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A Review of Methods of Removing Haze from An Image

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ABSTRACT- A literature review aids in comprehending and gaining further information about a certain area of a subject. The presence of haze, fog, smoke, rain, and other harsh weather conditions affects outdoor photos. Images taken in unnatural weather have weak contrast and poor colors. This may make detecting objects in the produced hazy pictures difficult. In computer vision, scenes and images taken in a foggy atmosphere suffer from blurring .This work covers a study of many remove haze algorithms for eliminating haze collected in real-world weather scenarios in order to recover haze-free images rapidly and with improved quality. The contrast, viewing range, and color accuracy have been enhanced. All of these techniques it is used in countless fields. Some of the applications that use this technology outdoor surveillance, object recognition, underwater photography, and so on.

Keywords: Methods of de-hazing, outdoor images, De-hazing, and AOD-Net.

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1. INTRODUCTION

Machine learning is as versatile as character recognition and categorization[1] . And with the tremendous development taking place using deep learning in the medical field in particular, and the techniques of society in general [2, 3]. Images of outdoor settings are generally degraded by air particles. As a result, there is a difference in the color and contrast of the photograph captured in unusual weather conditions. What causes haze to form? Haze is caused by suspended atmospheric particles in the air. This one is caused by desert areas, fires, or fumes generated from vehicle pillars or factories. Because the haze is mostly white, the color clarity of the images will suffer as a result. The light rays acquired by the camera from the object are transported along the line of sight while obtaining an exterior image in an odd weather state. The entering light combines with the light from all other directions to form air light. The progressive reduction of intensity is the second component of attenuation. As a result, there is severe color degradation. The degree of dispersion depends on the object's distance from the imaging equipment. As a result, degradation varies spatially variable. Dehazing is extremely important in photography and computer vision applications, applications of suffer because of low-contrast scene radiation. For example, fog in images captured by satellites is a problem. There are many methods available to remove fog from the external appearance. The importance of dehazing lies in its use in many fields, such as surveillance cameras, self-driving cars, robotics and, other important applications in the modern world. Fog is made up of tiny particles suspended in the atmosphere. Because of those minutes, images taken with any imaging device are often dull in color. The reason for this problem is that these suspensions block some of the rays, and the problem is sure to increase with the increase in the diameters of these particles. As a result, the reflected light is dispersed, resulting in hazy pictures. These interactions are classified as scattering, absorption, and radiation, with scattering and light modulus playing major roles [4].

Figure 1: Image before de-hazing[5]

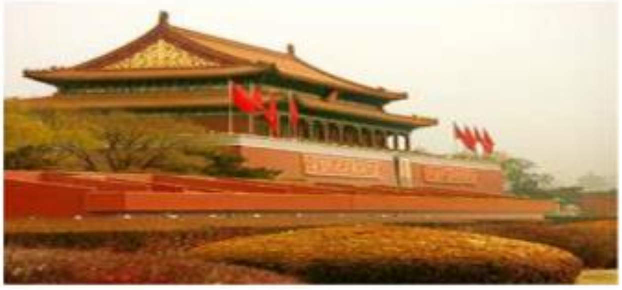

Figure 2: Image after de-hazing[5]

2. MODEL OF ATMOSPHERIC SCATTERING (ASM)

The physical description of dispersion is quite complex. Different, irregular, and heterogeneous suspended particles interfere with the reflected light, resulting in a considerable drop in light intensity throughout the propagation phase. Each particle of the fog particles of its various types acts as a wrecking factor for the paths of the incident and reflected light. Several factors affect this scattering. For clarity, (ASM) introduced in [6] was used to understand the generation of a hazy picture. McCartney initially developed the air scattering model to describe the creation of a hazy picture[7]. which is further developed by Narasimhan and Nayar [8] . ASM can be formally written as:

$$I(x) = J(x) * t(x) + A * (1 - t(x)) \,, \qquad (1)$$

Where I(x) is the observed intensity, J(x) is the intensity of light emitted by scene objects prior to scattering, t(x) is the scene transmittance, which represents the amount of light that reaches the observer after scattering, and A is the global light factor. Furthermore, t(x) is the median transmission matrix, which is defined as:

$$t(x) = e^{-\beta d(x)}, \qquad (2)$$

"Where β is the scattering coefficient of the atmosphere, and d(x) is the distance between the object and the camera"[9]. And the following *figure 2* shows (ASM).

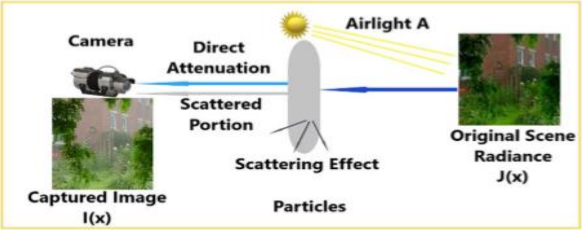

Figure 2: The atmospheric scattering model[10]

3. METHODS OF DEHAZING

In this paper, the methods of removing hazy are explained in general, and the focus is on the most important way currently used. It has witnessed tremendous development in recent years, namely, learning - based. Generally, the images produced by the last two methods prior-based and learning-based are having better details than those produced by the other ways. Image optimization is the principle on which the first three methods depend through mathematical modifications. These are the main ways to dehazing from a single image. It is of great importance, especially in surveillance devices (there may be more than one camera, but it takes pictures at the same time) and is considered a rather benevolent problem, in some special applications, especially the military. The last two methods are based on estimating specific values for defogging and reconstructing the image based on the estimation of these parameters, *figure 3:* Summary of ways to dehazing.

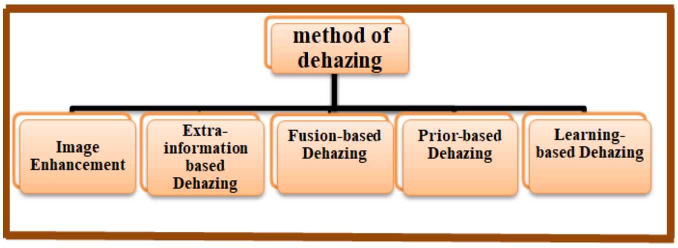

Figure 3: Summary of ways to de-hazing

3.1 Image Enhancement

Because cameras have trouble detecting scene depth, image haze reduction is generally considered an inherently challenging task. The most natural and straightforward method for remembering the visibility of buried sections is to use current image-enhancing algorithms [11-17] to restore the contrast of hazy images. Histogram equalization (HE)[11]. For example, improves the input image's overall contrast by increasing the color channels' dynamic range. In [18] adaptive histogram equalization (AHE) tackles the abovementioned issue, over-enhancement is possible and must be addressed because of its high processing complexity. They obtain better dynamic range compression and tonal rendition.

3.2 Dehazing Based on Extra Information

This method of dehazing is well renowned for its numerous photographs. Typically, Narasimhan et al. [6]developed dehazing way based on two images of the exact location taken under various weather circumstances. The initial input should include the infinite far-point and near-point, which is the foundation for employing this method. Oversaturation will be pushed into areas of small depth. Kopf et al. determined scene depth using geo-referenced digital terrain and urban models and then conducted haze reduction automatically [19].

3.3 Dehazing Based on Fusion

This approach[20-22] [23, 24] This technique works by creating more than one image for processing. First, an image is inserted and then enhanced; secondly, the original and the enhancer are combined to create an image with good restoration. The first processing is done by using faded color and contrast enhancement. This results in two copies of the image, but with different features. Finally, these two images are merged without fog using a pyramid representation of the cyan. They proposed the perceptual color correction framework (PCCF) [22] and the STRESS enhancement framework [23],which does image dehazing from a single input.

3.4 Prior Based Dehazing

The basic idea of Prior-based Dehazing [25-45] is based on a hypothetical use of atmospheric dispersal model (ASM) linking and then reconstructing the hair removal problem as a cost-reduction problem. The effective contribution of the dark channel before (DCP) [27] allows us to instantly determine the thickness of the fog, allowing us to restore appreciable results by optimizing the original transmission with a soft mat (SM) [31]**.**This precedence cannot be fully applicable to conditions when scene brightness is naturally close to air light, and is one of the challenges. To increase the estimated transmission performance, a dynamic repair method [25], a DCP based on the I2 standard [25], and a mechanism based on Laplacian [23, 33]were developed to improve the quality of DCP. Gibson and others [35]Select hybrid DCP to avoid halo effects in the retrieved data. However, when the assumption of constant flight is violated, the reconstructed sky experiences a significant color tone change. [44]the transmission was estimated using the described cost function, which consists of nodes and information loss conditions. The effect of epilation can be changed manually by adjusting the parameter included in the function. Unfortunately, the quality of the recovery cannot be guaranteed due to the unspecified dispersion coefficient. Only one image is required for haze reduction; transmission map is precisely approximated as only benefits. For Airtight estimation, it is necessary to assume that only 0.1 percent of the brightest pixels are used. It creates some Halo effects in the final photographs. One of the problems with this method**,** when the scene item is comparable to Airtight, such as automobile headlights, snowy ground, etc., this approach is incorrect.

3.5 Learning Based Dehazing

The last category is deep-learning-based approaches [25, 27, 30-33, 46-49] . Using the advancements in DL theory, dehazing may be accomplished by integrating or learning many haze-relevant characteristics with the DL framework. For example, in [30],a (CNN)-based dehazing system named DehazeNet was developed by completely exploiting the existing picture priors. Subsequently, a multi-scale CNN (MSCNN) was introduced in [27]to improve recovery quality by learning additional valuable characteristics. However, in order to fix the artifacts in the predicted rough transmission, these techniques must employ a guided filter or a fine-scale net. To address this, Li et al. [31]developed the All-in-One Dehazing Network (AOD-Net) to immediately restore the haze-free outcome without the requirement for transmission estimation. In [31], Learning confidence maps for three inputs processed from the original input were used to show a gated fusion network. This fusion network, like the second method for removing haze, lacks the capacity to restore haze-free scenes. In the next section, the types of methods that rely on supervised learning will be explained and we will consider the two networks most used in research today.

4. ML, DL AND CNN

Supervised dehazing models often require several forms of supervision input to assist the training process, such as transmission maps, atmospheric light, haze-free picture labels, etc. In theory, supervised dehazing algorithms may be separated into ASM-based and non-ASM-based ones. However, there may be overlaps because both ASM-based and non-ASM-based techniques can be used for segmentation, detection, and depth estimation. As a result, this section categorizes supervised algorithms according to their essential contributions so that the abilities useful for hazing research are visible[50].The development in machine learning techniques is a tremendous development. This development led to the expansion of ideas and techniques used in various fields, especially in the field of image processing[51]. The brilliance of these techniques increased with the emergence of deep learning during the past years. The use of deep learning is widely used, especially in convolutional neural networks, which have entered several fields. In medicine, it has been used in the classification of diseases, but its use in the field of regression is relatively recent.
This research focuses on the importance of deep learning in the field of image processing, especially the removal of blur. We mentioned above a set of ways to remove the ambiguity that suffered from challenges, and solutions. Unfortunately, no way can match human thinking, no matter how advanced the sciences are. Neural networks, especially convolutional networks, have inspired their techniques from human neurons. This study provided a fairly extensive explanation and understanding of networks. CNN, as it is known, consists of three layers. For CNN, there are three layers: convolutional, pooling, and fully connected. The types and number of layers of neural networks differ according to the different models and networks. We will take the two most important de-hazing networks based on CNN.

4.1 Dehaze-Net

This network is considered one of the networks that use the residual image after using one residual unit. To train the network at full speed, we use one residual unit and use batch normalization[52]. One of the reasons for accelerating network training, removing blur and improving its performance, is to use residual learning and batch normalization together, and they support each other. A hazy picture is fed into the network and the associated *figure (4)* residual image is produced. The objective is to reduce residuals to near-real residual levels for faster training and enhanced dehazing. Of networks that use residual learning and this shows the architecture of that network *figure (5)* this network is based on the physical model.

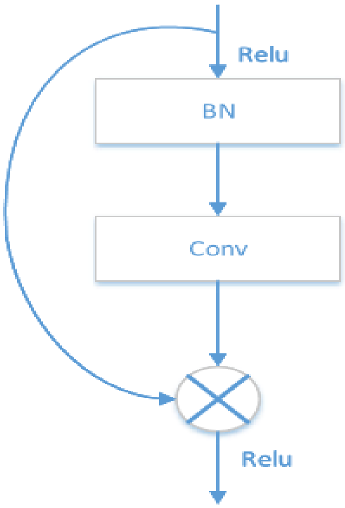

Figure 4: Shows Residual network element[52]

Physical model-based solutions improve the image's realism and bring it closer to the pre-degradation scenario. Although numerous approaches have produced good results, they are based on solid assumptions and need a variety of picture generation settings. Based on the standard dehazing model and the deep network approach, a novel algorithm is developed in this study to optimize the existing dehazing methods. DNN is built in two stages: We employ a CNN in the first stage to estimate the intermediate t(x); in the second stage, they use the results of the first stage to enter the ratio of the hazy picture to the t(x) into the residual network. Rather than providing the de-hazed image instantaneously, the residual network predicts the residual image, which is the difference between the hazy image and the prospective clean image. They are required to estimate the intermediate transmission map without accounting for atmospheric light to prevent the influence of incorrect parameters on network topology[52].

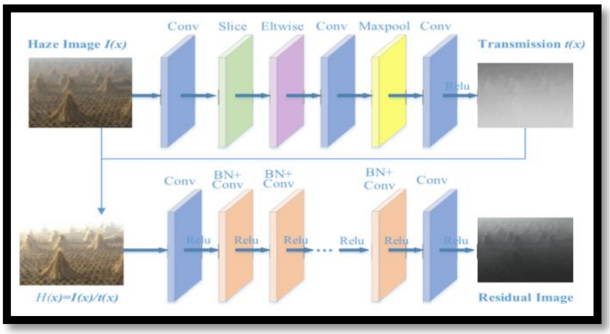

Figure 5: Structure of DehazeNet [52]

4.2 AOD-Net

one of important models is called AOD-Net.ASM can be included into CNN in a structured or embedded manner. AOD-Net[53] discovered that an end-to-end neural network may still be employed to solve the ASM without relying on ground truth t(x) and A. The expression of J(x) according to the original ASM is

$$J(x) = \frac{I(x)-A(1-t(x))}{t(x)} \qquad (2)$$

According to the original ASM, the dehazing picture J(x) is presented in (1).

$$J(x) = \frac{1}{t(x)} I(x) + A\frac{1}{t(x)} + A \qquad (3)$$

To avoid having to compute t(x) in the ASM, AOD-Net offered the K(x), an intermediate value with no physical significance:

$$K(x) = \frac{\frac{1}{t(x)}(I(x)-A) + (A-b)}{I(x)-1} \qquad (4)$$

Then comes the, just one parameter K(x) is required for the capture of the clear picture J(x):

$$J(x) = K(x)\, I(x) - K(x) + 1. \qquad (5)$$

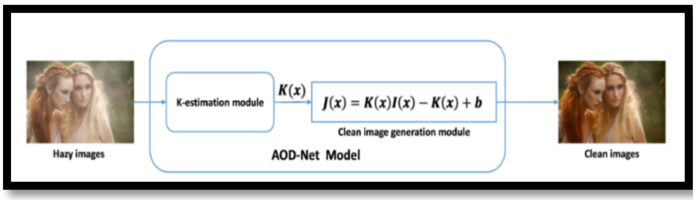

Figure 6: AOD-Net[53]

The AOD-Net experiment demonstrated that dependable dehazing performance may be achieved without separately estimating t(x) and A. Because collecting an image's t(x) is a time-consuming and costly task, finding novel ways to use ASM is a hot issue that can help to speed up the dehazing process.

After the topic of using deep learning in the field of regression and predicting the values of variables that affect the purity of the image has been discussed, an essential point needs to be clarified. That is the fact that the method's effectiveness cannot be confirmed until after several experiments have been carried out. Maybe some networks are still being created or tested later on. Second, although the network can produce fruitful results, the cost of its computations is relatively high. Required traders will remain for an undetermined amount of time. They will differentiate between the various implementation methods according to the specific conditions under which this essential technology must be used.

Finally, we will briefly summarize the advantages and disadvantages of each of the methods used to remove fog in the following *Table (1).*

Table 1: Summarize of the methods used to remove haze

Methods	**Image Enhancement**	**Dehazing based on Extra information**	**Dehazing based on Fusion**	**Prior-based Dehazing**	**Learning-based Dehazing**
characteristics	Some parts of the hazy images ignored it and sometimes caused unreal colors to appear	Additional information is difficult to trust, so its methods lack many real applications	Its advantage is high execution efficiency, but it is not suitable for use in the dark parts of the image. When evaluating the removal of haze, the estimation is very poor.	It has promising results in areas of dense haze, but it leads to an increase in excess and an increase in saturation.	It gets rid of all degrees of haze with satisfactory results, but its problem lies in the heterogeneous haze and the heterogeneous light sometimes.
Adopt the composition of the image	The use of mathematical transformations to create the image that is free of haze is not used ASM			The haze-free image is generated using ASM any estimating parameter values	

Removing haze will remain an impressive problem for researchers to get the best results. The two problems of dehazing from images is still unresolved until now, the first problem is that there is no way to eliminate the haze in all circumstances, leading to visual inconsistency in particular cases. As for the second problem, the long time and redundant calculations reduce the performance of the real-time de-fuzzing method.

5. CONCLUSION

With the brief explanation of each method for removing haze from images, and from what I have read in books and research, the last method, CNN in particular, takes the lead among all the methods by devising different methods and designing multiple networks to get the most out of an accurate picture of Terms of color, accuracy and quality of information to be obtained. The importance of removing haze is not limited to the quality of the image, but to the systems that use imaging, and its important applications, such as satellite imaging, military surveillance cameras and other important applications.

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