

DUAL ROBUST WATERMARKING USING INTEGER WAVELET TRANSFORM AND SINGULAR VALUE DECOMPOSITION

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Abstract

A robust and secure technique is required to protect confidential data as it can be claimed by third party as their copy. Digital watermarking is used for Intellectual Property Rights protection and authentication. In this paper, a lossless dual watermarking scheme based on Integer wavelet transform (IWT) and singular value decomposition (SVD) is implemented. First secondary watermark image is embedded on the elements of singular values of the low-low (LL) Sub band of primary watermark image and the resultant image SVD is again embedded in Host watermark image. The Integer Wavelet Transform is implemented based on lifting scheme. The secondary watermark is extracted from watermarked image and hence primary watermark is extracted . The retrieved image is highly correlated with the original watermark image in terms of Normalised correlation and Peak signal to noise ratio. The proposed algorithm is robust under different attacks.

Keywords :Dual watermarking, Integer Wavelet Transform, Singular Value Decomposition.

A. Introduction

Data hiding is a method of hiding secret data into cover media, such as digital images, videos, audios and recover original form without any distortion. The motivation behind the proposed research work is the realization of the need for lossless watermarking, thereby addressing an important issue in the field of digital watermarking. Several reversible watermarking methods have been proposed in Spatial Domain [2] and Transform Domain [3]. Chang et al, proposed an image watermarking scheme based on SVD. Non-fixed orthogonal bases and one-way non-symmetrical decomposition are employed in SVD. These properties provide the advantages of various sizes of transformation and more security. The robust performance of SVD-based methods is not always better than that of frequency based methods for most of attacks. SVD-based methods involve several attacks such as median, average, Gaussian filtering and noising [4]. Li- bao et al, proposed watermarking based on DWT. DWT (Discrete Wavelet Transform) has been successfully used for encoding of still images. However, the filter coefficients of DWT often have floating point coefficients. When the input image consist of sequences of integers, the outputs no longer consist of integers. Lot of

multiplications of floating point coefficients also increase the computational complexity [5]. Chin-Chin Lai (2010), proposed hybrid watermarking scheme based on Discrete Wavelet Transform and Singular Value Decomposition[4]. The watermark is embedded on the elements of singular values of host image. This approach is able to withstand a variety of image processing attacks. But Image extraction is not lossless. Hence to increase the robustness of embedding and lossless extraction , this work is implemented using integer wavelet transform and singular value decomposition on two watermark images and a meteorological host image.

B. Integer Wavelet Transform

A more efficient approach to lossless compression is the use of integer transforms, such as Integer Wavelet Transform. The transform coefficients exhibit the feature of being exactly represented by finite precision numbers, and this allows for truly lossless coding. Integer Wavelet Transform is much faster than the floating point arithmetic in almost all general purpose computers because the floating point wavelet transform demands for longer data length than the integer wavelet transform does. Another benefit of using integer wavelet is the reversibility. That is, the image can be reconstructed without any loss because all the coefficients are integers and can be stored without rounding off errors. The input data consist of integer samples. The lifting scheme is modified to a transform that maps integers to integers and that is still reversible [3,5].

Lifting scheme

The lifting scheme is a simple method for designing customized biorthogonal wavelets and offers several advantages , Allows a faster implementation of the wavelet transform, Saves storage by providing an in- place calculation of the wavelet transform, Simplifies determining the inverse wavelet transform, Provides a natural way to introduce and think about wavelets.

The Forward lifting scheme wavelet transform divides the data set being processed into an even half and odd half. Lifting scheme algorithms have the advantage that they do not require temporary arrays in the calculation steps.

The Predict step calculates the wavelet function in the wavelet transform. This is a high Pass filter. The update step

calculates the scaling function, which results in a smoother version of the data. This operation consists of three steps.

Splitting :First, the input signal $s[n]$ is down sampled into the even position signal $se(n)$ and the odd position signal $so(n)$, then modifying these values using alternating prediction and updating steps. $se(n) = s[2n]$ and $so(n) = s[2n+1]$.

Prediction :A prediction step consists of predicting each odd sample as a linear combination of the even samples and subtracting it from the odd sample to form the prediction error.

Update :An update step consists of updating the even samples by adding them to a linear combination of the prediction error to form the updated sequence. The prediction and update step may be calculated in several steps until the forward transform is reached.

C. Singular Value decomposition

Singular value decomposition (SVD) is a general linear algebra technique for a variety of applications including solving most linear least-squares problems, computing pseudo-inverse of a matrix and multivariate analysis.

SVD is an important tool in linear algebra, which is widely applied in many research fields such as principal component analysis, canonical correlation analysis and data compression. Let A denote a matrix with size $L \times K$. The decomposition for A can be represented as shown in figure 1, where U and V components are composed of eigenvectors of matrix A , and T represents the conjugate transpose operation. The U and V^T components are called the left eigenvector and right eigenvector, respectively.

$$A = \begin{pmatrix} A(1,1) & A(1,2) & \dots & A(1,K) \\ A(2,1) & A(2,2) & \dots & \dots \\ \dots & \dots & \dots & \dots \\ A(L,1) & \dots & \dots & A(L,K) \end{pmatrix}$$

$$A = USV^T = \begin{pmatrix} U(1,1) & U(1,2) & \dots & U(1,L) \\ U(2,1) & U(2,2) & \dots & \dots \\ \dots & \dots & \dots & \dots \\ U(L,1) & \dots & \dots & U(L,L) \end{pmatrix} \times \begin{pmatrix} S(1,1) & 0 & \dots & 0 \\ S(2,2) & \dots & 0 & \dots \\ \dots & \dots & \dots & \dots \\ 0 & 0 & \dots & S(L,K) \end{pmatrix} \begin{pmatrix} V(1,1) & V(1,2) & \dots & V(1,L) \\ V(2,1) & V(2,2) & \dots & \dots \\ \dots & \dots & \dots & \dots \\ V(L,1) & \dots & \dots & V(L,L) \end{pmatrix}$$

Figure 1: Representation of SVD as A matrix

D. Watermark embedding and detection

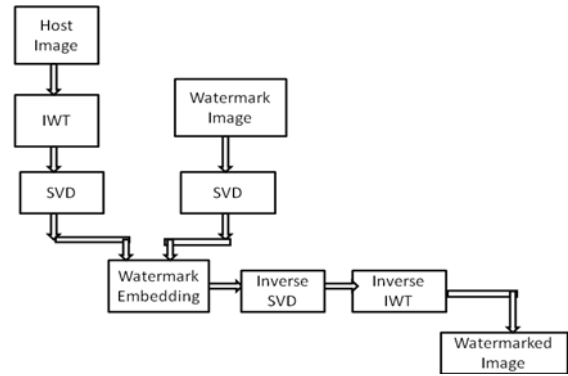


Figure 2: Dual watermark embedding architecture

The proposed architecture for embedding watermark image into original image is shown in figure 2. SVD is applied to IWT decomposed host image and two watermark images. Singular values of host image and watermark images are added to obtain the watermarked image.

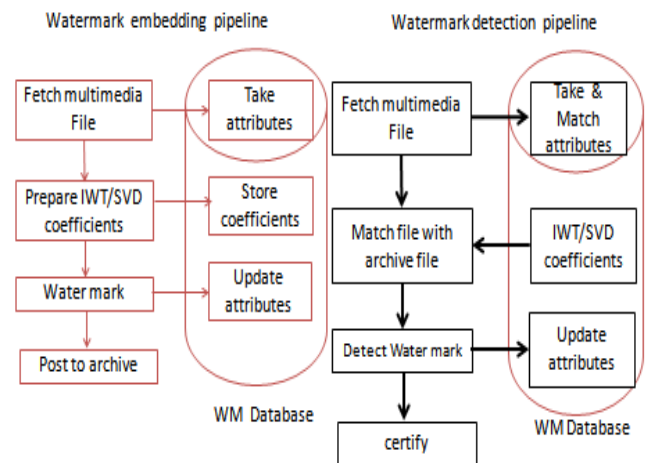


Figure 3: Watermark embedding & detection pipeline

These IWT, SVD coefficients are archived in database along with watermarked output images. In the detection pipeline, watermarked images SVD and IWT coefficients are matched with the archived database and their Normalised correlation and Peak signal to noise ratio are stored as attributes.

E. Watermark Embedding Procedure

Two Watermarks are embedded into host image by using the following steps.

- First level IWT is performed for a host image I with size $L \times K$.
- LL subband of the IWT image I is obtained.

- SVD is applied to LL_{org} subband of decomposed original image to get three components U_{org} , S_{org} , and V_{org} .
- SVD is applied to watermark images to get three components for each image U_w , S_w , and V_w , U_{w1} , S_{w1} , and V_{w1} .
- SVs of the watermarks are Combined with the SVs of the selected LL sub-band using appropriate scaling factor α , as illustrated in (1)

$$\begin{aligned} S_{wkd} &= S_{org} + \alpha S_{wkd1} \\ S_{wkd1} &= S_w + \alpha S_{w1} \end{aligned} \quad (1)$$

where α is the scale factor which controls the strength of each watermark bit to be embedded. Chaos map is applied on S_{wkd1} to provide security

- inverse SVD is performed to U_{org} , S_{wkd} , S_{wkd1} and V_{org} to get LL_{wkd} .
- Using inverse Integer Wavelet Transform, the watermarked image will be constructed.

Watermark Extraction Procedure

- Perform the 1-level IWT on a watermarked image I^w with size $L \times K$
- Get the LL subband of the IWT image I^w .
- SVD is applied to LL_{wkd} subband of decomposed watermarked image to get three components U_{wkd1} , S_{wkd1} , and V_{wkd1} .
- From these components, U_{wkd} , S_{wkd} , and V_{wkd} are obtained.
- SVD is applied to original image to get three components U_{org} , S_{org} , and V_{org} .
- Subtract the SVs of the watermarked image with the SVs of the selected LL sub-band of original image and divide the result using the same scaling factor α , as illustrated in Equation (2)
- Perform the multiplication of U_w , S_w , and V_w to get the watermark image
- Output the extracted Watermark Image. Obtain NC and PSNR coefficients to maintain in database as attributes for reference.

Normalized correlation (NC) is used to evaluate the similarity between the original watermark W and the extracted watermark W' which is retrieved from an attacked watermarked image as given in (3)

$$NC(w, w') = \frac{\sum_{i=1}^L \sum_{j=1}^K w_{ij} \oplus w'_{ij}}{L \times K} \quad (3)$$

where L and K represents the length and width of the watermark image. High NC value represents more resemblance between w and w' .

Peak signal-to-noise ratio (PSNR) is employed to evaluate the difference between I and I^w as in (4)

$$PSNR(I, I^w) = 10 \times \log_{10} \frac{255^2}{MSE(I, I^w)} \quad (4)$$

$$MSE(I, I^w) = \frac{1}{L \times K} \sum_{i=1}^L \sum_{j=1}^K |I_{ij} - I^w_{ij}|^2$$

where I and I^w denote the host image and the watermarked image. I_{ij} and I^w_{ij} stands for the original pixel value and its corresponding watermarked pixel value. The higher PSNR value for I and I^w represents few differences between original image and watermarked image.

F. Experimental Results

This section represents the experimental results for the lossless image watermarking scheme. The watermarking scheme was developed in JAVA with NetBeans environment. SVD of this scheme was developed using Java Matrix (JAMA) package. Singular value decomposition class of JAMA package is used to get three matrices from single input matrix.

Fig 4 shows the host image, watermark images. The images used in experiments are of size 512×512 for host image and of size 256×256 for the watermark images.



Fig 4:one watermark image & host image

Attacks on Watermarked Image

The robustness of the proposed method is shown in Table 1 as the attacked watermarked images and extracted watermark images along with PSNR and NC.

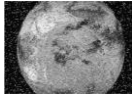

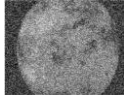



Attacks	Attacked Watermarked image	Extracted Dual Watermark image	PSNR (dB)	NC
Salt and Pepper Noise			16.98	0.29
Uniform Noise			8.54	0.41
Contrast			15.14	0.94

Table 1: Attacked watermarked images and extracted watermark image.

G. Conclusion

This work focuses on embedding dual watermark image into original image to provide copyright protection. After embedding, the quality of original host image is preserved. A semiblind watermarking scheme based on IWT and SVD was implemented. Modifying Singular Values of the host image in IWT domain provides high robustness against the common attacks. High PSNR of watermarked image is another benefit of the algorithm as the result of IWT implementation. Making trade off between PSNR of the watermarked image and correlation between extracted watermark and the original data lead to selecting the best value of the scaling factor. The proposed algorithm takes the advantages of the Wavelet Transform and SVD methods. The extracted watermarks are more robust against all mentioned attacks. IWT is useful for remote sensing applications because it produces lossless image.

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