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IMAGE WATERMARKING USING HYBRID WAVELETS AND DIRECTIONAL FILTER BANKS

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ABSTRACT:

This paper aims at developing a robust directional invisible watermark which focuses on copy control and near perceptual watermark images. Wavelets are small signals which are dealt simultaneously in time and frequency spaces, the directional filter banks used to study the directional nature of an image across its edges and curves causing more significant to human vision. The wavelet decomposition of an image along with application of modified directional filter banks to the higher resolution scales provides the significant coefficients which are more robust and invisible to many and capable of handling is watermark data. Generalized white Gaussian noise is used as the watermark and proved to be effective when compared with a more generalized wavelet transform watermark implementation. In this paper the quincunx non-separable sampling and filtering is used in directional filter banks along the horizontal and vertical wavelet frames. The correlation of the proposed method and the wavelet transform watermark are compared with a higher resemblance to the concerned method. The PSNR is also used to show the large watermark handling capability of the hybrid wavelet and directional filter banks application for watermarking of images.

Key words: Watermark, Directional filter banks, Wavelet, Correlation, PSNR.

I. Introduction

In the age of digital communication the process of duplication can cause a lot of damage to the revenue and secrecy of secure information. To improve the security and identity of the information in multimedia data the data hiding is used to track the data using data monitoring systems to counter act on the intruders, hackers and for proving the ownership of the digital data. Watermarking is a method of data hiding the information regarding the ownership, user identity, which was authorized to use which can be shown as proof during conflicts.

II. Watermarking

It has been found that watermarking can be invisible to human vision and can be robust enough to remain during application of image processing methods to remove the watermark by the tampering user and its loss will also cause loss of the digital data in which it was embedded in. it can be used as authorization to registered user by providing a unique watermark for every user and can trace the user by detecting the watermark present in the data.

The data watermarking is developed to provide data integrity and privacy. The watermarking method can be done in spatial domain where direct manipulation of pixels is follows a less efficient watermark which can be easily removed with an inverse operation. The frequency transform watermarking with the spread spectrum communication the insertion can be further improved to become robust, tamper resistant and invisible.

III. Wavelets

The wavelet are having higher resolution and having a compromise in time and frequency causing better study of finer details at lower resolution and coarse detail at high resolutions. The wavelets are more efficient due to their compromise to the time and frequency spaces and are much useful to determine the samples that are most useful for a given application such as perceptual coefficients in an image compression. In this paper a directional representation of image using directional filter banks along with wavelet transfer provided to improve the coefficients with directional significance. It is extended by spread spectrum technique to enhance the coefficients having significant influence in various directions.

IV. Directional Filter Banks

The directional representation of image is used to obtain the region of images which are not perceptual to human visual system causing higher data hiding and can also be immune to data compression. This directional information is obtained by studying them along various directions which are obtained by filter using directional filter banks. The directional information provides the edges and curves which are least effected in common signal processing methods still retaining the visual perception of the image.

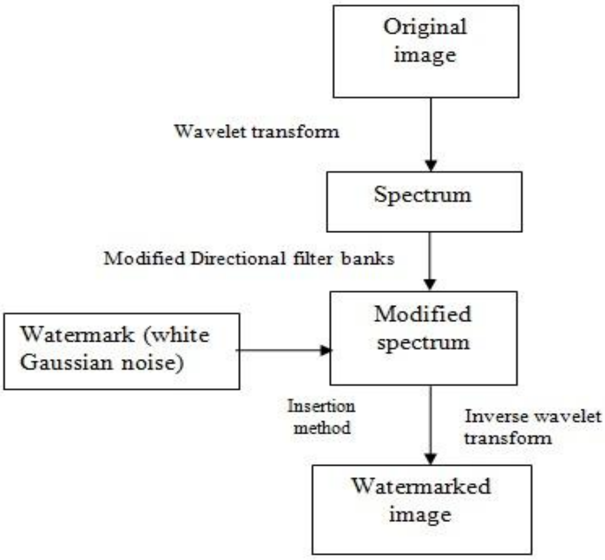

Fig: watermarking process using HWD transform

V. Horizontal and Vertical Directional Filter Banks

Directional filter banks (DFB) decompose the frequency space into wedge-shaped partitions. eight directions are used, where directional sub-bands of 1, 2, 3, and 4 represent *horizontal* directions (directions between -45° and +45°) and the rest stand for the *vertical* directions (directions between 45° and 135°). The DFB is realized using iterated quincunx filter banks. For the proposed HWD family, we are required to decompose the input into either horizontal directions or vertical directions or both. Hence, we propose *Vertical DFB* (VDFB) and *Horizontal DFB* (HDFB), where one can achieve either vertical or horizontal directional decompositions, respectively

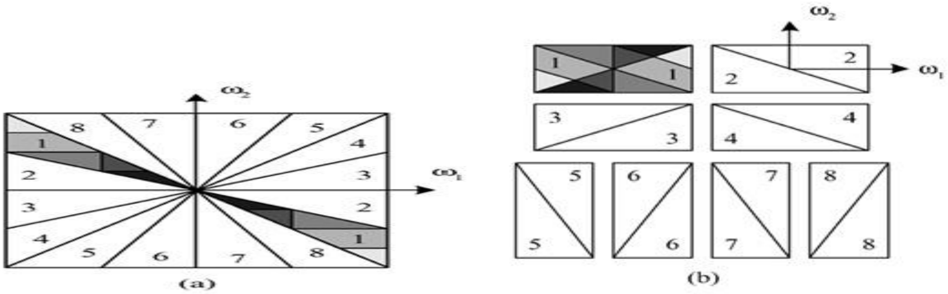

Fig. Frequency partition map for the eight-band directional filter bank

a) Directional frequencies to be decomposed

b) Decomposed frequency maps of the eight sub-bands

The implementation of these schemes is straightforward when we use the iterated tree-structured filter banks to realize the DFB. At the first level of the DFB, we employ a quincunx filter bank (QFB). The quincunx sampling matrix that we use is shows how down sampling by *Q* affects the input image. The image is rotated +45° clockwise. So in the DFB, since this is not a rectangular output, we decompose the image further by using two other QFBs at the outputs $y_0$and y_1. As a result, we obtain four outputs corresponding to the four directions of the DFB. At level three and higher we employ QFBs in conjunction with some resampling matrices to further decompose the DFB. In the proposed VDFB (HDFB), however, we stop at y_1(y_0*)* and just decompose the other channel (y_0 in VDFB and y_1 in HDFB) in a similar manner as we decompose the DFB Therefore, since we keep y_1 or y_0 , we have to find a way to represent these outputs in a rectangular form as in Fig 1.1.

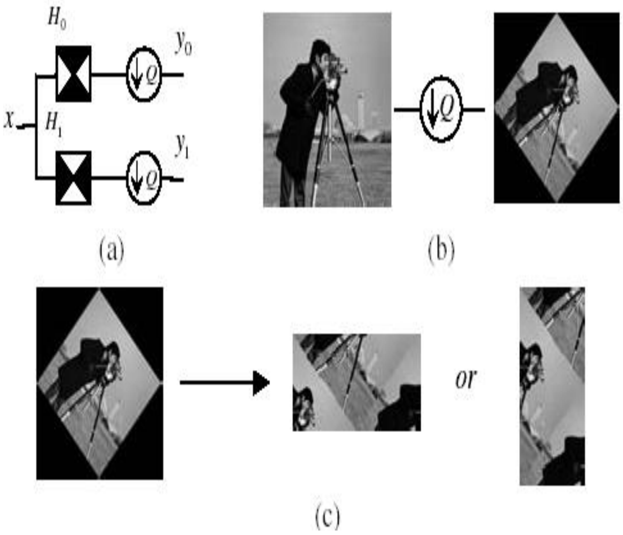

Fig. 1.1: a) quincunx filter bank H_0 and H_1 are fan filters and Q is sampling matrix

b) down-sampling of the image by Q

c) Horizontal and vertical strips of sampled image.

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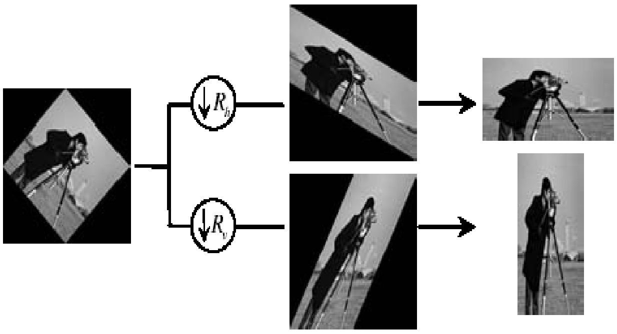

Fig.1.2. Applying resampling operation R_h and R_v on downsampled image by Q and then shifting to a rectangular box

$$R_h = \begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix} \text{ and } R_v = \begin{bmatrix} 1 & 0 \\ -1 & 1 \end{bmatrix} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1.1)$$

Assume one uses periodic filters one can select a rectangular strip of these outputs. However, for better visualization and possible further processing of the coefficients in image processing applications such as coding, we need a better representation. A solution to this issue is the use of a resampling matrix. During resampling, the sampling rate of the input image does not change and the samples are merely reordered. In particular, we find resampling matrices to reorder the samples of $y_1$or y_0 from a diamond shape to a shape of parallelogram. Remarkably, there exists no resampling matrix with integer elements to change those outputs to a rectangular form. Their functioning is as shown in fig 1.2.

Applying these resampling operations to the outputs of the QFB, we obtain parallelogram-shaped outputs as shown. Now we simply shift the resulting coefficients (column wise in the case of $R_h$and row-wise in the case of R_v) to obtain rectangular outputs. Thus, the resulting overall sampling matrix for representing $y_1$and $y_0$is $Q_h = QR_h$, or $Q_v = QR_v$, where Q_h(Q_v) in conjunction with a shifting operation results in a horizontal (vertical) rectangular output.

VI. Hybrid Wavelets and Directional Filter Banks (HWD)

Here we develop the image transform family of *Hybrid Wavelets and Directional filter banks* (HWD). For HWD, we consider the wavelet transform as themulti-resolution sub-band decomposition. The rationale for this is as follows: 1) wavelets have already shown their good nonlinear approximation property for piece-wise smoothsignals. thus, we expect that by adding the feature of directionality in an appropriate manner we could improve the nonlinear approximation results yielded from wavelets, 2)there are efficient algorithms developed for image processing applications such as image coding; therefore, one could properly adapt these algorithm to HWD, 3) similar adaptiveschemes such as those used for wavelet packets can be developed for this new family.

Regarding the human visual system, eyes are more sensitive to low-frequency portions of an image. To reduce artifacts, therefore, we just apply the (modified) DFB to m_d, (m_d< L , L is the number of wavelet levels) finest scales of the wavelet sub-bands. We propose the following two types of the HWD family basis functions.

1. HWD type 1
    a. Apply the DPF to the m_d finest diagonal wavelet sub-bands (HH_i, ($1 \le i \le m_d$)).
    b. Apply the VDFB to the m_d finest vertical wavelet sub-bands (HL_i, ($1 \le i \le m_d$)).
    c. Apply the HDFB to the m_d finest horizontal wavelet sub-bands (LH_i, ($1 \le i \le m_d$)).
2. HWD type 2
    a. Apply the DFB to the m_d finest diagonal wavelet sub-bands (HH_i, ($1 \le i \le m_d$)).
    b. Apply the VDFB to the m_d finest horizontal wavelet sub-bands (LH_i, ($1 \le i \le m_d$)).
    c. Apply the HDFB to the m_d finest vertical wavelet sub-bands (HL_i, ($1 \le i \le m_d$)).

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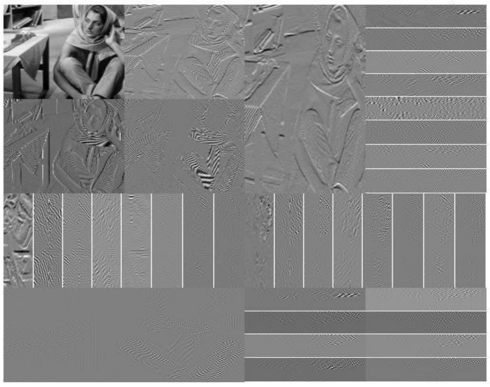
In HWD1, we further directionally decompose the vertical and horizontal coefficients already obtained through wavelet filtering. We use the proposed modified versions of the DFB to lower the complexity and to further reduce the artifacts. In HWD2, however, we decompose the horizontal sub-bands vertically and the vertical sub-bands horizontally. Indeed, there are still horizontal (vertical) coefficients with low magnitude in the vertical (horizontal) sub-bands. One can boost these coefficients by applying the HDFB (VDFB) to these sub-bands and improve the directionality of wavelets. Since we apply the HDFB or VDFB to the coefficients with low magnitude, we expect fewer artifacts during nonlinear approximation. In both HWD1 and HWD2 we use DFB with D ($d=D/2$ for VDFB and HDFB) directions at $i=1$, then we decrement the number of directions at every other levels.



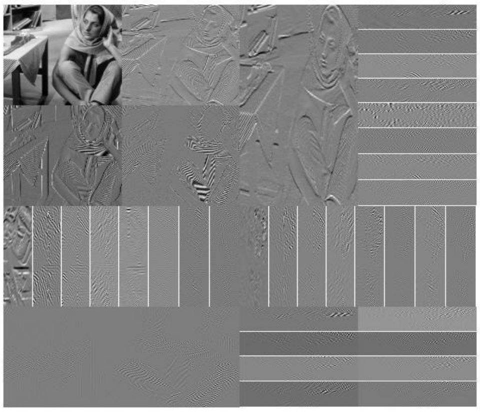


Fig: a) Barbara- HWD transform coefficients b) Barbara-watermarked HWD transform in significant coefficients

VII. ANALYSIS AND RESULTS

The analysis of the images involve the implementation of the proposed Hybrid wavelet and directional filter banks and the wavelets separately and the statistical measure of the image using correlation which is a measure of similarity between the obtained and original image.

Similarly the application of Peak Signal to Noise Ratio provides the effect of watermark information that affects the features of the image or disturbance in the image. It indirectly gives us the capacity of the image to contain a given watermark information. The two dimensional diamond shaped directional filters are displayed along with magnitude which are low pass diamond filter and the high-pass diamond filter both are shown in three dimensional view with their front and the top view and they form the directional filters used repeatedly at all the stages which depend on the number of directions being considered.

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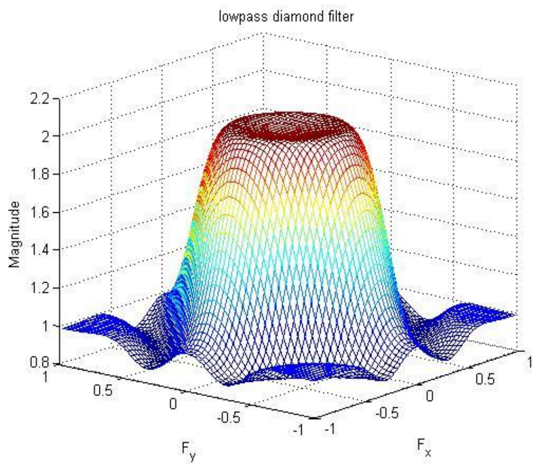
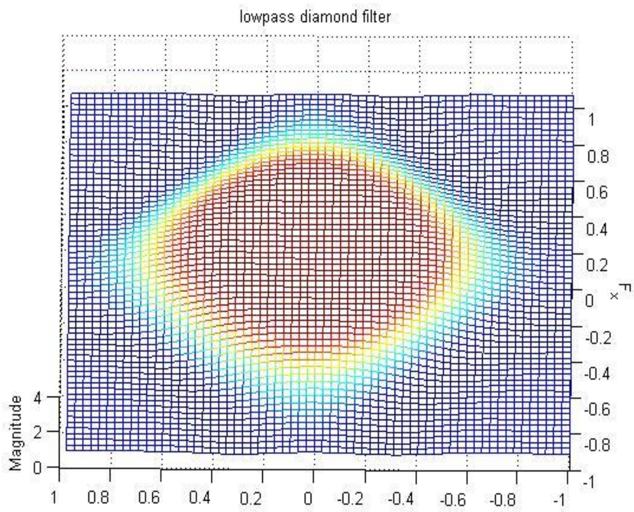
Table 7.1: comparison of correlation and PSNR of HWD and wavelet transform watermarking

Image name	Correlation		PSNR	
	HWD	Wavelet	HWD	Wavelet
Barbara	0.9686	0.918	31.2814	27.5879
Lena	0.9912	0.9454	25.9237	27.5879

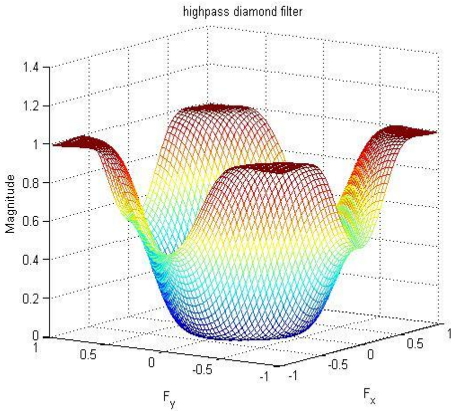


(a)

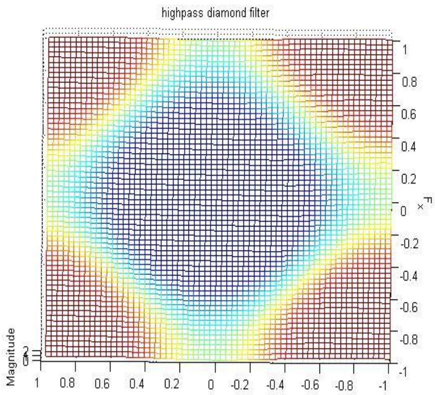


(b)

Fig 1.1:frequency spectrum of two dimensional low-pass diamond filter a) front view b) top view



(a)



(b)

Fig 1.2: frequency spectrum of two dimensional high-pass diamond filter a) front view b) top view

(a)

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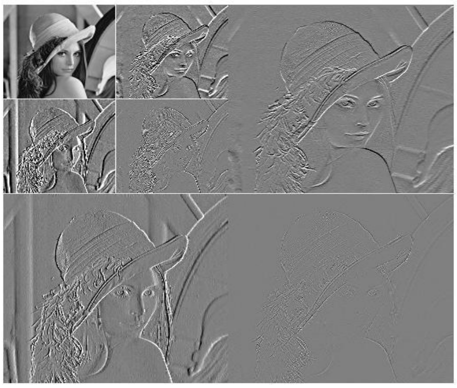
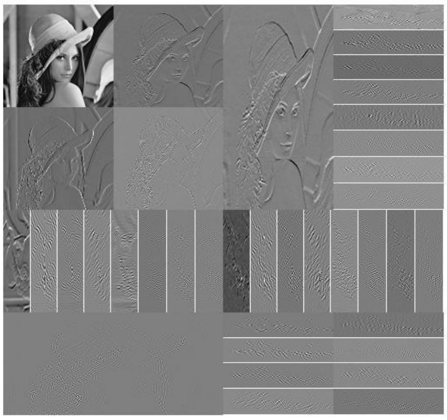
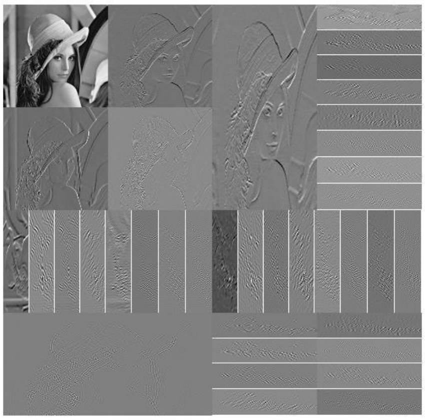


(b)

Fig. 1.3: a) lena-original image b) lena-wavelet coefficients with 2 stage decomposition



(a)



(b)

Fig. 1.4: a) lena-HWD transform coefficients b) lena-watermarked HWD transform in significant coefficients

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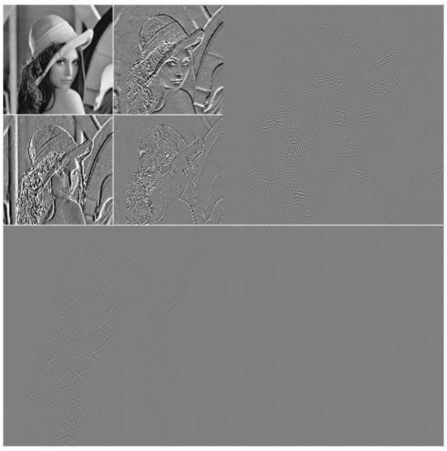
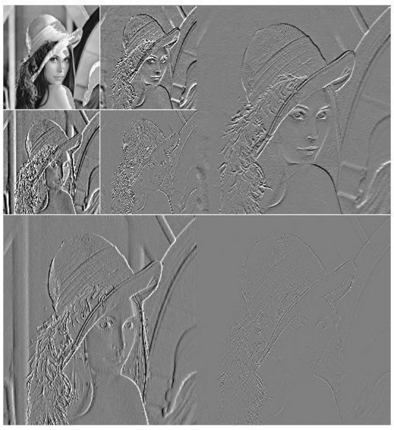


(a)

(b)

Fig. 1.5: a) lena-reconstructed wavelet coefficients with HWD watermark b)lena- reconstructed image of HWD watermark



(a)

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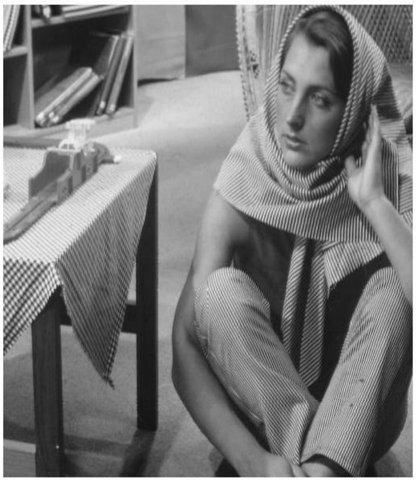
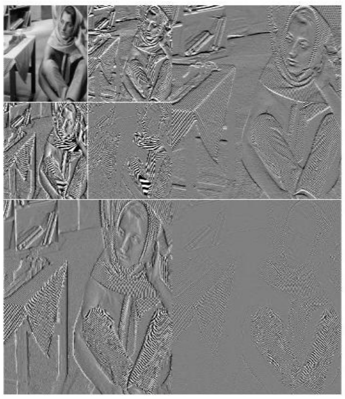
(b)

Fig. 1.6: a) lena-applying watermark on wavelet decomposition only b)lena-reconstructed wavelet watermark image



(a)



(b)

Fig. 1.7: a) Barbara-original image b) Barbara-wavelet coefficients with 2 stage decomposition

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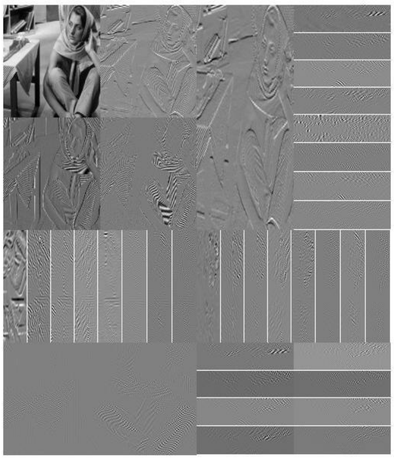
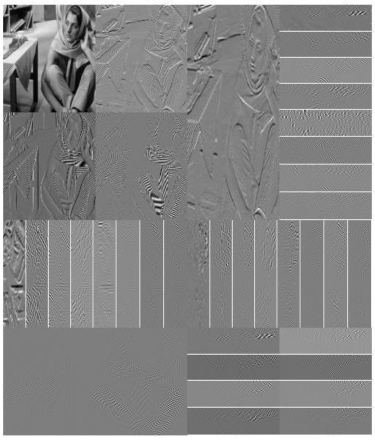
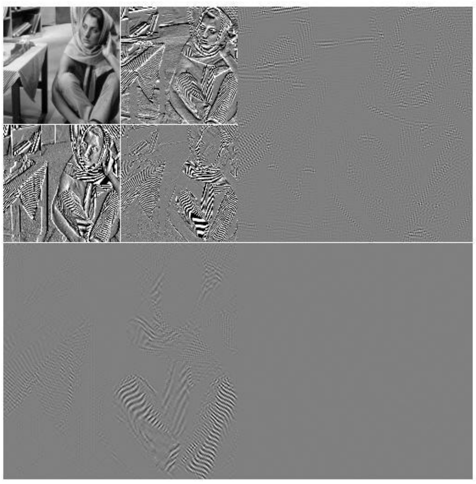


(a)



(b)

Fig. 1.8: a) Barbara- HWD transform coefficients b) Barbara-watermarked HWD transform in significant coefficients



(a)

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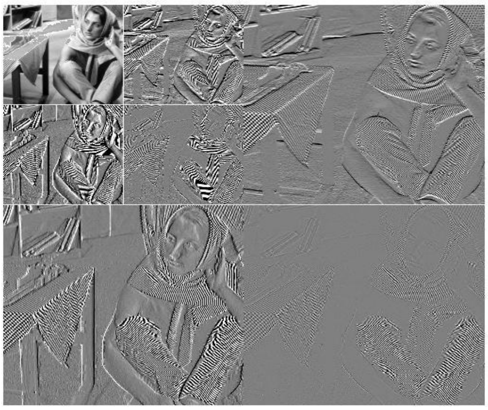
(b)

Fig. 1.9: a) Barbara-reconstructed wavelet coefficients with HWD watermark b)Barbara- reconstructed image of HWD watermark



(a)

(b)

Fig. 1.10: a) Barbara-applying watermark on wavelet decomposition only b)Barbara-constructed wavelet watermark image

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VIII.CONCLUSION

The HWD transform is geometrical transform that brings directional coefficients to use but require high computational that a traditional wavelet transform. It has the advantage of having high correlation with a generalized Gaussian noise as the watermark will not disclose the existence of watermark with in. this will help to owner identification, proof of ownership, copy control. The perceptual embedding in most significant coefficients makes it invisible to human vision. It has been suggested that it can be only detected rather than extraction of watermark which is immune to forgery attacks.

This transforms method need higher computational power with respect to wavelets. Its capacity is dependent on the image texture, it is having higher capacity to images with higher high frequency coefficients, and it is having lower capacity to images with lower high frequency coefficients. Due to its spread spectrum nature it can be extended regional enhancement. If higher wavelet levels are considered for the HWD there is possibility of embedding watermark in the low significant coefficients and causing geometrical distortion.

In the proposed transform the number of directions determines the computational cost and the invisibility of the watermark. It can be extended to a watermarking process where watermark is embedded only in a few directions causing it immune to rotation and skewing. It can be considered for large directions having higher levels in directional decomposition for better watermarking with robustness and capacity. It can be extended to natural images with RGB colors and can enhance the correlation with a 2d filter design having higher accuracy to diamond shape desired. Other directional transforms such as ridgelets, contourlets, curvelets, framelets can be used to improve its capacity and robustness.

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