Design and Implementation of Effective Architecture for Reversible Watermarking using FPGA

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Abstract— this paper presents reversible watermarking method for copyright protection and owner authentication. Watermarking is an important field for copyrights of digital media. This project focuses on the design and implementation of a fast FPGA (Field Programmable Gate Array) based architecture using discrete cosine transform (DCT) based image watermarking algorithm. DCT is Simple transform than others for the embedding and extracting of the watermark. Design and implementation of area efficient VLSI architecture has been done on Spartan 3 FPGA families. Security level offered by the watermarking techniques based on hardware is higher than the software based watermarking techniques. In hardware watermarking implementation, the data is untouched by an external party.

Key words: Watermarking, DCT, Reversible watermarking, VLSI Architecture, and FPGA

I. INTRODUCTION

The needs of internet increasing day to day and to show multimedia contents on the internet become necessary. Documents and Intellectual property right are not fast information but property. Torrents, face book, YouTube, pirate bay such other image, audio, video, documents resource websites are now necessary for youngsters across the globe like water and food so it is requirement to protect the rights of authors. So, it is necessary to protect and in-evitable digital media.

There are many popular techniques for this such as cryptography, Fingerprinting, Digital signature, Steganography and Digital watermarking but Digital watermarking is proved best out of them. The major problem in the digital age is protection of intellectual property. Important characteristics of the watermark are invisibility, robustness, readability and security. The watermarking is classified according to data such as text watermarking, image watermarking, audio watermarking and video watermarking.

Digital watermarking is that technology that provides and ensures security, data authentication and copyright protection to the digital media. “Digital watermarking” is the embedding of signal, secret information (i.e. Watermark) into the digital media such as image, audio and video. Later the embedded information is detected and extracted out to reveal the real owner/identity of the digital media. [5] It is important to restore the original image without any distortions for some applications like medical, military and law enforcement image system. “Reversible watermarking” is referred to as the watermarking techniques satisfying those requirements. [1] Reversible watermarking is designed so that it can be removed to completely restore the original image.

II. REVERSIBLE WATERMARKING TECHNIQUES

The basic techniques of reversible watermarking are:

(1) Difference Expansion
(2) Histogram bin Shifting
(3) Data hiding using DWT
(4) Contrast Mapping
(5) Integer DCT

1) Difference Expansion:

To represent the features of the original image this scheme usually generates some small values. After that, it enlarges the generated values to embed the bits of watermark data or information. The watermark information or data is usually embedded in the least significant bits (LSB) parts of the expanded values. By using the modified values watermarked image is reconstructed. [11] For the lossless recovery of the Original Image and the watermark, the similar process is required to be followed.

2) Histogram Bin Shifting:

The two types of reversible watermarking are not robust under distortion and image processing. The embedding target is replaced by the histogram of a block to enhance the robustness of the reversible watermarking. For the lossless recovery of the watermark and the original Image, similar process is used.

3) Distortion less data Hiding Algorithm Based on DWT:

It is a distortion less image data hiding algorithm based on DWT which can invert the steno-image into the real image without any change or distortion after the watermarked data are extracted.[10] In this algorithm, it hides data into one or more middle bit planes of the DWT coefficients in the high and middle frequency sub bands. The similar process is for the lossless recovery of the Original Image and the watermark. [10]

4) Contrast Mapping:

In this scheme, a simple integer transform defined on pairs of pixels. Reversible Contrast Mapping is perfectly invertible, even if the least significant bits of the transformed pixels are lost. This scheme is suitable for data hiding because the data space is occupied by the least significant bits. There are two steps in reversible Contrast mapping: (1) Marking and (2) Detection and original recovery.

5) Integer Discrete Cosine Transform:

Discrete cosine transform technique is still most popular and classic for image processing. To embed watermarking information into the middle frequency bands of an image, DCT allows an image to be broken up into different bands of frequency which is much easier. The middle frequency bands are chosen because it allows low frequencies (important parts of image) and rejects unwanted high frequencies (e.g. noise).

The DCT separate the image into differing importance parts w.r.t. the image's visual quality. [9] The DCT transforms an image or signal from the spatial domain to the frequency domain same as the Fourier transform. A DCT expresses a sequence of data points in terms of a sum of cosine functions oscillating at different frequencies.

Discrete cosine transforms are important to applications in engineering and science, from lossless compression of images (e.g. JPEG) & audio (e.g. MP3) (where high frequency components are discarded), to spectral for the numerical solution of partial differential equations.[11] For some critical applications like compression, use of cosine functions is better than sine functions. The cosine functions are much more efficient and for differential equations it expresses a particular choice of boundary conditions.

III. PROPOSED ALGORITHM

Discrete cosine transform separates image into parts of different frequencies where important frequencies are used to extract the image during decompression and less important frequencies are removed through quantization. DCT has many advantages as compared to other transforms:

(1) DCT has been implemented in single integrated circuit;
(2) In fewest coefficients, it can pack most information.
(3) When boundaries between sub images become visible, it minimizes the block appearance which is called blocking artefact. [9]

A. *Watermark Embedding:*

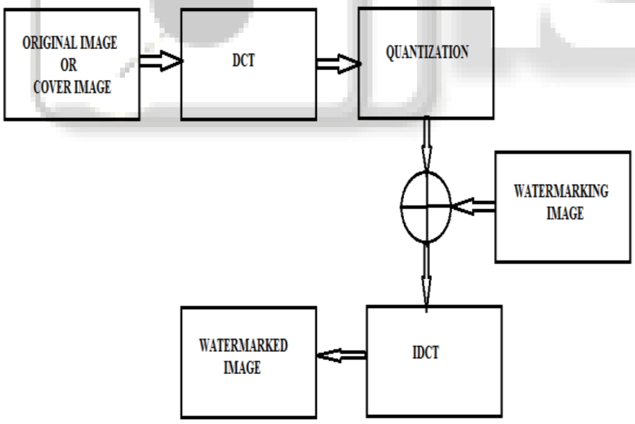

Fig. 1: Block Diagram of Watermark Embedding

B. *Steps for watermark embedding:*

(1) Read colour host image.
(2) Convert RGB colour values to YCbCr colour space components.
(3) Apply discrete cosine transform.
(4) The watermark components are embedding into the frequency subcomponents.
(5) Apply Inverse discrete Cosine Transform.
(6) Convert YCbCr colour space to RGB.
(7) Get watermarked image.
(8) Check Authentication.

C. *Watermark Extraction:*

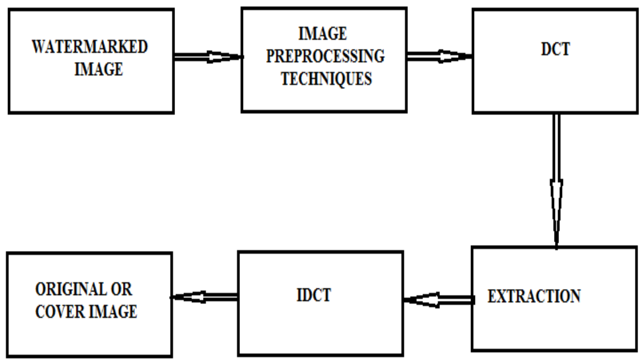

Fig. 2: Block Diagram of Watermark Extraction

D. *Steps for watermark extraction:*

(1) Read Watermarked image.
(2) Convert RGB colour values to YCbCr colour space components.
(3) Apply discrete cosine transform.
(4) The watermark components are extracted out from frequency subcomponents.
(5) Convert YCbCr colour space to RGB colour values.
(6) Get watermark image.
(7) Check Authentication.

E. *2D-DCT implementation:*

The following content gives a detailed description of DCT. The input is 12 bit signed pixels and it will provide an output of 16 bit signed coefficient for the DCT. There are 11 data bits in 12 bit input signed pixels and these bits can be multiplied 8 times for an 8x8 DCT. (Where 11 bits are represented by 3 bits). Here, 11 bits multiplied by 3 bits which gives result of 14 bits. These 14 bits are also adds the sign bit and the fraction bit which gives a result of 16 bits.

The following equation is for 2D-DCT algorithm:

$$XCpq = \sum_{m=0}^{M-1} \sum_{n=0}^{N-1} \mathrm{XNmn} \frac{\mathrm{C(p)C(q)}}{4} . \cos\left(\frac{\pi(2m+1)p}{2\mathrm{M}}\right). \cos\left(\frac{\pi(2n+1)q}{2\mathrm{N}}\right)$$

First the 1D DCT of the rows and then columns are calculated. The following equations are for the row and column part.

$$C = K.cos\frac{(2.col\# + 1).row\#.\pi}{2.M}$$

Where, K = $\sqrt{1}$ /N for row = 0 and $\sqrt{2}$ /N for row ≠0

$$C^t = K.cos\frac{(2.row\# + 1).col\#.\pi}{2.N}$$

Where, K = $\sqrt{1}$ /M for col = 0 and $\sqrt{2}$ /M for col ≠0

Where M = total no. of columns and N = total no. of rows

To form the architecture of the 2D-DCT, 8 point 1D-DCT is followed by internal buffer memory and it is followed by another 8 point 1D-DCT.

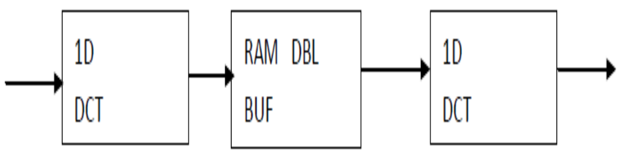

Fig. 3: 2D-DCT Using Vector Processing

Here we are using CSA adder in 2D-DCT implementation because it is the design of high speed multi operand adder. In CSA adder we are applying 2 input at a time and after applying two values we getting sum and subtract value and continually comparing with matrix value and after the difference in adder it store in adder if there is any difference else store in subtractor. It identifying and multiply with the value of matrix and after multiplying it goes to the final CSA adder and goes to final output of DCT. Here, we used Carry save adder instead of full adder. Because, there are many advantages of CSA adder like less delay, it uses less area, low power consumption, high speed and lower cost.

F. 2D-IDCT Implementation:

The following content gives a detailed description of IDCT. The input is 16 bit signed pixels and it will provide an output of 12 bit signed coefficient for the IDCT. In the total 16 bits, there are 15 bits of data including the fraction bit and excluding the sign bit. [7] After applying IDCT, it divides 15 bits of data by 8 which is represented by 3 bits is resulting in 12 bits. After the whole procedure, we can say that IDCT is best or perfect inverse of DCT. To give a final result of 12 bits, the 1 fraction bit is ignored & the sign bit is added back.

The following equation is for 2D-IDCT algorithm:

$$XNpq = \sum_{m=0}^{M-1} \sum_{n=0}^{N-1} XCmn \frac{C(p)C(q)}{4}.\cos\left(\frac{\pi(2m+1)p}{2M}\right).\cos\left(\frac{\pi(2n+1)q}{2N}\right)$$

First the 1D IDCT of the rows and then columns are calculated. [9] The row part and the column part of 1D IDCT coefficients are given below.

$$C = K.\cos\frac{(2.col\# + 1).row\#.\pi}{2.M}$$

Where, K = $\sqrt{1}$ /N for row = 0 and $\sqrt{2}$ /N for row ≠0

$$C^t = K.\cos\frac{(2.row\# + 1).col\#.\pi}{2.N}$$

Where, K = $\sqrt{1}$ /M for col = 0 and $\sqrt{2}$ /M for col ≠0

Where M = total no. of columns and N = total no. of rows

To form the architecture of the 2D-IDCT, 8 point 1D-IDCT is followed by internal buffer memory and it is followed by another 8 point 1D-IDCT.

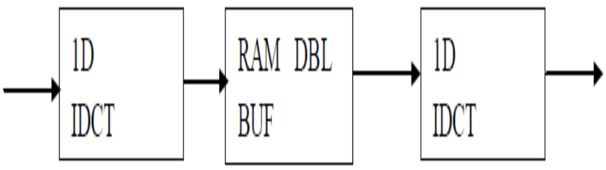

Fig. 4: 2D-IDCT Using Vector Processing

Here, applying shift operator with matrix values and after showing the difference in matrix it goes to final CSA adder and adder is generally showing possibilities of difference and goes to final IDCT output.

IV. ANALYSIS AND EXPERIMENTAL RESULTS

The synthesis reports of watermarking and reversible watermarking:

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Device Utilization Summary (estimated values)			
Logic Utilization	Used	Available	Utilization
Number of Slices	222	3584	6%
Number of Slice Flip Flops	93	7168	1%
Number of 4 input LUTs	419	7168	5%
Number of bonded IOBs	6	141	4%
Number of BRAMs	2	16	12%
Number of GCLKs	1	8	12%

Fig. 5: synthesis report of watermarking

Device Utilization Summary (estimated values)			
Logic Utilization	Used	Available	Utilization
Number of Slice Registers	63	93120	0%
Number of Slice LUTs	117	46560	0%
Number of fully used LUT-FF pairs	58	122	47%
Number of bonded IOBs	21	240	8%
Number of Block RAM/FIFO	1	156	0%
Number of BUFG/BUFGCTRLs	1	32	3%

Fig. 6: synthesis report of reversible watermarking

A. Implementation of reversible watermarking:

Fig. 7: Implementation of reversible watermarking

V. CONCLUSION

To improve the quality and some parameters of final image with respect to original image, the proposed algorithm reduces the calculation complexity of embedding and scaling factors. The discrete cosine transform algorithm is used to calculate the DCT coefficient values of the watermark image and host image. To minimize the power consumption and the resource utilization in terms of area/slice occupied by HDL language, DCT algorithm is used. There are many advantages of this hardware implementation such as reduced area and increased speed. We have been done watermarking and reversible watermarking on FPGA using HDL. To study the performance of this architecture, it is implementing in Xilinx.

REFERENCES

[1] Sudip Ghosh, BijoyKundu, DebopamDatta, Santi P Maity and HafizurRahaman, “Design and Implementation of Fast FPGA Based Architecture for Reversible Watermarking”, International Conference on Electrical Information and Communication Technology, 1-6, IEEE 2013.

[2] Ahmet TuranErozan, SubutayGiray Bashkir, Berne Anvil, “Hardware / Software Co-design for Watermarking in DCT Domain”,Signal Processing and Communications Applications Conference (SIU), IEEE 2013.

[3] S. Kiran, K.V.Nadhini Sri And Dr. J. Jaya,”Design And Implementation Of FPGA Based Invisible Image Watermarking Encoder Using Wavelet Transformation”, International Conference On Current Trends N Engineering And Technology, IEEE 2013.

[4] Chen Feifei, Li Yuhui, Li Bo, and Lian Yu, “FPGA Based Adaptive Image Watermark Embedding Method and Implementation”, Information Science and Control Engineering (ICISCE), IEEE 2012.

[5] Amit M Joshi, Prof.AnandDarji, Prof. Vivekanand Mishra, “Design and Implementation of Real-Time Image Watermarking”, Signal Processing, Communications and Computing (ICSPCC), IEEE 2011.

[6] Waikhom Mona Chanu, Bitan Chakraborty and Diwarkar R Marur, “Implementation of Blind Image Watermark Encoder in FPGA.” International Journal of Information and Computation Technology, 2014.

[7] Nirabh Agarwal, 2Arpit Jain, 3Prof. Sanjeev Sharma, “Design and Simulation of Dct Chip In Vhdl and Application in Watermark Extraction”,IOSR Journal of Computer Engineering (IOSR-JCE), 2014.

[8] AnandDarji, Dr. A.N.Chandorkar, Dr. S.N.Merchant and Vipul Mistry, “VLSI Architecture of DWT based Watermark Encoder for Secure Still Digital Camera Design” Third International Conference on Emerging Trends in Engineering and Technology,IEEE 2010

[9] Pravin M. Pithiya, “DCT Based Digital Image Watermarking, De-watermarking & Authentication” , International Journal of Latest Trends in Engineering and Technology (IJLTET), 2013

[10] Priyanka S. Aher, K. U. Rahane “Survey on Reversible Watermarking**”,** IOSR Journal of Computer Engineering (IOSR-JCE), 2013.

[11] NavnathNarawade, Dr. RajendraKanphade,” Reversible Watermarking: A Complete Review”, International Journal of Computer Science and Telecommunications, June 2011.

[12] Amitesh, K. and Santhi, V. “A review on geometric invariant digital image watermarking techniques”, International Journal of Computer Applications, Vol. 12, No. 9, pp. 31–36, 2011.

