A Robust Watermarking Technique for Compressed Digital Image based on Stationary Wavelet Transform and Singular Value Decomposition

Naina Choubey[1] , Mahendra Kumar Pandey[2]

[1] *Student , Electronics and Communication Department , Rustamji Institute of Technology,M.P. India*
[2] *Assistant Professor,Electronics And Communication Department,Rustamji Institute of Technology, M.P. ,India*

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***Abstract** - In this paper, a robust watermarking technique for digital image is proposed based on sub-band fusion using stationary wavelet transform and singular value decomposition. Here, aim of work to protect the watermark image information or hide such that assumption made like visible image is cover image and other is watermark image. Therefore, both the images decomposed with SWT into sub-bands; after that SVD compute the fusion of both approximation bands. There resultant new approximation band computer with remaining cover image of sub-bands as per the inverse SWT analysis. Proposed watermarking technique is tested with two different types of image which is natural uncompressed image and compressed image. Performance is evaluated in term of different fidelity parameter like as peak signal to noise ratio, normalize cross-correlation, these are shown the proposed technique is suitable for natural as well as compressed image.*

Key Words: *Image watermarking, Sub-band, SWT, SVD.*

1. INTRODUCTION

In recent years, digitization play big role in human life as numerous applications in field of engineering, healthcare, communication, documentation and many more. Here, multimedia content like image and video is major content involves. Therefore, authentication, information security and other various issues are raised with multimedia sources and content. Digital data can be stored efficiently and with a very high quality, and it can be manipulated very easily using Computers. Furthermore, digital data can be transmitted in a fast and inexpensive way through data communication networks without losing quality. Digital media offer several distinct advantages over analog media. The quality of digital audio, images and video signals are better than that of their analog counterparts. Editing is easy because one can access the exact discrete locations that need to be changed. Copying is simple with no loss of fidelity and a copy of a digital media is identical to the original [1-5].

Generally, the image watermarking can be done in spatial domain or in transform domain [6-24]. The quality of watermarked image can be determined based on some important factors given like as: Firstly, in imperceptibility the quality of original image must not be changed due to the watermark [5] [6]. Secondly, robustness of image, in this the watermark removal is difficult in case of different types of attacks like noise addition, compression, scaling and rotation etc. [7] [8]. Thirdly, in capacity the most information is embedded in spatial domain as well as in transformation domain. But there are some disadvantages in both spatial and transformation domain like in spatial domain it is not much robust against image processing attacks [9, 22-24]. Where as in transformation domain it is not simple and fast as in case of spatial domain, but is having better robust against image processing techniques, so DCT, DWT transformation techniques are mostly used. Nowadays, mostly DWT is being used. We know that the discrete wavelet transform (DWT) suffers a drawback; the DWT is not a time invariant transform. This means that, even with periodic signal extension, the DWT of a translated version of a signal X is not, in general, the translated version of the DWT of X. To avoid this, the idea to average some slightly different DWT, known as stationary wavelet transform (SWT) or un-decimated wavelet transform is proposed. The main advantage of SWT is image de-noising. Therefore, SWT is widely used in image analysis and image processing. In this paper, proposed SWT based robust digital image watermarking algorithm. The proposed technique is also compared with some of the present existing techniques to show the efficiency of the proposed method.

In this paper, new analysis and development for image watermarking based on sub-band coding using transform techniques. The proposed method is also framed around the watermarking in compressed domain; it can provide the secure and authentic multimedia with numerous benefit of compression. It's presents the novel watermarking scheme in compression environment. That deal with different problem of multimedia authenticity, information security as well as data handling solution.

2. METHODOLOGY

The proposed methodology is based on the sub-band fusion of cover image and watermark image using the SWT image decomposition. Here, SVD play critical role to compute the new coefficient set of LL band of decomposed watermark image with robust nature. Therefore, new computed watermark LL_{WI} band combined with LL_{CI} band of cover image. Thus the new LL band obtained, it is computed with remaining three LH_{CI}, HL_{CI} and HH_{CI} band of cover image. The resultant image is obtained similar to cover image and watermark image secretly combine with cover image, resultant image called watermarked image. The watermarking technique developed as two parts with embedded process and extraction process, it is discussed below as illustrated in fig. 1 and 2.

The watermark embedding process is described below as following and shown in fig. 1:

Step.1: Initialize the cover image and watermark image as I_c and I_w.

Step.2: Decomposed both the image into LL_c, LH_c, HL_c, HH_c and LL_w, LH_w, HL_w, HH_w sub-bands using SWT for cover and watermark images respectively.

***Step*.3**: Both LL band are decomposed with SVD to obtain US_cV^T and US_wV^T.

Step.4: Compute new sigma matrix using fusion of both sigma matrix, defined as $S_{new} = S_c + k\, S_w$. Where, k is scaling factor work as key in watermarking process.

Step.5: Using new computed signal matrix S_{new}, New LL band is computed with inverse SVD based on U_c and V_c matrix of cover image. It is defined as,

$$LL_{new} = U_c(S_c + kS_w)V_c^T$$

Step.5: Therefore, watermarked image obtained using inverse SWT based on LL_{new} band and reaming LH_c, HL_c, HH_c band. Its define as,

$$I_{wd} = \text{inverseswt}\,[LL_{new}, LH_c, HL_c, HH_c]$$

Watermark extraction process is also very important process, it give the hidden information from watermarked image; which are embedded into cover image. It is also important in terms of evaluation of watermarking techniques with following prospective such as robustness form noise, attacks; channel distortion etc, the watermark embedding process is described below as following and shown in fig. 2:

Step.1: Initialize the cover image and watermarked image as I_c and I_{wd}.

Step.2: Decomposed both the image into LL_c, LH_c, HL_c, HH_c and LL_{wd}, LH_{wd}, HL_{wd}, HH_w sub-bands using SWT for cover and watermark images respectively.

***Step*.3**: Both LL band are decomposed with SVD to obtain US_cV^T and $US_{wd}V^T$.

Step.4: Compute new sigma matrix using fusion of both sigma matrix, defined as $S_{new} = (S_{wd} - S_c)/k$. Where, k is scaling factor work as key in watermarking process.

Step.5: Using new computed signal matrix S_{new}, New LL band is computed with inverse SVD based on U_w and V_w matrix of watermark image. It is defined as,

$$LL_{EW} = U_c((S_{wd} - S_c)/k)V_c^T$$

Step.5: Therefore, extracted watermark image obtained using inverse SWT based on LL_{EW} band and reaming LH_w, HL_w, HH_w band. Its define as,

$$I_{ew} = \text{inverseswt}\,[LL_{EW}, LH_c, HL_c, HH_c]$$

Therefore, the extracted watermark image I_{ew} is evaluated with respect to original watermark image I_w using considered fidelity parameters for image quality.

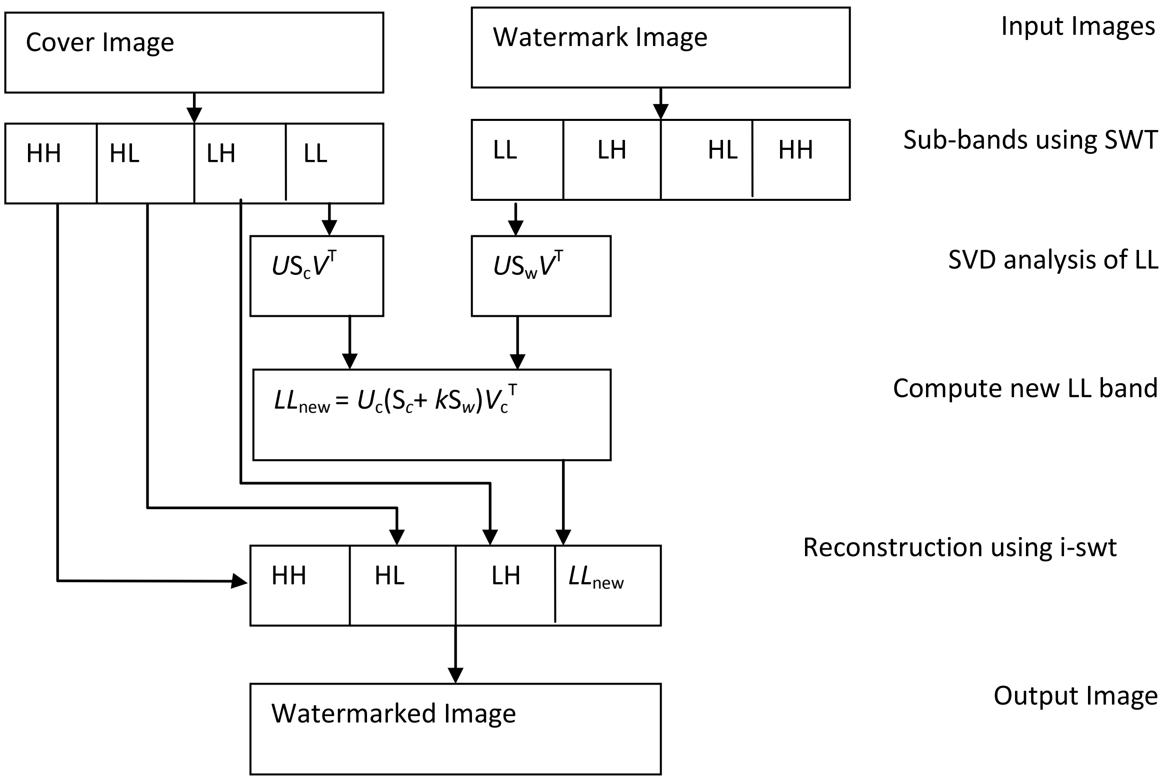


Fig. -1: Block Diagram of the proposed watermark embedding algorithm

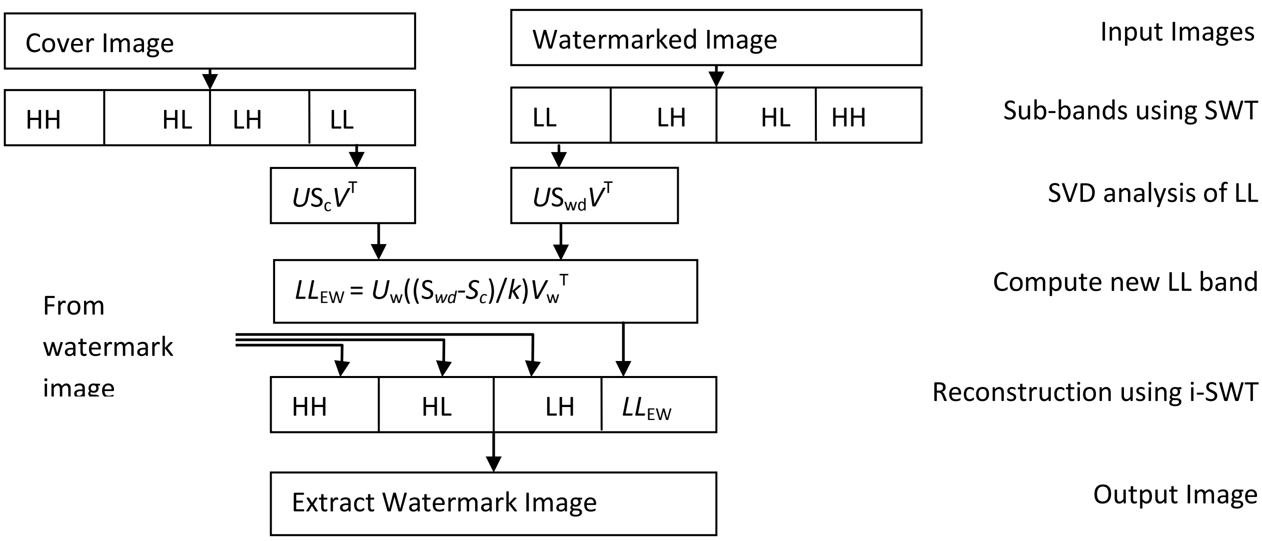


Fig. -2: Block Diagram of the proposed watermark extraction algorithm

2.1. RESULTS AND DISCUSSION

These experiments are illustrate the efficiency of proposed watermarking technique in different compression/compressed data environment. The analysis clearly had shown the motivation of works which fulfill the both aims as such watermarking and compression of multimedia data.

2.1.1MATERIALS AND METHODS

Over all analysis has done with gray scale image and evaluated with consider fidelity parameters. These are discussed in bellow as image database and evaluation parameters.

It is important to evaluate an image watermark algorithm on many different images. Images should cover a broad range of contents and types. Here, 8 images used which are obtained from USC-SIPI image database [25] as a standard evaluation database for watermarking algorithms.

2.1.2.EVALUATION FIDELITY PARAMETERS

The efficiency of the proposed algorithm is measured in two different experiments as well as compression attacks. 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 table I-VI; these parameters use continues to be predominant in the performance evaluation of any image coding system.

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

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

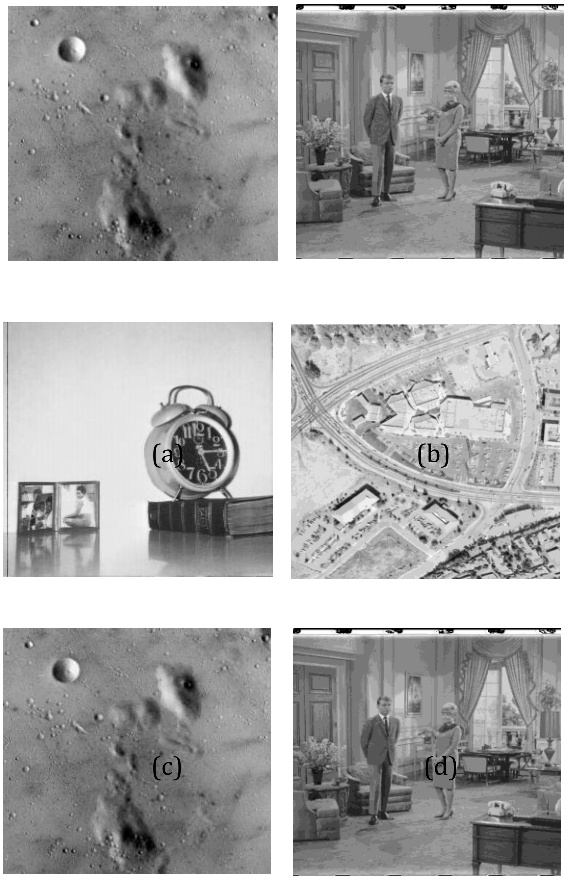
From eq. (1), L shows the values of pixel range. As MSE is inversely proportional to PSNR, thus the small mean square error tends to high signal to noise ratio. The quality measurement for image is directly measure from the pixel values. For better image quality the PSNR must be high. The quality of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

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

Here, PSNR considered for good efficiency is close to 35 dB to avoid having a visible watermark but at the same time including the watermark with a large energy to be resistant to attacks.

2.1.2.SIMULATED EXPERIMENTAL RESULTS

The proposed watermarking algorithm has tested on three different design examples such as natural uncompressed image, compressed embedded/watermark image and both compressed images. Here, Table 1 and 2 lists the simulated experimental results in term of PSNR and NCC. The average performance of algorithm in term of both parameters is 36.75 and 0.999; and 36.89 and 0.996 respectively for different size of images.



(e) (f)

Fig. 3 Visual representation of Watermarking of uncompressed image: watermarked **(a)** Moon surface**, (b)** Couple**,** extracted **watermark**: (c) clock, (d) Aerial, and **cover image: (e)** Moon surface**, (f)** Couple

surface

As seen in simulated results, watermarking algorithm is efficient in aim of work its can generate good quality of watermarked image as well as recover highly correlated extracted watermark image. Similarly, Table 3 lists the simulated experimental results in term of PSNR and NCC for compressed embedded watermark image of different compression rate.

Table- 2: Watermarking efficiency for uncompressed images of size 512×512

Cover Image	Embedded Image	PSNR	NCC
Couple	Aerial	34.86	0.995
Couple	Girl	37.02	0.998
Couple	Fishing Boat	37.38	0.998
Couple	APC	37.98	0.995

Table- 3: Watermarking efficiency for compressed watermark images of size 256×256

Cover Image	Embedded Image	CR	PSNR	NCC
Moon Surface	Clock	95.89	34.37	0.999
	Clock	88.32	34.38	0.999
Moon Surface	Chemical Plant	86.67	39.18	0.999
	Chemical Plant	62.61	39.14	0.999

Here, easily seen that the compress watermark image help to improve PSNR value of watermarked image. The proposed watermarking scheme gives better efficiency in term of PSNR of watermarked image for images with comparable correlation efficiency for watermark extraction. Therefore, analysis can explore the feasibility of watermark efficiency for compressed images. It can easily applicable of secure communication system for sharing multimedia with less data.

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 three experiments are shown the proposed algorithm is efficient in data hiding properties as per HVS. Fig.3 contain results of the uncompressed image based watermark experiment, it can illustrate the methodology is fulfill the basic aim of work.

The overall analysis clearly shown that proposed methodology is efficient for image watermarking scheme with different design problems such as natural image as well as compressed images. As comparison with state of art techniques it's shown the robustness for watermarking application in term of consider fidelity parameters.

3.CONCLUSION

A new watermarking based data hiding technique is presented, which is applicable for various applications such as information security as well as secure communication of multimedia data. This work deal with two different processes of watermarking and image compression, it is beneficial for low bandwidth channel communication with information security efficiency. Here, stationary wavelet transform and singular value decomposition based sub-band fusion watermarking algorithm is proposed. This technique has good efficiency of robust watermarking as well as watermark extraction as seen in simulated results. All most every case, watermarked image having PSNR value is around or more that the 35*db* and normalized cross correlation score between embedded image and extracted image is 0.998. The simulated results also reveal with HVS and found the proposed methodology is good for watermarking based data hiding scheme even for compressed data also. Throughout the analysis, wavelet based SPIHT image compression coding technique is exploded for image compression.

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