Single Image Rain Removal Using Guided Filter

Najiya C A[1]
Computer Science and Engineering
MEA Engineering College
Perinthalmanna – India

Sreeram S[2]
Computer Science and Engineering
MEA Engineering College
Perinthalmanna – India

Abstract: Presence of rain significantly reduces the visibility of images and videos. Rain removal from videos is discussed so far in literature where temporal information from adjacent frames is considered. But if only a single image is considered, it is rarely discussed. In this paper, we propose a single image rain removal method using guided filter. Guided filter is employed three times in our method to get the desired result. At first, our input rainy image undergoes guided image filtering. Guided filter outputs the low frequency part of the input image. Subtracting this low frequency part from input image gives the corresponding high frequency part of the image. This is followed by edge enhancement of low frequency part using sobel filter. The result of edge enhancement is used as guidance image for second time guided filtering with the high frequency part as the input image. Adding the result with the low frequency part, we restore the image. We further make it more clearly considering clear background edges.

Keywords: Edge enhancement; Guided filters; Rain removal; Sobel filter; weighted summation.

I. INTRODUCTION

Rain is a structured noise which causes significant degradation of quality of image. Rain noise removal in image processing is covered by a lot of researchers and is still a research area. Rain streaks removal from videos is mainly concentrated for studies so far, but the same from a single image is rarely discussed in literature.

The [2] proposed a frame work for removing rain from videos by considering temporal and chromatic properties. The authors applied dilation and Gaussian blurring on detected rain pixels in order to recover from blurring by both motion and defocus. The [3] combines irradiance light field and motion field so that only successive three frames is required for rain streaks removal. In [1], two models are developed that capture dynamics and photometry of rain. Based on these models, they developed an efficient algorithm for rain removal.

When only a single image is available, the task of rain removal becomes difficult. This problem is solved by a few of researchers in their works. The [2] proposed a frame work for removing rain from videos by considering temporal and chromatic properties. The authors applied dilation and Gaussian blurring on detected rain pixels in order to recover from blurring by both motion and defocus. The [3] combines irradiance light field and motion field so that only successive three frames is required for rain streaks removal. In [1], two models are developed that capture dynamics and photometry of rain. Based on these models, they developed an efficient algorithm for rain removal. Some authors developed a rain removal frame work with the help of guided filter. In this   paper, we propose a simple and efficient guided filter based method for rain removal. We use guided filter three times in our method. Guided filter introduce some negative effects. Our method resolves these effects by certain steps. It makes our final result more clearly and close to input image.

Najiya et al.,

International Journal of Advance Research in Computer Science and Management Studies
Volume 3, Issue 5, May 2015 pg. 135-142

II. GUIDE FILTERING

Guided filter is a fast non-approximate linear-time algorithm which generates the filtering output by considering the content of a guidance image, which can be the input image itself or a different image. It is a low pass filter which implies for an input image, guided filter outputs its low frequency part. The subtraction of low frequency part from the input image gives high frequency part of the image. This decomposition can be adjusted according to desired result by tuning degree of smoothness of guided filter. The function of guided filter for an input image I can be realized as follows:

$$I = I \_ L + I \_ H \qquad (1)$$

Where I_L is the low frequency part and I_H is the high frequency part of the image I.

Guided filter is an edge preserving smoothing filter like bilateral filter. But it is free from gradient reversal artifacts and stair case artifacts. It has an O (N) time algorithm which performs very well in terms of quality and efficiency in several applications. It brings better results in denoising, image enhancement etc. Guided filtering algorithm can be applied only for gray scale images. Thus to perform it on color images, R, G, and B components are extracted and apply guided filter for each component .

A.   Guided Filter Algorithm

1. Read the image say G (gray scale image), it acts as a guidance   image.

2. Make I=G, where p acts as our filtering image (gray scale image).

3. Enter the values assumed for r and ε, where r is the local window radius and ε is the regularization parameter.

4. Compute the mean of I, G, G*I.

5. The compute the covariance of (G,I) using the formula:-

    cov_GI=mean_GI -meanG_.*mean_I;

6. Then compute the mean of (G*G) and use it to compute the variance using the formula:-

    var_G = mean_GG - mean_G .* mean_G

7. Then compute the value of a, b. where a,b are the linear coefficients.

8. Then compute mean of both a and b.

9. Finally obtain the filtered output image q by using the mean of a and b in the formula

    q = mean_a .* G + mean_b;

The remainder of this paper is organized as follows. In Section 2, we explain related works regarding rain removal from images and videos. In Section 3, we discuss our proposed system .In section 4, experimental results are showed. Finally we conclude the paper in section 4.

III. RELATED WORK

K. Garg and S. K. Nayar [1] presented a detailed analysis of the visual effects of rain on images and videos. A summary of the physical properties of rain such as the spatial distribution, shapes, sizes and velocities of drops is included in this. They developed two separate models that capture the dynamics and the photometry of rain. A correlation model that represents the dynamics of rain and a physics-based motion blur model that describes the photometry of rain. Based on these models, they developed an algorithm for rain removal from videos. After detecting rainy pixel, they replace each of them with background pixels using certain steps.

X. Zhang, H. Li, Y. Qi, W. K. Leow, and T. K. Ng [2] introduced a rain removal algorithm that includes both temporal and chromatic properties of rain in video. The temporal property is stated as an image pixel is never always consists of rain

Najiya et al.,

International Journal of Advance Research in Computer Science and Management Studies
Volume 3, Issue 5, May 2015 pg. 135-142

throughout the full video. The chromatic property states that the variation of R, G, and B values of rainy pixels are approximately the same. By using both characteristics, along with k-means clustering the algorithm can detect and remove rain streaks. Rainy pixels are detected and replaced with background pixels which are got by k-means clustering.

Combining the properties of rain in irradiance light field and motion field, **M. Shen and P. Xue[3]** presented a different algorithm for rain detection and removal using only three successive frames. In this method, the rainy particle is distinguished from other moving particles using motion data. An anisotropic diffusion based smoothing is proposed for rain removal.

Y.-H. Fu, L.-W. Kang, C.-W. Lin, and C.-T. Hsu [4] are proposed a single frame rain removal method. They achieved this via properly formulating rain removal as an image decomposition problem. Image decomposition is done based on morphological component analysis (MCA). In this, they first decompose an image into the low-frequency part and high-frequency part using bilateral filter. This high-frequency part is then classified as "rain component" and "non-rain component" via performing dictionary learning and sparse coding.

L.-W. Kang, C.-W. Lin, C.-T. Lin, and Y.-C. Lin [5] proposed a single image rain streak removal framework just like in [4]. They extended the single image-based method to video-based rain removal in a static scene by exploiting the temporal information of adjacent frames and reusing the dictionaries learned by the frame(s) before in a video while maintaining the temporal consistency of the video.

C. Tomasi and R. Manduchi [8] introduced the concept of bilateral filtering for edge-preserving smoothing. It finds out, for each pixel, an average of nearby pixel values which are similar and use to replace the pixel. In smooth regions, values of pixel in a small neighborhood are similar to each other, and the normalized similarity function is close to one. This property is considered over here. The developed filter has less speed and it suffers from artifacts like gradient reversal and staircase effect.

IV. PROPOSED WORK

Figure 1 shows block diagram of proposed method. Our method employs three main modules namely pre-processing, Filtering and Recovering.

Figure 1: Block diagram of proposed method
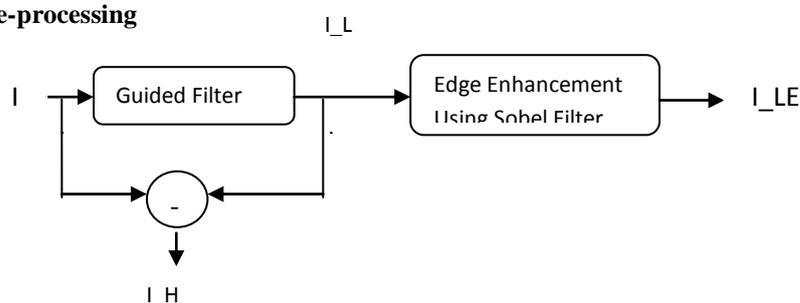
A. Pre-processing

Figure 2: Pre-processing

First, guided filter is applied to input image using the same as guidance. Since guided filter is a low pass filter, low frequency part of the image is obtained. We subtract the low frequency part from the image to get high frequency part. We adjust the degree of smoothness for the guided filter to get the low frequency part as it is free from rain components of image. This low frequency part is then used for restoration of the image in further steps.

$$I = I\_L + I\_H \qquad (2)$$

$$I\_H = I\_HR + I\_HNR \qquad (3)$$

Where I_HR is the rain components present in high frequency part and I_HNR is the non-rain particles present in high frequency part.

Using guided filter, edges of the image is getting smoothed very much. So the low frequency part contains only these smoothed edges. An edge enhancement is recommended to improvise the edges and to make them close to image. Edge enhancement can be done through various ways. We use sobel filter to perform edge enhancement of low frequency part. Thus we get an enhanced version of low frequency part which is denoted as I_LE . I_LE then used as the guidance image for the coming guided filter. The process is shown in figure 2.

B. Filtering

After preprocessing, we use guided filter once again with high frequency part as the input image. It uses the I_LE as the guidance image here. In order to get rain free high frequency part we adjust degree of smoothing for guided filter. The resulting high frequency part contains only non-rain particles. i.e.,

$$I \_ H = I \_ HNR \qquad (4)$$

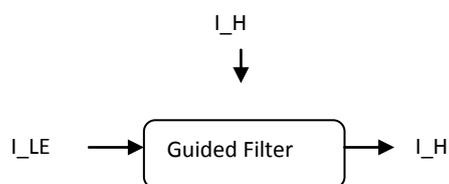This is used in further steps to restore the image.
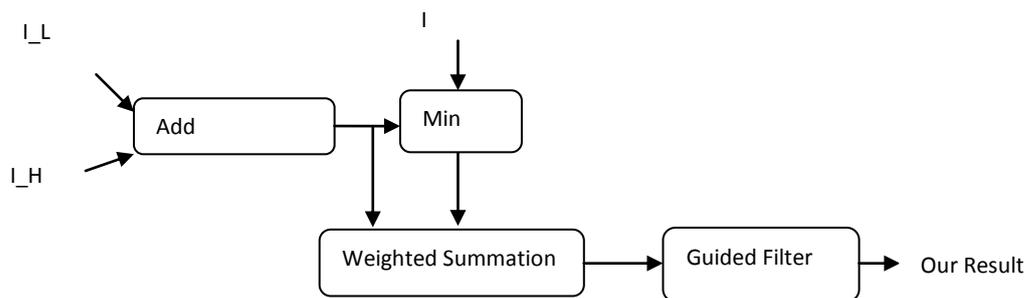

Figure 3 : Filtering

A. Recovering

Figure 4: Recovering

To bring a more refined and clear results, we go through certain recovery mechanisms. These mechanisms drive to form a good result which is more close to input image. As given in figure 4, First of all we want to restore the input image. For that we add the low frequency to the high frequency part. The resulting image contains the combination of low frequency part and filtered high frequency part. The resultant image is termed as recovered image and is denoted by I_Rec which can be realized as:

$$I \_ \mathrm{Re}\, c = I \_ L + I \_ H \qquad (5)$$

Due to the effect of guided filter, some pixels in this recovered image get blurred. The pixels near rain streaks suffer with this effect. So it has to be making more clear. To achieve this find minimum value among rough recovered image I_Rec and input image I. The resulting image is termed as clear image and is denoted with I_Clr as in the following expression:

Najiya et al.,

International Journal of Advance Research in Computer Science and Management Studies
Volume 3, Issue 5, May 2015 pg. 135-142

$$I\_Clr = Min\,(I\_\mathrm{Re}\,c, I) \qquad (6)$$

Now we solve another issue of guided filter. After using Guided filter, rain removed part values become slightly higher than adjacent pixel values. It disturbs visual goodness. In order to solve this, a weighted summation of I_Clr and I_Rec is performed. The obtained result is termed as refined guidance image and is denoted by I_Ref .It is termed like this because it is used as the guidance image for the coming guided filter. Weighted summation to be performed can be recognized with the following expression:

$$I\_\mathrm{Re}\,f = \alpha\,I\_Clr + (1-\alpha)\,I\_\mathrm{Re}\,c \qquad (7)$$

Where α = 0.8 in this paper. This is followed by guided filter once again with I_Clr as the input and I_Ref as the guidance image. Thus we get a more refined recovered rain removed image.
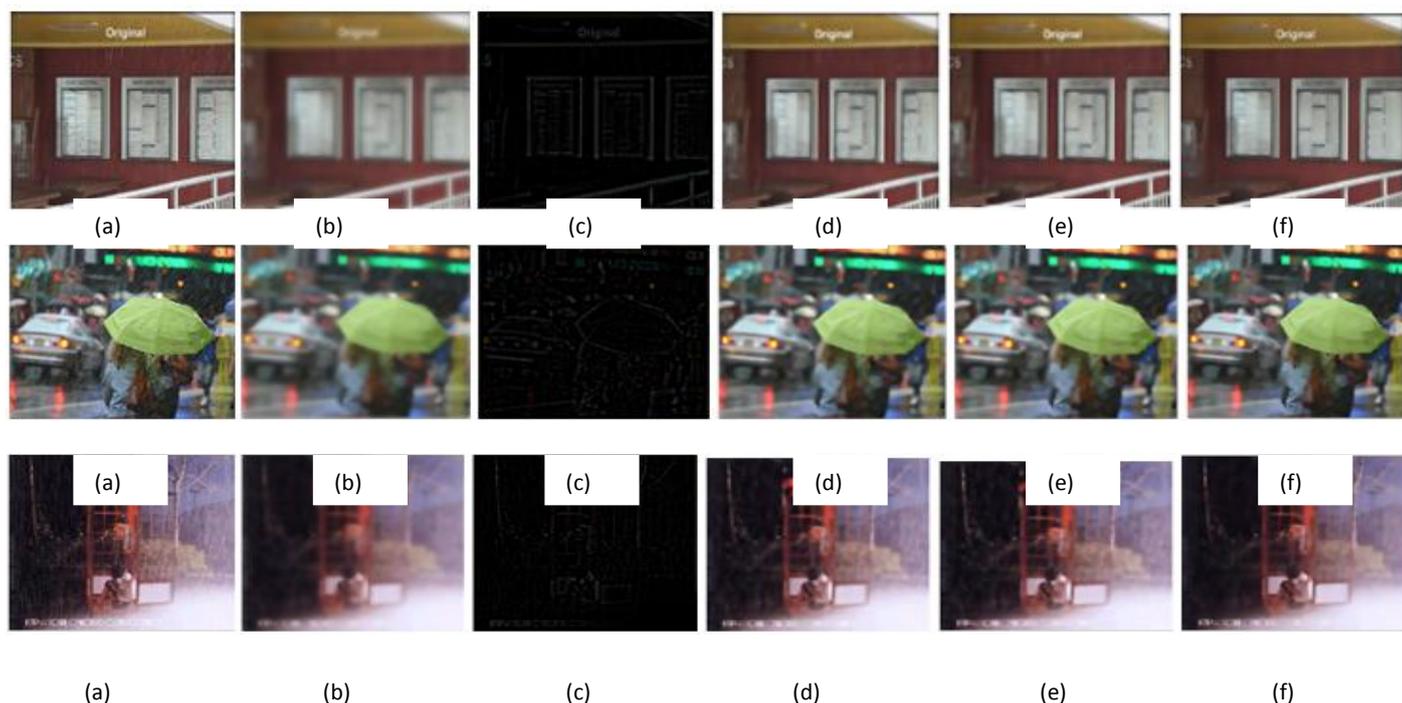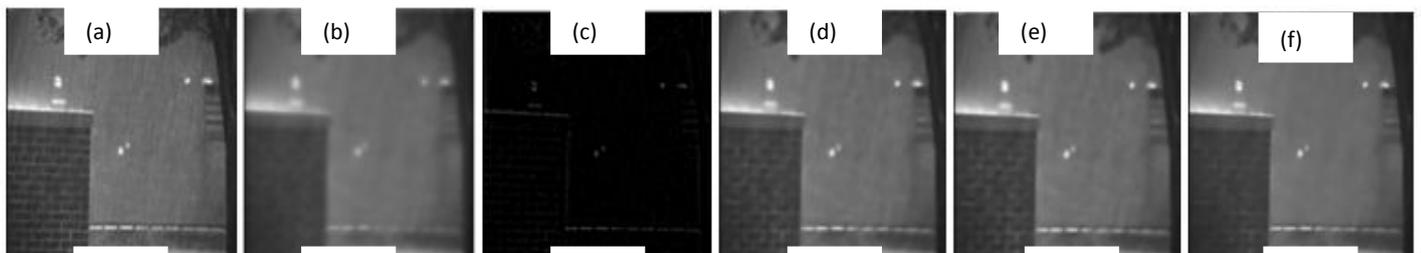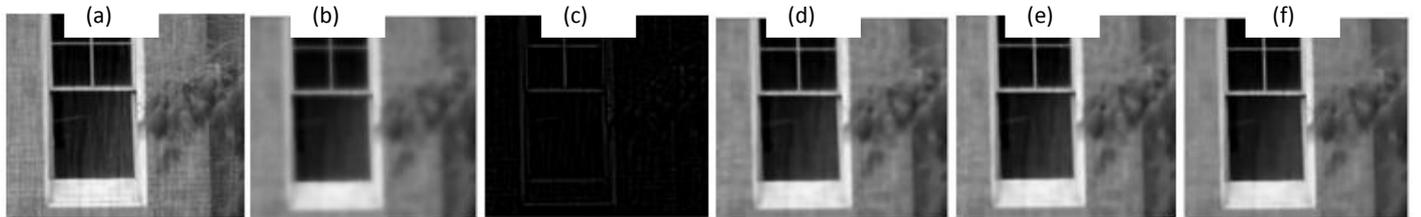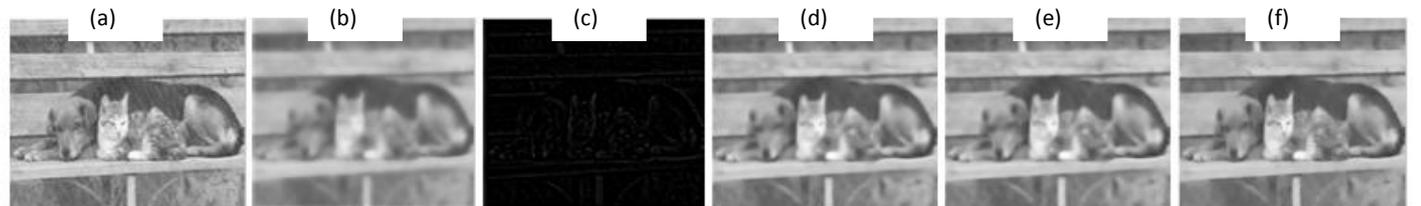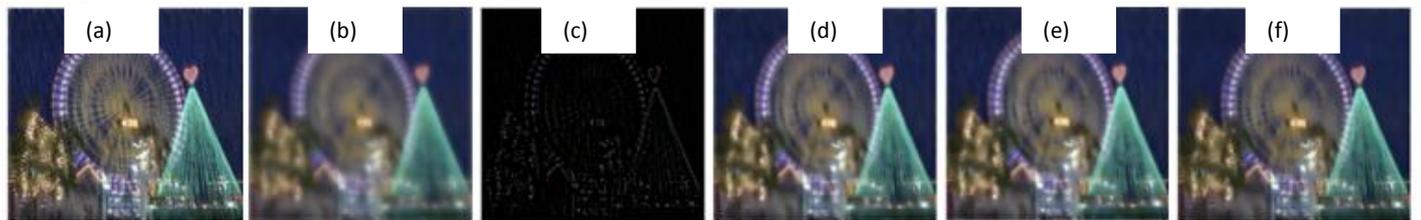
V. EXPERIMENTAL RESULTS

An input rainy image is read and our proposed frame work is applied. For getting good results, it is needed to tune degree of smoothness for each guided filter into some values. We set 0.1, 0.000001and 0.001 as degree of smoothness values for guided filters respectively to get desired result. Figure 5 shows an example input image and result using our method.

Figure 5: (a) Original image (b) Our result

Figure 6 shows intermediate results using our method. Figure 6(a) shows input images. In figure 6(b) and figure 6(c) the low frequency part and the high frequency part of the image at first guided filter is shown. Figure 6(d) is the recovered image got by applying equation (5). Figure 6(e) shows the clear image got using the equation (6). Figure 6(f) shows our final result. It can be seen that rain is removed effectively.
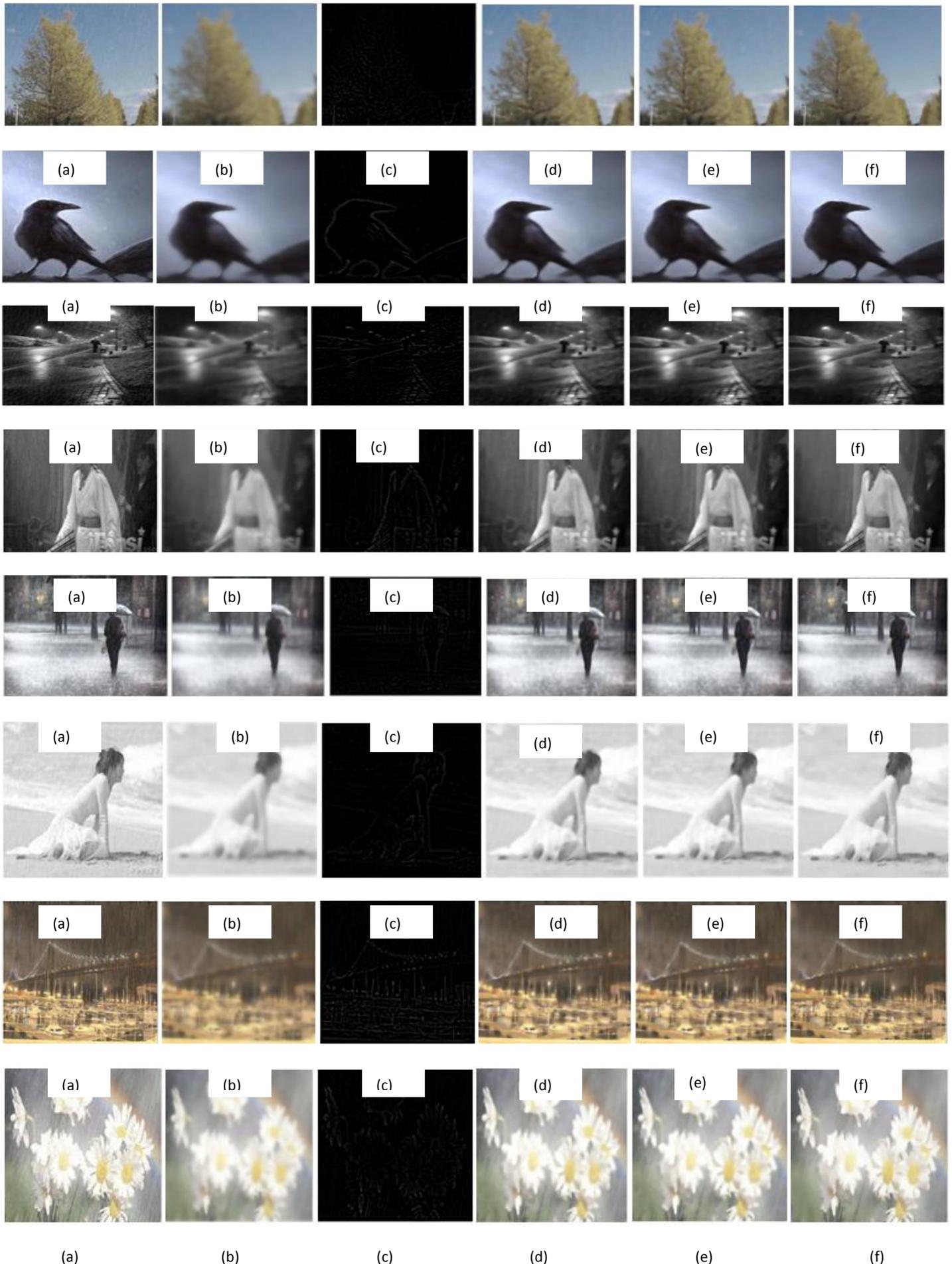

(a) (b) (c) (d) (e) (f)

Najiya et al.,

International Journal of Advance Research in Computer Science and Management Studies
Volume 3, Issue 5, May 2015 pg. 135-142

(a)   (b)   (c)   (d)   (e)   (f)

Najiya et al.,

International Journal of Advance Research in Computer Science and Management Studies
Volume 3, Issue 5, May 2015 pg. 135-142

Figure 6: Intermediate results using our method (a) Original image (b) Low frequency part (c) High frequency part(d)Recovered image (e) Clear image (f) Our result

VI. CONCLUSION AND FUTURE WORK

In this paper, we proposed an efficient rain removal method for single image using guided filter. The guided filter sometimes introduces some negative effects. These effects are identified and resolved using some recovery methods. Our method is simple and it can effectively remove presence of rain from images. Even though our system brings good results for rain removal, it has to compromise some quality of image which can be resolved in future.

ACKNOWLEDGEMENT

References

1. "K. Garg and S. K. Nayar, "Detection and removal of rain from videos," in Computer Vision and Pattern Recognition, 2004. CVPR 2004. Proceedings of the 2004 IEEE Computer Society Conference on, vol. 1. IEEE, 2004, pp. I-528.

2. X. Zhang, H. Li, Y. Qi, W. K. Leow, and T. K. Ng, "Rain removal in video by combining temporal and chromatic properties," in Multimedia and Expo, 2006 IEEE International Conference on. IEEE, 2006, pp. 461-464.

3. M. Shen and P. Xue, "A fast algorithm for rain detection and removal from videos," in Multimedia and Expo (ICME), 2011 IEEE International Conference on. IEEE, 2011, pp. 1-6.

4. Y.-H. Fu, L.-W. Kang, C.-W. Lin, and C.-T. Hsu, "Single-frame-based rain removal via image decomposition," in Acoustics, Speech and Signal Processing (ICASSP), 2011 IEEE International Conference on. IEEE, 2011, pp. 1453-1456.

5. L.-W. Kang, C.-W. Lin, C.-T. Lin, and Y.-C. Lin, "Self-learning based rain streak removal for image/video," in Circuits and Systems (ISCAS), 2012 IEEE International Symposium on. IEEE, 2012, pp. 1871-1874.

6. J. Xu, W. Zhao, P. Liu, and X. Tang, "Removing rain and snow in a single image using guided filter," in Computer Science and Automation Engineering (CSAE), 2012 IEEE International Conference on, vol. 2. IEEE, 2012, pp. 304-307.

7. M. Elad and M. Aharon, "Image denoising via sparse and redundant representations over learned dictionaries,".Image Processing, IEEE Transactions on, vol. 15, no. 12, pp. 3736-3745, 2006.

8. C. Tomasi and R. Manduchi, "Bilateral filtering for gray and color images," in Computer Vision, 1998. Sixth International Conference on. IEEE, 1998, pp. 839-846.

9. J. Bossu, N. Hauti_ere, and J.-P. Tarel, "Rain or snow detection in image sequences through use of a histogram of orientation of streaks," International journal of computer vision, vol. 93, no. 3, pp. 348-367, 2011.

10. L.-W. Kang, C.-W. Lin, and Y.-H. Fu, "Automatic single-image-based rain streaks removal via image decomposition,"