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Dr. A. Ravi Sankar | Mrs. M. Nesasudha

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Video Watermarking Using Wavelet Packets And Block Selection Technique

T.Jayamalar[1], V. Radha[2]
Department of Computer Science
Avinashilingam Deemed University
Coimbatore, India
[2]jayamalarskjin@gmail.com, [2]radharesearch@yahoo.com

Abstract— **Digital video watermarking has fascinated a great deal of research interest in the past few years in applications such as copyright protection, digital fingerprinting and owner identification. In this paper, a combined video watermarking scheme is proposed based on wavelet packets and block selection technique. The performance of the proposed video watermarking algorithm is measured in terms of normalized cross correlation. Further, this combined scheme provides good experimental results against temporal attacks such as frame averaging, frame dropping and compression.**

Keywords-wavelet packet; block selection; frame dropping;

I. Introduction

In recent years, the wide spread of multimedia content in the World Wide Web has made copyright protection and content authentication a necessity. In order to protect the ownership, digital watermarking techniques have been employed, where the copyright information is embedded into multimedia data. Watermarking [1] means embedding a piece of information into a multimedia content, such as a video, an audio, or an image. This embedded data can later be extracted from the multimedia for security purposes. Before the advent of digital watermarking, it was difficult to accomplish copyright protection and authentication, but now it is easy to achieve these goals. Every watermarking algorithm consists of an embedding algorithm and a detection algorithm. In multimedia applications, embedded watermarks should be invisible, robust, and have a high capacity [2].Invisibility refers to the degree of distortion introduced by the watermark and its affect on the viewers or listeners. Robustness describes whether the watermark can be reliably detected after media operations, format conversion, rotation, scaling or cropping. It means resistance to build, non-targeted modifications or common media operations. Capacity is the amount of data that can be represented by an embedded watermark. It also addresses the possibility of embedding multiple watermarks.

Digital watermarking techniques can be categorized as text based watermarking, image watermarking, video watermarking and audio watermarking. Among them image and video watermarking are two important areas that has attracted many researchers. According to Gwenael and Jean Luc [3], video watermarking is very different from image watermarking.

Digital video watermarking refers to techniques for embedding data in to the host video frames. Video watermarking approaches can be classified into two main categories based on how they hide watermark bits in the host video. The two categories are: Spatial domain watermarking and transform-domain watermarking [4, 5]. In spatial domain technique, the watermark is embedded in the source video by selecting pixel positions and replacing bit. The merits of spatial domain techniques are easy to perceive and it has low time complexity that does not exists in other domains. However, they are not robust against common digital signal processing operations such as video compression.

The above demerits can overcome by transform domain techniques. In transform domain watermarking systems, the insertion of watermark is done by transforming the image or video into the frequency domain using a discrete Fourier transform (DFT), full-image DCT, block-wise DCT, wavelet, Hadamard, Fourier-Mellin, DWT, Singular Value Decomposition (SVD) or other transforms. Transform-domain watermarking techniques are robust and imperceptible when compared to spatial domain techniques since they disperse the watermark in the spatial domain of video frame, making it very difficult to remove the embedded watermark [6, 7].

Video watermarking applications can be grouped as copy control, authentication, fingerprinting, ownership identification, and tamper resistance. Apart from these applications, video watermarking has also got value in applications like legacy system enhancement, database linking, video tagging, digital video broadcast monitoring [8] and Media Bridge.

Several algorithms have been proposed to solve the problem of video watermarking. Pröfrock et al. [9] proposed an enhanced version of algorithm for video watermarking. They used geometric warping method to embed watermarks, which did not require the original video during watermark extraction. The embedding procedure uses the geometric structure of the video because compression algorithms try to maintain the geometric structure, these watermarks can be very robust. In this paper, this method is enhanced by improving the embedding approach. The improvement is achieved by embedding the watermark into the video content without the necessity of selection of content depended embedding position. For this purpose, wavelet packet based segmentation is used. The rest of the paper is organized as follows: Section 2 presents the previous studies of video watermarking. Section 3 reviews the wavelet packet transform. Proposed Watermark embedding and watermark extraction technique is explained in section

4.Experimental results are explained in section 5 and finally conclusions are drawn in section 6.

II. PREVIOUS STUDIES

Solutions to video watermarking have been studied by various researchers who work with both raw uncompressed video data [10] and compressed video data [11]. Video watermarking techniques can be mainly grouped as spatial domain approaches and frequency domain approaches.

The spatial domain watermarking techniques embed the watermark by modifying the pixel values of the host image directly. Least Significant bit (LSB) technique is the most frequently used method [12]. Both [13] and [14] embedded the watermark in saturation on the HIS (Hue, Saturation, Intensity) color space. A variable block size based adaptive watermarking in spatial domain was proposed by [15]. In a later period, [16] proposed a probability block based watermarking method for color image with fixed block size. Recently, an algorithm based on chaotic maps was proposed by [17] to determine the pixel bit for embedding. The main advantages of pixel based methods are that they are conceptually simple and have very low computational complexities. However, they also exhibit some major limitations. The need for absolute spatial synchronization leads to high susceptibility to de-synchronization attacks; lack of consideration of the temporal axis results in vulnerability to video processing and multiple frame collusion; and watermark optimization is difficult using only spatial analysis techniques.

Frequency domain approaches use transformation techniques to embed the watermark into a video sequence. Discrete Cosine Transformation (DCT), Discrete Fourier Transformation (DFT) and Discrete Wavelet Transformation (DWT) are the three main methods of data transformation. A subsample based watermarking technique was proposed by [18], where the DCT coefficients of the subimages were utilized to store the watermark. The authors of [19], proposed an algorithm which was based on embedding the watermark image three times at three different frequency bands, namely, low, medium and high and the results proved that the watermark cannot be totally destroyed by either low pass, medium or high pass filter. In [20], two complementary watermarks were embedded into the host image in order to make it difficult for attackers to destroy both of them. The main benefit obtained from frequency domain techniques is that they can take advantage of properties of alternate domains to address the limitations of pixel-based methods. Besides, analysis of the host signal in a frequency domain is a prerequisite for applying more advanced masking properties of the HVS to enhance watermark robustness and imperceptibility. Generally, the main drawback of transform domain methods is the high computational requirement.

Another field where scientists focus is on embedding into a compressed domain which can be done during or after the encoding process [21, 22]. Alternatively, techniques to work on raw format have also received attention. In general, invisible watermark is embedded into irrelevant information of video data which can not be perceived by human eyes. This results in problems because compression algorithms, which also try to remove irrelevant information, might remove watermark accidentally. In [23], this problem was solved by embedding watermark in the relevant information of videos in an imperceptible manner. This approach is based on geometric warping of blocks. This approach through very efficient produced visible artifacts and video quality after extraction was low. Method to prevent these artifacts and improve the video quality was proposed by [9]. They used geometric warping method to embed watermarks, which did not require the original video during watermark extraction. This method improved [23] by removing artifacts and video quality, but was slow for applications where time was significant. This paper proposes a solution to solve this problem.

III. WAVELET PACKET TRANSFORM

The wavelet packet transform is a generalization of the wavelet transforms. Only the low pass filter is iterated in wavelet transform because it is assumed that lower frequencies contain more important than higher frequencies. This assumption is not true for many signals. DWPT differs from DWT by decomposing the high pass filtered output along with the low pass filtered output, thereby providing more sub bands for data hiding. In the wavelet packet transform domain procedure, the sub-band information is represented by approximation coefficients (LL1) and three sub-bands of detail coefficients (LH1 – HL1 – HH1). The approximation coefficient sub-band and each detail coefficients sub-band are further decomposed in to four sub-bands, which will generate the total of 16 sub bands.

LL_2LL_1	HL_2LL_1	LL_2HL_1	HL_2HL_1
LH_2LL_1	HH_2LL_1	LH_2HL_1	HH_2HL_1
LL_2LH_1	HL_2LH_1	LL_2HH_1	HL_2HH_1
LH_2LH_1	HH_2LH_1	LH_2HH_1	HH_2HH_1

Figure 1: Two level Discrete Wavelet packet transform

The DWPT for two levels is shown in Figure (1). It generates 16 sub-bands of coefficients comprising LL_2LL_1 through HH_2 HH_1. The advantages of further decomposition are that the time frequency plane is partitioned more precisely. The wavelet packet transform gives a huge amount of sub-bands of wavelet coefficients at different resolutions and thereby increases the robustness and imperceptibility of the watermarking scheme. This will also increase the watermarking security [24, 25]. Hence, in this paper a combined approach of block selection technique and wavelet packet based transform is proposed and implemented.

IV. PROPOSED METHOD

A. Watermark embedding

Watermark embedding algorithm makes use of wavelet packets and block selection technique to embed watermark in the host video. First the host video is transformed using wavelet packets. Using block selection technique, the blocks are selected in the transformed video. Once the blocks are selected, the watermark will be embedded and inverse transform is performed to obtain watermarked video.

In block selection technique, the selected blocks should maintain minimum distance d to each other in order to prevent artifacts and flickering effects. The minimum distance can be calculated using the following equation

$$[d_i = \lfloor \log(d.(i_{size} - 1) + 1) + 0,.5 \rfloor \quad (1)$$

where d = distance and i = dimensions (x, y or t).

The outline of the block selection algorithm is given as follows:

(i) The block group is chosen which is of arbitrary forms.

(ii) The minimum distance dx, dy and dt is computed for each dimension x, y and t of the block group using the equation 1.

(iii) The numbers of blocks inside an ellipsoid are counted for each block. The semi-axes of the ellipsoids are defined by dx, dy and dt. The current block defines the center of the current ellipsoid.

(iv) The blocks with the least neighbors are chosen for watermarking. Are more than one chosen blocks inside an ellipsoid, only one of them (the first) is used for watermarking. This process is unambiguous.

(v) The chosen blocks and all blocks within the ellipsoids around the chosen blocks will not be considered in the next steps.

(vi) The steps 3-4 are repeated until all blocks are chosen for watermarking or have a distance lower than the minimum to a chosen block.

The blocks chosen using the above algorithm are used for watermark embedding. The watermarking information is embedded by moving the x, y-coordinates on the quantization lattice to minima/maxima. This is done by geometric warping.

B. Watermark Extraction

The watermark extraction procedure is described in the following steps.

Step1: Decompose the watermarked video using wavelet packets.

Step2: Find the right blocks.

Step3: Using quantization table determine the watermark bit.

Step4: After extracting the watermark, normalized correlation is calculated between the original and extracted watermark sequence.

V. EXPERIMENTAL RESULTS

Several experiments were conducted to evaluate the performance of the proposed system. During experimentation several samples were used which included standard test videos and commercially-available movies. The results observed had similar pattern. The results projected in this paper is based on a video clip having 1526 frames (352 x 289 frame size) is used. The experiments were conducted on a Pentium IV with 512 MB memory. The attacks taken into consideration are frame dropping, frame averaging and compression. After extracting and refining the watermarks, a similarity measure, called Normalized Correlation (NC) is used (Equation 2), which gives the cross-correlation normalized by the reference watermark energy giving unity as the peak correlation.

$$NC = \frac{\sum_i \sum_j W_{ij} * RW_{ij}}{\sum_i \sum_j W_{i}{}^{2}{}_{j}} \quad (2)$$

where W_{ij} is the original watermark and RW_{ij} is the extracted watermark.

Number of frames dropped is a common attack encountered by video watermarking. The reason behind this is the large amount of redundancies that exists between the frames. The effect of this attack is projected in Figure 2a when tested with different percentage of frames dropped. From the results, it could be seen that the proposed watermarking scheme is better with this type of attack.

Frame averaging and statistical analysis is another common attack to the video watermark. When attackers collect a number of watermarked frames, they can estimate the watermark by statistical averaging and remove it from the watermarked video. Figure 2b shows the results obtained while taking the frame averaging attack into consideration. The results show that fact that the proposed scheme can resist statistical averaging quite well than the base model.

Figure 2c shows the NC values of the extracted watermarks with different quality factors. From the experiment, it is noted that the proposed scheme improves the robustness for watermark protection. It can further be noted, with high quality factor, the algorithm is better in resistance.

From the various results obtained, it can be concluded that the proposed watermarking scheme is superior to the existing system.

VI. CONCLUSION

This paper introduces a combined video watermarking scheme based on wavelet packets and block selection technique. By using the wavelet packets and block selection technique, watermarking signal is embedded into the host video and it also prevents artifacts and flickering effects. The experimental results showed that this watermarking system not only can keep the video quality well, but also can be robust against temporal attacks such as frame dropping, statistical averaging and compression. This algorithm has strong capability of embedding signal and anti-attack.

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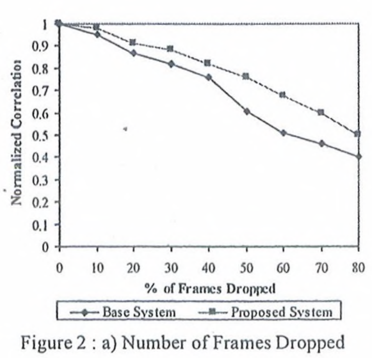

Figure 2 : a) Number of Frames Dropped

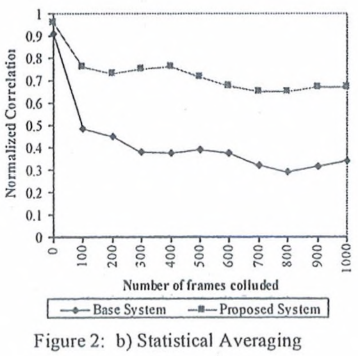

Figure 2: b) Statistical Averaging

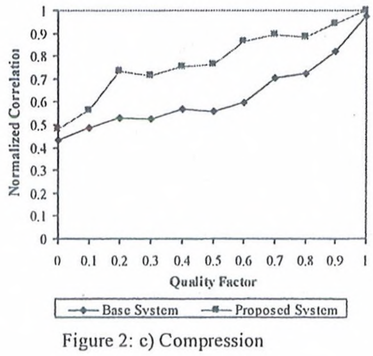

Figure 2: c) Compression