www.s2is.org
International Journal on Smart Sensing and Intelligent Systems
ISSN 1178-5608

AN INVESTIGATION OF DIFFERENT VIDEO WATERMARKING TECHNIQUES

B. Sridhar
Department of Electronics and Communication Engineering,
MLR Institute of Technology,
Hyderabad, India
Email: sridharbece@gmail.com

Submitted: Feb. 4, 2017 ***Accepted: Apr. 17, 2017*** ***Published: June 1, 2017***

Abstract- Watermarking is an advanced technology that identifies to solve the problem of illegal manipulation and distribution of digital data. It is the art of hiding the copyright information into host such that the embedded data is imperceptible. The covers in the forms of digital multimedia object, namely image, audio and video. The extensive literature collected related to the performance improvement of video watermarking techniques is critically reviewed and presented in this paper. Also, comprehensive review of the literature on the evolution of various video watermarking techniques to achieve robustness and to maintain the quality of watermarked video sequences.

Index terms: Copyright protection, DCT, Information hiding, PCA, SVD, Watermarking, Wavelet transform.

I. INTRODUCTION

Development of wireless innovation has freely allowed to widespread the multimedia contents; it has made it possible to distribute multimedia content digitally by means of the World Wide Web to a large number of people in a cost-effective manner. While in transmission, an unapproved person may effortlessly acquire to and control the data; in this manner, the shield of information and distinguishing controls is a vital task [1-2]. Since the computerized information has no conflict between in the quality of an original and its copy [3-6]. Various researchers have been drilled down the answers for copyright protection. The better way, in which the multimedia information is ensured against illegal transmission and recording is to put a signal on the cover medium for the confirmation of the proprietor of the information. Figure 1 shows the basic model of Information hiding tools.

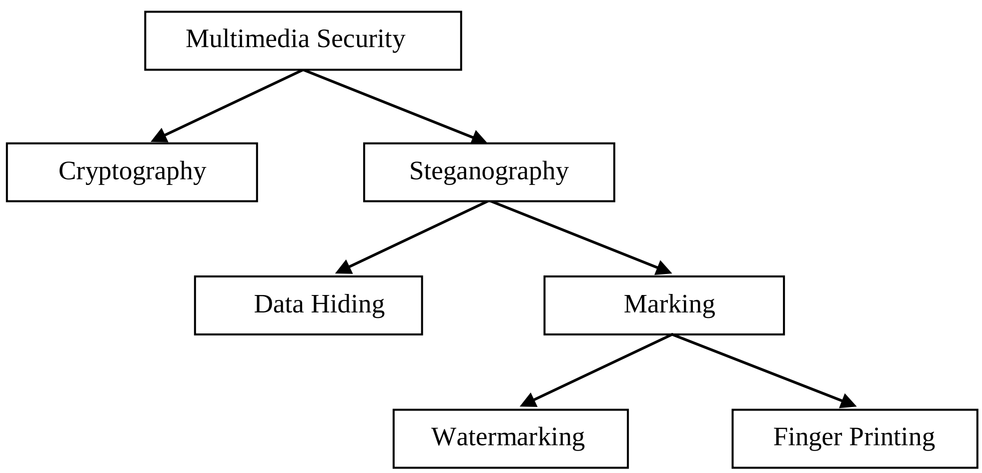

Figure 1. Information Hiding Tools

Watermarking which controls the problem of illegal copies and modification of digital contents. Based on the types of embedding data; watermarking is classified into Text, Image, Audio and Video. Among these video watermarking is a more challenging task. As part of the watermarking technique, a testing algorithm must be defined that tests an image to see if a particular watermark is contained in the image. It is also desirable for the testing procedure to determine if the image has been altered and to supply localization information as to where the image was altered. It is our feeling that to assert ownership that is consistent with current intellectual property right law, the watermarking technique must support the use of third-party cryptographic-based digital time stamping that is embedded in the image through the watermarking process. In several general scenarios were identified where copyright enforcement is needed:

(i). Invisible watermarking for content authentication

An example of this scenario is images taken by a digital camera used in news gathering. The images must be watermarked upon capture so that the news services can be sure that an image has not been altered. The unrestricted distribution of copies of the images is much less a concern more here than verifying an image's origin and content. This is a very critical issue in the protection of historical images and images used in courts of law as evidence.

(ii). Invisible watermarking for detecting unauthorized copies of images

Such watermarks can be used as follows:

- To prove ownership of an image. The mere presence of the owner's mark in a suspect image can prove the theft of that image by the unauthorized possessor.
- To identify the customer (who is a potential illegal distributor). The mark would represent the original purchaser whose copy has been illegally distributed. Requirements and properties for the digital watermarks in the scenarios above differ. For authentication, it is important that even slight changes to the image be detected and localized. Embedding a false mark must be practically impossible and the watermark must be easily destroyed. It is not desirable for the watermark to remain in the image after the attacks on the image such as filtering, although the watermark should survive cropping. These types of watermarks are known as fragile watermarks.

The two different approaches that are used to embed information according to the domain are Spatial and Transform domain [7]-[9]. In the spatial domain, it is easy to insert a watermark into a host image by changing the pixel values directly using bit substitution. Therefore, embedding task can be done very easily, and requires minimal computational power, but the inserted information can be easily detected using related techniques. Most of the watermarking techniques projected only on the frequency domain because it is more robust and stable. In this domain, a watermark is inserted into coefficients obtained by using an image transform process also a dismissal of a watermark is very difficult [10]. Most common transforms are Discrete Fourier Transform (DFT), Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT).

Video watermarking is another new zone of research which fundamental benefits from the results for still images [11]. In video watermarking acquired more challenges than an image watermarking scheme, such as that enormous volume of excessive data between frames. Research in video watermarking gained less consideration than an image watermarking; nonetheless, many algorithms have been proposed. Imperceptibility, Robustness, Security and Capacity are the main features of a video watermarking system. Applications of video watermarking are duplicate control, fingerprinting, evidence of ownership, authentication, video tagging, digital video broadcast monitoring, etc.

In a magic triangle, we have the capacity, Robustness and Invisibility[12-15]. But the watermarking algorithm should satisfy only any two parameters and one should be a trade off. Figure 2 shows the requirements of watermarking system.

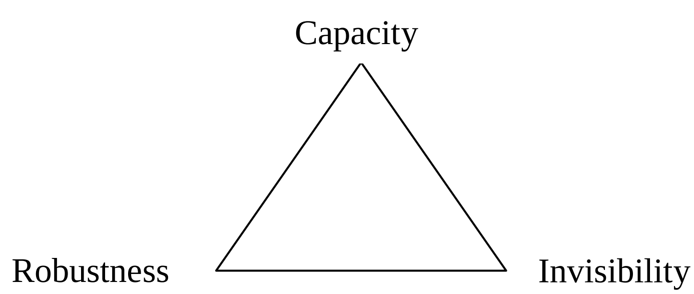

Figure 2. Requirements of watermarking system

Capacity: The amount of information that can be embedded in the cover medium. Mainly it depends on the method used for the watermarking.

Robust: A watermarking technique is said to be robust it can able to preserve the secret message under various attacks like filtering, compression or cropping.

Invisibility: A watermarking technique has a good invisibility property if we unable to notice the changes in the cover medium after concealing the watermark.

The performance of various schemes of watermarking can be evaluated on the bases of some of the visual quality matrices [16-18] given in equations 1 and 2. Peak Signal to Noise Ratio

(PSNR) and the Mean Square Error (MSE) are present the idea about the visual degradations of the watermarked cover medium, the strength of both watermark and the robustness of the algorithm.

$$MSE = \frac{1}{MN}\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}[X(i,j)-Y(i,j)]^2 \qquad (1)$$

$$PSNR = 10\log_{10}[255^2 / MSE] \qquad (2)$$

An error value between the original video frame *X(i, j)* and the extracted video frame *Y(i, j)* is called Mean Square Error, where M and N are the size of the image. PSNR used to measure the quality of the original and the watermarked image.

II. LITERATURE REVIEW

Many algorithms have been put forward in the scientific review. Zhu *et al.* (1998), proposed an algorithm of embedding watermark into the static and dynamic temporal components generated from a temporal wavelet transform of the video. Using this scheme, the multi-resolution, watermark may be detected on single frames without knowledge of the location of the frames in the video scene, and is robust to the common attacks that video suffers in daily application.

Choong-Hoon *et al.*(2000), described an adaptive video watermarking scheme that used motion information for watermark embedding. Appropriate blocks for watermark embedding are selected using some criteria such as motion vectors and DBD. Selected blocks are the target of watermark embedding. For watermark embedding, blocks are transformed using wavelet transform and wavelet coefficients are changed using random signal. All selected blocks are tracked frame-by-frame and same watermark is embedded into the same block.

Chen and G.W.Wornell (2000), QIM techniques use different quantization code-books to represent the covered data with the selection of code-books based on the hidden information. QIM-based techniques usually have higher capacities than spread-spectrum schemes. The capacity of any QIM scheme is determined by the design of the quantization schemes.

Zhang *et al.*(2001), proposed a video watermarking scheme to embed watermark into larger value motion vectors. This technique has some good performance for hiding information in the MPEG video sequence. However, due to their watermarking motion vector, the modified motion vector will lead to frame dithering. In this paper, the author proposed a novel video watermarking scheme to watermark the original video based on locating motion region, using the independent component analysis (ICA) and the quantization index modulation (QIM). ICA was originally developed for separating mixed audio signals into independent sources.

Liu *et al.* (2001), presented a video watermark algorithm in the motion vectors. Firstly, the Y component of P frame is categorized into a high-texture area and low-texture area. The motion vectors are altered according to the texture of the area. Secondly, the prediction errors of the matched blocks are calculated again according to the changed motion vectors. Finally, the new motion vectors together with new prediction errors are encoded into compressed bit-streams. This algorithm can reduce the flaws and block the effects of watermarked video.

Solanki et al (2002), the authors propose to hide the large volume of information into the nonzero DCT terms after quantization. This method cannot provide sufficient embedding capacity for our application because surveillance videos have high temporal correlation with a very large fraction of DCT coefficients being zero in the inter coded frames.

Sun and Liu (2005), proposed another scene-based video watermarking scheme by using independent component analysis (ICA) to extract motion content from different scenes. Both of the algorithms are based on scene. In order to extract watermark, they should segment the scene accurately. However, the technique of scene segmentation is still a challenging problem in practical applications, especially the gradual changing scenes.

Koubaa *et al.*(2007), presented an efficient method for video watermarking which resists to collusion attack and MPEG compression. For this aim, the authors have used video mosaiking technique to introduce the same watermark into the same physical point along the whole sequence so as to resist collusion attack. On the other hand, creating a mark which depends on the local activity and the frequency of appearance of each pixel, make it more robust especially against MPEG compression. The main problems occur if the estimated warping parameters are not sufficiently precise.

Zhaowan Sun *et al.* (2009), explains a video watermarking scheme to watermark the original video based on locating motion region, using the independent component analysis (ICA) and the quantization index modulation (QIM). A Watermark is embedded by the QIM method into the n^2 blocks (correspondingly, the length of watermark is n^2) of motion region in each original video frame. During the motion region location, the dynamic frame is extracted by ICA from two successive frames firstly, and then the variance of every 8x8 block of the dynamic frame is calculated, according to which the to-be-watermarked region in the former frame is determined. This region is centered by the 16x16 macro block, whose relative motion is drastic between the two successive frames.

J. Hussein *et al.* (2009), showed a new video watermarking scheme based on motion estimation for color video sequence in a frequency domain. This technique is tested on compressed (taken from DVD high quality film) and uncompressed (taken by digital camera) video movies. The watermark is the random Gaussian distribution which is embedded into the motion regions between frames (HL, LH bands). Experimental results show that the proposed new scheme has a higher degree of invisibility against the attack of frame dropping, adaptive quantization, and frame filtering than the previous developed scheme in spatial domain.

Mansouri *et al.* (2010), shows a new blind and readable H.264 compressed domain watermarking scheme in which the embedding/extracting is performed using the syntactic elements of the compressed bit stream. This approach is no need to fully decode a compressed video stream both in the embedding and extracting processes. Also presents an inexpensive spatiotemporal analysis that selects the appropriate submacroblocks for embedding, increasing watermark robustness while reducing its impact on visual quality. Meanwhile, the proposed method prevents bit-rate increase and restricts it within an acceptable limit by selecting appropriate quantized residuals for watermark insertion.

Emad E. Abdallah et al. (2010) present a robust, hybrid non-blind MPEG video watermarking technique based on a high-order tensor singular value decomposition and the discrete wavelet transform (DWT). The core idea behind this technique is to use the scene change analysis to embed the watermark repeatedly into the singular values of high-order tensors computed form the DWT coefficients of selected frames of each scene. Experimental results on video sequences are presented to illustrate the effectiveness of the proposed approach in terms of perceptual invisibility and robustness against attacks.

Maher El'Arbi, *et al.* (2011), proposed a video watermarking algorithm which embeds different parts of a single watermark into different shots of a video under the wavelet domain. Based on a Motion Activity Analysis, different regions of the original video are separated into perceptually distinct categories according to motion information and region complexity. Thus, the localizations of the watermark are adjusted adaptively in accordance with the human visual system.

Ali *et al.* (2012) proposed a wavelet based watermarking technique with the combination of PCA transform. Due to its excellent spatio-frequency localization properties, the DWT is very suitable to identify areas in the host video frame where a watermark can be embedded imperceptibly. PCA is basically used to hybridize the algorithm as it has the inherent property by removing the correlation among the data, i.e. the wavelet coefficients and it helps in distributing the watermark bits over the sub-band used for embedding thus resulting in a more robust watermarking scheme that is resistant to almost all possible attacks.

Yassin *et al.* (2012), introduced a comprehensive approach for digital video watermarking, where a binary watermark image is embedded into the video frames. Each video frame is decomposed into sub- images using 2 level DWT then the Principle Component Analysis (PCA) transformation are applied to each block in the two bands LL and HH. The watermark is embedded into the maximum coefficient of the PCA block of the two bands. The proposed scheme is tested using a number of video sequences. Experimental results show high imperceptibility where there is no noticeable difference between the watermarked video frames and the original frames.

Kashyap and Sinha (2012) have implemented a robust image watermarking technique for the copyright protection based on 3-level Discrete Wavelet Transformation (DWT). In this technique a multibit watermark is embedded into the low frequency sub-band of a cover image by using alpha blending technique. The insertion and extraction of the watermark in the grayscale cover image are found to be simpler than other transformation techniques. The proposed method is compared with the 1-level and 2-level DWT based image watermarking methods by using statistical parameters such as Peak Signal to Noise Ratio (PSNR) and Mean Square Error (MSE). The experimental results demonstrate that the watermarks generated by the proposed algorithm are invisible and the quality of watermarked image and the recovered image are improved

Bhatnagar and Raman (2012) proposed a Wavelet Packet Transformation (WPT)-based robust video watermarking algorithm. A visible, meaningful binary image is used as the watermark. First, a sequence of frames is extracted from the video clip. Then, WPT is applied on each frame and from each orientation one sub-band is selected based on block mean intensity value called robust sub-band. A watermark is embedded in the robust sub-bands based on the relationship between wavelet packet coefficient and its 8-neighbour (D8) coefficients considering the robustness and invisibility.

Karpe and Mukherji (2013), present a novel technique for embedding a binary logo watermark into video frames, based on Discrete Wavelet Transformation (DWT) and Principal Component Analysis (PCA). PCA is applied to each block of two bands (LL–HH) which results from DWT of every video frame. The video frames are first decomposed using DWT and the binary watermark is embedded in the principal components of the low frequency wavelet coefficients.

Osama Faragallah (2013), presented DWT-based SVD video watermarking method, the video frames are transformed with the DWT using two level decomposition. The frequency bands LH, HL and HH are undergoing the SVD transformed further watermark is hidden in it. The proposed method is characterized by the cascade of DWT based SVD using an additive method and an error correction code is applied to the frame and conceal the watermark with spatial and temporal redundancy. The improvements of the algorithm are to increase robustness against video processing attacks, realize high-security level, protect the watermark against bit errors and obtain good perceptual quality.

Jiang Xuemei et al. (2013) propose a new video watermarking algorithm based on shot segmentation and block classification to enhance the robustness, imperceptibility and real-time performance based on the H.264/AVC codec. A method of selecting host frames is proposed based on shot segmentation to avoid embedding watermark frame by frame, so as to improve the robustness and the real-time performance. The watermark signal is cropped into small watermarks according to the number of shots in the host video, and small watermarks are respectively embedded into different shots. The watermarking capacity and the perceptual quality are greatly improved by this way. A method of selecting host coefficients is proposed based on block classification in the Discrete Cosine Transformation (DCT) compressed domain. The texture characteristics of host blocks are considered in the classification and the places of host coefficients can change adaptively according to the content of the video. The imperceptibility of the watermarked video is greatly improved by this way. The simplified quantization index modulation (QIM) is applied to embed watermark. It brings fewer artifacts to the host signal than the current main watermarking method, such as spread spectrum (SS), differential energy watermarking (DEW) and so on.

Sridhar *et al.* (2014), proposed a video watermarking scheme, in this the secret color information is divided into notable pieces and conceals selected frames under the wavelet domain. Consequently the watermark is arranged properly in accordance with the human visual framework which makes them unobservable. Additionally the position of the secret data is settled on the cover image, and flows along with moving objects, thus the motion artifacts can be avoided. The different watermarked frame extraction guarantees that the watermark might be effectively recovered from a quite short fragment of video. Inserted watermark is less detectable as well as robust against regular video processing attacks with much lower unpredictability.

Yassin *et al.* (2014) described the digital video watermarking scheme based on DWT and PCA. In earliest 3 level DWT is employed on every video frame further choose the maximum entropy blocks and transformed using PCA. By using the Quantization Index Modulation (QIM) maximum coefficients of the sub-bands, blocks of the PCA is quantized. Such types of blocks are employed to conceal the watermark. In this approach, the secret key is generated at the time of inserting the watermark and it is used to recover the watermark.

Asikuzzaman et al. (2014), described a digital watermarking method for depth-image-based rendered 3D video. In this method, the watermark is embedded in both of the chrominance channels of a YUV representation of the center view using the dual-tree complex wavelet transform. Then, the left and right views are generated from the watermarked center view and depth map using a depth-image based rendering technique. This watermark is robust to geometric distortions, such as upscaling, rotation and cropping, downscaling to an arbitrary resolution, and the most common video distortions, including lossy compression and additive noise. Due to the approximate shift invariance characteristic of the dual-tree complex wavelet transform, the technique is robust against distortions in the left and right views generated using depth-image based rendering. The proposed method can also survive the baseline distance adjustment and both 2D and 3D camcording.

Sridhar *et al.* (2015), proposed a nested watermark on video based on sharing approach. Initially, primary secret information is grouped into alternative pixels shares and secondary watermark is concealed in one of the flipped shares. Further rearrange the concealed shares into normal form and stack the allotments into a single image. Now the primary watermarked image is sectioned into various pieces and hidden the piece of watermarked information into specific frames under wavelet. Accordingly the watermark data is requested for with acceptably with the human visual framework which makes them imperceptible. Concealed information is less perceivable and also robust against regular video processing attacks.

Shuvendu Rana et al.(2015) proposed a watermarking scheme for scalable video which is robust against spatial and quality scalability. In this scheme, a DC frame is generated by accumulating DC values of non-overlapping blocks for every frame in the input video sequence. DC frame sequence is up-sampled and subtracted from the original video sequence to generate the residual frame sequence. Then Discrete Cosine Transform (DCT) based temporal filtering is applied on DC as well as residual frame sequence. A watermark is embedded in low pass frames of DC frames and up sampled watermark is embedded in the low pass residual frames to achieve the graceful improvement of watermark signal in successive enhancement layers. A comprehensive set of experiments are performed to justify the superiority of the proposed scheme over existing literature with respect to spatial and quality adaptation attacks as well as visual quality.

Sridhar *et al.* (2015) explained the blind video watermarking technique with color watermark. In this approach a luminance layer of selected frames is interlaced into two even and odd rows of an image, further it is deinterlaced and equalizes the coefficients of the two shares. Color watermark is split into different blocks, and the pieces of block are concealed in one of the share under the wavelet transform. Stack the two images into a single image by introducing interlaced even and odd rows in the two shares. Finally, chrominance bands are concatenated with the watermarked luminance band. The safeguard levels of the secret information are high, and it is undetectable. Results show that the quality of the video is not changed also yields the better PSNR values.

Cabir Vural and Burhan Barakli (2015), described a reversible video watermarking method based on motion-compensated frame interpolation error expansion is developed. Interframe correlation is exploited more efficiently as a result of using motion-compensated frame interpolation error instead of motion-compensated prediction error that is used in the current reversible video watermarking methods. With this approach, the original video and watermark can be obtained reversibly from the watermarked video, and the amount of side information in the watermarked video required for watermark decoding and video restoration is extremely low. The method is shown to be superior to the existing methods in terms of capacity and visual video quality by performing computer simulations carried out for various widely used test video sequences.

Sridhar *et al.* (2016), proposed the video watermarking techniques with color watermarks. In this approach luminance band of the selected frames is taken further, it is grouped to alternative pixel shares and flip those images. Two color watermark images are split into distinctive pieces and concatenate its layers, further it is embedded into respective flipped shares under wavelet. Unfold the shares into normal image and stack the designations into single luminance layers. Results achieved the quality of the watermarked frame is high and also the concealed data is requested with acceptably by the human visual system which makes them undetectable. Extraction guarantees that the watermark could be effectively recaptured from a quite short portion of the video. Disguised data are less discernible as well as strong against regular video processing attacks.

Tian *et al.* (2016), explained a watermarking resistant against barrel distortion for Head Mounted Display HMDs Watermark mask is embedded into image in consideration of imperceptibility and robustness of watermarking. In order to detect watermarks from the pre-warped image with barrel distortion, an estimation method of the barrel distortion is proposed for HMDs. Then, the same warp is enforced on the embedded watermark mask with the estimated parameters of barrel distortion. The correlation between the warped watermark and the pre-warped image is computed to predicate the existence of watermark. The proposed scheme is resistant against combined barrel distortion and common post-processing, such as JPEG compression.

Ma *et al.* (2016), demonstrates a new watermarking method based on H.264 compressed domain for video DRM, in which the embedding and extracting procedure is performed using the syntactic elements of the compressed bit stream. Based on the analysis of the time and space, some appropriate sub-blocks are selected for embedding watermarks, increasing watermark robustness while reducing the declination of the visual quality. In order to avoid bit-rate increasing and strengthen the security of the proposed video watermarking scheme, only a set of nonzero coefficients quantized in different parts of macroblocks is chosen for inserting watermark. The experimental results show the proposed scheme can achieve excellent robustness against some common attacks, the proposed scheme is secure and efficient for video content DRM protection

Farnaz Arab et al. (2016), focus on video watermarking, particularly with respect to the Audio Video Interleaved (AVI) form of video file format. The two new watermarking schemes which seem to offer a high degree of imperceptibility and efficient tamper detection. Both schemes were subjected to nine different types of common attack, which revealed one scheme, VW8F, to be superior, particularly in terms of imperceptibility. VW8F was then compared with a range of similar schemes by other authors. The results show that VW8F offers both improved imperceptibility (average PSNR of 47.87 dB) and proven efficiency in detecting a wider range of tampering compared to the other similar schemes.

Pejman Rasti *et al.* (2016) addresses the aforementioned issue by introducing a robust and imperceptible non-blind color video frame watermarking algorithm. The method divides frames into moving and non-moving parts. The non-moving part of each color channel is processed separately using a block-based watermarking scheme. Blocks with an entropy lower than the average entropy of all blocks are subject to a further process for embedding the watermark image. Finally a watermarked frame is generated by adding, moving parts to it. Several signal processing attacks are applied to each watermarked frame in order to perform experiments and are compared with some recent algorithms. Experimental results show that the proposed scheme is imperceptible and robust against common signal processing attacks.

Agilandeeswari *et al.* (2016) presents a new bit plane sliced, scrambled color image watermark embedded on the color cover video using hybrid transforms such as Contourlet Transform (CT), Discrete Wavelet Transform (DWT) and Singular Value Decomposition (SVD) transformations with good imperceptibility. First the authors perform the slice of the color watermark image into 24 slices using the bit plane slicing mechanism. Subsequently, the so called Arnold transformation key is used to scramble those slices, to achieve the first-level of security. Thus, an authenticated receiver with an appropriate key alone can descramble the received slices. Next, embed those scrambled slices on one of the DWT mid-frequency coefficients (LH band) of successive 1-level CT non-motion frames of color cover video. Simulation results prove that the proposed system provides trustworthy performance against various notable image processing attacks, multiple attacks, geometrical attacks, and temporal attacks.

Unno *et al.* (2017), explained the technique uses a temporally bright modulated invisible pattern in a moving image, or video. Frame images over some periods are summed up when read out, enhancing the contrast of the invisible pattern to make it visible. Also propose a new method to solve an issue that occurs due to asynchronous operations of the display and video camera, and that was achieved by using time-shift sampling. The hidden binary image could be read out according to experiments that we conducted to confirm the results. Moreover, the patterns used in this technique were decidedly invisible when laid behind the main images, which suggested the proposed technique was highly feasible in practical applications according to this confirmation.

Nilkanta Sahu and Arijit Sur, (2017) proposed a watermarking technique which can resist temporal scaling such as frame dropping and frame rate adaptation due to scalable compression by exploiting the scale invariance property of the scale invariant feature transform (SIFT). A video scene can also be viewed from a side plane where height is the number of rows in a video frame, width is the number of frames in the scene and depth is the number of columns in the frame. In this work, intensity values of selected embedding locations changed such that strong SIFT feature can be generated. SIFT features are extracted from a side plane of the video. These newly generated SIFT features are used for watermark signal and are stored in the database for the authentication. A comprehensive set of experiments has been done to demonstrate the efficacy of the proposed scheme over the existing literature against temporal attacks.

III. CONCLUSION

Evident from the critical review, it is clear that video watermarking techniques are highly motivated by the copyright owners for secure their rights. Compare to the spatial domain, transform domain is more robust and the possible research directions have been done by researchers to improve the performance of DCT, DWT and hybrid based video watermarking systems. In the survey, some of the techniques based on compressed video, but there is a chance to destroy the watermark while choosing the compression standard. Many more systematic examination and novel algorithms are needed to enhance the process of video watermarking. Video watermarking based on blind detection considers only a single image for copyright watermarking. Future research can focus on to multiple image watermarking in video based on blind detection can be considered.

REFERENCES

[1] Qiao, L., and K. Nahrstedt, "Watermarking Schemes and Protocols For Protecting Rightful Ownership and Customer's Rights", Journal of Visual Communication and Image Representation, Vol.9**,** 1998, pp.194–210.

[2] Arnold, M, Schumucker, M and Wolthusen, S, "Techniques and Applications of Digital Watermarking and Content Protection", Artech House,2003.

[3] Cox, IJ, Kilian, J, Leighton, FT and Shamoon, T , "Secure spread spectrum watermarking for multimedia", IEEE Transactions on Image Processing, vol. 6, no. 12, 1997, pp. 1673-1687.

[4] Busch, C, Funk, W and Wolthusen, S, "Digital Watermarking: From Concepts to Real-Time Video Applications", IEEE Transactions on Computer Graphics and Applications, vol. 19, no. 1, 1999, pp. 25-35.

[5] C.T.Hsu and J.L.Wu, "Hidden digital watermarks in images", IEEE Transactions on Image Processing, vol.8, no.1, 1999, pp. 58–68.

[6] H. Y. Huang, C. H. Fan, and W. H. Hsu, "An effective watermark embedding algorithm for high JPEG compression", in Proc. Machine Vision Applications, 2007, pp. 256–259.

[7] D.Mukherjee, S. Maitra and S.T.Acton, "Spatial Domain Digital Watermarking of Multimedia Objects for Buyer Authentication", IEEE Transactions on Multimedia, vol. 6, no. 1,2004, pp. 1-15.

[8] R.Shah, A.Agarwal and S.Ganesan, "Frequency Domain Real Time Digital Watermarking", Proceedings of the IEEE 2005 International Conference on Electro Infotech, 2005, pp. 1-6.

[9] S.Riaz, M.Y.Javed and M.A.Anjum, "Invisible watermarking schemes in spatial and frequency domains", In proceedings 4th International Conference on Emerging Technologies, ICET 2008, 2008, pp. 211-216.

[10] A.A.Reddy and B.N.Chatterji, "A New Wavelet Based Logo-Watermarking Scheme", Pattern Recognition Letters, vol. 26, 2005, pp. 1019-1027.

[11] Hamid Shojanazeri, Wan Azizun Wan Adnan, Sharifah Mumtadzah Syed Ahmad, "Video Watermarking Techniques for Copyright protection and Content Authentication", International Journal of Computer Information Systems and Industrial Management Applications. vol. 5, 2013, pp. 652–660.

[12] Raymond B. Wolfgang and Christine I. Podilchuk, “Perceptual watermarks for digital images and video ” Proceedings of the IEEE,vol.87, no.7, 1999.

[13] Gerhard C. Langelaar, Iwan Setyawan and Reginald L. Lagendijk, “Watermarking of digital image and video data – A state of art rewiew” ,IEEE signal processing magazine,2000, pp. 20-46.

[14] R. Chandramouli, N. D. Memon, and M. Rabbani, “Digital watermarking,” in Encyclopedia of Imaging Science and Technology. NewYork: Wiley, 2002.

[15] C.-H. Huang and J.-L.Wu, “Attacking visible watermarking schemes,” IEEE Trans. Multimedia, vol. 6, no. 1, 2004,pp. 16–30.

[16] M. Kutter and F.A.P.Petitcolas, “A fair benchmark for image watermarking systems”, Electronic Imaging Security and Watermarking of Multimedia Contents, vol. 3657,1999, pp. 25-27.

[17] Fabien A.P. Petitcolas, “Watermarking Schemes Evaluation”, IEEE signal processing magazine, 2000, pp. 58-64.

[18] Mritha Ramalingam, “Stego Machine – Video Steganography using Modified LSB Algorithm”, World Academy of Science, Engineering and Technology 74, 2011, pp. 502-505.

[19] B.Zhu, M.D.Swanson and A.H.Tewfik, “Multiresolution scene based video watermarking using perceptual models”, IEEE J Sel Areas Comm. vol.16, no.4, 1998, pp.540–550.

[20] L.Choong-Hoon, O.Hwang-Seok and L. Heung-Kyu, “Adaptive video watermarking using motion information”, In: Proceedings of the SPIE security and watermarking of multimedia contents II, vol. 3971, 2000, pp 209–216.

[21] B. Chen and G.W.Wornell, “Quantization index modulation: a class of provably good methods for digital watermarking and information embedding,” in Proceedings of the IEEE International Symposium on Information Theory (ISIT “00), Sorrento, Italy, June 2000.

[22] J.Zhang, J.Li and L.Zhang , “Video watermark technique in motion vector”, In: Proceedings of XIV Brazilian symposium on computer graphics and image processing, 2001, pp.179–182.

[23] J. Liu, K.Nie and Z.He, “ Blind separation by redundancy reduction in a recurrent neural network”, Chin J Electron., vol.10, no.3, 2001, pp.415–419.

[24] K. Solanki, N. Jacobsen, S. Chandrasekaran, U. Madhow and B.Manjunath, “High-vol. data hiding in images: introducing perceptual criteria into quantization based embedding,” in

Proceedings of the IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP "02), vol. 4, 2002,pp. 3485– 3488.

[25] J.Sun and J. Liu, "A temporal desynchronization resilient video watermarking scheme based on independent component analysis", IEEE international conference on image processing (ICIP 2005) , 2005, pp.265–268.

[26] M.Koubaa, C.Ben Amar and H.Nicolas, "Adaptive video watermarking using mosaic images", In: International conference on signal processing and communications, 2007, pp 1143–1146.

[27] Zhaowan Sun, Ju Liu and Jiande Sun, "A Motion Location Based Video Watermarking Scheme Using ICA to Extract Dynamic Frames", Neural Computing and Applications, vol. 18, no.5, 2009, pp. 507-514.

[28] J.Hussein and A.Mohammed, "Robust video watermarking using multi-band wavelet transform", International Journal of Computer Science , vol.6, no.1, 2009, pp.44–49.

[29] Mansouri, A. M. Aznaveh, F. Torkamani-Azar and F. Kurugollu, "A Low Complexity Video Watermarking in H.264 Compressed Domain," in IEEE Transactions on Information Forensics and Security, vol. 5, no. 4, 2010, pp. 649-657.

[30] Emad E. Abdallah, A. Ben Hamza and Prabir Bhattacharya, "Video watermarking using wavelet transform and tensor algebra", Signal, Image and Video Processing, vol. 4, no.2, 2010, pp 233–245.

[31] Maher El"Arbi, M.Koubaa, M.Charfeddine and Ben Amar, "A dynamic video watermarking algorithm in fast motion areas in the wavelet domain", Multimedia Tools and Applications, vol. 55, no. 3, 2011, pp. 579-600.

[32] Ali, U.M., Kumar, E.V. and Kumar, A.J.S. "Wavelet based Watermarking Techniques using Principal Component Analysis Domain", International Journal of Computer Applications (IJCA), no. 3,2012, pp. 14-19.

[33] Yassin, NI, Salem, NM and El Adawy, "Block based video watermarking scheme using wavelet transform and principle component analysis", IJCSI International Journal of Computer Science Issues, vol. 9, no. 3, 2012, pp. 296-301.

[34] Kashyap, N. and Sinha, G.R., "Image Watermarking Using 3-Level Discrete Wavelet Transform (DWT)", International Journal of Modern Education and Computer Science, vol.3, 2012, pp. 50-56.

[35] Bhatnagar, G. and Raman, B., “Wavelet packet transform-based robust video watermarking technique”, Indian Academy of Sciences, vol. 37, Part 3, 2012, pp.371– 388.

[36] Kshama S. Karpe and Prachi Mukherji, “Hybrid Digital image Watermarking Technique Based on Discrete Wavelet Transform (DWT) and non blind method”, International Conference on Electronics and Communication Engineering (ICECE) -12th Sept, 2014.

[37] Osama S.Faragallah, “Efficient Video Watermarking based on singular value decomposition in the discrete wavelet transform domain”, International Journal of Electronics and Communications (AEU), vol. 67, no. 3, 2013, pp. 189-196.

[38] Jiang Xuemei, Liu Quan and Wu Qiaoyan, “A new video watermarking algorithm based on shot segmentation and block classification”, Multimedia Tools and Applications, vol. 62, no.3, 2013, pp 545–560.

[39] B.Sridhar and C.Arun, “Security Enhancement in Video Watermarking using Wavelet Transform”, Journal of Theoretical and Applied Information Technology (JATIT), vol.62, no.3, 2014, pp 733-739.

[40] N.I.Yassin, N.M.Salem and M.I.El Adawy, “QIM blind video watermarking scheme based on Wavelet transform and principal component analysis”, Alexandria Engineering Journal, vol. 53, no. 4, 2014, pp. 833-842.

[41] M.Asikuzzaman, M.J.Alam, A.J.Lambert and M.R.Pickering, “Imperceptible and robust blind video watermarking using chrominance embedding: A set of approaches in the DT CWT domain”, IEEE Transactions on Information Forensics and Security, vol. 9, no. 9, 2014, pp. 1502-1517.

[42] B.Sridhar and C.Arun, “Secure Video Watermarking Algorithm based on Wavelet with Multiple Watermarks”, Latin American Applied Research, Vol.45, no.3, pp.207-212, July- 2015.

[43] Shuvendu Rana, Nilkanta Sahu and Arijit Sur, “Robust watermarking for resolution and quality scalable video sequence”, Multimedia Tools and Applications, 2015, Vol. 74, no.18, pp 7773–7802

[44] B.Sridhar and C.Arun, “An Interlacing Technique-Based Blind Video Watermarking Using Wavelet”, World Academy of Science, Engineering and Technology, vol. 9, no. 6, 2015, pp.1341-1344.

[45] Cabir Vural and Burhan Barakli, “Reversible Video watermarking using motion-compensated frame interpolation error expansion”, Signal, Image and Video Processing, vol. 9, no. 7, 2015,pp 1613–1623.

[46] B.Sridhar and C.Arun, “An Enhanced Approach in Video Watermarking with Multiple Watermarks Using Wavelet”, Journal of Communications Technology and Electronics, vol. 61, no. 2, 2016, pp. 165-175.

[47] H. Tian, Y. Xiao, G. Cao, J. Ding and B. Ou, “Robust watermarking of mobile video resistant against barrel distortion”, in China Communications, vol. 13, no. 9, 2016, pp. 131-138.

[48] Z. Ma, J. Huang, M. Jiang and X. Niu, “A Video Watermarking DRM Method Based on H.264 Compressed Domain with Low Bit-Rate Increasement”, in Chinese Journal of Electronics, vol. 25, no. 4, 2016, pp. 641-647.

[49] Farnaz Arab,Shahidan M. Abdullah, Siti Zaiton Mohd Hashim, Azizah Abdul Manaf and Mazdak Zamani, “A robust video watermarking technique for the tamper detection of surveillance systems”, Multimedia Tools and Applications, vol. 75, no.18, 2016, pp 10855–10885.

[50] Pejman Rasti, Salma Samiei, Mary Agoyi, Sergio Escalera and Gholamreza Anbarjafari, “Robust non-blind color video watermarking using QR decomposition and entropy analysis”, Journal of Visual Communication and Image Representation, vol. 38, 2016, pp. 838-847

[51] L. Agilandeeswari and K. Ganesan, “A robust color video watermarking scheme based on hybrid embedding techniques”, Multimedia Tools and Applications, vol. 75, no. 14, 2016, pp 8745–8780

[52] H. Unno, R. Yamkum, C. Bunporn and K. Uehira, “A New Displaying Technology for Information Hiding Using Temporally Brightness Modulated Pattern”, in IEEE Transactions on Industry Applications, vol. 53, no. 1, 2017, pp. 596-601.

[53] Nilkanta Sahu and Arijit Sur, “SIFT based video watermarking resistant to temporal scaling”, Journal of Visual Communication and Image Representation, vol. 45, 2017, pp. 77-86.