Abstract:

With the proliferation of the World Wide Web, authors of digital media now have an inexpensive means to distribute their works to a growing audience. But there is always a fear that their work may be copied illegally or represented as another’s work. Digital watermarking provides way to place addition data within the digital media so if copies are made, the rightful owner can be determined.

I. INTRODUCTION

Generally by watermarking one is hiding a message signal into a host signal, without any perceptual distortion of the host signal. As the word “watermarking” suggests, the mark itself is “transparent” or unnoticeable for the human perception system. Usually, the host signal is a digital media, like audio, video or images. As we all know, the Human Visual System (HVS), is far from being perfect and for images/video it is possible to modify the pixel values without the watermark being visible. Providing that a certain HVS threshold is not exceeded, the modified (watermarked) image/video will be undistinguishable to the human eye compared with the original.

*Watermarking* is a key process in the protection of copyright ownership of electronic data (image, videos, audio).
With the growth of numerical technologies, it became extremely easy to reproduce a data without any damage. For instance, any image taken on the Internet can be saved for a personal usage and then be written on a CD-ROM or on another web page.

**II. BACKGROUND THEORY**

**MULTIRESOLUTION ANALYSIS**

A multiresolution analysis of $L^2(\mathbb{R})$ is a collection of subsets $\{V_j\}$ $j \in \mathbb{Z}$ of $L^2(\mathbb{R})$ such that:

1) There exists, $g \in L^2(\mathbb{R})$ so that $V_0$ consists of all (finite) linear combinations of $\{g(x-k) : k \in \mathbb{Z}\}$

2) The $g(x-k)$ are an orthonormal series in $V_0$,

3) $f(x) \in V_j \iff f(2x) \in V_{j+1}$,

4) $\bigcup V_j$, is dense in $L^2(\mathbb{R})$ for all $j \in \mathbb{Z}$

5) $\bigcup V_j = \{0\}$ for all $J \in \mathbb{Z}$

6) $V_j \subseteq V_{j+1}$

We may think of $g$ as our chosen approximation function. $V_0$ contains all the functions we can make by adding up translations of $g$ to the integers. When we give ourselves twice as many nodes and squash our generating function from $V_j$ to $V_{j+1}$. Condition 4 means that we can approximate any function $L^2(\mathbb{R})$ as closely as we choose. Condition 6 ensures that our approximation is improving all the time.

We can easily extend this definition to $L^2(\mathbb{R}^n)$ for any $n$ (for the case of images $n = 2$). We just replace $L^2(\mathbb{R})$ by $L^2(\mathbb{R}^n)$ throughout the definition and substitute $\{g(x-k) : k \in \mathbb{Z}\}$ with $\{g(x-k) : k \in \mathbb{Z}^n\}$ in condition 1.
MULTIRESOLUTION FREQUENCY BANDS
We can apply a pair of filters to divide the whole frequency band into two subbands, and then apply the same procedure recursively to the low frequency band on the current stage. Thus, it is possible to use a set of FIR filters to achieve the above multiresolution decomposition. Here is one way to decompose a signal using filter banks:

III. APPLICATION OF DIGITAL WATERMARKING

The main application of digital watermarking is in copyright protection. The owner of the image/video adds a watermark to his material before it is distributed. In this way is possible to track illegal copies of the copyrighted material.
Possible applications are:
- Broadcast monitoring of video sequences (digital TV)
- DVD protection and access control
- Database retrieval
- Robust identification of digital content

Type of marking

SPATIAL DOMAIN

FREQUENCY DOMAIN

DCT

DWT

FFT
FREQUENCY DOMAIN WATREMARKING

Watermarking method in the wavelet transform domain
We add pseudo-random codes to the large coefficients at the high and middle frequency bands of the discrete wavelet transform of an image.
The advantages of this method:-

1. This method has multiresolution characteristics and is hierarchical. In the case when the received image is not distorted significantly, the cross correlations with the whole size may not be necessary, therefore the computation load can be saved.
2. The human eye is not sensitive to the small changes on edges and texture of image but it is very sensitive to the smooth part of the image. With the DWT, the edges and textures are exploited very well in high frequency subbands, such as HH, LH, HL etc. The large coefficient in these bands usually indicates edges in the image. Therefore adding watermarks on these large coefficients is difficult for the human eye to perceive.

WATERMARKING IN DWT DOMAIN

The basic idea in the DWT for a one dimensional signal is the following. A signal is split into two parts of high frequencies and low frequencies.

1. The part with the high frequencies is basically the edge components of the signal.
2. The part with the low frequencies is split again into two parts of high and low frequencies.

This process is continued an arbitrary number of times, depending upon the application. By performing the inverse DWT (IDWT) the original signal can be reconstructed. The DWT and IDWT for two dimensional images $x[m, n]$ can be similarly defined by implementing the one dimensional DWT and IDWT for each dimension $m$ and $n$ separately: $\text{DWT}_n[\text{DWT}_m[x[m, n]]]$. An image can be decomposed into a pyramidal structure as shown below:
Watermarking in the DWT domain includes two parts:

1. Encoding
2. Decoding

1. Encoding: First the image is decomposed into several bands with a pyramidal structure, and then pseudo-random sequence is added to the large coefficients which are not located at the lowest resolution.

Let $y[m, n]$ denote the DWT coefficients, which are not located at the lowest frequency band, of an image $x[n, m]$. We add a Gaussian noise $N[m, n]$ with mean $0$ and variance $1$ to $y[m, n]$: 

$$\tilde{y}[m, n] = y[m, n] + \alpha(y[m, n])^2 N[m, n]$$

where $\alpha$ is a parameter to control the level of the watermark, the square is done to amplify the large DWT coefficients. We do not change the DWT coefficients at the lowest resolution. Then, we take the two dimensional IDWT of the modified DWT coefficients $\tilde{y}$ and the unchanged DWT coefficients at the lowest resolution. Let $\tilde{x}[m, n]$ denote the IDWT Coefficients. For the resultant image to fit within the 0 to 255 integer values, typical image data, it is modified as

$$\hat{x}[m, n] = \left[255 \frac{\tilde{x}[m, n] - \min_{m,n}(\tilde{x}[m, n])}{\max_{m,n}(\tilde{x}[m, n] - \min_{m,n}(\tilde{x}[m, n]))}\right].$$

The above operation is done to make the two dimensional data $\hat{x}[m, n]$ be an 8 bit level image. The resultant image is the watermarked image of $\tilde{x}[m, n]$. 
2. Decoding: The decoding method we propose is hierarchical and described as follows. We first decompose a received image and the original image (it is assumed that the original image is known) with DWT into four bands, i.e., low-low (LL1) band, low-high (LH1) band, high-low (HL1) band, and high-high (HH1) band, respectively. We then compare the signature added in the HH1 band and the difference of the DWT coefficients in HH1 bands of the received and the original images by calculating their cross correlations. If there is a peak in the cross correlations, the signature is called detected. Otherwise, compare the signature added in the HH1 and LH1 bands with the difference of the DWT coefficients in the HH1 and LH1 bands, respectively. If there is a peak, the signature is detected. Otherwise, we consider the signature added in the HL1, LH1, and HH1 bands. If there is still no peak in the cross correlations, we continue to decompose the original and the received signals in the LL1 band into four additional sub bands LL2, LH2, HL2 and HH2 and so on until a peak appears in the cross correlations. Otherwise, the signature can not be detected.
LEAST SIGNIFICANT BIT WATERMARKING

In this the watermark is embedded in the least significant bit of the cover object. Although it survives cropping but any addition of noise will defeat the watermark.
CONCLUSION

It is found that the DWT based watermark approach we proposed is robust to distortions while the DCT approach is not, in particular, to distortions, such as the compression, additive noise with large noise variance, and resolution reduction.

ACKNOWLEDGEMENT

We will like to thank Prof. V.M. Gadre for his valuable guidance and support.

REFERENCES