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REVIEW ARTICLE

A Review on Detection and Removal of Rain Streaks in an Image

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Abstract**—*****Outdoor vision system are used in various applications such as tracking, surveillance also in navigation. Rain introduces difficulty to the outdoor vision system. Rain, snow, fog, mist and haze are different types of weather condition that degrade the visual quality also the performance of outdoor vision system. Rain is one of the types of weather condition and major component for the dynamic bad weather condition. Due to the rain streaks the visual quality of an image goes down so it is necessary to remove this rain streaks. After Removal of rain streaks we can easily identify feature in the image also the pre-processing of various computer vision algorithms which gives various feature information i.e. object detection, tracking, segmentation and recognition. This paper reviews different techniques or methods used for the removal of rain streaks in an image.***

Keywords**— *****Outdoor vision system, Dynamic weather condition, Steady weather condition***

I. INTRODUCTION

With the more and more growth in computer technology, outdoor vision system is widely used and it plays vital role in traffic surveillance and military surveillance. Weather can reduce the performance of outdoor vision systems. Outdoor vision systems are used in various purposes in many applications such as surveillance and navigation. We need to remove the effects of weather for making outdoor vision systems efficient that perform in every weather conditions. Rain creates poor visibility at outdoor vision systems. The images captured by outdoor vision system in the rain have low contrast and are blurred and it can creates serious degradation. Mainly the images captured in the rain have high pollution levels and are blurred, and the recognition of detail content makes it impossible to make application process together with the feature extraction and target recognition. So it has more importance to process the images acquired in the rain which can make outdoor vision system reliable.

Images which are taken from an outdoor condition, bad weather like rain confuse human viewers also brings difficulty to image processing and also the performance of vision algorithms decreases. An area covered by a falling raindrop seems brighter than its original

background. But it is very difficult to identify rain only using the property of intensity changes. Because there exist so many things which have similar linear edges with rain streaks. Though in some cases, there is essential application value to remove the rain from only outdoor image, this image is used to get more information. If rain steaks is exist in the climate which shows that, it will not only deteriorate the feature of the scene but also it will deteriorate the performance of computer vision algorithm. For example, examine the case when the object trackers may fail if small portion of the image become occluded.
Rain is one of the type weather condition. Reducing or removing the effects of rain while preserving image information is a difficult task, as rain streaks move very quickly through a image and are difficult to separate from other motion from the image. Additionally, the visual appearance of rain depends both on the background of the streak and other imaging lighting conditions, which makes it difficult to build a general appearance model.

Garg and Nayar classified the weather based on the size of the weather particles into two types steady weather are fog and haze, and dynamic weather are rain and snow. In steady weather, particles are very small and steadily float in the air. In dynamic weather, rain drops are distributed anywhere in the scene and move all the time. This makes them difficult to identify and causes failures in vision applications. Outdoor vision systems are used for various purposes such as tracking, recognition and navigation. In order to develop vision systems that perform under all weather conditions, it is essential to develop algorithms that remove visual effects of the various weather conditions. Dynamic weather such as rain, snow, and haze normally brings unpleasant visual artifacts in outdoor vision system and would decrease the performance of vision tasks[1-2].

(a)Fog (b)Mist

Fig 1 Visual Appearance of Steady Weather Condition

(a)Rain (b)Snow

Fig 2 Visual Appearance of Dynamic Weather Condition

II. Literature Review

Many authors uses single image for rain streaks removal and proposed different techniques or methods. L-W Kang, C-W Lin and Y.-H. Fu proposed a single image based rain streaks removal framework by using image decomposition based on Morphological Component Analysis (MCA).Rather than directly applying a traditional image decomposition technique, the proposed method first decomposes input rain image into the low-frequency (LF) and high-frequency (HF) parts using a bilateral filter also called as smoothing filter. The LF part contains the most basic information and HF part contains rain streaks, edges or texture information. Dictionary learning and sparse coding is used for decomposing HF part into rain component and non-rain component. By combining non rain component of high frequency part with low frequency part they get the desired non rain image by separating rain component [3-6].

Y-L Chen and C-T Hsu proposed a generalized low-rank appearance model for rain streaks removal. This method does not required rain pixel detection nor dictionary learning stage. Instead as rain streaks generally release similar and repeated patterns on imaging scene. They proposed and generalized a low-rank model from matrix to tensor structure in order to represent the spatio-temporally correlated rain streaks. By using this appearance model they thus removed rain streaks from image[7].

X. Zheng, Y. Liao, W. Guo, X. Fu, and X. Ding proposed method for rain removal by using low frequency part of the image. This method depends on a key difference between clear background edges and rain streaks, normally low frequency part can determine the various properties. Low-frequency part is the geometric component, then this low-frequency part is then changed as a guidance image. The high-frequency part is treated as an input image of the guided filter, so that a non-rain component of the high-frequency part can be obtained. After getting non-rain component of high-frequency part and add low-frequency component in it they get desired image [8].

D-An Huang, L-Wei Kang, M-Chun Yang, C-Wen Lin, Wang proposed a learning-based structure for single image rain removal which primarily concentrates on the studying of context information from an input rain image and hence the rain patterns present in it can be automatically recognized and removed. This method for single image rain removal as the combination of image decomposition and self learning processes. More precisely, this method first implements context-constrained image segmentation on the input rain image, and they study dictionaries for the high-frequency part in distinct context categories by means of sparse coding for reconstruction value. For an image regions with the rain streaks, dictionaries of different context categories will allot common atoms which correspond to the rain patterns. By utilizing Principal Component Analysis and Support Vector Machine classifiers on the learned dictionaries, this structure focus at automatically recognizing the common rain patterns present in them, and thus rain streaks can be removed from the particular high-frequency components from the input image[9].

D-Yu Chen, C-Cheng Chen, and L-Wei Kang, proposed a single color image based rain removal structure by accurately designing rain removal as an image decomposition based on sparse representation. In this structure, initially an input rain image is partitioned into a low-frequency part and a high frequency part by applying the guided image filter so that the rain streaks present in the high-frequency part. High-frequency part contains with rain streaks, textures or edges. High-frequency part is again partitioned into a rain component and a non-rain i.e. geometric component by performing dictionary learning and sparse coding. After that split rain streaks from the high-frequency part, for this a hybrid feature set, together with the depth of field, eigen color and histogram of oriented gradients is implemented to moreover decomposed the high-frequency part. When they used hybrid feature set, almost all rain streaks can be removed; at the same time non-rain component can be enhanced. This method concentrates on the problem of single image rain removal and achieves good results with not only the entire rain component being eliminated more completely, but also the visual quality of deterioated images being improved[10-11].

J-Hwan Kim, C Lee, J-Young Sim, and C-Su Kim proposed an adaptive rain streak removal algorithm for a single image. They notice that a specific rain streak has an elongated elliptical shape with a vertical direction. So, by using this algorithm they first need to recognize an area of rain streak by examine the rotation angle and the aspect ratio of the elliptical kernel at every pixel location. After this they perform the nonlocal means filtering on the recognized rain streak regions by choosing nonlocal neighbor pixels and their weights [12].

C-Hung Yeh, P-Hsian Liu, C-En Yu, and C-Yang Lin, proposed a NMF-based rain removal method. In this method for rain removal of single image, firstly rain image is divided into the high frequency part and the low frequency part by implementing Gaussian filter. Non-negative matrix factorization (NMF) is used to remove the rain streaks in the low frequency part.NMF is good noise filtering. Then, Canny edge detection is applied to deal with the rain in the high frequency and the block copy method is employed to preserve the image quality. After that, they applied a rain dictionary to further divide the high frequency into rain and non-rain parts**.** This method not only remove most of the rain, but also preserve the image quality using only single rain image[13].

S Yu ,W Ou , X You, Yi Mou , X Jiang ,Y Tang proposed a new algorithm for rain streaks removal from single image which is based on self-learning framework and structured sparse representation. This algorithm firstly divide and classifies input image into rain streaks regions and non-rain i.e. geometric regions through texture analysis. Meanwhile, we also decompose input image into high-frequency (HF) and low-frequency (LF) parts with bilateral filtering. Followed that, we introduced our newly proposed structured dictionary learning to decompose HF part into rain texture details and non-rain geometric details, where patches for training rain and non-rain sub-dictionaries are selected from rain streaks and non-rain geometric regions. Finally, they combine LF part with non-rain geometric details to get rain streaks-removal image [14].

III. COMPARATIVE ANALYSIS

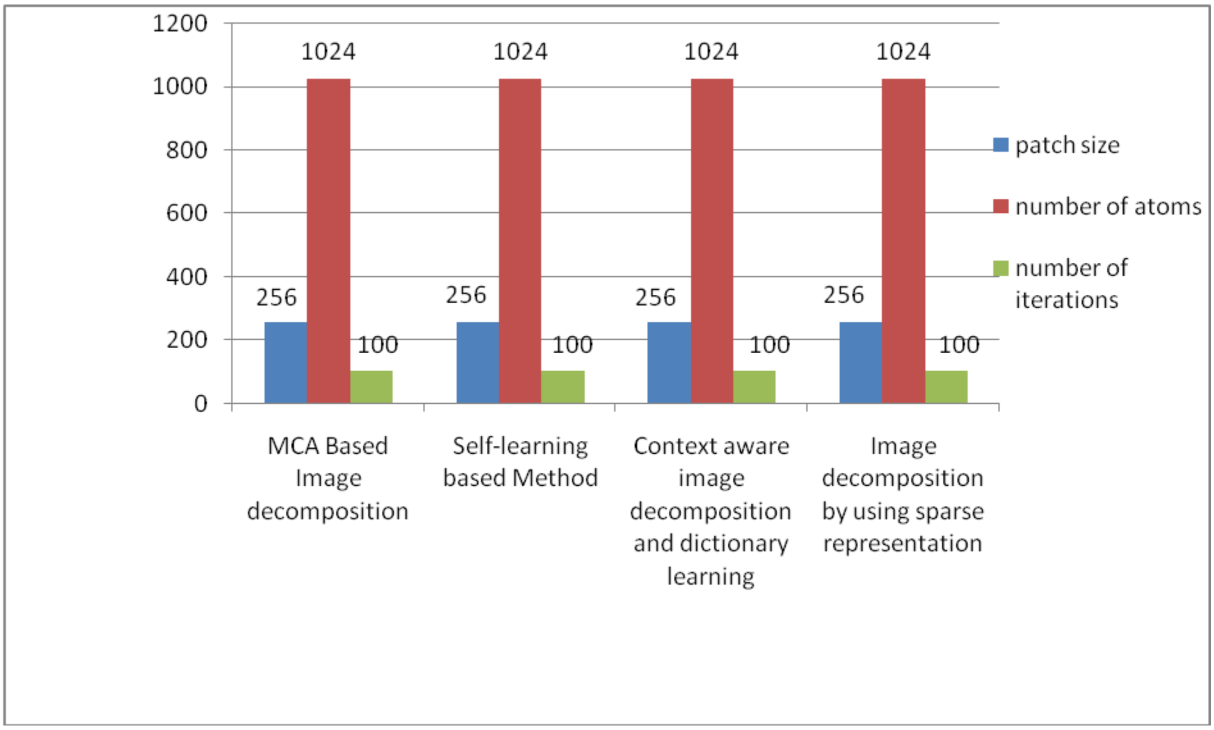

Figure 3: Comparative Analysis of different methods

From the comparative analysis we observe that by using image decomposition, separation of rain component and non rain component is possible. Many authors used image decomposition method for the rain streaks removal because of this rain component removed while preserving original image quality. Also they considered many parameter i.e. patch size, number of atoms which is also known as dictionary size, number of iterations in their proposed method. The comparative analysis of different method with respective parameter is shown in figure 3.In Table 1 we shows name of authors with there method used and related parameter also we mention advantage of their method.

Sr No	Author	Method used	Parameter	Advantages
1	L.W. Kang, C.W. Lin, Y.H. Fu	MCA based Image Decomposition	Patch size , number of atoms, number of iterations	This method removed rain streaks while keeping original image contents as it is.
2	Y.H. Fu, L.W. Kang, C.W. Lin, and C.T. Hsu	Image Decomposition by MCA	Dictionary	This method remove rain streaks from an image without blurring original image details
3	L.W. Kang, C.W. Lin, C.T. Lin, and Y.C. Lin	Self-learning based method	Patch size, dictionary size, number of iterations	This method removes rain streak from an image while keeping safely original image.
4	Li-Wei Kang, Yu-Hsiang Fu,	MCA based Image Decomposition	Patch size, number of atoms, number of iterations	This method remove rain streaks in an image without blurring.

5	Y.-L. Chen and C.-T. Hsu	Generalized low rank appearance model	Patch size, patch offset	This method is feasible to various inputs without pre-processing.
6	X. Zheng, Y. Liao, W. Guo, X. Fu, X. Ding	By using multi-guided filter	-	This method is effective and efficient in rain removal and snow removal.
7	D.-A. Huang, L.-W. Kang, M.-C. Yang, C.-W. Lin, Y.-C. F. Wang	Context aware image decomposition and dictionary learning	Patch size, dictionary size , number of iterations	This proposed method is able to extract image specific context information and thus rain patterns can be identified and removed from the image.
8	D-Yu Chen, C-Cheng Chen, Li-Wei Kang	Image decomposition by using sparse representation	Minibatch size, number of atoms, number of iterations, patch size	This method shows that rain components can be removed more effectively, but also the visual quality of degraded images can be improved.
9	D.Y. Chen, C.C. Chen, L.W. Kang	Visual depth guided filter via Sparse Coding	Dictionary	This method removes rain streaks as well as visual quality of rain image can be improved.
10	J H Kim, C Lee, J Y Sim, C S Kim	adaptive non-local means filter	Size of window, size of block	This method remove rain streaks, without producing visual artifacts.
11	C-Hung Yeh, P-Hsian Liu, C-En Yu, and C-Yang Lin	Negative Matrix Factorization based rain removal method	Size of block, number of iterations, sigma	This method can remove most of the rain, also preserve the image quality.
12	S Yu ,W Ou , X You, Y Mou , X Jiang ,Y Tang	Self learning structure and structured sparse representation	Dictionary, patch size	This method is good for extracting and identifying rain streak regions automatically.

Table 1:Comparative Analysis of different method

IV. CONCLUSION

In this paper, we review how rain streaks affects the outdoor vision system because of this visual quality of an image decreases and we also review different methods used for removal of rain streaks in an images. Also we make comparative analysis of different method from which we conclude that most of the method used image decomposition from which we get better result. Rain streaks removal is applicable in many applications such as image enhancement, image editing, image forensics. It is also used in pre-processing of various computer vision algorithms which use important feature information such as object detection, tracking, recognition also in segmentation. Also rain removal has found various applications in the field of security surveillance, vision based navigation.

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