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Image Watermarking Using Fibonacci Transform

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Abstract: Digital image watermarking is a technique for include secret information to the digital data to prove the authenticity. A digital watermarking is perceptually invisible to prevent obstruction of the original image. It is also used for tamper proofing, broadcast monitoring, covert communication etc. In this study a Fibonacci transform based watermarking approach for thrashing watermark image in host images is proposed. The host image is renewed into LL3 sub band of the host image. For increase the security level, apply Fibonacci Transform into the host image and then find SVD values for that. Apply DWT and SVD to that covert image. Finally covert image is embedded into the host image. This proposed methodology overcomes the drawback of the existing approaches and enhances the security by applying Fibonacci transform for embedding the resultant pattern in the host image. The watermark embedding process does not degrade the visual quality of the image.

Key words: Image watermarking, fibonacci transform, wavelet, SVD, DWT

INTRODUCTION

Watermarking techniques are appropriate for copyright protection: before distributing the data, the owner embeds an invisible signature, the watermark, into the host source (audio, text, image or video) using a secret key. In most applications, the existence of the signature is kept secret and the secret key, previously shared on a secure channel is used to verify the presence of the embedded sequence in the detection phase. The design of a watermarking scheme is based on some important requirements: imperceptibility of the hidden data, robustness against data processing, capacity of hiding as many bits as needed and granularity. As widely demonstrated in literature, such constraints are often in contrast to each other, forcing the designer to find a tradeoff among them. As far as robustness is concerned, the watermark must be detectable even after modifications, editing or transmission of the cover data. Therefore, several techniques insert the watermark into the most significant portions of the digital data, so that it cannot be removed without impairing the original content. A different approach for protecting data is given by cryptography whose aim is to make the to-be-protected data not intelligible to any unauthorized user who might intercept the message. The digital data have to be decrypted in order to extract its information, being vulnerable to attacks and manipulations. The knowledge of the embedding or of the watermarking algorithm, should not allow an unauthorized user to extract the message or to have information about the existence of hidden data. Discovering a hidden message should only be possible with the knowledge of the secret key. Besides this analogy, the two techniques are complementary rather than overlapping and can be combined to increase protection of the message.

In the proposed method use, the Fibonacci Transform is employed to add an additional level of security. The main contribution of this study is in the joint use of a key dependent wavelet transform with a secure Fibonacci scheme.

Literature review: Recent researchers on secure digital watermarking techniques have revealed the fact that the content of the images is used to improve the invisibility and robustness of a watermarking scheme. The quality of the watermarking based on the factors of robustness ,perceptual transparency, capacity (Bouslimi *et al.*, 2012; Zeki *et al.*, 2007). In this approach, watermark is created from the content of the host image and Discrete Wavelet Transform (DWT) is used for embedding watermarks, since it is an excellent time-frequency analysis method which is adapted well for extracting the information content of the image (Reddy *et al.*, 2009).

According to the domain watermarking can be classified into two types: Spatial domain and Frequency domain. In Spatial domain, watermark is added by modifying pixel value of the host image. Example of spatial domain is Least Significant bit (LSB) based watermarking. In Frequency domain, watermark is inserted into the transformed coefficients of the image (Nezhadavya *et al.*, 2011; Cruz *et al.*, 2009; Lai and Tsai, 2010). The example of

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frequency domain is Fourier Transform (FT), Discrete Cosine Transform (DCT), Discrete wavelet transform (DWT). Watermarking in frequency domain is more robust than watermarking in spatial domain because information can be spread out to entire image.

Wang *et al.* (2002) adopt a key dependent wavelet transform. To take the advantage of localization and multi-resolution property of the wavelet transform, Wang and Lin (2004) proposed wavelet tree based watermarking algorithm. Chen *et al.* (2010) proposed two DWT-based audio watermarking algorithms that one of them is based on optimization scheme using group-amplitude quantization and the other embeds information by energy-proportion scheme.

Therefore, normalized energy is used instead of probability which rewrites the entropy in information theory as energy-proportion function.

Preda and Vizireanu (2010) proposed three DWT-based video watermarking approaches in which the watermarks used are binary images. Although, In one of them a spread-spectrum technique is used to spread the power spectrum of the watermark data, in the two others, watermarking methods are based on a combination of spread spectrum and quantization.

Deng and Jiang (2012) proposed a DWT-based image watermarking algorithm in which the Code-Division Multiple Access (CDMA) encoded binary watermark, adaptively is embedded into the third level detail sub-band of DWT domain.

Based on the visibility of image watermarking can be classified into visible and invisible. It can also be implemented in spatial and in frequency domain. In visible watermarking use the method of compress data of cover image (Hu *et al.*, 2006; Hu and Jean, 2006; Wang and Lin, 2004) and spread spectrum (Huang and Tsai, 2003; Hu and Kwong, 2001).

Yang *et al.* (2009) represented the visible image watermarking for bitmap images. Invisible watermarking for gray scale images is presented in (Feng *et al.*, 2010). Fibonacci transformation, modified Fibonacci Transform, generalized Fibonacci transform (Zou *et al.*, 2004a), Arnold transform (Shanthi and Bhuvaneswaran, 2014; Shanthi and Bhuvaneswaran, 2014; Zou *et al.*, 2004b), grey code transformation (Na *et al.*, 2008), other watermark scrambling based methods are presented in (Yin *et al.*, 2007).

MATERIALS AND METHODS

Fibonacci transform: Named after Leonardo of Pisa, popularly known as Fibonacci, the Fibonacci sequence Fn is a sequence of integers given by the recurrence relation:

$$F_n = \begin{cases} 0 & \text{if } n = 1 \\ 1 & \text{if } n = 2 \\ F_{n-1} + F_{n-2} & \text{otherwise} \end{cases}$$

The series constitutes the numbers:

0, 1, 1, 2, 3, 5, 8, 13, 21, 34

It can be easily seen that a 2x2 matrix formed by any four consecutive terms of the Fibonacci series is a unimodular matrix and can be considered as an image scrambler. A generalised Fibonacci transform is defined as.

Definition: The generalized form of the Fibonacci F: $T^2 \rightarrow T^2$ such that:

$$\begin{pmatrix} x^1 \\ y_1 \end{pmatrix} = \begin{pmatrix} F_i & F_{i+1} \\ F_{i+2} & F_{i+3} \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} (\text{mod}\, en)$$

Where;

x, y∈{0, 1, 2, ... N-1} F_i = The ith term of the Fibonacci series

N {0, 1, 2, ... N-1} = The size of a digital image

Denoting $\begin{pmatrix} F_i & F_{i+1} \\ F_{i+2} & F_{i+3} \end{pmatrix}$ as FTi, the first matrix of this series will be given by:

$$FT_1 = \begin{pmatrix} F_1 & F_2 \\ F_3 & F_4 \end{pmatrix} = \begin{pmatrix} 0 & 1 \\ 1 & 2 \end{pmatrix}$$

And this way we can form many Fibonacci transforms (Wang *et al.*, 2002; Chen *et al.*, 2010) for different values of i.

Discrete wavelet transform: The wavelet transform describes a multi-resolution disintegration process in terms of expansion of an image into a set of wavelet basis functions. Discrete wavelet transformation has its own space regularity localization property. The input image is divided into four non-overlapping multi-resolution sub-bands by the filters, namely LL1 (approximation coefficients), LH1 (vertical details), HL1 (horizontal details) and HH1 (diagonal details). The sub-band (LL1) is processed further to obtain the next coarser scale of wavelet coefficients, until some final scale 'N' is reached. When 'N' is reached, 3N+1 sub-band are obtained consisting of the multi-resolution sub-bands, which are LLX and LHX, HLX and HHX, where 'X' ranges from 1 until 'N'. Generally, most of the image energy is stored in the LLX sub-bands.

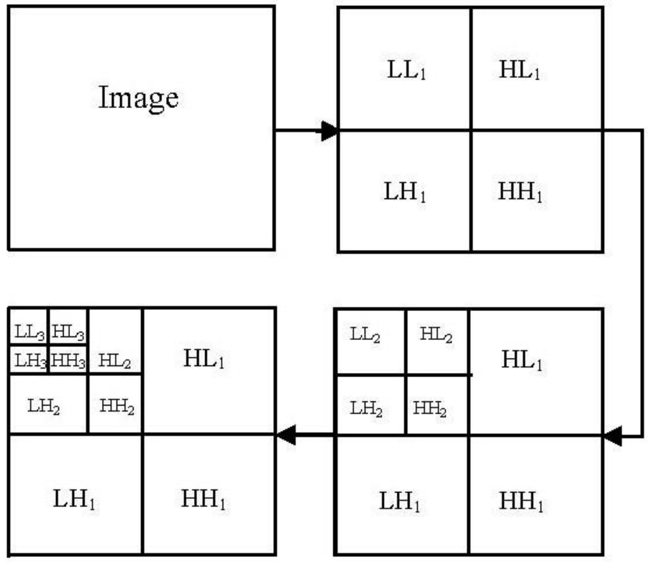

Fig. 1: DWT Watermark With Three levels

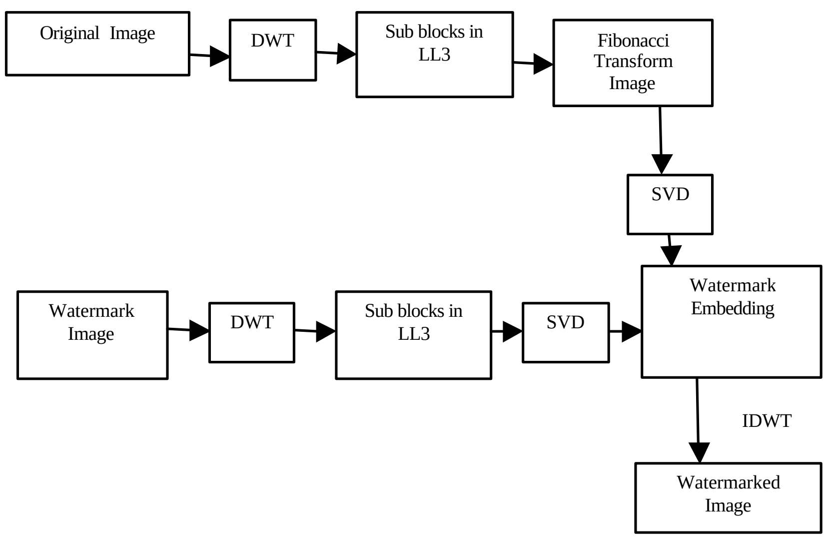

Fig. 2: Watermark embedding

As the image energy is rigorous at the lower frequency sub-band LLX and therefore the embedding process in such sub band degrades the performance of the image. However embedding in low frequency increases the robustness whereas high frequency HHX includes the edges and textures of the image and human eyes are not sensitive to the changes therefore allows performing arts embedding without human perception. Figure 1 shows the diagram of three level Dwt decomposition.

Image watermarking using fibonacci transform: Image watermarking using Fibonacci transform is used to increase the security level of the watermarked image. When a Fibonacci transform is used in conjunction with a wavelet-SVD, efficiency may be improved. Fibonacci transform is used to find the embedding position of an image. It is used to perform the better scrambling of an image. Wavelet and SVD are used in cascade to embed watermark image. Figure 2 shows the block diagram of embedding process.

In this study, image watermarking using Fibonacci series is proposed. Three level DWT is applied to the original image. The LL3 sub band of original image is given to the input of Fibonacci Transform. The result of Fibonacci transform of the original image is used to calculate SVD values of that image.

The three level DWT is applied to the secret image then calculate the SVD values of that secret image. To use

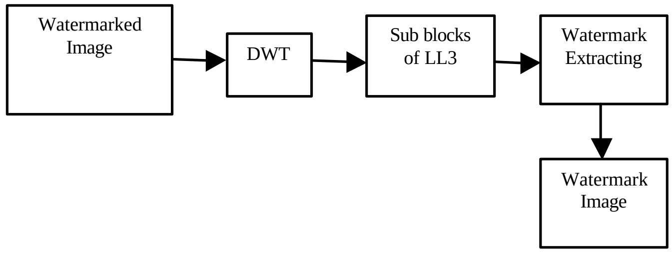

Fig. 3: Watermark extraction

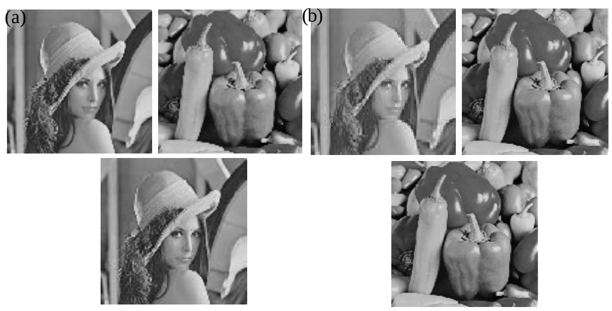

Fig. 4: a) Watermark embedding; b) watermark extraction

middle values of SVD provides better result. After that secret image is embedded into the host image. Finally, we apply inverse DWT, get the watermarked image. Figure 3 shows watermark extraction process. Figure 4a and b shows the embedding and extracting process.

The process explained above is stated as an algorithm is given below:

- **Step 1:** define the host image for embedding watermark and specify its size
- **Step 2:** decompose the host image into three level DWT sub-bands. The sub-band LL3 taken as the target sub-band for embedding watermark
- **Step 3:** the Fibonacci Transform is applied to LL3 sub band of host image
- **Step 4:** find SVD Values of that LL3 sub band. According to this representation very real matrix $A = USV^T$ can be expressed as product of three matrices: where U and V are orthogonal matrices and S is a diagonal matrix whose singular values are disposed in decreasing order. Since, the largest singular values have a stronger impact on the perceived image quality and the smallest ones are extremely sensitive to noise, we have selected the middle singular values
- **Step 5:** the secret image is selected to embed into host image
- **Step 6:** apply DWT and SVD to secret image
- **Step 7:** the inverse SVD of each block is computed
- **Step 8**: the inverse Fibonacci transform is computed

RESULTS AND DISCUSSION

In order to test our proposed algorithm, the simulation is made in MATLAB 7.9 environment. The proposed algorithm is implemented on standard test images lena, cameraman and pepper with pixel size 512×512. The fibonacci tansform is applied to the host image . Then DWT is used to embed watermark image into an original image. The simulation is carried out to analyze the imperceptibility and the robustness of the watermark image. Digital watermarking techniques must satisfy the following properties.

Evaluation of the effectiveness: The proposed algorithm is simulated on standard test image lena, pepper and cameraman with size 512×512. The simulation is carried out to analyze the imperceptibility and the robustness of the watermark image. The performance analysis is carried out to perform by as follows.

Peak signal noise ratio: The Peak Signal-to-Noise Ratio (PSNR) is used to evaluate the quality between the attacked image and the original image. The PSNR formula is defined as follows:

$$PSNR = 10\times\log_{10}\frac{255\times 255}{\frac{1}{H\times W}\sum_{x=0}^{H-1}\sum_{y=0}^{W-1}\left[f(x,y)-g(x,y)\right]^2}\,db \quad (1)$$

Correlation coefficient: The correlation coefficient is used to find the reliability of the extracted watermark through this Equation:

$$r = \frac{n\left(\sum xy\right) - \left(\sum x\right)\left(\sum y\right)}{\sqrt{\left[n\sum x^2 - \left(\sum x\right)^2\right]\left[n\sum y^2 - \left(\sum y\right)^2\right]}} \quad (2)$$

Robustness to attacks: To evaluate the robustness of the proposed method, several attacks have been applied to the watermarked image. In the experiments, both geometric and non geometric attacks were used.

Cropping: Cropping refers to the removal of any part of the image to improve framing. In MATLAB imcrop function is used to crop the image.

Gaussian noise: Gaussian noise is a process that adds a noise signal to an image in order to deliberately corrupt the image hence reducing its visual quality. In MATLAB controlling the distribution width is achieved by adjusting the third input parameter (denoted here as r) of the imnoise function.

Salt and pepper noise: Salt and pepper noise is a form of noise typically seen on images. It represents itself as randomly occurring white and black pixels.

Speckle noise: Speckle noise is a granular noise that inherently exist in and degrades the quality of the active radar and synthetic aperture radar images.

Histogram equalization: Histogram equalization is a method in image processing of contrast adjustment using the image's histogram. This method works by reducing the number of unique grey values in an image and reshape the histogram to approximate a uniform distribution. In effect, histogram equalization is controlled by adjusting the desired number of unique grey values. In MATLAB this is the equivalent of adjusting the second input parameter (denoted here as g) of the histeq function.

The performance of the new algorithm: To evaluate the performance of the new algorithms the PSNR and CC have been computed and compared with some famous benchmarks. The implementation of the new algorithm on Lena, cameraman, baboon and Peppers are presented. The histogram and the extracted logos using different attacks also are presented in the figures.

Additionally, Table 1 shows the comparison of PSNR values with various test images. Table 2 Show the comparison of correlation coefficient for the benchmarks. The result indicates, the proposed watermarking scheme improves the quality of the watermarking as well as increasing the security of images.

Table 1: Simulation results of psnr under different attacks

Image	Lena	Peppers	Cameraman	Baboon
Without attack	67.6458	65.3526	66.6321	64.2861
Gaussian noise	64.0463	62.3618	63.6173	61.9367
Salt and pepper noise	55.3456	54.2527	57.3245	54.7367
Gaussian smoothening	53.6534	57.3622	54.3782	53.2685
Median filter	54.3245	53.6452	51.8587	52.1645
Histogram equalization	32.4562	34.4772	37.2564	36.2871
Rotation	53.7623	54.6723	52.6712	51.7865
One quarter cropped	47.6255	48.2561	46.8725	45.8145

Table 2: Simulation results of correlation coefficient under different attacks

Image	Lena	Peppers	Cameraman	Baboon
Without attack	0.9961	0.9962	0.9963	0.9962
Gaussian noise	0.9934	0.8971	0.7834	0.9832
Salt and pepper noise	0.8672	0.7565	0.8454	0.7232
Gaussian smoothening	0.7631	0.7834	0.8753	0.7423
Median filter	0.7536	0.8737	0.7451	0.8532
Histogram equalization	0.8253	0.8542	0.6534	0.8623
Rotation	0.8734	0.7245	0.7983	0.8162
One quarter cropped	0.7832	0.7021	0.8352	0.8734

CONCLUSION

The image watermarking using fibonacci transform is used to provide better robustness and imperceptibility. In our proposed system is used to increase the security level and also provide higher PSNR value. Security level is increased with the help of Fibonacci transform. In Three level DWT is used to increase imperceptibility and robustness. It also provides high security to the watermarked Image.

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