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A Survey: Fast and Recent Advances in Single Color Image De-Hazing Using Structural and Statistical Features

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Abstract **- In real world scenario due to bad weather conditions the presence of fog and haze, the particles in the outdoor environment or atmosphere (e.g., droplets, smoke, sand, snow, mist, volcanic ash, liquid dust or solid dust) greatly reduces the visibility of the scene. As a consequence, the clarity of an image would be seriously degraded, which may decrease the performance of many image processing applications. Image Dehazing methods try to alleviate these problems by estimating a haze free version of the given hazy image. Traditionally the task of image dehazing can be processed as recovering the scene radiance from a noisy hazy image by estimating the atmospheric light and transmission properties. In those kinds of techniques, it additionally needs some more information regarding the image such as scene depth, weather condition parameters and so on. But this is not suitable for real world scenario. This research focus on proposing an approach to fully capture the intrinsic attributes of a hazy image and improves the performance of dehazing. Statistical and Structural attributes plays vital role in dehazing process. Hence this research focus on recovering dehaze version of the input image. So that all methods are comes under the categories image enhancement, image fusion image restoration based on statistical and structural features of the hazed image.**

Index Terms**—Image Restoration, Statistical and Structural Features, Image Dehazing, Visibility Enhancement.**

I. Introduction

The Land, water, air, sky, fire are our main five resources surrounding in earth. The Earth is a watery place. About 71 percent of the Earth's surface is water-covered, and the oceans hold about 96.5 percent of all Earth's water. Water also exists in the air as water vapor, in rivers and lakes, in icecaps and glaciers, in the ground as soil moisture and in aquifers. We didn't take photos every day in sea water. In casual life we take lot of photos in land only. Due to image destruction, socking up, disperse in the environment and the presence of haze in the atmosphere degrades the quality of images captured by visible camera sensors. The visibility of outdoor images [4] is often degraded due to the presence of haze, fog, sandstorms, and so on. Bad weather condition [8] such as haze, mist, fog and smoke degrade the quality of the outdoor scene. It diminishes the visibility of the scenes and it is a threat to the reliability of many applications [10] like outdoor surveillance, object detection, it also decreases the clarity of the satellite images and underwater images. For surveillance [10] we need correct reference images. So removing haze from images is an imperative and broadly demanded area in computer vision and computer graphics. Every person likes the clarity of images. To ameliorate or detach of haze, called "dehazing". The decision is taken by eyes only in major times. If vision is not clear, it will be diagnose by any method.

Therefore, it is necessary need for vision to improve the image. It is also called as "haze removal" or "defogging" [12]. Image dehazing methods try to alleviate the problems.

From the light the object is getting reflected and getting disturbed for the observer. For example the observer is camera means the original image is getting disturbed by illumination and the scattered particles. Fig. 1 Shows the original image and dehaze image.

Fig.1. (a) Haze Image (b) Dehaze Image

Fig. 1.Comparison of Haze image and Dehaze Image.

By preprocessing method many haze free scene is provided as input. The problem of haze formation has been extensively studied in atmospheric optics. The hazy image can be regarded as a convex combination of scene radiance and atmospheric light [5]. For single image dehazing with additional information needed such as restore the scene structure from captured under different weather condition [11]. Dehazing problem decomposed into three sub problems. (i) Estimate the atmospheric light 'A', (ii) Predict the transmission't', (iii) Recover scene radiance J. Fig. 2.

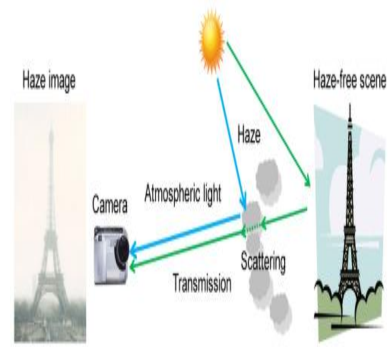

Fig.2. Formation of Haze Image

Light propagating through a scattering medium undergoes certain changes. Transformation of intensity is one of them. This change in intensity is modelled using the following equation [10].

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

t(x) is the transmission of image where I(x) is the observed intensity, J(x) is the intensity of light coming from the scene objects and before getting scattered, t(x) is the scene transmittance denoting the amount of light that reaches the observer after getting scattered and A denotes the global environmental illumination. The scene transmittance t(x) depends on the depth at position x and the scattering coefficient. This scattering coefficient depends on the size of the scattering particle and the wavelength of the light. So, in case of RGB images if we use this model of image formation, then for each colour channel t(x) needs to be different.

Fig.3. (a) Haze Image (b) Dehaze Image

Fig.3. Fog affected image and clear Image.

Single image dehazing:

As single image dehazing is an ill-posed problem, various priors and hypotheses have been proposed to tackle this problem. Assume a constant air-light and estimate it via finding the minimum of a global cost function. It removes the haze layer based on the observations that clear images have more contrast and the transmission tends to be smooth. It assumes that the shading and transmission functions are locally statistically uncorrelated. Which is further develop the underwater dark channel prior for image enhancement. These investigate the dehazing effects on image and video coding. They further use locally adaptive Wiener filter to refine the estimated density of haze. It reduces the amplified noise in the dehazed result image restored from dense haze. By utilizes the color-lines prior in local image patch. Apply the color-lines prior to estimate an appropriate global constant atmospheric light vector. It propose a multiscale depth fusion (MDF) method with local Markov regularization to blend multi-level details of chromaticity priors .It propose a color attenuation prior and further apply a linear model for haze removal and a fast method based on linear transformation. For each prior, it can be applied to a range of hazy images; however, there are often images which may not meet it. To this end, this paper aims at automatically learning information from massive data. Recently, there are several learning-based image dehazing methods. Then train a regression model to estimate the transmission via incorporating four types of haze-relevant features. Two recent works also adopt CNN to perform image dehazing. First one, directly estimate the whole transmission map from an input image via multi-scale CNN under the FCN framework. Second one use a regression network to estimate the transmission of each pixel from its surrounding patch. However, these works mainly exploit existing hand-crafted features or classical CNNs. In contrast, we propose a novel Ranking-CNN to simultaneously capture statistical and structure attributes, which both are essential for single image dehazing.

II. Classification of algorithm

Recently a machine learning technique allows more accurate and faster implementation of processing and computer vision task. There are four types in machine learning supervised, unsupervised, reinforcement, and evolutionary methods. In supervised learning, a training set of examples with the correct responses or target is provided and, based on this training set, the algorithm generalizes to respond correctly to all possible inputs. This is also called as learning from experience. In unsupervised, it doesn't provide correct response instead the algorithm tries to identify similarities between inputs. The statistical approach [19] is well known unsupervised learning for clustering and categorization. In reinforcement learning somewhat between supervised and unsupervised learning, it tells only the algorithm is correct or not telling the exact method or solution to rectify. In evolutionary learning, biological evolutionary can be seen as a learning process to improve the survival fates and chance of offspring in their environment. Offspring is the new generation development in the training set. Now deep learning is very famous for dehazing. This is the next step improvement in machine learning.

A. Image Enhancement methods

Image enhancement based methods [1] are not required to solve the physical model of image degradation, but rather directly enhance the image contrast and improve the image quality [9] from the perspective of human visual perception. These methods mainly include histogram equalization, the Retina method and frequency domain enhancement.

B. Fusion based methods

Image fusion is the process of combining relevant information from multiple source channels into a high quality image. Fusion strategies should maximize the extraction of information [2] from each channel in order to improve the utilization of image information. These methods have also been used in image dehazing in recent years.

C. Image restoration based methods

Image restoration based methods for dehazing are studied to explore the reasons for the image degradation and analyze the imaging mechanism [13], then recover the scene by an inverse transformation. In this method, the physical model of the degraded images is the basis, and many researchers have used the following general model for image restoration.

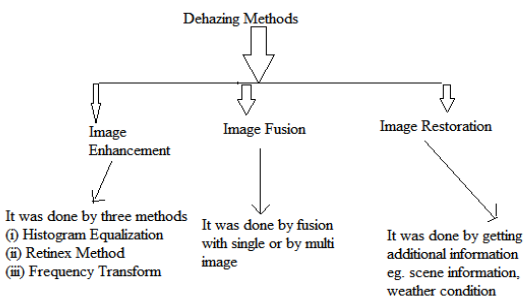

Fig.4.Methods of hazy free image classification

These methods are classified by structural and statistical features, Statistical are the basic information like atmospheric light A, transmission t by dark channel prior method and in structural features calculating the pattern and texture in single image. So these methods only finding how much of original image is affected and how much to rectified the hazy image.

III. Image Quality Assessment (IQA)

Image quality assessment (IQA) [18] is an important step in image dehazing. Generally, the assessment of image quality includes two main aspects: image fidelity and image readability which can be classified as the subjective assessment and the objective assessment.

A. Subjective Assessment

The subjective assessment method uses observers to make the quality assessment using a set of assessment criteria according to their visual opinion of the processed image. The results are summarized to compare the performance of the algorithm [6]. The score was divided into 5 grades. The assessment required that there were more than 20 assessors and that some people have experience in image processing while others should have no knowledge of image processing. The final quality score, called the mean opinion score (MOS), is computed to obtain the overall assessment score by averaging the subjective scores from all assessors. The assessment criteria are shown in Table I.

TABLE I

THE CRITERIA OF SUBJECTIVE ASSESSMENT

Image Assessment grade	Image Quality criteria	Mean Opinion Score
Worst	The worst in the group	1
Worse	Worse than average	2
Average	Average in the group	3
Better	Better than average	4
Best	The best in the group	5

Although this method is simple and can reflect the visual quality of the image, it lacks stability and is often subject to experimental conditions, the knowledge of the observers, their emotions, motivation, and many other factors [17]. In the current literature, the most common existing solution is to manually present several images in bad visibility alongside their corresponding enhanced images [3] which have been processed by different algorithms, and then enlarge some regions with key details for subjective comparison. This method lacks consistency from different assessors, and is difficult to use in engineering applications [7].

B. Objective Assessment

The objective assessment method evaluates the image with qualitative data according to objective criteria. In general, there are three major categories of quantitative metrics depending on the availability of an original image: full-reference methods, reduced-reference methods [15] and no-reference methods, with the first two categories needing to use a reference image. However, for image dehazing, the reference image of the same scene without haze is usually very difficult to obtain, so there is no ideal image to be used as a reference. Therefore, the no reference evaluation method [13] is often used or a dehazed image is used as the reference image to evaluate the performance of the algorithms..

IV. Conclusion and Expectation

There are three types of dehazing methods seen in current research: image enhancement based methods, image fusion based methods and image restoration based methods. All of these methods have advantages and disadvantages. (i) Image enhancement based methods [20] improve the image contrast from the perspective of subjective vision, using a colour correction which conforms to the perception of human visual system [16] on a colour scene by estimating airlight refinement. The early methods are mature and reliable, but these methods result in unpredictable distortion, especially where there is complex depth in the field image. (ii) Image fusion based methods maximize the beneficial information from multiple sources to finally form a high quality image. (iii) Image restoration based methods are related to the image degradation mechanism, and are suitable for image dehazing with different depth of fields. However, optimal tools are required to find the solution and these methods may be time-consuming. Image restoration based methods are better than the other two types of methods for real scene dehazing and is now the current research hotspot dehazing systems. At present, the research on quality assessment of dehazed images still requires further development, and the evaluation indexes are mainly concentrated on image clarity, contrast, colour and structural information, while lacking comprehensive scientific criteria. The no-reference IQA method based on feature cognition can better fit human visual characteristics, which can be combined with an image analysis model, a statistical model, a visual information model and machine learning theory to evaluate the image dehazing objectively, and will be a very important research direction. In summary, image dehazing techniques started relatively late due to the random nature and complexity of weather conditions, and there is only approximately a decade of research. At present, as a research hotspot in the field of machine vision, image dehazing techniques are developing rapidly, and a large number of new methods continue to appear. Although some research works have shown outstanding results under certain conditions, these methods still need further improvement. Exploiting image dehazing methods with universality, robustness and real-time performance will be a challenging task and usage of this in abounds in the future.

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