ISSN (Online) 2278-1021
ISSN (Print) 2319-5940
International Journal of Advanced Research in Computer and Communication Engineering (IJARCCE)
International Conference on Recent Trends in Computing and Communication (ICRTCC 2015)
Cochin College of Engineering & Technology
Vol. 4, Special Issue 1, June 2015

Hybrid DWT-DCT Video Watermarking Algorithm for Copyright Protection of Multimedia Color Videos

Alavi Kunhu[1], Nisi K[2], Sadeena Sabnam[3], Majida A[4]

Associate Professor, Cochin College of Engineering and Technology, Valanchery, Kerala, India[1]

Assistant professor, ECE Dept, Cochin College of Engineering and Technology, Valanchery, Kerala, India[2, 3,4]

Abstract: In this paper, we propose a new blind video watermarking algorithm for the copyright protection of multimedia colour videos. The novelty in the presented approach consists in designing a hybrid Discrete Wavelet Transform (DWT) and Discrete Cosine Transform (DCT) based digital video watermarking. The distortion caused by watermarking is assessed by using peak signal to noise ratio (PSNR) and similarity structure index measure (SSIM) and robustness against different types of attacks have been assessed using Stirmark. The proposed video watermarking algorithm provides better imperceptibility in harmony with the human visual system and offers higher robustness against signal processing attacks.

Keywords: Video watermarking; Copyright protection; DWT; DCT; PSNR; SSIM.

I. INTRODUCTION

As a result of the rapid growth in the digital computer technology, for the last few years there has been a large demand for video watermarking products due to the fact that there are so many videos available at no cost on the World Wide Web, which need to be, copyright protected and ownership authenticated [1]. The protection of intellectual property rights and digital media has become in great demand. Thus, the best way to protect multimedia products against illegal transactions is through hiding information within the cover called digital watermarking.

The use of digital watermark technology, which has become more convenient, depends on hiding watermark in a digital medium. The watermark is the information regarding the owner of a copyright for this digital media. This could be a brand image, a serial number or any other digital information that describes the copyright [2]. For this digital interface, a watermark and a digital interface can be merged to make it difficult to be separated from each other. Whenever it is required to validate the copyright, the watermark is extracted from the digital interface to prove their legal owner. The watermark must be robust against several attacks either intentional or non-intentional [3]. To be effective, a watermark needs to have certain features such as being imperceptible and undeletable.Any watermarking technique consists of an encoding algorithm which embeds the watermark information into the host cover and decoding algorithm to extract the watermark information from watermarked cover [4]. The objective of this project is to develop a hybrid discrete wavelet transform and discrete cosine transform based video watermarking algorithm which embeds robust ownership watermark information into video frames to protect the copyright ownership.

II. REVIEW OF DWT AND DCT

The proposed digital video watermarking algorithm is based on hybrid Discrete Wavelet Transform (DWT) and Discrete Cosine Transform (DCT). A brief review of DWT and DCT are described below.

A. Discrete Wavelet Transform (DWT)

A wavelet is a waveform of effectively limited duration that has an average value of zero. While comparing wavelets with smooth and predictable sinusoidal waves the basis of Fourier analysis, wavelets tend to be irregular and asymmetric. The wavelet analysis is the breaking up of a signal into shifted and scaled versions of mother wavelet. In discrete wavelet analysis, we use the concept of approximations and details. The approximations are the high-scale, low-frequency components of the signal, which gives the signal its identity, while the details are the low-scale, high-frequency components, which imparts flavor.

In the proposed video watermarking technique, the discrete wavelet transform (DWT) decompose a selected channel of a video frame into a lower resolution approximation (LL) as well as horizontal (HL), vertical (LH) and diagonal (HH) detail components. This decomposition process can be repeated to compute multiple "scale" wavelet decomposition and 2 levels DWT decomposition model is shown in Figure 1 [5, 6, 7]. Accurate aspects of the HVS is the one of main advantages of the wavelet transform as compared to the DCT and this allows us to use higher energy watermarks in regions that the HVS is known to be less sensitive to, such as the high resolution detail bands {LH, HL, HH}. Embedding watermarks in these regions allow us to increase the robustness of our watermark, at little to no additional impact on video quality.

ISSN (Online) 2278-1021
ISSN (Print) 2319-5940
International Journal of Advanced Research in Computer and Communication Engineering (IJARCCE)
International Conference on Recent Trends in Computing and Communication (ICRTCC 2015)
Cochin College of Engineering & Technology
Vol. 4, Special Issue 1, June 2015

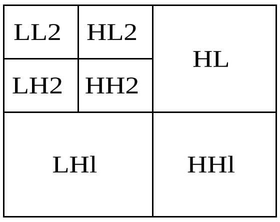

FIGURE 1. 2 LEVELS DWT DECOMPOSITION MODEL

B. Discrete Cosine Transform (DCT)

Basically, DCT is a process of converting a signal from spatial domain to frequency domain. There are three regions of frequency the image will be divided into low frequencies sub-band (FL), middle frequencies sub-band (FM) and high frequencies sub-band (FH). Figure 2 shows a block of components illustrating the regions of frequency sub-bands. The energy distributes from low frequency to high frequency which means that from high energy to low energy in a zigzag scanning manner as shown in Figure 3 [8, 9, 10].

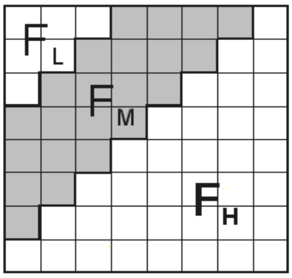

Figure 2.DCT frequency sub bands

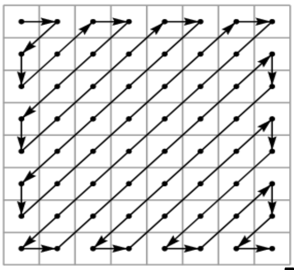

Figure 3.Zigzag scanning pattern

Mathematically, the DCT transform can be expressed as follows:

$$y(u,v)=\sqrt{\frac{2}{M}}\sqrt{\frac{2}{N}}\alpha_u\alpha_v\sum_{u=0}^{M-1}\sum_{v=0}^{N-1}x(m,n)\times\cos\frac{(2m+1)u\pi}{2M}\cos\frac{(2n+1)v\pi}{2N} \quad ...(1)$$

where α_u and α_v are given by:

$$\alpha_u=\begin{cases}1/\sqrt{2}, & u=0\\ 1, & u=1,2,....,N-1\end{cases},$$

$$\alpha_v=\begin{cases}1/\sqrt{2}, & v=0\\ 1, & v=1,2,....,N-1\end{cases}$$

The Inverse DCT transform can be expressed as follows:

$$x(m,n)=\sqrt{\frac{2}{M}}\sqrt{\frac{2}{N}}\sum_{u=0}^{M-1}\sum_{v=0}^{N-1}\alpha_u\alpha_v y(u,v)\times\cos\frac{(2m+1)u\pi}{2M}\cos\frac{(2n+1)v\pi}{2N} \quad ...(2)$$

where x(m, n) is the pixel intensity of selected channel of video frame block in row and column and y(u,v) is the DCT transform coefficients in row and column of the DCT block.

III.PROPOSED METHODOLAGY

A. Watermark Encoding Algorithm

The robust copyright encoding algorithm embeds the binary ownership information into the colour video file in hybrid frequency and wavelet domain using DWT and DCT, respectively. Initially, the colour video file is converted into frames and transformed into RGB color space and selects a suitable channel for watermarking. Then 2-level DWT 'haar' wavelet decomposition is applied to the selected channel to obtain the LL2 sub-band as shown in Figure 1. Subsequently, the LL2 sub-band is divided into a non-overlapping (8×8) blocks and converted into a frequency domain using DCT. The resultant coefficients are rearranged from low frequency to high frequency order using zigzag pattern selection criteria. Then, the ownership watermark is embedded into a selected coefficients using scaled odd/even embedding technique. The complete encoding algorithm is summarized in Algorithm 1, where fk indicate video frame, l(x,y) represent the watermark information, Qe represents even quantization and Qo represents odd quantization to the nearest integer number. The symbol "Δ" indicates the watermark strength scaling factor.

Algorithm 1: Embedding copyright watermark

Initialize: DCT block size, Wavelet type, Scaling factor (Δ)
Input: Selected channel of video frame (f_k), Watermark information (lo)
Output: Robust watermarked video frame (fw_k)

- Finding 2-level DWT
  [LL_1, LH_1, HL_1, HH_1] = DWT[f_k]
  [LL_2, LH_2, HL_2, HH_2] = DWT[LL_1]
- Finding DCT of N_{HB} 8×8 sub-blocks of **LL_2**
  for k=1 to N_{HB} do
  for i= 1 to 8 do
  for j= 1 to 8 **do**
  find LL_{2k} sub-block components from LL_2
  end for
  end for
  $DLL_{2k}(u,v)$ = DCT {$LL_{2k}(i,j)$}
  end for
- Encoding watermark bits
  for k= 1 to NHB do
  if lo(x,y) = 0 then

$$\textbf{DLL2k(x,y)} = \begin{cases}\Delta Q_e\left(\dfrac{DLL_{2k}(x,y)}{\Delta}\right)\\ DLL_{2k}(x,y)\end{cases} \quad ...(3)$$

  else

$$\textbf{DLL2k(x,y)} = \begin{cases}\Delta Q_o\left(\dfrac{DLL_{2k}(x,y)}{\Delta}\right)\\ DLL_{2k}(x,y)\end{cases}$$

  end if
  end for

A. Watermark Decoding Algorithm

ISSN (Online) 2278-1021
ISSN (Print) 2319-5940
International Journal of Advanced Research in Computer and Communication Engineering (IJARCCE)
International Conference on Recent Trends in Computing and Communication (ICRTCC 2015)
Cochin College of Engineering & Technology
Vol. 4, Special Issue 1, June 2015

The robust copyright decoding algorithm extracts the binary ownership watermark information from hybrid DWT-DCT watermarked colour video file. Initially, the hybrid DWT-DCT watermarked colour video is converted into frames and transformed into RGB color space. Then 2-level DWT 'haar' wavelet decomposition is applied to the selected channel of video frames. Afterward, LL_2 sub-band is divided into a non-overlapping **(8×8)** blocks and converted into a frequency domain using DCT. Then watermark information is extracted from selected coefficients using scaled odd/even extraction method of equation.

$$\text{if } Q\left(\frac{DLL_{2k}(u,v)}{\Delta}\right) \Rightarrow Odd \Rightarrow lr(i,j)=0$$

$$\Downarrow$$

$$\text{Even}$$

$$\Downarrow$$

$$lr(i,j)=1$$

where Q indicates the quantization to the nearest integer value, lr indicate the extracted watermark information and Δ is the watermark strength scaling factor.

IV. RESULT ANALYSIS

In this section, the performance of the proposed hybrid DWT-DCT video watermarking algorithm is evaluated experimentally using different colour video files and a (64×64) binary logo has been used as a watermark. The video frames and the watermark logo are shown in Figure 4. The experiments are implemented in MATLAB 2012 under a Windows7 environment on an Intel Core2 Duo 2.4 GHz processor with 4GB of RAM.

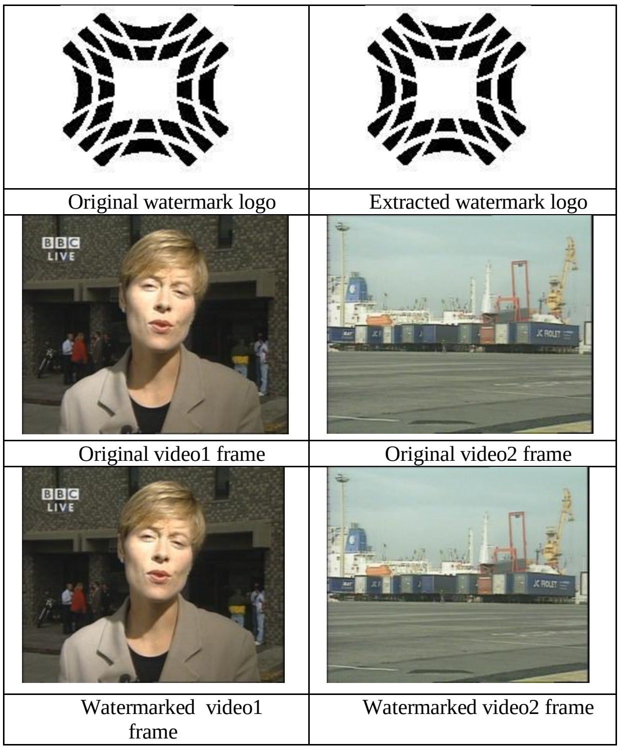

Figure 4. Watermark logo and video frames selected for watermarking

The Peak Signal-to-Noise Ratio (PSNR) and the Structural Similarity Index Measurement (SSIM) are used for distortion measurement between the cover video frames and the watermarked video frames [9, 11], Mean while the Bit Error Rate (BER) and the Normalized Correlation (NC) are used to measure the quality of extracted watermark logo from the video frames.

The Peak Signal to Noise Ratio (PSNR) is used as a metric to measure quality video frames. PSNR penalizes the visibility of noise in the video frames. Thus, two video frames that are exactly the same will produce an infinite PSNR value. PSNR is given by.

$$\mathrm{PSNR} = 10.\log_{10}\left(\frac{255^2}{\mathrm{MSE}}\right) \quad ...(4)$$

The Structural Similarity Index Measurement (SSIM) is a measure that compares local pattern of pixel intensities that have been normalized for luminance and contrast. The higher SSIM is, the larger the similarity between the compared video frames. SSIM is given by.

$$\mathrm{SSIM}(fo,fw) = \left(L(fo,fw)\right)^{\alpha}.\left(C(fo,fw)\right)^{\beta}.\left(S(fo,fw)\right)^{\gamma}$$

$$L(o,w) = \frac{2\mu_X\mu_Y + A}{\mu_X^2 + \mu_Y^2 + A}, \quad C(o,w) = \frac{2\sigma_X\sigma_Y + B}{\sigma_X^2 + \sigma_Y^2 + B},$$

$$S(o,w) = \frac{\sigma_{XY} + C}{\sigma_X\sigma_Y + C}$$

Where fo represents the original video frame and fw represents a watermarked video frame. L, C and S represent the luminance, contrast and structure components respectively, while α, β, γ are parameters used to adjust the relative importance of the luminance, contrast and structure components.

The Normalized Correlation (NC) is a measure used to analyze the performance of the extracted watermark information. If both the original and the extracted watermark are the same, then the value of NC will be 1. NC is given by.

$$\mathrm{NC} = \sum_{x,y}\left(lo_{x,y}le_{x,y}\right)/lo_{x,y}^2$$

Where lo, le represents the original watermark and the extracted watermark information.

TABLE 1. PSNR AND SSIM ANALYSIS OF WATERMARKED COLOUR VIDEO FRAME

	Δ = 8		**Δ = 16**		**Δ = 24**	
	PSNR	SSIM	PSNR	SSIM	PSNR	SSIM
Video1	63.50	0.9999	57.79	0.9996	54.60	0.9992
Video2	63.55	0.9999	57.73	0.9994	54.41	0.9985

TABLE II. NC AND BER ANALYSIS OF EXTRACTED WATERMARK UNDER FILTER ATTACK

Δ		**Filter 3x3**	**Filter 5x5**	**Filter 7x7**	**Filter 9x9**
8	NC	0.8561	0.7082	0.5757	0.5329
	BER	0.1406	0.2932	0.4238	0.4609
16	NC	0.9547	0.8974	0.7704	0.6668
	BER	0.0391	0.0942	0.2312	0.3418
24	NC	0.9809	0.9306	0.8471	0.7337
	BER	0.0166	0.0649	0.1460	0.2646

TABLE III. NC AND BER ANALYSIS OF EXTRACTED WATERMARK UNDER SCALING ATTACK

Δ		**80%**	**70%**	**60%**	**50%**	**40%**	**30**

ISSN (Online) 2278-1021
ISSN (Print) 2319-5940
International Journal of Advanced Research in Computer and Communication Engineering (IJARCCE)
International Conference on Recent Trends in Computing and Communication (ICRTCC 2015)
Cochin College of Engineering & Technology
Vol. 4, Special Issue 1, June 2015

							%
8	NC	0.9133	0.9165	0.9018	0.8852	0.8672	0.8248
	BER	0.0867	0.0857	0.0955	0.1135	0.1375	0.1748
16	NC	1.0000	0.9996	1.0000	0.9996	0.9982	0.9881
	BER	0	0.0002	0	0.0002	0.0017	0.0156
24	NC	1.0000	1.0000	1.0000	1.0000	0.9996	0.9971
	BER	0	0	0	0	0.0002	0.0046

TABLE IV. NC AND BER ANALYSIS OF EXTRACTED WATERMARK UNDER ROTATION

Δ		**1 degree**	**3 degree**	**5 degree**	**7 degree**	**9 degree**	**11 degree**
8	NC	0.9144	0.8899	0.8701	0.8474	0.8381	0.8244
	BER	0.0833	0.1040	0.1133	0.1333	0.1387	0.1489
16	NC	0.9773	0.9586	0.9356	0.9180	0.9007	0.8881
	BER	0.0159	0.0305	0.0459	0.0591	0.0713	0.0825
24	NC	0.9824	0.9554	0.9359	0.9147	0.8982	0.8917
	BER	0.0127	0.0320	0.0447	0.0613	0.0747	0.0815

The watermarked video frames are subjected to various attacks such as filter, scaling and rotation under different watermark strength scaling factor. The quality of watermarked video frames are analyzed using PSNR and SSIM, mean while the extracted watermark information is evaluated using the NC and the BER. Table1 shows the PSNR and SSIM of watermarked video frames under different watermark strength scaling factor, mean while Table 2, 3 and 4 are shows the NC and BER of extracted watermark logo under filter attack, scaling attack and rotation attack respectively. Figure 5, 7 and 9 are shows the NC analysis of extracted watermark logo under different attacks, mean while Figure 6, 8 and 10 are show the BER performance analysis.

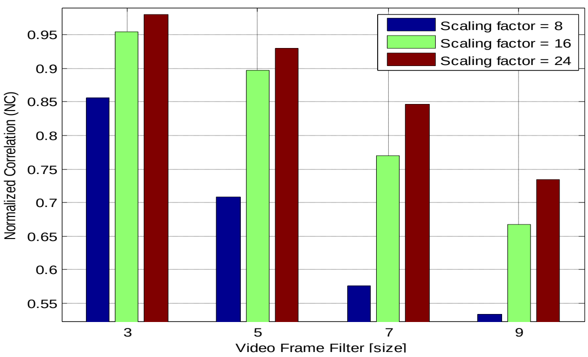

Figure 5. NC analysis of extracted watermark logo under filter attack

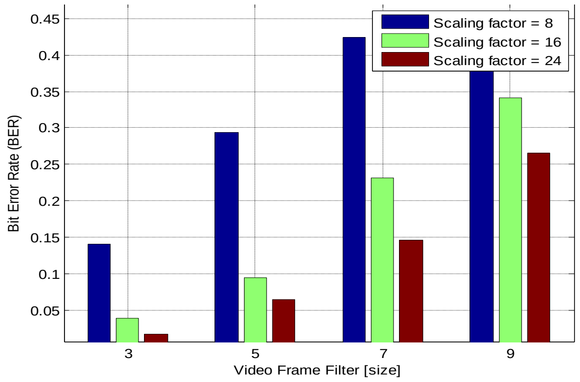

Figure 6. BER analysis of extracted watermark logo under filter attack

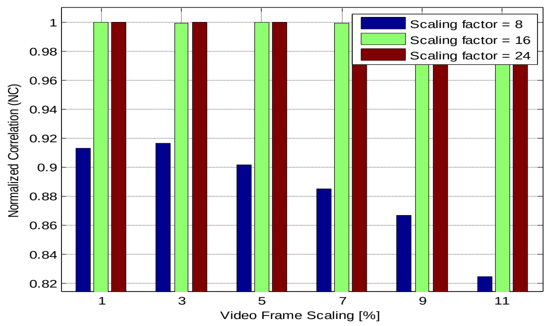

Figure 7. NC analysis of extracted watermark logo under scaling attack

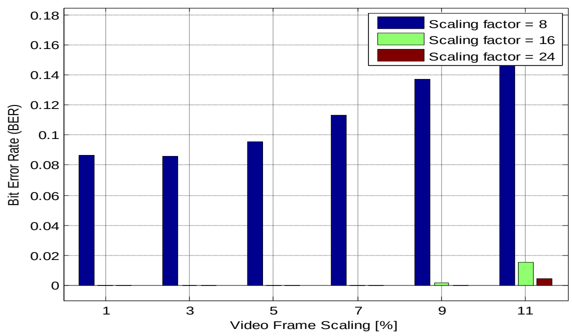

Figure 8. BER analysis of extracted watermark logo under scaling attack

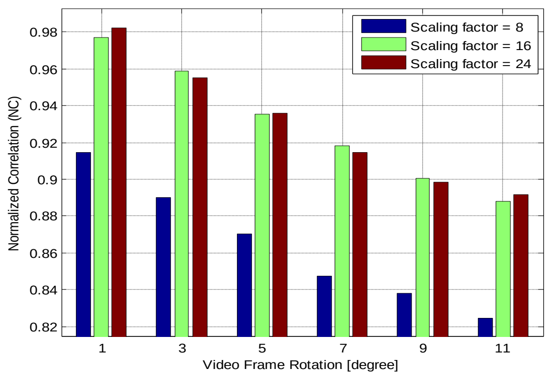

Figure 9. NC analysis of extracted watermark logo under rotation attack

ISSN (Online) 2278-1021
ISSN (Print) 2319-5940
International Journal of Advanced Research in Computer and Communication Engineering (IJARCCE)
International Conference on Recent Trends in Computing and Communication (ICRTCC 2015)
Cochin College of Engineering & Technology
Vol. 4, Special Issue 1, June 2015

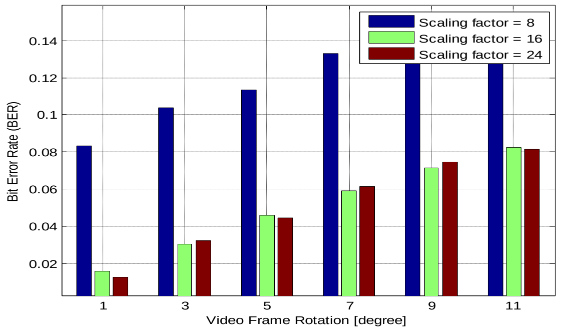

Figure 10. BER analysis of extracted watermark logo under rotation

V. CONCLUSION

This paper proposed a novel digital video watermarking technique using a hybrid DWT-DCT function. In this study, a binary logo is utilized as a watermark and colour video frames are utilized as a cover. Based on our experimental results analysis we have come to the conclusion that the proposed video water marking is highly efficient and is capable of withstanding almost all sorts of signal processing attacks. The distortion caused by watermarking is assessed by using peak signal to noise ratio (PSNR) and similarity structure index measure (SSIM) and robustness against different types of attacks have been assessed using Stirmark. Therefore, the proposed method is a very good candidate for copyright protection for video files.

ACKNOWLEDGMENT

The authors acknowledge all the reviewers and editor in charge for their valuable comments on improving this paper.

REFERENCES

[1] Saeed AL-Mansoori and Alavi Kunhu, “Multi-Watermarking Scheme for Copyright Protection and Content Authentication of DubaiSat-1 Satellite Imagery”, SPIE of Optics and Photonics Conference 2013, California, USA, August 2013.

[2] M.Kim, D.Li and S. Hong, “a Robust and Invisible Digital Watermarking Algorithm based on Multiple Transform Method for Image Contents”, Proceedings of the World Congress on Engineering and Computer Science 2013 Vol I, WCECS 2013,San Francisco, USA, October 2013.

[3] M. Swanson, M. Kobayashi, A. Tewfik, Multimedia data embedding and watermarking techniques, Proc. IEEE 86 (1998) 1064–1087.

[4] A. Al-Gindy, H. Al-Ahmad, R. Qahwaj, and A. Tawfik, "A frequency domain adaptive watermarking algorithm for still colour images," in International Conference on Advances in Computational Tools for Engineering Applications, ACTEA '09. , Beirut, Lebanon, 2009, pp. 186-191.

[5] D. Kundur and D. Hatzinakos, “Digital Watermarking using Multi-resolution Wavelet Decomposition”, Proceedings, IEEE International Conference Acoustic, Speech, Signal Processing, 1998.

[6] Alavi Kunhu and Hussain Al-Ahmad, “A New Multi Watermarking Algorithm Based on DWT and Hash Functions for Color Satellite Images”, IEEE International Conference on Electronics, Circuits, and Systems- ICECS2013, Abu Dhabi, UAE, December 2013.

[7] Huang Daren, Liu Jiufen, Huang Jiwu and Liu Hongmei “A DWT based image watermarking algorithm”, ICME IEEE International Conference on Multimedia and Expo, August 2001,pp. 313-316.

[8] W. Lie, G. Lin, C. Wu, and T. Wang, “ Robust Image Watermarking on DCT Domain,” ISCAS 2000, IEEE International Symposium on Circuits and Systems, Geneva, Switzerland, May 2000, pp. 228-231.

[9] Saeed AL-Mansoori and Alavi Kunhu, “Robust Watermarking Technique based on DCT to Protect the Ownership of DubaiSat-1 Images against Attacks”, IJCSNS International Journal of Computer Science and Network Security, VOL.12 No.6, June 2012.

[10] Alavi Kunhu and Hussain Al-Ahmad, “A New Watermarking Algorithm for Color Satellite Images Using Color Logos and Hash Functions”, 5th IEEE International Conference on Computational Intelligence, Communication System and Networks - CICSYN2013, Madrid, Spain, June, 2013.

[11] Z. Wang, A. Bovic, H. Sheikh, and E. Simoncelli, "Image Quality Assessment: From Error Visibility to Structural Similarity," IEEE Transactions on Image Processing, 2004, pp. 600-612.