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Literature Survey: Single Image Dehazing Using Deep Learning Techniques

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ABSTRACT:

Bad weather conditions, such as fog and haze, can significantly degrade the quality of a scene captured by a camera. Practically, this is due to the substantial presence of particles in the environment that absorb and scatter light. In computer vision, the absorption and scattering processes are commonly modeled by a linear combination of the direct attenuation and the airlight. To overcome such problem image dehazing techniques was adopted. In classic techniques dehazing was done by using some prior knowledge, but this technique gives color distortion, artifact effect etc in the output scene. In this paper we have discussed different types of Convolutional Neural Network techniques (CNN) which are based on training of dataset and overcome the problem of classic techniques.

Keywords: Atmospheric map, CNN, Deep learning, Single image dehazing

1. INTRODUCTION

In many cases the images of outdoor scenes are degraded by the bad weather conditions. Haze, fog, and smoke are such phenomena due to atmospheric absorption and scattering may degrade the quality of the output scene. Since the aerosol is misted by additional particles, the reflected light is scattered and as a result, distant objects and part of the scene are less visible being characterized by reduced contrast and faded colors. Their radiance received by the camera from the scene point is attenuated along the line of sight. Furthermore, the incoming light is blended with the airlight [1]—ambient light reflected into the line of sight by atmospheric particles. The degraded images lose contrast and color fidelity, as shown in Fig. 1. As the amount of scattering depends directly on the distance of the scene points from the camera, the degradation is spatially variants. To overcome such problem image dehazing techniques come into existence. Earlier different prior based techniques were used but it gives halo artifact, color distortion etc. Therefore deep learning techniques such as convolutional neural network (CNN) is becoming quite popular due to its better output than prior based techniques. In this paper different types of CNN techniques based on single image dehazing is discussed below.

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Nayar and Narasimhan further modified scattering model as:

$$I(x) = J(x)t(x) + A(1 - t(x)) \quad (1)$$

Where J(x)t(x) = attenuation model,
A(1-t(x)) = degradation model,
J(x) = clear scene,
A = global atmospheric light,
t(x) = transmission value which denotes amount of light not scattered and reaches the sensor.
I(x) = observed hazy scene
Transmission map value is given by:

$$t(x) = e^{-\beta(\lambda)d} \quad (2)$$

Where β is scattering coefficient, d is scene depth

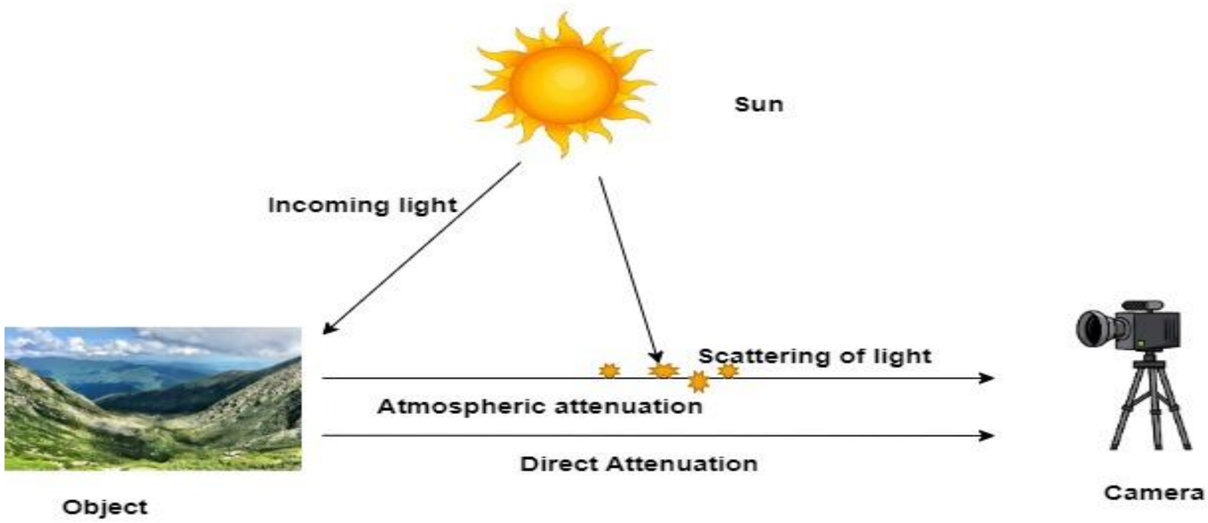

Fig.1: Scattering Model

2. Methodology

Convolutional neural network is based on training of dataset and different steps are discussed below [2, 3, 4]-

- *Convolution Operator:* Convolutional operator extract the dehazed feature from the input in the first hidden layer.
- *Second hidden layer:* In first hidden layer feature is not extracted, so to extract some high level feature it is passed to second hidden layer. Significant part is extracted by reducing the size of feature map. It contains 7 neurons in second hidden layer.
- *Third hidden layer:* It forwards the information in feed forward manner. It contains 8 neurons in third hidden layer.

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- *Pooling:* With down sampling factor of 2, CNN uses max pooling after each convolution layer.
- *Upsampling:* The size of the feature map is reduced to half after max pooling. Therefore upsampling is done to ensure the size of input hazy image and transmission map are equal.
- *Linearity:* For linear combination of the feature map in the hidden layer is done by using sigmoid activation function.

It is given by:

$$t_c = s(\sum_n w_n f_n^p + P) \quad (3)$$

Where t_c = output scene transmission map
n = feature map channel index
$s(.)$ = sigmoid function
f_n^p = feature map before the output of transmission map
w = weight
P = bias

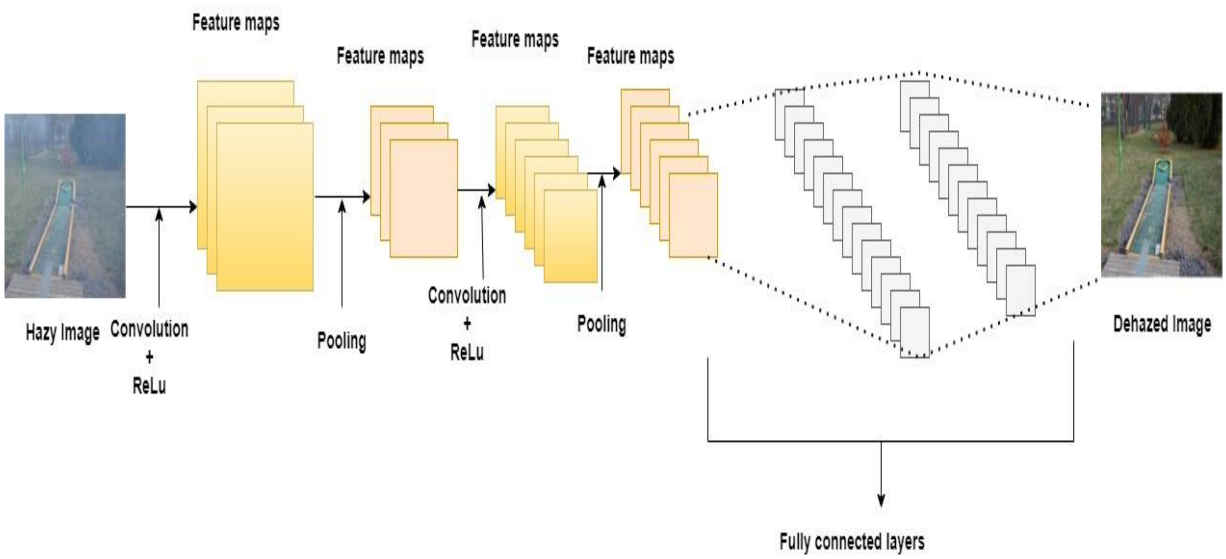

Fig.2: CNN block Diagram

3. Literature Review

In this paper literature review of different paper for single image dehazing using deep learning techniques are given below-

Ren, W., Liu, S., Zhang, H., Pan, J., Cao, X., & Yang, M. H. (2016, October). Proposed multi scale deep neural network for single image dehazing by learning mapping between hazy images and their corresponding transmissions map. The proposed algorithm which predicts a holistic transmission map by coarse scale network based on the entire image and results refine

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locally by fine scale network. Extensive experiments demonstrate that the proposed algorithm performs better than previous methods on both real and synthetic world Images in terms of speed and quality. This method fail for night time hazy image in future accurate estimation of atmospheric value and transmission map is required [2].

Li, J., Li, G. & Fan, H. (2018). Proposed a dehazing algorithm using residual based deep Convolutional Neural Network (CNN). This method has overcome the disadvantage of CNN. The network model is divided into two phases: in first phase, a haze image is input and estimates the transmission map of input image in the second stage the ratio of hazy image and transmission map is used as input, and the residual network is used to remove haze. It improves the efficiency of dehazing of image and estimation of atmospheric light is avoided. In future this method can be implemented on larger and realistic dataset with accurate prediction transmission map [3].

Rashidi, H., Zafar, N., Iqbal, M., I. & Dawood, H. (2018). Proposed single image dehazing method using CNN and outdoor filter are applied to find the haze in hazy image. Hazy image contains small value only in one color alpha channel from red, green and blue channel. The intensity of these pixels in color channel is mainly bestowed by air light depth map. To obtain a high quality dehazed image a low value of haze transmission map is estimated. To achieve a high quality dehazed image an end to end training model is used. This approach is applied on datasets containing 1500 outdoor images. To enhanced visibility in this method transmission map is also estimated. This method fails in thick haze and night time hazy image due to inaccuracy of estimation of atmospheric light [4].

Mondal, R., Santra, S., & Chanda, B. (2018). Proposed fully CNN which jointly estimate atmospheric as well as transmittance value. Bi directional consistency loss is designed to minimize error between restored image and haze free image. The main drawback is that performance of network affected by multi level training is still not investigated [5].

Liu, X., Ma, Y., Shi, Z., & Chen, J. (2019). GridDehazeNet uses three steps ie. Pre-processing, backbone and post-processing. The post processing uses CNN which train and generate learned input. The backbone module on a grid network implements a novel attention based multi scale estimation. The post processing module reduces artifact in the final output. The main disadvantage is that not used for non homogenous haze [6].

Yang, X., Li, H., Fan, Y. L., & Chen, R. (2019). A region detection network is proposed to learn in a patch wise manner relationship between hazy image and medium transmission map. The transmission map is then used to remove haze from image using an atmospheric scattering model to enhance the detail of de-hazed images. CNN consists of two types of network units which can be trained in an end to end manner. One network unit is module with the residual structure that facilitates the learning process of deep network. The other is a novel module

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cascaded cross channel pool, fuses multilevel haze relevant features and boosts the abstraction ability of the model on a non linear manifold. Moreover, an evolutionary based enhancement method is developed to improve the level of over smoothed results. In some case visual artifact may occur during image dehazing process [7].

Yang, Y., Hu, Z., Bian, K., & Song, L. (2019, April). An ImgsensingNet technique is used for forecasting and monitoring of air quality which uses UAV camera. It uses deep CNN and haze features for direct learning between hazy images and corresponding air quality index. ImgSensingNet has been deployed on two university campuses for daily monitoring and forecasting. The main advantage of this method is gives good inference accuracy [8].

Metwaly, K., Li, X., Guo, T., & Monga, V. (2020). Proposed deep network design, that directly estimate haze free image or haze model parameter such as atmospheric light or transmission map. It uses inverse haze model which uses DenseNet encoder and four distinct decoder to estimates transmission map along with atmospheric value. The main advantage is that uses for non homogenous image dehazing. The main disadvantage is that cannot be used for dense haze [9].

Park, J., Han, D. K., & Ko, H. (2020). Proposed heterogeneous adversarial network fusion for outdoor dataset. This technique consists of fusion of cycle generative adversarial network (GAN) and conditional GAN. Cycle GAN train outdoor dataset and gives clear output while conditional GAN preserve texture detail. This techniques work well for both synthetic and real world in future need to work for dark images [10].

Ren, W., Pan, J., Zhang, H., Cao, X., & Yang, M. H. (2020).Proposed the image dehazing problem via multi scale deep network which learns effective feature to learn scene transmission better as compared to traditional for a single hazy image. In multi scale model, a holistic estimation of the scene transmission is learned by coarse scale network and then to refine it use a fine scale network using local scale information from the output of the coarse-scale network. In addition, used holistic edge guided network to ensure that the objects should have the same transmission value for same depth. The result shows that this method does not work well for thick haze and night time hazy image in future better prediction of atmospheric light is needed [11].

4. Result and discussions

In this paper, deep learning techniques such as CNN and Fully CNN for single image dehazing are implemented as shown in figure 3 using python. Assessment of output of dehazed scene is done by using peak signal to noise ratio (PSNR), Structural Similarity Index Measure (SSIM) and Ciede2000. PSNR and SSIM values depend directly on the quality of output scene. PSNR

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and SSIM value is calculated with the help of ground truth or reference image. Ciede2000 value is inversely proportional to the quality of output scene.

Output scene

a. Hazy image

b. Ground truth image

c. CNN

d. Fully CNN

Fig. 3: Output of CNN and Fully FCN using single image dehazing techniques

Techniques	PSNR	SSIM	Ciede2000
CNN (Rashidi et al.)	28.14	0.52	2.38
Fully CNN (Mondal et al.)	28.17	0.59	2.64

Table.1: PSNR, SSIM and Ciede2000 value using CNN and Fully CNN techniques

Techniques	Advantages	Disadvantages
Multi scale CNN (Ren et al.)	• It refine transmission map for better output.	• Fail for night time hazy image and thick haze.
CNN (Rashidi et al.)	• Do not cause halo artifact.	• Slow processing speed. • Do not give better result for

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		dense haze and non homogenous haze.
ImgSensingNet (Yang et al.)	• Do not cause halo artifact.	• Causes color distortion.
Fully CNN (Mondal et al.)	• Fast processing speed. • Give good quality of output for real scene also.	• Do not give better result for dense haze.

Table.2: Comparison of different deep learning techniques for single image dehazing

5. CONCLUSION

In this paper different types of Convolutional Neural Network for image dehazing techniques are discussed. Classic single image dehazing techniques are based on some prior assumption or knowledge. This technique usually gives distorted, halo artifact output. To overcome such problem Convolutional Neural Network (CNN) adopted which gives better result than prior based techniques as it is based on training of dataset. CNN techniques are further modified to give better result. In case of dense haze, night time dehazing is still a challenging problem for single image dehazing techniques based on deep learning.

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