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Error Concealment Algorithm Using Interested Direction for JPEG 2000 Image Transmission

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***Abstract*—The newly defined JPEG 2000 delivers scalable and region-of-interest image with lower bit rate in internet and wireless communications. However, any data loss in JPEG 2000 bitstream will affect the consequent bitplanes and even possibly destroy the whole picture. We propose a new algorithm to recover the damaged bitplanes data according to the interested directional pattern in-subband. The simulation results show that the proposed concealment algorithm can achieve much smoother edge on the reconstructed image.**

I. INTRODUCTION

In recent years, internet and wireless communication have grown astronomically. However, it is known that un-reliable wireless channels and the congestion of internet may inject errors into the transmitted bit-stream. Since multimedia will have much wider application in the future, error resilience issue has become necessary for image/video transmission. JPEG2000 contains error resilience tools to detect and localize the errors, and also to resynchronize the decoding process. These tools can minimize the effect of errors on image quality. But standard error resilience tools cannot recover the lost data. Consequently, additional methods that can conceal the lost data are required during the decoding process. Various methods of concealing errors have been proposed. Zero is used to replace the missing wavelet coefficients for JPEG2000 standard [1,2]. [3] propose an algorithm for interpolating wavelet coefficients from neighboring lost coefficients. However, this algorithm cannot be used for real time error concealment.

It is known that once an error occurs, the remainder of the embedded bit-stream is useless and the subsequent decoding steps will produce erroneous results such that the whole image is influenced. For solving this problem, replacing all missing wavelet coefficients by zeros may affect lots of significant non-zero coefficients such that some high frequency components are lost. [4] conceals the lost bitplane by using the concept of cross-subband correlation. The method does not utilize low frequency subband (LL band and the lowest level). Therefore, when upper low frequency subband is lost, there is still significant image deterioration.

In this paper, we propose an efficient algorithm to recover damaged wavelet coefficients, in which the interested direction sets of in-subband are used to estimate the position of significant nodes of damaged bitplane. By the algorithm, the reconstructed image also preserves much smoother edge.

II. THE PROPOSED CONCEALMENT ALGORITHM

In the relative literatures, there are many efficient wavelet coding techniques to detect significant nodes. [5] utilizes the interested direction sets of in-subband to express the relationship among subands. We use the interested direction sets of in-subband to determine the lost bitplane data. The direction patterns are shown in Fig.1. For different subbands, the interested directions are different.

(I) In HL subbands, we only consider the directions v-1 to v-4, their 180-degree rotation, and reflection with respect to x and y axes, respectively.

(II) We consider h-1 to h-4 in LH subbands, their 180-degree rotation, and reflection with respect to x and y axes, respectively.

(III) In HH subbands, the interested direction set is d-1, we should consider both v-1 and h-1 directions and their 180-degree rotation.

For each lost bit in a bitplane, the following algorithm is to show the recovering procedure for the lost bit.

Step 1: Make sure which subband is the lost bit belonging to, and then consider the corresponding interested directions in Fig.1.

Step2: There are two cases as follows to be considered.

Case1: In the upper bitplane, the same location of the lost bit is "0". If its interested direction pattern is satisfied, the lost bit is set to "1". Otherwise, check the interested direction pattern with concealed bits in the current bitplane, if it is satisfied, then the lost bit is set to "1", else set to "0".

Case2: In the upper bitplane, the same location of the lost bit is "1". We only need to check the interested direction pattern with concealed bits in the current bitplane, if it is satisfied, then the lost bit is set to "1", else set to "0".

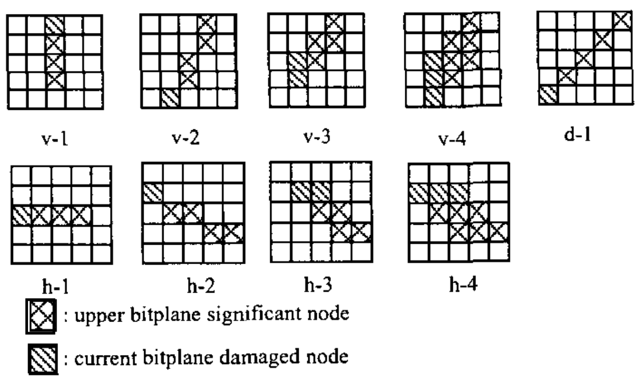

Fig.1 Directional patterns.

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When the compressed image bitstream comes into the decoder, every pass will be decoded. Then errors can be detected by the error resilience mechanism in JPEG2000. If errors are detected, the relevant bitplane data will be discarded. The above algorithm can recover the lost bitplane data. The recovered are collected for the coefficients of IDWT and for reconstructing the image. The proposed scheme is summarized as the flowchart in Fig.2.

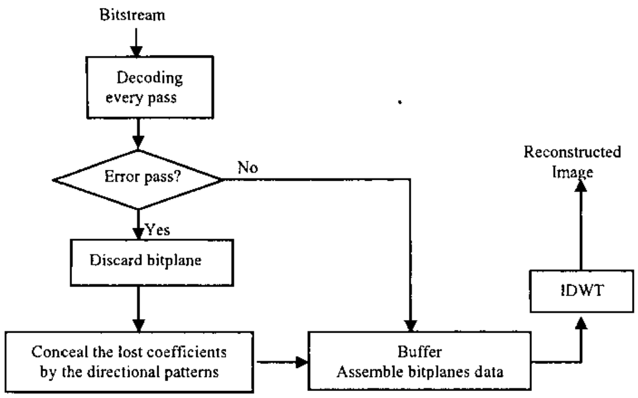


Fig.2 Flowchart of recovering damaged bitplane.

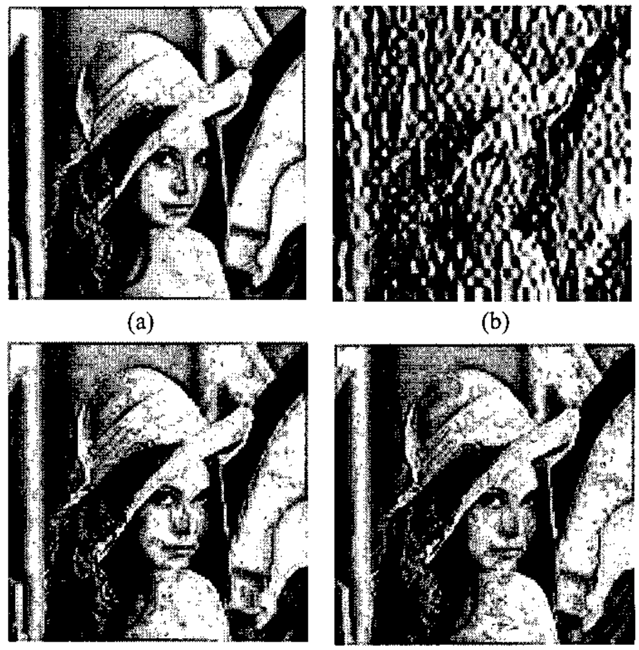
III. SIMULATION RESULTS

The simulation tests are based on JPEG2000 Verification Model VM7.2. For each test image, we compare three different cases: 1) Encoding with resynchronization marker at subband level: 2) Encoding with error resilient properties, such as, resynchronization marker for each subband, segmentation marker for each bitplane, and termination at each coding pass. When the error occurs, in decoding with error detection mechanism, those missing wavelet coefficients are simply replaced by zeros; 3) The procedure is the same as case 2) in encoding process, except that, in decoding process, the proposed error concealment algorithm is adopted.

The experimental results demonstrate that the proposed algorithm improves performance significantly in terms of subjective measurements compared with other methods as shown in Fig. 3. Fig.3(d) is the reconstructed image by our proposed algorithm, which has at least 2 dB improvement better than the other two methods Fig.3(b) and Fig.3(c). It also Illustrates that Fig.3(d) has much smoother edges than the other two figs in "mirror" and Lena's "shoulder" and "face", etc. The overall performance show that the proposed algorithm is much more efficient and robust for recovering the lost data in JPEG 2000 bitstream information.

IV. CONCLUSION

In this paper, we have proposed a new technique to improve the error resilience ability for JPEG2000. The proposed approach utilizes interested direction sets of in-subband and undamaged bitplane information instead of replacing the missing wavelet coefficients by zeros to recover damaged wavelet coefficients such that the recovered wavelet coefficients will be much similar with noise free data. The experiments show that we have the objective results with at least 2 dB improvement better than those without error resilient mechanism, and the subjective result is with much smoother edge on the reconstructed image by the proposed concealment algorithm.



(a) (b)

(c) (d)

Fig.3 The subjective results for "Lena" image by BER=10e-3, bit-rate=1bpp in the lowest HL subband. (a) reconstructed image by error free, PSNR=36.21dB ; (b) error resilience only by resynchronization marker, PSNR=14.49dB (case 1 + error); (c) missing wavelet coefficients replaced by zeros, PSNR=27.66dB (case 2 + error); (d) reconstructed image by our proposed algorithm, PSNR=29.57dB (case 3 + error).

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