PERFORMANCE ANALYSIS OF NON BLIND ARNOLD INTEGRATED HYBRID IMAGE WATERMARKING TECHNIQUE WITH DWT-SVD

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Abstract --With the widespread distribution of digital information over internet, the protection of intellectual property rights has become increasingly important. To achieve this goal for protecting secret digital image from illegal copy and manipulations, here in this paper we propose a robust non-blind hybrid image watermarking with Arnold transform. Arnold transform are used to scrambling the watermark image prior to its embedding. The singular value of bands is going to embedded with watermark singular values making use of scaling factor (α). We also compare performance of proposed image watermarking algorithms at different SF with DWT-SVD technique to satisfy both imperceptibility and robustness requirements of watermarked image. The experimental results show the effectiveness of proposed image watermarking scheme. Performance of methodology is evaluated using different fidelity parameters like as peak signal noise ratio (PSNR) and normalized cross correlation (NCC).

Keywords-- Image Watermarking, stationary Wavelet Transform, singular value decomposition (SVD), Arnold transform, Discrete Wavelet Transform PSNR, NCC

1. INTRODUCTION

With the rapid development of multimedia and the widespread distribution of digital data over the internet networks, it has become easy to obtain the intellectual properties. Consequently, the multimedia owners need more than ever before to protect their data and to prevent their unauthorized use. Digital watermarking has been proposed as an effective method for copyright protection and an unauthorized manipulation of the multimedia [1].The digital watermark is then introduced to solve this problem. Digital watermarking is a branch of information hiding which is used to hide proprietaryinformation in digital media like photographs, digital music, or digital video [2-4]. The ease with which digital content can be exchanged over the Internet has created copyright Infringement issues. Copyrighted material can be easily exchanged over peer-to-peer networks, and this has caused major concerns to those content providers who produce these digital contents.

Generally, the image watermarking can be done in spatial domain or in transform domain [5]. Compared to spatial domain techniques frequency-domain watermarking techniques proved to be more effective with respect to achieving the imperceptibility and robustness requirements of digital watermarking algorithms [6-8].Commonly used frequency-domain transforms include the Discrete Wavelet Transform (DWT), the Discrete Cosine Transform (DCT) and Discrete Fourier Transform (DFT) and stationary wavelet transform (SWT). However, DWT has been used in digital image watermarking more frequently due to its excellent spatial localization and multi-resolution characteristics, which are similar to the theoretical models of the human visual system. One of the most common methods used for watermarking is DWT, but one of the main drawbacks of this method is that because of the down-sampling of its bands, it does not provide shift invariance. This causes a major change in the wavelet coefficients of the image even for minor shifts in the input image. The shift variance of DWT causes inaccurate extraction of the cover and watermark image .since in watermarking; we need to know the exact locations of where the watermark information is embedded, to overcome this problem proposed using stationary wavelet transform. SVD is then performed on the transformed image, as SVD is more robust against attacks then traditional methods. It has the unique property that even large variations in the singular values do not affect the signal energy a lot. It is reversible non-blind watermarking scheme.

2. METHODOLOGY

2.1 Overview of Discrete Wavelet transforms (DWT)

Discrete Wavelet transform (DWT) is a mathematical tool for hierarchically decomposing an image.The transform of a signal is just another form of representing the signal. It does not change the information content present in the signal. It is useful for processing of non-stationary signals. Wavelet transform provides both frequency and spatial description of an image.

For 2-D images, applying DWT corresponds to processing the image by 2-D filters in each dimension. The filters divide the input image into four no overlapping multi-resolution sub-bands LL, LH, HL and HH. The sub-band LL represents the coarse-scale DWT coefficients while the sub-bands LH, HL and HH represent the fine-scale of DWT coefficients.

In general most of the image energy is concentrated at the lower frequency sub-bands LL and therefore embedding watermarks in these sub-bands may degrade the image significantly. Embedding in the low frequency sub-bands, however, could increase robustness significantly.

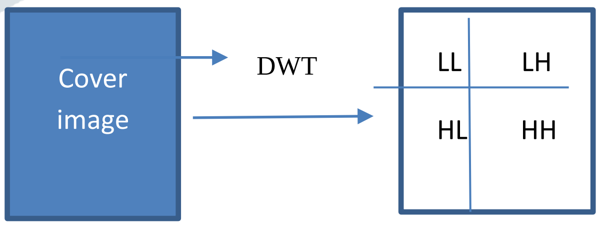

Fig.1 show DWT decomposition of image at level-1

2.2 Overview of stationary wavelet transform (SWT)

One of the most common methods used for watermarking is DWT, but one of the main drawbacks of this method is that because of the down-sampling of its bands, it does not provide shift invariance. This causes a major change in the wavelet coefficients of the image even for minor shifts in the input image. The shift variance of DWT causes inaccurate extraction of the cover and watermark image .since in watermarking; we need to know the exact locations of where the watermark information is embedded, to overcome this problem proposed using stationary wavelet transform [9-12].

Due to translation-invariance property of stationary wavelet transform (SWT), it is more efficient than other wavelet transforms like DWT etc. There is no much difference between SWT algorithm and DWT. In SWT, the output of each level of SWT contains the same number of samples as the input because of redundancy. So for a decomposition of N levels, there is a redundancy of N in the wavelet coefficients. The SWT is preferred as the wavelet transformation, since unlike the other wavelet transforms, the SWT procedures does not include any down sampling steps, instead, a null placing procedure is applied . In SWT domain LL (Approximation), HL (Vertical), LH (Horizontal), HH (Diagonal) sub-band information is present [9].

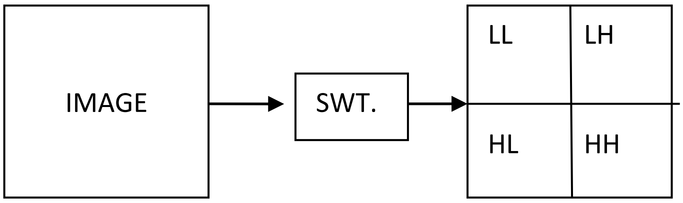

Fig.2, SWT decomposition of image at level-1

One of the most common methods used for watermarking is DWT, but one of the main drawbacks of this method is that because of the down-sampling of its bands, it does not provide shift invariance. This causes a major change in the wavelet coefficients of the image even for minor shifts in the input image. The shift variance of DWT causes inaccurate extraction of the cover and watermark image .since in watermarking; we need to know the exact locations of where the watermark information is embedded, to overcome this problem proposed using stationary wavelet transform [9-12].

2.2 (a) Arnold Transform

The Arnold transform, also commonly known as cat-face transformation, or cat-face mapping, was introduced by Arnold. For an imageC with N *N, the Arnold transform operation on the position (x, y)pixel is given by

$$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} 1 & 1 \\ 1 & 2 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} \bmod N$$

The Arnold transform, which changes the positions of the pixels, can be repeated many times in order to obtain a scrambled image. However, due to the periodicity of the Arnold transformation, the original image can be restored after a certain number of iterations [9].

(b) Anti-Arnold Transform

Use of the Arnold transform periodicity on a scrambled image to recover the original image could be achieved at the expense of possibly a large computational complexity depending on how much iteration have already been used to obtain the scrambled image. The anti-Arnold transform is given by

$$\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 2 & -1 \\ -1 & 1 \end{pmatrix} \begin{pmatrix} x' \\ y' \end{pmatrix} \bmod N$$

If a scrambled image is obtained by using n iterations of the operation of the Arnold transform, it needs the same number of iterations to recover the original image using the anti-Arnold transform. Therefore, the use of anti-Arnold transform to recover the original image can provide significant savings in computation, if n<<Tn. [9]

2.3 Overview of singular value decomposition (SVD)

The singular value decomposition of a matrix is a factorization of the matrix into a product of three matrices. Given an $m\times n$ matrix A, where $m \geq n$, the SVD of A is defined as eq. (2.1)

$$A = U\Sigma V^T \qquad (2.1)$$

Where, U is an $m\times n$ column-orthogonal matrix whose columns are referred to as left singular vectors; $\Sigma = \mathrm{diag}(\sigma_1, \sigma_2, \ldots, \sigma_n)$ is an $n\times n$ diagonal matrix whose diagonal elements are nonnegative singular values arranged in descending order; V is an $n\times n$ orthogonal matrix whose columns are referred to as right singular vectors.

If rank (A) = r, then Σ satisfies $\sigma_1 \geq \sigma_2 \geq \ldots \geq \sigma_r \geq \sigma_{r+1} = \sigma_{r+2} = \ldots \sigma_n = 0$.

Here, SVD efficiently represents intrinsic algebraic properties of an image, where singular values correspond to brightness of the image and singular vectors reflect geometry characteristics of the image. Since slight variations of singular values of an image may not affect the visual perception, watermark embedding through slight variations of singular values in the segmented image has been introduced as a choice for robust watermarking [12].

3. WATERMARKING TECHNIQUES

I. Proposed Watermarking method

Here, we propose an Arnold integrated hybrid image Watermarking Technique based onSWT-SVD in LL band. The proposed algorithm is divided into two parts, watermark embedding and watermark extraction.

A. Watermark Embedding

The watermark embedding process is described below as following:

Step.1: Load the cover image and watermark image.
Step.2: Decomposed cover the image into four sub-bands using SWT-SVD.
Step.3: Apply the Arnold transform on the watermark image to obtain scrambled watermark image using n iteration.
Step.3: Decomposed scrambled watermark image into four sub-bands using SWT-SVD.
Step.4: Compute new sigma matrix using fusion of both sigma matrix with scaling factor.
Step.5: Using new computed signal matrix.
Step.5: Therefore, watermarked image obtained using inverse SWT based on LLnew band and remainingsub band of cover image.

B. Watermark Extraction

Watermark extraction process is also very important process, it give the hidden information from watermarked image; which are embedded into cover image. The watermark embedding process is described below:

Step.1: Load the cover image, watermark image and watermarked image.
Step.2: Decomposed the images into sub-bands using SWT-SVD respectively.
Step.3: Compute new sigma matrix using fusion of both sigma matrix using scaling factor work as key in watermark embedding process.
Step.4: Using new computed signal matrix S, New LL band is computed.
Step.5: Therefore, extracted watermark image obtained by using inverse Arnold and SWT.

II. Watermarking technique based on DWT-SVD

Here, we explain a hybrid image Watermarking Technique using DWT-SVD in low frequency band.

A. Watermark Embedding

The watermark embedding process is described below as following:

Step.1: Load the cover image and watermark image.
Step.2: Decomposed both the image into four sub-bands using DWT for cover and watermark images respectively.
Step.3: after taking DWT, we decomposed both the image using SVD.

Step.4: Compute new sigma matrix using fusion of both sigma matrix with scaling factor.
Step.5: Using new computed signal matrix S, New LL band is computed.
Step.5: Therefore, watermarked image obtained using inverse DWT based on LLnew band and remaining sub band of cover image.

B. Watermark Extraction

Watermark extraction process is also very important process, it give the hidden information from watermarked image; which are embedded into cover image. The watermark embedding process is described below as following:

Step.1: Load the cover image, watermark image and watermarked image.
Step.2: Decomposed the images into sub-bands using DWT respectively.
Step.3: after taking DWT, we decomposed images using SVD
Step.4: Compute new sigma matrix using fusion of both sigma matrix using scaling factor work as key in watermark embedding process.
Step.5: Using new computed signal matrix S, New LL band is computed.
Step.5: Therefore, extracted watermark image obtained using inverse DWT based on LLnew band and reaming sub band.

4. RESULTS AND DISCUSSION

Over all analysis has done with 512X512 image and evaluated with consider fidelity parameters. Here, images used which are obtained from USC-SIPI image database as a standard evaluation database for watermarking algorithms.Here, results analysis of proposed technique illustrate the efficiency of proposed watermarking technique.

4.1. EVALUATION FIDELITY PARAMETERS

The visual performance of watermarked images is determined by using peak signal-to-noise ratio (PSNR) and Normalized Correlation which are historically adopted in image processing in order to evaluate the performance of the output results as shown in tables.

$$MSE = \frac{1}{NM}\sum_{i=1}^{N}\sum_{j=1}^{M}(f(i,j)-g(i,j))$$

$$PSNR = 10\log_{10}\frac{L^2}{MSE} \quad (1)$$

From eq. (1), L shows the values of pixel range. As MSE is inversely proportional to PSNR, thus the small mean square error tends to high signal to noise ratio. The quality measurement for image is directly measure from the pixel values. For better image quality the PSNR must be high. The quality of the image is measured using normalized cross co-relation (NCC) and is obtained by using eq. (2)

$$NCC = \frac{\sum_{i=1}^{N}\sum_{j=1}^{M} g(i,j) * g'(i,j)}{\sqrt{\sum_{i=1}^{N}\sum_{j=1}^{M}(g(i,j))^2}\sqrt{\sum_{i=1}^{N}\sum_{j=1}^{M}(g'(i,j))^2}} \quad (2)$$

4.3. SIMULATED EXPERIMENTAL RESULTS

Fig. 3(a). Lena& Mandrill (cover image)

Fig. 3(b). Cameraman& Dell logo (watermarkimage)

Fig. 3(a) and Fig. 3(b) show the cover image and watermark image for proposed work.

Table I shows the PSNR Value and NCC value for proposed image watermarking techniques at n=5 iteration of ARNOLD transform (Lena (as cover) & Cameraman (as watermark).

Scaling factor	Proposed method	
α	PSNR	NCC
0.01	45.90	0.9921
0.02	39.97	0.9977
0.025	38.06	0.9979
0.03	36.45	0.9983
0.05	*32.04*	*0.9989*
0.1	26.03	0.9991
1	9.21	0.9116

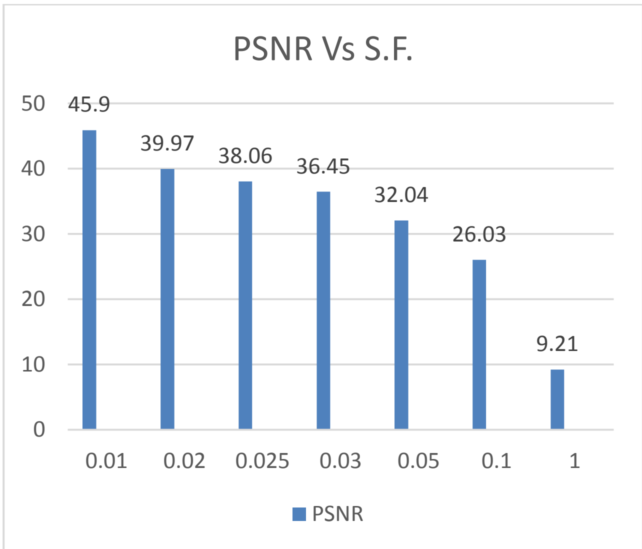

Fig.4 Bar chart for PSNR at different value of S.F

Fig: 4 show Bar chart of PSNR at different value of scaling factor for proposed method.

Table II shows the PSNR Value and NCC value for DWT-SVD based image watermarking techniques (Lena (as cover) & Cameraman (as watermark)

Scaling factor	Image Watermarking using **DWT-SVD**	
α	PSNR	NCC
0.01	45.52	0.9949
0.02	39.56	0.9989
0.025	37.70	0.9992
0.03	36.09	0.9995
0.05	*31.66*	*0.9997*
0.1	25.65	0.9998
1	8.99	0.9346

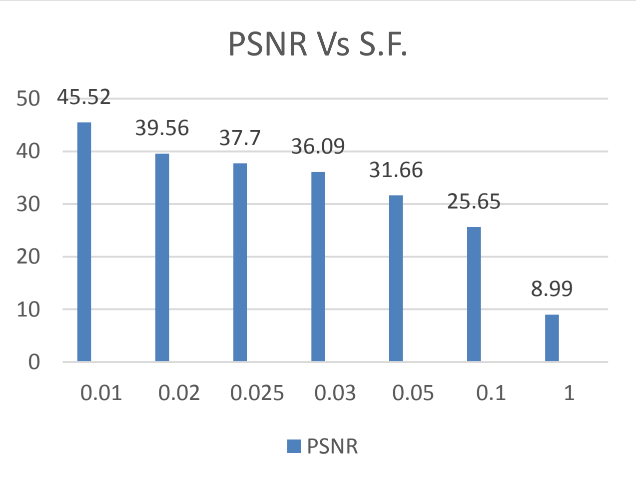

Fig.5 Bar chart for PSNR at different value of S.F

Fig: 5 show Bar chart of PSNR at different value of scaling factor for DWT-SVD.

6.(a) Watermarked image & recover water mark image at SF= 0.025 using proposed method

6(b) Watermarked image & recover water mark image at SF= 0.025 using DWT-SVD

Fig. 6(a-b) shows the visual representation of watermarked and recovered watermark image at different value of SF.

5. COMPARISON BETWEEN PROPOSED METHODS WITH DWT- SVD

Here in this section we compare the simulation results ofproposedmethods with DWT- SVD, for this purpose we use Mandrill as cover and dell logo as watermark image.

Table III shows the comparison of simulation results of proposed method with DWT-SVD for mandrill as cover image and the Dell-logo image as the watermark of size 512x512.

Scaling Factor	Proposed method PSNR	CC	Image Watermarking using **DWT-SVD** PSNR	CC
0.01	45.81	0.9970	45.06	0.9954
0.02	40.02	0.9993	39.07	0.9987
0.025	38.10	0.9995	37.14	0.9990
0.03	36.53	0.9997	35.57	0.9993
0.05	32.11	*0.9999*	*31.14*	*0.9997*
0.1	26.10	0.9999	25.13	0.9949
1	9.66	0.9619	8.84	0.9737

Table III shows the PSNR and NCC for the comparison of proposed method with DWT-SVD image watermarking.

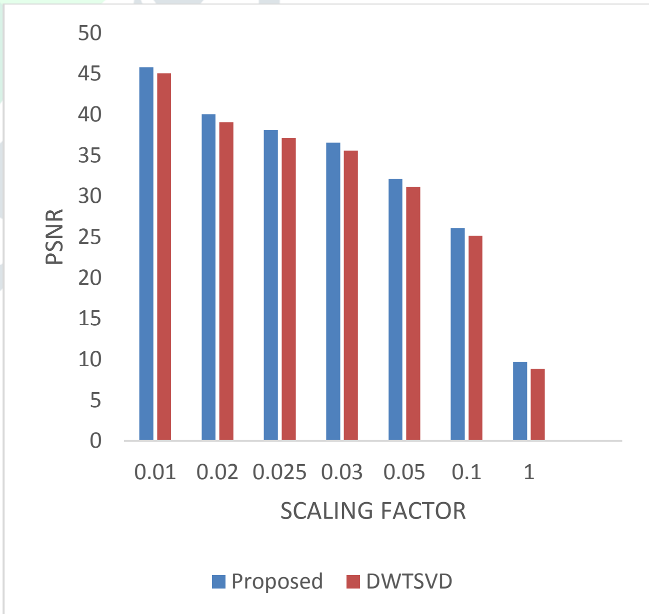

Fig. 7. Bar chart for the different values of PSNR of SWT-SVD and DWT-SVD at different scaling factor (Mandrill as cover & Dell as.

As seen in simulated results from Table III, it is easily seen that for the same value of scaling factor, proposed method show the better results in comparison for. All most every case. Watermarked image having good PSNR value *and* cross correlation score between embedded image and extracted image is above0.98.This technique is able to hide data as well as extract the information back from watermarked image.

Fig 8(a) Watermarked image & recover water mark image at SF= 0.025 using proposed method

Fig 8(b) Watermarked image & recover water mark image at SF= 0.025 using DWT-SVD

Fig. 8(a-b) shows the result of watermarked image and recover watermark image at different scaling factor for Mandrill and Dell logo images.

The simulated experimental results also evaluated with visual representation of watermarked and extracted watermark image for human vision system (HVS). Results are clearly seen that the proposed methodology having robust efficiency of watermarking with data hiding ability. All experiments are shown the proposed algorithm is efficient in data hiding properties as per HVS.

6. CONCLUSION

Digital watermarking based on transform domain is at the focus of current research because of their robustness and imperceptibility. Here in this paper, the performance of proposed algorithm is compared with DWT-SVD techniques. Both techniques based on slightly modifying singular values of the host image to fulfill the requirement of high robustness and simultaneously increase the value of transparency. Experiment results shows that the quality of the watermarked image and the recovered watermark are dependent only on the scaling factors and also seen from simulated results that for the same value of scaling factor, Arnold integrated SWT-SVD based watermarking show the good results in comparison to DWT-SVD technique. The robustness and effectiveness of this watermarking technique tested both quantitatively and qualitatively.

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