INTERNATIONAL JOURNAL OF PURE AND APPLIED RESEARCH IN ENGINEERING AND TECHNOLOGY

A PATH FOR HORIZING YOUR INNOVATIVE WORK

DWT BASED ROBUST WATERMARKING TECHNIQUE FOR COLOR IMAGES USING ARNOLD TRANSFORM

SNEHA NARGUNDKAR

Electronics & Telecommunication Dept., Shree Rayeshwar Institute of Engineering & Information Technology, Goa

Accepted Date: 05/03/2015; Published Date: 01/05/2015

Abstract: Due to the rapid evolution of the Internet, copyright protection of intellectual property and prevention of illegal copying has become a major area of concern. Inserting a watermark into potentially vulnerable data is one of the best ways to discourage illegal duplication. In this paper, we present a robust, non-blind digital watermarking method based on Discrete Wavelet Transform by embedding a scrambled watermark in a middle frequency sub-band of the image. The watermark is scrambled using Arnold Transform to improve security. The algorithm uses Haar wavelet for decomposition and is auto-adaptive to various grayscale images owing to the use of mean value of selected coefficients from the original image during embedding phase. We extend the technique for color images and show that the proposed algorithm achieves imperceptibility and is robust against common image processing attacks.

Keywords: Discrete Wavelet Transform, Colour Image watermarking, Image scrambling, Arnold Transform, robustness, imperceptibility, multi-resolution analysis, Haar wavelet

Corresponding Author: MS. SNEHA NARGUNDKAR

Access Online On:

www.ijpret.com

How to Cite This Article:

Sneha Nargundkar, IJPRET, 2015; Volume 3 (9): 187-195

PAPER-QR CODE

INTRODUCTION

With so many technological advances in the digital domain, protection of ownership and prevention of unauthorized tampering of multimedia data has become an important concern. The evolution of Internet has led to faster and easier duplication and distribution of multimedia. The cryptographic techniques, such as encryption, digital signature etc. while suitable for text documents, are not very efficient for protecting multimedia data such as images, audio and video. Recently, digital watermarking techniques have received considerable attention, since they have high commercial potential for copyright protection and authentication for multimedia data. A digital watermarking technique embeds a watermark such as a trade logo, a seal, or a sequence number, into an image. Subsequently, the watermark can be extracted from the watermarked image in order to verify the ownership. In contrast to cryptography, which immediately arouses suspicion of something secret or valuable, the watermark hides a message within digital media without noticeable changes to the host.

A watermarking technique should satisfy certain essential requirements to be considered acceptable [4]. Firstly, the embedded watermark must be perceptually invisible (imperceptibility). Secondly, the embedded watermark has to be strong enough to resist against attacks intending to remove the watermark (robustness). The attacks include common image processing applications and geometric distortions among others. A good watermarking algorithm should be able to achieve a trade-off between the two conflicting requirements of robustness & imperceptibility. A watermarking technique must identify the owner of an image without ambiguity. Also, the security of the watermark should not depend upon the assumption that the pirate does not know the watermarking algorithm. The watermarking algorithm must be public while the embedded watermark is undeletable.

In this paper, we extend the algorithm developed for grayscale images in our previous work [1] to color images. To make watermark robust we embed the watermark in the higher level sub-band even though it may affect the perceptual invisibility of the image. By carefully embedding the watermark, it will not cause much change in the image fidelity.

DISCRETE WAVELET TRANSFORM

When an image is passed through series of low pass and high pass filters, DWT decomposes the image into sub bands of different resolutions. Decompositions can be done at different DWT levels.

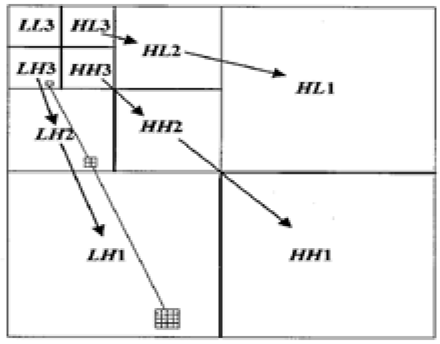


Figure 1. Three Level Image Decomposition

At level 1, DWT decomposes image into four sub bands: LLx (Approximate sub-band), HLx (Horizontal sub-band), LHx (Vertical sub-band) and HHx (Diagonal sub-band). To obtain next level wavelet coefficients, the sub-band LL1 is further processed until final N scale reached. At level N, we have 3N+1 sub-bands with LLx and HLx, LHx, where x ranges from 1 to N. The arrow points from the parent sub-band to its children sub-band. A wavelet tree consisting of all descendants of a single coefficient in the sub-band LH3 is also given.

Embedding watermark in low frequency coefficients can increase robustness significantly but maximum energy of most of the natural images is concentrated in approximate (LLx) sub-band. Hence watermark cannot be embedded in LLx sub-band because it will cause severe and unacceptable image degradation. The high frequency sub-bands (HLx, LHx and HHx) are better for watermark embedding as they yield effective watermarking without being perceived by human eyes. But since HHx sub-band includes edges and textures of the image, it is also excluded. The remaining options are HLx and LHx. We decided to perform watermarking in HLx region because Human Visual System (HVS) is more sensitive in horizontal than vertical. The image decomposition is done with Haar which is a simple, symmetric and orthogonal wavelet.

PROPOSED ALGORITHM

Watermark Embedding

Watermark Pretreatment:

Watermark scrambling is carried out through many steps to improve security levels. It makes sure that even if attackers intercepted the watermarking messages, they cannot get the exact secret messages [4]. We have use Arnold Transform for image scrambling which has a special property that image comes to its original state after a certain number of iterations called ‘Arnold Period’.

Given an N*N image, the Arnold transform that is applied to every pixel in the image is given by

$$\begin{pmatrix} x_n \\ y_n \end{pmatrix} = \begin{bmatrix} 1 & 1 \\ 1 & 2 \end{bmatrix} \begin{pmatrix} x \\ y \end{pmatrix} (\text{mod } N) \quad \text{--(1)}$$

where, (x, y) ={0,1,.....N} are pixel coordinates from original image. Arnold transform will shift the value of the pixel at position (x,y) to position (xn,yn). The periodicity of Arnold Transform (P) is dependent on size of given image and is calculated using the following algorithm:

for n=1 to ….

xn=x+y;

yn=x+2*y;

if (xn mod N==1 and yn mod N==1) then

Arnold Peridicity (P)=n;

Embedding Algorithm:

Step 1: Convert original image from RGB color space to YUV color space

Step 2: Perform a three-level decomposition of Y component of original image using Haar wavelet to get level 3 coffiecients-LL3, HL3, LH3, HH3.

Step 3: Find Arnold periodicity 'P' of watermark using the above algorithm.

Step 4: Determine 'key' where 0<key<P.

Step 5: Find two scrambled images by applying Arnold Transform on watermark with 'key1' and 'key2' where key1=key+count, key2=key-count.

Step 6: Take absolute difference of the two scrambled images to get 'final scrambled watermark'.

Step 7: Add 'final scrambled watermark' to HL3 coefficients of Y component of original image as follows:

HL3'(i,j) = HL3(i, j) + b*W(i, j) --(3)

where ?=k|m| where m is the mean value of selected original wavelet coefficients and k is the direct weighting factor.

Step 8: Apply Inverse Discrete Wavelet Transform at Level 3, Level 2 and Level 1 sequentially to get Y_new component i.e. Y component with watermark embedded in it.

Step 9: Combine Y_new, U and V to get YUV image and convert it to RGB color space to get the `Watermarked image'.

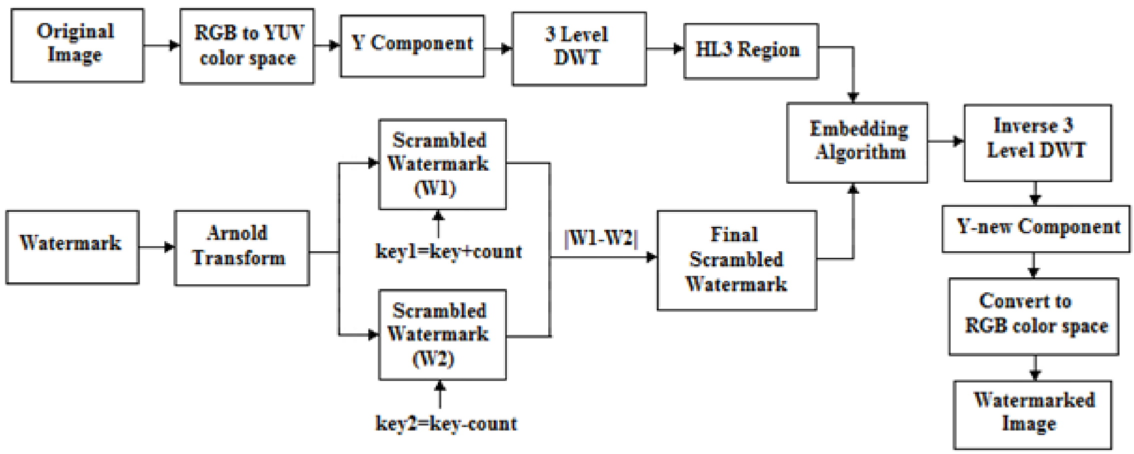


Figure 2. Watermark Embedding

Watermark Extraction

Step 1: Convert original image and watermarked image from RGB to YUV colour space.

Step 2: Decompose Y component of original image using Haar wavelet up to 3 levels to get HL3 coefficients.

Step 3: Decompose Y component of watermarked image using Haar wavelet up to 3 levels to get HL3' coefficients.

Step 4: Apply Extraction formula as follows:

Difference(i,j)=abs(HL3(i,j)-HL3'(i,j))/? --(4)

If Difference (i,j) < Threshold

then Extracted_Watermark(i,j)=0

otherwise Extracted_Watermark(i,j)=1 --(5)

Step 5: Perform image de-scrambling using Arnold Transform with ‘key1’ and ‘key2’ that we had used in embedding process to recover the watermark

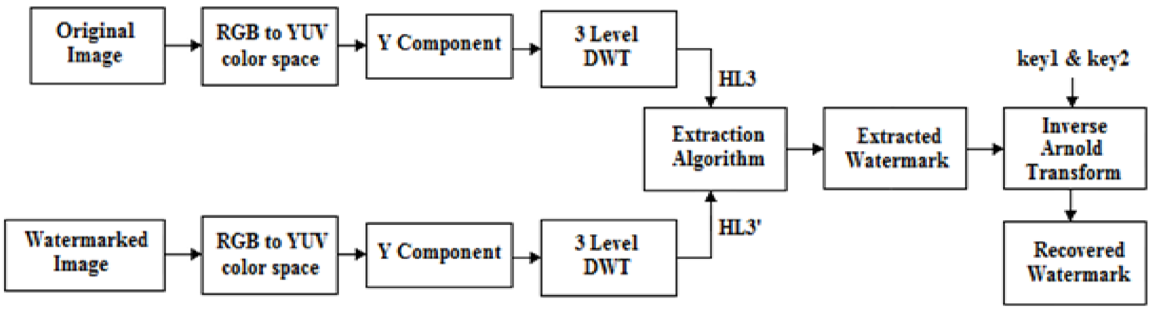


Figure 3. Watermark Extraction

EXPERIMENTAL RESULTS

The project is implemented in MATLAB 7.10 and standard database images with 512x512 sizes as cover image and 64x64 size binary watermark images are used for testing. The quality of watermarked image is measured using PSNR value. PSNR for image with size M x N is given by

$$PSNR(dB)=10\log_{10}\frac{(Max_I)^2}{\frac{1}{M\times N}\sum_{i=1}^{M}\sum_{j=1}^{N}[f(i,j)-g(i,j)]^2} \quad \text{-- (6)}$$

Where f(i,j) is pixel gray values of original image, g(i,j) is pixel gray values of watermarked image. A PSNR value of at least 30dB is required for the watermarked image to be perceptually transparent. Larger the PSNR, better is the quality of watermarked image.

Robustness is a measure of immunity of watermark against attempts to remove or destroy it by various manipulations like compression, filtering, rotation, scaling, collision attacks, resizing, cropping etc. It is measured in terms of normalized correlation factor (NC). The correlation factor measures the similarity between original watermark and extracted watermark. Its value generally varies from 0 to 1. Ideally it should be 1 but the value 0.75 is acceptable.

Robustness is given by:

$$NC=\frac{\sum_{i=1}^{N} w_i\, w_i'}{\sqrt{\sum_{i=1}^{N} w_i}\,\sqrt{\sum_{i=1}^{N} w_i'}} \quad \text{--(7)}$$

where, N is number of pixels in watermark, wi is original watermark, wi' is extracted watermark.

For standard color 'Lena' image using our algorithm we get PSNR=53.939 dB and NC=1, for weighting factor k=13 as shown in Fig. 4. The PSNR and NC values for various standard database images without any attacks for both the algorithms are shown in Table 1. Table 2 gives the simulation results for the standard 'Lena' image with various image processing attacks.

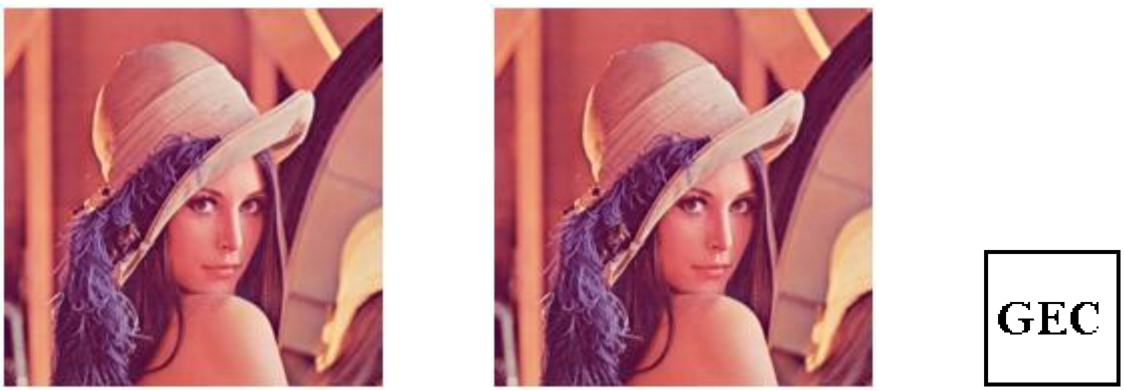


Figure 4. a) Original 'Lena' Image b) Watermarked 'Lena' Image c) Extracted Watermark

Table 1: Experimental results for standard database images with size 512x512

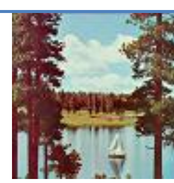
Standard Test Images					
Weighting factor (k)	9	5	17	9	6
PSNR (dB)	52.1932	49.8841	51.4040	53.4600	52.7091
NC	0.9999	1	1	1	1

Table 2: Experimental results for various attacks on 'Lena' standard image

Type of Attack	Parameters and Performance		
	Parameters	*PSNR(dB)*	*NC*
JPEG compression	Q=90	45.8275	1
JPEG compression	Q=60	42.2468	0.9984
JPEG compression	Q=30	40.5261	0.9639
Gaussian noise	Average=0 Variance=0.001	40.6431	0.9592
Salt & Pepper noise	Strength=0.002	49.1123	0.9743
Speckle Noise	Variance=0.001	45.6297	0.9971
Cropping	1/8th of image	53.4275	0.9740
Cropping	1/4th of image	54.0094	0.9408
Scaling	50%	53.4275	0.9740
Average filtering	3×3	41.9005	0.9356
Gaussian filtering	3×3	42.4603	0.9491

CONCLUSION

A robust algorithm of color image watermarking based on DWT is introduced. The algorithm is auto-adaptive due to use of mean value of selected pixels from original image during the embedding phase. Experimental results show that the proposed algorithm realizes both the requirements of imperceptibility as well as robustness by keeping the quality of original image and ability to extract the watermark under various image processing attacks. Also the proposed method supports more security due to the use of two secret keys while applying Arnold Transform.

REFERENCES

1. Sneha Nargundkar, V.K.Joseph, " Discrete Wavelet Transform Based Robust Digital Watermarking Technique using Arnold Transform", International Journal of Pure and Applied Research in Engineering and Technology, volume 1(8), pp. 608-615, April 2013.

2. Na Li; Xiaoshi Zheng; Yanling Zhao; Huimin Wu; Shifeng Li, "Robust Algorithm of Digital Image Watermarking Based on Discrete Wavelet Transform", International Symposium on Electronic Commerce and Security, 3-5Aug. 2008, pp:942- 945.

3. B.L.Gunjal and R.R.Manthalkar, "Discrete Wavelet Transform Based Strongly Robust Watermarking Scheme for Information Hiding in Digital Images", 3rd International Conference on Emerging Trends in Engineering and Technology, Nov 2010, pp:124-129.

4. Vidyasagar M. Potdar, Song Han, Elizabeth Chang, "A Survey of Digital Image Watermarking Techniques", 3rd IEEE International Conference on Industrial Informatics, August 2005, pp:709-716.