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A Novel Watermarking Approach Based On Singular Value Decomposition

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Abstract- Digital media, like video, audio, images and multimedia documents can be protected against copyright infringements with imperceptible, incorporated patterns. Such methods are based on steganography and digital watermarking techniques. Digital watermarking technology can provide persistent identification of copyrighted subject matter to facilitate rights management in the emerging complex hybrid digital/analog devices and home networks. For both analog and digital content, digital watermarks enable copyright holders to protect their content from unauthorized use, as well as enable content owners to effectively communicate their copyrights, monitor use of their content, and track unauthorized distribution of licensed content. Most watermarks are inserted as a plain-bit or adjusted digital signal using a key-based embedding algorithm. The embedded information is hidden and linked inseparably with the source data structure. For the most favourable watermarking application, a trade-off between opposing criteria like robustness, non-perceptibility, non-detectability and protection include to be ended. Most watermarking algorithms are not resistant in opposition to all attacks, and even gracious attacks like file and data modifications can demolish the watermark very easily.

Keywords- Singular value decomposition, Fals positive problem, Digital Watermarking.

I. INTRODUCTION

The process of embedding the watermark into a [37] digital data is known as Digital Watermarking. It is a[4] process of embedding unremarkable logos or labels or information data or pattern in the digital data. The concept of digital watermarking is associated [27] with the steganography. It is defined as [41] enclosed writing, which hides the important message in a covered medium while, digital watermarking is a way of hiding a secret or personal message to provide copyrights and the data integrity. Digital image watermarking is a [28] new approach, which is appropriate for medical, military, and archival based applications. The embedded watermarks are complex to eradicate and typically imperceptible, could be in the form of text, image, audio, or video. The embedding of secret watermark in digital data, no matter how much invisible it may be. However it leads to some degradation in the resultant embedded digital data. To overcome [34] this and to retrieve the original data, reversible watermarking has been implemented, which considered [42] as a best approach over the cryptography. In cryptography [50] after encryption the resultant data may not be visible or understandable also at the time of retrieval this may lead to loss of semantic information [37] of host data, which is not in the case of watermarking. In digital data several watermarks can be embedded at the same time and this is known as multiple watermarking techniques. A digital watermark also considered as digital signature which provides the authenticity. For a digital copy of data is the same as the [38] original, digital watermarking is a passive protection [54] tool. It just marks data, but does not degrade it or controls access to the data watermarking is also called *data embedding* and *information hiding*. A watermark is a visible embedded overlay on a digital photo consisting [28] of text, a logo, or a copyright notice. The purpose [26] of a watermark is to identify the work and discourage its unauthorized use. Though a visible watermark can't stop unauthorized use, it makes it more complex for those who may want to claim someone else's photo or artwork as their own.

II. LITERATURE SURVEY

Digital Watermarking has been used from decade to improve the various security concerns that arise due to advancement of internet and their associated services. In view of that a variety of image transformation techniques have been adopted such as DWT, DCT, SVD and hybrid domain. We have focused our concern towards DWT+SVD based reference watermarking schemes. The basic idea of reference watermarking is to segment host image into non-overlapping blocks by means of Hilbert space filling curve and by considering human visual system, a reference image is formed.

Bhatnagar & Raman, 2012 [16] presented a robust grayscale logo watermarking in wavelet domain. The logo watermark is embedded in the robust blocks of wavelet sub-bands obtained by non-overlapping segmentation using ZIG-ZAG sequence and the variance statistic. The benefit of

segmentation using ZIG-ZAG sequence is that the resultant blocks are the frequency bands from the lowest to highest. Ehsan Vahedi et al. 2012 [11] presented a new wavelet based watermarking approach for color images using bio-inspired optimization principles. Our method is able to achieve ownership protection. Initial, the original image is performed with the Discrete Wavelet Transform (DWT) and embedded with the watermark in the HL and LH blocks associated with an embedding rule. Our method improves the robustness and the quality of stego image by embedding watermarks into some fixed blocks rather than randomly selected blocks in the HL and LH sub bands and using general DWT instead of integer-DWT.

Run et al. 2012 [39] presented an improved SVD-based watermarking technique for copyright protection. In this paper, two methods are proposed to get better the reliability and robustness. To improve the reliability, for the first technique, the principal components of the watermark is embedded into the host image in the discrete cosine transform (DCT); and for the second technique, those are embedded into the host image in discrete wavelets transform (DWT). Ahmad A. Mohammad et al. 2008 [2] presented An improved SVD-based watermarking scheme for protecting rightful ownership. The proposed algorithm solves the difficulty of false-positive detection. A false positive is the identification of watermark from a cover work which does not contain one in reality. Rashmi Agarwal & M.S. Santhanam1, 2008 [37] presented a Digital watermarking in the singular vector domain. Recently numerous SVD based watermarking scheme has been proposed by the authors which tries to take advantage of the optimized image decomposition property of SVD for embedding a watermark in an image. These algorithms suffer from a major problem of false positive. The false positive problem occurs due to the fact that SVD subspace can preserve major information of an image, leads to the above-mentioned flaws; in which any reference watermark that is being searched for in an arbitrary image can be found [22]. Bhatnagar & Raman 2009[17] presented a new robust reference watermarking logo watermarking scheme .The idea of this scheme is to segment the non-overlapping blocks by using Hilbert space filling curve and a reference image is formed by using human visual system Then reference image is transformed using FrFT domain and embedding is done by using modified singular values .After embedding modified singular values is segmented into blocks and mapped on to their original positions and get a watermarked image . In the watermark detection stage, the fact that the employed SVD matrices depend on the reference watermark biases the false positive detection rate such that it has a probability of one. Thus, any reference watermark that is being Searched for in an arbitrary image can be found. The drawback of False positivity which analyzed in various papers is provided in Table.

Table: Information about the False Positive Problem exist in the DWT- SVD (Hybrid) domain watermarking techniques

Author	Identified problem	Disadvantage
Bhatnagar & Raman 2009	*False Positive*	*Not using DWT*
Jain & Panigrahi 2008	*False Positive*	*More quantization step values*
Wu et al. 2005	*False Positive*	*Not embedding multiple watermarks*
Zhang & Li 2005	*False Positive*	*Quantization parameter is difficult*

III. PROPOSED METHOD

We have analyzed the problem related to reference watermarking .In literature, there are various watermarking techniques based on purely SVD, Frft with SVD .To enhance the performance and security, hybridization is needed. The drawback of SVD based algorithm is that if the owner has more than one watermark, he cannot determine which watermark is in which image, every searched watermark gives high correlation. This method cannot be used for rightful ownership. In this paper, we are using Frft with DWT and SVD. We are taking host image represented as A and watermark is represented as W. The sizes of host and watermark images are M x N and mxn. Block diagram of the proposed watermarking scheme is shown in fig. In this algorithm we are calculating the mean and standard deviation of watermark image and get the modified singular values and these modified singular values are used externally for the extraction of watermark image.

The Embedding Algorithm for watermark is represented as follows:

Step 1.Perform fractional fourier transform on host image and get the FrFT image.

Step2. Use one level Haar DWT to decompose the FrFT image into 4 subbands i.e.LL,LH,HL,HH.

Step3. Apply svd on LL subband i. e.

$$\mathrm{SVD(LL)} = \mathrm{USV^T}$$

Step4.Embed the watermark and get singular values and again apply svd

$$\mathrm{S} + \alpha\,\mathrm{W} = \mathrm{U_w S_w V_w^T}$$

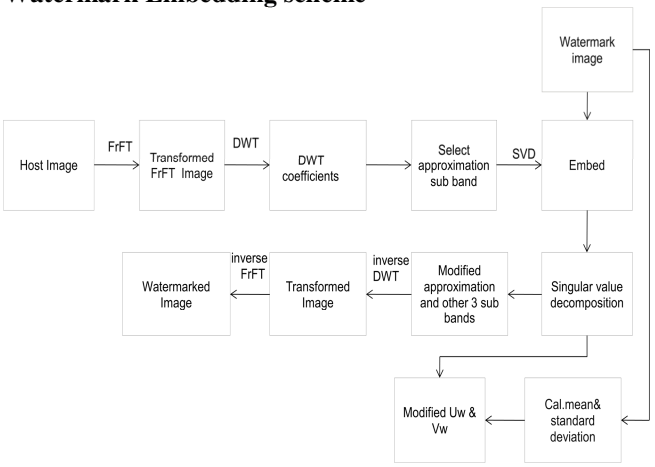
where α denotes the scaling factor i.e.watermark embedding strength

Step5.Apply inverse DWT on modified LL and other 3 subbands

Step6.Apply inverse FrFT and get the watermarked image

Step7.Calculate the mean and standard deviation of watermark image and get the modified U_w and V_w

Watermark Embedding scheme



Block diagram of proposed watermarking scheme (Embedding)

The extraction algorithm for watermark is represented as follows:

Step1. Apply fractional fourier transform on watermarked image and get watermarked FrFT image.

Step2.Use one level Haar DWT to decompose the watermarked FrFT image into 4 subbands i.e.

LL1,LH1,HL1,HH1.

Step3.Apply svd on LL1 subband

$$SVD(LL1) = U_{w1} S_{w1} V_{w1}^T$$

$$S_{w2} = U_w S_{w1} V_w^T$$

Step4.Extraction of singular values from watermarked and host image

$$A_{w1} = (S_{w2} - S)/\alpha$$

Step5. Apply inverse FrFT on A_{w1}

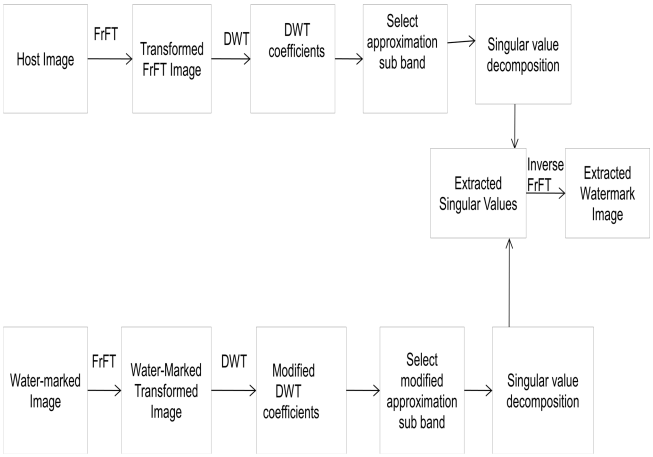
Step6. By using the modified U_w and V_w, mean and standard deviation , we get $U_{w_{ext}}$ and $V_{w_{ext}}$

Step7. Get the watermark image by using extracted singular values

$$extwatermark1 = U_{w\_ext}\, S_{w1}\, V_{w\_ext}^T$$

$$extwatermark = (extwatermark1 - S)/\alpha$$

Watermark Extraction scheme



Block diagram of proposed watermarking scheme (extraction)

Results and discussions

IV. EXPERIMENTAL SETUP

The robustness of our proposed scheme are demonstrated in MATLAB. We have various different gray scale images of size 512x512 which are used as host image namely Mandril, Birds, Pepper, Pirate .For watermark , grayscale logo 'BIST' of size 256x256 .This BIST logo is embedded in Mandril, Birds , pepper and pirate images. For further analysis, Birds and Pirate images are used because they have lowest and highest PSNR. In our experiment, watermark embedding strength is taken as 0.05.

The watermarked image quality is measured using Peak Signal to Noise Ratio. It can be defined as an engineering term [15] for the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. The signal in this case is the original data and the noise is the error introduced by watermarking scheme. When comparing the image , it is used as an approximation to human perception of reconstruction quality, thus in many cases one reconstruction may appear to be closer to the original than the other . There are various signals which have a very wide dynamic range , PSNR is expressed in terms of logarithmic decibel scale. The PSNR values for all 4 images are provided in Table.

$$PSNR(W, W^*) = 10\log_{10}\left(\frac{L_{\max}}{RMSE}\right)^2$$

Where Lmax is maximum possible pixel length of an image and RMSE is Root Mean Square Error which is defined as

$$RMSE = \sqrt{\frac{\sum_{i=1}^{N}\sum_{i=1}^{M}(X(i,j) - X^*(i,j))^2}{NxM}}$$

Typical values for PSNR in watermarking scheme are between 30 and 50 dB.If PSNR is higher then image is better. When two images are identical the RMSE is zero and PSNR is infinite.

We are using Peak Signal to Noise Ratio (PSNR) for determining imperceptibility of watermarked image and Normalized Correlation Coefficient (NCC) for determining the robustness of proposed watermarking algorithms against various attacks and Correlation Coefficient for all attacks is provided in Table.

$$NCC(W,W^*) = \frac{\sum_{I=1}^{N}\sum_{j=1}^{N}(W_{ij}-\overline{W})(W_{ij}^*-\overline{W_{ij}^*})}{\sqrt{\sum_{I=1}^{N}\sum_{j=1}^{N}(W_{ij}-\overline{W})^2}\cdot\sqrt{\sum_{I=1}^{N}\sum_{j=1}^{N}(W_{ij}^*-\overline{W_{ij}^*})^2}}$$

Where W is the original watermark, W* is the extracted watermark from distorted image. Normalized Correlation coefficient (NCC) is the number that lies between [−1, 1]. If the value of NCC is equal to 1 then the extracted watermark is just equal to the original one. If it is -1 then the difference [35] is negative for largest singular values .In this case, the lighter parts of the image will darker and darker parts of the image will lighter.

Fig. shows the embedding and extraction algorithm when no attacks are considered so we get the correlation coefficient 1. Here we have two host images, two watermark images , apply embedding algorithm to get the two watermarked images and then extracting algorithm is applied to get watermark images.

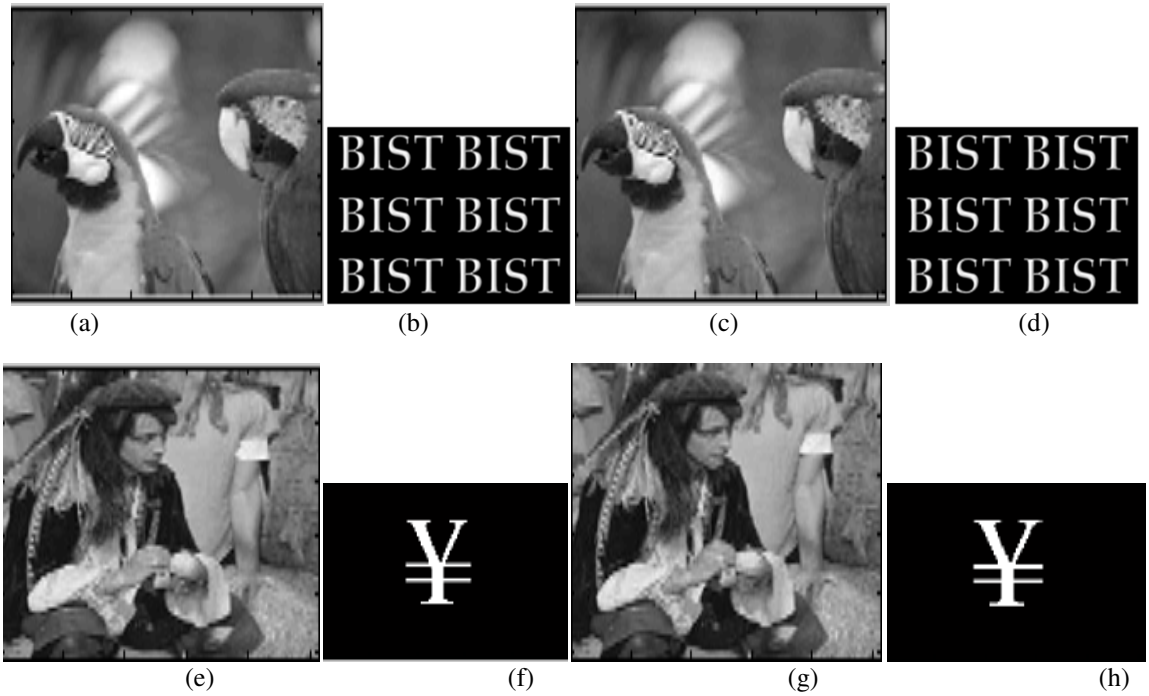


Fig a, e Host, b ,f watermark c ,g watermarked d ,h Extracted watermarked images

Table:- PSNR values (dB) watermark embedding strength =0.05

Image	Bhatnagar & Raman	Proposed
Mandril	48.9151	54.18
Birds	46.7275	52.62
Pepper	48.2464	53.31
Pirate	49.3558	53.45

Table: Correlation coefficient of extracted watermark

Attacks	Bhatnagar & Raman [15]		Proposed	
	Birds	Pirate	Birds	Pirate

No attack	0.9998	0.9999	1.0	1.0
Average filtering (11x11)	0.3167	0.3072	0.9421	0.8998
Median filtering (11x11)	0.4838	0.4573	0.9886	0.9827
Additive Gaussian noise(100%)	0.2848	0.2577	0.7925	0.7342
Salt & pepper noise (100%)	0.3100	0.3557	0.8257	0.8302
Resizing (512->64->512)	0.3098	0.2297	0.9668	0.9492
Cropping	-0.9038	-0.9925	0.9823	0.9931
Contrast adjustment	-0.3416	-0.3093	0.9960	0.9884
Histogram equalization	0.9320	0.9251	0.9846	0.9821

V. PERFORMANCE EVALUATION

To establish the effectiveness of proposed watermarking algorithms, a wide variety of experiments are performed. Several experiments have been performed on grayscale 'Pirate' images of size 512 x 512 and 'logo2' of size 256 x 256 which are used as the Cover image and Watermark image respectively. In this section ,the proposed scheme has been demonstrated for its robustness against wide variety of attacks namely Average and Median filtering, Gaussian ,Salt & Pepper and Speckle noise , JPEG compression, Rotation ,Blurring and Motion Blurring. The performance of proposed watermarking algorithms against Average filtering attack for various filter size is shown in fig. And against Median filtering attack for various filter size is shown in fig.6.16 .We have analyzed that proposed method confirms the improvement over existing methods.

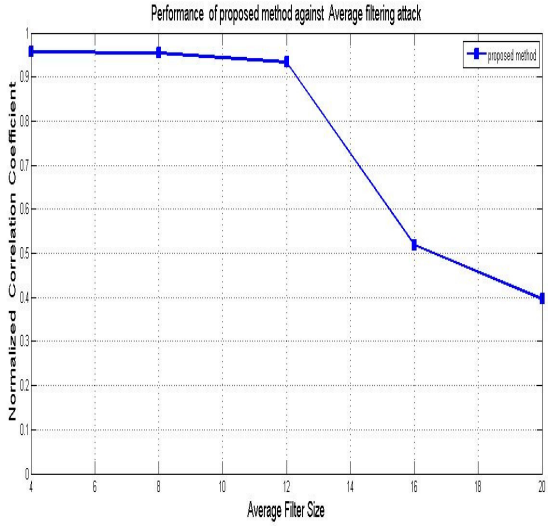


Fig. Performance of the proposed watermarking method by varying the average filter size

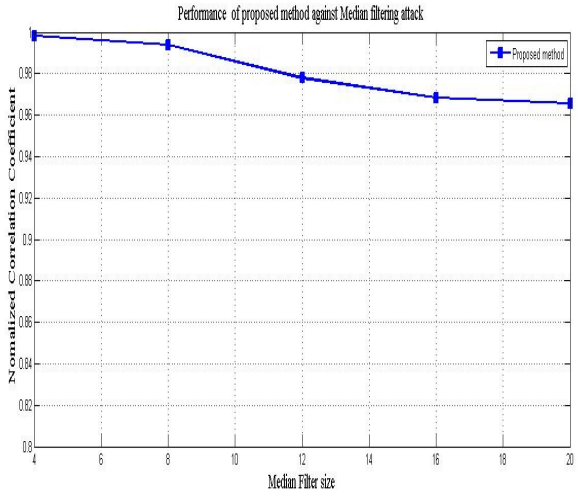


Fig. Performance of the proposed watermarking method by varying the Median filter size

We have seen that addition of Gaussian noise is a very common attack that is responsible for distortion and degradation of image, The watermark information is also degraded by noise addition and results in difficulty in watermark extraction. Robustness against Gaussian noise is analyzed by Gaussian noise density 0.01 .Fig. shows the performance of proposed watermarking schemes against Gaussian noise for various noise variance. There is another noise variance attack i.e. Salt & Pepper noise attack. This attack is very powerful and it affects the image fully as compare to Gaussian noise. The performance of proposed watermarking method against salt & Pepper noise and

speckle noise by adjusting the noise variance is shown in fig. and fig. After that the effect of rotation has been evaluated and compared for various degrees of rotation between 10 and 50 which is shown in fig.The proposed algorithm is quite robust against this rotation attack and proves superiority over other existing methods

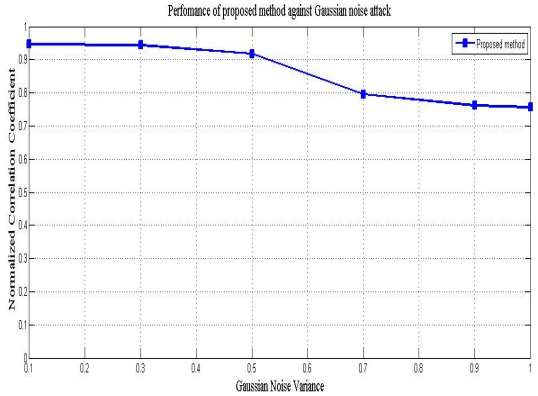


Fig Performance of proposed watermarking method for different Gaussian noise parameter

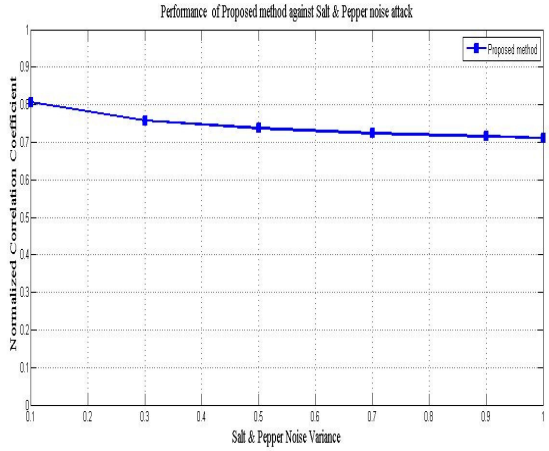


Fig. Performance of proposed watermarking method for different Salt & Pepper noise parameter

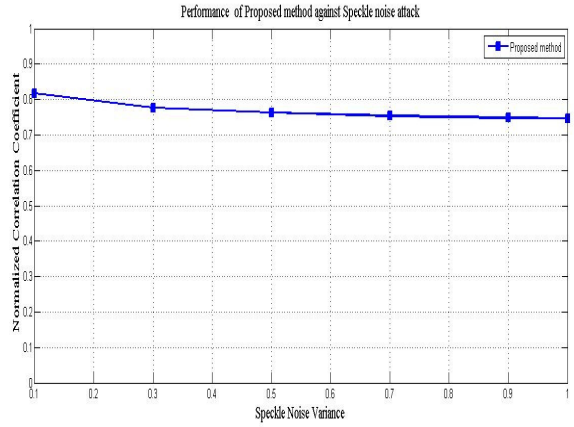


Fig Performance of proposed watermarking method for different Speckle noise parameter

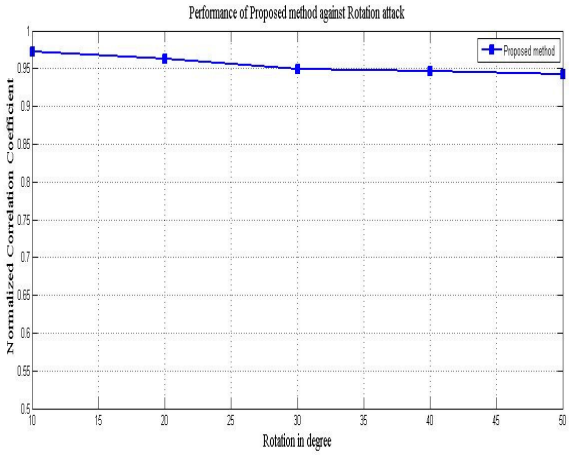


Fig Performance of proposed watermarking method by varying the degree of rotation

To check the robustness of the watermark against image compression, the watermarked image is tested with JPEG compression attacks .The extracted watermark and correlation coefficient of the logo2 image from compressed images of Pirate image at various quality factor is shown in fig. which provides a performance comparison of proposed method for JPEG compression attack by varying the different quality factor. Blurring is a very useful attack to verify the robustness .The performance evaluation for Blurring and Motion Blur attack is shown in fig.

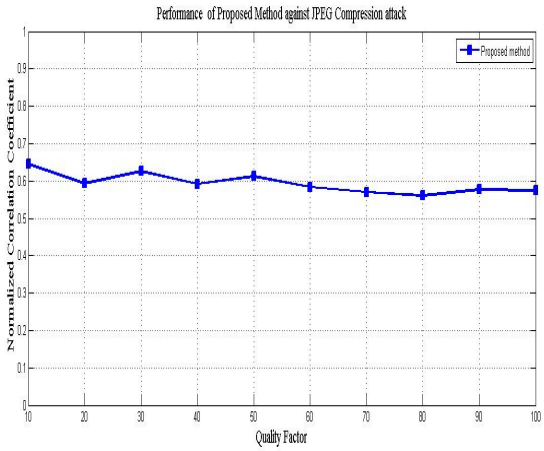


Fig Performance of proposed watermarking method for different Quality factor parameter

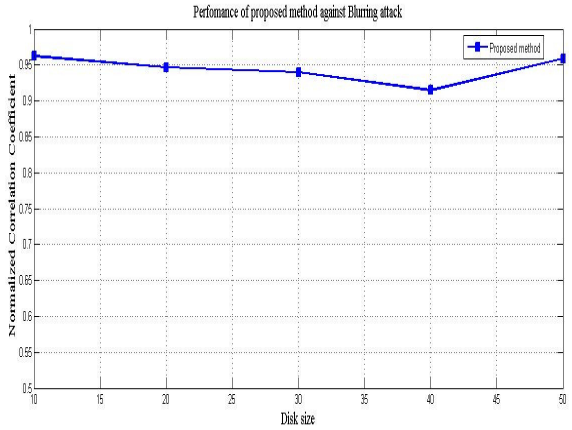


Fig Performance of proposed watermarking method by varying the Disk size

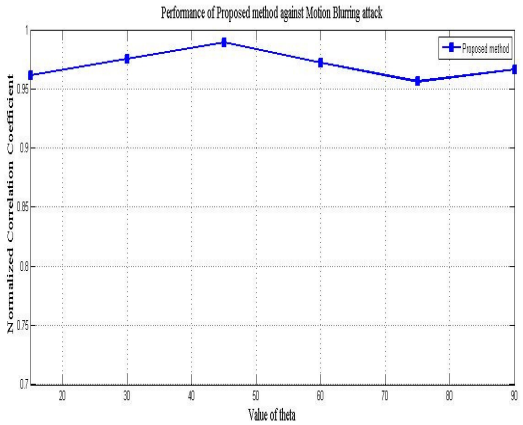


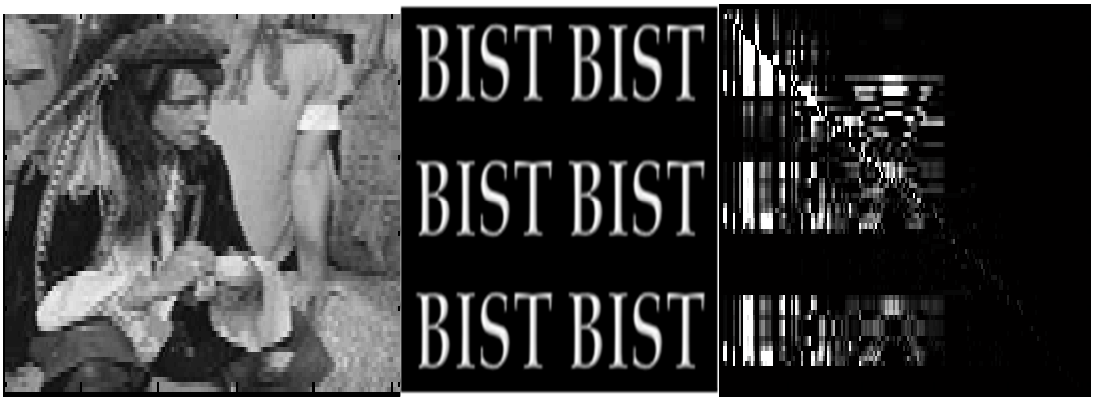
Fig Performance of the proposed watermarking method by varying the value of theta

VI. RELIABILITY TEST AGAINST FALSE POSITIVE PROBLEM

The experiment has been conducted to test the reliability of the proposed algorithm. Fig. (a) ,(b) and (c) shows the watermarked image ,original watermark and false watermark having Normalized correlation coefficient value 0.2016 by using logo2 image .Without knowing the modified singular values original watermark cannot be extracted .Since we calculate the mean and standard deviation of BIST watermark and embedding is done by using logo2 image so we get the singular values and by using the modified singular values we extract the false watermark. A secret key has been used at the time of extraction which is given as below:

Key = (std (W') * std (I)) / (Mean (W') * Mean (I))

Since we are using arbitrary watermark so the original watermark cannot be extracted by using our proposed algorithm.



(a) (b) (c)

Fig a Watermarked Pirate image b Extracted original watermark c Extracted false watermark from proposed method

We have analyzed the various noise attacks in our proposed algorithm and we have learn various attacks in other existing methods .In Table We compare various noise attacks for our proposed algorithm and other existing two methods which is given by Bhatnagar & Raman [15] . We conclude that our proposed algorithm is better because after applying various attacks our correlation coefficient is nearby same for all possible attacks while in other existing methods the correlation coefficient is varying very much.

Table: Normalized Correlation Coefficient

Attacks	Pirate image		
Correlation Coefficient of existing and proposed methods at various attacks			
	Bhatnagar DWT-SVD[17]	Bhatnagar [15]	Proposed method
No attack	Not Given	0.9999	1.0
Average filtering	- 0.6209	0.3072	0.8998
Median filtering	- 0.5636	0.4573	0.9827
Additive Gaussian noise(100%)	0.5604	0.2577	0.7342
Salt & pepper noise (100%)	0.3100	0.3557	0.8302
Speckle noise	Not Given	Not Given	0.7461
Resizing (512->64->512)	0.0326	0.2297	0.9492
Rotation	0.6297	-0.9925	0.9931
Contrast adjustment	0.7690	-0.3093	0.9884
Histogram equalization	0.8464	0.9251	0.9821
JPEG Compression	0.9829	0.9360	0.5739
Blurring	Not Given	Not Given	0.9399
Motion Blur	-0.5601	Not Given	0.9893

Conclusion

We have identified the problem of false positive in reference watermarking scheme based on FrFT and SVD. The algorithm has been formulated to extract the false watermark from FrFT based reference watermarking scheme. The experimental demonstration has been provided to support our formulation about identified problem. We have also used different watermarks and extracted the false one .In view of that we may conclude that the security of proposed reference watermarking method is vulnerable as we have extracted the false watermark from above. We have worked in same track and proposed a new method to deal with false positive problem. The proposed method uses FrFT, DWT and SVD. In the proposed algorithm, DWT is applied only in approximation sub band and we calculate the mean and standard deviation of watermark image and by using the algorithm we get the modified singular values and these modified singular values are used externally for extraction purposes. Results of the proposed scheme indicate that it is imperceptible and robust under various types of image processing attacks.

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