Comparison of wavelet based watermarking techniques Using SVD

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Abstract: Watermarking is a mechanism to provide security with audio or video. In this study we discuss video mechanism in which information can be hidden directly by modifying intensity values or frequency components of an image. Intensity values of an image can be modified directly, for modifying frequency components image need to transform image using different transformation techniques. Important properties of watermark include imperceptibility and robustness. Singular values of an image have very good stability when small values are added to the image, it does not effect the quality with great variation. Singular values correspond to intensity and singular vectors represent geometric characteristics.

Here we made a study of hiding information using different hybrid watermarking techniques, SVD with DWT, RDWT,CWT at various levels of transformations in low, high, mid bands of frequencies. The quality of watermarked data and extracted watermark is calculated using PSNR and NCC by applying various attacks. Depending on the level of transformation and band in which watermark is embedded for some attacks the image was robust and for some it was not.

Information can also be hidden in R G B or Y U V color spaces. Watermark extracted from three channels is studied, it was found that some of the channels were vulnerable to many attacks and some were not. Performance evaluation was made by applying various attacks.

Keywords : Digital Watermarking(DW), Singular Value Decomposition(SVD), , Discrete Wavelet Transformations(DWT), Complex Wavelet Transformations(CWT), Redundant Discrete Wavelet Transformations(RDWT). Normalized Correlation Coefficient(NCC), Correlation Coefficient(CC), Mean Square Error(MSE), Peak Signal to Noise Ratio(PSNR).

1. Introduction

Watermark can be used for copy right authentication or secret communication copy right achieved by invisible watermark**.** Secret communication can be tested for robustness by adding noise as a key. Watermark classified as blind and non-blind. Blind watermarking require secret key where as non-blind watermarking cover image and secret key for watermark extraction**.**

Video watermarking approaches can be classified into two main categories based on the method of hiding watermark information bits in the host video. The two categories are spatial-domain watermarking and transform-domain watermarking. In spatial-domain embedding is performed on spatial pixel values (luminance,

chrominance, color space). Spatial-domain techniques are easy to implement but not robust against attacks. Transform-domain techniques alter spatial pixel values according to a pre-determined transform. Commonly used transformations are DCT, DWT, FFT and the singular value decomposition. Transform-domain techniques proved to be more robust and imperceptible compared to spatial-domain techniques. Robustness of watermarking algorithm is a measure of resistance to attacks which is calculated with correlation coefficient between original and extracted watermark. Imperceptibility means that perceived quality of image should not be distorted by the presence of watermark. As a measure of the quality of watermarked image, PSNR is used. Data payload or watermarking capacity for a given image is defined as number of watermark pixels that can be embedded in the image without causing distortion to image.

2. Review of related work

SVD is optimal matrix decomposition technique in least square sense that it packs maximum signal energy in SV's. Each singular value specifies the luminance (energy), singular vectors represent image geometry. Slight variations of SV's cannot affect the visual perception of the quality variations the cover image. The robustness can be provided by embedding of watermark data through slight modifications in SV's[1].

DWT is a linear transformation used to describe discrete signal in multi resolution domain. DWT[2] image can be decomposed into pyramidal structure with various frequency bands such as LL(low), LH, HL(mid), HH(high). Magnitude of DWT coefficient is larger in LL band and smaller for other bands LH, HL, HH.

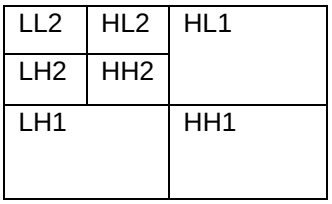

Fig1. Pyramidal structure of second level image decomposition

Embedding watermark in higher level sub bands increases the robustness of watermark with loss of image visual fidelity. Embedding in the lower level sub bands increases visual fidelity and reduces robustness. Image quality is studied measuring MSE, PSNR and NCC.

DWT and SVD are combined to develop a new hybrid non-blind scheme proposed by Eskicioglu resist a variety of attacks. CC for extracted watermark from four bands is measured. LL band withstands[3] compression, Gaussian noise, salt and pepper noise, resize. Middle band withstands for cropping and rotation. Shift invariance is not provided by DWT because of down sampling of its bands, where cover image and watermark images extracted are inaccurate.

SVD and RDWT: Because of down sampling of its bands DWT cannot provide shift invariance. The shift invariance of DWT causes inaccurate extraction of cover and watermark image. Since in watermarking we need to exact locations where watermark information is embedded, to overcome this problem researchers have proposed RDWT. This method eliminates down sampling and up sampling of coefficients during filtration. Redundant representation of input

stream is obtained by eliminating down sampling in the RDWT analysis. Frame expansion increases robustness with respect to additive noise [5]. Using this method large watermark can be embedded, it survives from common attacks. Large values of PSNR gives better watermark concealment.

SVD and CWT: This method is performed by modifications on singular value decomposition of images in CWT while CWT provides higher capacity than real wavelet domain [4]. Modification of approximate sub-bands leads to a watermarking scheme which favorably preserves the quality. CWT gives the potential to obtain suitable areas in which the information could be embedded. This is based on the fact that approximate shift invariance and good directional selectivity in comparison with DWT and DCT. DWT does not have separate sub-bands for two opposing diagonal direction, which is available in CWT. This method shows improve performance over pure SVD and hybrid SVD's. It's a non-blind watermarking technique gives efficient method for shift invariance properties and improved performance over pure SVD and hybrid SVD's. It uses multi dimensional signal filtering. Short linear phase filters are used for perfect reconstruction. Approximate shift invariance of this method give better robustness and good directional selectivity than DWT. Considering the best sub band data is disseminated in the whole image. Watermark embedded in LL gives less quality fidelity and data embedded in HH band decreases robustness. High capacity of CWT domain is applied to embed the watermark.

Hybrid color watermarking uses contourlet transforms: This is for color image watermarking. Contour transforms are improved curvelet transforms. Contourlet transform is a multidirectional and multi resolution expansion which represents images containing contours efficiently. These wavelets contain all features of wavelets and also show a high degree of directionality and anisotropy [8]. These transforms have any number of directional decompositions at every level of resolutions. SVD is applied to mid frequency coefficients. This algorithm is robust to JPEG2000,
cropping rotation, histogram equalization, low pass filtering, shearing, gaussian noise and salt and pepper noise.

DWT and SVD in YUV color space: Here RGB color domain is converted into YUV domain. Where Y represents intensity and UV represents chrominance (color) components[6]. In RGB color space pixel values are highly correlated where as in UV they are decor related. Secret data can be embedded into intensity or slight variations in SV may not effect visual perception.

Y components are higher than UV. These components are used for embedding after haar transformation is applied. Conversion of RGB to YUV color spaces

$$Y = 0.257\,R + 0.504\,G + 0.098\,B + 16$$

$$U = 0.148R - 0.291G + 0.439B + 128$$

$$V = 0.439\,R - 0.368\,G - 0.071B + 128$$

DWT is applied to each YUV. Scale the watermark with cover image by a scaling factor and measure PSNR and NC in three channels in all bands are

PSNR

NC

Y 36db

0.9980

U 33db

0.9994

V 30db

0.9498

b)watermark Extraction

Modified DWT is implemented by me where the image is divided into 16 x 16 blocks. Extract the bits of 8th column from each block to get the digital signature. Embed this signature in the LL band of DWT transformed image. Calculate PSNR & CC.

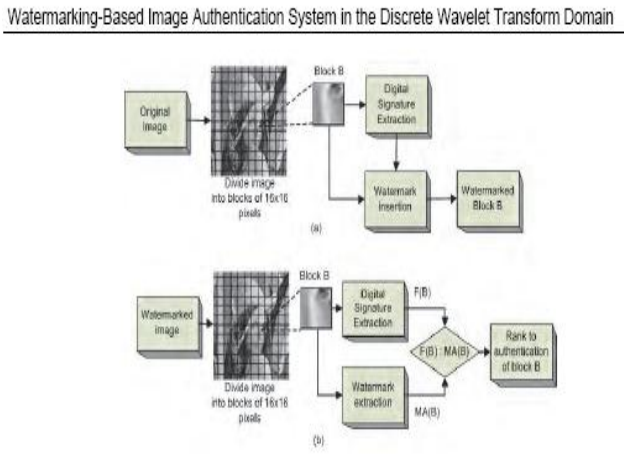

Fig 1 a) watermark insertion

3. Comparison of watermarking techniques

After attacks	SVD	SVD + DWT	SVD + RDWT	SVD + CWT	SVD + YUV color space	Modified DWT
PSNR	33db	34db	38db	48db	36db	52 db
CC	0.9987	0.9689	0.9987	1	0.9994	.0998
Size of watermark	Same as cover image	¼th cover image	Same as size of cover image	----	Large	¼th cover image
Sub bands selected for W.M insertion	No sub bands	All	HH	Best sub band	All frequency bands of color images	LL

4. Conclusion :

Drawback with SVD algorithm is quality of watermarked image is degraded and extracted watermark is not robust for common attacks. There fore researchers combine SVD with DCT or DWT .These hybrid techniques are better than SVD alone with respect to noise and robustness. RDWT is more robust to various attacks compared to DWT based methods. Here frame expansion increases robustness. Large watermarks can be embedded using this method. Advantage of CWT technique could be highlighted as high capacity and robustness

against different types of common attacks. Disseminating data in the whole image considering best sub-band is the main privilege of using CWT. In DWT YUV color space large size of watermark is embedded in all three channels of cover image. Here watermarked image quality is not degradable. NCC found good in U channel where as PSNR found good in Y channel.

In this paper I have implemented modified DWT algorithm a robust digital signature algorithm for image authentication. The highest advantage of this combination besides the digital signature robustness and the watermark imperceptibility, is that it is not necessary an additional band width to transmit the digital signature and found to be an efficient mechanism than other techniques.

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