A report on DCT, DWT, FFT

Submitted to

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Under the course of

Project & Thesis

CSE - 400

According to the different partitions, watermark can be parted in different types like these: significant watermark and the insignificant; the visible and the invisible; the brittle and the steady; the spatial domain watermark and the transformed domain watermark; the blind, the semiblind and the non-blind. One another partition is carrier and there are image watermark, audio watermark, video watermark, text watermark and so on

The main transformed domain algorithms are spread spectrum, DCT transformation method and DWT transform method.

Discrete Cosine Transform (DCT)

The DCT is a very popular transform function used in signal processing. It transforms a signal from spatial domain to frequency domain.

Two dimensional discrete cosine transform (2D-DCT) is defined as -

$$F(jk) = a(j)a(k) \sum_{m=0}^{m=N-1} \sum_{n=0}^{n=N-1} f(mn) \cos\left[\frac{(2m+1)j\pi}{2N}\right] \cos\left[\frac{(2n+1)k\pi}{2N}\right]$$

The corresponding inverse transformation (2D-IDCT) is defined as -

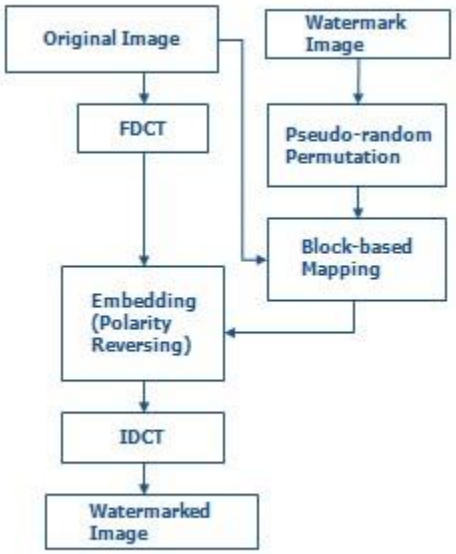
$$f(mn) = \sum_{m=0}^{m=N-1} \sum_{n=0}^{n=N-1} a(j)a(k)F(jk) \cos\left[\frac{(2m+1)j\pi}{2N}\right] \cos\left[\frac{(2n+1)k\pi}{2N}\right]$$

where
a(w) = 1 / 2 when w =0
a(w) = 1 when w =1,2,3, … n – 1

Advantages of Block DCT/IDCT

- It is a Fast method.
- It is Suitable for robustness against JPEG compression.

Block Diagrams of the Original Algorithm (embedding)



As an image transformed by the DCT, it is usually divided into non-overlapped m X m block. In general, a block always consists of 8 X 8 components. The zigzag scanning permutation is implied the energy distribution from high to low as well as from low frequency to high frequency.

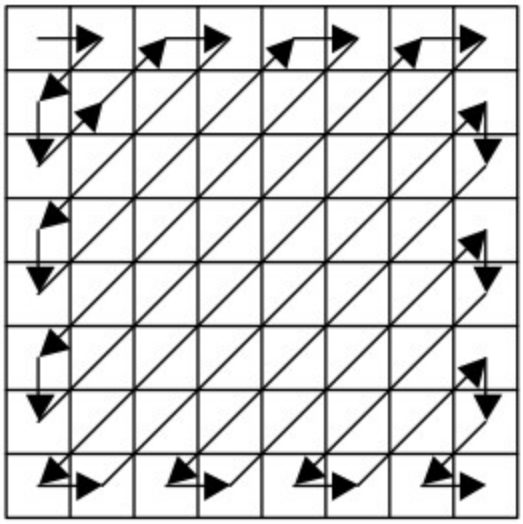


Figure: The DCT block coefficient and zig-zag.

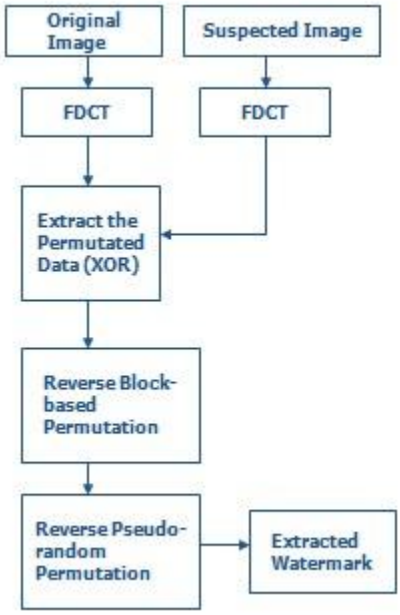
	1	5	6				
2	4	7					
3	8						

Figure: The eight lower -band coefficients.

Choices of embedding positions within each block

The energy of natural image is concentrated in the lower frequency range. The watermark hidden in the higher frequency band might be discarded after a lossy compression. In lower frequency, it may decreases robustness. Therefore, the watermark is always embedded in the middle-band range of the host image that transformed by DCT is perfect selection.

Block Diagrams of the Original Algorithm (extracting)



The extraction step of watermark from host image is similar to the process of the embedded algorithm. We use the same set of random number, which is applied in the embedded strategy. The watermarked image must be transformed to frequency domain by DCT approach. The 8-bit watermark data of each DCT block will be extracted by mean of the inverse step that is embedded. Once all of the 8-bit watermark data are extracted, we rearrange the watermark bit stream to configure the original watermark image as soon.

Discrete Wavelet Transform (DWT)

Wavelet transform is a time domain localized analysis method with the window's size fixed and form convertible. There is quite good time differentiated rate in high frequency part of signals DWT transformed. Also there is quite good

frequency differentiated rate in its low frequency part. It can distill the information from signal effectively.

The DWT separates an image into a lower resolution approximation image (LL) as well as horizontal (HL), vertical (LH) and diagonal (HH) detail components. The process can be repeated to computes multiple 'scale' wavelet decomposition.

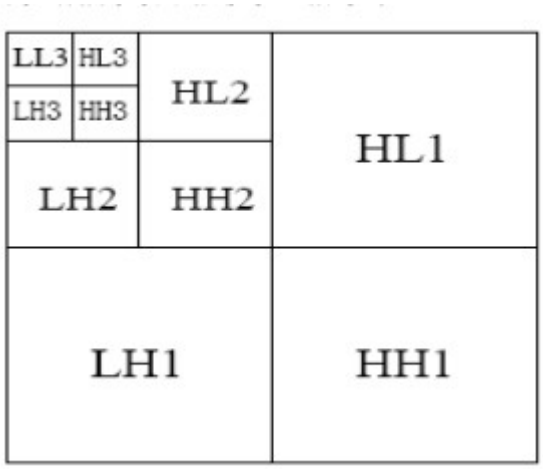


Figure: Sketch Map of Image DWT Decomposed

Advantages of DWT

Human eyes is sensitive to the change of smooth district of image, but not sensitive to the tiny change of edge, profile and streak. Therefore, it's hard to conscious that putting the watermarking signal into the big amplitude coefficient of high-grequency band of the image DWT transformed. Then it can carry more watermarking signal and has good concealing effect.

Fast Fourier Transformation (FFT)

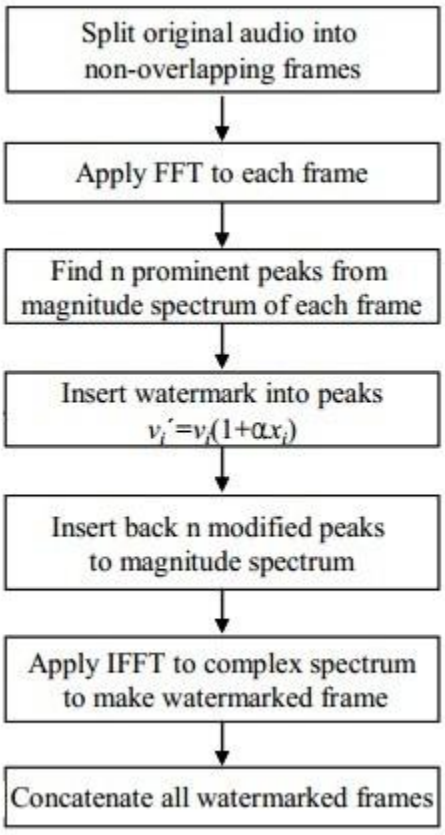
In frequency domain schemes, the Fourier transform is very popular. Among different FT, the FFT is often used due to its reduced computational burden.

In this method, after selecting frequency range or frequency band of the spectrum, divided into short frames and a single secret bit is embedded into each frame.

A watermark must not be embedded into insignificant region of the audio signal because many common signal processing attacks affect these components. For example, if a watermark is embedded in the high frequency spectrum of an audio signal, low-pass filtering can easily eliminate the watermark. Thus, it is very important to find the significant regions and embed a watermark into those regions without distortion of the original audio signal.

Watermark should be embedded into prominent peak spectrum. and prominent peaks can be found from magnitude spectrum. And magnitude of each frame can be calculated using FFT.

Block Diagrams of embedding watermark using FFT



Advantages of this FFT method

Provides better performance than Cox's method in terms of SNR result because of embedding watermarks into the selected prominent peaks of magnitude spectrum of each frame of the original audio signal.