REMOVING RAIN STREAKS FROM SINGLE IMAGES USING TOTAL VARIATION

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ABSTRACT

Rainy image restoration is considered as one of the most important image restorations aspects to improve the outdoor vision. Many fields have used this kind of restorations such as driving assistant, environment monitoring, animals monitoring, computer vision, face recognition, object recognition and personal photos. Image restoration simply means how to remove the noise from the images. Most of the images have some noises from the environment. Moreover, image quality assessment plays an important role in the valuation of image enhancement algorithms. In this research, we will use a total variation to remove rain streaks from a single image. It shows a good performance compared to other methods, using some measurements MSE, PSNR, and VIF for an image with references and BRISQUE for an image without references.

KEYWORDS

Rainy image, image restoration, removing rain streaks, single image

1. INTRODUCTION

The effect of noise means to change the digital value for actual pixels; these changes will make the real scene different. Moreover, numerous researches emerged to explain that the image noise comes by many methods. There are many models of noises such as rain streaks, raindrops, and other type of noises. As well as of these noise coming from media like that arrangement image, whereas acquisition of images, save the images, transfer images among the devices. Likewise, these differences of noise need various algorithms to image denoising based on the noise model. Then the calculation for the image is decreased or increased by the original data values. Although in this noisy image, there are some values of neighbor's pixel that did not change. It means the image is not fully corrupted, in other words, some pixels values changed in the image but not all. Mainly each of the digital images that have contained the original signals, are stable in the usual case and in random noise. It is representing in the following equation (1).

$$I'(x, y) = I(x, y) + N(x, y) \quad (1)$$

Where I' - noisy image; I - signal-only image; N - noise component; x, y - pixel coordinates. The diverse classes of noise that impacts on the quality of images and computer vision. Images consider a source of information in numerous implementations such as remote sensing, medical imaging, astronomy, and military activity. Therefore, images should be clean without noises or blur, but in reality, images have noise and may be influenced by many reasons. This factors such

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as outdoor things, such as weather conditions noises or damaged noises camera sensors, captured in cloudy weather, transmission in the channel bright light and dark area. However, these images still need enhancement to get a good quality level. Many algorithms and filters are applied to enhance the image quality to make the images more understandable.

Image restoration means how to reconstruct images without noise; it is one part of image processing. As well as increasing the quality of the outdoor image is a critical issue in the scientific researches. Most of the images need to conduct improvement to be more acceptable. Therefore, rain streaks noises mean remove the noise by applying the algorithm. In this paper, we will perform a rain streaks removal algorithm and measurement of the rain streaks noises from single images.

2. RESEARCH SIGNIFICANCE

The main strength points in this research will be helpful in removing the rain streaks from single images. The second issue is related to enhancement images that have rain streaks noise in the rainy weather. Moreover, Picture upgrade means an estimate of a unique picture from the degraded picture, this corruption is caused by a great deal of reasons, for example, rain, camera miss center, and arbitrary air choppiness [2]. In addition, the visual impacts in terrible climate conditions and commotion are complex. In a large portion of awful climate conditions and commotion, it causes weak invisibility and sharp power changes in pictures and recordings that can seriously influence the pictures investigation, highlight extraction, and execution of vision frameworks. These effects on the pictures thought process is to miss investigation which is directed to miss analysis and is powerless in recognizing objects in the pictures.

3. TOTAL VARIATION

Total variation founded by [10] relies upon primary center thought that the signs have a high total variation, so to make equalization for aggregate variety is to be a unique flag. It expels the loud points of interest from the picture to be all the more near the first with high consideration for saving the subtle elements, for example, edges. Various points of interest and advantages for total variation strategy over different procedures, for example, guided filter and median filter to denoising through affect edges. Therefore, total variation is very good and exceptional and is successful with each other to preserving edges smoothing away noise in flat regions, even at low signal-to-noise ratios [11]. The impact of total variation technique on rainy pictures was clear and different. Every one of the program codes designed is dependent on [12]**.** Total variation impact at the texture of the picture by means of making it smooth is dependent on the distinctions in the image.

The researchers in [17], [18], [19] proposed a TV method to solve structure-texture image problem, to formulate the total variation they expressed such as in equation (2).

$$a_s \sum_p \left\{ \frac{1}{2\lambda} \left(S_p - I_p \right)^2 + \left| (\nabla S)_p \right| \right\} \tag{2}$$

wherever I is the input as luminance, then p which is indexes 2D pixels. S is the outcome of image. Then (Sp –Ip) 2 which is towards create the formations like those in the input image. ∇S be a TV regularizer as in equation (3).

$$\sum_{p} \left|(\nabla S)_p\right| = \sum \left|(\partial_x S)_p\right| + \left|(\partial_x S)_p\right| \tag{3}$$

where the parameters here are partial derivatives in two directions that are ∂x and ∂y. According to [20] to estimate the noise image u in equation 4, which proposed by [10].

$$\arg\min_{u \in BV(\Omega)} \|u\| TV(\Omega) + \frac{\lambda}{2} \int_{\Omega} (f(x) - u(x))^2 dx. \tag{4}$$

Where λ is a positive parameter, likewise the search space is all bounded variation (BV) images. The TV may the solution have oscillations, but it does allow the solution to have discontinuities in equation 5.

$$\|u\| TV(\Omega) \approx \sum_{i,j} \sqrt{(\nabla_x u)_{i,j}^2 + (\nabla_y u)_{i,j}^2} \tag{5}$$

where ∇ x and ∇ y are discretizations of the horizontal and vertical derivatives[20].

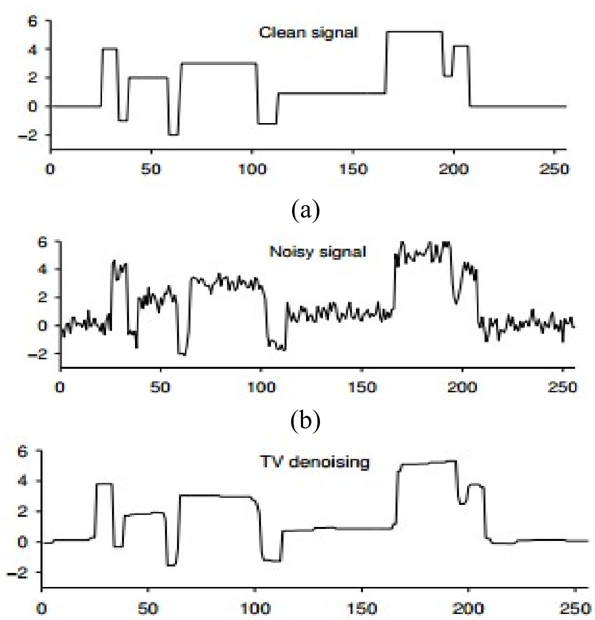


Figure 1. Total variation process (a) clean signal (b) Noisy signal (d) TV denoising [16].

The total variation technique produced a good quality output, the Figure 1 shows the how Total variation process. It is working to enhance the noising signals via detect the start and end the edges.

4. COLOR IMAGE

In the image processing, there are three main kinds of images, black and white, which means the value of pixels is zero or one. The second kind is a gray image, that means the value of pixels between 0-255, and the third kind is color space images, which contain three colors red, green, and blue by 24 bit for each pixel such as in Figure 2.

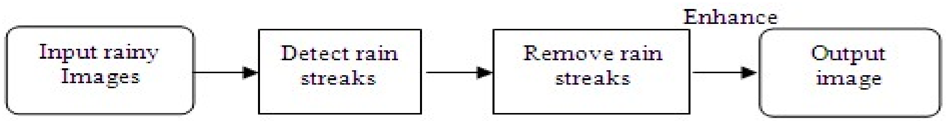


Figure 2. Flowchart on detection and removing rain streaks in the image

The noise impact on each of these colors is different, according to the color features. In this research, we will experiment these inferences.

5. IMAGE ENHANCEMENT

Picture upgrade activities typically recoup a changed form or boisterous picture of the first picture and frequently utilized as a preprocessing venture to build up the consequences of picture investigation methods. The upgrade methods can be divided into two classes which are transform domain and spatial domain [5]. Moreover, enhancement techniques include morphological filtering, contrast adjustment, filtering, and deblurring. Contrast Adjustment means histogram equalization, decorrelation stretching. Image Filtering is convolution and correlation, the main features for the filter should remove the noise while preserving the edges. Morphological Operations means to apply these methods on an image namely to dilate, reconstruct, and erode. Deblurring is deconvolution for deblurring. In the image processing arithmetic, there are numerous operations between images such as add two images, subtract, multiply, and divide images [7, 8].

Image enhancement is very significant for indoor and outdoor scenes. Indoor noise happens by bluer or light noise or by a camera sensor [6]. For an outdoor images that is caused by weather conditions such as rain, (see Figure 3) need to be enhanced.

Figure 3. Rainy images

6. NOISE EVALUATION

The motivation behind quality assessment (QA), think about it, is to make calculations for assessment of value in a way that is trustworthy with abstract human assessment into two classes change area and spatial space. QA techniques would confirm it important for testing, monitoring applications, benchmarking, and optimizing [3]. On the other side, according to [4], there are two main limitations in image accuracy which are categorized as blur and noise.

7. QUANTITATIVE MEASUREMENTS

The proposed method is an effective algorithm when compared with other existing strategies. The proposed method evaluation was conducted in two ways. The first method is visually compared outputs resulting in the stormy pictures that were an acquisition in clear climate conditions. The second method is dependent on the benchmarking with the present procedures with a view to stress the scene quality and accuracy details in the pictures using the statistical methods. Moreover, to be specific, estimations for pictures with references, such as mean square error (MSE), peak-signal noise ratio (PSNR), and visual information fidelity (VIF). This means the original and rainy images are available when conducting these experiments. Using images with references makes the comparison between the original and processed image easy to know the enhancement that affected it.

The second kind is an image without references such as unreferenced, which is a blind/reference-less image spatial quality evaluator (BRISQUE) [15]. Which means the rainy image is available to conduct the experiments. Likewise, this kind of images leads one to depend on BRISQUE to know how much enhancement is on rainy images.

7.1 THE EXPERIMENTS

The main parts for these trials are to get great outcomes, every one of the experiments conducted on matrix laboratory (Matlab) R2013a software by Cleve Moler in 1970 (Cleve, 2004)[13]. Therefore, the experiments used a statistical analysis on the BRISQUE, VIF, PSNR, and MSE measurements. The ratios for the following measurements are MSE, PSNR, VIF where the highest value is considered.

7.2 IMAGES WITH REFERENCES

Pictures with references mean the clean picture (reference) and a rainy picture (corrupted) is available.

(a) (b)

Figure 4. Red umbrella rainy image (a) Rainy Image (b) TV image

Table 1: Result of the 1st experiment

Figure 4	MSE	PSNR	VIF
Chen [9]	0.0102	68.0671	0.3175
TV _Sparse [15]	0.0028	73.7595	0.3939
TV	0.0076	69.3553	0.3173

In this experiment, it shows in MSE the Chen 0.0102, TV_sparse 0.0028 and TV 0.0076. In PSNR Chen(68.0671), TV_sparse (73.7595) and TV (69.3553). In VIF Chen (0.3175), TV_sparse (0.3939) and TV (0.3173). The TV method shows a good performance as compared with the latest techniques. TV method got a result better than Chen [9] in PSNR.

(a) (b)

Figure 5. Lady rainy image (a) Rainy Image (b) TV image

Table 2: Result of the 2nd experiment

Figure 5	MSE	PSNR	VIF
Chen [9]	0.0133	66.9166	0.4099
TV _ Sparse [15]	0.0121	67.3270	0.4422
TV	0.0126	67.1517	0.3824

Table 2shows the second experiment for the TV method and got a result (0.0126) and (67.1517) better than Chen [9] in MSE and PSNR respectively.

(a) (b)

Figure 6. Red umbrella rainy image (a) Rainy Image (b) TV image

Table 3: Result of the blind reference

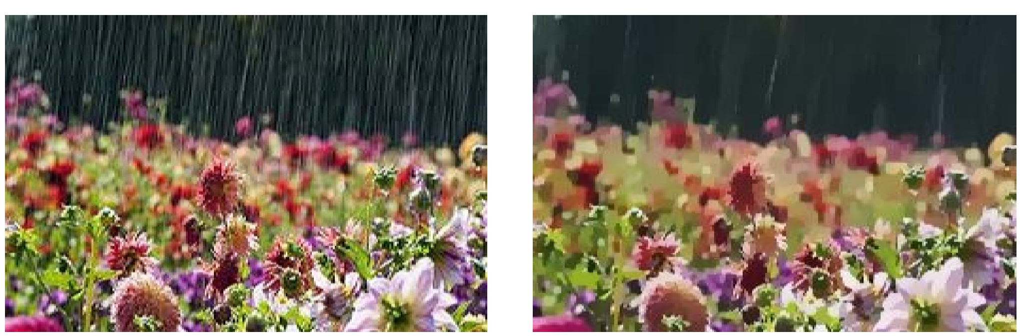
Figure 6	MSE	PSNR	VIF
Chen [9]	0.0097	68.2862	0.4195
TV _ Sparse [15]	0.0092	68.5174	0.4436
TV	0.0087	68.7528	0.4402

The third experiment in table 3 shows an improvement in the TV result, which got a result of (0.0087), (68.7528), and (0.4402) better than Chen in all measurements. As well as a TV good, result better than TV Sparse in MSE and PSNR. All the experiments show a fluctuation between the methods outcomes with the measurements.

7.3 Images without References

The picture without references implies that just the rainy picture is there without the original. While the larger portion of the picture, in reality, is from this kind. The measurement we will use

in the kind is blind/reference-less image spatial quality evaluator (BRISQUE) [14] (Mittal et al, 2012). The lowest value of (BRISQUE) is better.



(a) (b)

(c)

(d)

(e)

(f)

Figure 7. Blind reference rainy images (a) Rainy rose (b) TV rose(c) Rainy Obama (d) TV image Obama (e) Rainy lady pink (f) TV lady pink

Table 4: Result of blind reference

Figure 6	1st Rose	2nd Obama	3rd lady pink
Chen [9]	22.5705	11.9670	46.5009
TV _ Sparse [15]	20.2385	10.3307	45.7434
TV	16.7513	19.5801	37.3080

The experiments outcome shows the fluctuation between the results just as the previous experiments. The TV got good results in the first experiments (16.7513) and third experiments (37.3080) which are better than Chen and TV_sparse.

8. CONCLUSION

Based on the experiments that conducted on the single rainy image, this research has demonstrated total variation is a good method to remove rain streaks. Moreover, according to the results of references images in Table1, Table2, Table3, and non-references results in Table4, the TV method shows a competitive performance to Chen [9] and TV_sparse [15], in all measurement, namely MSE, PSNR, VIF, and unreferenced BRISQUE.

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