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Video Watermarking in Motion vectors Based on visual masking

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***Abstract*— Digital watermarking is an effective technology for digital products copyright protection and data security maintenance as well as an important branch of information hiding technology. By virtue of this technology, copyright information is embedded in the video data to provide ownership verification. Several watermarking schemes have been proposed in recent years, but most of them deal with still images, only some being extended over to the temporal domain for video watermarking. But again most of those approaches are applied to uncompressed video processing domain. In this paper, a new compressed video watermarking procedure is explained. We propose a novel hybrid digital video watermarking scheme embedding watermark in P-frames. Search its best match block by the watermark while embedding and the embedding strength of every block in the video sequence is calculated with the set of non-linear formulas that have been proposed, according to the entropy of motion information of every macro-block and the human visual masking system. The experimental results demonstrate that this method impacts the video quality slightly but bit rate is controlled to a large extent.**

Index Terms*— Introduction, MPEG-4 Video Compression, Related work, Visual masking, Video Watermarking in P-Frames, Experimental results & performance evaluation, conclusion.

I. INTRODUCTION

Digital video watermarking refers to techniques for embedding additional data into host video by utilizing the redundancy of the video due to the limitations of the human visual system (HVS). The information hidden in the host video can be used as an invisible label for copyright protection, or as auxiliary information for video segmentation, retrieval, annotation, indexing, error concealment, etc. The main requirements on invisible digital watermark normally include imperceptibility, robustness, and capacity. Encryption techniques are commonly used to control access of the multimedia Contents. However, they do not provide any protection after the digital contents have been decrypted. The copyright should be such that it would be both easy to detect, yet hard to remove, and with this kind of information being embedded in the object, the multimedia source would also be well protected. It would then be possible to prove copyright ownership if something is used illegally. This would make the multimedia providers feel more comfortable in supplying Copyrighted materials, and also benefit users by being able to share more of the information. Digital watermarking technology has emerged as an effective means to hide copyright information in the original content to protect the authenticity of the intellectual property. There are three principal processes involved in robust watermarking: watermark embedding, attack, and watermark detection. In watermark embedding, a watermark is constructed and then embedded into an original signal to produce the watermarked signal. For security, watermark embedding usually requires knowledge of a secret embedding key. In addition, some watermarks also allow auxiliary information to be encoded in the watermark, known as the message or payload. Once the watermark has been embedded, the watermarked signal may be subjected to attack. There are many different types of attacks, including those which attempt to remove the watermark, make the watermark more difficult to detect, or subvert the security of the watermark. In watermark detection, a test signal is provided to the watermark detector. The test signal may be watermarked and possibly attacked, or may not have been watermarked at all. The watermark detector examines its input signal and reports whether the watermark is present or not, and if applicable, extracts the payload. If the watermark detector does not require access to the original (unwatermarked) signal, the watermarking technique is known as a blind technique.

The video watermarking methods mainly have two kinds: Spatial domain methods and transformation domain method

Compared with the spatial domain, the watermarking methods on the transform domain, especially on the DCT (discrete cosine transformation) domain, have the following advantages: First of all, the characteristic of humanity vision System can be used effectively in the transformation domain; secondly, the watermarking methods can be compatible with the video compression standards (for example MPEG and so on); Lastly, the computation complexity of the watermarking algorithm in the DCT domain is often low. Typically the watermarking include transaction tracking, copy control, authentication, legacy system enhancement and database linking etc. Growing popularity of video based applications such as Internet multimedia, wireless video, personal video recorders, video-on-demand, set-top box, videophone and videoconferencing have a demand for much higher Compression to meet bandwidth criteria and best video quality as possible. Different video Encoder Decoders (Codec's) such as MPEG-1, MPEG-2, MPEG-4, ITU-T H.261, and H.263 have evolved to meet the current requirements of video application based products. Among various available Standards H.264 / Advanced Video Codec (AVC) is becoming an important alternative regarding reduced band width, better image quality in terms of peak-signal-to-noise-ratio (PSNR) and network friendliness, but it requires higher computational complexity.

Current video watermarking algorithms can be divided into three classes: watermarking in the raw, video, Watermarking in the compressed video streams and Watermarking in the encoding process [4-6]. Watermarking in the raw video can use many algorithms for still images, but it need 'large amounts of calculations and may lose some Watermark messages after video compression. Watermarking in the compressed video streams has small amounts of calculations so that the watermark can be real-time embedded. The disadvantage of this approach is that the amount of embedded message can't be too large due to the compression bit rate limit. The watermarking algorithms in the encoding process are robust against MPEG compression and will not increase bit rate of the video streams. It may farther be categorized into two kinds: watermark in I frame and watermark in P or B frame. During the encoding process, MPEG-2 deals with I frames similarly to JPEG dealing with still images, so the Watermark in I frame is often embedded in DCT coefficients.

But the' total number of I frames of a video is smaller, so the total message embedded in I frames is comparatively small. The video sequences contain a significant amount of P and B Frames. There are two positions in P or B frames that can be used to embed watermark. One is the prediction error; the other is the motion information. When embedding watermark in the prediction errors, the loss of prediction error data increases with the increase of compression ratio. Comparatively, embedding the watermark in the motion information is more robust.

This paper is organized into seven sections. The next section gives brief introduction of MPEG-4 Compressed. Section III describes the details of related works regarding compressed video watermarking schemes. Section IV describes about the visual masking and Section V describes the Video watermarking in P-Frames (vwm-p frames). The experimental results and performance evaluation are shown in section VI. Section VII presents a conclusion.

II. MPEG-4 VIDEO COMPRESSION

As the most advanced video compression standard at present, MPEG-4 is widely used. To take advantage of temporal redundancy, MPEG-4 standard includes three kinds of frames:

1) Intra picture frames (I-frames);

2) forward-predicted frames (P-frames);

3) Bidirectional-predicted frames (B-frames).

I-frames are coded without reference to other frames. P-frame applies motion prediction by referencing an I-frame or P-frame in front of it, motion vector points to the block in the referenced frame. B-frame applies motion prediction, referencing a frame in front of it and (or) a frame behind it. Each of the two referenced frames may be I-frame or P-frame. Macro block (MB) in video stream is represented as a 16x16 sample area. Each MB contains six 8x8 blocks, four for luminance and two for chrominance. A block of I-frame contains simply values of luminance or chrominance of its own. A block of P-frame or B-frame contains the difference between the values of itself and the referenced block. This process is called motion compensation. Each frame is divided into MBs. Coding process of each block includes DCT, quantization, run-level coding and entropy coding in order. The resulting video stream consists of entropy codes, motion vectors and control information about the structure of video and characteristics of coding. The structure of frame sequence, coding process and decoding process of MPEG-4 video can be described as following figures:

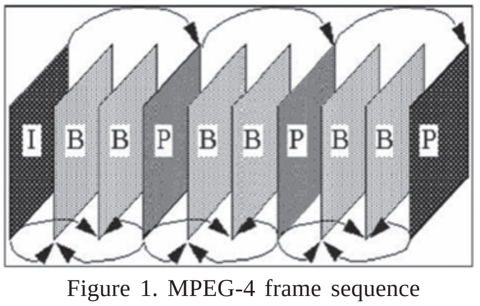

Figure 1. MPEG-4 frame sequence

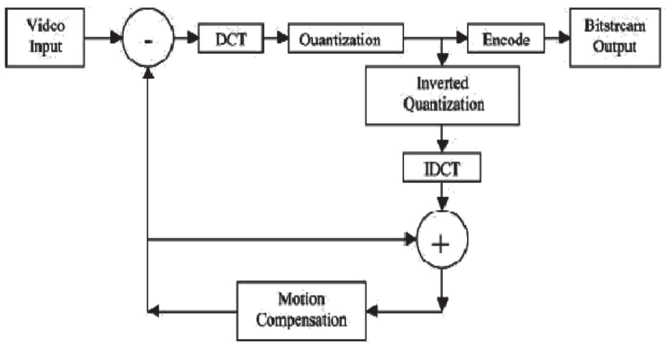

Figure 2. MPEG-4 encoding process

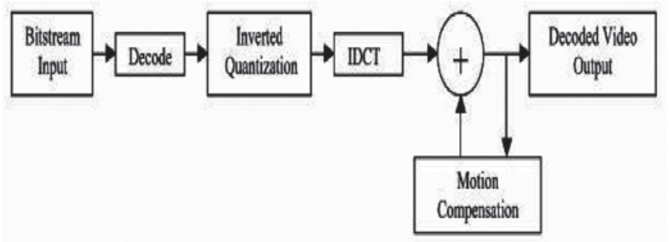

Figure 3. MPEG-4 decoding process

III. RELATED WORKS

Watermarking has received much attention due to the popularity of data communication through the internet. Among various media data, digital video is the one that carries the most amount of data. Hence, it is not easy and realistic to embed watermarks directly in a raw video in real time. Usually, a raw video has to be compressed first and then watermarked before it is transmitted through the network. However, the major concern is how to design a feasible compressed video watermarking scheme such that the hidden watermarks could be detected in real time.

In the literature, only a few compressed video watermarking schemes [7, 8] were proposed. In [7], the header/side information and motion vectors of MPEG2 bit stream are not changed during watermarking. They arranged a watermark sequence to be 2D and have the same size with video frame. Then the watermark signal is 8x8 DCT transformed and added into DCT coefficients of video streams. In other words their compressed domain video watermarking is infact performed in DCT domain. Therefore some processing operations such as inverse entropy coding and inverse quantization are required. Besides no attacks were tested in their experiments. In [8] Langelaar et al proposed a video watermarking scheme performed in compressed domain based on VLC codewords. At first, they divided run-level pairs into many groups with the same VLC codeword length under the constraint that the level difference in each group should be exactly one. During watermark embedding, a run-level pair was either unchanged or replaced depending on the incoming watermark value. Their method was basically a least significant bit (LSB) type. Recently, Langelaar et al. proposed a differential energy watermarking (DEW) algorithm performed in the DCT domain. DEW means that watermark bits are inserted by removing the high-frequency DCT coefficients. The authors claimed that it is not possible to remove the DEW watermark without causing perceptual degradation.

The pioneering work was reported by Hartung et al. [9].They proposed embedding a watermark into DCT coefficients in MPEG-2 compressed data. Their method was based on spread spectrum, and a modulated pseudo random pattern was added on the DCT coefficients. They also raised the drift problem in an inter-frame prediction loop between a video encoder and a decoder, and proposed a drift compensation algorithm. However, the compensation which is almost the same as video transcoding. Alattar, et al. [10] proposed a similar watermarking method, in which an embedded watermark signal has a kind of geometrical structure in order to provide resilience to geometrical attacks. The embedding process is almost the same as [9] with some adjustment to MPEG-4 encoding, but the detection process requires MPEG-4 decoding to analyze pixel data. Another approach is proposed by Ghosh, et al. [11]. Their method embeds a watermark during video compression. The watermark signal is constructed from a pixel pattern of a reference frame designated by a motion vector, and it is modulated by the messages to be embedded. It can be detected from the compressed data directly; however the watermark cannot be embedded into compressed video data. Sakazawa et al. [12] proposed a method that can detect the watermark from MPEG-2 encoded data directly. It employs alteration of DCT coefficients at spatiotemporally distributed locations, and the watermark can be detected by observing DCT coefficients in the MPEG bit stream. But it has to embed the watermark on the uncompressed domain. Thus, the conventional method does not satisfy the requirements for low complexity native watermarking.

IV. VISUAL MASKING

A. The temporal visual masking of video JNDt(x, y)

The great difference between the video watermarking and the still image watermarking is that the video exist a great mount of the redundancy on temporal axis. We should apply the inter-frame and temporal special motion redundancy of video sequences to calculate the temporal visual masking of videos. In [13] Zhi Li used the block-matching techniques to acquire the motion vector MV (u,v) in the corresponding macro-block M(x, y). Through the motion vector MV (u,v), we could obtain the motion velocity, direction of moving and the degree of the deformation for each macro-block. The following section we describe the criterion for calculating the temporal visual masking based on these moving characteristics in the video: a) the visual masking of motion velocity; b) the visual masking of deformation;

Visual masking of velocity. When embedding watermarking signals into moving objects in video sequence we consider the factor of velocity. The length of the motion vector of every macro-block M (u, v) indicates velocity of motion vector. When the value of velocity is large, macro-block M(x, y) moves fast, Watermarking signals embedded in this block will be more imperceptible.

$$|\ MV(u,v)\ | = \sqrt{(MV_c(u,v))^2 + (MV_c(u,v))^2}$$

Visual masking of deformation. At the same time we consider the influence of the deformation in the corresponding block between every two frames. If there has high degree of macro-block deformation, the HVS decrease its sensitivity to the deformation, it means embedded watermark in the macro-block will be more difficult to perceive. We calculated the degree of deformation Def (x, y) of macro-block M (x, y) according to the following formula.

$$D(x,y) = \sum_{i,j=0}^{15} \left| Y_c\ (x+i,y+j)\text{-}Y_p\ (x+k+i,\ y+1+j) \right|\ \text{-}\ 15\leq k,\ 1\leq 15$$

isual masking of moving direction. Finally, we consider the inter-frame motion characteristics randomness by statistic the information of moving direction for every two frames. We used temporal angle è (u, v) of motion vector in corresponding block as the degree of randomness in two frames. If the objects move randomly between frames, the value of temporal angle is large. Objects with a large temporal angle value are induced the embedded watermarking signals are more difficult to perceive than that with small temporal angle value. We use the following formula to calculate the temporal moving direction through using motion vector in corresponding block of every two frames

$$\theta(u,v) = across\ \frac{MV_c(u,v)\ \text{-}\ MV_p(u,v)}{|\ MV_c(u,v)\ | * |\ MV_p(u,v)\ |}$$

Then, we use the method below to acquire the JND t (u, v) with the formula

$$JND_t\ (u,v) = D\ (x,y) * \theta(u,v) * |\ MV(u,v)\ |$$

B. The motion entropy

Entropy of a source could indicate the amount of the information come from the source. As the entropy increases, we can say the source increase its amount of information to the perceiver. We extend the concept of the entropy to the video sequence to get the motion entropy of the video sequence. The motion entropy increase and decrease is respected to the increase and decrease in the motion complexity of the video. We calculate the motion entropy of the |MV (u, v) |, θ (u, v) of every macro-block to indicate whether the area where much motion occurs in the video sequence or not, by using the below formula. To get the accurate and really motion information we did not quantify the motion entropy of the |MV (u, v) |, θ (u, v) in every macro-block. Where, Hp (|MV (u, v)|), Hp (θ (u, v)) is the motion entropy of the |MV (u, v)|, θ (u, v) in the pth frame. After getting Hp(|MV(u, v)|), Hp(θ (u, v)) of every p frame in the video, we project all of Hp(|MV(u, v)|) and Hp(θ (u, v)) to the histogram to get the threshold Tv, Tθ. We could adjust whether the motion entropy of the video sequence is larger than the thresholds Tv, Tθ or not. So we could know the macro block is motion area or static area.

C. Non-linear formula calculate visual masking JND(x,y)

We conclude the visual masking of the video is consisted of the spatial and temporal visual masking. We get the accurate motion information according to the motion entropy of every macro-block. So we apply the non-linear formula and the motion entropy to calculate the visual masking of video sequence that depends on the temporal visual masking of the moving information as well as the spatial visual masking of still image properties. So we get the two kinds of areas by the following describe.

Motion areas: block in which the motion entropy of length of motion vector Hp(|MV(u, v)|) is not less than threshold Tv or the motion entropy of moving direction Hp(θ (u, v)) is not less than threshold Tθ. Objects in these areas are moving fast or random. To the moving fast or random areas we use the following formula to calculate the visual masking of video

JND(x,y)=JNDs(x,y)+JNDt(x,y)á*min{JNDs(x,y),JNDt(x,y)} $0<\alpha\leq 1$

Static areas: blocks in which the motion entropy of length of motion vector Hp(|MV(u, v)|) is less than threshold Tv and the motion entropy of moving direction Hp(θ (u, v)) is less than threshold Tθ. Objects in these areas are static. To the static areas we use the below formula to calculate the visual masking of video

$$JND\ (x,\ y) = \beta * JNDs\ (x,\ y),\ 0<\beta\leq 1$$

We use visual masking JND (x, y) of every block in video as the maximum embedding strength, which could guarantee the excellence imperceptibility of this scheme.

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V. VIDEO WATERMARKING IN P-FRAMES (VWM-P FRAMES)

In the MPEG compression algorithms, a good search algorithm will lead to good video quality and less time spent in motion estimation. FS (full search algorithm) is one of the commonest algorithms. FS can gain the best video quality, but it spends the most time. So many fast search algorithms are researched to take the place of FS such as 3SS (three step search), N3SS (new three step search), DS (diamond search), HS (hexagon search), etc. But new problem appeared that it is easy for the macro block searched to get into the local best, which leads that the bit rate is increased and the video quality may be decreased. From many researches, we know that as long as we use fast search algorithm, it is difficulty to avoid the occurrence of local best. This local character arouses our interest.

A. Embedding scheme

Watermarking information can be easily embedded into MPEG video stream by the following steps.

1. Confirm which search algorithm is used in MPEG-4
2. We will select only p-frames and restrict the search region in search algorithm to embed the watermarking information
3. Execute the search algorithm to find the motion vector of the best matching block.
4. Different information can be embedded into motion vector as mentioned above and by making use of motion entropy and visual masking JND (x, y) of every block in the video as the maximum embedding strength, will guarantee the excellent imperceptibility of this scheme.

B. Retrieving scheme

Watermarking information can be easily extracted from MPEG video stream by the following steps.

1. We will take the mpeg-4 watermarked video.
2. We will take only p-frames and restrict the search region in search algorithm to extract the watermarking information.
3. Execute the search algorithm to find the motion vector of the best matching block.
4. by making use of motion entropy and visual masking of every block in the video the watermark will be extracted.

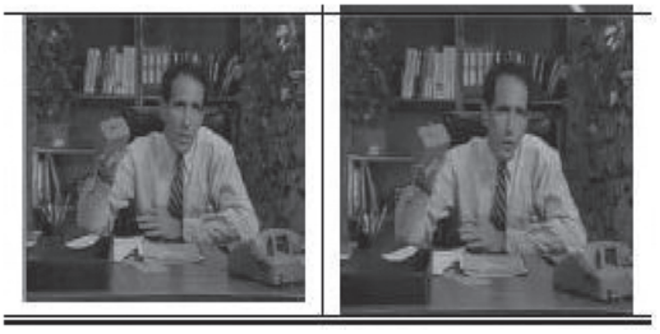
VI. EXPERIMENTAL RESULTS AND PERFORMANCE EVALUATION

As a measure of Imperceptibility, the peak signal to noise ratio is typically used. From the result, we can see that there is no much change in PSNR and bit rate impacted is complicated when algorithm [14] is used but bit rate is controlled to a large extent in our algorithm as we are embedding only in the motion vectors which are having high imperceptibility based on motion entropy of visual masking. We came to know that when there are many smooth regions in the picture, the bit rate is increased slightly .In such cases less watermarking information should be embedded to avoid increase in the bit rate.

Table 1.Results of salesman sequence

	Original video	Nvwm in motion vectors[14]	vwm-p frames
PSNR Y	35.82	35.80	35.81
PSNR U	39.54	39.53	39.52
PSNR V	40.23	40.19	40.20
Bit rate	91504	94816	93310

Original video Watermark embedded



VII. CONCLUSION

In this paper, a novel video watermarking scheme in motion vectors is proposed. The visual masking information of the motion vector is used to embed the watermarking information. This method impacts the video quality slightly but bit rate is controlled to a large extent as we are embedding in p-frames and that to in the motion vectors which are having high imperceptibility.

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It is a low power base station communicating in a licensed spectrum, offering improved indoor coverage with increased performance, improved voice and broadband services in low cost with the operators approval.