



Video Watermarking Techniques for Digital Right Management: A Review tour

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Abstract: With the growing and rapid use of internet services, issues like integrity, authenticity, copyright protection have become more important, since the duplication and unauthorized use of the digital content has become easier results in development of various watermarking techniques to maintain originality of data. Digital watermarking is a method where by copyright information can be imperceptibly embedded into digital media, to ensure security against signal manipulations and intentional or unintentional attacks. A large number of watermarking schemes have been proposed. Digital watermarking for video based applications such as Internet multimedia, video-on-demand, set-top box, videoconferencing has increased the demand for a secure distribution of videos with good quality. The digital watermarking for video is an effective method to protect the video copyright. This paper summarizes the model and properties application and various techniques implemented for video watermarking.

Keywords: video watermarking techniques, spatial domain, transform domain, compressed domain, digital right management.

I. INTRODUCTION

Digital watermarking is a technique of watermark embedding into multimedia data called cover media e.g. text, audio, image, video. The embedded information called watermark is ownership or a copyright messages. The techniques modify the original media to generate the watermarked media. There may be no or little perceptible differences between the original media and the watermarked media. Fig.1 shows the basic watermarking technique for generating watermarked data and extracting original data.

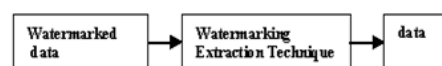
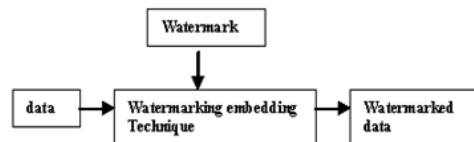


Fig. 1

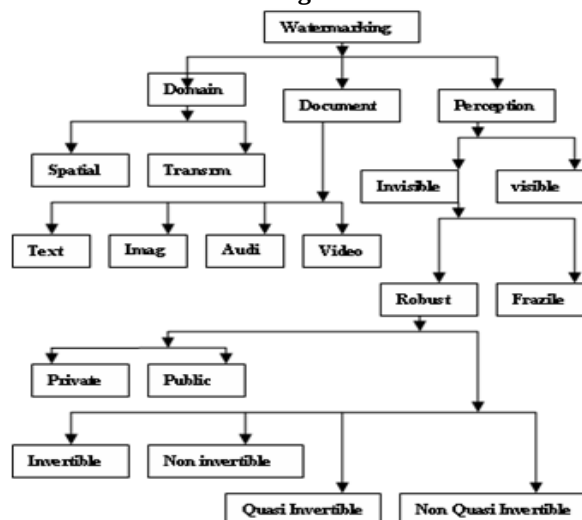


Fig. 2

After embedding watermark, the watermarked media are sent over Internet or some other transmission channels. The watermarked data is decoded to identify copyright owner.

The decoding process extract the watermark from the watermarked media (watermark extraction) or can detect the existence of watermark in it (watermark detection). Fig. 2 gives an overview of different types of watermarking methodologies depending on their working domains, cover media, perceptibility and application areas.

II. Video Watermarking

Digital video watermarking [1] is the process which is used for copyright protection of digital video. It is done by inserting a special watermark into the original video. There are two methods of embedding watermark in a video first is by converting video into still images frame and then apply watermarking technique[2] and second by considering the whole video as one dimensional signal acquired by line scanning and embed watermark into direct domain of video stream[3]. Video Watermarking can be visible or invisible. It can also be blind or non-blind based on detecting watermark. In blind video watermarking techniques [4],[5], we don't need the original video cover signal for detecting the inserted watermark signal, while in non-blind video watermarking techniques [6], the original video signal is required for watermark detection.

Requirements specific to video watermarking:

1. **Invisibility:** The digital watermark embedded into the video data should be invisible to the naked eyes.
2. **Robustness:** A robust video watermarking technique is one which is resilient to any malicious attacks may be intentional or unintentional for removal of watermark by signal processing techniques, dropping of frames etc
3. **Fidelity:** A watermarking should have high fidelity so that the resulting video object which has been embedded with the watermarks will maintain its originality.
4. **Constant Bit Rate:** Watermarking in the bit stream domain should not increase the bit rate, at least for constant bit rate applications where transmission channel bandwidth has to be obeyed and the video watermark has to resist to changes of frame- rate.
5. **Statistical Imperceptibility :**An invisible watermarking technique is not just one which watermarks are imperceptible to viewer, in addition it is also desirable that the watermarks should be imperceptible to any statistical analysis technique.
6. **Low Error Probability:** Basically this criterion implies the high level of detecting the watermark under the ideal situation .In other words, an ideal watermarking technique should possess a low probability of failing to detect the watermark, i.e. false-negative and a low probability of detecting a non-exist watermark i.e. false-positive.
7. **Attack proof:** Watermarked video sequences are highly susceptible to pirate attacks such as frame averaging, frame swapping, statistical analysis, digital-analog (DA/AD) conversion, and lossy compression (MPEG).

III. Survey on video watermarking techniques

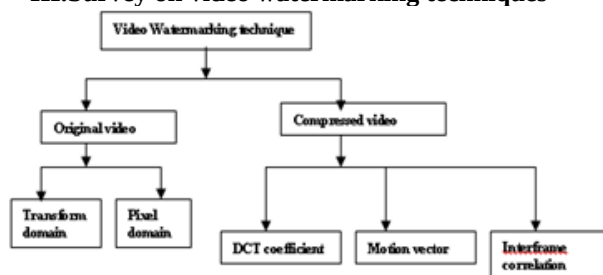


Fig. 3

Classification of the existing video Watermarking techniques is divided in three main categories as shown in fig3.

1. Watermarking in Pixel Domain
2. Watermarking in Frequency Domain
3. Compressed domain

A. Pixel Domain Technique

Pixel Domain Technique [7] is less complex with high payload also called spatial domain technique. In pixel domain watermarking techniques, watermark is embedded directly on the pixel value of the host video like Least Significant Bit is implemented by modifying the least significant bit of the image pixel data. The problem of all the spatial domain techniques is that, they change the host image during embedding phase. Also, their bit capacity is lowest and they provide lowest resistance to JPEG compression. This type of technique cannot stand low pass filtering and the common attacks .

A.1 Correlation-Based method

In correlation based watermarking technique, PN sequence(Pseudo-random number) is added to the luminance value of the pixel of host file(Image/ Video) in spatial domain .For watermark embedding, correlation properties of additive pseudo-random noise patterns as applied to a Video frame are used. A code $W(x, y)$ is added to the covert video frame $I(x, y)$. as given below[6]

$$I_w(x,y)= I(x, y) + K*W(x,y)$$

Where K denotes the gain factor and $I_w(x,y)$ is the resulting watermarked video frame. Increase in K increases the robustness of watermark at the expense of quality of the watermarked image. To recover the watermark, the video frame is embed with the same key and the correlation between the noise pattern and the watermarked image is calculated. If the correlation exceeds a certain threshold T , the watermark is detected and a single bit is set. This method is easily extended to a multiple-bit watermark by dividing the image into blocks and performing the above procedure independently on each block. The algorithm is modified by pre-filtering the video frame before applying the watermark, and then increasing the higher correlation .The algorithm can be improved in a numerous ways. Firstly, the notion of a threshold is used for determining a '1' or '0' can be resulting eliminated by using two separate pseudorandom noise patterns. One pattern is designated as a logical '1' and the other a '0'. The above procedure is then performed once for each pattern, and the pattern with the higher resulting correlation is used. This increases the probability of a correct detection, even if the image has been subjected to an attack.

A.2. Least Significant Bit Modification method

It is simple technique of watermarking [8][9]. It takes less time to embed watermark in the cover image. In this method Image is viewed in matrix format having array of values These value represent the intensities of the three colour describe a pixel that is red, green and blue .The watermark is embed into the least significant bits of the original image. In the LSB domain we change the least significant bit of the cover image. Video frame is described in terms of pixel and pixels of a grey level video frame are represented by an 8-bit data value, the video frame can be sliced up into an 8 bit planes. The least significant bit plane of video frame does not contain visually significant information so it can easily be replaced by a huge amount of watermark bits. . Video frame is described in terms of pixel and pixels of a grey level video frame are represented by an 8-bit data value, the video frame can be sliced up into an 8 bit planes. The least significant bit plane of video frame does not contain visually significant information so it can easily be replaced by a huge amount of watermark bits.

B. Transform Domain Technique

Transform domain techniques can take advantage of transform coefficients rather than pixel value used in LSB to support additional features. Finding a watermarking method in the transform domain leads to better result with common video coding algorithms such as Moving Pictures Experts group (MPEG)-2. The main problem of transform domain algorithms is that they require higher computational requirement. The Frequency domain base method are Discrete cosine Transform (DCT), Discrete Fourier Transform (DFT), Singular value decomposition (SVD), Principal Component Analysis (PCA) and Discrete wavelet transform (DWT)

B.1 Discrete Cosine Transform

Discrete Cosine Transform [9] [10][11] is a very popular transform domain watermarking technique. DCT is faster, highly used in image watermarking and gives accurate result Using The Discrete cosine [12]transform image get decompose into different frequency bands, as low (FL), medium (FM) and high (FH). It allows selecting the band to embed data or watermark into the image. But we are interested in middle frequency band considered best region for modification, it cannot affect the image quality avoids the most visual important parts of the image which is off low frequency. The second fact is that high frequency components of the image are usually removed through compression and noise attacks .This is important method for video processing. DCT gives accurate result in video watermarking also and show the resistance against various attacks .DCT also improve the Peak signal to noise ratio. Also DCT is more robust can survive attacks like compression, noising, sharpening and filtering.

B.2 Discrete Fourier Transform

In this technique, first of all, video is divided in to frames and then DFT of each frame is computed to get the DFT coefficients. Than DFT coefficients of each frames are modified as per the watermark bit. Once the watermark is embedded in frames then inverse discrete Transform is computed to get back the watermarked frames which then converted in to a video to obtain the watermarked video. This method shows good robustness against some image processing operation like filtering, compression, geometric transformation, rotation and cropping. [13] This is a multi bit watermarking technique for video sequences. the Discrete Fourier Transformation (DFT) is considered in the field of watermarking because it controls the frequency of

the host signal. The DFT method select the good area where watermark information is embed and give more perceptibility and robustness

B.3 Discrete Wavelet Transform

Discrete wavelet transform (DWT)[9] [14] is a tool for transform domain watermarking technique that continuously decomposing an image. The DWT splits the signal into high and low frequency parts. The high frequency part contains information about the edge components, while the low frequency part is split again into high and low frequency parts. As the human eyes are less sensitive to the changes in the edges the high frequency components are used for watermarking. There is various level of decomposition, after the first level of decomposition, there are 4 sub-bands: LL1, LH1, HL1, and HH1. This breaking process can be repeated to have multi-level wavelet components like 2-Level, 3-Level etc. For each successive level of decomposition, the LL sub band of the previous level is used as the input. To perform second level decomposition, the DWT is applied to LL1 band which decomposes the LL1 band into the four sub bands LL2, LH2, HL2, and HH2. To perform third level decomposition, the DWT is applied to LL2 band which decompose this band into the four sub-bands: LL3, LH3, HL3, HH3. if we increase the level of decomposition for embedding the watermark then proposed video watermarking scheme made much robust for video watermarking. For watermark detection, the correlation between the watermark signal and the watermarked video is compared with a threshold value obtained from embedded watermark signal. The experimental results demonstrate that the watermarking method has strong robustness against some common attacks such as cropping, Gaussian noise adding, Salt & pepper noise adding, frame dropping and frame adding Index.

B.4 Singular value decomposition (SVD)

Singular Value Decomposition (SVD) [15] is mathematical technique for diagonal matrices in that the transformed domain consists of basis states that are optimal. The singular value decomposition (SVD) is a method of representing an image in a matrix for with many applications in image processing. The singular value decomposition of a complex matrix X is given below

$$X=U \Sigma V^*$$

Where U is an $m \times m$ real or complex unitary matrix, Σ is an $m \times n$ rectangular diagonal matrix with nonnegative real numbers on the diagonal, and V^* is an $n \times n$ real or complex unitary matrix. The diagonal entries of Σ are called the singular values of A and are assumed to be arranged in decreasing order the columns of the U matrix are called the left singular vectors while the columns of the V matrix are called the right singular vectors of A . Singular value of the matrix shows the luminance of an video frame layer while the corresponding pair of singular vectors specifies the geometry of the video frame layer. In the SVD-based watermarking, a video frame is treated as a matrix, which further broke by SVD base method into the three matrices such as U , Σ and V . the small changes in the elements of matrix Σ does not affect visual perception of the quality of the cover video frame, SVD-based watermarking algorithms add the watermark information to the singular values of the diagonal matrix Σ in such a way to meet the imperceptibility and robustness requirements of effective digital image watermarking algorithms. In SVD based watermarking, proposed two effective, robust and imperceptible video watermarking algorithms. In the first algorithm, watermark bit information are embedded in the SVD-transformed video in a diagonal wise fashion, and in the second algorithm bits are embedded in a blocks-wise fashion. The concert of the two proposed algorithms evaluated on the verge of imperceptibility, robustness and data payload. Both algorithms showed similar but high level of imperceptibility, however their performance varied with respect to robustness and payload. The diagonal-wise based algorithm achieved better robustness results, while the block-wise algorithm gave higher data payload rate. Each algorithm embeds the watermark in the transform-domain YCbCr space thus spreading the watermark in each frame of the video. The first algorithm suggests hiding watermark information in a diagonal-wise manner in one of three SVD matrices; U , Σ and V . On the other hand, the second algorithm hides the watermark information in a block-wise manner in either the U or V matrices [16].

IV. Compressed video watermarking

The MPEG coding standards are usually considered in the video watermarking [17][18]. There are three kinds of video in MPEG coding standards: I-frame, P- frame and b-frame. I frame encoding is similar to JPEG, using intra-frame neighbouring pixels of space to compress redundant information; P Frame need use the previous frame when it is encoding and current frame can be used as a reference frame for prediction. B frame requires the previous frame and follows up frame for prediction. The watermarking technique in compressed video data, embed the watermark signal into bit sequence compressed by standard coding, such as MPEG-2 and MPEG-4, etc. Generally this technique has lower computational cost, compared with other methods. A robust and novel video watermarking of MPEG stream in compressed domain using perceptual embedding technique is proposed in [19]. Noorkami [20] proposed Digital video watermarking in P frame with controlled Video bit Rate increase. Hartung and Girod [3] proposed a scheme for additive spread-spectrum watermarking of video. In the algorithm proposed by Wang *et al.* (2004), the watermark signal is embedded only into the I-frames using JND concept.

Also in the algorithm proposed by Langelaar and Lagendik (2001), the watermark signal is embedded into the I-frames in the DCT domain. One of the major disadvantages of method based on MPEG coding structures is that they are highly susceptible to re-compression with different parameters, as well as conversion to formats other than MPEG. The motivation of combining the compression with watermarking introduce the techniques that use MPEG-2 or MPEG-4 coding structure as the basic components. These techniques apply for real-time applications to reduce the overall time of processing. The method of block based compression such as MPEG-2 remove the temporal redundancy by using forward and bi-directional prediction, and statistical methods to remove spatial redundancy. The main drawbacks of this method are re-compression with other parameter or converting the compression format to another format is not being able to be done [21] [22].

A. Embed watermark in the DCT coefficients

The algorithm, which embeds watermark in the DCT coefficients, is the most studied technique and can be learned from the results of the image DCT watermarking. This technology is also the most mature. Hartung [3] and others proposed the use of spread spectrum MPEG-2 compressed video watermarking method. Watermarking signal had been expanded, amplified and modulated by a pseudo-random sequence; the sequence had a $8 * 8$ DCT transformation; DCT coefficients was added to the MPEG-2 streams of $8 * 8$ DCT coefficients. Here two questions are considered: (1) The DCT coefficients of MPEG-2 are encoded using variable length codes. The encode length of coefficients before adding a watermark is different from the length after adding a watermark. On the condition that the request does not need to increase the length of the video stream, if increasing after adding a watermark in coding DCT coefficients, the coefficient will still retain the original coefficient; (2) In MPEG-2 encoding, inter-frame coded frame (P frames and B frames) are predicted from other frames and with a motion compensation vector the current frame can be rebuilt from other frames. P frames themselves may be used as the other frames prediction reference. The small changes of a frame will be spread in time and space. Therefore, in addition to the watermark signal, we need an offset compensation signal to compensate for the previous frame watermark signal.

B. Embed watermark in motion vector

Zhang [22] proposed a motion vector based on the phase angle of the video watermarking scheme. First, $[0, 2\pi)$ range was divided into two different point of view angle interval set, then the angle range of each other part was divided into two halves. By determining the embedded watermark information is "0" or "1", judging the motion vector range of the phase angle was the angle set and the left part or right part of the motion vector, and rotating the motion vector for a fixed small angle, the watermarking was embedded. After embedding the watermarking, the image cannot distinguish from subjective, peak signal to noise ratio (PSNR) values were in a narrow range, and the noise, filter, delete, rotate and other attacks could not destroy the watermarking. [23] proposed a novel watermarking scheme in the compressed domain for video copyright protection in which robust watermark is embedded in motion vector of bitstream on the relationship between one pixel accuracy and half pixel accuracy motion vector at the encoder and hence areal time watermarking process is executed without affecting visual quality

C. Watermarking using inter-frame correlation

Motoo Yamamoto, Akira Shiozaki, Motoi Iwata Akio Ogihara [24] presents a correlation-based watermarking method for video using the similarity of adjacent frames. In general, the adjacent frames of a video sequence is very similar. In the proposed scheme, we use an adjoining frame in detection process instead of an original image in the watermarking scheme of Cox et al. So the proposed method does not need an original video sequence in detection process. When a watermarked video sequence is attacked by overwriting copy or frame dropping, the pair of the frames that is not adjoining in an original video sequence is used in detection process. However, since a watermark is embedded in a part of each frame and embedding positions are different for each frame in the proposed method, we can detect the watermark even from an overwriting-copied video sequence and a frame-dropped video sequence. Experimental results show that the proposed method is robust against overwriting copy and frame dropping. Moreover, it is shown from experimental results that the method has robustness to low bit rate MPEG compression and Stir Mark attack.

VI. APPLICATIONS OF WATERMARKING

The major applications include copy control, broadcast monitoring, fingerprinting, video authentication, copyright protection and enhanced video coding.

1.Copy Control: It is possible for recording and playback devices to react to embedded signals, in which a recording device might inhibit recording of a signal if it detects a watermark that indicates recording is prohibited

2. Broadcast Monitoring: Many valuable products are distributed over the television network. As a result, a broadcast surveillance system has to be built in order to check all broadcasted channels. We can use watermarks for broadcast monitoring by putting a unique watermark in each video or sound clip prior to broadcast. Automated monitoring stations can then receive broadcasts and look for these watermarks, identifying when and where each clip appears.

3. Fingerprinting: Electronic distribution of content allows each copy distributed to be customized for each recipient. This allows a unique watermark to be embedded in the copy of each customer like customer name or ID. This allows the distribution companies to track down the source of illegal copy in case of a leakage.

4. Video Authentication: There are many applications in legal and medical imaging where it is important to preserve the content from tempering. Authentication can be carried out by storing the signature in header field but this header will still be prone to tampering. A preferable solution to this problem is to embed the signature directly into the image using watermarking. This ensures that the signal stays with the image and any change made to the image will also propagate to the watermark.

5. Copyright Protection: The underlying strategy consists in embedding a watermark, identifying the copyright owner, in digital multimedia data. The rightful owner can show the watermark in case of a dispute. Watermarking algorithms are consequently required to be non-invertible in order to provide copyright protection services especially in cases of multiple ownership issues.

VII. CONCLUSION

In this paper the study of different video watermarking technique is performed. A great scope exists for more improvements. By studying these techniques we can conclude that LSB is simplest among all but cannot be considered as a good technique. DCT domain based technique is more robust than LSB and can sustain various types of attacks. Same as DWT domain based technique also proved to be better than LSB. But this technique has more computational requirements. The combination of DCT and DWT domain can be one of the future aspects to have more secured watermarking. Compressed domain watermarking technique has lower computational cost, compared with other methods with robustness. Various attacks have influence on the imperceptibility and robustness of watermarked digital images is discussed. Various performance evaluating parameters stated guide us, to know about better robust techniques.

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