Scalable Insertion of Persistent Association Data for Ubiquitous Multimedia

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Abstract

We present a persistent association method that is designed to relate scalable coding architecture such as FGS. Multimedia has a major role in the ubiquitous network. Every multimedia data has a metadata. It is used to record the information about the transaction of delivery, copyright, retrieval, etc. In order to manage the metadata well with multimedia data itself, the Persistent Association Tools are used. The scalable coding technique has a merit when it is used to transmit over wire/wireless networks. It can control the volume of source data quickly when network capacity is varied. Conventional PAT algorithm such as digital watermarking did not consider the transmission over networks. In this paper, we propose a persistent association algorithm which is designed to match the scalable coding algorithm as Fine Granular Scalable coding. Experimental results demonstrate that the proposed method has an ability to control information data with the variation of compression rate.

Key words: Persistent Association, Watermarking, Scalable Coding

1. Introduction

Ubiquitous network comes up with a new trend of IT research and industry field. The concept of ubiquity reflects the trend where computing devices become increasingly embedded, intelligent, and deployed in a variety of settings such as home, office, vehicle, and other environs to argument human capabilities.[1] Multimedia services will support a core component of ubiquitous environment.[2]

In ubiquitous network, majority part of multimedia contents should be delivered over networks. In order to deliver multimedia contents efficiently, there are several researches on content adaptation that guarantees quality. A representative technology of content adaptation is a scalable video coding technique.[3]

Ubiquitous media should be managed well, because many kinds of that are related to digital rights management or security problems. The MPEG (Moving Picture Experts Group) provides the MPEG-21 framework that is multimedia framework.[4] The MPEG gives a guideline making a persistent association tool that combine digital item with its metadata.[5] Among the persistent technologies, the digital watermarking is widely used with good visual qualities, robustness, etc.[6] To satisfy the scalable representation of multimedia, the persistent association technique should be changed to cope with coding scalable form. In this paper, we present a scalable representation of persistent association method to image data.

This paper is organized as follows: In section 2, notion of persistent association will be explained. Following, in section 3, we will explain our proposed method, scalable representation of persistent association method. Simulation results will be followed in section 4, and then we will make a conclusion in section 5.

2. Persistent Association

In the context of MPEG-21 resources and other scenarios, it is often necessary to create and recover associations between content items and related information (e.g. MPEG-7 metadata, unique identifiers and copy control information). A multitude of solutions encompasses the use of mark-up tags, databases, file headers, etc. Such associations can be fragile, in the sense that if tags are stripped away (e.g. as happens when content is sent over legacy interfaces) then the association is lost. The field of "persistent association" is concerned with techniques by which non-fragile associations can be re-established. Presently, the main techniques of the field are watermarking and fingerprinting. The main application areas are where analog signals (such as audiovisual content) are contained within a digital environment.[5] In Fig.1, we draw a generic PAT (Persistent Association Technology) reference model.

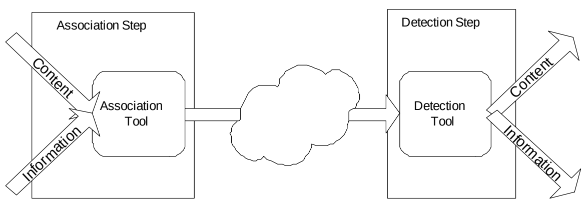

Fig. 1 Generic PAT Reference Model [5]

In MPEG-21 standard documents, they give 4-PAT models: headers, digital signatures, fingerprinting, and watermarking. Watermarking does not need database, and it is more robust to impairment than others. However, watermarking can be adopted to non-text-based resources, such as audio clips, video streams and pictures only.[5]

The most famous watermarking method was proposed by Cox *et al*.[6] This method does not have effect on visual perceptibility and robust to several kinds of tampering. It represents watermark message by pseudo-random real number normal distribution sequence. In that paper, they gave three watermarking insertion ways like this

$$v_i' = v_i + \alpha x_i \quad (1)$$

$$v_i' = v_i\,(1 + \alpha\, x_i) \quad (2)$$

$$v_i' = v_i\,(e^{\alpha\, xi}) \quad (3)$$

where α is a scaling parameter, v_i' is a watermarked signal, x_i is a original signal.

When we want to decode, we can similarity measure as a decision of watermark detection. The similarity is given

$$sim(X, X^*) = \frac{X^* \cdot X}{\sqrt{X^* \cdot X^*}} \quad (4)$$

where X is original watermark and X^* is detected watermark.

3. Scalable Persistent Association Method

We propose a new watermarking method as a persistent association technology considering scalable coding algorithm. Comparing with conventional digital watermarking methods, our method is able to scale the size of watermark payload. Conventional watermark has fixed-size watermark payload. For the purposes of storage or transmission of multimedia data, compression is essential. The lossy compression is widely used in common compression algorithm, for example JPEG, MPEG. It uses the human visual property that we can not recognize the change of some part in image where rapidly changed region. These regions are removed during the compression is applied.

Most of watermarking algorithms use the human visual property also. They use the high frequency part as a region of watermark embedding. When the compression is applied to watermarked image, the watermark must be altered by lossy compression, quantization. Therefore, it is regarded as a kind of attacks to watermark. There are a lot of research results on robust watermarking algorithm against the compression.

Our method has somewhat different concept of watermarking and compression. Both of them are considered simultaneously in watermarking embedding process. Moreover, we choose coding architecture as scalable form with considering the adaptation ability. The bit-plane architectures are used in several scalable coding. Our watermarking embedding process is applied in the procedure of compressing. In Fig.2, we draw the procedure of our system. The 8x8 DCT, lossy quantization, and bitplane coding are adopted in our system.

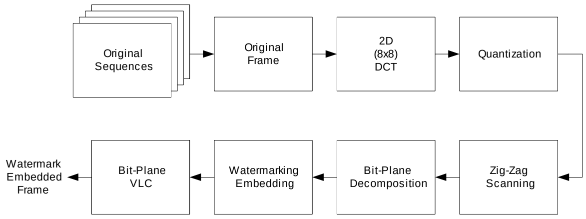

Fig. 2 Structure of Our System

3.1. Scalable Persistent Association Method

The bit-plane architecture is widely used for several scalable coding methods such as MPEG-4 FGS (Fine Granular Scalability) codec[3] and JPEG codec for progressive transmission.[7] By organizing bitstream from MSB to LSB, we can view image progressively. The FGS video codec makes layers by bitplane coding. These fine granular layers make adaptation to the variation of network condition rapidly and efficiently. Our watermarking embedding process is taken on DCT bitplane. Watermarked image is coded by DCT-bitplane coding method that was used in FGS codec.[5]

3.2. Watermark Sequence Generation

We use a binary number sequence as a persistent association data because our system has the DCT bitplane architecture. In Cox's paper[6], they generate a real number sequence that has 1000 numbers with normal distribution. They embed the watermark sequence to DCT coefficient. Our method can not adopt Cox's method directly, because our embedding domain is binary decomposed 8x8 DCT coefficients. For this reason, we generate a binary sequence. For convenience, we generate sequence randomly. Our watermark system is designed that has at least 1000-bit long sequence.

3.3. Watermark Inserting Procedure

3.3.1. Length of Watermark

The object of the conventional watermarking system is to be robust against tampering. Therefore, fixed length watermark should be robust to such modification. But our watermarking system has different philosophy of watermark compare to conventional method. Our method can adjust embedded watermark amount according to the strength of compression. Adjusting the quantization parameter, we can control compression ratio. When the scalable coding method is applied, the quantization parameter is pre-determined. It controls coding gain by selecting layer. In other words, when we want to reduce the coding rate, we can drop least significant part. In both cases, our method can decide amount of watermarking length by adjusting quantization parameter. Our watermark information may not altered by compression. Moreover, we can embed information as an importance order in image. More important data can be embedded in higher bitplane. Because lower bitplane may be dropped first when encoder reduces the coding rate. We present the result of capacity of watermark as the quantization parameter is varied.

3.3.2. Selecting DCT Coefficient

The problem of selecting coefficient is important when we want to embed watermark to frequency domain, such as DCT, DFT, and DWT. The two important requirements for watermarking are invisible and robustness against tampering.

If a watermark is embedded in low frequency region, the watermark is robust against the attack of compression that removes high frequency region. However, it violates the invisible condition because the human visual system is sensitive to low frequency. The high frequency region is easy to fragile, so we can not use that frequency region to embed watermark. Like this reason, many watermark algorithms uses the middle frequency coefficient to embed watermark.[8]

In this paper, we adopt the selecting coefficient method for 8x8 DCT domain as in Fig. 3.[8]

1	2	6	7	15	16	28	29
3	5	8	14	17	27	30	43
4	9	13	18	26	31	42	44
10	12	19	25	32	41	45	54
11	20	24	33	40	46	53	55
21	23	34	39	47	52	56	61
22	35	38	48	51	57	60	62
36	37	49	50	58	59	63	64

Fig. 3 Selected DCT Coefficients

3.3.3. Watermark Embedding in DCT Bit-plane

Select DCT coefficient No.4 to No.10 as Fig.3, then we embedding the watermark on its bitplanes. Bitplanes consist of 8-bitplanes representing the pixel values and 1-bitplane for sign of pixels. Embedding process is performed along DCT zigzag scan order from No.4 to No. 10, and from MSB to LSB. It is explained in Fig.4. Each bit is checked by this order. It is modified by Eq. (5) with the watermark sequence as described before. The MSB of each pixel will not be altered, in order to minimize the visual quality degradation.

$$V_i = X_i \oplus w_j \qquad (5)$$

where X is quantized coefficient of DCT, expressed in bit-plane, V is watermarked DCT coefficient, also in bit-plane. w is binary random sequence watermark. i represents bit-plane level that varies from 1 to $MSB\text{-}1$, j is watermark index.

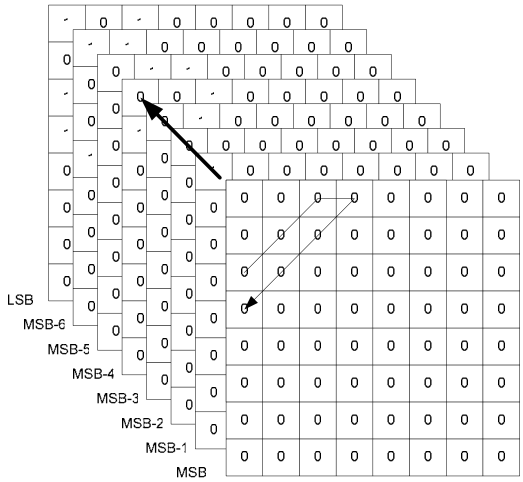

Fig. 4 Information Embedding Order in DCT Bit-plane

3. Experimental Results

In order to evaluate our proposed inserting watermark method, we have some experimental results. We perform simplified test by considering only inter frame of video sequence. We use Lena image (256x256 pixels) as an extracted frame from sequences.

In first experiment, we change quantization parameter and observe image quality of watermarked image in decoder side. In Fig. 4 We vary quantization parameter

(a) Original (a) Q=0.5

(b) Q=1.0 (c) Q=1.5

Fig. 4 Watermark Embedded Images

from 0.1 to 2.0. In Fig. 4, we show image of watermarked at Q=0.5, 1.0, and 1.5. Image quality is 34.61, 32.05, and 30.55 dB respectively. In Fig.5, we show the result of image quality in PSNR when quantization parameter is varied. Degradation due to watermark is about 0.2 dB in same quantization without watermark. We can find that the degradation on image quality due to watermark insertion is acceptable.

The second experiment is that we observe the variation of watermark length when quantization parameter is varied. In Fig. 6, we draw the result. As quantization parameter increases, the embedding bit capacity is reduced. In most bit rates, number of watermark bits is over 1000. In this experiment, we find that the watermarking length is dependent on quantization parameter.

4. Conclusion

In this paper, we propose a scalable persistent association method using modified watermarking method in bit-plane architecture. Our watermark is generated in binary in order to apply on bit-plane. The bit-plane architecture has a merit of making scalable bitstream. In our experiments, we get scalable property of watermark length with quantization parameter variation. Our proposed architecture can show an example of scalable persistent association technology.

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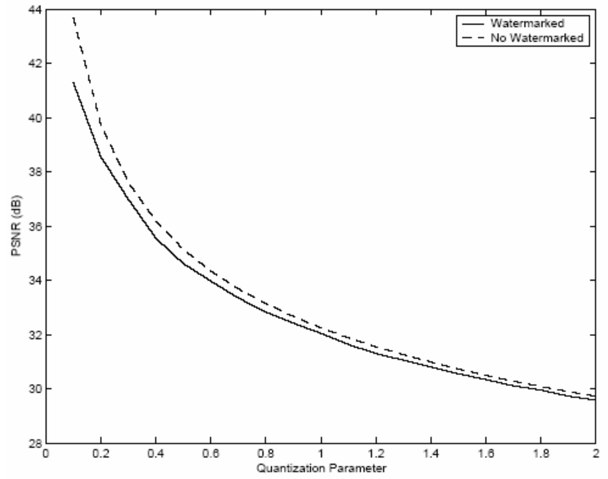

Fig. 5 Quality of Watermarked Image

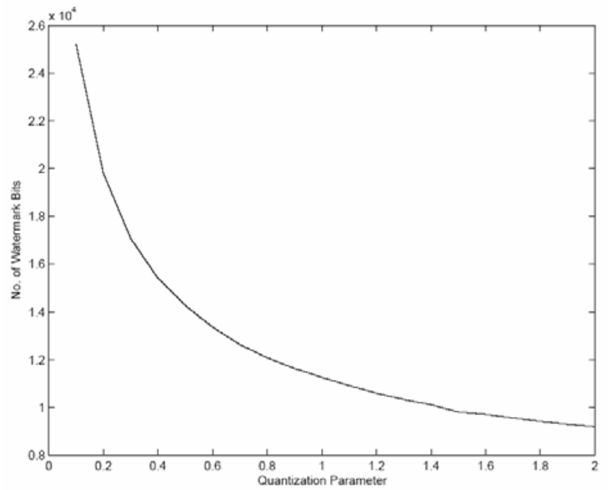

Fig. 6 Number of Watermark Bits