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Image Dehazing Techniques: A Review of Research Trends

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Abstract: Haziness is a huge obstacle in the visibility applications, it is very important to remove efficiently. Outdoor scenes and images lose the quality, degrade under the bad weather conditions, and provide the Hazy images. Many researchers have worked on various proposed techniques to enhance the clarity, visibility of the hazy image, mostly worked on saturation and brightness. For an image, the process of haze removal is not a simple task so it plays a vital role in image processing. Due to haziness, an image generally lost color and edges, so dehazing/ haze removal technique restores edge losses and color impacts badly. By using polarization, RETINEX based approach etc. dehazing has been simpler. To enhance the quality of an image (hazy) the various parameters are required for processing to get the superior computer vision applications and haze free images. And contrast enhancement is also important step for more clear applications.

Keywords: dehaze, polarization, edge preservation, dark channel prior, color preserving, contrast enhancement.

I. INTRODUCTION

Haze removal is a classical topic in the image processing domain. Haze removal is a difficult problem due the inherent unclearness between the haze and the surrounded scene. All images contain some noise due to sensor error that can be amplified in the haze removal process. Haze or fog can be a useful depth clue for scene understanding. A bad hazy image can be put good use. However, haze removal is a challenging problem because the haze is dependent on the unknown depth. Haze removal from a single image has been a very challenging problem due to its ill-posed nature. Most of the automatic systems are strongly depend on the definition of the input images, fail to work normally caused by the degraded images. Hence, an improvement in the technique of image haze removal will benefit many image understanding and computer vision applications such as aerial imagery, image classification, image/video retrieval, remote sensing and video analysis and recognition. Latterly, researchers tried in the improvement of the dehazing performance of the multiple images. The methods based on the polarization, which are used for dehazing of the multiple images, taken with different degrees of polarization. Based upon the given depth information the dehazing is conducted. Under the assumption, the local contrast of the haze-free image is much higher than that in the hazy image. Recently, significant progress has been made in single imagedehazing based on the physical model. The work proposes a novel haze removal method by maximizing the local contrast of the image based on Markov Random Field (MRF).

II. OVERVIEW OF GENERAL DEHAZING TECHNIQUES

Aerial imagery of the Earth introduces an invaluable tool for the assessment of ground features [3], especially during times of the disasters. The researchers who workat NASA's Langley Research Center have developed the technique which is useful for such imagery. Aerial imagery from the various sources, including Langley's Boeing 757 Aries aircraft, has been studied extensively. This proposed work discusses these studies and demonstrates that better-than observer's imagery can be obtained even when the visibility of image is severely compromised.

Recently, the Microsoft Kinect sensor, which has the low-cost introduces by Li Liuet. al. [4], which can capture high-resolution RGB in real-time and depth visual information. It has increasingly attentions for a wide range of applications in computer vision. Existing technique extracts the hand-tuned features from the RGB and the depth data separately. Then also heuristically fuses the both, which would not exploit the complementarity of both the sources of data fully. In the paper, an adaptive learning methodology is introduced to extract (holistic) spatial-temporal features automatically. Then fusing the RGB and depth information from the RGB-D video data for the tasks happens in visual recognition simultaneously. It is addressed that as an optimization problem using the proposed approach is Restricted Graph-based Genetic Programming (RGGP). In this approach a group of primitive 3D operators are randomly assembled as the graph-based combinations and then evolved generation by generation which is by evaluating on a set of RGB-D video samples. Finally, the best-performed combination is selected can called it as the near optimal representation for a pre-defined task. The proposed method is systematically evaluated on the new hand gesture dataset, SKIG, that is collected and the public MSR Daily Activity 3D dataset,

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respectively. The proposed approach of extensive experimental results shows that it leads to significant advantages are compared with state-of-the-art handcrafted and the machine-learned features.

III. SURVEY OF TRADITIONALTECHNIQUES OF DEHAZING

A haze removal approach with multiple images of the same scene under different weather conditions provides different algorithms and results.

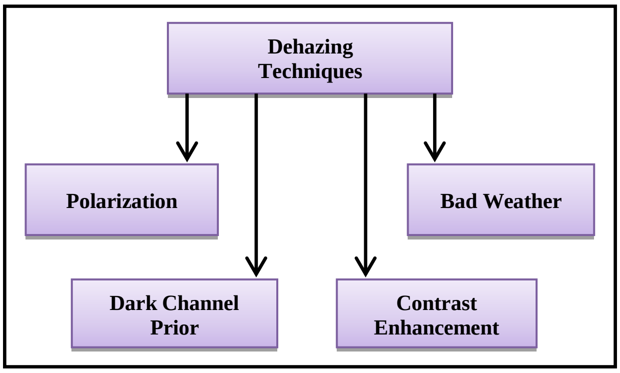

Fig. 1: Traditional Approaches of Dehazing Techniques

A. Polarization

In the partial polarized approach for easily removing the effects of haze from passively acquired images. The proposed approach based on the fact of usually the natural illuminating light scattered by atmospheric particles air-light is partially polarized. Optical filtering cannot remove the haze effects alone, except in restricted situations. In this method, however, stems from the physics-based analysis that works under a wide range of atmospheric and viewing conditions, even though the low polarization is exist. The approach does not rely on specific scattering models such as Rayleigh scattering and the knowledge of illumination directions does not rely. It can be used as few as two images taken through the polarizer at the various orientations. As a by-product, it yields a range map of a scene, which enables scene rendering as in the situation, if image has taken from the different viewpoints. It also yields information about the atmospheric particles. The experimental results of complete dehazing of outdoor scenes are shown, in far-from-ideal conditions for polarization filtering. Then it is obtained that a great improvement of scene contrast and correction of colour [6].

The effects of haze can be removingfrom images easily [1].Usually air light scattered by atmospheric particles is partially polarized based system. Polarization filtering alone cannot remove the haze effects well, except in restricted situations. However, system works under a wide range of atmospheric and viewing conditions. Analysis of an image formation process, taking intothe account polarization effects of an atmospheric scattering. Then invert the process of removing the haze from images. The work showed that image analysis that follows acquisition of polarization filtered images can remove the visual effects of haze. This approach enables dehazing when the problem cannot be solved by optics alone. Additionally with the dehazed image, the method also yields information about scene structure and about the density and size distribution of the atmospheric particles. It can be used with as few as two images taken through a polarizer at the different orientations and then it instantly works, without relying on changes of weather conditions. Experimental results show the complete dehazing in far from ideal conditions for polarization filtering. Proposed system achieved great improvement of scene contrast and correction of colour. The method also yields a range map (depth) of a scene, and the information about properties of atmospheric particles. The method is based on the partial polarization of air light so; its stability will decrease as the degree of polarization decreases effectively.

B. Bad Weather

Outdoor imaging is cursed by poor visibility conditions due to atmospheric scattering, mainly in haze. A severe problem is varying spatially reduction of contrast by stray radiance (air light), which is scattered by the haze particles towards the camera. Recently, computer vision methods have shown that images can be compensated for the haze, even yield a depth map of an image in a scene. An important key step in such a scene recovery is subtraction of the air light. Particularly, it can be achieved by analysing polarization-filtered images. However, the recovery requires parameters of the air light. These parameters were estimated in past studies by measuring pixels in sky areas. The proposed work derives an approach for the parameter needed to separate the air light from the measurements which recovered blindly, so recovering contrast, without user interaction and also without existence of the sky in the frame. It eases the conditions and the interaction needed for the dehazing of image, which also requires compensation for attenuation. The approach has proved successful experiments, some of which are shown [2].

Haze is one of the major factorsthat degrade the outdoor imaging. Removing the haze from a single image is known which is to be much ill-posed, and the assumptions are made in previous methods to do not hold in many situations. In the proposed work, it is systematically investigated the different haze-relevant features in a learning framework for the identification of the best feature combination to dehaze an image. The dark-channel feature is the most informative one for this task, which confirms the observation from a learning perspective, while other haze-relevant features also significantly contributed in a complementary way. It is also found that surprisingly, the synthetic hazy image patches it is used for feature investigation serve well as training data for realworld images, allows the training to the specific models for specific applications [5].

In the conventional vision systems, which aredesigned to perform in clear weather condition. Any outdoor vision system is incomplete without some mechanisms provide satisfactory performance under the deficient weather conditions. It is known that the atmosphere can alter the light energy reaching significantly to an observer. So, the atmospheric scattering models must be used to make vision systems in bad weather robustly. In the proposed work, a geometric framework is developed for the analysis of chromatic effects of atmospheric scattering. Firstly, a simple colour model for atmospheric scattering is studied as well as verified it for fog and haze. Then, it is based on the physics of scattering; several geometric constraints derived on scene colour changes, caused by varying atmospheric conditions. Then at the last, using these constraints algorithms are developed for computing fog/haze colour, segmentation of the depth, extraction of the 3D structures, and recovering the "true" scene/images colours, from two or more images taken under different but not for the known weather conditions [7].

Images of scenes acquired in defective weather have degraded contrasts and colours. It is known that the degradation in the image quality because of bad weather is exponentially in the depths of the scene points. So, in the restoration of scene colours and contrasts from a single image of the scene may be under-constrained. Recently, the multiple images of the same scene under different weather conditions or different images taken by varying imaging optics can be used to break the ambiguities in de-weathering. In this paper, the question of de weathering a single image is addressed by using simple additional information provided interactively by the user. The physics-based models are exploited as described in prior work and develop three interactive algorithms used to remove weather effects from, and add weather effects to, a single image. An effective colour and contrast restoration is demonstrated using several images taken under poor weather conditions. Furthermore, an example of adding weather effects to images. These interactive methods for image (de)weathering can fulfileasily to use plug-ins for the various software of image processing [8].

C. Dark Channel Prior

A simple but very effective image prior i.e. dark channel prior to remove haze from a single image given as input. The dark channel prior approach is a statistics of the haze-free outdoor images. It is based on a key observation mostly; local patches in the haze-free outdoor imaging contain some pixels which have very low intensities in at least one colour channel. Using this prior with the hazy imaging model, it can be directly estimates the thickness of the haze and recover a high quality haze-free image. The experimental results gained on a variety of outdoor haze images demonstrate the proposed prior's power. Moreover, the high quality of the depth map can also be obtained as a by-product of haze removal [9]. In an approach about the most interesting problems in recent times in image processing and computer vision is fog, haze and rain removal from images. In this paper, it is considered the problem of haze removal. One of the latest haze removal algorithms proposed by Kaiming et al. uses a dark channel prior based approach for haze removal. This approach gives very good results, but this method is computationally little bit complex. In this paper, it is proposed that a RETINEX based approach that gives good results. It is also computationally simpler. This method gives better results than given by the dark channel prior based approach. The advantage of this method is computationally very simple mainly [10].

D. Contrast Enhancement

An approach of block-overlapped histogram equalization system for enhancing contrast of image sequences is explained [11]. There are various applications with this system such as video door phone, security video cameras, in addition to the original target video camcorders. A contrast enhancement system is proposed for image sequences which can enhance local contrast well with undesired suppression of noise amplification based on spatial-temporal processing.
An algorithm of advanced Histogram-Equalization for contrast enhancement is introduced by J.Y. Kimet. al. [12]. Histogram equalization is the most well-liked algorithm for the enhancement of contrast due to its effectiveness and simplicity. It can be classified into two branches as per the transformation function used: global or local. Global histogram equalization is easy, simple and fast also, but its power of the contrast enhancement is relatively low. On the other hand Local histogram equalization can enhance the overall contrast more effectively, but a complexity of the computation required is very high because of its fully overlapped sub-blocks. A low-pass filter-type mask is used in the paper to get a non-overlapped sub-block histogram-equalization function used to produce the high contrast associated with the local histogram equalization and the simplicity of global histogram equalization. This mask eliminates the blocking effect of the non-overlapped sub-block histogram-equalization also. The low-pass filter-type mask is realized by the overlapped sub-block histogram-equalization (POSHE) partially. With the proposed method, since the sub-blocks are much less overlapped. A computation overhead is reduced by the factor of about 100 which is compared to that of the local histogram equalization while still achieving high contrast.

A scheme for an adaptive image contrast enhancement based on a generalization of histogram equalization (HE) is proposed byJ. A. Starket. al.[13]. HE is a useful technique for improving image contrast, but its effect is too severe for many purposes. However, different results can be obtained dramatically with relatively minor modifications. A concise description of adaptive HE is set out, and the framework is used in a discussion of the past suggestions for variations on HE. A key feature is the "cumulating function," which is used to generate a grey level mapping from the local histogram. By choosing many alternative forms of cumulating function, one can achieve a wide variety of effects. A specific form is proposed. Through the dissimilarity of one or two parameters, the resulting process can produce a range of degrees of contrast enhancement at the one extreme leaving as the image unchanged, at another yielding full adaptive equalization.

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Appendix A summarizes above approaches providing additional knowledge about positive aspects and limitations of comparative approaches.

APPENDIX A:

TABLE I: RESEARCH TRENDS OF HAZE REMOVAL TECHNIQUES

Publication / Year	Title	Overview	Positive Aspects	Limitations
IEEE/ 2000	Chromatic Framework for Vision in Bad Weather [7]	Proposes an general chromatic framework for scene in bad weather. Model based on simple useful dichromatic model.	+Algorithm can be demonstrated for both real scenes and synthetic data +Simple algorithm for recovery of 3D structure and true colour scenes	-Cannot works on clear day image of the scene
IEEE/ 2001	An Advanced Contrast Enhancement Using Partially Overlapped Sub-Block Histogram Equalization [12]	New contrast enhancement algorithm is proposed called POSHE. Derived for local histogram equalization	+Low-pass filter shaped mask obtains sub-region probability density function is important feature +Simple hardware and processed in real-time	-Due to the heavy blocking effects system cannot work properly
IEEE/ 2006	Blind Haze Separation [2]	Based on separation of air-light and blind estimation. Also, recovering contrast, without existence of sky in frame as well as without user interaction	+Can be used for underwater photography with extended work	-Depth variations in the scene due to the independent air-light from direct transmission -Contrast degradation is more
IEEE/ 2011	Single image haze removal using dark channel prior [9]	Proposed powerful feature called dark channel prior approach. Based on statistics of the outdoor images	+Simpler and more effective, powerful method	-Invalid for some images which are inherently similar to atmospheric light and no shadow is cast on them -Underestimate the transmission for some objects like white marble
IEEE/ 2012	A RETINEX based Haze Removal Method [10]	RETINEX provides results as good as given by dark channel prior based method	+Computationally very simple	-Takes computationally some more time as 32.737 sec. to process 1024*1024 image in MATLAB
IEEE/ 2014	Investigating Haze-relevant Features in A Learning Framework for Image Dehazing [5]	Dark channel is the most informative feature. It is the learning based system for robust dehazing	+More accurate haze estimation in learning framework +Algorithm is better than state-of-art methods on synthetic data as well as real-world images	-Dehazing model may boost noise due to low SNR ratio -Transmission smoothing is needed because model is still based on local cues without knowing contrast

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IV. CONCLUSION

Due to the less accuracy and limitations of some techniques the results are considered undesirably. Some more advanced physical models can be taken into account for more accurate results. It is leaved for the future research. The knowledge about different techniques isstudied comparatively in well manner. A novel linear edge preservation and colour attenuation prior approach can be proposes and implement in future scope, based on the difference between the brightness and the saturation of the pixels within the hazy image. The proposed approaches studied well which achieves dramatically with high efficiency and outstanding dehazing effects as well. In future, haze removal/dehazing algorithm can be implementing with preserving colour and edges of images with greater accuracy.

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