A Survey on Rain Pixel Recovery Techniques for Videos

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***Abstract*— Rain produces sharp intensity variation in images and videos, which degrade the performance of outdoor vision systems. These intensity variation depend on various factors, such as the camera parameters, the properties of rain, and the brightness of the scene. Removal of rain streaks in video is a challenging problem due to the random spatial distribution and fast motion of rain. There are several rain removal algorithms, where photometric, chromatic, and probabilistic properties of the rain have been used to detect and remove the rainy effect. Rain removal has found various applications in the field of security surveillance, vision based navigation, video/movie editing and video indexing/retrieval. This paper provides various techniques or methods that are used to detect and remove the rainy effect.**

***Keywords*— Motion segmentation, motion occlusion, dynamic scene, motion buffering, adaptive filters, rain removal, image decomposition, Morphological Component Analysis(MAC).**

I. INTRODUCTION

Bad weather degrades the perceptual image quality as well as the performance of various computer vision algorithms which use feature information such as object detection, tracking, segmentation and recognition. Thus, it is very difficult to implement these computer vision algorithms robust to weather changes. There are different types of bad weather conditions, e.g., fog, rain, snow, haze, mist, etc. Based on the type of the visual effects, bad weather conditions are classified into two categories: steady (viz., fog, mist and haze) and dynamic (viz., rain, snow and hail). In steady bad weather, constituent droplets are very small and steadily float in the air. In dynamic bad weather, constituent droplets are 1000 times larger than those of the steady weather.

The dynamic bad weather model is evaluate, for the purpose of restoration. Rain is the major component of the dynamic bad weather. Due to the high velocity of the raindrops, their perspective projection forms the rain streaks. Removal of rain streaks in video is a challenging problem due to the random spatial distribution and fast motion of rain. In rainy videos pixels exhibit small but frequent intensity variations, and this variation could be caused by several other reasons besides rain fall, namely, global illumination change, camera move, and object motion etc.

In order to remove the rainy effect, it is necessary to detect the variations that are caused by rain, and then replace them with their original value.

II. RELATED WORKS

Rain removal is a very useful and important technique in applications such as security surveillance, video/movie editing, vision based navigation, and video indexing/retrieval. Wide range of algorithms using various types of techniques is been used by various authors.

A. Photometric and Dynamic Model

Kshitiz Garg and Shree K. Nayar [1] in 2007 present the first complete analysis of the visual effects of rain on an imaging system and the various factors that affect it. To handle photometric rendering of rain in computer graphics and rain in computer vision they develop systematic algorithm. They first develop a photometric model that describes the intensities produced by individual rain streaks and then develop a dynamic model that captures the spatiotemporal properties of rain. Together, these models describe the complete visual appearance of rain. Using these model they develop a new algorithm for rain detection and removal.

By modeling the scattering and chromatic effects, Narasimhan and Nayar successfully recovered "clear day" scenes from images taken in bad weather. But, their assumptions such as the uniform velocities and directions of the rain drops limited its performance.

B. Temporal and Chromatic Properties

By using both temporal and chromatic properties of rain Xiaopeng Zhang, Hao Li [2] presents a K-mean clustering algorithm for rain detection and removal. The temporal property states that an image pixel is never always covered by rain throughout the entire video. The chromatic property states that the changes of R, G, and B values of rain affected pixels are approximately the same. The algorithm can detect and remove rain streaks in both stationary and dynamic scenes, by using both temporal and chromatic properties which are taken by stationary cameras.

But it gives wrong result for those scenes which are taken by moving cameras. To handle these situation the video can be stabilized for rain removal, and destabilized to restore camera motion after rain removal. It can handle both light rain and heavy rain conditions.

This method is only applicable with static background, and it gives out false result for particular foreground colours.

C. Probabilistic Model

K. Tripathi and S. Mukhopadhyay [3] proposed a efficient, simple, and probabilistic model based rain removal algorithm. This algorithm is better to the rain intensity variations. Probabilistic approach automatically adjust the threshold and effectively differentiate the rain pixels and non-rain moving object pixels. Differentiation is done between the rain and non-rain moving objects by using the time evolution of pixels in consecutive frames. This algorithm does not assume the shape, size and velocity of the raindrops and intensity of rain, which makes it robust to different rain conditions. Advantage of this algorithm is that it automates the algorithm and reduces the user intervention.

Here, it is assumed that the video capturing camera is static. There is a significant difference in time evolution between the rain and non-rain pixels in videos. This difference is analysed with the help of the skewness and Pitman test for symmetry. Quantitative results show that proposed algorithm gives lower number of miss and false detection in comparison with other algorithms. This algorithm helps to reduce the complexity and execution time of the algorithm because it works only on the intensity plane.

This method is more robust dealing with dynamic scenes, however some statistical feature it proposes works poorly in many occasions, and it gives a lot of false detections.

D. *Motion Segmentation*

Jie Chen and Lap-Pui Chau [5] used a novel approach for rain removal. These algorithm is based on motion segmentation of dynamic scene. The pixel intensity variation of a rainy scene is caused by rain and object motion. The variation caused by rain need to be removed, and the ones caused by object motion need to keep it as it is. Thus motion field segmentation naturally becomes a fundamental procedure of these algorithm.

Proper threshold value is set to detect the intensity variation caused by rain. After applying photometric and chromatic constraints for rain detection, rain removal filters are applied on pixels such that their dynamic property as well as motion occlusion clue are considered; both spatial and temporal information are then adaptively use during rain pixel recovery. These algorithm gives better performance over others for rain removal in highly dynamic scenes with heavier rainfall. Fig.1 shows the block diagram of rain removal pixel using motion segmentation.

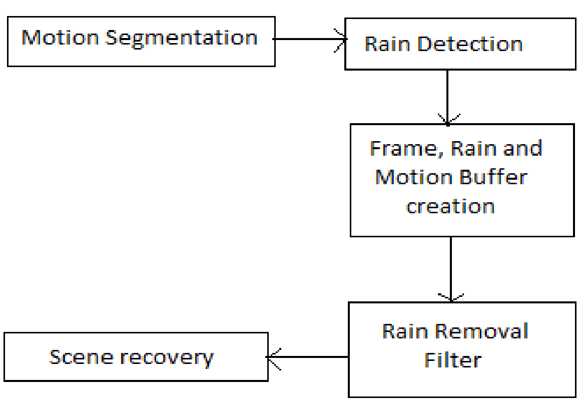

Fig. 1 Block Diagram of rain removal pixel using motion segmentation

E. *Spatiotemporal Properties*

A. Tripathi and S. Mukhopadhyay [4] used a spatiotemporal properties for detection and removal of rain from video. The spatiotemporal properties are involved to separate rain pixels from non-rain pixels. It is thus possible to involve less number of consecutive frames, reducing the buffer size and delay. It works only on the intensity plane which further reduces the complexity and execution time significantly. This algorithm does not assume the shape, size and velocity of raindrops which makes it robust to different rain conditions. This method reduces the buffer size, which reduces the system cost, delay and power consumption. This method gives out false result for dynamic scenes.

F. *Bilateral Filter*

Li-Wei Kang and Yu-Hsiang Fu [6] propose a single-image-based rain removal framework via properly formulating rain removal as an image decomposition problem based on morphological component analysis. Instead of directly applying a conventional image decomposition technique, the proposed method first decomposes an image into the low- and high-frequency (HF) parts using a bilateral filter. The HF part is then decomposed into a "rain component" and a "nonrain component" by performing dictionary learning and sparse coding based on MCA (morphological component analysis).

These is first method which remove rain streak while preserving geometrical details in a single frame, where no temporal or motion information among successive images is required. In these method decomposing rain steaks from an image is fully automatic and self-contained, where no extra training samples are required. Fig. 2 shows the single-image-based rain streak removal framework.

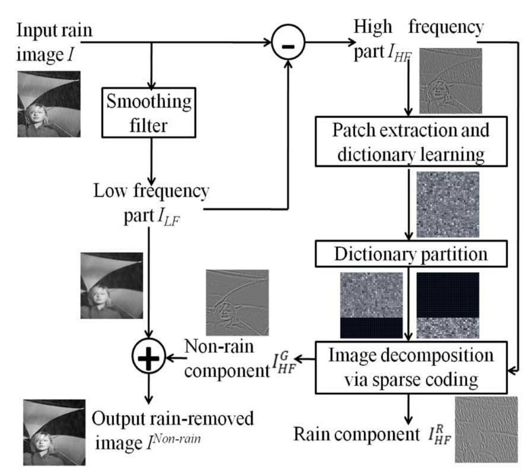

Fig. 2 Block diagram of the proposed rain streak removal method

III. APPLICATIONS

Rain Pixel recovery algorithm finds its application in the field of:

- Security surveillance
- Vision based navigation
- Video/movie editing
- video indexing/retrieval

IV.CONCLUSION

This paper presents an extensive survey on rain pixel recovery techniques for video. Currently, many new schemes are proposed in the field of video compression. Rain pixel removal using motion segmentation is widely used technique and it gives better result for highly dynamic scene. Many research issues have been highlighted and direction for future work have been suggested. Many open issues have been highlighted by the researchers such as dealing with heavier rainfall and dynamic scene.

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