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SVD Based Performance Improvement in Hiding a Message Behind an Image

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ABSTRACT

The paper describes an effective method to embed grayscale images or watermarks in the original cover images. To do so, we used a famous linear algebra technique called Singular Value Decomposition. To carry out the test work results and analysis, we observed the two most common metrics namely Peak Signal to Noise Ratio (PSNR) and Mean Square Error (MSE) during the research work. Correlation was found between the original image and the recovered image during extraction of watermark. This method was found fully robust against various attacks which were carried out throughout the research.

Key words: Image watermarking, MSE, PSNR, Singular Value Decomposition.

1. INTRODUCTION

Techniques for hiding information can be divided into three main types steganography, cryptography and watermarking. In all these techniques of hiding information, watermarking is a useful, reliable and genuine method of hiding information. The next approach, Steganography provides hidden data in such a way that only the recipient knows about it. Finally, cryptography, data is transformed in a cryptic code before transmitting it. This gives rise to the limitation that to decode the message, the person must be having the encryption key. Around 13th century in Italy, watermarks first came to existence, they were used as a mark of recognition in the manufacture of paper. In the year 1992, Tirkel and Charles Osborne initially used this expression digital watermarking [1-2]. The method of digital watermarking can be classified as hiding of information in which a watermark is to be hidden in a form of secret information in the multimedia data. For example text, images, video or audio. Mostly, a digital image watermark is preferred to be embedded inside the picture[17]. There are two steps for the process of embedding a watermark in the cover image and extracting the watermark from the watermarked image. Two resources are considered during embedding & the watermark itself, which is to be embedded on the original information. During the extraction process, the watermark is extracted from the test image using detector and confirmed if the watermark is embedded or not [2-3].

2. SINGULAR VALUE DECOMPOSITION

Singular Value Decomposition (SVD) is a linear allegorical numerical technique. SVD is a technique which makes use of the linear algebra. There are numbers of different fields where SVD has its usage and applicable. Whenever SVD is performed on an Image I of size MxN, three diverse matrices can be found, namely U, V and S.

$I = USV^T$ can be used to represent SVD. U and V matrices are called orthogonal matrices. They are made up sizes MxM and NxN correspondingly. It is important to note that S matrix is also known as diagonal matrix which has a size of MxN. In this connection, matrix U has been labeled left and matrix V has been labeled right singular values for matrix I.

Matrix S is essential for the purpose of watermarking and entries in this matrix are arranged diagonally and in an ascending manner. The most significant attribute about the singular values is that they are quite balanced in nature and so if any minor alteration is introduced in the cover, then also, its singular values do not undergo major modification.

Singular value decomposition has the ability to strongly represent the properties for any given image, where singular values represents the brightness of the image and singular vectors signify geometric properties about the image. An image or a bitmap matrix made of various minute singular values which are evaluated with the previous singular value. It should be clear that if those singular values are unnoticed then, there is no major difference inside the recreated bitmap[4-8].

3. IMPLEMENTATION

Mainly two parameters have been selected the following image quality matrices [9,10,] for the purpose of evaluation for degradation after the watermark is included in the bitmap.

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

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

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 [11-15] is used which can be represented in mathematically expressed by above equation (2). Hence at the receiver end it is observed that we have extracted the watermark and computed the correlation [10,16] for recovered watermark and original watermark for the purpose of assessing the robustness.

4. PROPOSED TECHNIQUE

4.1 Embedding Algorithm

Step 1: To decay the cover image I, Apply SVD matrices coordinate U, V and S, I= U*S*VT^s
Step 2: Select Y image to embedding process
Step 3: Applied the SVD algorithm
Step 4: Rescaled the S components for watermark
Step 5: Apply S = S + (Kg * Wi)
Where Wi is the watermark, Kg is the gain factor
Step 6: Singular Component modification
Step 7: Novel_Cost = U * (Modification_S) * VT
Step 8: Obtain the Resultant/watermarked image

4.2 Extraction Algorithm

Step 1: Decay the Watermarked Image Wi
Step 2: Apply Extract process to Y image
Step 3: Apply SVD algorithm in Y image
Step 4: Apply Do = (S) * (U) * (VT) for resize singular part
Step 5: Apply (Do - S) / K for output watermark image

5. EXPERIMENTAL RESULTS

5.1 Without Attacks

In this proposed algorithm, we have experimented with various test images as shown in figure 2 and we have taken a watermark image that is to be hidden in the original cover images as shown in the figure 1. Watermarked images is shown in figure 3 and Recovered Watermark images are shown in figure 4. Table 1: shows Result of SVD Method with gain factor at 100. Table 2: shows result using SVD method on one image Niyu with various gain factors. Table 1 shows all images with 100 gain factor and Table 2 shows one image with various gain factor.

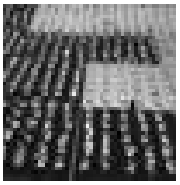


Figure 1: Watermark Image.

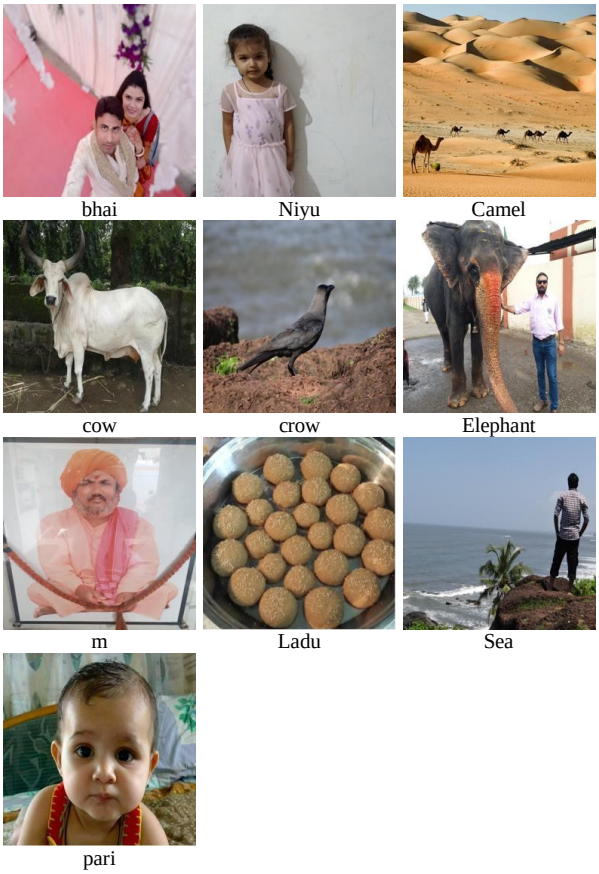


Figure 2: Cover Images.

Figure 3: Watermarked images

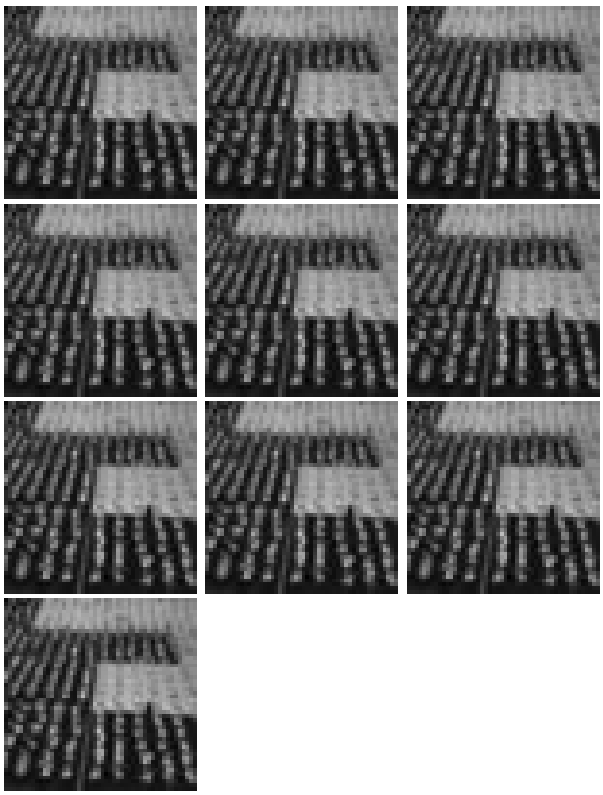


Figure 4: Recovered Watermark.

Table 1: Results of SVD Method with a Gain Factor of 100.

Images	Parameter Value	Images	Parameter Value
	PSNR = 29.88		PSNR = 30.43
	MSE = 66.81		MSE = 58.88
	Corr. = 0.9914		Corr. = 0.9917
	PSNR = 30.78		PSNR = 28.47
	MSE = 54.32		MSE = 92.30
	Corr. = 0.9918		Corr. = 0.9918
	PSNR = 29.99		PSNR = 28.79
	MSE = 65.15		MSE = 85.80
	Corr. = 0.9913		Corr. = 0.9917
	PSNR = 29.08		PSNR = 29.42
	MSE = 80.24		MSE = 78.24
	Corr. = 0.9921		Corr. = 0.992
	PSNR = 28.93		PSNR = 29.05
	MSE = 83.16		MSE = 80.84
	Corr. = 0.9906		Corr. = 0.9914

Table 2: Results using SVD Method on Image Niyu, Here Various Gain Factors are applied.

Alpha	PSNR	MSE	Correlation
1	88.51	0.00001	0.9882
2	71.86	0.0042	0.9886
3	64.76	0.0217	0.9996
4	60.319	0.0604	0.991
5	57.545	0.1144	0.9912
6	55.402	0.1874	0.9914
7	53.5534	0.2869	0.9915
8	51.8432	0.4254	0.9917
9	50.0487	0.643	0.9919
10	48.0565	1.0173	0.9919

5.2 With Various Attacks

Here many attacks are compared with each other and their PSNR to MSE ratio are also compared. For traceability, tests resulted illustrated here are for only on one image Niyu. The test results with attacks are as follows. Table 3 to Table 10 shows the collective results for various attacks that were performed on the image Niyu with gain factor 100. Table 3: Shows the results for Average Filtering attack. Table 4: Shows results for Compression attack. Table 5: Shows the results for Cropping attack. Table 6: Shows the results for Gaussian Law Pass Filter. Table 7: Shows the results for Gaussian Noise attack. Table 8: Shows the results for Median Filtering attack. Table 9: Shows the results for Rotation attack. Table 10: Shows the results for Histogram Equalization attack

Table 3: Average Filtering with Various Mask-Sizes.

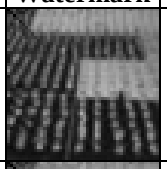
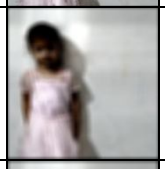
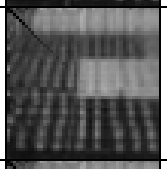
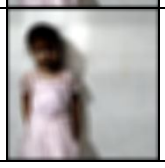
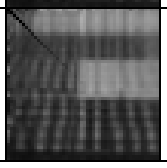
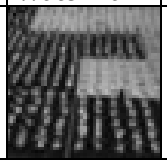
Mask Size	Image	PSNR	Extracted Watermark	Correlation
3		30.2352		0.9795
11		29.6501		0.9073
15		29.4021		0.878

Table 4: Compression with Various Quality Values.

Mask Size	Image	PSNR	Extracted Watermark	Correlation
5		30.1329		0.9893

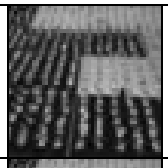
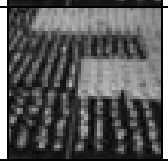
60		30.4344		0.991
95		30.4372		0.9917

Table 5: Cropping with Various Crop Regions.

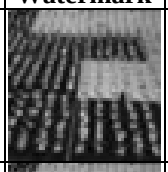
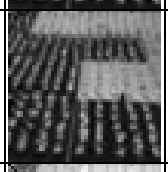
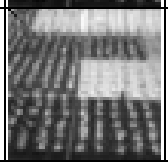
Crop Region	Image	PSNR	Extracted Watermark	Correlation
25		30.376		0.9913
50		29.9525		0.9894
100		29.0662		0.9519

Table 6: Gaussian Law Pass Filter with Various Standard Deviations.

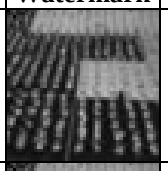
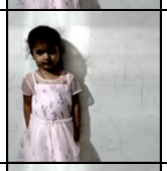
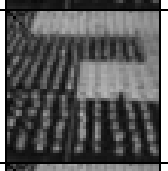
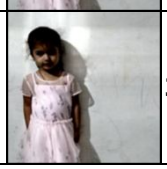
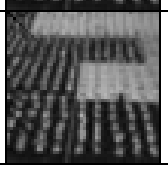
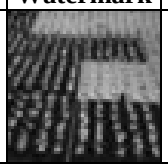
Standard Deviation	Image	PSNR	Extracted Watermark	Correlation
0.5		30.3009		0.9883
2		30.235		0.98
3		30.2357		0.9797

Table 7: Gaussian Noise Attack with Mean Value 0 & Various Variants.

Noise Variants	Image	PSNR	Extracted Watermark	Correlation
0.00005		30.1447		0.9921

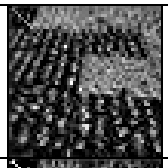
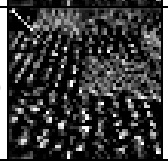
0.09		27.6651		0.8926
1		27.2356		0.6507

Table 8: Median Filtering With Various Mask-Size.

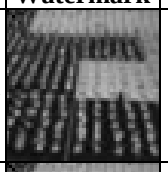
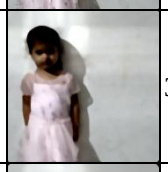
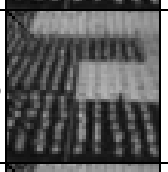
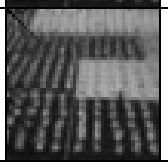
Mask Size	Image	PSNR	Extracted Watermark	Correlation
3		30.4781		0.9871
7		30.4905		0.974
15		30.607		0.9649

Table 9: Rotation with Various Angles.

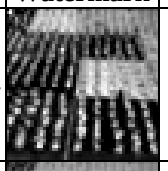
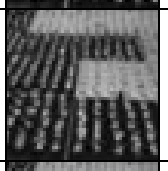
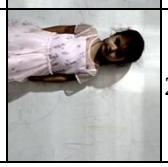
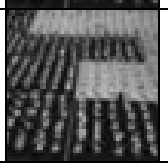
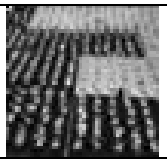
Angles	Image	PSNR	Extracted Watermark	Correlation
30		28.1554		0.9581
90		28.2295		0.9917
270		28.9043		0.9917

Table 10: Histogram Equalization.

Image	PSNR	Extracted Watermark	Correlation
	25.6182		0.9887

5. CONCLUSION

As per the conducted research SVD was found better for watermarking purpose. We have tested 10 different images with watermarks and also extracted watermark with high ratio of PSNR and Correlation values. We also performed various attacks on the watermarked images to check the perceptibility and robustness of the SVD algorithm. In this method, when the gain factor is increased, perceptibility and robustness decreases. We state this by testing it with various images and by Comparing their PSNR (Peak Signal to Noise Ratio), MSE (Mean Square Error) & Correlation values. By our tests we found that the proposed technique works best with all kinds of attacks like Cropping, Rotating, Gaussian Filtering, etc [9]. In this paper, we compare our proposed method with [11]. They tested on the gray scale image only, whereas we have compared the test results based on color images. Also we compared attack results with [11]. Our proposed algorithm achieved approximately 0.9893 correlation coefficient, at the compression value of 5.

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REFERENCES

1. R.G. Schyndel, A. Tirkel, and C.F Osborne, ―"A Digital Watermark", Proceedings of IEEE International conference on Image Processing, ICIP, pp. 86-90,1994.
2. Cox, Ingemar J., Joe Kilian, F. Thomson Leighton, and Talal Shamoon. "Secure spread spectrum watermarking for multimedia.",IEEE transactions on image processing 6, no. 12 ,1673-1687,1997. https://doi.org/10.1109/83.650120
3. Kutter, Martin, and Fabien AP Petitcolas. "Fair benchmark for image watermarking systems." Security and Watermarking of Multimedia Contents 3657,226-239,1999. https://doi.org/10.1117/12.344672
4. H. C. Andrews and C. L. Patterson, "Singular Value Decomposition (SVD) image coding", IEEE Trans. On Communications, pp. 425-432, 1976. https://doi.org/10.1109/TCOM.1976.1093309
5. G. H. Golub and C. Reinsch, "Singular value decomposition and least squares solutions", Numer. Math., Vol. 14, pp. 403-420, 1970. https://doi.org/10.1007/BF02163027
6. Liu, R., and T. Tan, "A SVD-Based Watermarking Scheme for Protecting Rightful Ownership", IEEE Trans. Multimedia 4, pp.121-128, 2002. https://doi.org/10.1109/6046.985560
7. Chang, C., P.Tsai, and C. Lin,"SVD-based digital image watermarking scheme", Pattern Recognition Letters 26, pp.1577-1586,2005. https://doi.org/10.1016/j.patrec.2005.01.004
8. Wu, Y, "On the Security of SVD-Based Ownership Watermarking", IEEE Trans. Multimedia 7, pp. 624-627, 2005. https://doi.org/10.1109/TMM.2005.846774
9. M. Kutter & F.A.P.Petitcolas, "A fair benchmark for image watermarking systems", Electronic Imaging '99. Security and Watermarking of Multimedia Contents, vol. 3657, Sans Jose, CA, USA, 25-27 January 1999 https://doi.org/10.1117/12.344672
10. V.Santhi and Dr. Arunkumar Thangavelu, "DWT-SVD Combined Full Band Robust Watermarking Technique for Color Images in YUV Color Space", International Journal of Computer Theory and Engineering, Vol. 1, No. 4, October 2009. https://doi.org/10.7763/IJCTE.2009.V1.68
11. R. Z. Liu and T. N. Tan, "An SVD-based watermarking scheme for protecting rightful ownership," IEEE Transactions on Multimedia, vol. 4, no. 1, pp. 121-128, 2002. https://doi.org/10.1109/6046.985560
12. Ashish M. Kothari, Ved Vyas Dwivedi," Video Watermarking – Combination of Discrete Wavelet & Cosine Transform to Achieve Extra Robustness", International Journal of Image, Graphics and Signal Processing (IJIGSP), ISSN 2074-9074, Online: ISSN 2074-9082, 2013.
13. Kapil S. Raviya, Dwivedi Ved Vyas, Ashish M. Kothari,"An Evaluation and Improved Matching Cost of Stereo Matching Method", I.J. Image,Graphics and Signal Processing, 2016, 1, pp.1-11
14. AM Kothari, AC Suthar, RS Gajre ,"Performance Analysis of Digital Image Watermarking Technique–Combined DWT–DCT over individual DWT", International Journal of Advanced Engineering & Applications,pp.177-182,2010.
15. Ashish M. Kothari, Ved Vyas Dwivedi "Hybridization of DCT and SVD in the Implementation and Performance Analysis of Video Watermarking", International Journal of Image, Graphics and Signal Processing,2012. https://doi.org/10.5815/ijigsp.2012.05.02
16. Ashish M Kothari, Ved Vyas Dwivedi "Video Watermarking–Embedding binary watermark into the digital video using hybridization of three transforms", 2015.International Journal of Signal and Image Processing Issues.
17. Chen, B. Mulgrew, and P. M. Grant. A clustering technique for digital communications channel equalization using radial basis function networks, 1993. *IEEE Trans. on Neural Networks*, Vol. 4, pp. 570-578. https://doi.org/10.1109/72.238312.