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Block Based Adaptive Videodata Hiding Technique

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ABSTRACT

Video data hiding is still an important research topic due to the design complexities involved. We propose a new video data hiding method that makes use of erasure correction capability of Repeat Accumulate codes and superiority of Forbidden Zone Data Hiding. Selective embedding is utilized in the proposed method to determine host signal samples suitable for data hiding. This method also contains a temporal synchronization scheme in order to withstand frame drop and insert attacks. The proposed framework is tested by typical broadcast material against MPEG-2, H.264 compression, frame-rate conversion attacks, as well as other well-known video data hiding methods. The decoding error values are reported for typical system parameters. The simulation results indicate that the framework can be successfully utilized in video data hiding applications.

Index Terms— Data hiding, digital watermarking, Quantization Index Modulation, Forbidden Zone Data Hiding, Repeat Accumulate codes, selective embedding.

1. INTRODUCTION

Data hiding is the process of embedding information into a host medium. In general, visual and arual media are preferred due to their wide presence and the tolerance of human perceptual systems involved. Although the general structure of data hiding process does not depend on the host media type, the methods vary depending on the nature of such media. For instance, image and video data hiding share many common points; however video data hiding necessitates more complex designs [6], [7] as a result of the additional temporal dimension. Therefore, video data hiding continues to constitute an active research area. Data hiding in video sequences is performed in two major ways: bitstream-level and data-level. In bitstream-level, the redundancies within the current compression standards are exploited. Typically, encoders have various options during encoding and this freedom of selection is suitable for manipulation with the aim of data hiding. However, these methods highly rely on the structure of the bitstream; hence, they are quite fragile, in the sense that in many cases they cannot survive any format conversion or transcoding, even without any significant loss of perceptual quality. As a result, this type of data hiding methods is generally proposed for fragile applications, such as authentication. On the other hand, data-level methods are more robust to attacks. Therefore, they are suitable for a broader range of applications. Despite their fragility, the bitstream-based methods are still attractive for data hiding applications. For instance, in[1], the redundancy in block size selection of H.264 encoding is exploited for hiding data. In another approach [17], the quantization parameter and DCT (Discrete Cosine Transform) coefficients are altered in the bitstream-level. However, most of the video data hiding methods utilize uncompressed video data. Sarkar et. al. [2] proposes a high volume transform domain data hiding in MPEG-2 videos. They apply QIM to low-frequency DCT coefficients and adapt the quantization parameter based on MPEG-2 parameters. Furthermore, they vary the embedding rate depending on the type of the frame. As a result, insertions and erasures occur at the decoder, which causes desynchronization. They utilize Repeat Accumulate (RA) codes in order to withstand erasures. Since they adapt the parameters according to type of frame, each frame is processed separately. RA codes are already applied in image data hiding. In [3], adaptive block selection results in de-synchronization and they utilize RA codes to handle erasures. Insertions and erasures can be also handled by convolutional codes as in [4]. The authors use convolutional codes at embedder. However, the burden is placed on the decoder. Multiple parallel Viterbi decoders are used to correct desynchronization errors. However, it is observed [4] that such a scheme is successful when the number of selected host signal samples is much less than the total number of host signals samples. In [5], 3-D DWT domain is used to hide data. They use LL subband coefficients and do not perform any adaptive selection. Therefore, they do not use error correction codes robust to erasures. Instead, they use BCH code to increase error correction capability. The authors perform 3D interleaving in order to get rid of local burst of errors. Additionally, they propose a temporal synchronization technique to cope with temporal attacks, such as frame drop, insert and repeat.

In this paper, we propose a new block-based selective embedding type data hiding framework that encapsulates Forbidden Zone Data Hiding (FZDH) [8] and RA codes in accordance with an additional temporal synchronization mechanism. FZDH is a practical data hiding method, which is shown to be superior to the conventional Quantization Index Modulation (QIM) [9]. RA codes are already used in image [3] and video [2] data hiding due to their robustness against erasures. This robustness allows handling desynchronization between embedder and decoder that occurs as a result of the differences in the selected coefficients. In order to incorporate frame synchronization markers, we partition the blocks into two groups. One group is used for frame marker embedding and the other is used for message bits. By means of simple rules applied to the frame markers, we introduce certain level of robustness against frame drop, repeat and insert attacks. We utilize systematic RA codes to encode message bits and frame marker bits. Each bit is associated with a block residing in a group of frames. Random interleaving is performed spatio-temporally; hence, dependency to local characteristics is reduced. Host signal coefficients used for data hiding are selected at four stages. First, frame selection is performed. Frames with sufficient number of blocks are selected. Next, only some predetermined low frequency DCT coefficients are permitted to hide data. Then the average energy of the block is expected to be greater than a predetermined threshold. In the final stage, the energy of each coefficient is compared against another threshold. The unselected blocks are labeled as erasures and they are not processed. For each selected block, there exists variable number of coefficients. These coefficients are used to embed and decode single message bit by employing multi-dimensional form of FZDH that uses cubic lattice as its base quantizer.

We describe the utilized data hiding method in Section II. Then the proposed video data hiding method is presented in Section III. Experiment results are given in Section IV, which is followed by the conclusion remarks.

2. PROPOSED VIDEO DATA HIDING FRAMEWORK

We propose a block based adaptive video data hiding method that incorporates FZDH, which is shown to be superior to QIM and competitive with DC-QIM [8], and erasure handling through RA Codes. We utilize selective embedding to determine which host signal coefficients will be used in data hiding as in [3]. Unlike the method in [3], we employ block selection (Entropy Selection Scheme [3]) and coefficient selection (Selectively Embedding in Coefficients Scheme [3]) together. The de-synchronization due to block selection is handled via RA Codes as in [3], [2]. The desynchronization due to coefficient selection is handled by using multi-dimensional form of FZDH in varying dimensions. In [2], the frames are processed independently. It is observed that [10] intra and inter frames do not yield significant differences. Therefore, in order to overcome local bursts of error, we utilize 3-D interleaving similar to [5], which does not utilize selective embedding, but uses the whole LL subband of Discrete Wavelet Transform. Furthermore, as in [5], we equip the method with frame synchronization markers in order to handle frame drop, insert or repeat attacks.

Hence, it can be stated the original contribution of this work is to devise a complete video data hiding method that is resistant to de-synchronization due to selective embedding and robust to temporal attacks, while making use of the superiority of FZDH.

A. Framework

The embedding operation for a single frame is shown in Fig. 2. Y-channel is utilized for data embedding. In the first step, frame selection is performed and the selected frames are processed block-wise. For each block, only a single bit is hidden. After obtaining 8x8 DCT of the block, energy check is performed on the coefficients that are predefined in a mask. Selected coefficients of variable length are used to hide data bit m. m is a member of message bits or frame synchronization markers. Message sequence of each group is obtained by using RA codes for T consecutive frames. Each block is assigned to one of these groups at the beginning. After the inverse transform host frame is obtained.

Decoder is the dual of the embedder, with the exception that frame selection is not performed. Fig. 3 shows the flowchart for a single frame. Marked frames are detected by using frame synchronization markers. Decoder employs the same system parameters and determines the marked signal values that will be fed to data extraction step. Non-selected blocks are handled as erasures. Erasures and decoded message data probabilities (*om*) are passed to RA decoder for T consecutive frames as a whole and then the hidden data is decoded.

B. Selective Embedding

Host signal samples, which will be used in data hiding, are determined adaptively. The selection is performed at four stages: frame selection, frequency band determination, block selection, and coefficient selection.

- ***Frame Selection****:* Selected number of blocks in the whole frame is counted. If the ratio of selected blocks to all blocks is above a certain value (*T0*) the frame is processed. Otherwise, this frame is skipped.
- ***Frequency Band****:* Only certain DCT coefficients are utilized. Middle frequency band of DCT coefficients shown in Fig. 4 is utilized similar to [2].
- ***Block Selection****:* Energy of the coefficients in the mask is computed. If the energy of the block is above a certain value (*T1*) then the block is processed. Otherwise, it is skipped.
- ***Coefficient Selection***: Energy of each coefficient is compared to another threshold *T2*. If the energy is above *T2*, then it is used during data embedding together with other selected coefficients in the same block.

C. Block Partitioning

Two disjoint data sets are embedded: message bits (*m1*) and frame synchronization markers (*m2*). The block locations of *m2* are determined randomly depending on a random key. The rest of the blocks are reserved for *m1*. The same partitioning is used for all frames. A typical partitioning is shown in Fig. 5. *m2* is embedded frame by frame. On the other hand, *m1* is dispersed to *T* consecutive frames. Both of them are obtained as the outcomes of the RA encoder.

D. Erasure Handling

Due to adaptive block selection, de-synchronization occurs between embedder and decoder. As a result of attacks or even embedding operation decoder may not perfectly determine the selected blocks at the embedder. In order to overcome this problem, error correction codes resilient to erasures, such as RA codes are used in image [3] and video [2] data hiding in previous efforts.

RA code is a low complexity turbo-like code [11]. It is composed of repetition code, interleaver and a convolutional encoder. The source bits (*u*) are repeated *R* times and randomly permuted depending on a key. The interleaved sequence is passed through a convolutional encoder with a transfer function $1/(1+D)$, where *D* represents a first order delay.

In systematic RA code, input is placed at the beginning of the output as shown in Fig. 6. In this work, we utilize systematic RA codes to obtain *m1* as $u1+v1$ and *m2* as $u2+v2$. Here, *u1* denotes the uncoded message bits and *u2* is the uncoded frame synchronization marker bits.

RA code is decoded using *sum-product algorithm*. We utilize the message passing algorithm given in [12].

E. Frame Synchronization Markers

Each frame within a group of *T* consecutive frames is assigned a local frame index starting from 0 to *T-1*. These markers are used to determine the frame drops, inserts and repeats, as well as the end of the group of frames at which point all necessary message bits are available for RA decoder.

Frame indices are represented by *K2* bits. After RA encoder *RK2* bits are obtained. Hence, *RK2* blocks are reserved for frame markers. *K2 >> log2T*, so that a small portion of $2K2$ code words is valid. Therefore, we can detect the valid frames with higher probability. Using the sequential frame index information, the robustness increases. Furthermore, RA code spreads the output code words of the adjacent frame indices; hence, errors are less likely to occur when decoding adjacent frame indices.

Once one reserves *RK2* blocks for frame markers, *T(NRK2)* blocks remain for message bits. Then, the actual number of message bits (*K1*) becomes equal to $\lfloor T(N RK_{2}) / R \rfloor$, where $\lfloor\cdot\rfloor$ denotes floor operation. The remaining blocks at the end of last frame is left untouched.

F. Soft Decoding

At the decoder, a data structure of length *RK1* is kept for channel observation probability values, *om*. The structure is initialized with erasures (*om*= 0.5 for *m=0* and *m=1*). At each frame, frame synchronization markers are decoded first. Message decoding is performed once the end of the group of frames is detected. Two frame index values are stored: current and previous indices. Let *fcur* and *fpre* denote the current and previous frame indices, respectively. Then the following rules are used to decode *u1*.

- If *fcur>T*, then skip this frame. (This case corresponds to unmarked frame.)
- If *fcur= fpre*, then skip this frame. (This case corresponds to frame repeat.)
- Otherwise, process the current frame. Put *om* values in the corresponding place of the data structure. Non-selected blocks are left as erasures.

If *fcur< fpre*, then the end of the group of frames is reached. Decode the message bits and obtain *u1*. Initialize data structure.

3. CONCLUSION

In this paper, we propose a new video data hiding framework that makes use of erasure correction capability of RA codes and superiority of FZDH. The method is also robust to frame manipulation attacks via frame synchronization markers.

First, we compare FZDH and QIM as the data hiding method of the proposed framework. We observe that FZDH is superior to QIM, especially for low embedding distortion levels.

The framework is tested with MPEG-2, H.264 compression, scaling and frame-rate conversion attacks. Typical system parameters are reported for error-free decoding. The results indicate that the framework can be successfully utilized in video data hiding applications. For instance, Tardos fingerprinting [18], which is a randomized construction of binary fingerprint codes that are optimal against collusion attack, can be employed within the proposed framework with the following settings. The length of the Tardos fingerprint is $Ac_0^2 \ln 1/\square_1$ [19], where A is a function of false positive probability ($\square_1$), false negative probability, and maximum size of colluder coalition, (c_0). The minimum segment duration required for Tardos fingerprinting at different operating conditions are given in Table VI.

We also compared the proposed framework against the canonical watermarking method, JAWS, and a more recent quantization based method [2]. The results indicate a significant superiority over JAWS and a comparable performance with [2]. The experiments also shed light on possible improvements on the proposed method. Firstly, the framework involves a number of thresholds (*T0*, *T1*, and *T2*), which are determined manually. The range of these thresholds can be analyzed by using a training set. Then some heuristics can be deduced for proper selection of these threshold values.

Additionally, incorporation of Human Visual System based spatio-temporally adaptation of data hiding method parameters as in [13] remains as a future direction.

4. REFERENCES

[1] S. K. Kapotas, E. E. Varsaki, and A. N. Skodras, "Data Hiding in H-264 Encoded Video Sequences," in IEEE 9th Workshop on Multimedia Signal Processing, MMSP 2007, pp. 373—376.

[2] A. Sarkar, U. Madhow, S. Chandrasekaran, and B. S. Manjunath, "Adaptive MPEG-2 Video Data Hiding Scheme," in Proceedings of SPIE Security, Steganography, and Watermarking of Multimedia Contents IX, 2007.

[3] K. Solanki, N. Jacobsen, U. Madhow, B. S. Manjunath, , and S. Chandrasekaran, "Robust image-adaptive data hiding using erasure and error correction," IEEE Transactions on Image Processing, vol.13, Dec. 2004, pp. 1627--1639.

[4] M. Schlauweg, D. Profrock, and E. Muller, "Correction of Insertions and Deletions in Selective Watermarking," in IEEE International Conference on Signal Image Technology and Internet Based Systems, SITIS '08, 2008, pp.277—284.

[5] H.Liu, J.Huang, and Y. Q. Shi, "DWT-Based Video Data Hiding Robust to MPEG Compression and Frame Loss," Int. Journal of Image and Graphics, vol. 5, pp. 111-134, Jan. 2005.

[6] M. Wu, H. Yu, and B. Liu, "Data hiding in image and video I. Fundamental issues and solutions," IEEE Transactions on Image Processing, vol. 12, pp. 685—695, June 2003.

[7] M. Wu, H. Yu, and B. Liu, "Data hiding in image and video II: Designs and applications," IEEE Transactions on Image Processing, vol. 12, pp. 696—705, June 2003.

[8] E. Esen and A. A. Alatan, "Forbidden zone data hiding," in IEEE International Conference on Image Processing, 2006, pp. 1393—1396.

[9] B. Chen and G. W. Wornell, "Quantization index modulation: a class of provably good methods for digital watermarking and information embedding," IEEE Transactions on Information Theory, vol. 47, May 2001, pp. 1423-1443, May 2001,.

[10] E. Esen, Z. Doğan, T. K. Ates, and A. A. Alatan, "Comparison of Quantization Index Modulation and Forbidden Zone Data Hiding for Compressed Domain Video Data Hiding,"in IEEE 17th Signal Processing and Communications Applications Conference SIU, 2009.

[11] D. Divsalar, H. Jin, and R. J. McEliece, "Coding theorems for turbolike codes," in Proc. 36th Allerton Conf. Communications, Control, and Computing, 1998, pp. 201—210.

[12] M. M. Mansour, "A Turbo-Decoding Message-Passing Algorithm for Sparse Parity-Check Matrix Codes," IEEE Transactions on Signal Processing, vol. 54, pp. 4376—4392, Nov. 2006.

[13] Z. Wei, K. N. Ngan, "Spatio-Temporal Just Noticeable Distortion Profile for Grey Scale Image/Video in DCT Domain," IEEE Transactions on Circuits and Systems for Video Technology, vol. 19, pp. 337—346, Mar. 2009.

[14] M. Maes, T. Kalker, J. Haitsma, and G. Depovere, "Exploiting Shift Invariance to Obtain a High Payload in Digital Image Watermarking," in IEEE International Conference on Multimedia Computing and Systems (ICMCS'99), vol. 1, 1999.

[15] T. Kalker, G. Depovere, J. Haitsma, and M. J. Maes, "Video watermarking system for broadcast monitoring," in Security and watermarking of multimedia contents Conference, SPIE Proceedings vol. 3657 , 1999, pp. 103—112.

[16] M. Maes, T. Kalker, J. -P. M. G., J. Talstra, F. G. Depovere, and J. Haitsma, "Digital watermarking for DVD video copy protection," IEEE Signal Processing Magazine, vol. 17, pp. 47—57, Sep. 2000.

[17] K. Wong, K. Tanaka, K. Takagi, and Y. Nakajima, "Complete video quality-preserving data hiding," IEEE Transactions on Circuits and Systems for Video Technology, vol. 19, pp. 1499—1512, Oct. 2009.

[18] G. Tardos, "Optimal probabilistic fingerprint codes," in Proceedings of the thirty fifth annual ACM symposium on Theory of computing (STOC '03), New York, NY, USA, 116—125.

[19] B. Skoric, T. U. Vladimirova, M. Celik, and J. C. Talstra, "Tardos fingerprinting is better than we thought," IEEE Transactions on Information Theory, vol. 54, no. 8, pp. 3663—3676, 2008

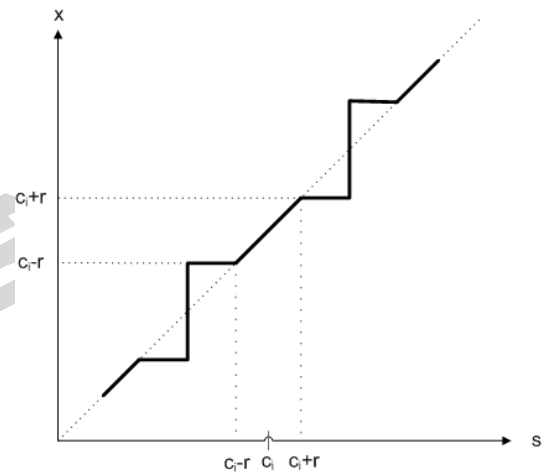

Fig. 1. A sample embedding function of FZDH in 1D. *ci* is a reconstruction point of the quantizer.

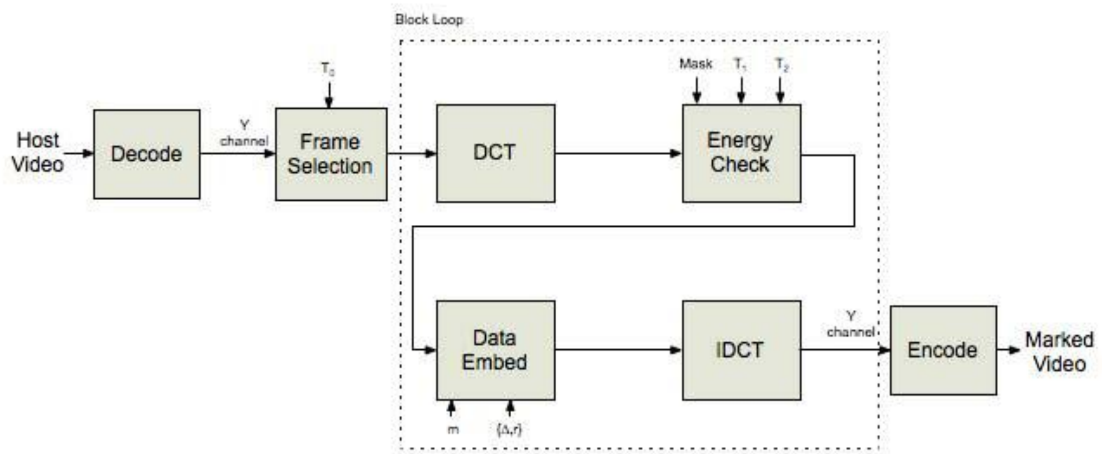

Fig. 2. Embedder flowchart of the proposed video data hiding framework for a single frame.

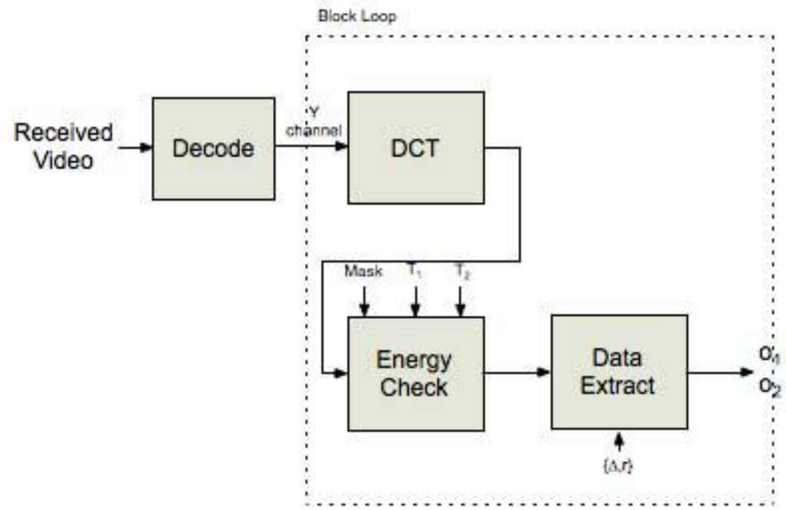

Fig. 3. Decoder flowchart of the proposed video data hiding framework for a single frame.

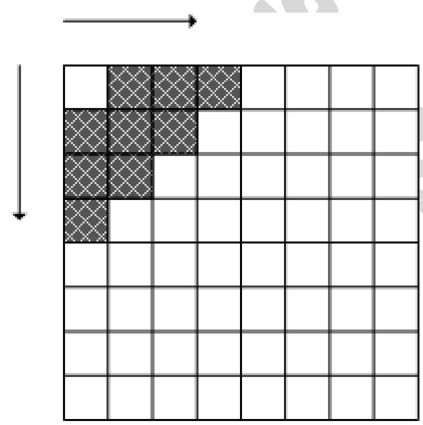

Fig. 4. Sample coefficient mask denoting the selected frequency band.

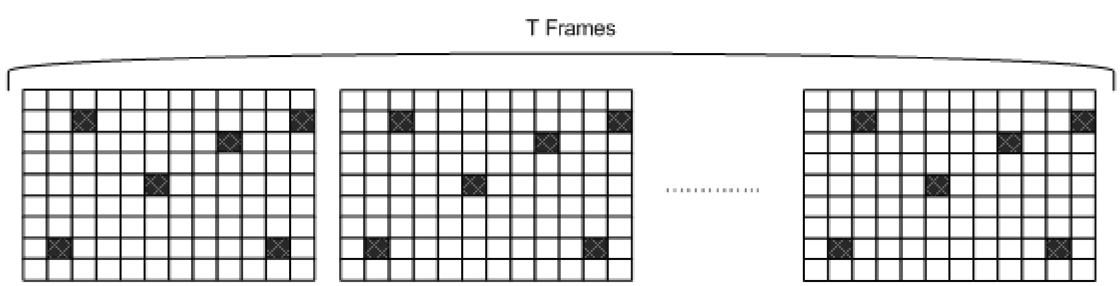

Fig. 5. A typical block partitioning for message bits and frame synchronization markers