A SIMPLE ALGORITHM FOR REDUCTION OF BLOCKING ARTIFACTS USING SAWS TECHNIQUE BASED ON FUZZY LOGIC

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ABSTRACT
Reducing blocking artifacts encountered in highly compressed images is a very active research area in image processing. Coding artifacts are very annoying in these highly compressed images. Most of the artifact reduction techniques blur the details of the images while removing coding artifacts. In this paper , we propose a novel and explicit approach for reducing coding artifacts in an image by using the combination of SAWS equation and Fuzzy Rules. We use FIDRM for the detection of noisy pixel and NAFSM filter for correction. Experimental results demonstrate that the proposed approach achieves excellent visual quality and PSNR as compared to a number of deblocking methods in the literature.

Keywords: Block Based Discrete Cosine Transform (BDCT), Deblocking Block (DB), Fuzzy Impulse Artifact Detection and Reduction Method (FIDRM), Noise Adaptive Fuzzy Switching Median Filter (NAFSM), Signal Adaptive Weighted Sum Technique (SAWS).

I. Introduction
Image compression is a very important issue in both image and video coding applications. The main purpose of image compression is to reduce storage and transmission costs while maintaining image quality.
It is known that blocking artifacts are introduced by coarse quantization of transform coefficients at low bit rates and independent quantization of each block [2]. There are three types of blocking artifacts in BDCT coded images. One is staircase noise along the image edges, another is grid noise in monotone area, and the other one is corner outliers in corner point of 8 x 8 DCT block.[1] To remove blocking artifacts, many deblocking techniques have been proposed in last decade, but they often introduce excessive blurring, ringing and in many cases they produce poor deblocking results at certain areas of image. So to reduce excessive blurring and removing artifacts a algorithm is proposed for BDCT- coded images, based on Signal Adaptive Weighted Sum Technique. In this method the center pixel is calculated as the weighted sum of the boundary pixels. Therefore SAWS technique is applied to center pixel and boundary pixels. We adjust the weights according to directional correlation and block activities [3]. In this paper, we propose a blocking artifact removal algorithm for BDCT-coded images using SAWS technique based on combination of FIDRM And NAFSM. FIDRM is a two step filter: the detection phase and the filtering phase. The detection phase uses fuzzy rule to determine whether a pixel is corrupted or not. Then we try to indicate the values of detected pixels p_k (k ∈ {1,..., n} with 1≤ n< 255). After this detection fuzzy filtering focuses on only p_k values [4]. The NAFSM filter uses a square filtering window with odd dimensions which is used to satisfy the criterion of choosing only a noise free pixel as the median pixel [5]. The rest of the paper is organised as follows. Section II introduces SAWS technique. Section III represents the proposed method of reducing artifacts using SAWS technique along with NAFSM and FIDRM filters. Experimental results and Conclusion are presented in Sections IV and V.

II. Saws Equation
A Deblocking block and its subblocks are shown in the Fig. 1. A pixel in Deblocking Block (DB) is modified by using three pixels at block boundaries, to remove block discontinuities in this SAWS technique. And these three pixels belongs to three SubBlocks except for the SubBlock containing the to-be-modified pixel.
Let $p'_{i,j}$ be the modified pixel of $p_{i,j}$ in the DB, and the weighted sum equation is given by

$$p'_{i,j} = \frac{p_{i,j} + \alpha_{i,j} p_{i,n} + \beta_{i,j} p_{m,j} + \gamma_{i,j} p_{m,n}}{1 + \alpha_{i,j} + \beta_{i,j} + \gamma_{i,j}} \qquad (1)$$

Where m is N/2 if I is less than N/2; otherwise, (N/2)-1, and n is N/2 if j is less than N/2 otherwise, (N/2)-1. In the above equation $p_{i,n}$ and $p_{m,j}$ are the boundary pixels lying on the $p_{i,j}$'s row and column, respectively, and $p_{m,n}$ is a boundary pixel lying on diagonal position.

The weights a, b and c are functions of distance between $p_{i,j}$ and its boundary pixel.

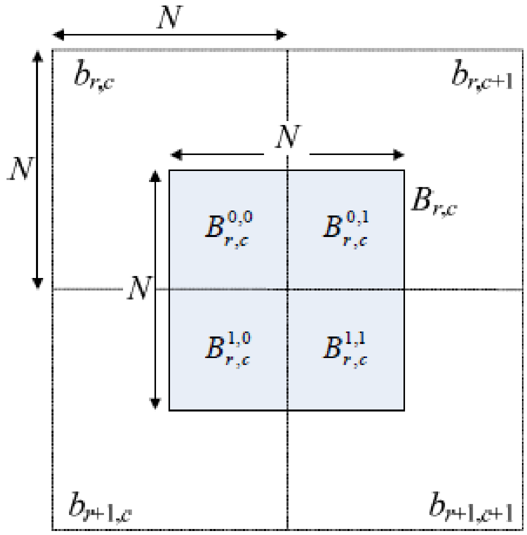


Fig. 1. A Deblocking Block (DB) and its SubBlocks.

III. PROPOSED METHOD

In our proposed method instead of using only above saws equation we are using the combination of SAWS technique, fuzzy gradient values as introduced with GOA filter [6],[7] and median filter[5].

3.1 Fuzzy Gradient Values

For each pixel (i,j) of the image, not a border pixel, we use a 3x3 neighborhood window as shown in Fig. 2

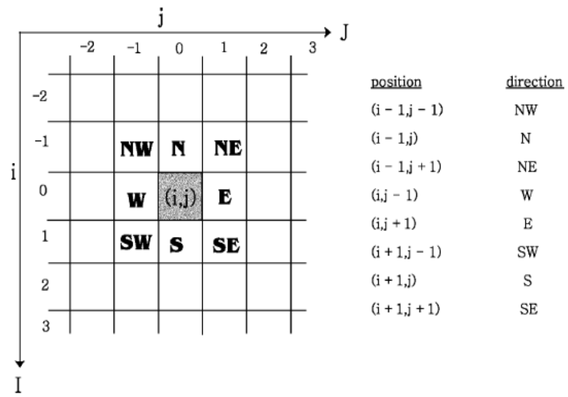


Fig. 2. Neighborhood of a central pixel.

Each neighbor with respect to (i,j) corresponds to one direction {NW= north west, N= north, NE= north east, W= west, E= east, S= south, SE= south east, SW= south West}.

If A denotes input image then the gradient is defined as the difference

$$Del(k,l)A(i,j) = A(i+k, j+l) – A(i,j) \text{ with } k,l € \{-1,0,1\} \quad (2)$$

where the pair (k,l) corresponds to one of the eight directions and (i,j) is called center of gradient. The eight gradient values are called the basic gradient values. One such gradient value can be used to determine if a central pixel is corrupted or not because if gradient is large it indicates that some artifacts are present in the central pixel (i,j), but this conclusion is wrong in two cases.

1) If the central pixel is not noisy, but one of the neighbors is then this can also cause large gradient values.
2) An edge in an image causes some kind of natural large gradient values.

To solve first case, only only one gradient value is used, and to solve the second case one basic and two related gradient values for each direction. The two related gradient values are determined by the centers making a right angle with the direction of the basic gradient.

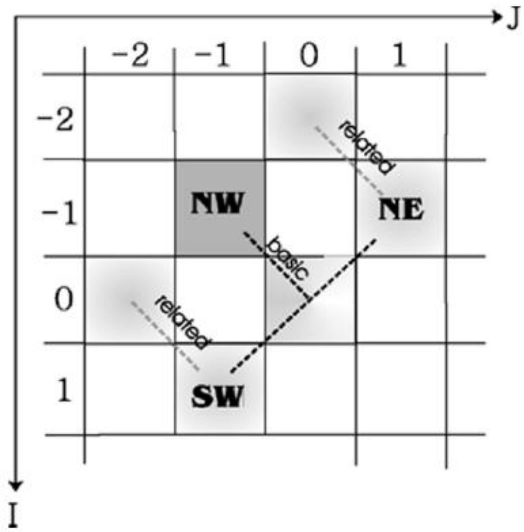


Fig. 3. Involved centers for the calculation of the related gradient values in the NW-direction.

Table1. Involved gradient values to calculate fuzzy gradient

R	basic gradient	related gradients
NW	$\nabla_{NW}A(i,j)$	$\nabla_{NW}A(i+1,j-1), \nabla_{NW}A(i-1,j+1)$
N	$\nabla_{N}A(i,j)$	$\nabla_{N}A(i,j-1), \nabla_{N}A(i,j+1)$
NE	$\nabla_{NE}A(i,j)$	$\nabla_{NE}A(i-1,j-1), \nabla_{NE}A(i+1,j+1)$
E	$\nabla_{E}A(i,j)$	$\nabla_{E}A(i-1,j), \nabla_{E}A(i+1,j)$
SE	$\nabla_{SE}A(i,j)$	$\nabla_{SE}A(i-1,j+1), \nabla_{SE}A(i+1,j-1)$
S	$\nabla_{S}A(i,j)$	$\nabla_{S}A(i,j-1), \nabla_{S}A(i,j+1)$
SW	$\nabla_{SW}A(i,j)$	$\nabla_{SW}A(i-1,j-1), \nabla_{SW}A(i+1,j+1)$
W	$\nabla_{W}A(i,j)$	$\nabla_{W}A(i-1,j), \nabla_{W}A(i+1,j)$

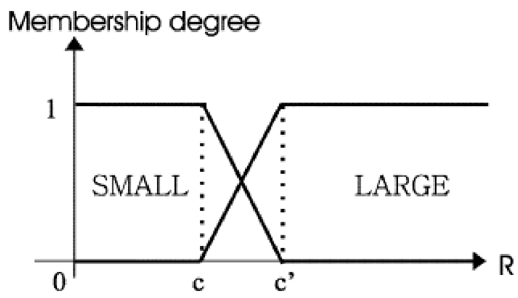
Table 1 gives an overview of the involved gradient values. First column gives the direction corresponds to a position with respect to central position. Column two gives basic gradient values and column three gives the two related gradients. Eight fuzzy gradient values are defined for each of the eight directions. The fuzzy gradient value for direction R(R€ {NW, N, NE, E, SE, S, SW, W}), is calculated by the fuzzy rule.

IF |*delR A(i,j)*| *is large AND* |*del'R A(i,j)*| *is small*
OR
|delR A(i,j)| is large AND |del''R A(i,j)| is small
OR
delR A(i,j) is big positive AND del'R A(i,j) AND del''R A(i,j) are big negative
OR
delR A(i,j) is big negative AND del'R A(i,j) AND del'' A(i,j) are big positive

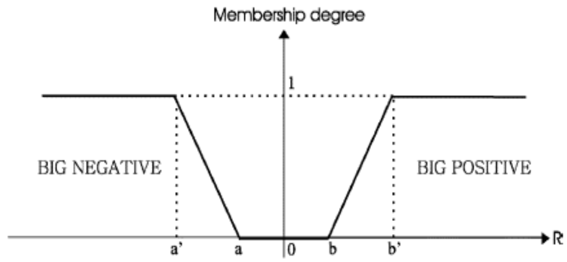
THEN fuzzy gradient value is large.

Where delR A(i,j) is basic gradient value and del'R A(i,j) and del''R A(i,j) are two related gradient values for direction R. Large, small, big positive and big negative are nondeterministic features, therefore these can be represented as fuzzy sets [8].

Fuzzy set can be represented by membership functions, as the membership function large represents fuzzy set large, small represents fuzzy set small, big positive represents fuzzy set big positive and big negative represents fuzzy set big negative as shown in fig.4.



(a)



(b)

Fig. 4 . Membership functions (a) SMALL, respectively, LARGE; (b) BIG NEGATIVE, respectively, BIG POSITIVE.

A. Detection stage

To decide whether the central pixel contains block discontinuity or not, we use the following fuzzy rule:

IF most of the eight gradient values are large THEN the central pixel A(i,j) is an block discontinuous pixel.

We translate this rule by: if for a certain central pixel (i,j) more than half of the fuzzy gradient values are part of the support of the fuzzy set large[8], then we can conclude that pixel as a block discontinued pixel.

B. Filtering stage

The NAFSM filter uses a square filtering window W(i,j) with odd (2s+1) x (2s+1) dimensions. The noise free pixels are used for selecting median pixel, given by

$$M(i,j) = \text{median}\{X(i+m, j+n)\} \quad \text{with } N(i+m, j+n) = 1 \tag{3}$$

After median pixel M(i,j) is found, the local information in a 3x3 window is extracted by first computing the absolute luminous difference d(i,j) as given by

$$D(i+k, j+l) = |X(i+k, j+l) - X(i,j)| \quad \text{with } (i+k, j+l) \neq (i,j) \tag{4}$$

Then the local information is defined as the maximum absolute luminance difference in the 3x3 filtering window

$$D(i,j) = \max\{d(i+k, j+l)\} \tag{5}$$

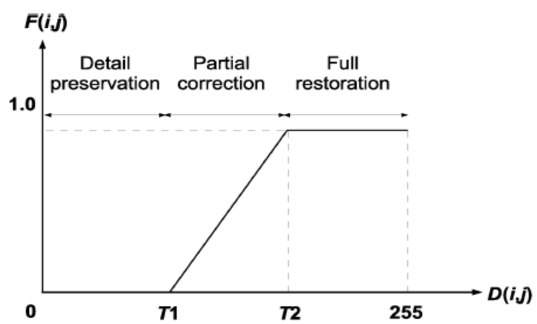


Fig.5 Fuzzy set adopted by NAFSM filter

In NAFSM filter, fuzzy reasoning is applied to the extracted local information D(i,j). The fuzzy set adopted is shown in fig.5 and defined by the fuzzy membership function F(i,j)

$$F(i,j) = \begin{cases} 0, & : \quad D(i,j) < T_1 \\ \frac{D(i,j)-T_1}{T_2-T_1}, & : \quad T_1 \le D(i,j) < T_2 \\ 1, & : \quad D(i,j) \ge T_2 \end{cases} \tag{6}$$

where the local information D(i,j) is used as fuzzy input variable and the two predefined thresholds T1 and T2 are set to 10 and 30, respectively, for optimal performance[9][10].

Finally, the correction term to restore a detected 'noise pixel' is a linear combination between the processing pixel X(i,j) and median pixel M(i,j). the restoration term Y(i,j) is given as

$$Y(i,j) = [1- F(i,j)] \cdot X(i,j) + F(i,j) \cdot M(i,j) \tag{7}$$

where the fuzzy membership value F(i,j) lends a weight on whether more of pixel X(i,j) or M(i,j) is to be used.

4. Experimental Results

To demonstrate the performance of the proposed algorithm, we conduct comprehensive experiments with a number of 512x512 grayscale images, Lena, Peppers, and Goldhill. These images are compressed at various bit rates. Initially, we provide the objective performance in PSNR by proposed algorithm, and compare them with some of the existing deblocking methods. Experimental results shows that the proposed algorithm gives improved PSNR then the other debloking methods in the literature.

5. Conclusion

In this paper a new approach for reducing artifact is presented which is based on two types of filter i.e FIDRM and NAFSM filters. These filters are based on fuzzy rules. The main feature of FIDRM filter is that it leaves the noise free pixels unchanged. Experimental results show the feasibility of the new algorithm. A numerical measure, such as PSNR, and visual quality show convincing results for grayscale images . The proposed approach can be used in many mobile devices that have limted storage and bandwidth and therefore suffer from blocking artifacts.

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