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A ROBUST DIGITAL IMAGE WATERMARKING USING DWT -PCA

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ABSTRACT
A comprehensive approach for watermarking is introduced in this system, and a hybrid digital watermarking scheme based on Discrete Wavelet Transform (DWT) and Principal Component Analysis (PCA) is used. There are some watermarking techniques like DCT, DWT, and DWT-SVD, but there is disadvantage in the watermarking to withstand attacks. Hence the new digital image watermarking algorithm is proposed which provide robust watermarking with minimal amount of distortion in case of attacks. DWT offers scalability and PCA helps in reducing correlation among the wavelet coefficients obtained from wavelet decomposition of each block thereby dispersing the watermark bits into the uncorrelated coefficient. Peak signal ratio is used to measure invisibility whereas similarity between two images by normalized correlation coefficient test the transparency and robustness against various attacks like cropping, noise, rotation, filtering etc. The proposed system should provide recoverable watermark without any reasonable amount of distortion even in case of attacks.

Index Terms—Watermarking, DWT, PCA, PSNR, MSE.

INTRODUCTION
Conventional analog media distribution systems have an inherent built-in defense against copying, alteration and fraud. Each time a new copy is issued the quality of the duplicated content is degraded accordingly. In contrast to that, digital multimedia documents are completely susceptible to exact replication and alteration. This, together with the rapid proliferation of digital documents, multimedia processing tools and the world-wide availability of internet access have created an ideal medium for piracy, copyright fraud and uncontrollable distribution of high quality but unregistered multimedia content. With advances in computer network and multimedia technology, digital media is rapidly proliferating, calling for greater copyright protection for electronic publishing. Digital watermarking is a technique to protect intellectual property in digital form. By adding an invisible signal (called watermark) to the original media, it is hoped that such a signal will provide evidence of the legal ownership or at least help the owner to detect copyright violations , have been proposed, mainly focusing on the invisibility of the watermark and its robustness against various signal manipulations and hostile attacks. We notice that one weakness for many previous spatial frequency domain approaches is that the human visual system (HVS) is not taken into account when selecting positions to insert the watermark. Because of the invisibility constraint of a watermark, these techniques have to use signals of relatively lower power than would otherwise be possible, to avoid degrading the image quality, inevitably limiting the robustness of the watermark.

I. GENERAL FLOW OF IMAGE WATERMARKING:
The general way of image watermarking is as shown in fig 1.1. Original image will undergo few transform lime DCT (Discrete Cosine Transform) or DWT (Discrete wavelet transform).Watermark will be embedded in the transformed domain to increase the robustness the algorithm, and by taking its inverse transform we will obtain the Watermarked image.
Similarly the process of extraction of watermark from the watermarked image is as shown in the fig 1.2.The focus will be on extraction of transformed coefficients. You can extract the information by correlation method as comparison the algorithm should be fairly simple in case of detection of watermark

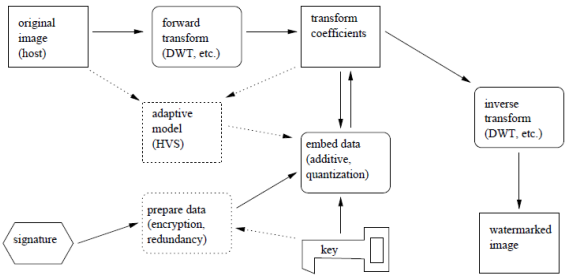

Fig 1.1: General Flow of Image watermarking

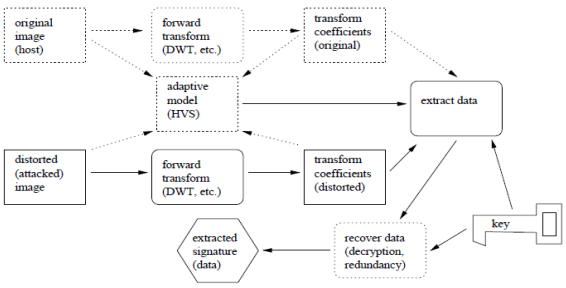

Fig 1.2: General Flow of watermark extraction

II. METHODOLOGY

In this method we converted the watermark image into gray scale and is embedded into the cover image by decomposing it into DWT sub bands followed by the application of block based PCA on the sub-block of one sub-band.

a. Algorithm for Embedding:

Step 1: Select the Cover Image from Database.
Step2: Select the watermark image Iwm from Database.
Step 3: Convert the given watermark image into grayscale image.
Step 4: Apply DWT on watermark gray scale image and generates LL, LH, HL, HH Sub bands.
Step 5: As we want to merge LL and Ib. Generate Resize image (Ibr) of Ib image as same size of LL
Step 6: Apply PCA function on Ibr and generate coefficient matrix Ibrcoef.
Step 7: Generate new data set of Watermark Image Ibr using coefficient matrix. On New PCA Axes.

Ibpca2=Ibr x Ibrcoef

Step 8: Set blending parameter Alpha, Add this updated PCA data to LL Band
LL2=LL+ (Alpha x Ibpca)
Step 9: Perform inverse DWT using LL2, LH, HL, HH and generate watermarked Image Iro
Step10: Apply different method for noise analysis No Noise, Gaussian Noise, Salt n Paper Noise on original image
Iro. Ir= Iro + Noise.
Step 11: Find similarity between original grayscale image I and watermarked image Ir display PSNR and MSE

b. Algorithm for Decoding:

Step 1: Apply dwt2 on watermarked image Ir and generate LLd, LH, HL, and HH.
Step 2: As our information lies on LL band apply extraction formula to extract PCA matrix
Ibpcat=(LLd-LL)/Alpha.
Step 3: Remove any extra column and resize to Ibpcat2 .
Step 4: Now we have recovered PCA matrix Ibpcat2 and coefficient matrix, generate original dataset (image).
Ib2=Ibpcat2 x Ibrcoef'
Step 5: As our main watermark image is in Black n White convert Ib2 into BW image Ib3
Step 6: Compare original input resized watermark image Ibr and extracted watermark image Ib3 and display PSNR and MSE

III. RESULT

A. Digital image watermarking scheme using DWT-PCA:

The invisible digital image watermarking scheme has been implemented in which graphical user interface (GUI) has been designed. It is explained stepwise with the help of results as follows

GUI:

In proposed system, we have designed graphical user interface to provide access to the system. With the help of GUI, user is able to communicate with the system in easy and simple way. Menu consists of total 03 options which allows user to select original image and watermark image, perform DWT-PCA

decomposition of images, watermark embedding and extraction, calculation of mean square error (MSE) and peak signal to noise ratio (PSNR). Created GUI is shown as below in Fig. 6.1.

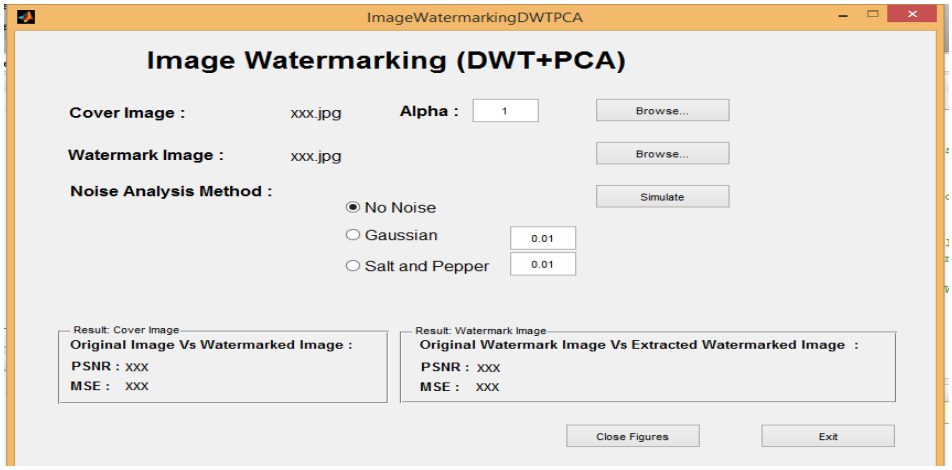

Fig.4.1 Graphical User Interface

Step 1: Selection of input cover or original image

The input RGB image is read from self-created database. System is also able to choose input from other location but, we have preferred selection from database to maintain Uniformity.

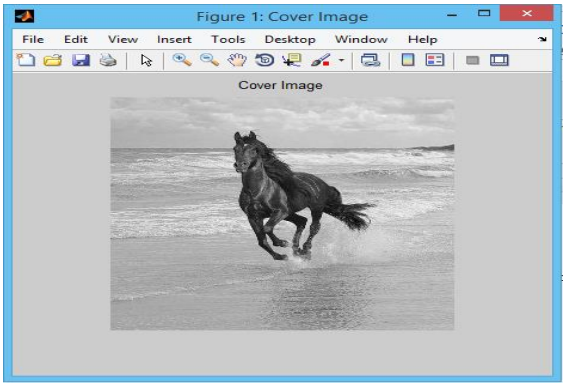

Fig 4.2 Selection of original or cover image from database of size 512 × 512

Step 2: Selection of input watermark image

In this step, second input image i. e. watermark image is selected. Here, any image from database is selected. Database consist images of different sizes such as 256 × 256, 128 × 128, and 64 × 64. After selection of watermark image, it is pre-processed i.e. converted from RGB to gray scale and resized. Fig. 6.3 shows original image and pre-processed image

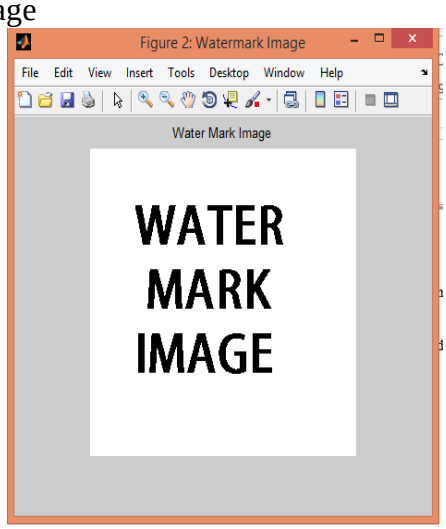

Fig 4.3 Selection of watermark image from database

Step 3: Application of DWT to an original image:

This is the most crucial step of experimentation because; image needs to be decomposed for watermark embedding and extraction process. Here, pre-processed original image is decomposed by performing DWT and PCA up to 2 levels. Sub-bands such as LL, LH, HL and HH are obtained which represent different coefficients. Out of all sub-bands only LL sub-band is used in order to modify original image along with watermark. Figure 6.4 shows LL sub-band obtained after application of 2 levels DWT to original image.

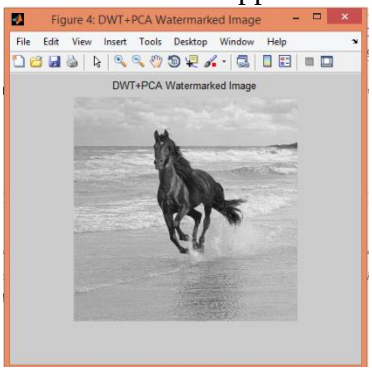

Fig 4.4 DWT-PCA Watermark image

Step 5: Watermark extraction:

Watermark extraction is the last and most important step of the experimentation. In this step, embedded watermark image is extracted from original image. For the watermark extraction, watermarked image is used as input image which is obtained in previous step. By Apply dwt2 on watermarked image Ir and generate LLd, LH, HL, HH.As our information lies on LL band apply extraction formula to extract PCA matrix Now we have recoved PCA matrix Ibpcat2 and coefficient matrix, generate original dataset (image).

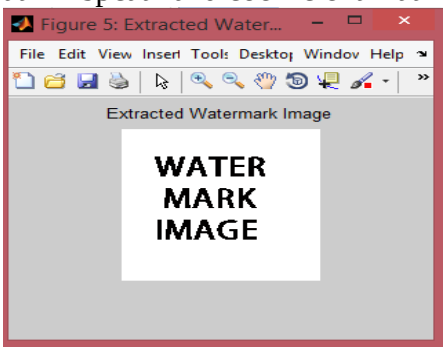

Figure 4.5 shows final result showing watermark image extracted from original image

Step 7: Calculation of Mean Squared Error (MSE):

This is the step where, performance of watermarking scheme is evaluated. Mean squared error (MSE) measures the average of the squares of the "errors". In case of watermarking scheme, error is evaluated by using original image and watermarked image. Ideally, mean squared error should be zero. It can be calculated by the formula given below:

$$\text{MSE} = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}[f(i,j)-f'(i,j)]^2}{M \text{ X } N}$$

Where, f is original image and f′ is watermarked image;
M: number of rows and N: number of columns.

1. Obtained value of MSE for Cover images used in watermarking scheme is **0.2266**
2. Obtained value of MSE for extracted Watermark image used in watermarking scheme is **0.**

Step8: Calculation of Peak Signal to Noise Ratio (PSNR):

Peak Signal to Noise Ratio, often abbreviated as PSNR. The PSNR is most commonly used as a measure of quality of reconstruction in image compression etc. Here, for measurement of quality of watermark image PSNR is used. PSNR is measured in decibels scale (dB). In ideal case, value of PSNR is

infinite because ideally, Mean Squares Error must be zero. Hence, we can say more is the value of PSNR, performance of system is better.

$$\text{PSNR} = 10 \log_{10} \frac{(\text{Max})^2}{\text{MSE}} (\text{dB})$$

For gray scale images, value of MAX is 255

Value of PSNR for watermarking scheme for Cover image which have been selected above is **54.59Db**

Value of PSNR for watermarking scheme for Extracted watermark image which have been selected above is **Infinite**

B. Results of digital image watermarking scheme according to variable scaling factor alpha.

In our experimentation, we have utilized scaling factor in the watermark embedding process. For watermark embedding, LL sub-band i.e. approximation coefficient obtained from 2 level dwt decomposition of original image and watermark image has been used. Approximation coefficient of original image is modified with approximation coefficient of watermark image which is scaled with scaling factor. Suggested range of scaling factor is from 0.1 to 1.0 with the variable scaling factor we have demonstrated some results in the following table. Tabulated results in Table 4.1 are helpful observe effect of variable scaling factor on watermarking scheme. As scaling factor increases, value of PSNR decreases. Hence we can say that, system gives better performance for less value of scaling factor.

Scaling factor is also responsible for visibility of watermark image. If scaling factor has been increased watermark image becomes more dominant to original image and hence, watermark image becomes visible. Example is shown in the following table.

Table 4.1 Results of digital image watermarking scheme according to alpha.

Sr.No	Alpha	MSE	PSNR(dB)
1	0.1	0.002256	74.5962
2	0.2	0.009026	68.5757
3	0.3	0.02031	65.0538
4	0.4	0.03010	62.555
5	0.5	0.05654	60.6168
6	0.6	0.08112	59.0332
7	0.7	0.11058	57.6942
8	0.8	0.14422	56.5344
9	0.9	0.18279	55.5113
10	1.0	0.22566	54.5962

C. Results of watermarking system for robustness test:

A quality of watermarked image and similarity of extracted watermark is measured in order to evaluate the imperceptibility, robustness of the proposed method. Various attacks geometric and image processing attacks are used to test the robustness of the watermark. Here, robustness is tested by observing PSNR values of extracted watermarks. If we compare value of PSNR of image having no attack with other attacked images, there is no bigger decrement in PSNR values. Extracted watermark has acceptable PSNR values. So, from summarized results of table 6.2 we can say implemented scheme has good robustness.

Table 4.2 Results of watermarking system for robustness tests

Attack	MSE of Watermarked Image	PSNR(dB) Watermarked Image
No attack	0	Infinite
Salt and pepper	0.34795	52.7157
Gaussian	0.45052	51.5937

IV. CONCLUSION:

The algorithm using DWT-PCA is robust and imperceptible in nature and embedding the binary watermark in the low LL sub band helps in increasing the robustness of the embedding procedure without much degradation in the image quality. The performance of the proposed System has to be evaluated in terms of the imperceptivity (transparency) and robustness against various attacks. Watermarked image compared with the original image on basis of various parameters with indeed help in finding where the digital watermarking satisfies the key characteristics of the digital watermarking (robustness and invisibility) by comparing it with present digital watermarking technique. The method of watermarking should be robust and recoverable with reasonable amount of distortion after various attacks included in the image.

7.1 Future Scope:

The improvement of the work can be done on the colour image as here work is restricted with gray scale images only. Nowadays the data availability on multimedia and internet is found to be colour. The work can be further extended for video watermarking.

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