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Image Watermarking – Hybrid Approach for Embedding Binary Watermark into the Digital Image

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Abstract: ***This paper illustrates a unique approach for embedding binary image watermarks into the digital images. or the purpose of watermarking; we made use of three most influential transforms in the field of image processing i.e. Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT) and Singular Value Decomposition (SVD). For the sake of estimation, comparison and calculation of our approach we calculated three image quality parameters specifically peak signal to noise ratio (PSNR), Mean square error (MSE) and Correlation.***

Keywords: Watermarking, DWT, DCT, SVD, Attacks, PSNR, MSE

I. INTRODUCTION

This era is an era of ultimate connectivity which is connectivity & communication through internet and wireless networks spread all across the world. We have some of the most extraordinary innovations like digital camera, camcorders, MP3 players, PDA's etc. for making, handling and using the multimedia information. These days, the expansion of internet has provided us some cherished gifts like electronically publishing of files, e-marketing, online newspaper, online magazine, online libraries, online videos, online audio, online commerce, online money transactions, real time data deliverance and much more. Because of all these things, containing, sharing and manipulating digital images over the internet have become a very simple task. So, authors of the images are afraid of sharing and giving their valuable piece of art, personal photographs, and important images through internet because of the problem of copyright protection [1, 2]. It becomes such a simple task to copy the digital information and then it is pasted somewhere else, it looks and works like the original data and thus it leads towards what is universally known as data piracy. The best case scenario to protect multimedia images or information against illegal usage is to implant a watermark, called digital watermark or copyright information into the cover data that authenticates the ownership of the data. This technique is called digital watermarking or in our case digital image watermarking which is a technique to hide an undisclosed signature, message or watermark inside the cover guess or make out the message with his naked eye and also he/she considers it as a normal image. The implanted message may be the creator name, emblem of his organization, or any sign which proves his or her ownership over the given image, data or information [3,4]. These days, both industrial individuals and research scholars are working hard to develop techniques that help us to provide evidence of proprietorship and to avoid illegal modification of the multimedia data. In our case, we try to focus on the digital images as our prime target. Various techniques and algorithms have been implemented in the field of digital image watermarking; few have been robust yet use too many resources and few that use little resources but does not pertain quality. Here we try to develop a sophisticated approach which may solve most of the problems experienced in the previously deployed techniques.

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II. QUALITY ASSESSMENT PARAMETER

Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR), Correlation are the Images quality assessment parameters, used in this paper. The Correlation is calculated using the cover watermark and resultant image. Value of The correlation is always measured between 0 and 1.The three parameters have been selected the following image quality matrices [10]. for the purpose of evaluation for degradation after the watermark is included in the bitmap.

$$MSE = \frac{1}{M \times N}\sum_{x=1}^{m}\sum_{y=1}^{n}\{\left(f(x,y) - f'(x,y)\right)^2\} \qquad (1)$$

$$PSNR = 10log_{10}\frac{255^2}{MSE} \qquad (2)$$

$$\mathrm{CC} = \frac{\sum_i \sum_j W_c(i,j)\mathrm{W_w}(i,j)}{\sum_i \sum_j \mathrm{W_c}(i,j)^2} \qquad (3)$$

Here, Mean Square Error is denoted by MSE, while Peak Signal to noise Ratio is denoted by PSNR, f(x, y) is the cover Image, f'(x, y) is Watermarked Image. MSE is defined as the average squared difference between a reference image and a distorted image presented by equation (1) and to calculate the similarity between the original image and watermarked image, PSNR is used which can be represented in mathematically expressed by above equation (2)[11,12]. Hence at the receiver end it is observed that we have extracted the watermark and computed the correlation for recovered watermark and original watermark for the purpose of assessing the robustness. [13, 14].

III. IMPLEMENTATION

In this algorithm, for the purpose of watermark embedding and extraction, Hybrid methods are used in a mixture of DWT, DCT and SVD this method shown in Fig.1& Fig.2.

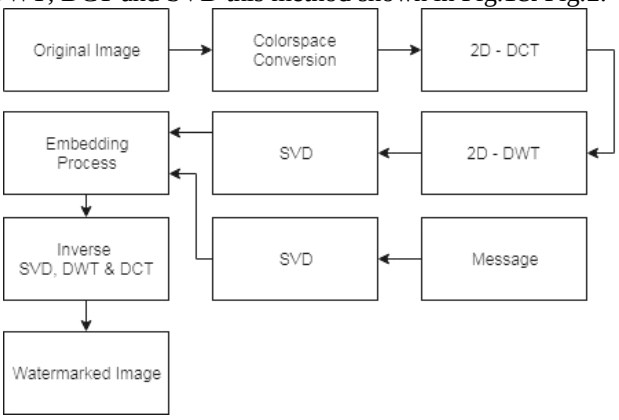


Fig. 1. Block Diagram for Hybrid Watermark Embedding

Fig.1 describes the watermark embedding process done on a host image. First of all the original image is passed the colorspace conversion process for converting RGB to YcbCr. Then the 2-dimenstional Discrete cosine transform [5,7,9] is applied on the converted image. After applying DCT, 2-dimenstional Discrete wavelet transform [6,7] is applied. Then finally Singular value decomposition [8,15] if performed on the image. Meanwhile, the watermark is under passed SVD process. The then watermark is embedded on the image. After the embedding is done, Inverse DCT, DWT and SVD is applied to output image. Then colorspace conversion is done on the image and at last we get our watermarked image.

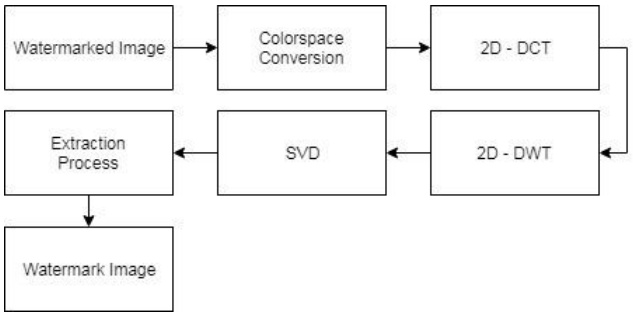


Fig. 2. Block Diagram for Hybrid Watermark Extraction

Fig. 2 describes the watermark extracting process done on a watermarked image. Firstly the watermarked image is passed through the colorspace conversion process. Then 2-Dimensional DCT is performed followed by a 2-Dimensional DWT. Then after, SVD is applied on the image. Then the extraction process is started. At the end of the process we get the watermark image which was previously embedded onto the image.

IV. RESULT & DISCUSSION

We have experimented the Mixture of DWT, DCT & SVD as the watermarking algorithm on different cover image and watermark. The performance is calculated by measuring PSNR and MSE. Simulation results show that hybrid technique is imperceptible and robust against variety of attacks.

A. Experimental result of custom images watermarked with binary message without attack

The Table I, as shown in a watermark has been implanted in an original image and parameters like PSNR, MSE& Correlation are also described. A common watermark is embedded in all custom images here the name of all watermarked images.

Table I. Result of hybrid based method with gain factor 100 & binary message

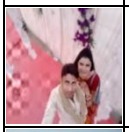
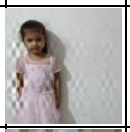
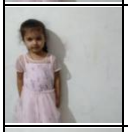
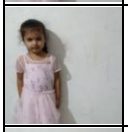
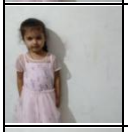
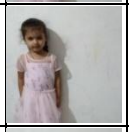
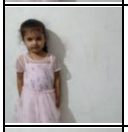
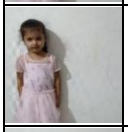
Images	Parameter Value	Images	Parameter Value
	PSNR = 36.1823 MSE = 15.662 Correlation = 0.9377		PSNR = 36.6182 MSE = 14.1665 Correlation = 0.938
	PSNR = 37.5106 MSE = 11.5351 Correlation = 0.9159		PSNR = 38.6799 MSE = 8.8124 Correlation = 0.9323
	PSNR = 38.8857 MSE = 8.4045 Correlation = 0.8983		PSNR = 37.6299 MSE = 11.2226 Correlation = 0.9197
	PSNR = 36.962 MSE = 13.0884 Correlation = 0.9362		PSNR = 37.1592 MSE = 12.5073 Correlation =0.9386
	PSNR = 39.1897 MSE = 7.8363 Correlation = 0.9386		

Table II. Recovered watermark images extracted from the custom watermarked images (a) bhai (b) niyu (c) camel (d) pari (e) crow (f) elephant (g) m (h) ladu (i) sea

 (a)	 (b)	 (c)
 (d)	 (e)	 (f)
 (g)	 (h)	 (i)

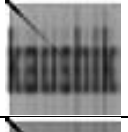
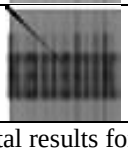
Table III. Result of hybrid based method on image niyu with different gain factor& binary message.

Images	Parameter Value	Images	Parameter Value
	Alpha = 1 PSNR = INF MSE = 0 Correlation = 0.80		Alpha = 2 PSNR = 77.1048 MSE = 0.0013 Correlation = 0.87
	Alpha = 3 PSNR = 70.3961 MSE = 0.0059 Correlation = 0.91		Alpha = 4 PSNR = 66.792 MSE = 0.0136 Correlation = 0.92
	Alpha = 5 PSNR =64.1287 MSE = 0.0251 Correlation = 0.93		Alpha = 6 PSNR = 61.8724 MSE = 0.0423 Correlation =0.93
	Alpha = 7 PSNR =59.7025 MSE = 0.0696 Correlation = 0.93		Alpha = 8 PSNR = 57.8737 MSE = 0.1061 Correlation = 0.93
	Alpha = 9 PSNR = 56.2262 MSE = 0.155 Correlation = 0.938		Alpha = 10 PSNR =54.8145 MSE = 0.2146 Correlation = 0.938
	Alpha = 30 PSNR = 43.2177 MSE = 3.0996 Correlation = 0.938		Alpha = 50 PSNR =40.0107 MSE =6.4865 Correlation = 0.938
	Alpha = 70 PSNR = 38.2099 MSE = 9.8195 Correlation = 0.939		Alpha = 90 PSNR = 37.0527 MSE = 12.8177 Correlation = 0.938
	Alpha = 100 PSNR = 36.6182 MSE = 14.1665 Correlation = 0.93		

The Table III shows the image niyu at various gain factors. Gain factors can be measured in an enormous range of alpha factors. Table 3 illustrates image niyu in alpha factors 1 to 10, 30, 50, 70, 90 & 100. Also parameters like PSNR, MSE & Correlation is recorded for same set of images and displayed in the table.

B. Experimental result of custom images watermarked with binary message with attack

Table IV. Average filtering with various masks sizes

Image	Parameters	Extracted watermark
	Mask Size: 3x3 PNSR: 35.0628 Correlation: 0.8824	
	Mask Size: 5x5 PNSR: 33.8981 Correlation: 0.8010	
	Mask Size: 7x7 PNSR: 33.1089 Correlation: 0.7062	
	Mask Size: 9x9 PNSR: 32.4939 Correlation: 0.6028	

As illustrated in Table IV experimental results for average filtering attack done on the image niyu.It displays various mask size of the attack that was applied. Also the attacked image niyu with its PSNR reading & the extracted watermark with its correlation readings are displayed.

Table V. Compression with various quality values

Image	Parameters	Extracted watermark
	Quality Value: 5 PSNR: 32.4028 Correlation: 0.8965	
	Quality Value: 20 PSNR: 34.6735 Correlation: 0.9293	
	Quality Value: 60 PSNR: 35.9832 Correlation: 0.9358	
	Quality Value: 80 PSNR: 36.4888 Correlation: 0.9376	

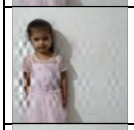
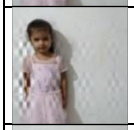
As illustrated in Table V, experimental results for compression attack done on the image niyu. It displays various quality values of the attack that was applied. Also the attacked image niyu with its PSNR reading & the extracted watermark with its correlation readings are displayed.

Table VI. Cropping with various crop regions

Image	Parameters	Extracted watermark
	Crop Regions: 25 PSNR: 35.931 Correlation: 0.9401	
	Crop Regions: 50 PSNR: 34.4163 Correlation: 0.9373	
	Crop Regions: 75 PSNR: 32.6948 Correlation: 0.9304	
	Crop Regions: 100 PSNR: 31.1532 Correlation: 0.9138	

As illustrated in Table VI experimental results for cropping attack done on the image niyu. It displays various crop regions of the attack that was applied. Also the attacked image niyu with its PSNR reading & the extracted watermark with its correlation readings are displayed. As illustrated in Table VII experimental results for Gaussian law pass filter attack done on the image niyu. It displays various deviations of the attack that was applied. Also the attacked image niyu with its PSNR reading & the extracted watermark with its correlation readings are displayed.

Table VII. Gaussian law pass filter with various standard deviations

Image	Parameters	Extracted watermark
	Stand. Dev.: 0.5 PSNR: 35.6105 Correlation: 0.9292	
	Stand. Dev.: 1.5 PSNR: 35.1217 Correlation: 0.8871	
	Stand. Dev.: 2 PSNR: 35.0955 Correlation: 0.8848	
	Stand. Dev.: 3 PSNR: 35.0768 Correlation: 0.8834	

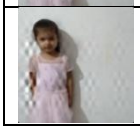
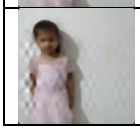
As illustrated in Table VII experimental results for Gaussian noise attack done on the image niyu. It displays various variances of the attack that was applied. Also the attacked image niyu with its PSNR reading & the extracted watermark with its correlation readings are displayed.

Table VIII. Gaussian noise with 0 mean and various variances

Image	Parameters	Extracted watermark
	Variance.: 0.0005 PSNR: 33.6843 Correlation: 0.9404	
	Variance.: 0.01 PSNR: 28.6867 Correlation: 0.9327	
	Variance.: 0.09 PSNR: 27.5954 Correlation: 0.852	
	Variance.: 1.0 PSNR: 27.2384 Correlation: 0.6158	

As illustrated in Table IXexperimental results for Median Filtering attack done on the image niyu. It displays the various mask size of the attack that was applied. Also the attacked image niyu with its PSNR reading & the extracted watermark with its correlation readings are displayed.

Table IX. Median filtering with various mask sizes

Image	Parameters	Extracted watermark
	Mask Size: 3 PNSR: 36.4516 Correlation: 0.9067	
	Mask Size: 5 PNSR: 36.2008 Correlation: 0.8315	
	Mask Size: 7 PNSR: 36.095 Correlation: 0.7495	
	Mask Size: 9 PNSR: 36.0647 Correlation: 0.6598	

As illustrated in Table X experimental results for Rotation attack done on the image niyu. It displays various rotation angles of the attack that was applied. Also the attacked image niyu with its PSNR reading & the extracted watermark with its correlation readings are displayed.

Table X. Rotation with various angles

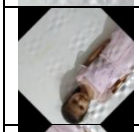
Image	Parameters	Extracted watermark
	Angle: 30 PNSR: 28.0956 Correlation: 0.5605	
	Angle: 90 PNSR: 28.0331 Correlation: 0.2709	
	Angle: 135 PNSR: 26.8519 Correlation: 0.6599	
	Angle: 225 PNSR: 27.2539 Correlation: 0.5946	

Table XI. Histogram equalization

Image	PSNR	Extracted watermark	Correlation
	25.504		0.7149

As illustrated in Table XI experimental results for histogram equalization attack done on the image niyu.The attacked image niyu with its PSNR reading & the extracted watermark with its correlation readings are displayed.

V. CONCLUSION

From the work we carried out, we can conclude that our proposed algorithm, The Mixture of DWT-DCT-SVD hybrid algorithm was found robust against various attacks like Compression, Cropping, Gaussian Law Pass Filter, Gaussian Noise, Median Filtering, and Rotation& Histogram Equalization. All the tests result show better and higher Peak Signal to Noise Ratio (PSNR) value, as well as minimal Mean Square Error (MSE) value. All these factors prove that proposed algorithm is a powerful approach that helps to embed and extract a watermark from an image which has gone through different attacks.

Taking PSNR, MSE and Correlation to note, our proposed method holds its robustness and sheer visual clarity of the image even after attacked by various attacks which was not the case in other proposed techniques in the past like DWT, DCT, SVD and mixture of either of the techniques.

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