International Journal of Security and Its Applications
Vol.9, No.1 (2015), pp.283-294
http://dx.doi.org/10.14257/ijsia.2015.9.1.27

An Effective Approach of Distortion-Resistant Video Watermarking for Piracy Deterrence

Nilesh Kumar Dubey and Shishir Kumar

Department of Computer Science and Engineering
Jaypee University of Engineering and Technology, Guna, (M.P) India
ndnilesh6@gmail.com, dr.shishir@yahoo.com

Abstract

An effective approach of distortion-resistant video watermarking has been developed and presented through this paper. This watermarking approach is based on the additive spread spectrum way and periodic watermark concept that make it robust. Objective of this work is to protect the piracy of video files. Some time, many illegal copies of videos are found on street market or on the internet before their official release. During copying or after copying the pirate may distort the video by scaling, rotation, translation etc. In this paper, a deterrent system has been proposed which is robust enough against the distortion and can identify the pirate, by embedding a payload into original video that consist the time stamp of video playback. Many experiments are done to prove that the proposed scheme fulfil the invisibility, real time processing and robustness requirements against distortion.

Keywords: *additive spread spectrum, distortion, real time, piracy deterrence, periodic watermark, DCT*

1. Introduction

Piracy of video has become a problem due to use of internet services or storage devices to share it. In most cases the video piracy takes place when it is transmitted from one place to another. Now a day's digital video files are used very frequently for entertainment, learning and information sharing so it required protection against copyright and illegal copying. In copyright protection system a secret message and logo by owner is inserted into a digital media file without affecting its originality. As an ownership problem arises, that who is the original owner then the embedded message is extracted and the original owner can be identified. As a method of copyright protection, digital video watermarking [1-2] has recently emerged as a significant field of interest and a very active area of research. In watermarking a secret message is embedded into a multimedia files and this secret message is known as watermark or digital signature such that the watermark can be detected or extracted later to make an assertion about the object. Multimedia file may be an image, audio or video. Watermarking techniques should fulfil the all required necessary characteristics like perceptibility, robustness against all types of attack and security.

Lots of digital watermarking methods have been developed for still images and videos [6]. Most of them operate on uncompressed videos, while others embed watermarks directly into compressed video [7-12]. There are a number of issues that are in the video Watermarking but not present in image watermarking. Due to duplicity in video frames, video signals are highly susceptible to attacks such as frame averaging, frame dropping, frame swapping and statistical analysis.

All developed watermarking algorithms have been broadly divided into two categories, namely spatial and frequency-domain. In spatial domain watermarking algorithm to directly alter the pixel values of the cover image while the transformed coefficients of the covert images have been altered to embed the watermarks in the frequency domain

ISSN: 1738-9976 IJSIA

algorithm. All developed watermarking algorithms suffer from a variety of malicious and non-malicious attacks. Some algorithms are resistant to one type of attacks, then, on the other side, its robustness may suffer from other type of attacks. Implementation of spatial domain algorithms is easy, however, not robust, while the transform domain techniques are relatively reliable and robust to various attacks [13-14]. The frequency domain algorithms are resistant to filtering and compressions attacks and are generally, rotation, translation and scale invariant. Discrete Cosine Transform (DCT) [15-18] and Discrete Wavelet Transform (DWT) [19-23] are commonly used frequency domain techniques. Our system can be used for identifying the pirate person due to the payload that has been embedded consist the time stamp of video playback, so the suspect list can be limited. In this paper a robust and imperceptible video watermarking algorithm based on additive spread spectrum in the frequency domain is proposed for deterring the pirate. The concept of spread spectrum watermarking has taken from a spread spectrum communication in which a narrow-band signal is transmitted over a much larger bandwidth such that the signal energy presented in a channel is undetectable similar in SS watermarking a watermark is spread over many frequency bins so that the energy in one bin is very small and certainly undetectable. The concept of local weight factor has been used which is computed for each pixel of watermark by a mask or window chosen by Embedder. As a blind detector concept has been used, so there is no need of the original file and weight factor at the place of extraction so the extraction process is fast. In our system a periodic watermark [24] has been used and this periodic watermark can be obtained after tilling the basic pattern, this periodic watermark makes our system more robust against crop and rotation attack. The periodic watermark concept can be used for distortion measure in extracting watermark.

After understanding the scenario, some facts should be assumed. First, the watermark embedding process has to be done in real-time. Second, the embedded watermark must survive to camcorder piracy. The illegal copies were made by recording the projected movie at various angles, according to the location of the pirate. They are suffering from composite geometric distortions, including translation, rotation, scaling, and perspective projection. Therefore, the watermarking system should have the robustness to arbitrary geometric distortions and signal processing attacks that are accompanied with camcorder piracy.

In our system the watermark embedding and extraction has been done in the frequency domain that provide greater control than spatial domain so DCT concept have been used for transforming an image from the spatial domain to frequency domain. In DCT transformation the image is divided into 8x8 pixel blocks, where each block is transformed into 64 transform coefficients, further, the perceptual mask has been computed to highlight the most significant regions in the spectrum that can support the watermark without affecting the image fidelity.

2. Preliminary of DCT and Spread Spectrum Way

In this section concept of DCT and Spread spectrum has been explained and it is borrowed from mathematics and electronic communication respectively.

2.1. Discrete Cosine Transforms (DCT)

The discrete cosine transforms [30] is a member of a family of sinusoidal unitary transforms [25]. Computationally DCT is a real and fast algorithm and it is similar to the Fourier Transform that transforms a signal from the spatial or time domain to the frequency domain, mainly for watermarking and compressing an image. As after modification in the Fourier Transform [21] can be done in a smaller amount of computation by the use of the Fast Fourier Transform (FFT), similarly the complexity of DCT to compute the DCT coefficient of any icon can also be cut back. A method called the Fast Cosine Transform, or FCT, can be used when N = 2^p, where N is the number of vectors to be transformed and p is a constituent of the whole numbers, and the complexity is cut back, just as with the FFT, from O (N2) computation to a bit of calculations on the decree of O (Nlog2N). The FFT is actually the basis for computing the FCT. The discrete cosine transform represents an image as a sum of sine curves of varying magnitudes and frequencies. The DCT has the property that, for a typical image, most of the visually significant information about the image is concentrated in only a few coefficients of the DCT. For this cause, the DCT is often employed in image compression and watermarking applications. For instance, the DCT is at the center of the international standard lossy image compression algorithm known as JPEG. Further, DCT method is employed in two ways first in blocked based and another is global means. In this paper block based DCT watermarking is used. In this method, a 2D-DCT applies to the frames. Each frame is divided into non- overlapping 8*8 blocks. 2D-DCT is applied to each block and the same is repeated for each frame, by using the following equations:

The 1-D discrete cosine transform is defined as

$$C(u) = a(u)\sum_{x=0}^{N-1} f(x)\cos\left[((2x+1)u\pi)/2N\right]$$

For u = 0, 1, 2… N-1, similarly, the inverse DCT is defined as

$$f(x) = \sum_{x=0}^{N-1} a(u)C(u)\cos\left[((2x+1)u\pi)/2N\right]$$

For x = 0, 1, 2… N-1. In both the equations, α(u) is defined as,

$$a(u) = \sqrt{1/N} \text{ For u=0}$$

$$a(u) = \sqrt{2/N} \text{ For u=1, 2, 3.....N-1}$$

The corresponding 2-D DCT pair is

$$C(u,v) = a(u)b(v)\sum_{x=0}^{N-1}\sum_{y=0}^{N-1} f(x,y)\cos\left[(2x+1)u\pi/2N\right]\cos\left[(2y+1)v\pi/2N\right]$$

For u, v = 0, 1, 2… N-1 and the values C (u, v) are called the DCT coefficients of f(x, y). Similarly the inverse 2-D DCT is defined as

$$f(x,y) = \sum_{x=0}^{N-1}\sum_{y=0}^{N-1} a(u)a(v)C(u,v)\cos\left[(2x+1)u\pi/2N\right]\cos\left[(2y+1)v\pi/2N\right]$$

For x, y = 0, 1, 2… N-1, where α is given as

$$a(u) = \sqrt{1/N} \text{ For u=0}$$

$$a(u) = \sqrt{2/N} \text{ For u=1, 2, 3.....N-1,}$$

$$\text{And } a(v) = \sqrt{1/N} \text{ For u=0}$$

$$a(v) = \sqrt{2/N} \text{ For u=1, 2, 3.....N-1}$$

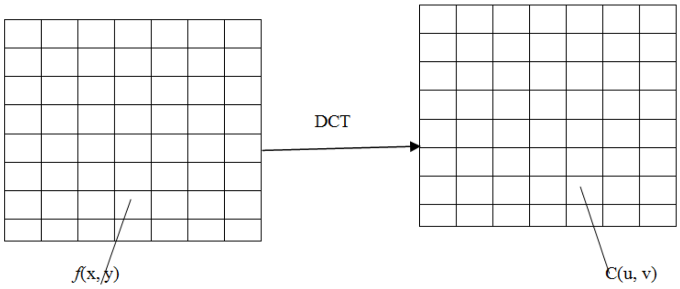


Figure 2.1. Spatial Domain to the Frequency Domain using DCT

2.2. Spread Spectrum (SS) Way

Concept on the spread spectrum way of watermarking has been borrowed from spread spectrum communication in which a narrow band signal is transmitted through wider bandwidth channel such a way that harder to intercept or detect, similarly in watermarking the image or video is treated as a communication channel, and correspondingly, a watermark is treated as a signal that is transmitted through it. Attack and other unintentional interception are thus treated as noise that the immersed signal must be immune. Passing around the watermark throughout the spectrum of an image ensures a great bill of security against unintentional or intentional attack: First, the placement of the watermark is not recognized.

Furthermore, frequency regions should be selected in a manner that ensures severe degradation of the original data following an onslaught on the watermark. A watermark that is well placed in the frequency domain of an image or in the video will be practically impossible to see or perceived [26]. This will forever be the case if the vigor in the watermark is sufficiently diminished in any single frequency coefficient. Moreover, it is possible to increase the vitality present in particular frequencies by exploiting knowledge of masking phenomena in the human visual systems. Perception masking refers to any situation information in certain areas of an image or in a video is occluded by perceptually more salient information in another portion of the picture.

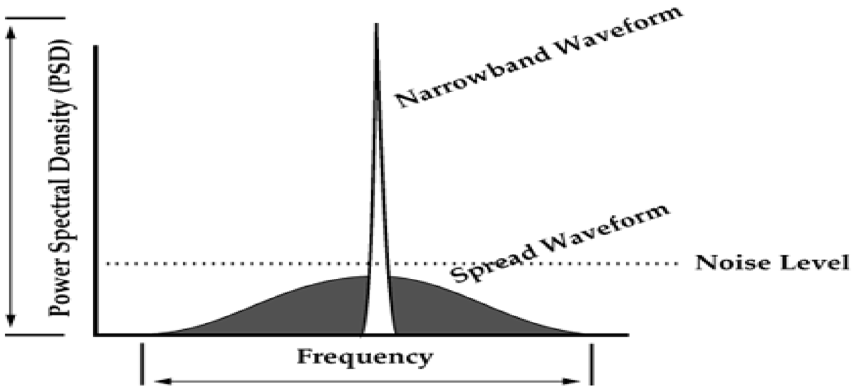


Figure 2.2. Concept of Spread Spectrum Communication

3. Proposed Scheme

The suggested system is built up to make the watermarking scheme robust against distortion. There are many video watermarking scheme has been broken to protect the video file from piracy and fraud ownership, but there are lots of attack that becomes the barrier of watermarking system one of them is a straining that is may be intentional or due to piracy device you can say that unintentional distortion. Our purpose to develop the watermarking system is to make it resistant against the distortion that is may be in the form of translation, rotation, scaling or composite. Our proposed scheme is based on spread spectrum way of watermarking with periodic watermark which make our system robust against all attacks that is defined above.

This segment is at present split into two sub part in one part the detailed watermark embedding process and in the next part watermark extraction process is mentioned:

3.1. Watermark Embedding

In this paper YCbCr [28] color space has been used for watermarking because it provides greater control over the video. In YCbCr, Y stands for luminance value and CbCr for the color part in which, the cab part represents the blue and a reference value differences and the Cr part represents the red and a reference value difference. The relationship between RGB and YCbCr color model is given below,

$$\begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix} = \begin{bmatrix} 16 \\ 128 \\ 128 \end{bmatrix} + \begin{pmatrix} 65.481 & 128.553 & 24.966 \\ -37.797 & -74.203 & 112.000 \\ 112.000 & -93.786 & -18.214 \end{pmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

Again, for the transformation of YCbCr to RGB color model is given as,

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{pmatrix} 1 & 1 & 1 \\ 0 & -0.344 & 1.770 \\ 1.103 & -0.714 & 0 \end{pmatrix} \begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix}$$

The watermark pattern is produced and then embedded into the video frames based on spread spectrum way, taking the human visual system (HVS) into account. The watermark pattern should have periodicity to make our system robust against distortion. The periodicity is obtained by tiling the basic pattern [24]. The basic pattern for a periodic watermark, which conforms a Gaussian distribution with zero mean and unit variance, is generated using a secret key. Tilling of basic pattern means repeat the basic pattern horizontally and vertically. Suppose our basic pattern is of size (M/m * N/n) then repeat it m * n time to get a periodic watermark of size M * N, where M and N denote height and width of a video frame, and m and n denote the number of repetitions in horizontal and vertical direction respectively.

Embedding Algorithm:

Step1: convert input cover video into frames
Step2: convert frames into image and apply RGB to YCbCr conversion.
Step3: apply 2D-DCT transform on Y component of each cover video frame.
Step4: apply perceptual masking on each transformed video frame to identify significance area for watermarking.
Step5: watermark is embedded using an additive spread spectrum method while following the below formula.

$$F_w(x,y)=F(x, y)+\eta £(x, y)*w(x, y)$$

Where η is a global weight factor and £ is the local weight factor of the pixel (x, y) from HVS and w(x, y) is the periodic watermark generated after tiling the basic periodic watermark. £ can be computed for the each video frame by selecting a suitable 3*3 mask. Here compass operator has been used as a local weighting mask [27]. The compass operator measures gradients in a selected number of directions and can reduce computational costs by utilizing its separable property.

3.2. Watermark Extraction

A blind detector has been used for watermark extraction. The embedded watermark is extracted by using the Wiener filter [28] as a dancing filter. Subtracting the de-noised frame from the watermarked frame, an approximate version of the embedded watermark pattern has been obtained. The Wiener filter valuates the original signal from the watermarked frame:

$$F'(x,\ y) \ = \mu(x,y) + ?\frac{\sigma^2(x,y) - v^2}{\sigma^2(x,y)} \ F_w(x,y) - \mu(x,y))$$

Where $\mu(x,y)$ and $\sigma^2(x,y)$ are the local mean and local variance of the F_w, respectively. v^2 is the noise variance. Since the extractor has no knowledge about the probability distribution of the noise, so average of the local variances is chosen as v^2 . The estimated watermark w' that is yielded by the Wiener filter is given by:

$$w' = \ F_w(x,\ y) - \ F'(x,y)$$

For the goal of heightening the vitality of the valuated watermark, the values of each pixel of the valuated watermark from each frame have been summarized in the series of frames for t seconds.

For computing local mean of the image any averaging mask of 3*3 has been used.

4. Experimental Analysis

I have taken a test video file of size 640*360 which is consisting 180 frames. The secret timestamp size is 64*64.The global weight factor η value 0.3 is selected. The experiment is performed in MATLAB 2012a. The PSNR of our method is 53.05db.

Figure 4.1. Basic Watermark

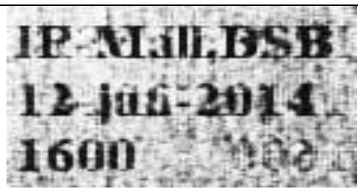
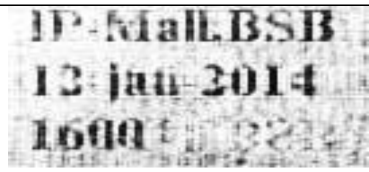
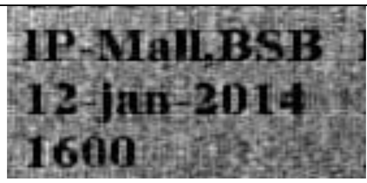
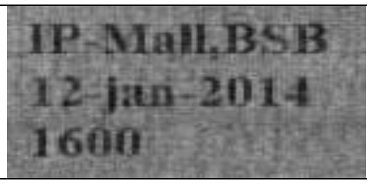
Figure 4.2. Original Periodic Watermark

Figure 4.3. Original Video Frame

Figure 4.4. Watermarked Video Frame

Figure 4.5. Extracted Periodic Watermark

Table 1. Extracted Watermark Frame after the Attack with its Normalized Correlation Coefficient

S. No.	Type of attack	NCC	Extracted Watermark
1	Salt &pepper Noise (Density=0.001)	0.834	
2	Gaussian Noise (mean=0, Variance=0.001)	0.712	
3	Frame Removal	0.934	
4	Frame Averaging	0.923	

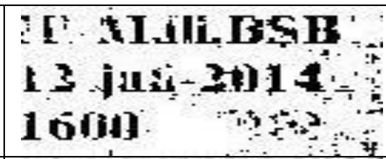
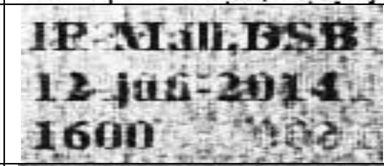
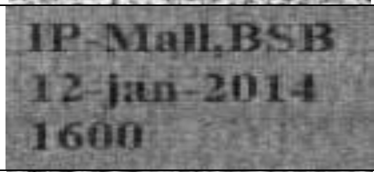
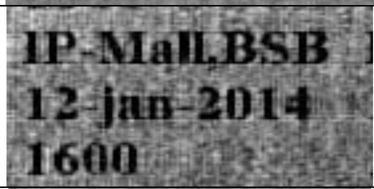
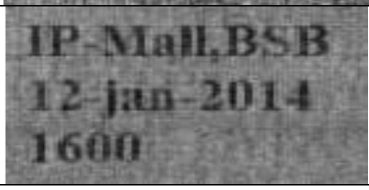
5	**MPEG-4**	**0.812**	
6	**Compressed JPEG AVI**	**0.723**	
7	**Averaging Filter**	**0.834**	
8	**Rotation**	**0.923**	
9	**Frame Resizing**	**0.940**	

Table 2. Comparison of Performance

Parameter	Lu Jianfeng Method [29]	Proposed method
Average PSNR(db)	**36.29**	**49.54**
No. of attack Applied	**4**	**9**

Cross correlation coefficient: The correlation co-efficient is another parameter like PSNR to evaluate the validity of the watermarking algorithm against the potential approaches. The maximum value of this coefficient can be 1 and the minimum value can be 0. 0 coefficient value indicates that the given two images or watermark is unrelated and 1 means highly correlated. The correlation co-efficient between the original watermark (w) and extracted watermark (w’) after possible attack is figure out using the following formula:

$$NCC = \frac{\sum_{i=1}^{M} \sum_{j=1}^{N} w(i,j) * w'(i,j)}{\sum_{i=1}^{M} \sum_{j=1}^{N} w(i,j)^2}$$

5. Conclusion

In this paper, an additive spread spectrum watermarking technique has been practiced with a concept of periodic watermark, which prepare it robust against the geometric distortion. In this paper the local weight factor has been used during watermark embedding by which embedded watermark become robust. A video is divided into frames then the RGB video is divided into luminance and chroma components with the help of rgb2ycbcr. The video is embedded in luminance component, i.e. Y, because our eye is less sensitive to the luminance factor and sensitive to the color factor. Each block is transformed into DCT domain by using two dimensional discrete cosine transform equation.

References

[1] M. Natarajan, G. Makhdumi, Safeguarding the Digital Contents: Digital Watermarking", DESIDOC Journal of Library & Information Technology, **(2009)**, vol. 29, pp. 29-35.

[2] C. I. Podilchuk and E. J. Delp, "Digital watermarking: algorithms and application", IEEE-Signal Processing Magazine **(2001)**, vol. 18, pp. 33-46.

[3] G. Doerr, J.L. Dugelay, "Security Pitfall of Frame by Frame Approaches to Video Watermarking", Signal Processing IEEE Transaction **(2004)**, vol. 52, pp. 2955-2964.

[4] M. K. Thakur, V. Saxena and J. P.Gupta, "A Performance Analysis of Objective Video Quality Metrics for Digital Video Watermarking", Computer Science and Information Technology, 3rd IEEE International Conference **(2010)**, vol. 4, pp. 12-17.

[5] S. Voloshynovskiy, S. Pereira and T. Pun, "Watermark Attacks. Erlangen Watermarking Workshop 99", **(1999)**.

[6] G. Langelaar, I. Setyawan, and R. Lagendijk, "Watermarking Digital Image and Video Data: A State of - Art Overview", IEEESignal Processing Magazine **(2000)**, vol. 34, pp. 20-46.

[7] F. Hartung and B. Girod, "Watermarking of uncompressed and compressed video", Signal Processing vol. 66, (**1998),** pp. 283-301.

[8] T. Tokar, T. Kanocz and D. Levicky, "Digital watermarking of uncompressed video in spatial domain", 9th International Conference on Radioelectronica, IEEE, **(2009),** pp. 319-322.

[9] P. W. Chan, M. R. Lyu and R. T. Chin, "A Novel Scheme for Hybrid Digital Video Watermarking", IEEE Transactions on Circuits and Systems For Video Technology, vol. 15, no. 12, **(2005)**.

[10] G. Doerr and J. L. Dugelay, "A guide tour of video watermarking", Signal Processing: Image Commun., vol. 18, no. 4, **(2003)**, pp. 263-282.

[11] Y. R. Lin, H.Y. Huang and W. H. Hsu, "An embedded watermark technique in video for copyright protection", IEEE, 18th International Conference on Pattern Recognition, vol-00, **(2006)**, pp. 795-798.

[12] S. Sinha, P. Bardhan and S. Pramanick, "Digital Video Watermarking using Discrete Wavelet Transform and Principal Component Analysis", International Journal of Wisdom Based Computing, vol. 1, **(2011)**, pp. 7-12.

[13] I. Cox, J. Kilian, T. Leighton and T. Shamoon, "Secure Spread Spectrum Watermarking for Multimedia", IEEE Trans. Image Process, vol. 6, no. 12, **(1997),** pp. 1673–1687.

[14] H. Qi, D. Zheng and J. Zhao, "Human visual system based adaptive digital image watermarking", Signal Process., vol. 88, **(2008)**, pp. 174–188.

[15] M. Barni, F. Bartolini and Piva, "A DCT domain system for robust image watermarking", IEEE Trans Signal Process., vol. 66, **(1998)**, pp. 357–372.

[16] C. C. Chang, J. C. Chuang and T. S. Chen, "Recognition of image authenticity using significant DCT coefficients quantization", Informatica, vol. 26, no. 4, **(1998)**, pp. 359–366.

[17] C. C. Chang, J. Y. Hsiao and J. C. Yeh, "A color image copyright protection scheme based on visual cryptography and discrete cosine transform", Image Sci. J., vol. 50, **(2002)**, pp. 133–140.

[18] W. C. Chu, "DCT based image watermarking using sub sampling", IEEE Trans Multimedia, vol. 5, **(2003)**, pp. 34–38.

[19] M. Barni, F. Bartolini and Piva, "Improved wavelet based image watermarking through pixel wise masking", IEEE Trans Image Process, vol. 10, no. 5, **(2003)**, pp. 783–791.

[20] P. Pandey, S. Kumar and S. K. Singh, "A robust logo watermarking technique in divisive normalization transform domain", Multimed. Tools Appl. DOI 10.1007/s11042, pp. 1577-7.

[21] W. S. Kim, O. H. Hyung and R. H. Park, "Wavelet based watermarking method for digital images using human visual system", Electron Lett., vol. 35, no. 6, **(2003)**, pp. 466–468.

[22] D. Kundur and D. Hatzinakos, "Towards robust logo watermarking using multi resolution image fusion", IEEE Trans Multimed., vol. 6, **(2004)**, pp. 185–197.

[23] Pandey, S. Kumar and S. K Singh, "Rightful ownership through image adaptive DWT-SVD watermarking algorithm and perceptual tweaking", Multimed Tools Appl DOI 10.1007/s11042 **(2004)**, pp. 1375-2.

[24] M.-Je. ong Lee, K.-S. Kim and H.-K. Lee, "Digital Cinema Watermarking for Estimating the Position of the Pirate", IEEE TRANSACTIONS ON MULTIMEDIA, vol. 12, no. 7, **(2010)**, pp. 605-622.

[25] K. R. Rao and P. C. Yip, "The Transform And Data Compression Handbook",**(2004)**.
[26] I. J. Cox, "Secure Spread Spectrum Watermarking for Multimedia", IEEE TRANSACTIONS ON IMAGE PROCESSING, vol. 6, no. 12, **(1997)**, pp. 1673-1687.
[27] K. S. Kim, H. Y. Lee, D. H. Im, and H. K. Lee, "Practical, real-time, and robust watermarking on the spatial main for high-definition video contents", IEICE Trans. Inf. Syst. vol. E91-D, **(2008)**, pp. 1359-1368.
[28] I. G. Karybali and K. Berberidis, "Efficient spatial image watermarking via new perceptual masking and blind detection schemes", IEEE Trans Inf. Forensics Security, vol. 1, no. 2, **(2006)**, pp. 256-274.
[29] L. Jianfeng, Y. Zhenhua, Y. Fan and L. Li, "A MPEG2 Video Watermarking Algorithm Based on DCT Domain", Institute of Computer Graphics and Image Processing IEEE Computer society **(2011)**, pp. 1-5.
[30] N. Jagdish, "A blind robust video watermarking in DCT", IJEIT **(2011),** vol. 2, no. 2, pp. 128-132.

Authors

Nilesh Kumar Dubey, he has completed B. Tech from Sachdeva Institute of Technology in 2011 and M.Tech from Jaypee University of Engineering and Technology in 2014. Currently he is Assistant Professor in Faculty of Computer Engineering at Charotar University of Science and Technology, Gujrat, India. He is member of ACM computer society, advisory member and reviewer of IJICSE.

Shishir Kumar, he is working as Professor in Jaypee University of Engineering and Technology Guna, India. He has completed his Ph. D. in 2005. He has fifteen years of teaching & research experience in various organizations of repute for PG & UG courses of Computer Science & IT. His area of work is Network Management and Image Processing.