Block Based Digital Watermarking of Gray Images in the Singular Domain

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ABSTRACT
To secure digital images transmitted through communication networks, we have used a block based digital image watermarking scheme based on singular value decomposition (SVD). Traditional SVD watermarking already exists for embedding watermark on the image as a whole. In the proposed approach, the original image is divided into blocks, and then the watermarks are embedded in the singular vector domain of each block separately instead of using singular values. This segmentation and watermarking process makes the algorithm more secure as we can embed many watermarks using blocked based approach. Watermark detection is implemented by extracting the watermark from the watermarked blocks. The proposed method is encouraging as far as imperceptibility and robustness are concerned.

Keywords
Digital communication, Block based watermarking, Gray Images, Singular Value Decomposition.ax

1. INTRODUCTION
Easy access to the internet has caused wide use of network for transmitting digital data. This has also caused widespread unauthorised use of digital contents without offering appropriate credits to the owner. Many owners of the digital contents are forced to abstain from use of Internet for data sharing in the absence of proper security. Digital watermarking technique is a solution to the copyright protection problem of digital media. In addition to copyright protection, digital watermark has various other applications, such as recipient marker, image fingerprinting (authentication), hidden annotation, and secret communication.In this work we are primarily concerned with the digital watermarking of gray images using block based approach. By dividing image into four blocks and using SVD on each block separately, enhances security compared to whole image based approach. In this approach one can select the desired area in the host image and can hide watermark image in the selected area. Apart from this one can also vary the number of watermarks to be embedded. The above features provide flexibility to embed watermark in various different aspects. Present approach can be used to hide various sizes of images in the host as well. Images watermarking means embedding an image into host to get secured image called the watermarked image. The image so placed in the host can be done in such a way that it may be visible or invisible. To complete the task one still has to successfully extract the embedded image from the watermarked image. Only when both the embedding and extraction are satisfactorily done we can say that watermarking procedure is complete.In the literature watermarking techniques can be classified into spatial [1], [2], and frequency [3], [4], based. Watermarking algorithms that rely on spatial domains, hide the watermark by modifying the pixel values of the host image. On the other hand in frequency based techniques the host image is first converted into different frequencies by a suitable transform. The transformed domain coefficients are then modified by the watermark. To recover the watermark the inverse transform is finally applied on the watermarked image. Some of the popular transform techniques that have been used are the discrete cosine transform (DCT) [5], [6], the discrete fourier transform (DFT), and the discrete wavelet transform (DWT) [7]. A new approach based on the singular vector domain of images [8], [9], [10], [11] is also popular and is based on the matrix factorization technique of the singular value decomposition (SVD) [12. Many authors have developed hybrid algorithms [13] to improve the watermarking procedure.The layout of the manuscript is as follows. In the next section we will present our embedding and extraction algorithm. This is then followed by section 3 wherein, we will explicitly apply the watermarking and the extraction algorithm. The conclusions of our work are presented in section 4.

2. SVD-BASED WATERMARKING
Any watermarking procedure can be divided into two parts, one is the embedding algorithm, wherein the image that needs to be hidden is placed into another image called the host or the carrier image and second, extraction algorithm, in which the image that was embedded in the host is removed so that we obtain the host and the watermark separately. Our watermarking procedure makes use of the fact that we can treat the images, host as well as blocks of host image and the watermark, as a matrix. The elements of this matrix are given by the various pixel values. Now that the image has been converted to a matrix, we employ the well-known matrix factorization technique of SVD to the host and the watermark matrices. This splits a single matrix into product of three matrices. Further details about this factorization can be found in [12]. These three matrices, of the host and the watermark, are then used as the raw material for the construction of embedding and the extraction algorithm.It must be mentioned that the original algorithm was presented, in our earlier work [10], in the context of a gray scale image as a whole. Same algorithm has been used for embedding color image in to color image [14] and multiple gray images into a color image as a whole [15]. In the present work the same algorithm has been used for the block based approach.

2.1 The Embedding Algorithm
First we are dividing the host Image (H) into four blocks, Block1 (H1), Block2 (H2), Block3 (H3) and Block4 (H4) and treating each block as a separate image on which the embedding and extraction process is applied separately as if it were a different four images. Thus, the watermark1 embedded in the Block1 of the host, similarly the process is repeated for the Block2, Block3 and Block4 as well. Finally, these four blocks are combined to yield the watermarked image.

Let H and W be the matrices representing the host and the watermark. As mentioned above, in fact the host/watermark image is divided into four blocks H1, H2, H3 and H4. The embedding algorithm is presented for Block1. As a first step, we compute the SVD of host

$$H_1 = U_H D_H V^T_H = A_H V_H^T \qquad (1)$$

and the watermark image

$$W_1 = U_{W1} D_{W1} V^T_{W1} = A_{W1} V_{W1}^T \qquad (2)$$

Where $A_{H/W} = U_{H/W} D_{H/W}$ are also called the principal components in the language of principal component analysis. Now, we add the scaled eigenvector V_W of watermark to that of the original image,

$$V = V_H + \lambda V_{HW} \qquad (3)$$

Here □ is the scaling factor. Typically, $0 \leq$ □ ≤ 1, smaller the value of □ lesser is the distortion of the host. As □ $\rightarrow 0$, the approximation that V is a orthogonal matrix, i.e., $V V^T \approx I$ gets better. This property is important in the next step for constructing the watermarked image:

$$H_C = A_H V^T \qquad (4)$$

Equations (1-4) constitute the algorithm for watermarking using SVD in eigenvector domain.

2.2 The Extraction Algorithm

In the previous subsection we have shown how to embed a watermark, in the present we will explain how the watermark can be regained. Our starting point will be the watermarked matrix, H_C , that has been obtained after adding the watermark. Once again let us point out that this watermarked image has four watermarks embedded in the blocks which need to be extracted. So the first step of extraction will be to divide watermarked image into four blocks (Block size is same as watermark image) and getting four blocks. In the second step, the extraction algorithm, given below, will then be applied to each individual block.

This extraction algorithm relies on the fact that we have access to A_H, A_W, V_H and also the value of λ. The recovery of the watermark is a straightforward reversal of the embedding algorithm. Multiplying both sides of Eq. (4) by A_H^{-1} and substituting the expression of V^T from Eq. (3), it is easy to obtain V_W^T:

$$V_W^T = \frac{A_H^{-1} H_c - V_H^T}{\lambda} \qquad (5)$$

Finally, using Eq. (2), the watermark image can be constructed as,

$$\tilde{W} = A_W V_W^T \qquad (6)$$

Eq. (6), along with Eq. (5) constitutes the watermark extraction algorithm.

3. IMPLEMENTATION OF THE ALGORITHM

In the present section we will give the results of the implementation of the above algorithm. As the host we take Fig. 1 (Mysail)and the watermarks are given in Fig. 2(Lena, Goldhill, Peppers and Baboon). Notice that the host image chosen is of size 256 × 256 and watermarks are of size 128 × 128. For these set of images $\lambda = 0.2$ is chosen, which gives the best result. Fig. 3 shows the watermarked image which is satisfactory. Fig. 4 shows extracted watermarks after applying extraction algorithm. For the completeness we have obtained image difference of host image and watermark image which is shown in fig. 5. This conclusion is also borne out from the peak signal to noise ratio-root mean square error (PSNR-RMSE) values given below the various figures. Experimental result shows a highest value of RMSE and consequently the lowest PSNR value at $\lambda = 0.2$.

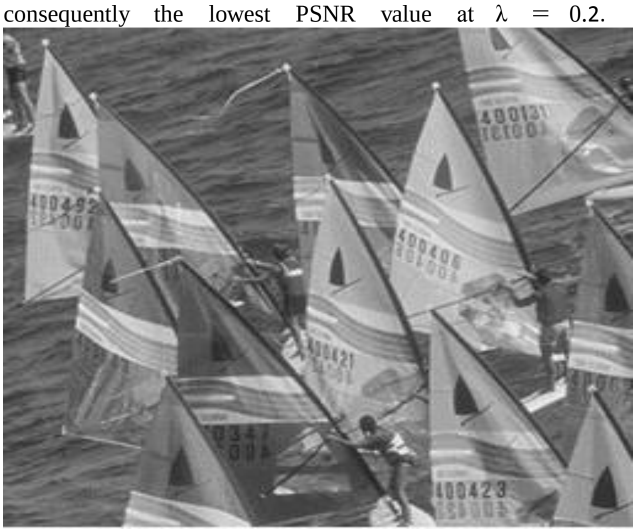
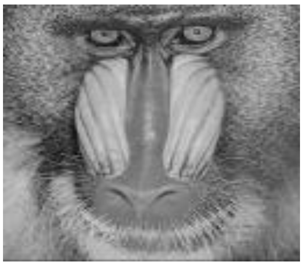


Figure 1 (Host Image 256 × 256)

(a)

(b)

(c)



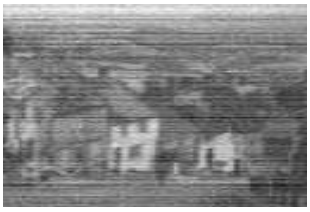
(d)

Figure 2 (Watermark images 128 × 128)

Figure 3 (Watemarked Image 256 × 256)

PSNR=19.73 RMSE=26.28

(a)



(b)

(c)

(d)

Figure 4 (Extracted Watermarks 128 × 128)

(a) PSNR=20.12 RMSE=24.14

(b) PSNR=19.25 RMSE=25.82

(c) PSNR=18.27 RMSE=27.43

(d) PSNR=19.20 RMSE=23.01

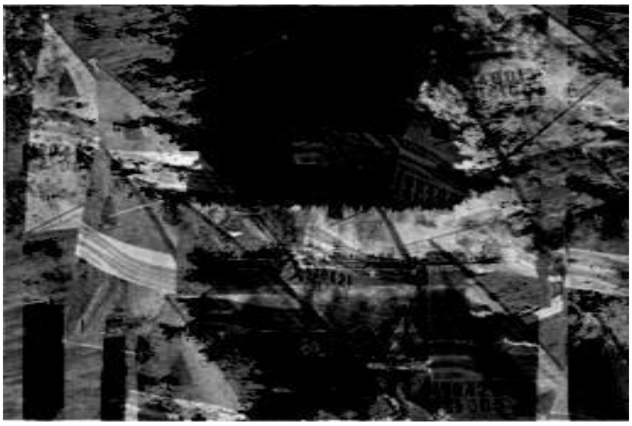


Figure 5 (Image Difference between Watermarked and Host image)

4. CONCLUSIONS

In the present work we have utilized a block based SVD approach in which singular vector of the host and watermark images have been used to embed watermark images. We have made use of the fact that a gray image can be divided into many blocks and SVD approach can be applied separately on each block to hide and extract watermark images. The result shows very satisfactory imperceptibility of image. Further work on various attacks is in progress.

5. REFERENCES

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