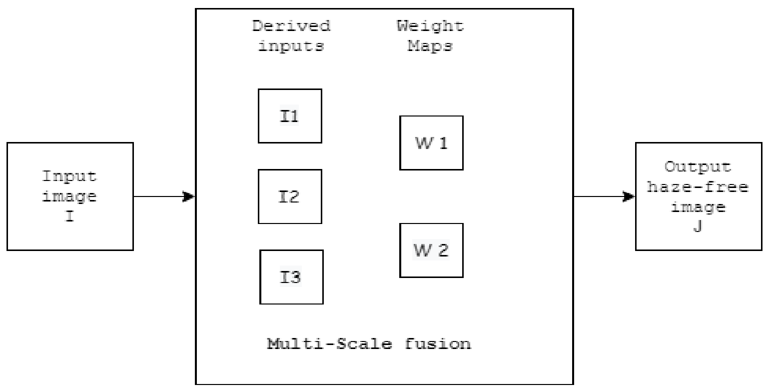
where J(x) is the scene radiance or haze-free pixel color, T(x) is the transmitivity along the cone of vision, and A_∞ is the atmospheric intensity, resulting from the environmental illumination.The haze free image can be derived from the equation :

$$J(x) = [(I(x) * A)/T] + A$$

Dark channel prior is basically used for single image dehazing method. It is used to measure the statistics of the outdoor fog free image. In this method assume that some pixels are having very low intensity in any one of the color channel. But in this case, take only that region which does not cover the sky. These pixels are known as the dark pixels. These dark pixels are used to estimate the transmission map. After the transmission map estimation refined transmission map is estimated to remove some blocky effect. The aim of this technique is to restore fog free image. Main advantages of this method are in this method Single image is used for restoration of foggy image and Transmission map is estimated accurately.DCP with guided filter method is introducing to overcome disadvantage produce blocky effects in the output image. Image dehazing will be done by combining dark channel prior and guided filter. Guided Filter is an edgepreserving smoothing operator. So it could remove halo artifacts effectively Dark channel is same as DCP method and atmospheric light is estimated based on the imaging law of very dense hazy regions. In this method transmission map is refined using guided filter. Refinement of transmission map is needed to remove the halo effects.

Chapter 3

Project Design



3.1 Main Algorithm

3.1.1 Main algorithm

step 0 : Input a hazy scenes (**I**)

Step 1 : Deriving Inputs for Fusion
  step 1.1 : Apply DCP on selected small patch size of I (I1)
  step 1.2 : Apply DCP on selected large patch size of I (I2)
  step 1.3 : Apply Laplacian filter on I (I3)

step 2 : Filter I1,I2 and I3 using weight maps.

step 3 : Multi-Scale fusion, using a Laplacian pyramid decomposition of the inputs and a Gaussian pyramid of the normalized weights.

Dark Channel Prior(DCP) Algorithm

step 1 : Find the dark channel

$$\min_{y\in\Omega(x)}(\min_{c\in r,g,b}(J^c/A^c_\infty) = 0$$

step 2 : find transmission T(x) ;

$$T(x) = 1 - \min_{y \in \Omega(x)} (\min_{c \in r,g,b} (J^c / A^c_\infty)$$

step 3 : Atmospheric Intensity Estimation using :

$$A^c_{L\infty}(x) = \max_{y \in \Psi} (I^c_{MIN}(y))$$

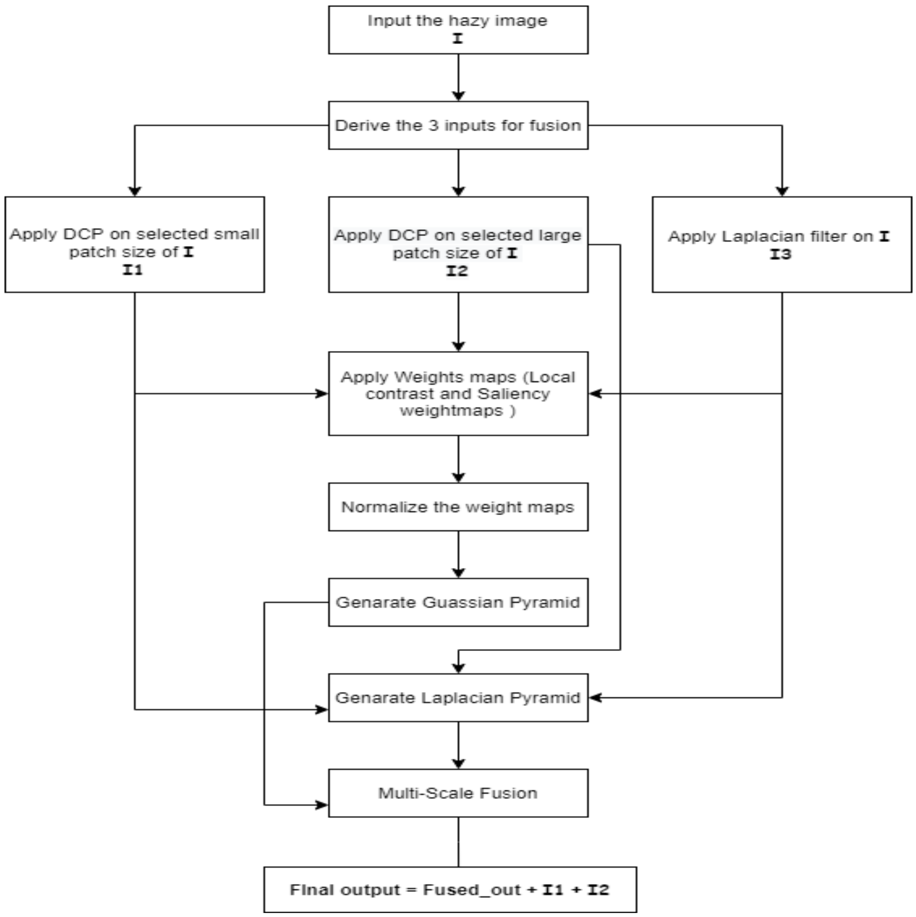
step 4 : find haze free image :

$$J(x) = ((I(x) - A)/T(x)) + A$$

3.2 Hardware & Software Requirements

Operating System : Windows 10
Supporting software : Python,Numpy,Opencv
Processor : Intel Core i5 10th GEN
RAM : 8GB

3.3 Flow chart

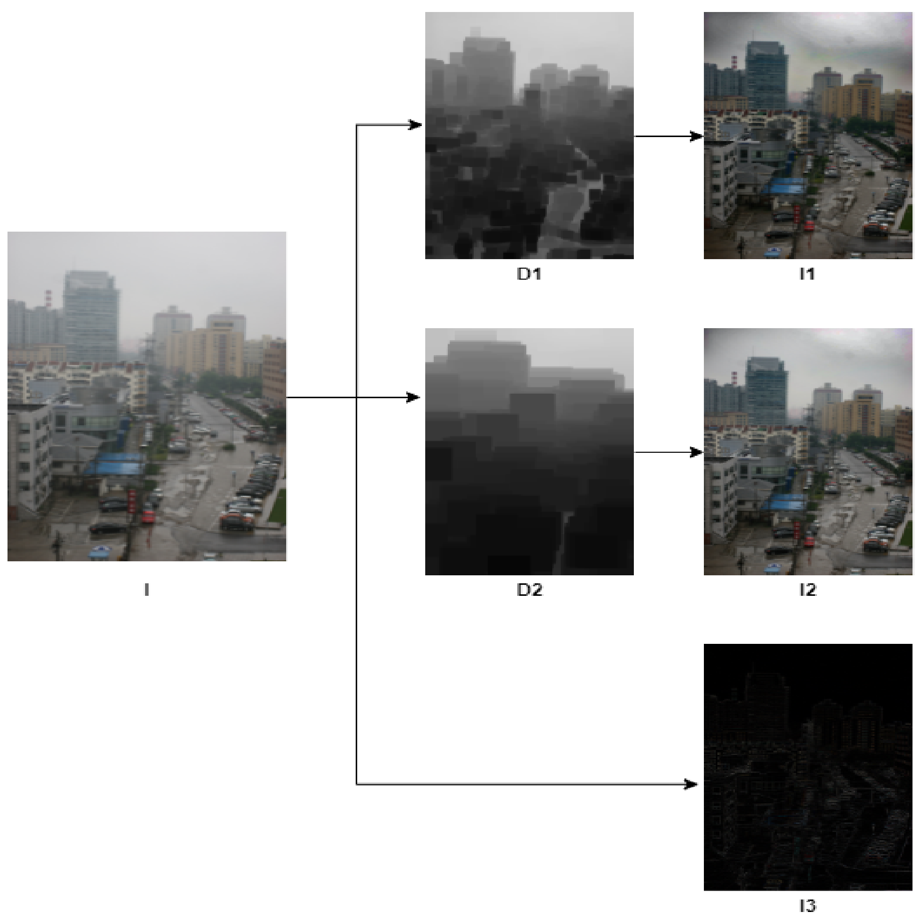


Chapter 4

Implementation

4.1 Generation of input images

Three inputs are genarated for the fusion. First input(**I1**) is computed by applying DCP alogorithm on small patch sizes(say, 20X20) and similarly second input(**I2**) generated by applying DCP in large patch size (say, 80X80) on the input hazy image. to rreduce the glowimg effect we take Laplacian of input hazy image as the third input(**I3**).



4.2 Generation of Weight Maps

The derived inputs alone cannot restore a haze free image and this necessitates the need for weight maps. Here 2 weightsmaps are used.
Local contrast weightis computed by applying a Laplacian filter to the luminance of each processed image.
Saliency weight map is computed as a difference between a Gaussian smoothed version of the input and its mean value.

4.3 Multi-Scale Fusion

The final step of this method is multi-scale fusion. In this process we fuse between the laplacian pyramid of the 3 derived inputs and Guassian pyramid of the normalized weight maps.
Initially, We compute the 3 weight maps for each of the inputs and then for each of the input we compute the normalized weight map as :

$$weightmap(i) = localconstrast(i) + saliency(i)$$

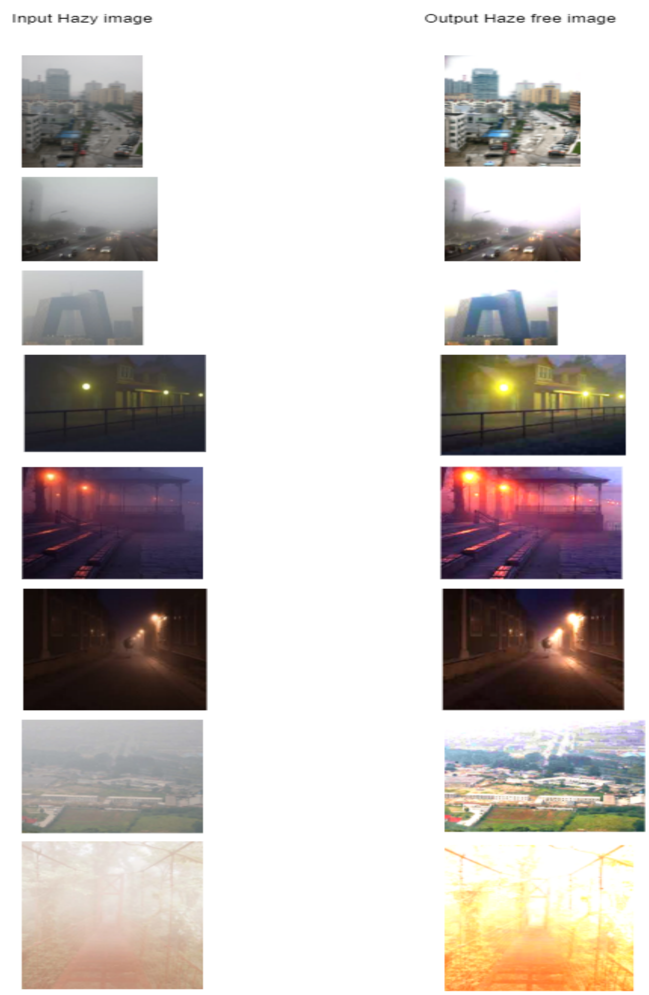
$$Normalizedweightmap(i) = weightmap(i)/(weightmap1 + weightmap2 + weightmap3)$$

For fusion considering that both the Gaussian and Laplacian pyramids have the same number of levels, the mixing between the Laplacian inputs and Gaussian normalized weights is performed at each level independently yielding the fused pyramid. The Gaussian pyramids are formed by forming the pyramid for each of the normalized weight maps and Laplacian pyramids are formed by forming the pyramid for inputs by applying the Laplacian operator.Then fusion of the Gaussian and the Laplacian pyramids of each of the inputs. As a final step of the algorithm fused final output is added with the first two derived ouputs (I1 and I2).

Chapter 5

Results & Conclusions

5.1 Results



5.2 Conclusion

In this work, implemented a simple version of single image dehazing technique by fusion, that work for both day and night hazy scenes. This work produce a good result for both day and night scenes with smaller haze. Also observed that the sky region in the day-time hazy scene become more brighter and for night time the single light sources are highlated.So here explained a image fusion technique that takes 3 dervied inputs from single hazy image. Two weightmap are applied to each input of the fusion and then it is normalized by by dividing the weight of each map by the sum of the weights of the over all maps. Then the Laplacian pyramid of each derived output and Guassian pyramids of each normalized weightmap are fused as a multi-scale fusion.

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