New Proposed Algorithm To Conceals Error In Wireless Image Transmission Based on Framelet Transform

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Abstract

In this paper, we present a new proposed error concealment algorithm to improve the image quality degraded during its transmission over wireless channel. Different error concealment strategies are applied to different locations of blocks in order to achieve better visual quality. The proposed algorithm conceal the lost block using Framelet Transform (FT), this is achieved by finding the average of framelet subbands in neighbors of the lost block. Finally, the results of this algorithm compared with the results of MultiWavelet Averaging (MWA) algorithm in terms of signal to noise ratio (SNR) and human vision.

خوارزمية مقترحة جديدة لإخْفاء الخطأِ عند ارسال الصور لاسلكيا عن طريق إستعمال (التحويل الإطاري)

الخلاصة

في هذا البحث، نُقدّم خوارزمية مقترحة جديدة لإخفاء الخَطأ وتَحسين نوعيةِ الصورةَ أثناء إرسالِها لاسلكيا. طُبِقتْ انواع عديدة من إستراتيجيات إخفاءِ الخطأ على مواقع مختلفة مِنْ الاجزاء المفقودة لغرض الحصول على روئية بصرية أفضلَ. الخوارزمية المقترحة لإعادة بناء اجزاء الصورة المفقودة عن طريق إستعمال (التحويل الإطاري), وذلك من خلال إيجاد معدل المركبات المحيطه حول الأجزاء المفقودة.
أخيراً، نَتائِج هذه الخوارزمية قورنت بنَتائِج خوارزمية(التمثيل المتعدد المويجات) بدلالة (نسبة الإشارة الى الضوضاء) والرؤية البصرية .

Introduction

Transmission of video over networks has been increasing significantly in recent years. However, many networks such as wireless network and the Internet are unreliable. The data packets can be corrupted or lost during the transmission. The loss of information caused by the transmission errors can produce an adverse degradation in visual quality. In such situation, retransmission mechanism such as Automatic Repeat Request (ARQ) will be applied. However, retransmission of data packet is not suitable for real-time application because of the excessive relay, and hence, decoder error concealment provides a feasible solution for error handling.

Error concealment algorithms can be divided into two categories: spatial and temporal error concealment. Spatial error concealment uses the information of neighboring MacroBlocks (MBs) to recover lost information. Temporal error concealment tries to recover the motion vectors and find the best block in the previous decoded frame to replace the missing MBs [1, 2, 3].

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One inherent problem with any communication system is that information may be altered or lost during transmissions due to channel noise. The loss of a packet may result in the loss of a whole video frame. The technique for combating transmission errors for video communication have been developed on the hand of signal-reconstruction and error concealment techniques have been proposed to obtain a close approximation of the original signal or attempt to make the output at the decoder least objectionable to humane vision. Note that unlike data transmission, where lossless delivery is required absolutely, human eyes can tolerate a certain degree of distortion in image and video signals [4, 5, 6].

2. Framelet Transform

Though standard Discrete Wavelet Transform (DWT) is a powerful tool for analysis and processing of many real-world signals and images, it suffers from three major disadvantages, Shift-sensitivity, Poor directionality, and Lack of phase information. These disadvantages severely restrict its scope for certain signal and image processing applications (e.g. edge detection, image registration /segmentation, motion estimation) [7, 8, 9].

Other extensions of standard DWT such as Wavelet Packet Transform (WPT) and Stationary Wavelet Transform (SWT) reduce only the first disadvantage of shift-sensitivity but with the cost of very high redundancy and involved computation. Recent research suggests the possibility of reducing two or more of these disadvantages [7].

Introducing the Double-Density Wavelet Transform (DDWT) as the tight-frame equivalent of Daubechies orthonormal wavelet transform; the wavelet filters are of minimal length and satisfy certain important polynomial properties is an oversampled framework. Because the DDWT, at each scale, has twice as many wavelets as the DWT, it achieves lower shift sensitivity than the DWT, [8].

2.1. Computation of Framelet Transform for 2-D Signal using Non- Separable method [13]

To compute a single level Orthogonal –based discrete framelet for 2-D signal the next steps should be followed:

1) Checking input dimensions: Input matrix should be of length N*N where N must be even and N>=length (analysis filters).
2) For an N*N matrix input 2-D signal X, construct a 3N/2*N transformation matrix, W using transformation matrices for length-7 given as:
3) Apply transformation by multiplying the transformation matrix by the input matrix by the transpose of the transformation matrix Y=W. X. WT then multiplication of the three matrices result in the final discrete framelet transformed matrix.

2.2. Computation of Inverse Framelet Transform for 2-D Signal [12]

To reconstruct the original signal from discrete framelet transformed signal, Inverse Discrete Framelet Transformed (IDFT) should be used. The inverse transformation matrix is the transpose of the transformation matrix as the transform is orthogonal.

To compute a single level 2-D inverse discrete Framelet Transform using non-separable method the next steps should be followed:

1) Let Y_0 be the $3N/2 \times 3N/2$ framelet transformed matrix.
2) Construct $N \times 3N/2$ reconstruction matrix, $T=W^T$ using transformation matrix given in eq(1).
3) Reconstruction of the input matrix by multiplying the reconstruction matrix by the input matrix by the transpose of the reconstruction matrix.

$$X=T.\ Y0\ .T^T \quad \text{…..}\ (2)$$

At a given level in the iterated filter bank, this separable extension produces nine 2D subbands. These subbands are illustrated in figure (1). Since L is a low-pass filter (h0(n)) while both H1 and H2 are high-pass filters (h1(n) and h2(n)), the H2H2, H1H2, H2H1, H1H1 subbands each have a frequency-domain Support comparable to that of the HH subband in a DWT. A similar scheme creates the H1L, H2L LH1, and LH2 subbands the same frequency-domain support as the corresponding HL (LH) subbands of the DWT, but with twice as many coefficients. Finally, note that there is only one subbands LL with the same frequency-domain as the LL subbands in a DWT.

3. Proposed Framelet Averaging (FA) Algorithm:-

When the lost block, which is assumed of size (N*N), is found the concealment of the lost blocks using the proposed averaging algorithm will be initiated. The Flowchart of the Framelet Averaging (FA) Algorithm is shown in figure (2).

When the missing block has been detected, the concealment of lost block will include the following steps (Note that it is assumed that the low frequency components have already been received correctly):-

1) The sides that are at the: Top (T), Bottom (B), Left (L), Right (R), and the edges at the: Left Top (LT), Left Bottom (LB), Right Top (RT), and Right Bottom (RB) will be used in the concealment process, each side or edge has same size of the lost block which is assumed to be of (N×N).
2) Take the 2-D Framelet Transform (FT) for all tiles and edges in step (1).
3) Find the subbands for each side and edge around the lost block (S):

a. If one of these subbands (H2H2, H2H1, H1H2, H1H1, H1L and H2L) is missing, obtain the frequency components through averaging the corresponding high frequency components from the eight surrounding tiles (T, B, R, L, LT, LB, RT, and RB).
b. If LH1 subband is lost, reconstruct it through averaging corresponding frequency components from the four surrounding sides (T, B, R, and L).
c. If LH2 subband is lost, reconstruct it as:
   New LH2=0.4×LH2 of left side + 0.4×LH2 of right side + 0.1×LH2 of top side + 0.1×LH2 of bottom side.

4) Reconstruct the approximate matrix with size ($\frac{3N}{2} \times \frac{3N}{2}$) from its new subbands.
5) Take 2-D Inverse Framelet Transform (2DIFT) to get the approximate lost block which is of size (N*N).
6) Finally, store the new block in the position of Lost Block.

4. Simulation Results and Discussion:-

Figure (3) shows three lost blocks of size (8×8) and its corresponding reconstructions. It can be easily seen that the reconstruction is perfect using the subjective human display.

The commonly used objective measure is the Signal to Noise Ratio (SNR). The error between an original and reconstructed pixel values is defined as [14]:

error(x,y)=O(x,y)-R(x,y)...........(2)

where O(x,y) is the pixel value at position (x,y) of the original block and R(x,y) is the pixel value at position (x,y) of the reconstructed block.

Defining the Total Error (TE) between the original and reconstructed block of size (N×N) as [15]:

$$TE = \sum_{x=1}^{N}\sum_{y=1}^{N} O(x,y) - R(x,y) \quad ......\ (3)$$

Both signal and noise power (or amplitude) must be measured at the same or equivalent points in a system.

The SNR metric considers the reconstructed block R(x,y) to be the "signal", and the error to be the "noise". So SNR can be defined as [15]:

$$SNR = 10\log_{10}\left(\frac{\sum_{x=1}^{N}\sum_{y=1}^{N}(R(x,y))^2}{\sum_{x=1}^{N}\sum_{y=1}^{N}(O(x,y)-R(x,y))^2}\right) \quad (4)$$

Table (1) shows the effect of the number of analysis filter on the performance of reconstruction of Lost Blocks using Framelet Averaging (FA) Algorithm. It can be concluded that increasing the number of analysis filter, the performance of algorithm is increased in terms of SNR values.

Table (2) shows a comparison between Multiwavelet Averaging (MWA) algorithm that suggested in [4] and the propsed Framelet Averaging (FA) algorithm and it shows that the performance is much better in Framelet based algorithm rather than the Multiwavelet based algorithm. On the other hand, the FA algorithm has less computatioinal efforts because it has less subbands than in (MWA) algorithm.

5. Conclusions:-

In this paper, we present a new procedure for averaging the subbands in Framelet Transform (FT), the proposed algorithm exploits the information in neighbors of lost block to reconstruct the frequency components (the low frequency components of the lost block has already been received correctly) this is achieved by fast orthogonal-based transform (Framelet Transform) to get better error concealment and low computational complexity than Multiwavelet Transform (MWT) in terms of signal to noise ratio (SNR) and human vision.

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$$W=\begin{bmatrix} h_0(0) & h_0(1) & h_0(2) & h_0(3) & h_0(4) & h_0(5) & h_0(6) & 0 & 0 & \dots & 0 & 0 \\ 0 & 0 & h_0(0) & h_0(1) & h_0(2) & h_0(3) & h_0(4) & h_0(5) & h_0(6) & \dots & 0 & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ h_0(2) & h_0(3) & h_0(4) & h_0(5) & h_0(6) & 0 & 0 & \dots & 0 & 0 & h_0(0) & h_0(1) \\ h_1(0) & h_1(1) & h_1(2) & h_1(3) & h_1(4) & h_1(5) & h_1(6) & 0 & 0 & \dots & 0 & 0 \\ 0 & 0 & h_1(0) & h_1(1) & h_1(2) & h_1(3) & h_1(4) & h_1(5) & h_1(6) & \dots & 0 & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ h_1(2) & h_1(3) & h_1(4) & h_1(5) & h_1(6) & 0 & 0 & 0 & 0 & \dots & h_1(0) & h_1(1) \\ h_2(0) & h_2(1) & h_2(2) & h_2(3) & h_2(4) & 0 & 0 & 0 & 0 & \dots & 0 & 0 \\ 0 & 0 & h_2(0) & h_2(1) & h_2(2) & h_2(3) & h_2(4) & 0 & 0 & \dots & 0 & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ h_2(2) & h_2(3) & h_2(4) & 0 & 0 & 0 & 0 & 0 & 0 & \dots & h_2(0) & h_2(1) \end{bmatrix}_{\frac{3N}{3}\times N} \quad \dots (1)$$

Table (1) A comparison between analyses filters for reconstruction of lost blocks using (FA) Algorithm:

The subbands of Framelet	SNR with filter length (6)	SNR with filter length (7)
H2H2	87.6727	93.9357
H2H1	110.8693	104.0472
H1H2	104.8559	99.8354
H1H1	109.9048	96.1971
LH1	88.9180	82.2222
LH2	61.8485	64.2105
H1L	78.2840	72.5348
H2L	51.9326	53.7044

Table (2) A comparison between (MWA) and (FA) algorithms:

The subbands in (MWA) algorithm	SNR	The subbads in (FA) algorithm	SNR
H1L1	39.2901	H2H2	93.9357
H2L1	33.6353	H2H1	104.0472
L1H1	42.0501	H1H2	99.8354
L2H1	45.6147	H1H1	96.1971
H1H1	51.8814	LH1	82.2222
H2H1	49.8323	LH2	64.2105
H1L2	43.8776	H1L	72.5348
H2L2	36.7794	H2L	53.7044
L1H2	37.2211		
2H2	41.3500		
H1H2	47.6193		
H2H2	47.4258		

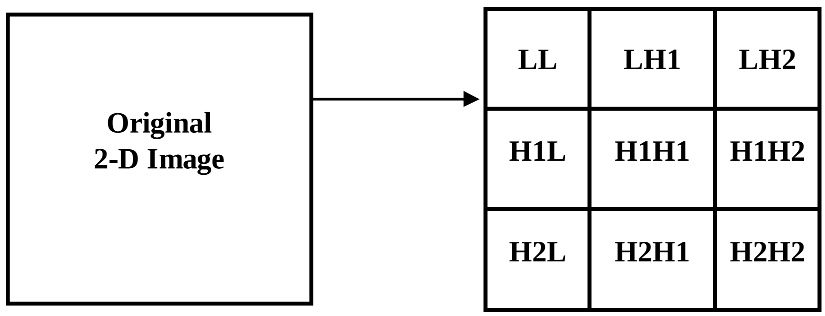

Figure (1) Image subbands after a single-level decomposition of Framelet [11]

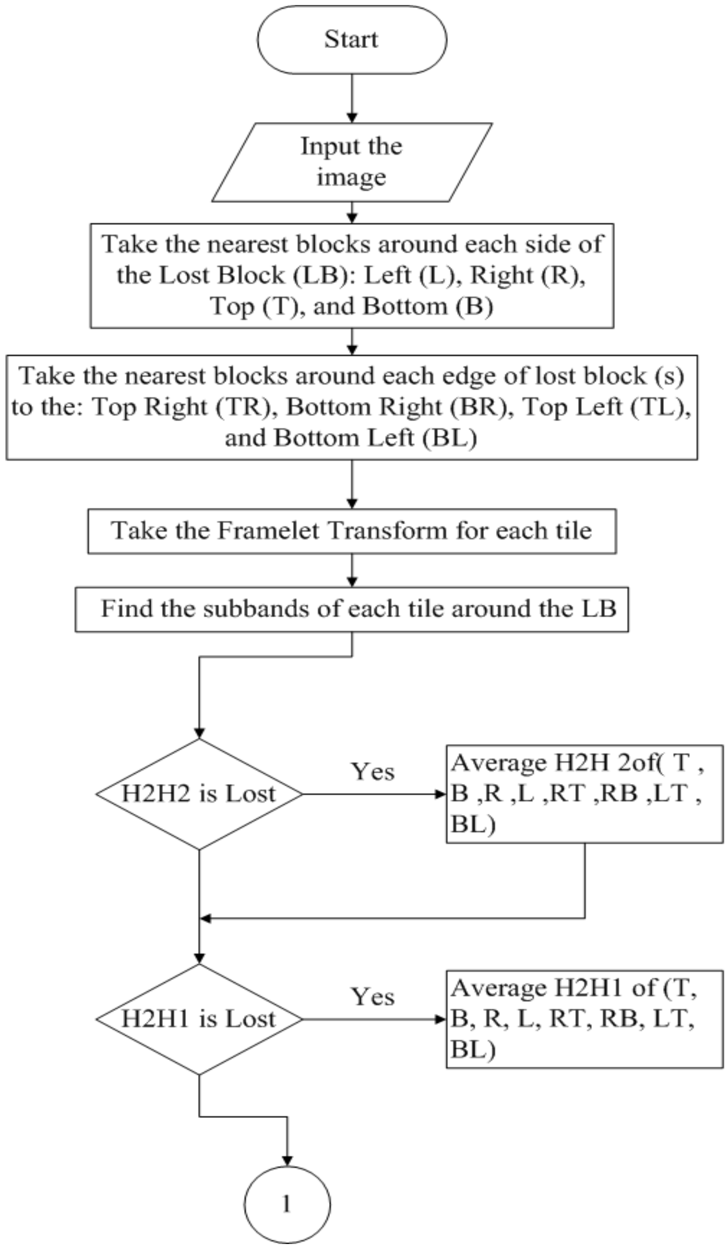

Figure (2) The Flowchart of the Framelet Averaging (FA) Algorithm

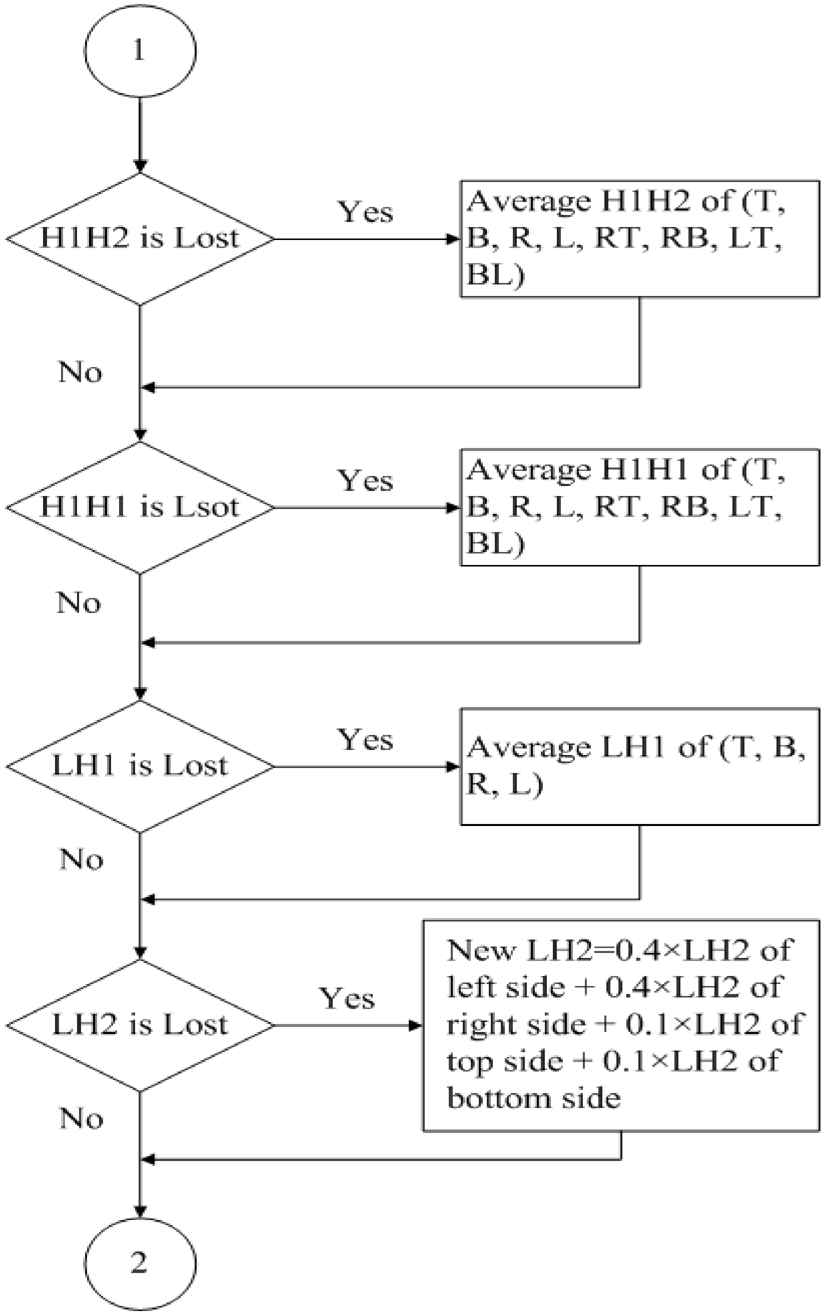

Figure (2) Continued

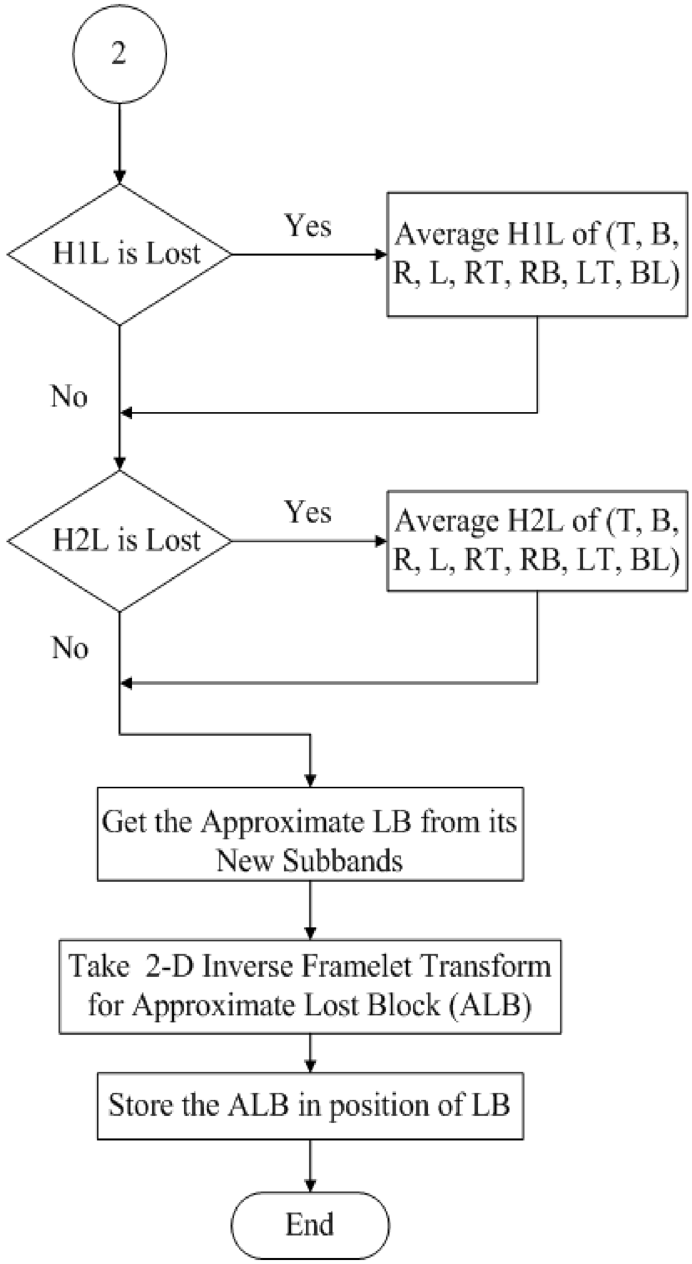

Figure (2) Continued

(a) The original signal

(b) Locations of Lost Blocks

(C) Reconstruction of H2H2

(d) Reconstruction of H2H1

(e) Reconstruction of H1H1

(f) Reconstruction of H1H2

Figure (3) Reconstruction of Lost Blocks for (Lena) Image using Framelet Averaging (FA) algorithm

(g) Reconstruction of LH2

(h) Reconstruction of LH1

(i) Reconstruction of H1L

(j) Reconstruction of H2L

Figure (3) Continued