**International Journal of Electronics and Electrical Engineering**
ISSN : 2277-7040 Volume 2 Issue 9 (September 2012)
http://www.ijecee.com/ https://sites.google.com/site/ijeceejournal/

# Compression Artifact Removal Using SAWS Technique Based On Fuzzy Logic

Sonia Malik[1], Nripender Singh[2] , Rohit Anand[3]
[1] Department of Electronics and Communication Engineering ,NCCE , Panipat
[2]Assistant Professor,Electronics and Communication Engineering,KITM, Karnal
[3]Assistant Professor,Electronics and Communication Engineering, NCCE, Panipat, INDIA
soniamalik88@gmail.com, nirpender@gmail.com, roh_anand@rediffmail.com

**Abstract.** Many mobile devices compress images to meet limited bandwidth requirements and adopt Block Discrete Cosine Transform. This produces visually annoying artifacts 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)

## 1 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[1].

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.[3] 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].

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. Therefore, a number of adaptive spatial filtering techniques have been proposed to solve this blurring problem [3]-[7], [9]-[11], [14]-[16]. Several image restoration techniques to alleviate blocking artifacts have been suggested such as constrained least squares (CLS) [12], projection onto convex sets (POCS) [8], [12], and maximum *a posteriori*(MAP) restoration [13]. 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. We adjust the weights according to directional correlation and block activities [17].

In this paper, we propose a blocking artifact removal algorithm for BDCT-coded images using SAWS technique based on combination of FIDRM and NAFSM filters. FIDRM is a two step filter: the detection phase and the filtering phase [18]. 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 [19].

The rest of the paper is organised as follows. Section II introduces SAWS Equation. 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.

## 2. 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 belong to three SubBlocks except for the SubBlock containing the to-be-modified pixel.

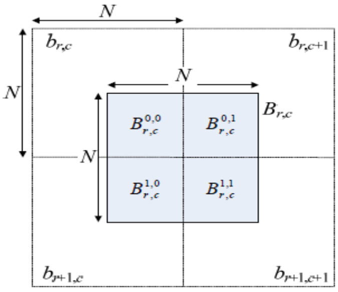


Fig. 1. A Deblocking Block (DB) and its SubBlocks.

Let [illegible] be the modified pixel of [illegible] in the DB, and the weighted sum equation is given by

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

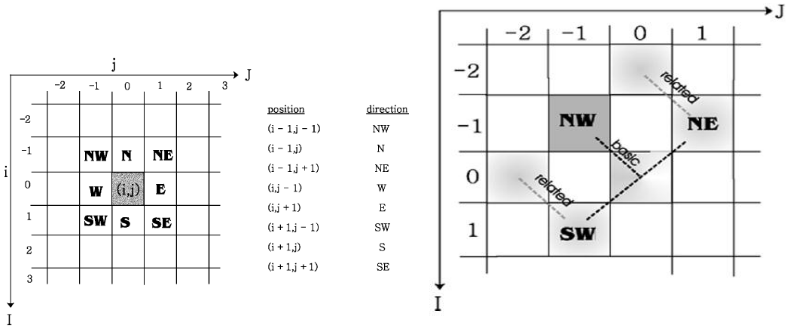
Where m is N/2 if I is less than N/2; otherwise, (N/2)-1, and n is N/2 if j is less than N/2 otherwise, (N/2)-1. In the above equation [illegible] and [illegible] are the boundary pixels lying on [illegible]'s row and column, respectively, and [illegible] is a boundary pixel lying on diagonal position. The weights a, b and c are functions of distance between [illegible] and its boundary pixel.

## 3. 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 [21],[22] and median filter[20].

### 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



| position | direction |
|---|---|
| (i − 1,j − 1) | NW |
| (i − 1,j) | N |
| (i − 1,j + 1) | NE |
| (i,j − 1) | W |
| (i,j + 1) | E |
| (i + 1,j − 1) | SW |
| (i + 1,j) | S |
| (i + 1,j + 1) | SE |

Fig. 2. Neighborhood of a central pixel and Involved centers for the calculation of the related gradient values in the NW-direction

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) with k,l € {-1,0,1} (2)

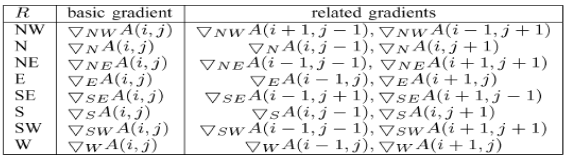
where the pair (k,l) corresponds to one of the eight directions and (i,j) is called center of gradient. The eight gradient values are called the basic gradient values. One such gradient value can be used to determine if a central pixel is corrupted or not because if gradient is large it indicates that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

**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. 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 [23].

*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.*

*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

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

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

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

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

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

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[23][24]. 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

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

(a) (b)

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

## 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 compared on the basis of quality.

(a) (b) (c)

Fig.6. Comparison of subjective visual performance for Lena at quality 2. (a) Original Image (b) Image processed by SAWS technique (PSNR= 31.23db), (c) By Proposed Algorithm (PSNR=31.79db

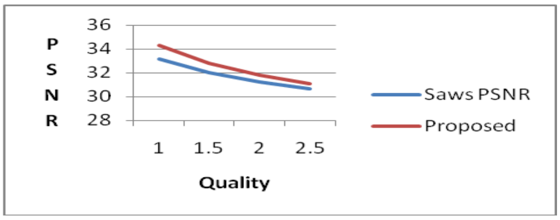


Fig.7. Shows Variation of PSNR in the proposed and existing technique.

Table II: The table shows the comparison of SAWS technique with the proposed one.

| Image | Quality | Saws PSNR | Saws MSE | Proposed PSNR | Proposed MSE |
|---|---|---|---|---|---|
| | 1 | 33.1414 | 31.5458 | 34.2732 | 24.3087 |
| Lenna | 1.5 | 31.9796 | 41.2209 | 32.7582 | 34.4557 |
| | 2 | 31.2399 | 48.8756 | 31.7976 | 42.9856 |
| | 2.5 | 30.6430 | 56.0759 | 31.0496 | 51.0652 |

## 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, MSE , and visual quality show convincing results for grayscale images.

## Acknowledgement

With a deep sense of gratitude and heartiest honour, I would like to express my immense thanks to Dr. Vijay Nehra, Associate Professor, ECE Dept, BPSMV Khanpur, Sonipat for providing me all the facilities to pursue my dessertation to its successful accomplishment. I proudly acknowledge my sincere and heartfelt thanks to Mr. Rohit Anand, Assistant Professor, N.C College of Engineering, Panipat for their valuable and sustained guidance, constant encouragement and careful supervision during the entire course which made the project successful.

## References

[1] R. C. Gonzalez and R. E. Woods, *Digital Image Processing*. Englewood Cliffs, NJ: Prentice-Hall, 1992.

[2] T. Chen, H. R. Wu, and B. Qiu, “Adaptive postfiltering of transform coefficients for the reduction of blocking artifacts,” *IEEE Trans. Circuits Syst. Video Technol.*, vol. 11, no. 5, pp. 594-602, May 2001.

[3] Y. Lee, H. Kim, and H. Park, “Blocking effect reduction of JPEG images by signal adaptive filtering,” *IEEE Trans. Image Process.*, vol. 7, no. 2, pp. 229-234, Feb. 1998.

[4]B. Ramamurthi and A. Gersho, “Nonlinear space-variant postprocessing of block coded images,” *IEEE Trans. Acoust., Speech, and Signal Process.*, vol. ASSP-34, no. 5, pp. 1258-1268, Oct. 1986.

[5]S. Kim, J. Yi, H. Kim, and J. Ra, “A deblocking filter with two separate modes in block-based video coding,” *IEEE Trans. Circuits Syst. Video Technol.*, vol. 9, no. 1, pp. 156-160, Feb. 1998

[6] P. List, A. Joch, J. Lainema, G. Bjontegaar, and M. Karczewicz, “Adaptive deblocking filter,” *IEEE Trans. Circuits Syst. Video Technol.*, vol. 13, no. 7, pp. 614-619, Jul. 2003

[7] R. Castagno, S. Marsi, and G. Ramponi, “A simple algorithm for the reduction of blocking artifacts in images and its implementation,” *IEEE Trans. Consumer Electron.*, vol. 44, no. 3, pp. 1062-1070, Aug. 1998.

[8] A. Zakhor, “Iterative procedures for reduction of blocking artifacts in transform image coding,” *IEEE Trans. Circuits Syst. Video Technol.*, vol. 2, no. 2, pp. 91-95, Mar. 1992.

[9] T. Chen, H. R. Wu, and B. Qiu, “Adaptive postfiltering of transform coefficients for the reduction of blocking artifacts,” *IEEE Trans. Circuits Syst. Video Technol.*, vol. 11, no. 5, pp. 594-602, May 2001.

[10] A. Z. Averbuch, A. Schclar, and D. L. Donoho, “Deblocking of blocktransform compressed images using weighted sums of symmetrically aligned pixels,” *IEEE Trans. Image Process.*, vol. 14, no. 2, pp. 200-212, Feb. 2005.

[11] L. Shao and I. Kirenko,“Coding artifact reduction based on local entropy analysis,” *IEEE Trans. Consumer Electron.*, vol. 53, no. 2, pp. 691-696, May 2007.

[12] Y. Yang, N. P. Galatsanos, and A. K. Katsaggelos, “Regularized reconstruction to reduce blocking artifacts of block discrete cosine transform compressed images,” *IEEE Trans. Circuits Syst. Video Technol.*, vol. 3, no. 6, pp. 421-432, Dec. 1993.

[13] T. P. O’Rourke and R. L. Stevenson, “Improved image decompression for reduced transform coding artifacts,” *IEEE Trans. Circuits Syst. Video Technol.*, vol. 5, no. 6, pp. 490-499, Dec. 1995.

[14] A. P. Witkin, “Scale-space filtering,” *Proc. Int. Joint Conf. Artificial Intelligence*, Karlsruhe, Germany, pp. 1019-1021, 1983.

[15] P. Perona and J. Malik, “Scale-space and edge detection using anisotropic diffusion ,” *IEEE Trans. Pattern.*, vol. 12, no. 7, pp. 629-639, Jul. 1990.

[16] L. Alvarez, P. L. Lions J. M. Morel, “Image selective smoothing and edge detection by non-linear diffusion II,” *SIAM J. Numer. Anal.*, vol. 29, no. 3, pp. 845-866, Jun. 1992.

[17] Jongho Kim and Chun Bo Sim, “Compression artifacts removal by signal adaptive weighted sum technique,” *IEEE Transactions on Consumer Electronics*, Vol. 57, No. 4, November 2011.

[18] Stefan Schulte, Mike Nachtegael, Valérie De Witte, Dietrich Van der Weken, and Etienne E. Kerre, “A Fuzzy Impulse Noise Detection and Reduction Method*,”* *IEEE Transactions On Image Processing*, Vol. 15, No. 5, May 2006.

[19] Kenny Kal Vin Toh, *Student Member, IEEE*, and Nor Ashidi Mat Isa*, Member, IEEE, “*Noise adaptive fuzzy switching median filter for salt-and-pepper noise reduction” *IEEE Signal Processing Letters*, Vol. 17, No. 3, March 2010.

[20] D. Van De Ville, M. Nachtegael, D. Van derWeken, E. E. Kerre, and W. Philips, “Noise reduction by fuzzy image filtering,” *IEEE Trans. Fuzzy Syst.*, vol. 11, no. 4, pp. 429–436, Aug. 2001.

[21] M. Nachtegael, D. Van der Weken, and E. E. Kerre, “Fuzzy techniques in image processing,” *Int. J. Comput. Anticipatory Syst*, vol. 12, pp. 89–104, Aug. 2002.

[22] E. E. Kerre, *Fuzzy Sets and Approximate Reasoning* . Xian, China: Xian Jiaotong Univ. Press, 1998.

[23] K. K. V. Toh, H. Ibrahim, and M. N. Mahyuddin, “Salt-and-pepper noise detection and reduction using fuzzy switching median filter,” *IEEE Trans. Consumer Electron.*, vol. 54, no. 4, pp. 1956–1961, Nov. 2008.

[24] W. Luo, “ Eficient removal of impulse noise from digital images,” *IEEE Trans. Consumer Electron.*, vol. 52, no. 2, pp. 523–527, May 2006.