INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

IJARIIT

ISSN: 2454-132X
Impact factor: 4.295
(Volume 4, Issue 1)
Available online at www.ijariit.com

Survey on Removal of Rain or Snow from a Single Color Image

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Abstract: ***It is well-known that a bad weather, e.g., haze, rain, or snow, affects severely the quality of the captured images or videos, which consequently degrades the performance of many image processing and computer vision algorithms such as object detection, tracking, recognition, and surveillance. Rain/snow removal from a video or a single image has been an active research topic over the past decade. Today, it continues to draw attentions in outdoor vision systems (e.g., surveillance) where the ultimate goal is to produce a clear and clean image or video. Here, the most critical task is to separate rain/snow components from the other part.***

Keywords: Rain and Snow Removal, Guided Filter, Trained Dictionary, Low-rank Appearance Model, Dynamic Weather.

I. INTRODUCTION

Visual distortions on images caused by bad weather conditions can have a negative impact on the performance of many outdoor vision systems. One often saw bad weather is rain which causes significant yet complex local intensity fluctuations in images. A study by Garg et al. [1] reveals that rain and snow belong to the dynamic weather - they contain constituent particles of relatively large sizes so that they can be captured easily by cameras. On the other hand, haze belongs to the steady weather - the particles are much smaller in size and can hardly be filmed. As a result, rain or snow leads to complex pixel variations and obscures the information that is conveyed in the image or video. Especially, the degradation of the involved algorithm's performance would be severe if the algorithm is based on some features in the image or video. As compared to the de-haze problem where some excellent solutions have been achieved, removing of rain or snow is much more challenging.

Though belonging to the dynamic weather category, rain and snow still have some differences when appearing in the image or video. First, rain is semi-transparent. Because of this, the objects will not be occluded completely but some blurring may appear. Second, pixels with different intensities will be affected by rain differently. When the pixel's primary intensity is relatively low, rain will enhance its intensity. When a high intensity pixel is affected by rain, its intensity will become lower. This is to say that rain-affected pixels tend to have the same intensity because the reflection of rain is dominating under this scenario. On the other hand, snow is un-transparent and can largely occlude the object behind it. In addition, snow has bright and white colour, and snow's reflection is strong. Consequently, snow often possesses high intensity values in an image, which is hardly affected by the background. Fig.1 shows a rain image and a snow image, respectively.

Fig. 1: A Rain Image and a Snow Image

II. LITERATURE SURVEY

A. A Hierarchical Approach for Rain or Snow Removing in a Single Colour Image

In this work [2], they consider the rain/snow removal from a single colour image, in which several new designs are introduced. The main contributions of our work are summarized as follows:

1) They have outlined several common characteristics of rain and snow, from which two metrics are defined, namely, the sensitivity of variance across color channels (SVCC) and the principal direction of an image patch (PDIP).
2) 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 (as the low-pass filter), while the corresponding high-frequency part is made complementary to the low frequency part.
3) 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 (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.

B. Automatic Rain Streak Removal: Review

The better image quality is a very important factor in various applications. Weather conditions i.e. rain, snow, fog, mist, and haze degrade the quality also the performance of outdoor vision system. Rain is one of the major contributors to the dynamic bad weather. It causes intensity variations in the image which reduces the quality of the image and it is difficult to view for human observers. The intensity variation depends on different parameters. For a better image, it is necessary the image will be noise free. Most of the rain streak removal has been done on video based approaches and with a collection of training images. Color image based rain streak removal widely used in different applications in the field of security surveillance, vision based navigation, video or movie editing and video indexing or retrieval. So it is necessary to develop an algorithm to remove rain streaks from the images with preserving the original details. In this method, the detection and removal of rain streaks in an image are based on image decomposition which depends on Morphological Component Analysis (MCA) by performing dictionary learning. It is a review of IEEE paper.

The main idea of the work [3] is to develop a method that can separate rain streaks from the high-frequency part, a hybrid feature set, including a histogram of oriented gradients (HoGs), depth of field (DoF) and Eigen colour, is employed to further decompose the high frequency part. With the hybrid feature set applied, most rain streaks can be removed, while the non-rain component can be enhanced. The rain streaks in an image are usually more blurred than the focused subject(s), their visual effect is relatively weak and likely appears as fog. Therefore, properly employing the DoF feature is helpful for identifying the main subjects to be preserved in a rain image. The rain streaks usually reveal neutral colour in analysing the atoms of rain in the method. Hence colour information is also a key feature to be employed for rain removal, where the Eigen colour feature is used.

C. Removing Rain From A Single Image Via Discriminative Sparse Coding

The paper [4] aims at developing an effective algorithm to remove visual effects of rain from a single rain image, i.e. separate the rain layer and the de-rained image layer from a rain image. Built upon a nonlinear generative model of rain image, namely screen blend model, we propose a dictionary learning based algorithm for single image de-raining. The basic idea is to sparsely approximate the patches of two layers by very high discriminative codes over a learned dictionary with strong mutual exclusivity property. Such discriminative sparse codes lead to accurate separation of two layers from their non-linear composite. The experiments show that the proposed method outperforms the existing single image de-raining methods on tested rain images.

Fig. 2: Left: Rain Image; and Right: De-rained Image

In this paper, they are interested in studying the image recovery problem for outdoor images taken in rainy weather, i.e., how to remove visual effects of rain from a single image; see Fig. 2 for an illustration.

Rain image recovery: There are two sub-problems in rain image recovery: 1) how to identify rain in images, and 2) how to remove visual effects caused by rain from images. Indeed both of them are problems difficult to solve.

D. Fully Connected Guided Image Filtering

This paper [5] presents a linear time fully connected guided filter by introducing the minimum spanning tree (MST) to the guided filter (GF). Since the intensity based filtering kernel of GF is apt to overly smooth edges and the fixed-shape local box support region adopted by GF is not geometric-adaptive, the filter introduces an extra spatial term, the tree similarity, to the filtering kernel of GF and substitutes the box window with the implicit support region by establishing all-pairs-connections among pixels in the image and assigning the spatial-intensity-aware similarity to these connections. The adaptive implicit support region composed by the pixels with large kernel weights in the entire image domain has a big advantage over the predefined local box window in presenting the structure of an image for the reason that: 1, MST can efficiently present the structure of an image; 2, the kernel weight of our filter considers the tree distance defined on the MST. Due to these reasons, the filter achieves better edge-preserving results. They demonstrate the strength of the proposed filter in several applications.

E. A Generalized Low-Rank Appearance Model For Spatio-Temporally Correlated Rain Streaks

In this paper [6], propose a novel low-rank appearance model for removing rain streaks. This method needs neither rain pixel detection nor time-consuming dictionary learning stage. Instead, as rain streaks usually reveal similar and repeated patterns on imaging scene, they propose and generalize a low-rank model from matrix to tensor structure in order to capture the spatio-temporally correlated rain streaks. With the appearance model, thus remove rain streaks from image/video (and also other high-order image structure) in a unified way.

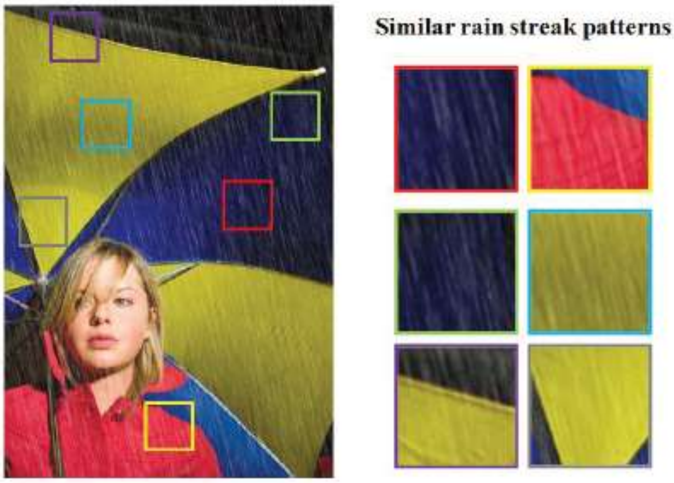

Fig. 3: An Observation of Similar Patterns in a Raining Image

Fig. 3 is used to explain the motivation of this paper: a rainy scene usually contains similar patterns of rain streak in different local patches. With this observation, the goal is to model the patch dependency in an elegant way. In this paper, they assume this dependency is linear and propose to use the low-rank model to characterize the appearance of rain streaks.

F. An Improved Guidance Image Based Method To Remove Rain And Snow In A Single Image

Rain and snow bring poor visibility to outdoor vision systems. The commonly used image processing methods may be not suitable for a degraded image. In this paper [7], a guidance image method is proposed to remove rain and snow in a single image. To removal rain and snow only using one image, a guidance image is derived from the imaging model of a raindrop or a snowflake when it is passing through an element on the CCD of the camera. Since only using this guidance image may lose some detailed information, in this paper, a refined guidance image is proposed. This refined guidance image has a similar contour with the un-degraded image and also maintains the detailed information which may be lost in the guidance image. Then a removal procedure is given by the use of the refined guidance image. Some comparison results are made between different methods using the guidance image and the refined guidance image. The refined guidance image can be used to get a better removal result.

In this paper first, analyse the imaging model of rain and snow formation to find a guidance image. Second, propose a refined guidance image such that this novel image could keep detailed information and at the same time remove the linear edges caused by rain and snow. Thereby use filtering method to remove rain and snow from this guidance image.

III. CONCLUSIONS

This paper presents a literature survey of various rain or snow removal techniques from a single colour image. There are different methods through which we can remove rain or snow from the image in an efficient manner. Compared to all these methods the one that uses two step-processing in “A Hierarchical Approach for Rain or Snow Removing in A Single Colour Image” is found to be more effective. It provides 98% accuracy. This method can enhance the visual quality of the rain/snow-removed images.

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