ROBUST IMAGE ADAPTIVE WATERMARKING USING FUZZY LOGIC AN FPGA APPROACH

Pankaj U.Lande	Sanjay N. Talbar	G.N. Shinde
Dept.Instrumentation Science	*S.G.G.S. Institute of*	*Indira Gandhi college*
University of Pune, Pune.	*Engineering and Technology, Nanded.*	*CIDCO, Nanded*
pul@usic.unipune.ernet.in	*sntalbar@yahoo.com*	*shindegn@yahoo.co.in*

Abstract

In this paper we have proposed novel hardware for an adaptive encrypted watermarking method based on fuzzy logic. Fuzzy logic is used for data fusion, and it builds a human visual system (HVS) model for spatial masking in a wavelet domain. Encryption and digital watermarking both techniques must be incorporated to give best solution for digital rights management. It is obvious that these two technologies complement each other, and are both responsible for complete security of the digital information. Encryption transforms the original content into an unreadable format and watermarking leaves the digital object intact and recognizable. The aim of hardware assisted watermarking is to achieve low power usage, real-time performance, reliability, and ease of integration with existing consumer electronic devices. The experimental results demonstrate the high robustness of the proposed algorithm against the geometric distortion such as rotation and scaling.

Keywords: *DWT, FPGA, HVS, Fuzzy logic.*

1. Introduction

Digital right management (DRM) is a collection of technologies and a technique that enables the licensing of digital information including the multimedia content such images, video and music. Digitized multimedia can be easily created, copied, processed, stored, and distributed using commercially and freely available software. The simplicity and cost effectiveness of managing digitized multimedia have greatly benefited both content providers and consumers. However digital content providers are reluctant to distribute their multimedia content over internet due to lack of security. The digital revolution provides tools to unlimited copying without loss in fidelity [1].

Digital watermarking is a process in which an informed signal (watermark) is incorporated in multimedia content such as images to protect the owner's copyright over that content. The watermark can be later be extracted from a suspected image and be verified in order to identify the copyright owner. A watermarking scheme consists of three parts: the watermark, the encoder, and the decoder and comparator. The watermarking algorithm incorporates the watermark in the object, whereas the verification algorithm authenticates the object by determining the presence of the watermark and its actual data bits [2].

Watermarking techniques can be divided into various categories in numerous ways. In the case of still digital images, there are three primary methods for insertion and extraction of a watermark. These are spatial domain, transform domain and color space methods. The spatial domain method [3] involves an algorithm that directly operates on the pixel values of the host image. In the transform domain method the pixel values are transformed into another domain by applying appropriate transform technique like discrete cosine transform (DCT) [4][6],discrete wavelet transform(DWT)[7][8][5]and Hadamard transform[9]. A watermark is then embedded by modifying these coefficients. However it is observed that spatial domain watermarks are weaker than frequency domain ones [10][11]. A DCT based watermarking algorithm has been described in many literatures; however DWT based watermarking algorithms are more effective for several reasons [13]. For instance they offer excellent space-frequency localization of salient image features such as textures and edges. Specifically, the high-frequency content of an image corresponds to a large coefficient in the detail sub-band. Hence, watermark encoders operating in the wavelet domain can easily locate the high-frequency features of an image and embed most of the watermark energy. Such a method of embedding results in an implicit visual masking of the watermark, because the ability of human visual system (HVS) to detect high frequency signals is limited [14].

2. Related Work

Several software algorithms have been proposed for image adaptive watermarking in the transform domain methods; some of these algorithms have been presented in [15] [16]. However hardware implementations offer an optimized specific design to incorporate a small, fast, and potentially cheap watermarking unit. A hardware based watermarking unit can be easily integrated with digital cameras and graphics processing units. Watermarking unit consumes lesser power than software, which requires a general purpose processor. Hardware based watermarking unit are ideal for battery operated applications. The cost is low compared to that software used explicitly for watermarking; this is because a hardware based watermarking unit can be monolithically built on a single unified system in the context of system-on-chip (SoC) technology in digital cameras and graphics processing units with a minimal hardware overhead when compared to a system without DRM. The hardware can be implemented as a soft core expressed in the structural hardware description language like VHDL and Verilog. The soft core can be modified as algorithm changes and can be resynthesized into new silicon technology. The hardware based watermarking scheme has been presented in following literatures.

Tsai and Lu in [17] presented JPEG architecture with a watermarking scheme. The watermarking system is used to embed a pseudo-random sequence of real numbers in a set of selected DCT coefficients. The watermark is extracted without the original image. The watermark chip is implemented using TSMC 0.35μm technology.

A scheme for invisible fragile watermarking in a spatial domain is described in [18]. The encrypted watermark is embedded in the LSB of the gray scale image pixel. The encrypted ASCII is used for watermarking.

A color space watermarking method is presented in [19]. The image is converted from RGB color space to a YUV color space. Two LSBs of the Y components are modified for watermarking. The encrypted ASCII is used for watermarking.

An invisible robust watermarking method is proposed in [20]. The watermark is embedded in the original image using an encoding function that involves the addition of gray scale values of the neighboring pixels. The drawback of above mentioned methods that they are using ASCII data for watermarking; hence, if even one of the bits is missing, the watermark cannot be detected.

Fan *et al.* [21] presented a scheme for visible watermarking in the wavelet domain. This scheme involves the use of a multi-resolution representation of the wavelet transform for watermarking. In order to satisfy real time constraints, a parallel processing architecture is used. The watermark is embedded by modifying its coefficients.

A watermarking scheme based on DCT and HVS is proposed in [22]. This scheme involves embedding of a compound watermark consisting of perceptually significant regions of the cover image and the watermark logo. Because the watermark is embedded in a perceptually significant region, it is robust against attacks. A non-blind Watermark detection scheme is used.

An FPGA prototype of biometric watermarking or security scheme is described in [23]. In this scheme the original image is divided into 8×8 blocks and DCT is performed for each block. The biometric image (watermark) is divided into blocks and embedded into perceptually significant regions; original image is required for watermark detection. This prototype was implemented in VHDL and synthesized using Xilinx Virtex II technology.

Mohanty [24] proposed a novel algorithm for encrypted watermarking based on block-wise DCT. This algorithm converts RGB color space into a YCbCr color space; the Y component is used for watermarking. The architecture was modeled using VHDL and synthesized using Virtex II technology.

Image adaptive watermarking and its hardware architecture is described in [25]. The proposed scheme of watermarking is invisible and robust against JPEG attacks. Cover image is divided in 8×8 blocks and DHT is calculated. PN sequence is generated through user key and embedded into DHT coefficients. The strength factor is calculated from quantization table for DHT domain. Watermark detection method is blind. The proposed method is robust against the common signal processing attacks like median filtering and noise addition. The algorithm was implemented on XC3SD1800A-4FGG676C and functional simulation was performed using Xilinx tools. The chip was tested using hardware co-simulation which was run at 33.3MHz.

In this paper we present novel hardware architecture for watermarking based on FPGA. The proposed scheme is an invisible, robust and wavelet domain watermarking method. The chip was modeled using Verilog and a function simulation was performed. This chip was tested using AccelDSP by using hardware in the loop (HIL) arrangement. The proposed scheme is robust against several geometric attacks. We have tested our watermarking scheme using standard benchmark such as StirMark software.

We have divided this paper into three main sections. The first section provides an introduction and background of watermarking. The second section describes the watermarking algorithm and the corresponding hardware architecture. The results and conclusion are presented in the final section.

3. Proposed Scheme for Watermarking

3.1. Algorithm for Watermark Insertion

In this section we describe the invisible algorithm implemented in the hardware**.** The following notations have been used throughout the paper

I -:cover image, **B×B** –: block size
$\mathbf{I_N}$ –: N'th block of cover image, **W -:** original watermark
W*-: encrypted watermark, **D -**: defuzzified output
β -: Scaling factor, **K** -: key to generate PN sequence

The original image I is divided into non-overlapping blocks of size B×B. Wavelet transform is performed for each block separately. A PN sequence of {0, 1} is generated using a user key 'K'. A binary logo image is selected as the watermark 'W'. This watermark is bitwise XORed with the generated PN sequence to obtain an encrypted binary watermark 'W*'. This encrypted watermark is embedded into the cover image with a gain factor obtained using equation (1)

$$W^*(x,y)=W(x,y) \oplus PN(x,y) \quad (1)$$

$$I_{W,N}(x,y)= I_N(x,y)+\alpha \times W^*(x,y) \quad (2)$$

$$\text{Where} \qquad \alpha = \beta \times D \quad (3)$$

$I_{W,N}$ is the N^{th} block of the watermarked image; W is the binary water mark logo; x and y the index numbers; β, a global scaling factor and D, the defuzzified output of Fuzzy interface system (FIS).

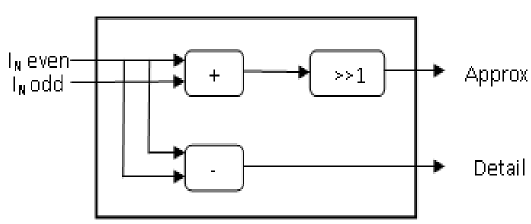
3.2 Hardware Architecture for Proposed Scheme

In this section, we discuss the hardware architecture for the scheme described above. The watermarking chips mainly consist of a block processing unit, control unit and fuzzy interface system (FIS).

3.2.1 Block processing unit: The block processing unit considers the original image block as the input. This image block is wavelet transformed and the watermark is embedded using equation (2). The block processing unit consists of wavelet filters, watermarking unit and IDWT calculation block.

3.2.1.1. DWT and IDWT filters: DWT is a popular being a popular technique as it is very efficient signal analysis tool for several practical applications like image watermarking. DWT can analyze the data in different scales and resolutions; this process is termed as multi-resolution analysis [26]. This process has certain factures that make it suitable for image watermarking, such as the ability to consider the characteristics HVS. It also acts as the basis for a compression standard such as JPEG2000 [27] and MPEG-4[28].

In the proposed algorithm, a Haar wavelet is used, which is the simplest wavelet [29]. The use of the Haar wavelet affords the advantage of providing a simple, memory efficient exactly of reversible calculation that requires less hardware. The Haar wavelet can be obtained by performing simple operations like averaging and finding the difference between a pair of pixel values. In the wavelet transform technique, the signal is divided into low-pass and high-pass components. The low-pass component is called as approximation shows general trend of pixel values and detail sub-band shows vertical, horizontal and diagonal changes in image.



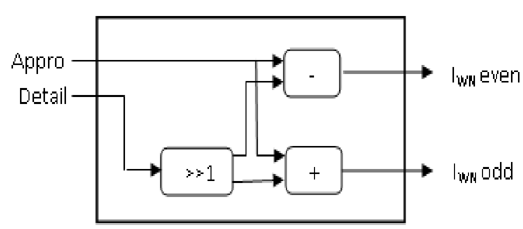


Figure 1(a). Forward wavelets filter **Figure 1(b). Inverse wavelet filter**

With the aim of satisfying the real time constraint, we have used two filters in parallel to calculate the forward and inverse transform. The forward wavelet filter and inverse wavelet filter are shown in figure 1 (a) and figure 1 (b) respectively. In order to calculate the 2D wavelet, these filters first calculate the coefficients row-wise and then column-wise. The intermediate results are stored in the memory. The inverse wavelet is calculated in a similar manner.

3.2.1.2. Watermarking unit: The watermarking unit consists of linear feedback shift register (LFSR), XOR gates, multiplier and an adder. LFSR generates a PN sequence by using user key 'K'. Encrypted watermark W* is obtained by XOR operation between W and the PN sequence. This encrypted watermark is embedded using equation (2). Because a multiplier requires more hardware, only one multiplier is implemented. The wavelet transformed block is fed serially to the watermarking unit. The gain is multiplied by W and added to the wavelet transformed coefficients. The intermediate results are stored in the memory.

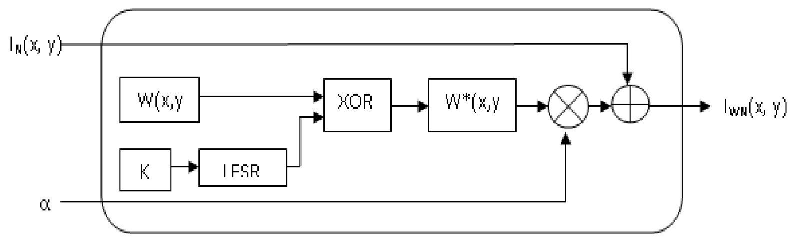


Figure 2. Watermarking unit

3.2.2 Fuzzy Interface System (FIS): This block is used to calculate the local variance of the image block. The calculated variance is fed to the FIS. Each input is composed of three membership functions minimum medium, maximum based on the variance distributed among smooth, slightly rough and rough subsets, respectively. The output of the FIS is the gain factor for the particular block. This gain is based on the three membership functions. It is important to realize that this approach enables adjustment of gain so as to best fit the image properties.

In order to calculate and correct the amount of gain for a particular block, the fuzzy rules and the membership function were developed using intuition logic and the characteristics of HVS. The following simple fuzzy rules are given bellow.

1. If the image block is smooth (low variance), then the gain is minimum.
2. If the image block is slightly rough (medium variance), then the gain is medium.
3. If the image block is rough (high variance), then the gain is maximum.

D is calculated for the composite output set using a weighted average defuzzification method given by using equation (4)

$$D = \frac{\sum z_j c_j}{\sum z_j} \qquad (4)$$

Where C_j is center of the consequent set of rules j, and Z_j is the extent to which rule is fired. Figure.3 shows the graph of block number Vs gain and variance. The weighted average method requires simple calculations and it requires less hardware. It can be observed from the graph that gain varies according to the variance of the block.

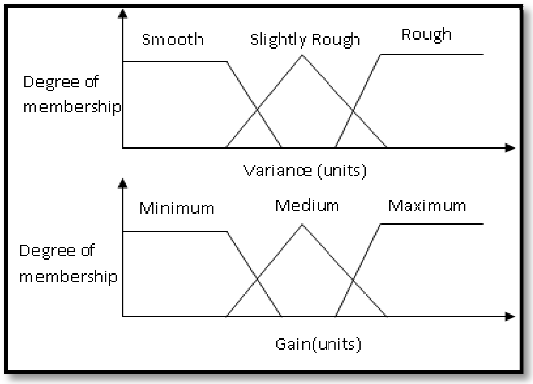


Figure 3.Fuzzy membership function

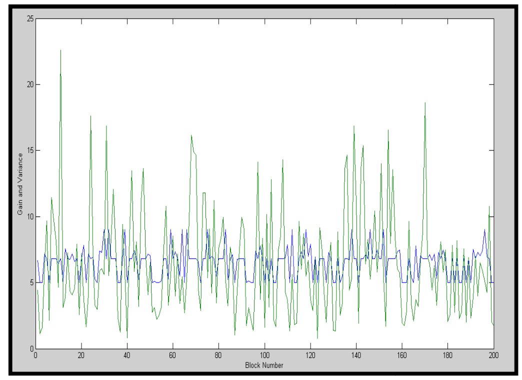


Figure 4. Block numbers Vs Gain and Variance

3.2.3. Control unit

The control unit generates the necessary control signals for the entire system during the watermarking process. This unit undergoes seven states; a particular task is performed in state and the finite state machine (FSM) begins to the next state. Figure 5 shows the state diagram of FSM

S1: reading the cover image block
S2: calculation of DWT
S3: calculation of variance of the block
S4: calculation of α by using FIS and encryption of the watermark
S5: embedding of the watermark
S6: calculation of inverse DWT
S7: generation of a ready signal

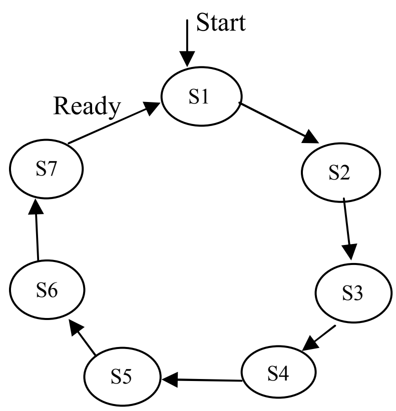


Figure 5. Finite State Machine

3.2.4 Watermark detection: The watermark detection algorithm is implemented using MatLab. The watermark can be detected using two methods blind and non-blind. In the non-blind method original and suspected image both are required to detect a watermark. Suspected image and original image are divided into B×B blocks, and DWT coefficients are calculated for both images. The watermark is recovered using equation (4).

$$W^*(i,j)=\begin{cases}1 & \text{if } I_{WN}(x,y)-I_N(x,y)>\tau \\ 0 & \text{other wise}\end{cases} \tag{4}$$

τ represent threshold for non-blind detection
recovered watermark is decrypted to obtain the original watermark using Equation(5)

$$W(x, y) = W^*(x, y) \oplus PN(x, y) \tag{5}$$

In the blind watermark detection method the suspected image is divided into B×B blocks, and DWT coefficients are calculated. The original watermark is encrypted using PN sequence generated through 'K'. The correlation between encrypted watermark and wavelet transformed block is calculated using equation (6)

$$\gamma = \frac{\sum_m \sum_n (I_{WN}(x,y)-\bar{I}_{WN})(w(x,y)-\bar{w})}{\sqrt{\sum_m \sum_n (I_{WN}(x,y)-\bar{I}_{WN}) \sum_m \sum_n (w(x,y)-\bar{w})}} \tag{6}$$

If $\gamma > \rho$ then the watermark is detected. ρ is threshold for blind detection.

4. Experimental Results

4.1 Synthesis and Implementation

The chip was modeled using a Verilog and functional simulation was performed. The code was synthesized using Spartan 3A technology on XC3SD1800A-4FGG676C device using the AccelDSP tool from Xilinx. The results are verified by hardware co-simulation using AccelDSP. The hardware co simulation ran at a 33.3 MHz clock frequency, and the samples were fed to the target device at the rate of 319.585 Ksps through a JTAG USB cable. The design utilizes 243 startup clock cycles, and 242 clock cycles per function call. The device utilization summary is given in Table 1.

Slices	7%
Slice Flip- flop	5%
4 input LUT	3%
Bounded IOB 's	84%
GCLK	4%
BRAM	4%

Table 1. Device utilization summary

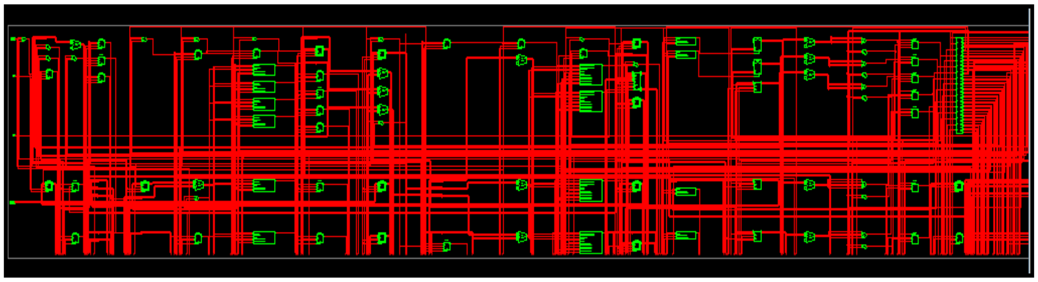


Figure 6. RTL of the proposed scheme

Quality Measures	Lena	Wall	Mandril
Mean square error	0.62	0.15	0.62
PSNR	50.17	56.20	50.17
Normalized cross correlation	1	1	1
Average Difference	-0.25	-0.06	-0.25
Structural content	0.99	0.99	0.99
Maximum difference	1	1	3
Normalized absolute error	0.007	0.009	0.0009
Image Fidelity	1	1	1
correlation quality	1	1	1

Table 2.Image Quality Measures

4.2 Image Performance Evaluations on Various Attacks.

In this section we evaluate the performance of the watermarking algorithm against various attacks using standard benchmark software. StirMark is the one of the earliest benchmark software. The StirMark software includes several attacks such as compression, geometric transformation, noise addition etc. The geometric attacks includes rotation, cropping, scaling and geometric transformation with medium compression. Some of the results of these evaluations are summarized in Table 3. These results indicate that the proposed watermarking scheme is robust against the geometric attacks.

The proposed scheme of watermarking scheme embeds several same watermarks in cover image. The objective was, at least a single watermark will survive after attacks. In detection algorithm all the watermarks are detected, and the watermark which is having highest correlation with the original watermark is treated as the recovered watermark. As scheme implements several watermark in the cover image, due to which scheme is robust against various geometric attacks. In this paper we have presented the watermark detected by non-blind watermark detection method due to less space.

5. Conclusion

In this paper, we proposed a novel image adaptive invisible watermarking algorithm and developed efficient hardware architecture for wavelet based invisible watermarking. The experimental results showed that the proposed watermarking scheme is imperceptible and robust against geometric attacks. This was achieved because of the space and frequency localizing property that is characteristics to the discrete wavelet transform technique. The importance of fuzzy logic to calculate the gain factor with respect to the texture sensitivity of the image was also proved.

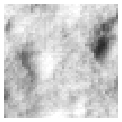
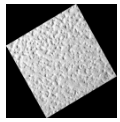
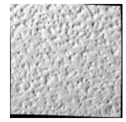
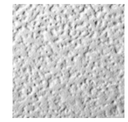
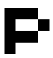
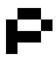
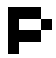
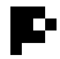
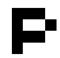
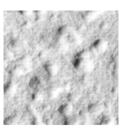
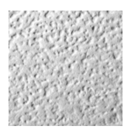
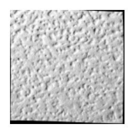
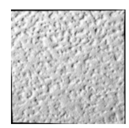
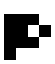
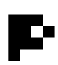
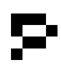
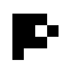
Attacks					
 Crop_10	 RESC_90	 ROT_30°	 ROTSCALE_-1	 RNDDIST_1.1	 ROTSCALE_0.75
Recovered watermark					
					
Attacks					
 Crop_25	 RESC_90	 ROT_-0.75°	 ROTCROP_2	 RNDDIST_1.05	 ROTSCALE_0.75
Recovered watermark					
					

Table 3.Performance against different attacks

References

[1] Er-Hsinen, “Literature Survey on Digital Image Watermarking,”*EE381K-Multidimentional Signal Processing,* 8/19/98.

[2] C.C. Chang and J. C. Chuan, “An image intellectual property protection scheme for gray- level images using visual secret sharing strategy,” *Pattern Recognition Letters, vol. 23*, June 2002, pp. 931-941.

[3] N. Nikolaidis, I. Pitas, “Robust Image Watermarking in Spatial Domain”, *International journal of signal processing, 66*(3), 1988,pp-385-403,.

[4] Pankaj U. Lande,Sanjay N.Talbar and G.N. Shinde "Adaptive DCT Domain Watermarking For Still Images", *International Conference RACE-07*,Bikaner, Rajastan, India,2007
[5] Pankaj U.lande,Sanjay N.Talbar and G.N. shinde "Hiding A Digital Watermark Using Spread Spectrum At Multi-Resolution Representation", *International conference ACVIT07*, Aurangabad, India,2007.
[6] Juan R.Hernandez,Martin Amado,Fernando Perez-Gonzalez "DCT Domain watermarking technique for still Image :Detectors Performance analysis and New Structure", *IEEE transaction on image processing,VOL.9*,no.1,Jan ,2000.
[7] Juan R. Hernandez, Martin Amado, Fernando Perez-Gonzalez "DCT Domain watermarking technique for still Image: Detectors Performance analysis and New Structure", *IEEE Transaction on Image Processing, VOL.9*,No.1, Jan 2000.
[8] Pik Wah Chan,Michael R.lyu and Roland T. Chin, "A Novel scheme For Hybrid Digital Video Watermarking : Approach, Evaluation And Experimentation", *IEEE Transactions on circuits and system for video technology,VOL 15*,No. 12,Dec, 2005.
[9] Pankaj U.Lande,S.N. Talbar,G.N. Shinde, "FPGA implementation of image adaptive watermarking using human visual model",ICGST-PDCS,Vol.9,Issue1,Oct. 2009.
[10] I. J. Cox, J. Kilian, T. Shamoon, T. Leighton, Secure Spread Spectrum Watermarking of Images, Audio and Video, in: Proc IEEE International Conf on Image Processing, Vol. 3, 1996, pp. 243–246.
[11] I. J. Cox, J. Kilian, T. Shamoon, T. Leighton, A Secure Robust Watermarking for Multimedia, in: Proc. of First International Workshop on Information Hiding, Vol. 1174,1996, pp. 185–206
[12] I. J. Cox, J. Kilian, T. Leighton, T. Shamoon, Secure Spread Spectrum Watermarking for Multimedia, IEEE Transactions on Image Processing 6 (12) 1673–1687.
[13] P. Meerwald and A. Uhl,(2001) "A survey of wavelet-domain watermarking algorithms," Proceedings of SPIE, Electronic Imaging, Security and Watermarking of Multimedia Contents *III*, San Jose, California, vol. 4314.
[14] R. Dugad, K. Ratakonda, and N. Ahuja,(1998) "A new wavelet-based scheme for watermarking images," *Proceedings of the IEEE International Conference on Image Processing, ICIP '98*, Chicago, Illinois,1997, pp. 419-423.
[15] C.-T. Hsu and J.-L. Wu, "Multiresolution watermarking for digital images," *IEEE Trans. Circuits Syst. II*, vol. 45,1998, pp. 1097–1101.
[16] J. Wang and G. Wiederhold, "WaveMark: Digital image watermarking using daubechies' wavelets and error correcting codes," in *Proc. SPIE Int. Symp. Voice, Video, Data Communications*, Boston, MA, Nov. 1998.
[17] T. H. Tsai and C. Y Lu, "A System Level Design for EmbeddedWatermark Technique using DSC System," in *Proceedings of the IEEE InternationalWorkshop on Intelligent Signal Processing and Communication System*, 2001.
[18] A. Garimella, M. V. V. Satyanarayan, R. S. Kumar, P. S. Murugesh, U. C. Niranjan, "VLSI Impementation of Online Digital Watermarking Techniques with Difference Encoding for the 8-bit Gray Scale Images, in: Proceedings of the International Conference on VLSI Design,,2003, pp. 283–288.
[19] A. Garimella, M. V. V. Satyanarayana, P. S. Murugesh, U. C. Niranjan,(2004) "ASIC for Digital Color Image Watermarking", in: Proceedings of 11th IEEE Digital Signal Processing Workshop,2004, pp. 292–295.
[20] S. P. Mohanty, E. Kougianos, N. Ranganathan,"VLSI architecture and chip for combined invisible robust and fragile watermarking", IET Computers & Digital Techniques (CDT) 1 (5),2007, pp 600–611.
[21] Y. C. Fan, L. D. Van, C. M. Huang, and H. W. Tsao, "Hardware-Efficient Architecture Design of Wavelet-based Adaptive Visible Watermarking," in *Proceedings of 9th IEEE International Symposium on Consumer Electronics*, ,2005, pp. 399–403.
[22] S. P. Mohanty and B. K. Bhargava, "Invisible Watermarking Based on Creation and Robust Insertion-Extraction of Image Adaptive Watermarks", *ACM Transactions on Multimedia Computing, Communications, and Applications (TOMCCAP)*, Volume 5, Issue 2,November 2008, pp. 12:1-12:22.
[23] S. P. Mohanty, O. B. Adamo, and E. Kougianos, "VLSI Architecture of an Invisible Watermarking Unit for a Biometric-Based Security System in a Digital Camera", in *Proceedings of the 25th IEEE International Conference on Consumer Electronics (ICCE)*, 2007, pp. 485-486.
[24] S. P. Mohanty, "A Secure Digital Camera Architecture for Integrated Real-Time Digital Rights Management", *Elsevier Journal of Systems Architecture (JSA)*, Volume 55, Issues 10-12,October-December 2009, pp. 468-480.
[25] Pankaj U.Lande,S.N. Talbar,G.N. Shinde, "FPGA iplimentation of image adaptive watermarking using human visual model",ICGST-PDCS,Vol.9,Issue1,Oct. 2009.
[26] Burrus, C., Gopinath, R., and Guo, H. *Introduction to Wavelets and Wavelet Transforms: A Primer*. (Prentice Hall, 1998).
[27] T. Ebrahimi and F. Pereira, *The MPEG-4 Book.* , Prentice Hall, 2002.

[28] D. Taubman and M. Marcellin. *JPEG2000: Image compression fundamentals, standards, and practice,*springer, 2002.
[29] James S. Walker. 1999. *A Primer on Wavelets and Scientific Applications,* Kluwer Academic Publishers, 2001.

Pankaj U.Lande received his BSc and Msc in Electronics science from University of Pune,Pune India in 2003 and 2005 respectively. He received a Late Satish Bhide award for the best project from university of Pune. Presently he is working as an assistant professor in Instrumentation Science Department, University of Pune, Pune, India. He has published seven papers on digital watermarking technology in journals and International conferences. His research interest includes Digital Image Processing Neural Network, Fuzzy logic.

Sanjay N. Talbar received his B.E and M.E degrees from SGGS Institute of Technology, Nanded, India in 1985 and 1990 respectively. He obtained his PhD from SRTM University, Nanded, India in 2000. He received the "Young Scientist Award" by URSI, Italy in 2003. He had Collaborative research programme at Cardiff University Wales, UK. Presently he is working as Professor and Head, Department of Electronics & Telecommunication Engg., SGGS Institute of Engineering & Technology Nanded, India. He has published 12 journal papers and more than 65 papers in referred National as well as International Conferences. His research interests includes Image processing, Multimedia Computing and Embedded System Design. He is a member of many prestigious committees in academic field of India.

Dr. G. N. Shinde is Principal in Indira Gandhi College, Nanded, Maharashtra, INDIA. He has received M. Sc. & Ph.D. degree from Dr. B.A. M. University, Aurangabad. He has awarded Benjongi Jalnawala award for securing highest marks at B.Sc. He has published 27 papers in the International Journals and presented 15 papers in International Conferences. In his account one book is published, which is reference book for different courses. He is also member of different academic & professional bodies such as IAENG (Hon Kong), ANAS (Jordan).He is in reviewer panel for different Journals such as IEEE (Transactions on Neural Networks), International Journal of Physical Sciences (U.S.A.), Journal of Electromagnetic Waves and Applications (JEMWA, U.S.A.).He was the Chairperson for F-9 session of International Conference on Computational and Experimental Science & Engineering which was held at Honolulu, U.S.A. He is member of Management Council & Senate of S.R.T.M. University, Nanded, INDIA. His research interest includes Filters, Image processing and Multimedia analysis and retrieval system.