Color Image Denoising Using Decision Based Vector Median Filter

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Abstract — A new Decision based algorithm for impulse identification in color images is proposed. In vector median filter all the pixels are processed irrespective of whether it is corrupted or uncorrupted. The proposed algorithm overcomes this drawback where Vector Median is calculated only if the processing pixel is corrupted. This in turn reduces the computation time. The proposed algorithm gives better results than Vector Median Filter(VMF), Vector Directional Filter (VDF), Peer Group Filter (PGF) and Vector Median Filter with Directional Detector.

Index terms - Vector Median Filter, Vector Directional Filter, Peer Group Filter, Vector Median Filter with Directional Detector, Impulse identification, Decision based Vector Median Filter.

I. INTRODUCTION

Images are often corrupted by impulse noises which occur during image acquisition or due to bit errors during image transmission. Impulse noises are of two types, they are random valued noise and Salt and Pepper noise. Salt and pepper noise usually takes the value of either 0 or 255. There are several non-linear filtering techniques available for gray scale image denoising. One among them is the standard Median filter [1]. Nowadays, effective impulse noise removal from color images becomes current research hot spot [2-6]. There are several filtering techniques available for color image denoising and one among them is Scalar Median Filter (SMF). It is obtained by application of traditional Median Filter on each color channel separately. This method may result in color distortion since it isolates the three color channels and ignores the inherent correlation. Astola et al. [7] have proposed Vector Median Filter (VMF) by viewing the three color channels as vectors. The VMF replaces the processing vector pixel by a vector pixel which has the minimum sum of distances to all other vector pixels in the chosen window. The VMF processes all the pixels irrespective of whether it is corrupted or uncorrupted. Though VMF may introduce blur into the color image, it provides new idea for color image filtering. Numerous filters have been proposed for improving the VMF, Which can be classified into the following categories:(i) Weighted vector filters, which utilize the local spatial relationship of the pixels in the filtering window [8,9];(ii) Switching vector filters, which are only applied to pixels corrupted by impulsive noise [10–13]; (iii) Fuzzy vector filters which can distinguish between noise and image characteristics [14–16]; (iv) Similarity-based vector filters, which use similarity to distinguish between noise and image pixels and select the most similar pixel as the filter output [17–19];and (v) Hybrid vector filters, which mean the combination of linear and non-linear filters or the integration of different filtering ideas [20,21]. There are several other several filters proposed for color image denoising such as Vector Directional Filter (VDF), Peer Group Filter (PGF) and Vector Median Filter with Directional Detector (VMF- DD).

The family of vector directional filters (VDF) represents a different type of vector processing filters. These filters operate on the directions of image vectors, aiming to eliminate vectors with atypical directions in the color space [8]. Recently developed peer group filter (PGF) is based on the evaluation of statistical properties of a sorted sequence of accumulated distances used for the calculation of vector median of samples belonging to the filtering window. PGF output switches between vector median and the original central pixel [22].

The rest of the paper is organized as follows. The Vector Median Filtering concept is explained in section I. The proposed algorithm and its different cases are discussed in section II. The simulation results are given under section III. Conclusion is given section IV.

II. VECTOR MEDIAN FILTER

The concept of Vector Median Filter is explained with an example below. The various steps involved are given as follows.

STEP 1: Consider a noisy color image. Let the window size be 3. The three planes of the image are shown in Fig. 1.

62	63	64
61	0	63
62	63	62

R

29	30	31
28	29	30
31	255	28

G

64	63	61
61	62	64
63	62	61

B

Fig. 1 Representation of Planes

STEP 2: Choose the vector pixel of concern. For the given window the vector pixel is {0, 29, 62}.

STEP 3: Calculate the vector sum of distances from every vector pixel to other vector pixel.

There are 9 vector pixels in the window and they are

{62,29,64},{63,30,63},{64,31,61},

{61,28,61},{0,29,62},{63,30,64},

{62, 31, 63}, {63, 255, 62} and {62, 28, 61}.

Calculate the vector sum of distances from every vector pixel to other vector pixels in the chosen window.

Let, d1 be the sum of distances from the first vector pixel to the other vector pixels.

The distance d1 is calculated as given by the following equation,

$$d1 = \sqrt{(62-62)^2+(29-29)^2+(64-64)^2} + \sqrt{(62-63)^2+(29-30)^2+(64-63)^2} + \sqrt{(62-64)^2+(29-31)^2+(64-61)^2} + \sqrt{(62-61)^2+(29-28)^2+(64-61)^2} + \sqrt{(62-0)^2+(29-29)^2+(64-62)^2} + \sqrt{(62-63)^2+(29-30)^2+(64-64)^2} + \sqrt{(62-62)^2+(29-31)^2+(64-63)^2} + \sqrt{(62-63)^2+(29-255)^2+(64-62)^2} + \sqrt{(62-62)^2+(29-28)^2+(64-61)^2}$$

d1=311.78

Similarly, the other nine distances d1, d2…d9 are calculated.

STEP 3: Find the vector median.

The distances are sorted and the minimum distance is found. The vector pixel corresponding to this distance is the required vector median.

The sorted distances are d1< d7< d9< d4< d1< d6< d3< d5< d8. The vector pixel corresponding to the minimum distance d2 is the vector median and it is {63, 30, 63}.

STEP 4: The processing pixel is then replaced by the vector median obtained in step 2.

In the window considered the processing pixel is {0, 29, 62} and it is replaced by {63, 30, 63}.

The vector median filter works well for very low density noises but it may cause blurring. In this filtering technique all the pixels are processed irrespective of whether the pixel of concern is noisy or nonnoisy. This drawback is overcome by the proposed algorithm discussed in the following section.

III. PROPOSED ALGORITHM

The proposed Decision based Vector Median Filter processes the noisy image by detecting the presence of Salt and Pepper noise. If the processing vector pixel takes either the value of 0 or 255, it is identified as corrupted vector pixel else it is considered as uncorrupted pixel and it is left unchanged.

The various steps in the proposed algorithm are given below.

STEP 1: Read a noisy image.

STEP 2: Select the window size (w).

STEP 3: Choose the processing vector pixel. Check whether it is corrupted or not. Even if one plane gets corrupted it is considered as corrupted vector pixel. If the processing vector pixel doesn't contain 0 or 255, then it is left unchanged.

STEP 4: Find the total number of corrupted pixels.

Case 1): If the number of corrupted pixels is greater than or equal to five.

Calculate the vector median for the uncorrupted pixels and replace the processing pixel by the vector median.

Else,

Calculate the vector median and replace the processing pixel by the obtained vector median.

Case 2): If all the pixels in the chosen window are corrupted, increment the window size by 2 and replace the processing pixel by the vector median calculated for the uncorrupted pixels.

STEP 5: Repeat the steps from 2 to 4 until the entire corrupted image is processed.

The flowchart of the proposed algorithm is shown in Fig. 2.

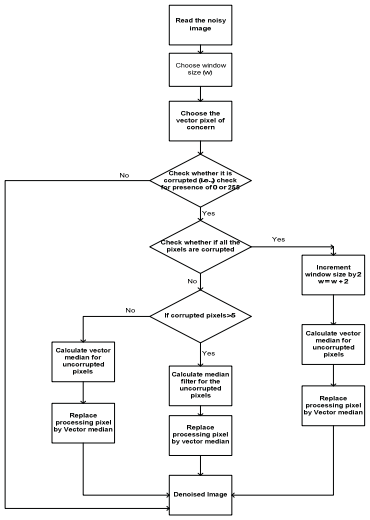

Fig. 2 Decision based Vector Median Filter

IV. RESULTS OF THE PROPOSED ALGORITHM

The results obtained using various algorithms are compared using PSNR is shown in Table I. The output obtained using the proposed algorithm for 50 % noise level for Mandrill image is shown in Fig. 5.

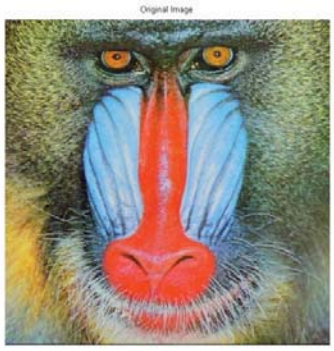

Fig. 3 Original Image

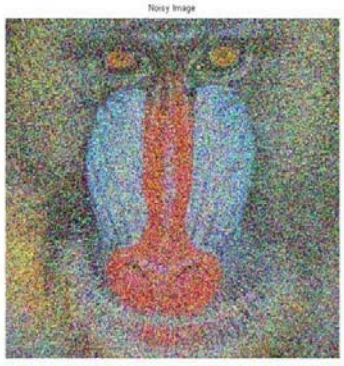

Fig. 4 Noisy Image (50 % noise level)

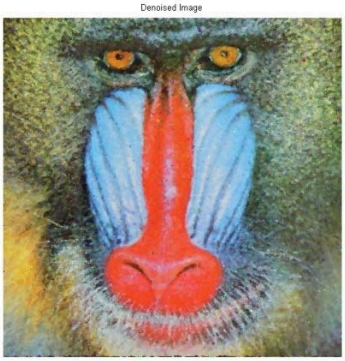

Fig. 5 Output of the proposed algorithm

TABLE I

COMPARISION OF PSNR VALUES FOR DIFFERENT ALGORITHMS FOR PEPPERS IMAGE AT DIFFERENT NOISE INTENSITIES

Noise Levels	VMF	VDF	PGF [23]	VMF-DD [23]	PROPOSED ALGORITHM
0.02	30.20	33.6	33.8	38.9	42.20
0.06	30.76	32.02	33.1	36.1	39.32
0.1	29.90	29.31	32.5	34.9	37.49
0.2	29.50	25.65	29.78	30.53	33.96
0.3	26.12	26.01	28.02	28.47	31.30
0.4	24.27	24.20	24.10	25.21	28.02
0.5	20.03	19.78	19.89	20.13	22.64

V. CONCLUSION

In this paper, a new decision based algorithm for denoising of color images is proposed. This algorithm gives better performance than VMF, VDF and VMF-DD in terms of PSNR for Salt and Pepper noise levels up to 50 %.

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