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Secured Digital Image Watermarking by using a Hybrid Technique with Kalman Filtering

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Abstract: **The growing need to protect the digital media from unauthorized access results into the development of different watermarking techniques. The choice of a good watermarking technique leads to the best watermarking process. In this paper watermarking process is performed by taken a hybrid technique which consists of three different techniques of frequency domain. The quality of the watermarked images is enhanced by following a hybrid technique with Kalman filtering. Singular value decomposition, discrete wavelet transform and discrete cosine transform along with Kalman Filtering are used as a hybrid technique to protect the image from unauthorized attacks. The obtained watermarked image is then going through various image processing attacks. The results have shown that the hybrid technique gives acceptable values against these attacks.**

Keywords: SVD, DWT, DCT, Kalman Filter, PSNR, MSE.

1. INTRODUCTION

The usage of internet is increasing day by day. It is a huge way of communication and exchanging information. Due to the development in technology it becomes very easy to change someone's information. So authentication is required in every field to protect the information from unauthorized access. Watermarking and Steganography are the two ways to protect the information from unauthorized access. Watermarking is a widely used concept now a day. It is a technique of protecting digital media from other than authorized users. The digital media can be an image, a video, a text or an audio. In this paper, image is used as a digital media. For performing image watermarking, two images required. One image is inserted into another image to protect itself from misuse. The image which is inserted into another image is called the watermark image or the useful information which is to be hidden from unauthorized access. The results of the watermarking process contain an image called watermarked image. If the watermarking technique is highly concerned with security purposes then the watermarked image should be highly robust and imperceptible. Robustness is concerned with the idea of protecting the image from a variety of attacks. An image is highly imperceptible if the difference between the original image and the watermarked image is hardly noticed by the naked image. According to the domain in which the watermarking process takes place, the techniques are decomposed into two domains, Spatial Domain and Frequency Domain. In this paper frequency domain techniques are taken to perform watermarking. The singular value decomposition, discrete wavelet transform and discrete cosine transform along with Kalman Filtering are taken as a hybrid technique to obtain a robust and imperceptible watermarked image. The watermarked image is then go through various image processing attacks. Acceptable results are obtained by using this hybrid technique of watermarking. The performance of the watermarked image is measured by two performance metrics: PSNR and MSE.

A. Singular Value Decomposition:

Singular Value Decomposition is an algorithm of linear algebra. The important amount of information is preserved by SVD subspace and that's why it is used for solving the false positive problem. The principle components of watermark are inserted into the singular values of the original image. It makes impossible for the unauthorized author to know the exact principle components and singular values of the image. The other key point of SVD based image watermarking is the stability property of the singular value matrix. A digital Image X of size M×N, with M ≥ N, can be represented by its SVD as follows:

$$X = USV^T \quad [1]$$

U = [U1, U2……Um], [2]

V = [V1, V2……Vn], [3]

$$S = \begin{bmatrix} \sigma_1 & & & \\ & \sigma_2 & & \\ & & 0 & \\ & & & \sigma_n \end{bmatrix} \quad [4]$$

where U is an M×M matrix, V is an N×N matrix, and S is an M×N matrix with the diagonal elements representing the singular values of X. T denotes the transpose of the matrix. The columns of the orthogonal matrix U are called left singular vectors and the columns of the orthogonal matrix V are called right singular vectors. For solving the ownership problem, relevant scaling factor is used which can preserve the robustness of the watermark. For performing SVD based image watermarking, two images, original image and watermark image, are required. If colored watermark image is there then it is changed into gray scale image first and then the procedure is followed [4] [8].

B. Discrete Wavelet Frequency:

DWT is a frequency domain technique which shows robust results. DWT consists of filters which divides an image into four multiresolution sub bands. These sub bands are denoted by LL, LH, HL and HH. LL band describes the

coarse level coefficients of the image and the other three bands describe the finest scale of wavelet coefficients. LL band of the DWT has the greatest magnitude. The advantage of greatest magnitude and high resolution is that it indicates the edges and patterns of an image. DWT technique is the most commonly used technique in image watermarking, audio and video watermarking [4].

C. Discrete Cosine Frequency:

DCT separates the image into three frequency coefficients. These frequency coefficients may vary through low, high and middle frequency coefficients. For robust results, the embedding is performed in the middle frequency. The visibility of the image is not affected if the image is embedded in the middle frequency components of the discrete cosine frequency. Also DCT describe the location of the image in which the watermark is to be embedded. Middle frequency of the DCT usually gives robust and imperceptible results [6].

E. Kalman Filtering:

Kalman Filter is highly based upon digital signal processing. The various types of estimates can be given through this filter. The past, present and future estimates or states of a system can be measured through this filter. This filter has been used in the enhanced technique present in this paper. It minimizes the noise and improves the robustness of the image. The main purpose of using Kalman filter is to minimize the MSE and increase the PSNR value [12].

F. Performance parameters:

The quality of watermarked image is measured with two main performance metrics: PSNR (Peak Signal to noise ratio) and MSE (Mean Square Error). The MSE is calculated as follows:

$$MSE = \sum_{M,N} \frac{[c(m,n) - e(m,n)]^2}{M * N} \quad [5]$$

where M, N are the number of rows and columns in input image, *c(m,n)* and *e(m,n)* are the watermarked image and the original image respectively.

The value of PSNR is obtained as:

$$PSNR = 10\log_{10}\left(\frac{L * L}{MSE}\right) \quad [6]$$

where L is the maximum fluctuation in input image data type. In this experiment L=255 is taken. It is expressed in terms of logarithmic decibel scale [13].

2. Related Work

Nikolaidis, N. and Pitas, I. describes the different data hiding methods which are used for the purpose of copyright protection. Authors described the various spatial domain watermarking techniques that work with pixel values of the image directly. They concluded that the frequency domain techniques give better and robust results as compared to the spatial domain watermarking techniques [1]. Emir Ganic, et al. presented a hybrid scheme based on DWT and SVD. The original image is decomposed into four sub bands by applying DWT technique first. Singular value decomposition is performed on each of the decomposed band by modifying the singular values. The modifications develop the development of the watermarking scheme by displaying robust results on wide range of attacks [4].

Rawat K.S. et.al, presents a review on digital image watermarking methods against piracy of color images. Different types of watermarks are described in this paper with its applications. The review has proved that the frequency domain methods gave better robustness against spatial domain methods [5]. Run R.S. et. al, propose two methods with DWT and DCT to improve the reliability and robustness of the watermarked image. The results have prove that this method solve a problem of false positiveness [8]. Divecha N.H. et.al, proposed a hybrid technique with SVD-DWT-DCT. The results have proved that this hybrid technique gives robust watermarked images. The results are taken on the basis of Normalized coefficients as a performance parameter[9]. Kaur S. et.al, proposed SVD-DWT-DCT technique with Kalman filtering. Acceptable values of the PSNR and MSE are achieved and the watermarked image is highly robust which show that this technique is better than the traditional hybrid technique. The evaluation has shown that the SVD-DWT-DCT with Kalman Filtering gives better results in contrast to SVD-DWTDCT technique [13].

Though all the research works that have been done on digital image watermarking gave acceptable results. But this paper focuses on the image quality of the watermarked image by using Kalman Filtering. Also some of the above papers give good results by using any technique, but not all the techniques gave better results against various attacks. This paper shows the acceptable values of the PSNR of the watermarked image as well as gives better results against various image processing attacks.

3. Proposed Work

The principal objective of the proposed methodology is to obtain better results of the existing methodology. The better results should be measure on the basis of performance evaluation parameters. PSNR and MSE are the two parameters through which quality of the image is measured. The first methodology can be explained through following simple steps:

1. Two images are taken for the experiment-Original image and Watermark image.
2. First of all SVD is applied on the original image as well as the watermark image. It distributes the image into three parts. Horizontal part is denoted by U component, vertical part is denoted by V component and diagonal part is denoted by S component.
3. An output image is obtained by replacing the diagonal component of the watermark image with the diagonal component of the original image.
4. DWT is applied on the SVD based image. LH band is selected from all the four bands of the DWT image.
5. DCT is applied on the DWT based image. After go through this technique an image is obtained which is called watermarked image.

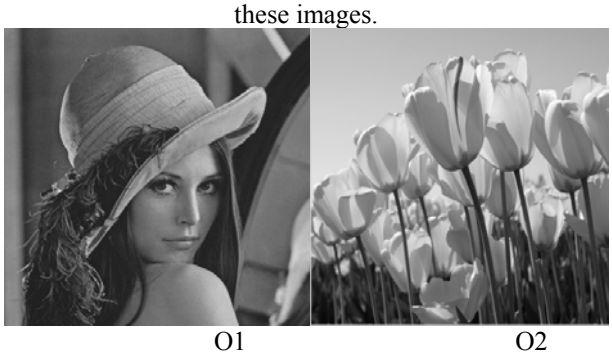
6. The quality of the watermarked image is measured through PSNR and MSE parameters. Also various types of attacks are applied on this technique and their corresponding PSNR and MSE value is obtained.
7. Then the Kalman Filtering is performed on the SVD-DCT-DWT technique. The quality of the image is again measured which gives better results that existing.
8. A number of attacks are applied on the watermarked image. A comparison is performed with the SVD-DCT-DWT technique and SVD-DCT-DWT and Kalman Filtering to check the robustness and imperceptibility of the watermarked images.

It is to be obtained that the given technique gives better results and tolerates all the applied attacks with better quality.

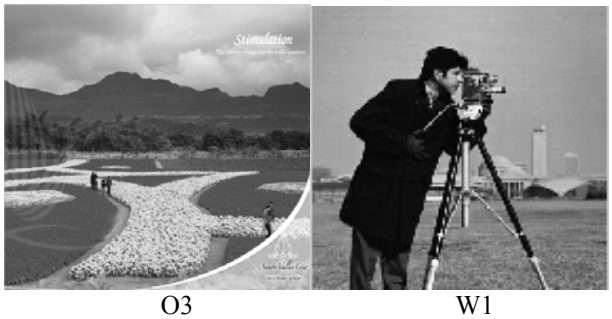
4. RESULTS AND DISCUSSIONS

In the experiment following images are taken as test images. The experiments on these images had performed in Matlab. All the input images had taken in gray scale.

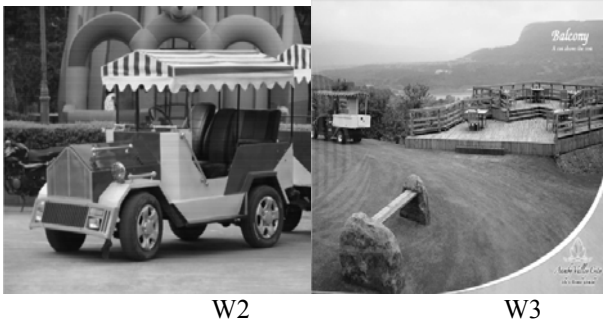
4.1 First of all SVD-DWT-DCT technique is applied on these images.



O1 O2



O3 W1



W2 W3

Fig 1 Different Test Images

The first three images are the original images (O1, O2, O3) and the watermarked images are (W1, W2, W3). By performing hybrid technique of watermarking a third type of images are obtained which are called watermarked images (Wk1, Wk2, and Wk3).

Wk1 WK2

Wk3

Fig 2 Watermarked images obtained by SVD-DWT-DCT.

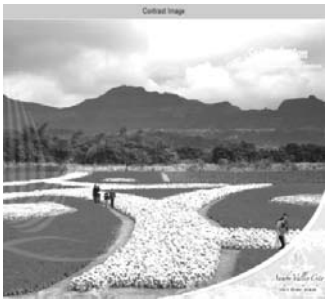
The performance of these watermarked images is measured by PSNR and MSE. Different types of attacks are applied on these watermarked images and their corresponding PSNR and MSE value is obtained. The watermarked images obtained with various attacks are shown below.

Wks1 Wks2

Wks3

Wkc1

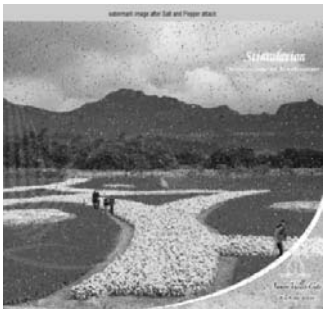
Wkc2



Wkc3

Wkp1

Wkp2



Wkp3

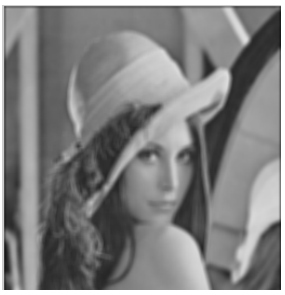
Fig 3 Watermarked images with different attacks (Sharpening attack, Contrast Stretching and Salt and pepper noise attack)

Wks1,Wk2,Wk3 are the images obtained while applying sharpened attack from on the SVD-DWT-DCT watermarked image. Wkc1,Wkc2,Wk3 are the images obtained while applying contrast stretching on the watermarked image. Wkp1,Wkp2,Wkp3 are the images obtained while applying Salt and pepper noise on the watermarked images. The performance of these is also calculated on the basis of two performance parameters. It has been assumed that by using this hybrid technique acceptable values of performance metrics are obtained. The following table shows the obtained values with and without attacks on the SVD-DCT-DWT technique.

TABLE 1 Performance Evaluation of SVD-DWT-DCT based watermarked images with PSNR and MSE.

Existing technique with or without attacks	Watermarked Images	PSNR	MSE
Without any attack	Wk1	24.17	251.00
	Wk2	24.47	250.95
	Wk3	24.10	251.30
With Sharpened attack	Wks1	30.00	65.32
	Wks2	30.09	64.52
	Wks3	30.07	64.25
With Contrast Stretching	Wkc1	24.29	244.29
	Wkc2	24.55	230.10
	Wkc3	24.22	252.30
With Salt and Pepper Noise	Wkp1	30.05	64.83
	Wkp2	30.06	64.32
	Wkp3	30.08	64.60

All the above obtained results are acceptable. For obtaining the better quality of watermarked images Kalman filtering is applied with the hybrid technique. Following are the images which are obtained by taking hybrid technique with Kalman filtering.



wk1

wk2

wk3

Fig 4 Watermarked images obtained by SVD-DWT-DCT and Kalman.

Different types of attacks are applied on these images to check the performance of the enhanced technique. Following images shows the quality of the watermarked images with different attacks.The images denoted by wks series are the images obatined with hybrid technique with kalman filtering but tolerates sharpened attack. Similarly, contrast strecthed and salt and pepper noised images are shown.

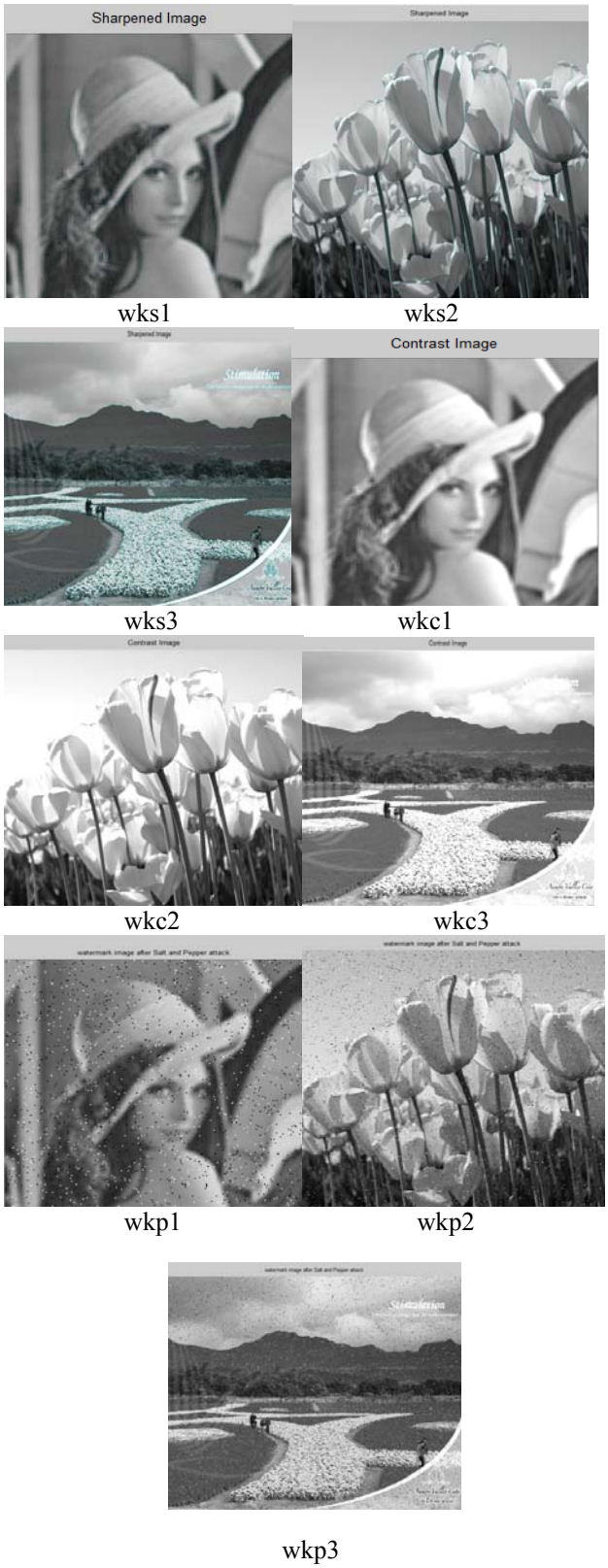


Fig 5 Watermarked images by enhanced technique with different attacks (Sharpening attack, Contrast Stretching and Salt and pepper noise attack)

Though invisible watermarking is used in this paper, the quality of the image could not be measured by just seeing it. The quality of the above images is measured through the two given parameters. Following table shows the acceptable results of the enhanced technique.

TABLE 2 Performance Evaluation of SVD-DWT-DCT with Kalman Filtering based watermarked images with PSNR and MSE.

Enhanced technique with or without attacks	Watermarked Images	PSNR	MSE
Without any attack	wk1	30.26	61.72
	wk2	30.54	57.27
	wk3	30.34	60.66
With Sharpened attack	wks1	29.98	57.83
	wks2	30.04	60.50
	wks3	32.77	61.91
With Contrast Stretching	wkc1	24.29	183.06
	wkc2	24.55	211.59
	wkc3	24.22	244.29
With Salt and Pepper Noise	wkp1	30.04	64.79
	wkp2	30.52	58.15
	wkp3	30.22	63.88

The above obtained results in the table shows that the enhanced technique gives better results than the previous technique. The PSNR value directly describes the clarity of thewatermarked image or the robustness of the watermarked

Image. In the enhanced technique the PSNR value is highly increased by the existing technique which shows the robustness of the enhanced technique. The MSE describe the number of errornous in the watermarked images. The results obtained by the enhanced image shows that there is decrease in MSE value of the watermarked images which shows the imperceptibility of the enhanced technique. The enhanced technique gives better results with different attacks also which shows that the enhanced technique easily tolerates the different attacks on the watermarked images.

5. CONCLUSION

The quality of the watermarked image is highly depends upon the technique used. More the robustness of the watermarked image is, more is the security of the useful information. So it hs been observed that the given technique is highly robust against various attacks and gives better results than the existing technique.The two performance metrics helps in determining the quality of the watermarked image which gives positive and acceptable results with the SVD-DWT-DCT and Kalman Filtering technique than the existing technique.

REFERENCES

[1]. Nikolaidis, N and Pitas I (1999), "Digital image watermarking: an overview", IEEE international conference on multimedia computing and systems, Vol. 1, pp.1–6.

[2]. Hsu, C.T and Wu J.L (1999), "Hidden Digital watermarks in Images", IEEE Transaction on Image processing", Vol 8, No. 1, pp.58-68.

[3]. Lihyang, W. and Peichung (2002), "On the Protection and Authentication of Digital Image Based on Wavelet Transformation", TENCON 02 Proceedings of IEEE Region 10 Conference on Computers, Communications, Control and Power Engineering, Vol. 1, pp.148-151.

[4]. Ganic, E. and Eskicioglu, A.M (2004), "Robust DWT-SVD Domain Image Watermarking: Embedding Data in all frequencies", International Journal of Computer Science and Engineering, Vol.1, pp.168-174.

[5]. Rawat KS and Tomar DS (2009), "Digital watermarking schemes for authorization against copying or piracy of color images". Indian Journal of Computer Science and Engineering Vol.1 No. 4, pp.295-300.

[6]. Gunjal B.L and Mali S.N (2011), "Secured Color image watermarking technique in DWT-DCT Domain". International Journal of Computer Science, Engineering and Information Technology, Vol.1, No.3, pp. 36-44.

[7]. Chaturvedi N, Basha SJ (2012) Comparison of Digital Image watermarking Methods DWT & DWT-DCT on the basis of PSNR. International Journal of Innovative Research in Science, Engineering and Technology Vol. 1 No.2, pp-147-153.

[8]. Run RS, Horng SJ, Lai JL, Kao TW, Chen RJ (2012), "An improved SVD-based watermarking technique for copyright protection". Experts systems with applications, Vol.39, pp-673-689.

[9]. Divecha NH and Jani N.N (2012), "Image watermarking Algorithm using Dct, Dwt and Svd". In Proceedings of National Conference on Innovative Paradigms in Engineering & Technology published by International Journal of Computer Applications, pp.13-16.

[10]. Bisla N and Chaudhary P (2013) "Comparative Study of DWT and DWT-SVD Image Watermarking Techniques". International Journal of Advanced Research in Computer Science and Software Engineering 3(6):821-825.

[11]. Durvey M and Satyarthi D (2014) "A Review Paper on Digital Watermarking". International Journal of Emerging Trends and Technology in Computer Science (IJETICS) 3(4):99-105.

[12]. Sunitha P and Chitneedi SP (2014), "Speech Compression for Better Audibility Using Wavelet Transformation with Adaptive Kalman Filtering". International Journal of Engineering Research and General Science Vol.2, No.4, pp379-384.

[13]. Kaur S and Sidhu R.K (2016) "Robust Digital Image Watermarking for Copyright Protection with SVD-DWT-DCT and Kalman Filtering". International Journal of Emerging Technologies in Engineering Research Vol 4, No. 1,pp 59-63.