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Video Watermarking Techniques: A Review

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Abstract— Digital watermarking is meant to protect the digital information from unauthorized agencies or person. Internet has opened a new door to share their thoughts, text , images and video. This makes it possible to manipulate and redistribute these information illegally. Video watermarking is another variant of digital watermarking which is used for video authentication and for other purpose. This paper presents a review work in video watermarking research field.

Keywords— DCT (Discrete Cosine Transform), DWT (Discrete wavelet Transform), LSB (Least significant Bit), contourlet Transform(CT).

I. INTRODUCTION

Sharing of information now a days has become common among the agencies and people across the world. Introduction of 3G and 4G network for high speed communication, emergence of social media like facebook, Twitter to Wats up application in mobile enable the people to share information 24/7. Sharing the information from other has posed a problem of data tempering and later on republishing it in some other name. These problems motivated the researchers to design some algorithm to put an stop to such practice by incorporating some security to the digital content. Digital watermarking is the outcome of this effort. A Digital watermark is basically an ownership information which is embedded in digital information to protect it from unauthorised access. Digital video watermarking is just the enhanced version of digital image watermarking. Digital video is a sequence of consecutive still images known as frames. The amount of information which is embedded in information is known as the payload. Unlike image watermarking, video watermarking also address the problem of large volume. Watermark embedding algorithm hide the watermark directly to the host media (image/video) or to the transformed version of host media. In transform domain watermarking approach, frames of the video is converted to frequency domain using some frequency domain conversion methodology and then watermark is embedded in transfer domain media. Once the watermark is embedded then the host signal is again converted back to pixel domain. Discrete Cosine transform (DCT)[2,3], discrete wavelet transform[4] are some common method of transform domain. In case of spatial domain watermarking process, transformation take place directly on the pixel of video frames. Transform domain model of watermarking is also useful in audio watermarking [3,4].

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This paper is divided in to 5 different sections. Section II described some common term or properties of watermark and its significance in video watermarking.
Section III list various application of watermarking while the section IV present a some noteworthy contribution suggested in video watermarking by several authors.

II. PROPERTIES OF VIDEO WATERMARKING

Video is basically a collection of equally time spaced still images known as frame. Generally all the algorithm of image watermarking can be extended for video watermarking, but in reality, there are some more challenges that video watermarking address. Watermarked video are prone to pirates attack like compression[1], frame swapping, frame averaging etc.
There are number of properties of watermarking system like embedding effectiveness, fidelity data payload, capacity, robustness etc. This section discuss some common properties of video watermarking.

A. Perceptual Transparency

Invisibility can be defined as the degree for which an embedded watermark remain unnoticed in watermarked media. Perceptual transparency is one of the requirement of watermarking. Temper resistance and robustness are other requirement which conflicts with this requirement.

B. Robustness

Robustness can be defined as the resistance offered by the embedded watermark against removal by common signal processing operation. During processing period, images, video and audio undergoes different signal processing operations such as filtering, compression, rotation etc. A good watermarking algorithm must be able to recover the watermark from watermarked media even after such signal processing operations. In order to achieve the robustness, watermark must be placed in perceptually significant part of the media.

C. Capacity

Capacity can be defined as the amount of information that can be inserted by embedding watermark. Watermark embedding algorithm must be able to carry more and more information.

III. APPLICATION OF VIDEO WATERMARKING

Video watermarking is mostly used for authentication purpose. Some of the common application of watermarking is

1. For copy control[8].
2. In fingerprinting.
3. For identification of ownership.

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4. For Authentication.
5. Monitoring of digital video broadcast[8].
6. In video tagging.etc.

IV. LITERATURE REVIEW

Lots of algorithms have been presented in the past for video watermarking. Algorithm used in image watermarking can be applied directly to the video watermarking therefore many algorithm of image watermarking is also used in video watermarking. Each and every algorithm has its advantages and disadvantages. In video watermarking, watermark is generally embedded in uncompressed video [8,11,13] or some time in compressed video[12, 13]. In broader sense or in the basis of domain on which watermark is inserted, video watermarking can be grouped in to three different categories as shown in the figure 1.

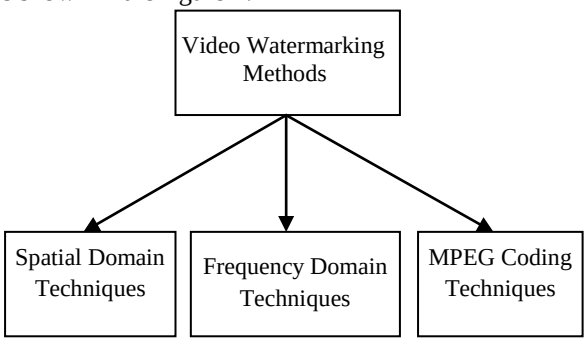

Figure 1 Categories of Video Watermarking

A. Spatial Domain Techniques of watermarking

Spatial domain techniques are also known as the pixel domain techniques as in this techniques pixel are modified. In spatial Domain watermarking techniques, watermark is embedded directly on the pixel value of the host video. In this approach, pixel values of the host video is modified as per the watermark bit by some predefined rule. Pros of this techniques are its simplicity and low complexity but cons are less security and robustness.

- ***Least Significant Bit Technique [15].***

It is simplest spatial domain technique. In this method, least significant bit of each pixel is used for inserting the watermark bit or information bit. Since least significant bit of each pixel has least weight and hence changing this bit has negligible effect in the quality of the image. This techniques is least complex but has the disadvantage of poor security. This technique is good for steganography application but it is not suitable for watermarking application due to its poor robustness.

- ***Correlation Based Watermarking Technique[14].***

In correlation based watermarking technique, PN sequence(Psudo-random number) is added to the luminance value of the pixel of host file(Image/ Video) in spatial domain. If luminance value of the pixel of the host is represented by I(i,j), watermark is represented by W(i,j) then the watermarked image is given by

$$Iw(i,j)=I(i,j) + k\times W(i,j)$$

Here k is a gain factor and *Iw* is watermarked host (i.e. host after embedding watermark). Gain factor is important parameter in this algorithm as it decides the quality of the host image and the robustness of the algorithm. Higher value of k degrades the quality of the host but at the same time it also increases the robustness of this algorithm. Lower value of k doesn't affect the quality of the host much but it also reduces the robustness of this algorithm. In this algorithm the key which initialize the PN-sequence is very important. This same key is used in extraction phase of this algorithm to extract out the watermark from the host. In the extraction part, correlation is computed between PN-sequence and noisy watermarked host and if the computed correlation is exceeded to a certain threshold T, the watermark bit is detected and extracted.

B. Frequency Domain Watermarking Techniques.

Watermark is also embedded in frequency domain[6-8] and embedding watermark in frequency domain is more robust than embedding watermark in spatial domain. Discrete Fourier transform(DFT), Discrete Cosine Transform(DCT) and Discrete Wavelet Transform(DWT) are the three techniques which convert the host file in to frequency domain. This technique is also known as the transform domain techniques.

Transform domain techniques has the ability to overcome the problem or limitation posed by the spatial domain techniques but this techniques require more computational power.

- ***Discrete Fourier Transform[14]***

In this technique, first of all, video is divided in to a 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.

- ***Discrete Cosine Transform[14]***

In this technique videos are converted in to a frames and then each frames are broken into different frequency bands using discrete cosine transform. Mid frequency band is chosen for watermark embedding. This technique follows the following procedure to embed the watermark in video.

i. Convert the video in to a frames.
ii. Each frame is broken into a N×N blocks of pixels.
iii. DCT is applied to each block of pixel.
iv. Quantization operation is performed to get the compressed frame.
v. These quantized framed which is in compressed form then scanned in zig-zag fashion to get the frequency bands.
vi. Watermark is embedded in this frequency band by applying some suitable rule.
vii. Inverse discrete transform is applied to get back the original frame.

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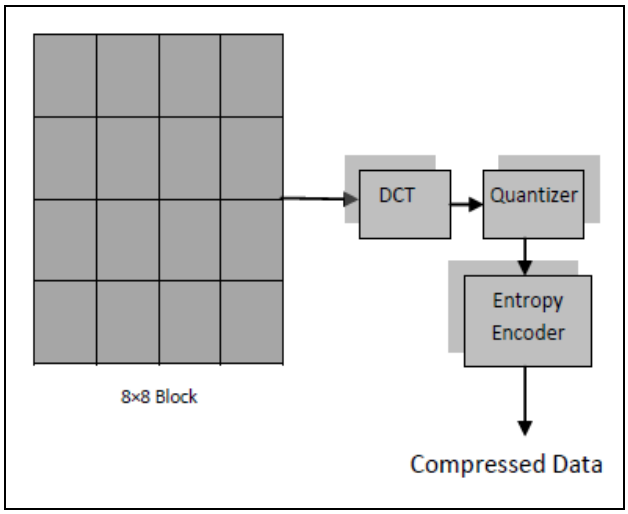

Figure 2 Discrete Cosine Transform Procedure

- ***Discrete Wavelet Transform***

In this technique, video frames are decomposed into four frequency component i.e. LL(Low frequency Component), LH(Mid Frequency Component), HL(Mid Frequency Component) and HH(High Frequency Component). Watermark is generally embedded in mid frequency component because this frequency band is least affected by video manipulation therefore it is easy to extract the correct watermark. The decomposition can be of first level or two level. Once the watermark is embedded then inverse discrete transform is applied to get the embedded video frames. Watermark extraction is generally performed by correlation method or sometimes by applying some other method.

- ***Contourlet Transform(CT)***

Discrete wavelet Transform provides localization of time and frequency but even after this it is not able to present the direction information effectively like contour in different direction.

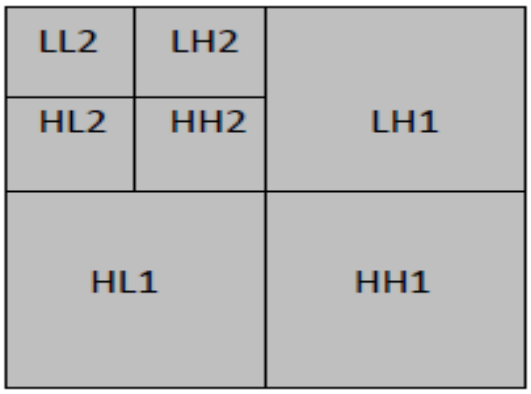

Figure 3 DWT Decomposition

Contourlet transform is able to address this problem Contourlet transform is combination of Laplacian Pyramis (LP) and Direction filter bank(DFB)[4]. Multiscaling operation and Directional decomposition operation is performed with the help of laplacian Pyramid(LP) and directional filter Bank(DFB)[4]. Directional Filter bank here used for capturing the direction information. Contourlet transform has contourlet filter bank which actually decompose the image or frames in to directional sub-bands at multiple-scale.

This process decomposes the video frames in to different frequency sub-bands. In this technique, watermark is also broken in different frequency band using contourlet transform. This band of watermark is then embedded in the low frequency band of host video. At last inverse Contourlet transform is applied to get back the original host video.

In order to reduce the video processing complexity, Some techniques embed the watermark.

In MPEG1 MPEG2 and MPEG3 compressed coding structure. MPEG@ is basically block based approach of compression in which compression is accomplished by predicting the motion in video. This idea can be utilized for watermarking embedding and hence lots of watermarking algorithm have been proposed for MPEG2 and MPEG4 coding structure like manipulation of high frequency DCT coefficients and by classification of DCT block[1].

Watermarking based on MPEG4 structure is proposed in [5]. This technique uses the DCT transform. Some predefined pairs of quantized DCT coefficients are altered in the luminance block. These blocks are selected randomly.

This technique divides the image in to blocks of equal size. With the help of binary sequence is generated which is finally added to the frames or images. In the algorithm presented in paper[6], watermark is added in to a transparent video sequence. In this techniques, watermark is bit is added to the frames using PN-sequence which depends on the video sequence. Perceptual masking characteristics of video are used for embedding thw watermark. Authors of this paper claim invisibility and robustness of the watermark for this algorithm. Noisy nature of watermark in this methods make it difficult to remove the watermark by unauthorised person. In[7], authors presented direct sequence watermarking algorithm using m-frames. In this scheme first the video sequence is arranged on time axis and then direct sequence spread spectrum model is used for watermark insertion.

In [7], Mobasseri proposed direct sequence watermarking using m-frames This scheme applies a direct sequence spread spectrum model to the watermarking of the digital video. First, video signal is modeled as a sequence of bit planes arranged along the time axis. Watermarking of this sequence is a two layer operation. A controlling m-sequence first establishes a pseudorandom order in the bit plane stream for later watermarking.

Video watermark method which is collusion resistant (CR) is proposed in [8]. This is basically frame by frame watermarking technique. In this technique, watermark pattern of size R × C is embedded repatedly in every video frames. Watermark is embedded in such a way that it always remain within a selected points in every frames. These points are known as anchors. all the anchors points are computed by feature extraction algorithm .Once all the watermarking frames are extracted then spatial masking is applied for robustness. Watermark is embedded in the video frames by addition. In [9], CDMA modulation based watermarking method is a presented.

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In this approach, four least significant bit planes of the video frame is replaced by the four bit of watermark. These bit planes on which the watermark is to be inserted is selected by PN-sequence(Psudo random sequence).

In this approach, 1-D spread spectrum method is used for watermark plane generation.

Variable length Code(VLC) based watermarking algorithm was proposed in [10]. Variable length code is used in MPEG-2, H.261 standard video. In this video this method is used for inserting the watermark. In this approach variable length code (VLC) swapping is carried out for watermarking. In VLC based video, there is a table of code word pair $(r, l) \rightarrow c_0$ and $(r, l \pm 1) \rightarrow c_1$ and length (c_0) = length(c_1), lsb (c_0)≠ lsb (c_1). All the pair which satisfy this property is called level-carrying VLC (lc-VLC). The data bit of watermark is embedded in to eligible lc-VLC and swapping the code word. One of the disadvantage of this method is that it is not robust against known watermark attack due to absence of random key.

Perceptual watermarking approach is also carried out in the past for watermarking. In this approach the properties of HSV model like frequency sensitivity, contrast masking, temporal masking, luminance sensitivity and contrast masking is exploited for watermarking in video [11][12].

Mahesh R. Sanghavi and his associates in their paper published in 2011[16] proposed scrambling based video watermarking algorithm. In their approach, first of all they decomposed the video frames in to 4-level sub bands using two dimensional wavelet transform. They have used scene change detection algorithm to embed the watermark in video frames. In their paper they have shown that this method is robust against some watermarking attacks. Tamanna Tabassum, and S.M.Mohidul Islam ,2012[17] applied 3-level discrete wavelet transform for watermark embedding and showed that this method is robust against attacks like noise adding, cropping , frame dropping and even frame adding. Sonjoy Deb Roy, Xin Li, Yonatan Shoshan, Alexander Fish in (2013) published the hardware implementation of watermarking [18]using discrete cosine transform and claimed that it is cost effective and power effective with high processing speed.

V. CONCLUSION

Evolution and past work in any research field is a valuable repository for young researchers which help them to grasp the past methodology. This paper discusses various techniques of video watermarking, its advantages and limitations. Spatial domain techniques such as Least significant bit (LSB) and its variants are easy and require less computational power but its poor security and poor robustness against some watermarking attack makes it unsuitable for watermarking purpose. Transfer domain or frequency domain techniques are though resource and computational power hungry but these techniques are robust against the watermark attack. Advance research in this field is going on in other domain as well. Adopting spatial domain techniques or frequency domain techniques depends on the requirement of the application.

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