Robust SWT SVD Based Digital Image Watermarking Technique

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Abstract—Due to the advancement in computer technology and readily available tools, it is very easy for the unknown users to produce illegal copies of multimedia data which are floating across the Internet. In order to protect those multimedia data on the Internet many techniques are available including various encryption techniques, steganography techniques, watermarking techniques and information hiding techniques. Digital watermarking is a technique in which a piece of digital information is embedded into an image and extracted later for ownership verification. Secret digital data can be embedded either in spatial domain or in frequency domain of the cover data. In this paper, frequency domain technique is used. Here, singular value decomposition (SVD) and stationary wavelet transformation (SWT) based water marking technique is proposed for hiding watermark. The quality of the watermarked image and extracted watermark is measured using peak signal to noise ratio (PSNR). A user defined or predefined watermark can be embedded within the camera itself during capturing of the image without disturbing quality of the image. It is observed that the quality of the watermarked image is maintained. Robustness of proposed algorithm is tested for various attacks which include Salt and Pepper noise, Gaussian noise, cropping and compression. A large payload can also be embedded in this proposed algorithm.

Keywords: Watermarking, Stationary wavelet transformation (SWT), Singular Value Decomposition (SVD), Discrete Wavelet Transform (DWT), large payload, Robustness

I. INTRODUCTION

In recent days, usage of computer networks for communication and for information sharing leads to increase in size of Internet. As the size of the Internet grows, the volume of multimedia data (images, text, video / audio) floating around also increases day by day. As many advanced tools are readily available to duplicate and modify those data in the Internet easily, the security is the major concern, which requires some mechanisms to protect digital multimedia data. The watermarking is a technique that supports with feasible solution.

Digital watermarking is defined as the process of hiding a piece of digital data in the cover data which is to be protected and extracted later for ownership verification. Some of the important applications of watermarking technique are copyright protection, ownership verification, finger printing, and broadcast monitoring. The features of watermarking include robustness and perceptibility. Robustness indicates the resistivity of watermark against different types of attacks such as cropping, rotating, scaling, low pass filtering, resizing, addition of noise, JPEG compression, sharpness, histogram equalization and contrast adjustment. Those attacks are either intentional or unintentional. Robustness is the property which is important for ownership verification whereas the fragility is important for image authentication. Robustness of watermarking algorithm is obtained to a maximum level when information is hidden in robust components of cover data. The increasing perceptibility will also decrease the quality of watermarked image. Generally information could be hidden, directly by modifying the intensity value or pixel value of an image or its frequency components. The former technique is called spatial domain technique and later is called frequency domain technique.

II. OVERVIEW OF SWT

A. Discrete Stationary Wavelet Transform1-D:

The stationary wavelet transform (SWT) is a wavelet transform algorithm designed to overcome the lack of translation-invariance of the discrete wavelet transform (DWT). SWT algorithm is very simple and is close to DWT [3]. The SWT is an inherently redundant scheme as the output of each level of SWT contains the same number of samples as the input. So for a decomposition of N levels, there is a redundancy of N in the wavelet coefficients. The following block diagram depicts the digital implementation of SWT.

I. Description: Stationary Wavelet Transform performs a multilevel 1-D stationary wavelet decomposition using either a specific orthogonal wavelet or specific orthogonal wavelet decomposition filters. N must be a strictly positive integer and length(X) must be a multiple of 2N.

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 [6]. We simply apply appropriate high and low pass filters to the data at each level to produce two sequences at each level. Instead of decimation, two new sequences will be generated of same
length as the original sequence. Instead, filters are modified at each level, by padding them with zeros [10].

\[
\text{Fig-1: A 3 level SWT filter bank (courtesy www.wikipedia.com)}
\]

As shown in fig-2, filters in each level are up-sampled versions of the previous.

\[
\text{Fig-2: SWT Filters (courtesy www.wikipedia.com)}
\]

In this algorithm, using the stationary wavelet transform, the image is decomposed into high and low frequency components, called first level decomposition. Once again the low frequency components of first level are decomposed into low and high frequency components, called second level decomposition. The preferred watermark is embedded into the second level decomposed low frequency components for robustness.

### III. OVERVIEW OF SVD

**Introduction:** In linear algebra, the singular value decomposition (SVD) is a factorization of a real or complex matrix, with many useful applications in signal processing and statistics.

Formally, the singular value decomposition of an M×N real or complex matrix \( M \) is a factorization of the form

\[
M = U \sum V^T
\]

where \( U \) is an M×M real or complex unitary matrix, \( \sum \) is an M×N rectangular diagonal matrix with nonnegative real numbers on the diagonal, and \( V \) is an N×N real or complex unity matrix.

Any M×N (M\geq N) real matrix \( A \), can be written as, for \((1\leq i\leq N)\),

\[
A = USV^T = \sum_{i=1}^{N} S_i U_i V_i^T
\]

where \( U \) and \( V \) are orthogonal matrices, and \( S \) is an M×N matrix with the diagonal elements \( S_i \), representing the singular values of \( A \). \( U_i \) is the \( i^{th} \) column vector of \( U \), \( V_i \) is the \( i^{th} \) column vector of \( V \). \( U_i \), \( V_i \) are called left and right singular vectors of \( A \) respectively. \( S \) has the structure of

\[
S = \begin{pmatrix} S_1 & 0 & \cdots & 0 \\ 0 & S_2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & S_N \end{pmatrix}
\]

**Description:** Singular value decomposition is a linear algebra technique used to solve many mathematical problems. The theoretical background of SVD technique in image processing applications to be noticed is:

- a) The SVs (Singular Values) of an image has very good stability, which means that when a small value is added to an image, this does not affect the quality with great variation.
- b) SVD is able to efficiently represent the intrinsic algebraic properties of an image, where singular values correspond to the brightness of the image and singular vectors reflect geometry characteristics of the image.
- c) An image matrix has many small singular values compared with the first singular value. Even ignoring these small singular values in the reconstruction of the image does not affect the quality of the reconstructed image. Any image can be considered as a square matrix without loss of generality.

So SVD technique can be applied to any kind of images. If it is a gray-scale image, the matrix values are considered as intensity values and it could be modified directly or changes could be done after transforming images into frequency domain.

The SVD belongs to orthogonal transform which decomposes the given matrix into three matrices of same size. To decompose the matrix using SVD technique it need not be a square matrix.

### IV. PROPOSED SYSTEM

**a) Embedding process:**

The block diagram for embedding watermark using SWT-SVD technique is shown in Fig.3. Original image transformed by SWT, which performs multilevel 2-D stationary wavelet decomposition and produces four 3-D arrays namely A, \( H \), \( V \), D which contains the coefficients. Array D, singular value decomposed and returns a vector of singular values. Similarly, the watermark is also gone through the same process. The watermarked image is obtained by applying ISWT to these coefficients.
Algorithm for embedding process:

**Step 1:** Stationary wavelet transformation technique applied to original host image, input is transformed into four 3-D arrays namely A, H, V, D.

**Step 2:** SVD technique is applied to high frequency component ‘D’, and the result is a vector of singular values.

**Step 3:** Same procedure applied to watermark image also.

**Step 4:** Diagonal matrices of both host image and watermark image are added with scaling factor.

**Step 5:** Inverse SWT applied to result to get the embedded watermarked image.

**b) Extraction process:**

The block diagram for extracting watermark using SWT-SVD technique is shown in Fig.4. SWT, SVD, ISWT transformations applied in same order to get watermark from the watermarked image.

**Algorithm for extraction process:**

**Step 1:** Stationary wavelet transformation technique is applied to watermarked image, input is transformed into four 3-D arrays namely A2, H2, V2, D2.

**Step 2:** SVD technique is applied to high frequency component D2, and the result is a vector of singular values.

**Step 3:** Watermark image components extracted from SVD transformed image by using same scaling factor.

**Step 4:** Inverse SWT applied to result to get the retrieved watermark image.

**V. PERFORMANCE ANALYSIS**

The performance of algorithm is analysed through the results which are obtained by embedding large sized watermark. The quality of the watermarked image can be measured either subjectively or objectively and it is observed that both subjective and objective quality of watermarked image is good. The PSNR is the objective criteria used to measure the quality of the watermarked image. Similarly the quality of the extracted watermark is measured by comparing it with the original watermark and is called similarity measure. The peak signal to noise ratio is obtained using following equation.

$$PSNR = 10 \log_{10} \left( \frac{R^2}{MSE} \right)$$

In the previous equation, R is the maximum fluctuation in the input image data type. For example, if the input image has a double-precision floating-point data type, then R is 1. If it has an 8-bit unsigned integer data type, R is 255, etc. The original image, watermark image and watermarked image is shown in Fig.5.

The quality of the watermarked image is measured through PSNR and the calculated values are tabulated in the table I.

<table>
<thead>
<tr>
<th>Image</th>
<th>Watermark</th>
<th>PSNR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original</td>
<td></td>
<td>71.237573</td>
</tr>
<tr>
<td>Compressed</td>
<td></td>
<td>40.875451</td>
</tr>
<tr>
<td>Cropped</td>
<td></td>
<td>29.021748</td>
</tr>
</tbody>
</table>
VI. CONCLUSION

SWT-SVD combined full band watermarking technique discussed in this paper. The quality of the extracted watermark shows that the new proposed algorithm is robust and also the quality of cover image is not degraded. The usage of SWT helps to increase the payload i.e., large size watermark, which is an advantage over many other techniques to embed large data content in an image. In future, this algorithm can be extended for colour images.

VII. REFERENCES