Proceedings of the 6th WSEAS International Conference on Multimedia Systems & Signal Processing, Hangzhou, China, April 16-18, 2006 (pp13-18)

A New Statistical Algorithm to Detect Errors in MPEG-2 Video

*YUK YING CHUNG, *SIQI LI, *XIAOMING CHEN, **CHANGSEOK BAE
*School of Information Technologies, University of Sydney, NSW 2006, AUSTRALIA
**Post-PC Research Group, ETRI, 161 Gajeong Dong, Yuseong Gu, Daejeon, KOREA

Abstract: - In this paper a new error detection algorithm, based on a new statistical algorithm , **S**tatistical **P**arity **P**air **E**mbedding (***SPPE***) has been proposed and implemented. They are the pairs of high and low frequency signals which forced to be correlated in term of same parity. The way to correlate them is by embedding the parity of the low frequency coefficient into the corresponding high frequency coefficient. This SPPE algorithm has been proved to have better performance than other traditional algorithms and is very suitable for using in multipoint communications since we do not need to add any extra information into the video in order to detect the errors correctly.

Key-Words: - MPEG-2, video compression, error detection.

1 Introduction

Video compression techniques [6] explore the temporal, spatial and coding redundancies within the video sequence and offer solutions to reduce these redundancies. MPEG2 [1]- [3] is one of the popular technique which has been widely used in HDTV and Video on Demand broadcasting. Due to the inherent problems of all communication systems, video data may be lost or altered due to the noise during transmission over wire or wireless networks. **R**andom **B**it **E**rror (***RBE***) and **E**rasure **E**rror (***EE***) [7] [8] are two types of errors which always occur during video transmission.

The transmission errors in MPEG-2 may propagate in the temporal direction. The error in intra-coded picture (I-frame) will propagate into the associated P-B frame if they are in the same **G**roup **O**f **P**icture (***GOP***) [4]-[6]. Therefore it is important to detect the error in I-frame rather than P-B frame.

This paper has proposed and implemented a new **E**rror **D**etection (**ED**) algorithm based on **S**tatistical **P**arity **P**air **E**mbedding (***SPPE***). The SPPE can locate errors in the compressed I-frame bit stream. The SPPE is based on the digital watermark embedding technique.

The proposed SPPE system embeds a certain number of parities into the high frequency coefficients of each 8x8 DCT block in the I-Frame, followed by a stipulated embedding pattern. The number of embedded parities per DCT block, and the embedding pattern, are obtained through appropriate experiments. The final results achieve the best compromise with Compression Ratio, Average Zeroty of Embedded Coefficient, Error Detection-ability and PSNR. The new idea of Zeroty enables the filtering out of the embedded parity noise after ED routines.

In this paper Section 2 explains the details of the new proposed SPPE system. Section 3 and 4 give the testing results and conclusion respectively.

2 The proposed *SPPE* algorithm

In this paper a new **S**tatistical **P**arity **P**air **E**mbedding (***SPPE***) algorithm is proposed and implemented. Figure 1 shows the SPPE encoder. According to Figure 1 the DCT process transform an 8x8 block of spatial domain into an 8x8 block of frequency domain. Quantization process cuts out some less-sensitive frequencies. The parity embedding process correlates some parities of the high and low frequency coefficients, enabling error detection. The output is an 8x8 parity embedded block, which is scanned with predefined patterns forming a bit stream. The resulting bit stream passes into a Variable Length Coder to form a further compressed coded bit stream.

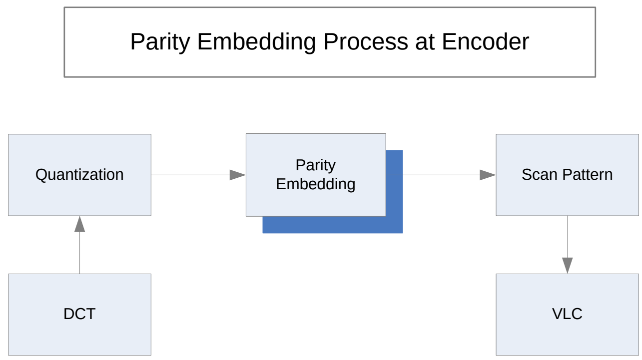

Figure 1 The block diagram of SPPE encoder

Figure 2 shows the SPPE decoder. According to Figure 2 the Variable Length Decoder reads in the compressed coded bit streams and output the decompressed coefficients. Meanwhile the coefficients are allocated back into their original positions within the 8x8 DCT block, guided by the Scanning Pattern. The Parity Detection Process checks the parities between correlated high and low frequencies and report if a block is corrupted or not. Then the 8x8 block is passed into the Parity Filter which removes the embedded parities in order to gain more PSNR. An Inverse Quantization Process will minimize the side effects of Quantization Process. Later the Saturation Process corrects some out bound value within the block. Finally, Inverse DCT transforms the block from frequency domain back into spatial domain.

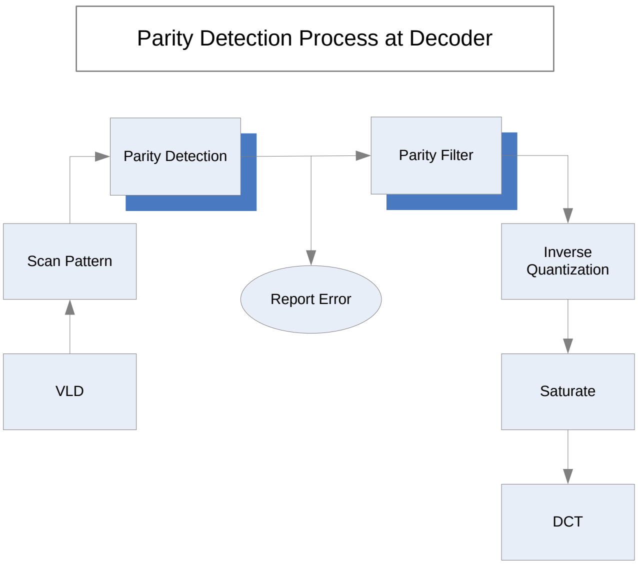

Figure 2 The block diagram of SPPE decoder

2.1 Parity correlation

According to the SPPE encoding process in Figure 1, the **P**arity **P**airs ***(PPs)*** are constructed and embeded into the I-frame pictures. PPs is a pair of high and low frequency coefficients, which are forced to be correlated in term of same parities. The procedure for correlation is to embed the parity bit of low frequency coefficient into the corresponding high frequency coefficient. Figure 3 shows the PPs in the SPPE decoder.

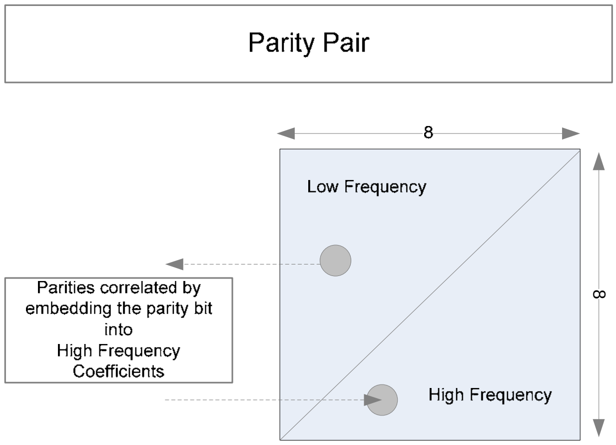

Figure 3 The Parity Pairs in the SPPE decoder

For the purpose of increasing error detection-ability, there will be more than one Parity Pair embedded per DCT block. There will be numbers of low frequency coefficients mapped onto corresponding high frequency coefficients to form **P**arity **P**airs **(*PPs*)**. This mapping pattern is called the **Parity Mapping Pattern.** Figure 4 shows an example of the Parity Mapping Pattern.

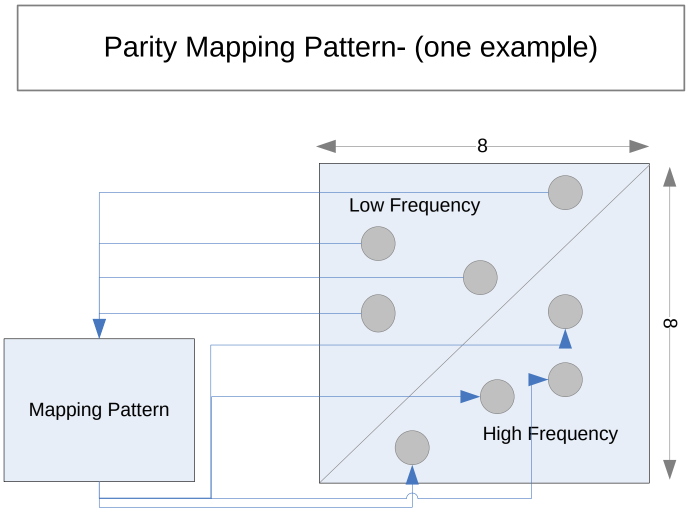

Figure 4 An example of Parity Mapping Pattern

2.2 Zeroty

Quantization Process affects the majority high frequency coefficients by cutting them to the value of zero. If we embed Parities into those coefficient. We can recover them later by simply reset them back to zero.

We have defined a new statistical probability which is termed **Zeroty**. It will express the probability that a particular DCT coefficient will be zero. The zeroty of a frequency can be sampled from the same frequency coefficients in each DCT blocks of all I-Frames. Therefore the resultant Zeroty of a frequency is in general to this frequency of all DCT blocks. The sampling process and formula are illustrated in Figure 5 below.

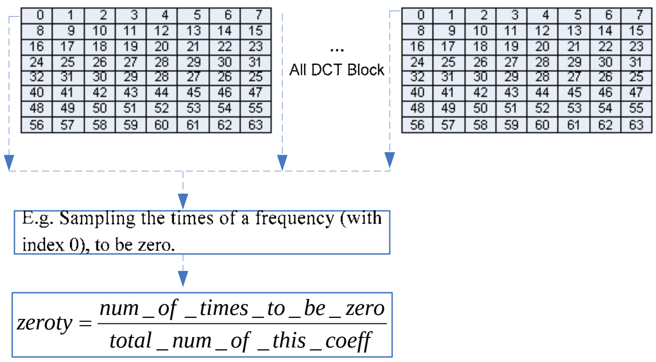

Figure 5 Diagram explaining the concept of **Zeroty**

We have defined the **Zeroty Matrix** as an 8x8 matrix which contains the Zeroty of 64 coefficients. The Zeroty Matrix provides a concrete view of the zeroty of each coefficient across the three different components (Y/Cr/Cb) of DCT blocks. The purpose of these matrixes is to perform Probability Filtering during the linear re-interpolation of the error coefficient from neighboring block.

2.3 Parity Mapping Pattern

According to the SPPE decoder in Figure 2, the parity mapping patterns are correlating the first lowest frequency coefficient with first highest frequency coefficient; correlating the second lowest frequency coefficient with second highest frequency coefficient and so on. Figure 6 explains the Parity Mapping Pattern.

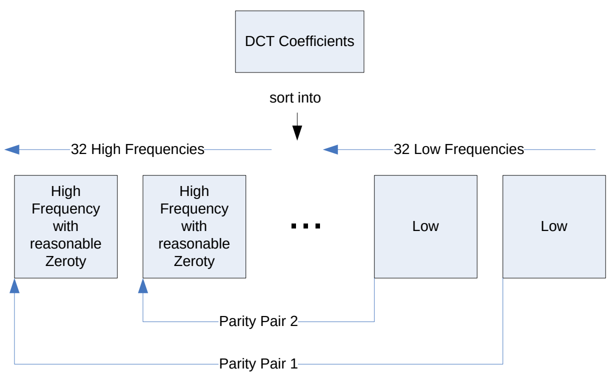

Figure 6 An example of Parity Mapping Pattern

In this paper two frequencies scanning pattern for MPEG-2 have been implemented. They are Zig-Zag and Alternative sequences. Zig-Zag sequences strictly follow the increment of frequency, whereas alternative sequence explored improve Run Length Coding as well. To a certain extent, a better RLC implies that it follows the increment of Zeroty. Both mapping patterns were adopted and tested for the proposed SPPE algorithm. The testing results are shown in Section 3. Figure 7 illustrates the Zig-Zag Parity Embedding Pattern algorithm. Figure 8 illustrates the alternative Parity Embedding pattern algorithm.

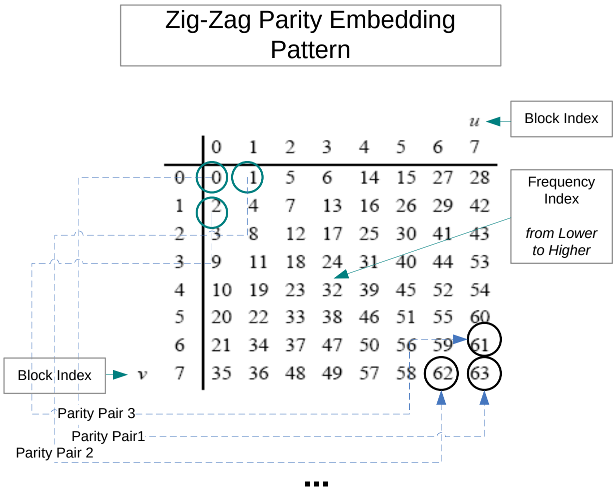

Figure 7 The Zig-Zag Parity Embedding Pattern

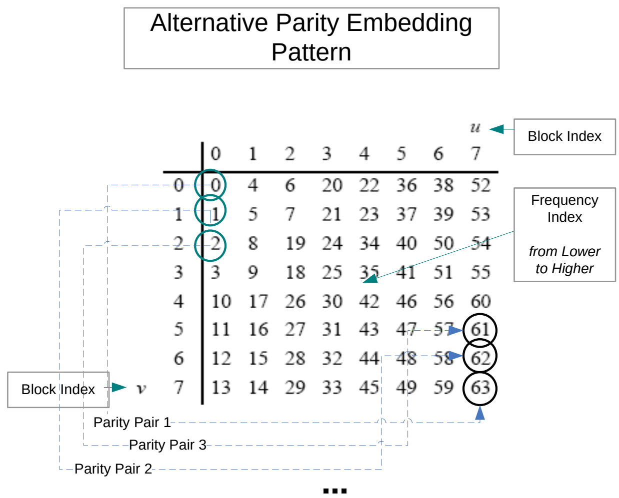

Figure 8 The alternative Parity Embedding Pattern

3 Testing Results

In the **S**tatistical **P**arity **P**air **E**mbedding (***SPPE***) encoder, some testing was done to test how many **P**arity **P**airs (***PPs***) should be embedding into each DCT block. Figure 9 is the block diagram for the error detection ability test scheme. Intuitively, better error detection ability should be obtained by embedding more parity pairs.

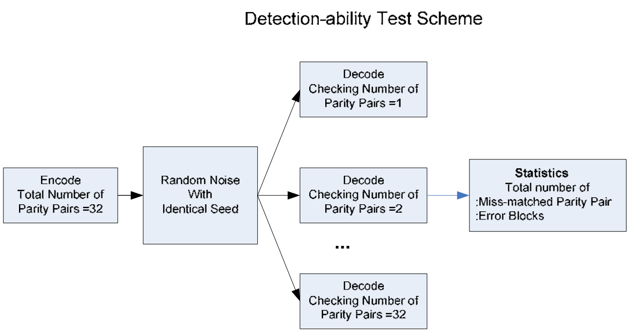

Figure 9 The block diagram for the error detection ability test scheme

The test process follows the following three steps:

1) The frames are encoded only once with the total number of embedded Parity Pairs equal to 32.
2) Identical Uniform Random Noise is applied to the video stream; and
3) The decoder only checks certain instances of Parity Pairs, under Alternative Mapping Pattern or Zig-Zag Mapping Pattern. This means some embedded Parity Pairs will be ignored by some decoder. For example, if the decoder only checks one Parity Pair followed by a certain Parity Mapping Pattern, the remaining 31 pairs of parities will be ignored.

PSNR Results						
No. of PPs	**Ave PSNR I-Frame Alternative Mapping**			**Ave PSNR I-Frame Zig_Zag Mapping**		
	Y	Cr	Cb	Y	Cr	Cb
0	43.6	47.6	47.5	43.6	47.6	47.5
1	34.6	39.4	39.5	34.6	39.4	39.5
2	33.9	37.7	38.1	33.9	37.3	37.6
3	33.4	37.5	38.1	32.9	36.6	37.2
4	33.1	37.1	37.8	32.5	36.5	37.2
5	31.9	35.9	36.5	32	35.4	36
6	31.7	35.2	35.9	31.5	35.6	36.4
7	31.4	35.2	36	31.3	35.4	36.4
8	31.3	35	35.9	31.1	35.2	36.1
9	31	35.4	36.4	30.8	34.8	35.7

Table 1 The experimental results arising from embedding different Parity Pair numbers using both Alternative and Zig-Zag Mapping Patterns

Table 1 shows the experimental results for embedding different Parity Pair numbers using both Alternative and Zig-Zag Mapping Patterns. The visual picture quality of embedding different number of Parity Pairs using these two Mapping Pattern techniques have been shown in Figure 12.

The testing results for the error detection of different Parity Pairs using Alternative Mapping Pattern technique have been show in Figure 10. The testing results for the error detection of different Parity Pairs using Zig-Zag Mapping Pattern technique have been show in Figure 11.

According to the result in table 1, Figure 10 and 11, we find that Alternative Mapping Pattern technique can achieve better PSNR result than Zig-Zag mapping technique. The four Parity Pairs with Alternative Mapping Pattern technique for the proposed SPPE algorithm can obtain the best result.

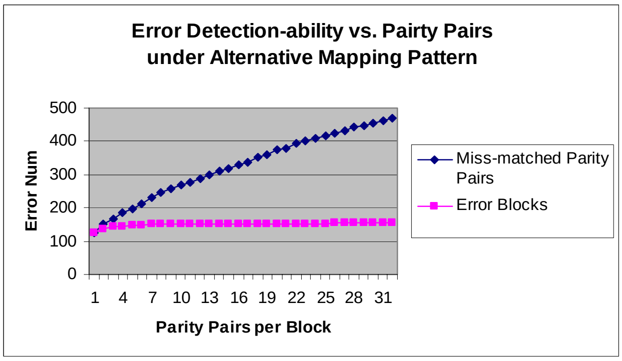

Figure 10 The results for Alternative Mapping Pattern

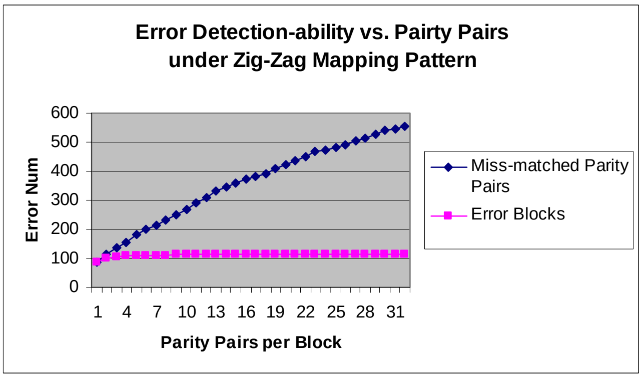

Figure 11 The results for Zag-Zig Mapping Pattern

4 Conclusion

In this paper a new **S**tatistical **P**arity **P**air **E**mbedding (***SPPE***) algorithm is proposed and implemented. The SPPE algorithm is based on the **P**arity **P**airs (***PPs***). They are the pairs of high and low frequency signals which forced to be correlated in term of same parity. The procedure for correlating them is to embed the parity of low frequency coefficient into the corresponding high frequency coefficient. The testing results in Section 3 indicate the best results are achieved when each of the DCT block embedding four parity pairs and uses the Alternative Mapping Pattern algorithm.

The advantage of this SPPE algorithm is that we do not need to add any extra information into the video in order to detect the errors correctly. It is very suitable for the multipoint communication where the receivers do not require any extra information to detect the errors.

References:

[1] Watkinson J., *The Art of Digital Video*. 3 ed. 2000, Linacre House, Jordan Hill,Oxford UK: focal Press. p.303.

[2] Tudor P.N. *MPEG-2 video compression tutorial*. in *MPEG-2 - What it is and What it isn't, IEEE Colloquium on*. 1995.

[3] Matzner R., Eck P., and Xie C.S. *MPEG-2 decoding of noisy input data*. in *Image Processing, 1996. Proceedings., International Conference on*. 1996.

[4] Eskicioglu A.M. and Fisher P.S., *Image quality measures and their performance.* Communications, IEEE Transactions on, 1995. **43**(12): p. 2959-2965.

[5] Group, M.S.E., *Generic coding of Moving Pictures and Associated Audio Infomation:Video*, in 1994, ISO/IEC 13818-2.

[6] Schafer R. and Sikora T., *Digital video coding standards and their role in video communications.* Proceedings of the IEEE, 1995. **83**(6): p. 907-924.

[7] Wada M., *Selective recovery of video packet loss using error concealment.* Selected Areas in Communications, IEEE Journal on, 1989. **7**(5): p. 807-814.

[8] Ayanoglu E., et al. *Forward error control for MPEG-2 video transport in a wireless ATM LAN*. in *Image Processing, 1996. Proceedings., International Conference on*. 1996.

	Alternative Mapping Pattern	Zig-Zag Mapping Pattern
No. of Parity Pairs = 1		
No. of Parity Pairs = 2		
No. of Parity Pairs = 3		
No. of Parity Pairs = 4		
No. of Parity Pairs = 5		
No. of Parity Pairs = 6		
No. of Parity Pairs = 7		
No. of Parity Pairs = 8		
No. of Parity Pairs = 9		

Figure 12 The results of embedding different no. of Parity Pairs using Alternative Mapping and Zig-Zag Mapping Patterns.