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SVD-Based Digital Image Watermarking

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***Abstract*—**To embed watermark is a way to increase the robustness of the image. In this paper the singular value decomposition (SVD) based image watermarking scheme is projected. From the obtained results we state that, the output result of SVD is more secure and robust. The result of SVD gives good accuracy, good robustness and good imperceptibility in resolving rightful ownership of watermarked image. In the proposed scheme D and U components are used for embedding watermark, contrasting to other transforms which uses fixed orthogonal bases, SVD uses none fixed orthogonal bases. With the improved utilization of SVD watermarking scheme, the watermarking technology in the transform domain has been developed to a great extent. The paper contains three parts: In part I 'Introduction to Digital Image Watermarking' is given, Part II includes 'Survey on Digital Image Watermarking'; the survey has been focused on adding watermark using Singular Value Decomposition in the image. Part III contains the proposed work of watermarking and effect of different image processing such as noise, cropping, blurring, rotation, etc. on the watermarked image. The proposed work is implemented using MATLAB.

Index Terms—. Watermark, Singular value decomposition, Peak Signals to Noise Ratio, Correlation Factor,Robustness, Imperceptibility,Blind Watermarking.

1. Introduction

Digital watermarking has been recommended as key to the problem of exclusive rights protection of multimedia documents in networked surroundings. There are two significantconcerns that watermarking algorithms need to concentrate on first, watermarking methods are required to provide truthful indication for protecting equitable rights second, good watermarking method should satisfy the requirement of robustness and resist distortions due to common image manipulations (such as filtering, compression, etc.).[1]

The advent of the Internet and the wide availability of computers, scanners, and printers make digital data acquisition, exchange, and transmission simple responsibilities. However constructing digital recordsreachable to others through networks also generatesprospects for malicious parties to make salable copies of copyrighted content without permission of the content owner. Digital watermarking techniques have been proposed in recent years as methods to keep the exclusive rights of multimedia data.

There are four important factors those are commonly used to decide quality of watermarking scheme; they are robustness, imperceptibility, capacity, and blindness. [4][5]

- Robustness: Watermark should be difficult to remove or destroy. Robustness is a measure of immunity of watermark against attempts to image modification and manipulation like compression, filtering, rotation, scaling, collision attacks, resizing, cropping, etc.
- Imperceptibility: It means superiority of host image should not be damaged by existence of watermark.
- Capacity: It includes techniques that make it possible to embed majority of watermark information.
- Blind Watermarking: Extraction of watermark from watermarked image without original image is favored because sometimes it's unfeasible to gain original image.

Performance assessment of watermarking algorithm is done by two performance assessment metrics: Perceptual clearness and Robustness [3] Perceptual clearness means apparent quality of image should not be damaged by occurrence of watermark. The quality of watermarked image is measured by PSNR (Peak signal to Noise Ratio). Bigger is PSNR, better is quality of watermarked image. PSNR for image with size M x N is given by [6]:

$$PSNR(db)10log_{10}\frac{(Max_I)^2}{\frac{1}{M*N}\sum_{i=1}^{M}\sum_{j=1}^{N}[f(i,j)-f'(i,j)]^2}$$

Where, f (i, j) is pixel gray values of original image. f' (i, j) is pixel gray values of watermarked image.

Max_I is the maximum pixel value of image which is equal to 255 for gray scale image where pixels are represented with 8 bits. [3][6]

Robustness is measure of immunity of watermark against attempts to remove or destroy it by image modification and manipulation like compression, filtering, rotation, scaling, collision attacks, resizing, cropping etc. It is measured in terms of correlation factor. The correlation factor decides the similarity and difference between original watermark and extracted watermark. Its value is generally in between 0 to 1. Ideally it should be 1 but the value 0.75 is satisfactory, Robustness is given by [6]:

$$\rho = \frac{\sum_{i=1}^{N} w_i w_i'}{\sqrt{\sum_{i=1}^{N} w_i}\sqrt{\sum_{i=1}^{N} w_i'}}$$

Where N is number of pixels in watermark, w_i is original watermark, w_i' is extracted watermark. [3][6]

2. Survey on Digital Image Watermarking

In SVD-based digital image watermarking scheme Chin-Chen Chang, Piyu Tsai, Chia-Chen Lin [1] measured the image quality by peak signal to-noise ratio (PSNR) among the watermarked images was greater than 42dB. This indicated that the proposed watermarking scheme only caused a slight image distortion; while in SVD based Image Watermarking Scheme Deepa Mathew K [2] obtained the peak signal to-noise ratio (PSNR) 46.11dB, 47.66dB, 47.51dB respectively for different three images.

In hidden digital watermarks in Images [7], watermarks are embedded by modifying the middle-frequency coefficients within each image block of the original image in considering the effect of quantization. The method can survive for several kinds of image processing and the JPEG lossy compression. Several watermarking schemes have been suggested, these schemes can be classified into two categories: spatial domain watermarking schemes and frequency domain watermarking schemes. (Celik et al., 2002; Chang etal., 2003; Lu et al., 2000; Van Schyndel etal., 1994)

In Medical Image Watermarking based on SVD-DWT technique [3], it has been showing that employing digital wavelet transform (DWT) in watermarking of image information shows precedence over other data hiding procedures, especially when DWT is joined with other methods to increase the robustness. Singular value decomposition (SVD) is one of the mainly suitable tools of linear algebra with frequent applications in image compression, watermarking and other areas of signal processing. Maximum SVD- based watermarking methodschanges the singular values of host image by the singular values of watermark.

In [8], R.G.vanSchyndel, A.Z.Tirke, C.F.Osborne proposed two methods of implementation are discussed; the first is based on bit plane manipulation of the LSB, which offers easy and rapid decoding. The second method utilizes linear addition of the water mark to the image data and is more problematic to decrypt, proposingessentialsafety. This linearity property also allows some image processing such as averaging to take place on the image without corrupting the water mark away from retrieval. Each method is possiblycompanionable with JPEG and MPEG processing.

In the literature, a number of techniques have been developed for watermarking. In [9], three coding methods for hiding electronic marking in document were proposed. In [10]–[11], the watermarks are applied on the spatial domain. The main drawback of spatial domain watermarking is that an ordinary picture cropping operation may remove the watermark.

Other than spatial domain watermarking, frequency domain approaches have also been proposed. In [12], a copyright code and its random sequence of locations for embedding are produced and then superimposed on the image based on a JPEG model. In [13], the spread spectrum communication technique is also used in multimedia watermarking.

In most of the previous works [12]–[14], the watermark is a symbol or a random number which comprises of a sequence of bits and can only be "detected" by employing the "detection theory." That is during the verification phase the original image is subtracted from the image in question and the similarity between the difference and the specific watermark is obtained.

Therefore an experimental threshold is chosen and compared to determine whether the image is watermarked. In this paper we propose a technique for embedding digital watermarks with visually recognizable patterns into the images. Since in daily life one claim a document a creative work and so on, by adopting one's sign, imprinting a privatestamp or an organization's logo such kinds of visually recognizable patterns are more intuitive for representing one's identity than a arrangement of random numbers.Additional specifically, during the confirmationstage of our work an "extracted" visual pattern in conjunction with the similarity measurement will be provided for verification.

3. Proposed Watermarking method

The proposed work SVD is one of the effective tools to analyze the matrices. While using the SVD transformation a matrix is decomposed into three matrices U, D, V. U and V are the unitary matrices and D is a diagonal matrix. There are two steps in the proposed watermarking scheme. The first step is watermark embedding procedure and the next step is watermark extracting procedure. [1][2]

we have taken the image named" peppers.jpeg" of 512×512 pixel size as a host image and another "symbol.jpeg" of 75×75 pixel size as a watermarked image. The 512×512 pixel image is portioned into 8×8 pixel image. After that apply Singular Value Decomposition algorithm on it from that take out the largest coefficient D (1, 1) from each D component and quantize it by using a predefined quantization coefficient Q. Let Z = D (1, 1) mod Q. After that if Z < 3Q/4, D (1, 1) modify to D' (1, 1) = D (1, 1) + Q/4 - Z. Otherwise D' (1, 1) = D (1, 1) + 5Q/4 - Z. for an embedded watermark bit valued of 0.While For an embedded watermark bit valued of 1, if Z < Q/4, D (1, 1) modify to D' (1, 1) = D (1, 1) - Q/4 + Z. Otherwise D' (1, 1) = D (1, 1) + 3Q/4 Z. After that perform the inverse of the SVD transformation to reconstruct the watermarked image. This completes the first half part our proposed work. [1]

If there is only fewer modification in the U component means the image quality is superior, but the resistance is weaker. But if the more modification in the U component implies the less quality image and it gives more robust output. [2]

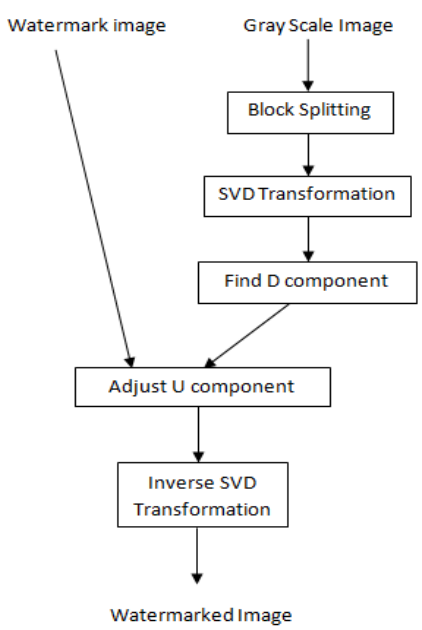

Figure1: The watermark embedding algorithm

After that the watermark extraction is done, for that first partitioned the watermarked image into blocks in to 8×8 pixel size. Then apply Singular Value Decomposition algorithm on it same as above mentioned from that take out the largest coefficient D' (1, 1) from each D component and quantize it by using the predefined quantization coefficient Q. Let Z = D' (1, 1) mod Q. If Z < Q/2, the extracted watermark has a bit value of 0. Otherwise the extracted watermark has a bit value of 1. [1]

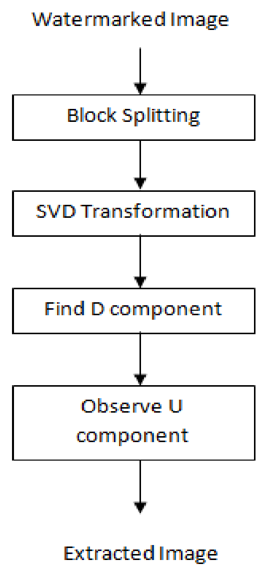

Figure 2: The watermark extracting Algorithm

4.Experimental Results

A gray scale image of size 512×512 pixel is selected as an input image as shown in fig 3. While 75x75 pixel image is usedas a watermark as shown in fig 4. First the images are split into 8x8 pixels. Then SVD transformation is applied to each block of splits image. After that number of nonzero coefficients of D components is calculated. Also the greater complexity block also calculated using PRNG. The magnitude difference is calculated in U component and it is modified according to the watermark added. The watermarked image is as shown in fig.5. The peak signals to noise ratio (PSNR) between the input and output image is calculated. The calculated PSNR is high that means the proposed watermarking method is added only a minor distortion in watermarked images. The extraction of watermark is also getting better extracted watermark which is identical to watermark added as shown in fig.6.

After that performed different image processing such as noise, cropping, blurring, rotation, etc. on the watermarked image as shown in fig .7. Each processing operations on image are obtained reduced PSNR and Correlation factor than original watermarked image. The experimental results are shown in table 1.

Figure 3: Gray Scale Image

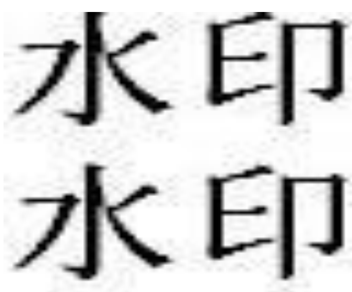

Figure 4: Watermark Image

Figure 5: Watermarked Image

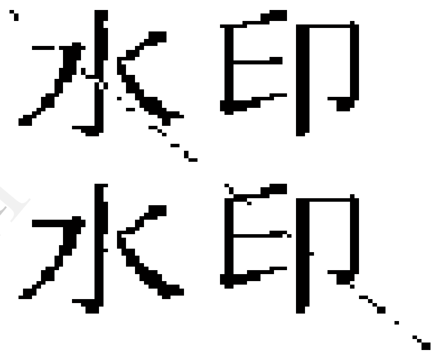

Figure 6: Extracted Watermark


Cropped Image Rotation (45^0)


BlurringImage Motion Blurring Image

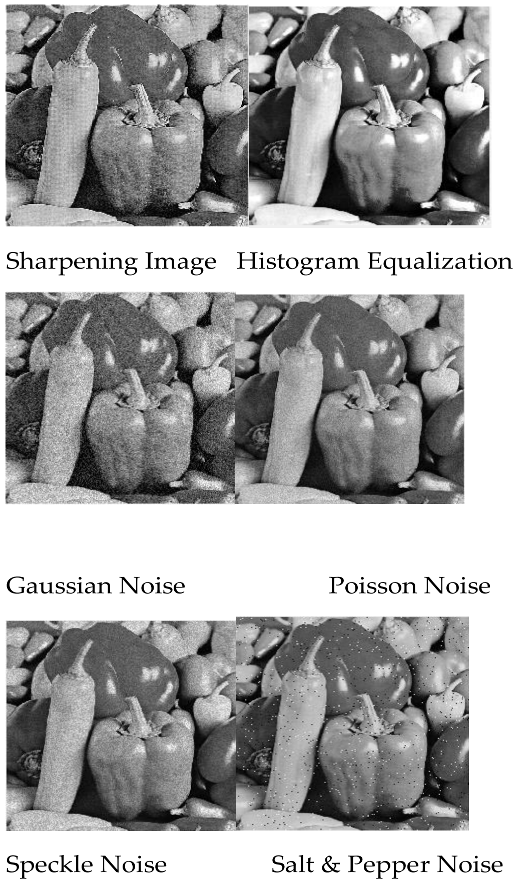

Figure 7: Different Image Processing.

Table 1.The corresponding results of PSNR & correlation factor for different image processing

Sr No.	Image Processing	PSNR(dB)	Correlation Factor
1	Watermarking (Default)	22.5876	0.97572
2	Cropping	19.5078	0.951546
3	Rotation (45^0)	20.7802	0.963566
4	Blurring	18.5803	0.940961
5	Motion Blurring	15.7403	0.892426
6	Sharpening	20.1773	0.958513
7	Histogram Equalization	20.7802	0.963566
8	Gaussian Noise	20.2585	0.959243
9	Poisson Noise	21.3734	0.968114
10	Speckle Noise	21.1665	0.966703
11	Salt & Pepper Noise	20.1773	0.958412

5. Conclusion

In this paper we proposed a watermarking algorithm based on SVD. The experimental results show that it is better performance on imperceptibility and robustness. It is more effective against different image processing operations like noise, cropping, rotation, blurring and sharpening, etc. The PSNR and correlation factor calculated by this method is effectively good. It is averagely greater than 22dB, while it is slightly affected by different image processing like noise, cropping, blurring, rotation, etc. The extracted watermark from watermarked image is also more identical to the watermark embedded in the gray scale images.

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