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REMOVAL OF RAIN AND SNOW IN A COLOR IMAGE

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ABSTRACT

An algorithm to remove rain or snow from a single color image is proposed here. Two popular techniques are used for image processing, namely, image decomposition and dictionary learning. At first, a combination of rain/snow detection and a guided filter is used to decompose the input image into a complementary pair: (1) the low-frequency part that is free of rain or snow almost completely and (2) the high-frequency part that contains not only the rain/snow component but also some or even many details of the image. Then, we focus on the extraction of image's details from the high-frequency part. To this end, we design a 3-layer hierarchical scheme. In the first layer, an over-complete dictionary is trained and three classifications are carried out to classify the high-frequency part into rain/snow and non-rain/snow components in which some common characteristics of rain/snow have been utilized. In the second layer, another combination of rain/snow detection and guided filtering is performed on the rain/snow component obtained in the first layer. In the third layer, the sensitivity of variance across color channels (SVCC) is computed to enhance the visual quality of rain/snow-removed image. The effectiveness of our algorithm is verified through both subjective (the visual quality) and objective (through rendering rain/snow on some ground-truth images) approaches, which shows a superiority over several state-of-the-art works.

KEYWORDS: Digital image processing, 3-layer hierarchy

I. INTRODUCTION

Digital image processing is the use of computer algorithms to perform image processing on digital images. As a subcategory or field of digital signal processing, digital image processing has many advantages over analog image processing. It allows a much wider range of algorithms to be applied to the input data and can avoid problems such as build-up of noise and signal distortion during processing. Since images are defined over two dimensions (perhaps more) digital image processing may be modeled in the form of multidimensional systems.

A 3-layer hierarchy of extracting image's details from the high-frequency part has been used. Specifically, the first layer is a 3-times classification that is based on a trained dictionary (over-complete), the second layer applies another combination of rain/snow detection and a guided filter, and the third layer utilizes the SVCC to enhance the visual quality of the rain/snow-removed image

II. LITERATURE REVIEW

A. Detection and removal of rain from videos

In this paper,K. Garg and S. K. Nayar[1] presents the first comprehensive analysis of the visual effects of rain on an imaging system. The visual effects of rain are complex. Rain consists of spatially distributed drops falling at high velocities. Each drop refracts and reflects the environment, producing sharp intensity changes in an image. A group of such falling drops creates a complex time varying signal in images and videos. In addition, due to the finite exposure time of the camera, intensities due to rain are motion blurred and hence depend on the background intensities. Thus, the visual manifestations of rain are a combination of both the dynamics of rain and the photometry of the environment. This paper, presents the first comprehensive analysis of the visual effects of rain on an imaging system. We develop a correlation model that captures the dynamics of rain and a physics-based motion blur model that explains the photometry of rain. Based on these models, we develop efficient algorithms for detecting and removing rain from videos. The effectiveness of our algorithms is demonstrated using experiments on videos of complex scenes with moving objects and time-varying textures. The techniques described in this paper can be used in a wide range of applications including video surveillance, vision based navigation, video/movie editing and video indexing/retrieval.

B.Single image haze removal using dark channel prior

In this paper, K. He, J. Sun and X. Tang[2] proposes a simple but effective image prior-dark channel prior to remove haze from a single input image. The dark channel prior is a kind of statistics of outdoor haze-free images. It is based on a key observation-most local patches in outdoor haze-free images contain some pixels whose intensity is very low in at least one color channel. Using this prior with the haze imaging model, we can directly estimate the thickness of the haze and recover a high-quality haze-free image. Results on a variety of hazy images demonstrate the power of the proposed prior. Moreover, a high-quality depth map can also be obtained as a by-product of haze removal.

C.The distribution of raindrops with size

In this paper,J. S. Marshall and W. Mc K.Palmer[3] presents design of radio systems such as terrestrial and satellite communication links at frequencies above 10 GHz, rain attenuation is an important problem. A Weibull raindrop-size distribution is proposed by fitting the measurements of rainfall observed using a distrometer in Tokyo. A propagation experiment at 103 GHz is introduced. Rain attenuation coefficients are calculated by considering the Mie scattering using this Weibull distribution for raindrop size are compared with some experimental data. The results of frequency characteristics from this Weibull raindrop-size distribution agrees well with some experimental data for the range 8-312.5 GHz.

D. Rain or snow detection in image sequences through use of a histogram of orientation of streaks

The detection of bad weather conditions is crucial for meteorological centers [4], especially with demand for air, sea and ground traffic management. In this article, a system based on computer vision is presented which detects the presence of rain or snow. To separate the foreground from the background in image sequences, a classical Gaussian Mixture Model is used. The foreground model serves to detect rain and snow, since these are dynamic weather phenomena. Selection rules based on photometry and size are proposed in order to select the potential rain streaks. Then a Histogram of Orientations of rain or snow Streaks (HOS), estimated with the method of geometric moments, is computed, which is assumed to follow a model of Gaussian-uniform mixture. The Gaussian distribution represents the orientation of the rain or the snow whereas the uniform distribution represents the orientation of the noise. An algorithm of expectation maximization is used to separate these two distributions. Following a goodness-of-fit test, the Gaussian distribution is temporally smoothed and its amplitude allows deciding the presence of rain or snow. When the presence of rain or of snow is detected, the HOS makes it possible to detect the pixels of rain or of snow in the foreground images, and to estimate the intensity of the precipitation of rain or of snow. The applications of the method are numerous and include the detection of critical weather conditions, the observation of weather, the reliability improvement of video-surveillance systems and rain rendering.

III. PROPOSED METHOD

In the proposed method the rain/snow removal from a single color image, in which several new designs are introduced. At first decompose a rain or snow image into the low-frequency and high-frequency parts. A low-frequency part that is free of rain or snow almost completely has been generated, thanks to the use of a combination of rain/snow detection and a guided filter, while the corresponding high-frequency part is made complementary to the low frequency part. A 3-layer hierarchy of extracting image's details from the high-frequency part has been designed. Specifically, the first layer is a 3-times classification that is based on a trained dictionary, the second layer applies another combination of rain/snow detection and a guided filter, and the third layer utilizes the SVCC to enhance the visual quality of the rain/snow-removed image.

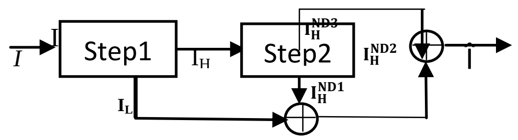

Fig.1 The simplified pipeline of the algorithm

IV.ALGORITHM

Specifically, proposed algorithm consists of two steps.

1. The input image is decomposed into the low frequency part I_L and high-frequency part I_H.Note that I_L while $I_H$contains rain/snow components and some or even many details of the image.
2. We design a 3-layer hierarchy of extracting non-dynamic components (i.e., the image's details) from I_H, which are denoted as I_H^{ND1}, I_H^{ND2}, and I_H^{ND3}respectively.
3. The final rain/snow-removed image is obtained as:

Eq.1 $\hat{\mathbf{I}} = \mathbf{I_L} + \mathbf{I_H^{ND1}} + \mathbf{I_H^{ND2}} + \mathbf{I_H^{ND3}}$

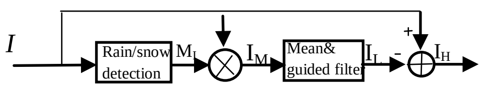

Fig. 2. The flow chart of the first step

I is the input rain/snow image; M_I is the location map; I_M is the Hardman Product of *I* and M_I; I_L and I_H are, respectively, the low-frequency and high-frequency parts obtained after decomposition

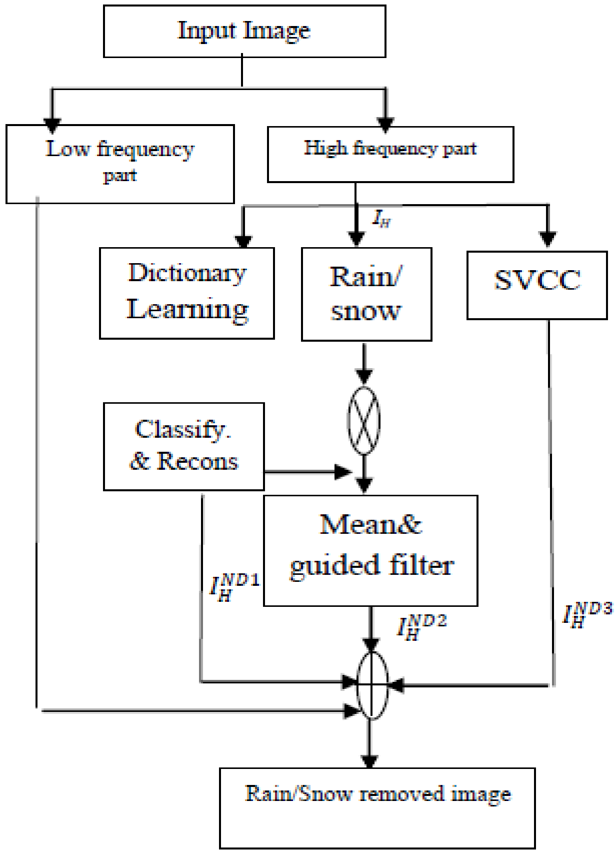

Fig.3 Flow chart of the full step

First, rain/snow detection is performed to produce a binary location map M_I and the Hadamard product between I and M_I yields an output image I_M. .because the location map is binary, holes appear at the rain/snow locations. Then, we fill each hole with the mean value of its neighboring non-rain/snow pixels. At last, a guided filter is utilized to generate the low-frequency part I_L, and the high-frequency part is obtained as $I_H = I - I_L$.

In this system first the input image given after that the image decomposed into Low frequency component and high frequency component by using discrete wavelength transform. After that the low frequency and the high frequency part of the image is perform a rain/snow detection to obtain the coarse locations of these dynamic components (rain/snow) and then apply a guided filter to obtain the low-frequency part that would become free of rain or snow almost completely. High frequency part of the image contains more image details so we need to recover these image details as much as possible so that they can be added back to the low-frequency part to obtain the final rain/snow-removed image. For that propose a three layer hierarchical approach is used, they are:-

1. A dictionary learning and dictionary atoms classification are used to classify dynamic components (i.e., rain or snow) from non-dynamic components so that the first layer non-dynamic I_H^{ND1} can be extracted.
2. Then the classified dynamic component I_H^D is processed by another combination of rain/snow detection and guided filtering to produce the second layer recovering of image details I_H^{ND2} .The SVCC defined earlier is employed to produce the third layer recovering of image detailsI_H^{ND3}.

3. Then the final rain/snow removed image is obtained by combine low frequency and all the 3 layer outputs.

V. CONCLUSION

This paper has attempted to solve the rain/snow-removing problem from a single color image by utilizing the common characteristics of rain and snow. To this end, we defined the principal direction of an image patch (PDIP) and the sensitivity of variance of color channel (SVCC) to describe the difference of rain or snow from other image components. We acquired the low and high frequency parts by implementing a rain/snow detection and applying a guided filter. For the high frequency part, a dictionary learning and three classifications of dictionary atoms are implemented to decompose it into non dynamic components and dynamic (rain or snow) components, where some common characteristics of rain/snow defined earlier in our work are utilized. Moreover, we have designed two additional layers of extracting image details from the high frequency part, which are based on, respectively, the SVCC map and another combination of a rain/snow detection and a guided filtering. Finally, we have presented a large set of results to show that our method can remove rain or snow from images effectively, leading to an enhanced visual quality in the rain/snow-removed images.

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