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TDBLMS based Adaptive Filter for Color Image Noise Abolition

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ABSTRACT
The image noise abolition is still an interesting field in research due to the dynamic nature of images in special domain. To separate out the noise behavior from color image several approaches has been identified adaptive filter which is extension of LMS filter is one of them to achieve higher signal to noise ratio. In this paper, an adaptive filter with two dimensional block processing for color image noise abolition is proposed. Simulations for different block size (2x2, 4x4, 16x16 and 32x32) are performed to signify the approach. The simulation results show that approach performs well.
Keywords - adaptive algorithm, block processing, least mean square approximation, noise abolition and PSNR.

I. INTRODUCTION

Image noise is random variation of brightness or colour information in images, and is usually a type of electronic noise. It can be produced by the sensor and circuitry of a scanner or digital camera. Image noise can also originate in film grain and in the unavoidable shot noise of an ideal photon detector. Image noise is an undesirable by-product of image capture that adds spurious and extraneous information.

Main types of noises are

Gaussian noise: caused by poor illumination and/or high temperature, and/or transmission e.g. electronic circuit noise

Salt and paper noise: impulsive noise is sometimes called salt-and-pepper noise or spike noise

Shot noise: typically that caused by statistical quantum fluctuations, that is, variation in the number of photons sensed at a given exposure level. This noise is known as photon shot noise

Quantization noise: The noise caused by quantizing the pixels of a sensed image to a number of discrete levels is known as quantization noise.

Adaptive filters are widely used in various applications for achieving a better performance [1]. An adaptive filter is a filter that self-adjusts its transfer function according to an optimization algorithm driven by an error signal the dimension of the adaptive filters varies from application to application. In the fields of digital signal processing and communication echo cancellation, noise canceling, and channel equalization [2]-[6], the one-dimensional adaptive algorithm are generally adopted.

The 1-D adaptive algorithms are usually classified into two families. One is the least-mean-square (LMS) family and the other is the recursive-least-square (RLS) family. The algorithms in the LMS family have the characteristics of easy implementation and low computational complexity [1]. In 1981, Clark [7] pro- posed the block least-mean-square (BLMS) approach which is an application extended from the block processing scheme proposed by Burrus [8]. In such an approach, the computational complexity is dramatically reduced.

In the applications of digital image processing, two-dimensional (2-D) adaptive algorithms such as TDLMS, TD- BLMS, OBA, OBAI, and TDOBSG are usually used [9]- [12]. Either in TDLMS or TDBLMS, the convergence factors are constant. Instead of the constant convergence factors in TDLMS and TDBLMS, the space-varying convergence factors are used in OBA, OBAI, and TDOBSG for better convergence performance. However, such space-varying convergence factors will increase the computational complexity due to the computations for the new convergence factor of next block. TDBLMS adaptive filter with weight-training mechanism by finding a suitable weight (coefficient) matrix for the digital filter in advance was proposed by Chuen-Yau Chen and Chih-Wen Hsia[13] .Then, treat this weight matrix as the initial weight matrix for the processing of noise abolition. In this paper we proposed weight training mechanism for adaptive filter used for color image that will process three colours i.e. red, green and blue individually.

II. 2-D BLOCK LMS ALGORITHM

2-D signal is partitioned into blocks with a dimension of LxL for each in the 2-D disjoint block-by-block image processing. An image with R rows of pixel and C columns of pixel partitioned into $\frac{R}{L} \times \frac{C}{L}$ blocks is illustrated in Fig. 1. The block index S and the spatial block index (r, c) is related by [12]

$$s = (r-1).\left(\frac{c}{L}\right) + c \quad (1)$$

Where r 1,2 ......R/L and c=1,2,....C/L.

for convenience, the (r, c)-th element $d(r, c)$ of the image can be treated as the (r_b, c_b)-th element in the S-th block and denoted as the element $d_s(r_b, c_b)$

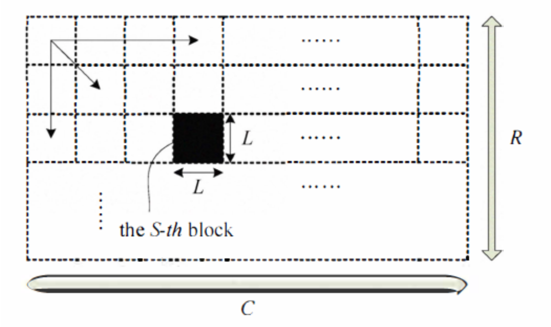


Fig-1 2D block by block processing with disjoint square block of dimension LxL

The relationship is

$$d_s(r_b, c_b) = d[(r-1)L + r_b, (c-1)L + cb \quad (2)$$

where r_b= 1,2… Land c_b = 1,2… L

The block processing is started by processing the image block-by-block sequentially from left to right and from top to bottom in which each pixel is convolved the pixel in a filter window with a dimension of M x N. Fig. 2 illustrates this approach which performs the operations from (3) to (5) iteratively [10]. That is,

$$y_s(r_b, c_b) = \sum_{i=1}^{M}\sum_{j=1}^{N} W_s(i,j) \times X_s(rb, cb) = \sum_{i=1}^{M}\sum_{J=1}^{N} W_s(i,j) \times X[(r-1)L + r_b + (M-1) - i, (c-1)L + c_b + (N-1) - j \quad (3)$$

where $y_s(r_b, c_b)$is the image of the S-th block after processing,$W_s(i,j)$ is the (i,j)-th element in the weight matrix $Ws$of the S-th block. The error signal$e_s(r_b, c_b)$is then obtainedby subtracting the image$y_s(r_b, c_b)$from the primary input image $d_s(r_b, c_b)$.

$$e_s(r_b, c_b) = d_s(r_b, c_b) - y_s(r_b, c_b) \quad (4)$$

the weight matrix W_{s+1} of (S+1)- th block is then updated by

$$W_{s+1}(i,j) = W_s(i,j) + \frac{2}{L^2}\,?\sum_{r_{b=1}}^{L}\sum_{c_{b=1}}^{L} e_s(r_b, c_b) \times X(r_b + rL - i, c_b + cL - j) \quad (5)$$

Where ? is convergence factor

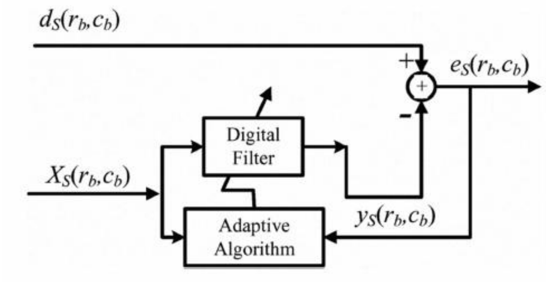


Fig-2 D adaptive filter for image noise cancellation

III. ADAPTIVE FILTER WITH WEIGHT TRAINING AND WEIGHT ADAPTION

3.1 *Weight-Training Phase (WTP)*

To enhance the convergence rate, a suitable weight matrix W_{Ta} will be treated as the initial weight matrix and $W_1$for the the processing in the block-adaption phase is found in the weight-training phase. In weight training phase, all the elements of the initial weight matrix W_{t1} are set to be zero. That is,$W_{t1} = [W_{t1}(i,j)_{M\times N}]$ where $W_{t1}(i,j) = 0$ for i= 1,2… M and j = 1,2… N. Then, the TDBLMS algorithm is applied to process the original noisy image that will be scanned block-by-block from left to right and from top to down for updating the weight matrix of each block iteratively until the termination criterion is reached [10].Fig. 3 illustrates this approach, the termination criterion is

$$|BNCR| < P \quad (6)$$

Where P is termination parameter and $BNCR$ is block noise cancellation ratio and defined as

$$BNCR = 10\log[(\delta_X^2 - (\delta_d^2 - \delta_e^2)/\delta_X^2)] \quad (7)$$

Where $\delta_x^2$is power of reference signal and $X_s(rb, cb)$can be related as

$$\delta_X^2 = \sum_{k=1}^{M+N-1}\sum_{l=1}^{M+N-1}\frac{[X_s(k,l) - X_{mean}]^2}{[L+(M-1)-1][L+(N-1)-1]} \quad (8)$$

the term δ_d^2 is the power of the primary input signal $d_s(r_b, c_b)$and can be expressed as

$$\delta_d^2 = 1/(L-1)^2 \sum_{r_b=1}^{L}\sum_{c_b=1}^{L} [d_s(r_b, c_b) - d_{mean}]^2 \qquad (9)$$

the term δ_e^2 is the power of the error signal $e_s(r_b, c_b)$and can be expressed as

$$\delta_e^2 = 1/(L-1)^2 \sum_{r_b=1}^{L}\sum_{c_b=1}^{L} [e_s(r_b, c_b) - e_{mean}]^2 \qquad (10)$$

In (8)-(10) X_{mean} , d_{mean} , and e_{mean} stand for the means of
X_s , d_s , and e_s, respectively.

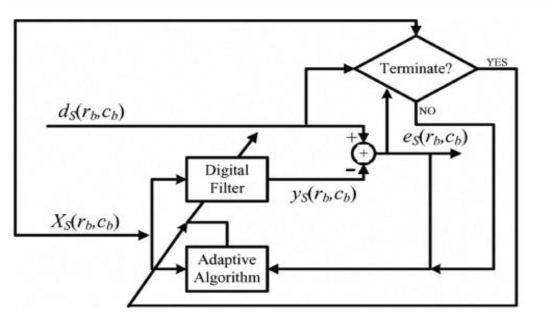


Fig-3.Adaptive filter with weight training mechanism

3.2 *Block-Adapting Phase (BAP)*
Once the suitable weight matrix W_{Ta} in the weight training phase is found, this weight matrix is treated as the initial weight matrix W_i in the block-adapting phase. In this phase, the original noisy image is processed according to the TDBLMS algorithm [10] again for the noise cancellation

IV. PROPOSED EXPERIMENTAL WORK

There are two phase for an adaptive filter they are weight training and weight adaption phase in this work we proposed a new two dimensional adaptive filter which will process a colour image. Original image will be first convert in to frames of three colours they are red, green, blue of different intensity level then these frames will be process by two dimensional block least mean square filter individually. Output of three parallel filters will combine at the last to abolish noise from original image

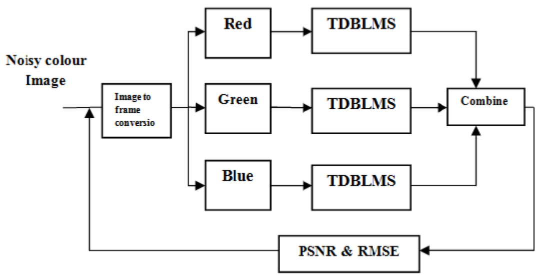
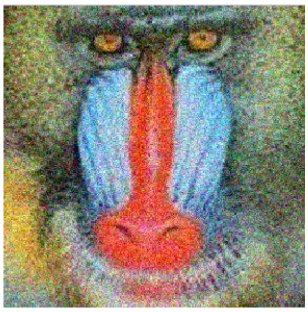


Fig-4 Two dimensional adaptive filter for color image

V. SIMULATION RESULTS

The primary input signal with a dimension of 400x400 in the simulation phase is created by adding a Gaussian noise with zero mean and 0.02 variance to the ideal image Baboon with 400 color-levels in Fig. 4(a) shows the primary input image with a dimension of 400 x 400 and Fig. 4(b) shows the noisy primary input image with an SNR of 0 dB. The convergence factor is 4.5 X 10-7. For digital filter, the 4-th order transversal FIR filter is chosen to convolved the reference image and the filter window with a dimension of 2 x 2 (M = 2, N = 2).

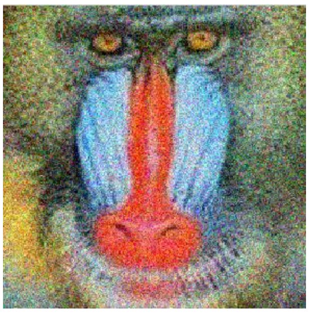
(a)



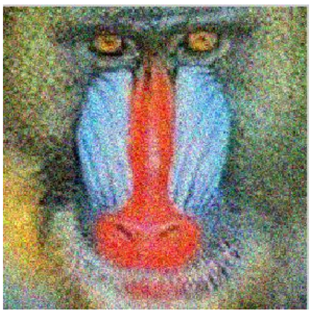
(b)

Figure 4 (a) Primary input image Baboon with a dimension of 400x400 (b) Noisy primary input image with SNR= 0 dB

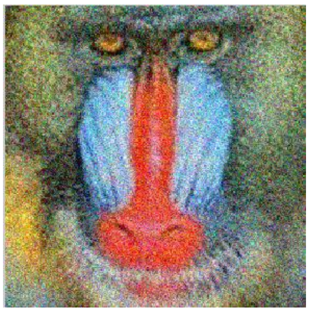
In order to observe the effect of block size on the performance, four different block sizes of 4 x 4 (L = 4), 8 x 8 (L = 8), 16 x 16 (L = 16), and 32 x 32 (L = 32) are simulated. Table 1 lists the performance comparison.Fig. 5(a) is the restored image for the proposed adaptive filter where the termination parameter P is chosen to be -10 dB. Fig. 5(b)is the restored image for the proposed adaptive filter where the termination parameter P is chosen to be -10 dB The simulation results indicate that the proposed adaptive filter achieves a better performance; however, the performance of the TDBLMS algorithm is not so good for the first several blocks.



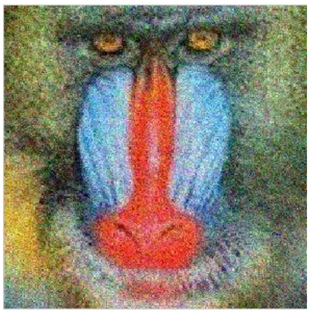
(a)



(b)



(c)



(d)

Figure 5 simulation result of predicted image (a) predicted image with (L, M, N) = (4, 2, 2).(b) Predicted image with (L, M, N) = (8, 2, 2). (c) Predicted image with (L, M, N) = (16, 2, 2). (d) Predicted image with (L, M, N) = (4, 2, 2)

Table 1 output PSNR and RMSE for adaptive TDLMS noise canceller

Block size	**Proposed work for color image**		**TDBLMS for gray image**
	PSNR(dB)	RMSE(dB)	PSNR(dB)
4x4	20.6095	23.7721	26.7341
8x8	20.6112	23.7672	20.8253
16x16	20.6520	23.6559	16.2340
32x32	20.4283	24.2732	14.4419

VI. CONCLUSION

An adaptive filter for color image with weight-training mechanism was proposed in this paper. First, a suitable weight matrix was found by scanning the image block-by-block and updating the weight matrix for each until the termination criterion is reached in the weight-training phase. Process runs parallel for three colors. The simulation performed on the noisy image Baboon with a dimension of 400x400 with an SNR of 0 dB shows that this approach can achieve the PSNR's of 20.6095, 20.6112, 20.6520 and 20.4283 for the block sizes of 4 x 4, 8 x 8, 16 x 16, and 32 x 32, respectively. The proposed method provides improved image. The proposed has been tested on well-known benchmark images, where their PSNR and visual results show the superiority of the proposed technique over the conventional techniques.

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