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A Survey on Different Video Watermarking Techniques and Comparative Analysis

A.V.Paramkusam
Professor, Department of Electronics and Communication Engineering,
MLR Institute of Technology, Dundigal, Hyderabad, Telangana, India.
Orcid Id: 0000-0001-5652-9550

J. Chandra Shekar
Assistant Professor, Department of Electronics and Communication Engineering,
MLR Institute of Technology, Dundigal, Hyderabad, Telangana, India.

MD. Abdul Rawoof
Assistant Professor, Department of Electronics and Communication Engineering,
MLR Institute of Technology, Dundigal, Hyderabad, Telangana, India.

G Manisha
Assistant Professor, Department of Electronics and Communication Engineering,
Institute of Aeronautical Engineering, Dundigal, Hyderabad, Telangana, India.

Abstract

Digital video watermarking provides the copyright protection of the video by hiding appropriate information in the original video. Earlier digital video watermarking algorithms based on frequency domain methods were explored, but at present the focus is laid on embedding the watermark in compressed domain with certain amendments. The compressed video watermarking has been drawing much attention since the time when video signals were stored and conveyed in packed format. In this article, a survey on different video watermarking techniques with comparative analysis along with the performance of five different algorithms was assessed with regard to two metrics, imperceptibility and robustness, on different types of video sequences.

Keywords: Singular value decomposition, Video Watermarking, Payload.

INTRODUCTION

The evolution of the Internet and the augmentation of the digital multimedia technology have not only permitted the people to practice, dispense and accumulate digital content effortlessly, but also have endowed the ability of replicating it swiftly and absolutely without loss of quality, with no restriction on the number of copies, avoiding and hacking without authorization. Service providers are unwilling to extend services in digital form, even though digital data comprise various advantages in contrast to analog data, as they panic unimpeded replication and spreading of copyrighted material.

The intellectual property ought to be guarded [1]. The consequences of illegal replication on a huge scale made the content creators and owners more anxious. This issue is not just theoretical. The financial damage due to illicit replication of copyrighted materials [2] runs into billions of dollars. Hence, there is an enormous requirement for the methods which can safeguard the financial value of digital video and preserve the rights of content owners. The watermark contains information of the origin, ownership, destination, copy control and transaction. A watermark can hold any information but the quantity of information is restricted. The information gets affected if the watermark holds more information. Moreover, the capacity of watermark is limited by the size of a particular video sequence.

There are primarily three assessment constraints in video watermarking and at the same time there is an intricate trade-off among these constraints which are imperceptibility, robustness and payload. Simultaneously, security (authoritative persons only can spot the watermark) and complexity (number of computations incorporated while embedding and extracting the watermark) are the two requirements for the efficient and robust watermarking techniques.

WATERMARKING OVERVIEW

Watermark Theory**:** The watermark contains information of the origin, ownership, destination, copy control and transaction. A watermark is inserted into cover content like a digital code into a video sequence. A watermark can hold any information but the quantity of information is restricted. The information gets affected if the watermark holds more information. Moreover, the capacity of watermark is limited by the size of a particular video sequence.

There are primarily three assessment constraints in video watermarking and at the same time there is an intricate trade-off among these constraints which are imperceptibility, robustness and payload. Simultaneously, security (authoritative persons only can spot the watermark) and complexity (number of computations incorporated while embedding and extracting the watermark) are the two requirements for the efficient and robust watermarking techniques. Besides the essential obligations, a watermarking technique to succeed as a real-time method ought to gather the following additional requisites for compressed image and video data valid to recording device.

Oblivious**:** Even after lacking the original unwatermarked data, it must be viable to extort the watermark information, as a recorder and a set-top box at their disposal lack the original data.

Low complexity**:** The watermarking techniques cannot be too intricate since they are to be practiced in real time and also utilized in customer products, so they have to be economical. This means that entirely decompressing the data, inserting a watermark and compressing the data; do not constitute a choice for inserting a watermark.

Preserve host data size**:** The dimension of the compressed host data must not be augmented with the watermark. Sending the data over a preset bit-rate channel can create problems like the one in hardware decoders where the buffers rush out of space; otherwise there will be a problem in the synchronization of audio and video incase the dimension of a compressed MPEG-video stream enhances.

Security systems that exploit watermarking methods have in common a sequence of cryptographic methods. Primarily the watermark information has to be encrypted. Consequently, the processed watermark information is appended to the host data in the course of inserting methods. The encryption and inserting methods exercise keys; these keys may differ in time. Cryptography protocols have to look after the key-management intricacy. The center of attention is on extending, analyzing and verifying the inserting methods for watermarks.

Watermark Attacks: This section offers a study of possible attacks on watermarks. Watermark attacks can be organized into four major groups [3]: Simple attacks are theoretically simple. They endeavor to destroy the inserted watermark by amendments to the entire image without any attempt to identify and segregate the watermark. Examples include the frequency reliant compression, noise addition, cropping and adjustment.

Detection-disabling attacks strive to shatter correlation and to make identification of the watermark unattainable. Typically, they make a few geometric alterations akin to zooming, transfer in spatial or temporal direction, rotation, cropping or pixel transformation, deletion or inclusion. The watermark in the cover content can be retrieved with enhanced intelligence by the watermark detector.

Ambiguity attacks try to confound the detector by generating forged watermarked data to lessen the influence of the watermark by inserting numerous extra watermarks so that it becomes obscure. Removal attacks assess or guess the watermark from a number of unusual watermarked copies, detach it and dispose of the watermark. Collusion attack, denoising and utilizing theoretical cryptographic fault of the watermark method are a few examples. A few attacks do not obviously fit into a solitary group.

CLASSIFICATIONS OF WATERMARKING TECHNIQUES

Watermarking techniques can be categorized as fragile, semi-fragile and robust. Lossy transformations applied on the original host signal cannot stay alive by the fragile watermarks; their role is to tamper recognition of the original signal. Imperceptibility is caused by inserting the watermark information into the perceptually trivial parts of the data. Robust watermarks are applied for the sake of copyright safety along with security applications. Thus the challenge is to offer both transparency and robustness, which are technically contradictory parameters.

A robust watermark has to be inserted into the different parts of the data. Semi-fragile watermarks are supposed to be insensate to various familiar transformations like compression, but are ought to be susceptible to image transformations that change the information, such as, restoring a part of the image. From a signal processing approach the challenge in favor of semi-fragile watermarking is to present a watermark that can differentiate information varying as well as uncomplicated signal processing alterations.

The techniques of watermarking are categorized as public and private. The original image is not required by the public or blind watermarking techniques to extract the watermark. Public watermarks are usually used for applications involving a robust watermark, similar to identifying the consumer to avert illegal replication and circulation. The original image is required by the private or non-blind watermarking techniques to confirm the watermark. Private watermarks are required for a few fragile watermarking applications, which involve authentication along with tamper recognition.

Watermarking algorithms can be categorized as spatial-domain, transform-domain or compressed-domain based on the domain in which the watermark is embedded. These algorithms are expanded below. A summary of a huge number of watermarking algorithms in the dissimilar domains can be learned in [4].

SPATIAL DOMAIN WATERMARKING

The watermark is inserted directly into pixels in the spatial domain watermarking schemes. Numerous spatial watermarking techniques present easy and efficient methods for inserting a watermark into an image. But they are not robust enough to regular attacks. In the spatial domain, watermarking schemes are not robust enough to attacks like noise, such as, JPEG lossy compression. But, the watermark can be recovered effortlessly despite the fact that the image is cropped or deciphered. We present here some of the methods in spatial domain. Hartung et. al [4] have given some spatial domain techniques. Delaigle et. al [5]-[6] established the notion of tagging images to conceal information and guarantee ownership privileges. Next, Mansouri et. al [7] explained the unofficial image circulation. They projected marking images by means of spatial signal modulation and entitled the process as tagging.

A squared tag consisted of a stable value relative to the utmost image intensity inside the square and decomposed the exterior border. An elected image region is tagged by accumulating or deducting the tag along with a random, zero mean, noise model. In the same year, Alattar et. al accepted the significance of digital watermarking and probable applications in favor of image tagging, copyright enforcement, forged security, and restricted entry to image data [8]. In their method, the resultant m-sequence PN code is inserted as watermark in the least significant bit (LSB) plane of the image data. This method is, in fact, an addition to basic LSB coding methods wherein the LSBs are substituted by the coding information.

The proposal of applying m-sequences along with LSB accumulation was extended and enhanced by the authors as a result of utilizing 2-D m-sequences, with the outcome of more robust watermarks [9]. G. Doerr et. al projected quite a lot of watermarking algorithms [10]. Their initial scheme depending on predictive coding method was applied on gray scale images; their subsequent scheme adapts the ordered dithering method in favor of binary pictures. Moreover, in their final method the watermark is inserted within the facsimile documents. From the time when the above schemes were originated, investigations and awareness in watermarking have augmented extensively.

In the primary method entitled, Patchwork, arbitrarily preferred pixel pairs are employed to conceal one bit, by escalating individual pixel by one and declining the further pixel by one. In the subsequent method, entitled, Texture Block Coding, the watermark is inserted by replicating one image texture block into a different region in the image through a related texture. The watermark can be extracted by computing the autocorrelation function. To raise the effort of spread-spectrum watermarking in the spatial domain, Kutter et. al projected a scheme which entirely works by means of the blue image component (in the RGB color model) to enhance the strength of watermark, while sustaining negligible visual artifacts. Delaigle et. al initiated watermarking, customized to the human visual system (HVS) by means of masking and modulation [5]. In their method, the watermark which is a spatially restricted binary pattern, is low-pass filtered, frequency transformed, masked plus subsequently added to the host image.

TRANSFORM DOMAIN WATERMARKING

Watermark is inserted by transforming the image into the frequency domain by utilizing Discrete Fourier transform (DFT), full-image DCT, block-wise DCT, DWT, Schur, SVD, Hadamard, Fourier-Mellin or supplementary transforms in transform domain watermarking schemes. It is frequently asserted that inserting the watermark in the transform domain is beneficial with regard to perceptibility as well as safety. Designing watermarking techniques in the transform domain is complicated compared with designing spatial domain watermarking techniques. Yet, there are various block DCT-domain techniques, as this transform is applied by several compression standards which include JPEG, MPEG2, H.263, etc. Well-organized watermarking in the DCT domain was initially established in [6]-[7].

In the JPEG coding method, the image is primarily alienated into square blocks of 8×8 size. Afterwards the DCT is calculated for these square blocks. Amongst the pseudo randomly preferred blocks, a couple of mid-frequency coefficients are chosen from among 12 prearranged pairs. To insert a bit, the coefficients are next adapted depending on the bit value such that the variation among them is either positive or negative. Alattar et.al [8]-[9] established perceptual watermarking exploiting the noticeable difference (JND) to ascertain an image-reliant watermark modulation mask. The watermark is inserted into preferred coefficients in both the DCT and wavelet transform domain. In support of DCT coefficients, the perceptual model delineated by Watson et. al exploited frequency and intensity sensitivity in addition to the local contrast masking. This method presents image-reliant masking thresholds for all the DCT blocks of size 8 × 8.

G. Doerr et. al [10] initiated the frequency-domain watermarking for the first time and Cox et. al [11] expanded perceptually adaptive techniques based on modulation. Cox et. al sketched correspondence among their technique and spread-spectrum communication, as the watermark is stretched over a group of visually significant frequency components. M.Noorkami et.al projected watermarking in the frequency domain [12] through the amendment of the phase. The phase of a preferred coefficient of an N1×N2, DFT is adopted to insert a bit by adding a small 'δ'. A discrepancy of their scheme based on the Radon transform was projected in [13].

For methods functioning in other transform domains, the watermark is typically specified by a pseudo-random 2-D model. 2-D wavelet transform decomposes the image and the watermark. A weighted version of the watermark is also added to all sub-bands of the image. As usual the decoding of watermark is based on the NC, connecting the approximate of the inserted watermark and the watermark itself. The dissimilarity among the schemes stretches out in the manner the watermark is weighted consecutively to lessen visual artifacts.

COMPRESSED-DOMAIN VIDEO WATERMARKING

From the time the video signals are stored and disseminated in the compressed format, it is unfeasible initially to decipher the video sequence, insert the watermark, and subsequently re-program it. Consequently, designing low-complexity video watermarking technique to insert the watermark in the compressed domain is appealing. The most of the earlier work in compressed-domain video watermarking showed interest in inserting the watermark into the MPEG2 bit stream.

In the MPEG2 standard, the residual blocks are coded first by the DCT transform, then quantized and reorganized, followed by run-level coding in addition to the variable length coding. Elizee et. al projected two real-time watermarking schemes [14]. Either of the methods inserted the watermark instantly into the MPEG compressed bit stream. The initial method inserted the watermark by varying the variable length codes (VLCs). By choosing appropriate VLCs and compelling their least significant bits (LSB), the watermark is inserted to match the subsequent watermark bits. The next scheme eliminated a few of the high-frequency DCT coefficients of the bit stream to insert the watermark.

Priyanka Singh et. al [15] proposed an image adaptive DCT-based (IA-DCT) method that employed the visual model depicted in [16]. This method comprises an image-independent part related to frequency sensitivity as well as an image-dependent part related to luminance sensitivity, along with contrast masking. IA-DCT techniques have been developed to video by them. Employing the IA-DCT watermarking technique at all the I-frames and relating the linear interpolation of the watermarks to the frames among two successive I-frames made it possible to acquire the preeminent visual quality. Only some of the newly- published papers have concerted on inserting a watermark in the sequence of H.264 bit-stream.

Qiu et. al proposed a hybrid watermarking scheme that inserted in the DCT domain a robust watermark. A fragile watermark was also inserted in the motion vectors [17]. Their method inserts the watermark inside the compressed H.264 video; however, it is not robust against familiar watermarking attacks. Wu et. al proposed a private watermarking technique of inserting the watermark in I-frames of H.264 [18] that tolerates H.264 compression attacks in I-frames.

VIDEO WATERMARKING TECHNIQUES:

DWT-SVD Video Watermarking Scheme: In this method, a cascade of two primary mathematical transforms, the discrete wavelet transform (DWT) and the Singular value decomposition (SVD), are applied. DWT can recognize areas within specified frame, owing to its exceptional spatio frequency localization properties, in which a watermark can be imperceptibly inserted. In particular, this property permits exploitation of human visual system (HVS) masking effect. If a DWT coefficient is adapted, only the region consequent to that coefficient will be altered. Newly projected DWT-based watermarking algorithms can be determined in [19]-[20].

In SVD-based watermarking a frame is treated as a matrix decomposed by SVD into three matrices: U, S and Vt. The majority, if not all, of SVD-based watermarking techniques append the watermark data to the singular value ‘σ’ of the diagonal matrix ‘S’ in an approach to convene the imperceptibility and robustness of experiments. In this method watermark bits are not inserted directly into the wavelet coefficients, but rather on the elements of singular values of the matrices 'S' of the frames DWT sub-bands. The SVD operation SVD (A) generates the matrices USV.B

Scene Based Video Watermarking Scheme: This method is based on scene changes [19]. In this method, the input is taken as a video and afterward a watermark is decomposed into dissimilar parts which are inserted into successive frames of dissimilar scenes in the original video. Since applying a fixed image watermark to all frames in the video adds to the difficulty of sustaining statistical and perceptual invisibility, this method uses independent watermarks for consecutive but dissimilar scenes.

Conversely, applying independent watermarks to all frames in addition, presents a difficulty if regions in all video frames retain little or no motion frame after frame. These motionless regions might be statistically contrasted or averaged to take away the independent watermarks. Hence an identical watermark surrounded by every motionless scene is exploited. Through these mechanisms, this method is robust against attacks of frame dropping, frame averaging, and frame swapping and statistical analysis. In this method, a watermark is scrambled into minute parts in a pre-process and they are inserted into distinct scenes. As a result, the method can defy numerous of attacks towards the video [21]. In this method, the watermark is simply inserted in the centre frequency sub-bands and is based on 4-levels of DWT. The capacity would be declined, if below 4-levels is applied. Moreover, if higher than 4-levels are applied, the watermarked video quality is affected. Furthermore, scene changes are identified from the video by exercising the histogram difference technique on the video stream. If the discrepancy among two scenes is greater than the threshold it is regarded as a change of scene. The threshold is obtained as a result of experiments.

The watermark for all scenes can be elected by a pseudo-random permutation, such that just a legitimate watermark detector can reconstruct the original watermark. Since an identical watermark is employed for all frames inside a scene, several copies of all parts of the watermark may be acquired. The watermark is recovered by averaging the watermarks extorted from different frames [11].

Video Watermarking Scheme Based on Genetic Algorithm: The Video Watermarking scheme based on DWT and GA has been projected to carry on three-DWT to the video frame behind the scene analysis as elucidated in the scene-based video watermarking. In this scheme, GA is employed to insert the watermark image that has been altered by Arnold scrambling algorithm and ensures that the hidden data are visually indiscernible. GA is a novel type of optimization which is developed based on the natural selection as well as the exploration of iterative adaptive probability of genetic mechanism. Typically, a natural GA is primarily alienated into three parts, namely selection, crossover and mutation. Its basic processing flowchart is depicted in Fig 1.

GA is an individual process of the new generation that performs the crossing variant to form, starting from the population in a convinced dimension through the option of parents that has progressed into seeking the maximum benefit in space and has a convergence there. Scrambling algorithm is a type of encryption to the watermark image. It is a reversible transform. Two features ought to be considered with the use of scrambling technology in watermark algorithm. Initially the computation load is supposed to be as little as possible and next, the scrambling must be as large as feasible. Thus the security and secrecy are improved with the Arnold scrambling algorithm. Simultaneously the algorithm surmounts the non-recovery of the random substitution. Thus the scene division to the video frequency frame is made and the pre-processed watermark image is inserted into a particular scene by exploiting GA. The size of population is set as 20 in the GA, the largest of the evolution of generation is 200, the probability of crossover is 0.5, the mutation rate is 0.05 and frame size is 352*288 video for testing.

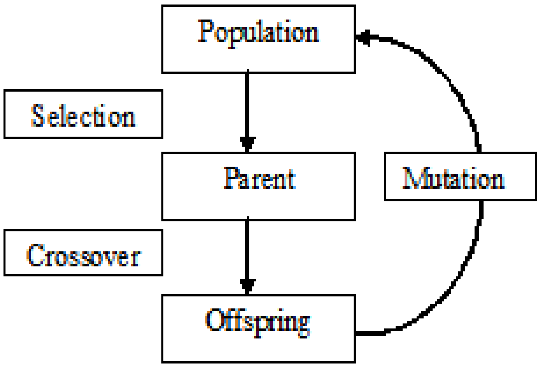

Figure 1: GA Basic processing.

Video Watermarking Based on Motion Characteristics Detection And Model Of Entropy: It is a new self-adaptive video watermarking in which amalgamation of motion characteristics detection with the model of entropy is projected. By connecting the HVS with the block–matching techniques they attained the motion information of all macroblocks in video sequence such as the velocity, the motion angle, and the deformation. According to the entropy of motion information in each macro-block and the human visual masking system, a set of non-linear formulas have been exercised to compute the maximum embedding strength of each block in the video sequence to enhance the imperceptibility of watermarking. In this method, primarily they took the inter-frame and temporal characteristics of video into consideration to compute the embedding strength of videos. Secondly they adopt a suitable mode of motion entropy to decide and subdivide the content of the videos according to visual characteristics of HVS. Thirdly, they united the temporal visual masking with the still image visual masking to analyze the maximum embedding strength to assure the imperceptibility and the robustness according to the content of the videos. The experimental evaluation reveals that the video watermarking algorithm has outstanding imperceptibility and robustness. This method can be merged with GA for the selection of watermark image to be inserted into subsequent detailed band depending on the visual masking of video.

Video Watermarking Scheme Based on Principal Component Analysis : A video file is a continuous collection of static images and all images are composed of three color channels. This method permits insertion of the watermark into three color channels, RGB, of an input video file. In this method, the video stream is separated into sequences, next to scenes, afterwards to shots, and at last they extort each frame in each shot, and insert the watermark in each frame to attain robustness. In digital image processing field, the PCA are also called the KL transform and regarded as a linear transform technique to express most of the information in relation to the image to principal components. In this method, first each frame is separated into three RGB color channels and independently the PCA transform is applied to each of the sub-frames prior to proper watermarking procedure and then extort the principal component of sub pixels of all sub frames by finding the PCA transformation matrix. Each sub pixel is transformed by the PCA transformation matrix [φ]. Thus PCA based watermarking method permits choice of suitable PCA coefficients for inserting and reveals that it is forever feasible to watermark a color video file without influencing its perceptual quality.

SIMULATION RESULTS AND PERFORMANCE EVALUATION

The performance of the five dissimilar algorithms was assessed by doing simulations with regard to two metrics: Imperceptibility and Robustness.

Imperceptibility Results: As a measure of quality of watermarked image, the peak signal to noise ratio is used. Highest PSNR is attained among the discussed algorithms when the Principal Component Analysis algorithm is used.

Robustness Results: Robustness is a measure of immunity of watermark against efforts to eliminate or demean it by distinct types of digital signal processing attacks. In video watermarking application, robustness is measured against two types of attacks: standard and frame attacks. Standard attacks comprise compression, rotation, Gaussian noise, salt & pepper noise among several others [22]. Frame attacks consist of frame swapping, frame dropping, frame averaging, etc. For either types of attacks we measured the similarity linking the original and extracted watermarks by means of the correlation factor 'ρ' which may take values between '0' to '1'. In Table 1, we contrasted the results acquired by making use of five different algorithms. High PSNR is accomplished by making use of Principal Component Analysis algorithm. DWT-SVD scheme is mainly robust to lossy compression. Motion characteristics and model of entropy algorithms can defend against frame averaging and frame swapping attack. In addition to this, wavelet transform with Genetic Algorithm is for the most part robust against noise attack and frame dropping attack and its fidelity can be improved.

Table 1: Comparison between correlation values and PSNR acquired using disparate algorithms.

Attacks	DWT-SVD	Scene-based	DWT With GA	Motion char's &model of Entropy	PCA
PSNR	48.13	48.59	49.20	51.36	55.32
Compression	0.95	0.54	0.85	0.51	0.73
Frame averaging	0.9	0.69	___	1	0.63
Frame dropping	0.88	0.63	0.9	___	0.91
Noise attack	0.679	0.63	0.89	0.8	0.70
Frame swapping	___	___	___	1	0.75

CONCLUSION

Since the volume of literature accessible in the field is vast, we focus on review of techniques for video watermarking relevant works only are mentioned. Simulations are conducted to reveal that all the schemes are robust against attacks, such as, frame dropping, frame averaging, frame swapping, compression, noise addition and statistical analysis. The imperceptibility was also measured by evaluating the PSNR All the schemes are resistant to attacks based on video characteristics and image processing techniques. The efficacy of all the schemes is determined through a number of tests. We executed a sequence of simulations to verify its effectiveness. These watermarking schemes can further be allied with disparate applications to attain a refined system as well as the concept of genetic algorithm, and motion estimation can be amalgamated to get improved robustness and imperceptibility results. This research can also be expanded by relating the scheme to precise environments or applications and test its effectiveness. Thus embedding the watermark in compressed domain and exploiting the hybridization of different transforms along with the optimization techniques, can further improve the efficiency of results in terms of PSNR, NC and payload

REFERENCES

[1] E. T. Lin, A. M. Eskicioglu, R. L. Lagendijk, and E. J. Delp, "Advances in digital video content protection," Proceedings of the IEEE: Special Issue on Advances in Video Coding and Delivery, vol. 93, no. 1, pp. 171–183, Jan. 2005.

[2] J. Litman, Digital Copyright. Amherst, NY: Prometheus Books, 2001.

[3] Frank Hartung, Jonathan K. Su and Bernd Girod: Spread Spectrum Watermarking: Malicious Attacks and Counterattacks. Security and Watermarking of Multimedia Contents, 1999.

[4] Hartung, F. and Kutter, M., "Multimedia watermarking techniques", Proceedings of the IEEE, vol. 87, pp. 1079–1107, July 1999.

[5] Delaigle, J.F., Vleeschouwer, C. D., and Macq, B., "Digital watermarking", in Proceedings of the SPIE - The International Society for Optical Engineering, vol. 2659, (San Jose, CA, USA), pp. 99–110, February 1996.

[6] H. A. Aly, "Data Hiding in Motion Vectors of Compressed Video Based on Their Associated Prediction Error", IEEE Transactions on Information Forensics and Security. 2011, pp.14-18.

[7] Azadeh Mansouri, Ahmad Mahmoudi Aznaveh, FarahTarkamani-Azar, Fatih Kurugollu," A low complexity video watermarking in H.264 Compressed domain", IEEE Transactions of Information Forensics and Security, Vol.5, NO.4, December 2010.

[8] A. M. Alattar, E. T. Lin, and M. U. Celik, "Digital watermarking of low bit rate advanced simple profile MPEG-4 compressed video," IEEE Transactions on Circuits and Systems for Video Technology, vol. 13, no. 8, pp. 787–800, Aug. 2003.

[9] G. Langelaar and R. Lagendijk, "Optimal differential energy watermarking of DCT encoded images and video," IEEE Transactions on Image Processing, vol. 10, no. 1, pp. 148–158, Jan. 2001.

[10] G. Doerr and J.L. Dugelay, "Security pitfalls of frame-by-frame approaches to video watermarking," IEEE Transactions on Signal Processing: Supplement on Secure Media, vol. 52, no. 10, pp. 2955–2964, Oct. 2004.

[11] Cox, I. J., Kilian, J., Leighton, F. T., and Shamoon, T., "Secure spread spectrum watermarking for multimedia", IEEE Transactions on Image Processing, vol. 6, pp. 1673–1687, December 1997.

[12] M.Noorkami and R.M.Mersereau, "Digital Video Watermarking in P frames with controlled video bit rate increase", IEEE Transactions on Information Forensics and Security. vol. 3, no.3, September 2008, pp.441-455.

[13] B. Chandra Mohan and K. Veera Swamy Z, " On the use of Schur Decomposition for Copyright Protection of Digital Images", International Journal of Computer and Electrical Engineering, Vol. 2, No. 4, August, 2010, pp. 1793-8163.

[14] Z. A. Elizee, A. Babazadeh, S. Mohammad and S. Hosseini, "Optimizing Product Design through a Particle Swarm Induced Logistic Regression Model," Majlesi Journal of Mechanical Engineering, Vol. 3/ No. 2/ Winter -2010.

[15] Priyanka Singh, and Suneeta Agarwal, "A Hybrid DCT-SVD Based Robust watermarking scheme for copyright protection", International Conference on Emerging Trends in Engineering and Technology (ICETET'2013) Dec. 7-8, 2013 Patong Beach, Phuket (Thailand), pp.1-5.

[16] Anurag Mishra, Charu Agarwal, Arpita Sharma, Punam Bedi, "Optimized gray-scale image watermarking using DWT–SVD and Firefly Algorithm", Expert Systems with Applications 41 (2014) 7858–7867.

[17] Qiu, G., Marziliano, P., Ho, A. T. S., He, D., and Sun, Q., "A hybrid watermarking scheme for H.264/AVC video," in Proceedings of the 17th International Conference on Pattern Recognition, vol. 4, (Cambridge, UK), pp. 865–868, August 2004.

[18] Wu, G.-Z., Wang, Y.-J., and Hsu, W.-H., "Robust watermark embedding/ detection algorithm for H.264," Journal of Electronic Imaging, vol. 14, pp. 13013–1–9, January 2005.

[19] P.Chan and M.Lyu, "A Dwt-based digital video watermarking scheme with error correcting code", in proceedings of the 5th international conference on information and communications security ,2003, pp.202-213.

[20] X.Niu and S.Sun, "A new wavelet based digital watermarking for video", in proceedings of the 9th IEEE digital signal processing workshop, 2000,

pp.241-245.

[21] P.Dang and P.Chau" image encryption for secure internet multimedia applications," IEEE trans. consum. electron ,vol .46, no.3, pp .395-403, Aug 2000.

[22] S.Voloshynovskiy, S.Pereira and T.Pun, "attacks on digital watermarks: classification, estimation,-based attacks and benchmarks", comm. magazine, vol. pp118-126, Aug.2001.