# Combined DWT and DFT Based Watermarking Technique with Improved Robustness

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*Abstract*— To protects intellectual property rights, the amount of exchanged digital content calls are rapidly growing based on efficient and practical techniques. During the past two decades, watermarking techniques have been presented to embed and detect information within such contents, with different four key requirements at hand, that are – capacity, invisibility, robustness, and security. So far, researchers mainly focused on the first three. Earlier work used novel DFT watermarking scheme featuring perceptually optimal visibility versus robustness. Then the perceptual model of the human visual system (HVS) based on the contrast sensitivity function (CSF) and a local contrast pooling is used to determine the optimal strength of the visibility threshold. However the problem found in this work is that robust watermarking result is not obtained and improved HVS is not produced for determining optimal strength of visibility threshold. To deal with this problem, the present work proposes Combined DWT and DFT to improve the watermarking accuracy. In the proposed method, host image is first wavelet transformed by using DWT and then DFT is applied to some selected high-frequency sub-bands of transformed image. In addition improved Human visual model is used based on identifying the areas of true high contrast texture while protecting connected directional edges. This improved HVS is used to determine the optimal strength of the visibility threshold. Experimental result provides better result when compare with the existing one.

***Key words:*** HVS, DWT, DFT

## I. INTRODUCTION

### A. *Image Processing:*

#### 1) *Overview:*

An image is an array, or a matrix, of square pixels organized in columns and rows.

The greyscale image has each picture element in an assigned intensity that ranges from 0 to 255. A grey scale image is what people generally call stresses a black and white picture, but the name that such an image will also contain many shades of grey.

An ordinary greyscale image has 8 bit colour depth = 256 greyscales. A "true colour" images have 24 bit colour depth = 8 x 8 x 8 bits = 256 x 256 x 256 colours = ~16 million colours. Some greyscale images have much greyscales, for some cases 16 bit = 65536 greyscales.

There are two common types of 'images': vector graphics (or line art) and bitmaps (pixel-based or 'images').

#### 2) *Fundamental Steps of Digital Image Processing:*

There are different fundamental steps but as they are fundamental, all these steps will have sub-steps. The fundamental steps are explained below with a neat diagram.

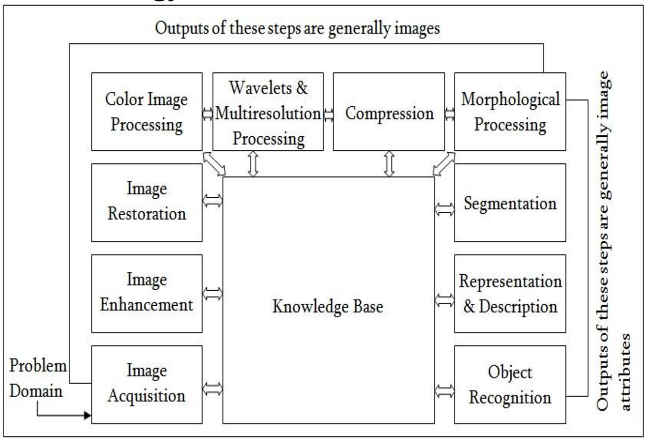


Fig. 1: Fundamental Steps In Image Processing

1) Image Acquisition
It is the first step of the fundamental steps of digital image processing. Image acquisition can be as modest as being given an image that is already in digital form. Commonly, the image acquisition level includes preprocessing, such as scaling.
2) Image Enhancement
Image enhancement is the simplest and most appealing areas of digital image processing. Fundamentally, the idea of enhancement techniques is to bring out detail that is obscured or easly to highlight certain features of interest in an image. Such as, differing brightness & contrast
3) Image Restoration
Image restoration is also dealing with enhancing the appearance of an image. Though, unlike enhancement, which is subjective, image restoration is objective, in the sense that restoration techniques is built on mathematical or probabilistic models of image degradation.
4) Color Image Processing
Color image processing is an area that has been acquiring its significance because of the significant increase in the use of digital images over the Internet. This contains color modeling and processing in a digital domain.
5) Wavelets and Multi resolution Processing
Wavelets are the base for modeling images in various degrees of resolution. Image subdivision sequentially into smaller regions for data compression
6) Compression
Compression is the techniques for reducing the storage required to store an image or the bandwidth to transmit it. Especially in the uses of internet it is very much required to compress data.
7) Morphological Processing

Morphological processing involves tools for extracting image components that are helpful in the representation and description of shape.

8) Segmentation
Segmentation task partition an image into its constituent parts or objects. Generally, autonomous segmentation is one of the toughest tasks in digital image processing. A rugged segmentation technique brings the process a long way toward successful solution of imaging issues that need objects to be recognized individually.

9) Representation and Description
Representation and description always follow the output of a segmentation step. It usually is raw pixel data, constituting either the boundary of an area or all the points in the area itself. Choosing a representation is only part of the remedy for transforming raw information into a form suitable for subsequent computer processing. Description deals with deriving attributes that result in some quantitative data of interest or are basic for distinguishing one class of objects from another.

10) Object recognition- Recognition is the process that allots a label, such as, “plant” to an object based on its descriptors.

11) Knowledge Base
Knowledge may be as simple as describing regions of an image where the information of interest is known to be located, thus restricting the search that has to be conducted in searching that information. The knowledge base also can be quite complex, such as an interrelated list of all major probable defects in a materials inspection issue or an image database containing high-resolution satellite images of an area in connection with change-detection functions.

## II. RESEARCH METHODOLOGY

### A. Existing System:

A new DFT watermarking is presented here. The watermark, a square patch of coefficients, was embedded in the Fourier domain by addition of both the magnitude and the phase. The watermark strength is perceptually improved. The revealing features both template matching and outlier detection, finally being applied to the existed correlation matrix. The conclusion is positive if minimum one outlier is detected, and negative otherwise. Then the optimal strength at which visibility threshold was reached by perceptual model of the human visual system based on the contrast sensitivity function and a local contrast. This technique uses different characteristics of the HVS to determine and adjust the visibility level of the embedded watermark, therefor resulting in an optimal invisibility versus robustness tradeoff.

### B. Disadvantages:

- Better watermarking performance is not showing.
- Improved optimal strength of the visibility threshold is not defined.
- Very low scanning quality is not robust

### C. Proposed System:

A combination of DWT and DFT are proposed to enhance the watermarking performance is using. It is transforming the host image by DWT initially.

Discrete Wavelet Transform is applied to analyze a signal at various frequency bands with various resolutions by decomposing the signal into a coarse approximation and detail information. A 2D-DWT is used to an image once decomposes the image into four sub-bands called as LL, HL, LH and HH sub-bands. LL is known as approximation band which shows low frequency coefficients and HL1, LH1 and HH1 are detailed bands containing horizontal, vertical and diagonal edges of the image. Then DFT is used to some selected high-frequency sub-bands of transformed image from DWT. In DFT watermarking noise like square patch of coefficients, is embedded by substitution in the Fourier domain; the amplitude instance adjusts the watermark strength, and the phase component stores the information. Then the inverse DFT is used to the selected HF sub-bands that were transformed using DFT before. Then inverse DWT is performed to get the watermarked image.

The optimal strength of the visibility threshold is defined by the enhanced Human visual model. This detects the areas of true high contrast texture during protecting connected directional edges. This method differentiates the connected directional edges and high frequency textured areas. The mapping function is drawn by defining the noticeable point difference between reference image and reference image with watermark. Experimental result gives better result when compare with the existing technique.

### D. Advantages:

- Robust watermarking performance is achieved.
- Optimal strength of visibility threshold is enhanced.
- Proposed perceptual model accurately sets the watermark to its visibility threshold

## III. SYSTEM IMPLEMENTATION

### A. List of Modules:

- Image decomposition using discrete wavelet transform
- Watermarking embedding technique
- Watermark decryption
- Performance analysis

### B. Module Description:

#### *1) Image Decomposition Using Discrete Wavelet Transforms:*

Discrete Wavelet Transform is applied to analyze a signal at various frequency bands with various resolutions by decomposing the signal into a coarse approximation and detail information. 1D-DWT includes two sets of functions, known as scaling functions and wavelet functions that are related with low-pass and high-pass filters. The decomposition of the signal into different frequency bands is simply existed by successive high-pass and low-pass filtering of the time-domain signal. The process of single stage of DWT for 1D-signal is as follows: The original signal $x[n]$ is first passed through a half band high-pass filter $g[n]$ and a low-pass filter $h[n]$. When completing the filtering, half of the samples of signal $x[n]$ can be eliminated according to the Nyquist's criteria, since the signal now has a highest frequency of $\pi/2$ radians instead of $\pi$. The signal can therefore be sub-sampled by 2, simply by removing every other sample. This constitutes one state of decomposition and can mathematically be expressed as follows:

$$Y_{high}[K] = \sum_{n} x[n] \otimes g[2k - n]$$

$$Y_{low}[k] = \sum_{n} x[n] \otimes h[2k - n]$$

Where$y_{high}$ [k] and $y_{low}$ [k] are the outputs of the high-pass and low-pass filters respectively, after sub-sampling by two. Symbol ⊗ denotes convolution operation between two signals. At every decomposition level, the filtering and sub-sampling will result in half the time resolution and double the frequency resolution.

Since DWT is a separable transform, 1D-DWT can easily be extended to 2D-DWT, by applying 1D transform first by row-wise and then by column-wise. A 2D-DWT applied to an image once decomposes the image into four sub-bands known as LL, HL, LH and HH sub-bands. LL is called approximation band which possesses low frequency coefficients and HL1, LH1 and HH1 are detailed bands containing horizontal, vertical and diagonal edges (high-frequencies) of the image. In dyadic DWT, the same process is repeated on LL sub-band to decompose images into (3n+1) sub-bands, where n is the number of decomposition levels.

*2) DFT in DWT Decomposed Image:*

Two-level DWT decomposition of a gray scale host image (I) is performed using Haar filters. The watermark data is embedded in selected HF sub-bands, i.e. in the one or two sub-bands selected among LH1, HL1, HH1, LH2, HL2 and HH2. The criterion to select the sub-bands is the perceptibility of watermarked image. Each of the selected HF sub-bands is further transformed using DFRFT and then the transformed coefficients are concatenated in a single one-dimensional array (using raster scan). The DFT coefficients of concatenated array are sorted in ascending order of their magnitudes. Some of these coefficients (equal to the watermark length) in contiguous order are selected for watermark embedding and the watermark is added in these coefficients. These watermarked and remaining DFT coefficients of sorted array are then placed at their original locations which are finally placed back in HF sub-bands of which they belong.

In watermark embedding process, first a n-levels DWT decomposition of the host image (I) is performed which results into (3n+1) sub-bands, one approximation sub-band ($LL_n$) and 3n detailed sub-bands.

Select a set of sub-bands from the detailed sub-bands (HF sub-bands), say this set is $s^i$, where i may have any value from 2 to 7.

DFT can be performed in Fourier domain. The embedding technique relies on both the amplitude and the phase Fourier components to modulate a binary watermark. The amplitude lets to adjust the watermark strength whereas the phase holds the binary information.

Let an N-bits binary sequence $M_{1..N}$ be the message to embed. A binary watermark $W(i, j)$, $0 \leq i < M$, $0 \leq j < M$, is generated from $M_{1..N}$ using a PRNG and arranged into a $M \times M$ matrix.Let $F_Y(u, v)$ denote the Fourier transform of $Y_{local}$ over frequency domain

$\Omega = \{(u,v): -R_x/2 \leq u < R_x/2, -R_y/2 \leq u < R_y/2\}$

Here $u$ and $v$ are the horizontal and vertical frequencies.

Two subsets such as $\Omega^+_w = \{(u,v): uw \leq u_w \leq u < uw + M, v_w \leq v < v_w\}$ and $\Omega^-_w = \{(u,v): (-u,-v) \in \Omega^+_w\}$ be two subsets of $\Omega$ within which the watermark will be embedded; $u_w$ and $v_w$ are called watermark modulation frequencies. The watermarked spectrum is found by substitution as follows:

$$\tilde{F}_Y(u,v) = \begin{cases} \alpha/2.A^*_{peak}(u,v).e^{\pi.W(u-u_w, v-v_w)}, & (u,v) \in \Omega^+_W \\ \alpha/2.A^*_{peak}(u,v).e^{\pi.W(-u-u_w, -v-v_w)}, & (u,v) \in \Omega^-_W \\ F_Y(u,v), & \text{elsewhere} \end{cases}$$

Where $\alpha$ is a weighting factor that limits the watermark energy relatively to the predicted visibility level.

*3) Watermark Decryption:*

Here watermark decryption is done. Initially inverse of DFT and DWT is performed to decrypt the watermarked bit. Additionally, the watermark extraction process also requires information such as number of DWT decomposition levels, powers of DFT transform and index of sub-bands in which watermark was embedded etc. This additional information may be sent as headers in the watermarked image. In order to elaborate the step-by-step watermark extraction procedure, let $I$ and $I^w$ represent the host and the received watermarked images respectively. The steps included in extraction are as follows:

- The first step in this process is to apply one or two levels of 2D-DWT on both $I$ and $I^w$.
- Using the index of HF sub-band from the header, perform DFT of HF sub-bands (in which watermark was embedded) for both host and watermarked images.
- If R is an array containing the DFT of set of HF sub-bands for original host image ($I$) and $R^w$ is an array containing the DFT of set of HF sub-bands for watermarked image ($I^w$) then sort the elements of sets R and $R^w$ in ascending order of their magnitudes and store the sorted data in an arrays $Z_s$ and $Z_s^w$ respectively
- The watermark is then mined by performing element-wise subtraction of first M elements of array $Z_s$ and $Z_s^w$
- $w_d = Z_s^w[k] - Z_s[k]$ for $1 \leq k \leq M$

*4) Performance Evaluation:*

The functioning of the proposed image watermarking algorithm is deliberated in terms of Peak Signal-to-Noise Ratio (PSNR) of watermarked image and Bit Error Rate (BER) in watermark extraction. These parameters are defined below:

Peak Signal to Noise Ratio (PSNR)- One of the important features of digital watermarking is that the perceptual quality of the watermarked image should not be degraded much as compared to original one. Imperceptibility of watermarked images is evaluated by measuring its PSNR. Imperceptibility may also be checked by visual inspection of watermarked image and comparing with original host image. PSNR is used to measure the objective quality of watermarked images. The value of

 

PSNR is the measure of similarity between watermarked and the host images. It is expressed as

$$\mathrm{PSNR} = 10\log_{10}\left(\frac{255^2}{\mathrm{MSE}}\right), \mathrm{dB}$$

Where, MSE is the mean square error between host images (I) and watermarked images *($I^w$)* each of size MxN. It is defined as:

$$\mathrm{MSE} = \frac{1}{M \times N}\sum_{x=1}^{M}\sum_{y=1}^{N}[I(x, y) - I^w(x, y)]^2$$

Where, $I(x, y)$ and $I^W(x, y)$ are pixel intensities of host and watermarked images at (x, y), respectively.

## IV. Conclusion and Future Work

### A. *Conclusion:*

A watermark is a recognizable image or pattern that appears as various shades of lightness or darkness when viewed by transmitted light, affected by thickness or density variations in the paper. Watermarks are being used on postage stamps, currency, and other government documents to deject counterfeiting. In this paper, the new water method is proposed to improve the water mark accuracy. Combined DWT and DFT approach is proposed in this method to improve the watermarking accuracy. In the proposed method, host image is first wavelet transformed by using DWT and then DFT is applied to some selected high-frequency sub-bands of transformed image. In addition improved Human visual model is used based on identifying the areas of true high contrast texture while protecting connected directional edges. This improved HVS is used to determine the optimal strength of the visibility threshold. Experimental result provides better result when compare with the existing one.

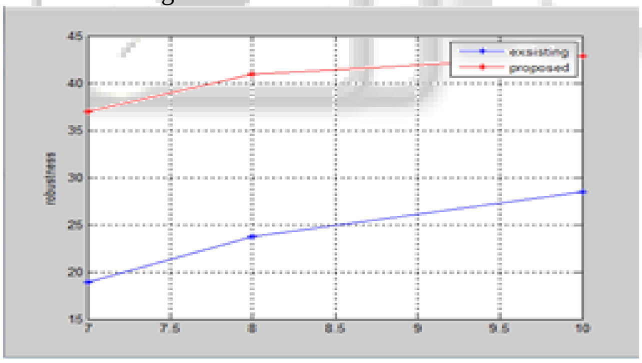


Fig. 2: Conclusion

### B. *Future Work:*

Proposed dissertation can be further refined for specific resolution images and application e.g. watermarking algorithm for a bank statement, passport text, emails, etc. This work can be extended for colored images and for all ASCII characters, including capital and small letters.

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