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Fusion Of HWD And Non Negative Matrix Factorization For Video Watermarking

Gopika V Mane[1], G. G. Chiddarwar[2]

* (Department of Computer Engineering, Sinhgad College of Engineering, University of Pune, India

** (Department of Computer Engineering, Sinhgad College of Engineering, University of Pune, India

ABSTRACT : *In the era of high speed network and World Wide Web, data can be easily accessed in a number of ways to share among each other. This data can be manipulated without any quality loss. Threat of intellectual property rights becomes a crucial issue due to this. The security of these online assets can be obtained using different techniques like encryption, fingerprinting, watermarking. In this paper we propose watermarking algorithms for protecting digital contents like images,audio,video. This algorithm uses a new family of perfect reconstruction, non-redundant, and multiresolution geometrical transforms using the wavelet transform in conjunction with modified versions of directional filter banks (DFB) for decomposition of video frames into frequency bands. Low frequency band is factored using Nonnegative matrix factorization for dimension reduction. This hybrid algorithm proposes a more robust technique for video watermarking with no perceptual quality loss of video.*

Keywords : *Content protection, Digital properties, Directional filter banks (DFB), Security, SVD, Wavelet Based Contourlet transform (WBCT), Watermarking techniques.*

I. INTRODUCTION

With the rapid development of digital multimedia technique and the spread of the internet, digital productions are easily copied and manipulated, so there exists a strong demand to protect the ownership and the copyright of this digital production. Digital watermarking is an excellent tool of copyright protection by embedding some information into the digital production.Copyright protection inserts authentication data such as ownership information and logo in the digital media without affecting its perceptual quality. In recent years, digital watermarking is one of the best potential tools for multimedia authentication by embedding some information into the digital production.

A watermarking algorithm consists of watermark structure, an embedding algorithm and extraction or detection algorithm. In multimedia applications, embedded watermark should be invisible, robust and have a high capacity. Robustness is the resistance of an embedded watermark against intentional attack and normal signal processing operations such as noise, filtering, rotation, scaling, cropping and lossy compression etc. Watermarking techniques may be classified in different ways. The classification may be based on the type of watermark being used, i.e., the watermark may be a visually recognizable logo or sequence of random numbers. A second classification is based on whether the watermark is applied in the spatial domain or the transform domain.

In literature many techniques were proposed for digital watermarking. In the spatial domain, Least significant bit (LSB) substitution is used to embed watermark. In transform domain DFT, DCT, DWT are techniques to embed watermark. Wavelets have been successfully applied to many image processing tasks such as low bit-rate compression and denoising [8]. However, they lack the important feature of directionality and hence, they are not efficient in retaining textures and fine details in these applications [3][4]. There have been several efforts towards developing geometrical image transforms. Directional wavelet transforms [1], complex wavelets [6], curvelets [2] and contourlets [3] are a few examples where all of them are redundant.

In Wavelet-Based Contourlet Transform (WBCT) [4], where DFB is applied to all the detail subbands of wavelets in a similar way that one constructs contourlets. The main difference is that we used wavelets instead of the Laplacian pyramids employed in contourlets. Therefore, the WBCT is non-redundant and can be adapted for some efficient wavelet-based image coding methods [4].

The main disadvantage of the WBCT (and other contourlet-based transforms) is the occurrence of artifacts that are caused by setting some transform coefficients to zero for nonlinear approximation and also due to quantizing the coefficients for coding. In this paper, we introduce Hybrid Wavelets and Directional filter banks (HWD) as a solution for this problem. Here we employ wavelets as the subband multiresolution decomposition. Then we apply the DFB and modified versions of the DFB to some of the wavelet subbands.

This paper is organized into six sections. The second section discusses basic concepts of directional filter bank used in Hybrid Wavelets and Directional filter banks. In third section types of Hybrid Wavelets and Directional filter banks are discussed. Fourth section explains Nonnegative matrix factorization for image dimension reduction. The fifth section illustrates a method for color space separation. Final section states algorithm for video watermarking.

II. HORIZONTAL AND VERTICAL DIRECTIONAL FILTER BANK

Directional filter banks (DFB) [7] decompose the frequency space into wedge-shaped partitions as illustrated in Fig. 1. In this example, eight directions are used, where directional subbands 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 an iterated quincunx filter banks.

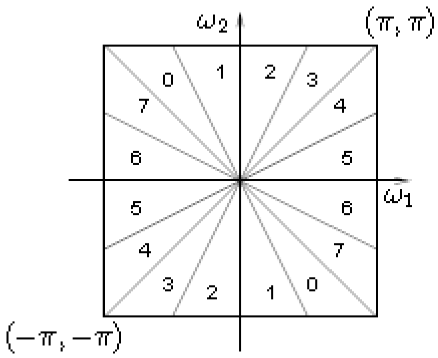

Fig 1. Diretional filter bank frequency partitioning using 8 directions

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. 2 shows the frequency space partitioned by the VDFB and HDFB.

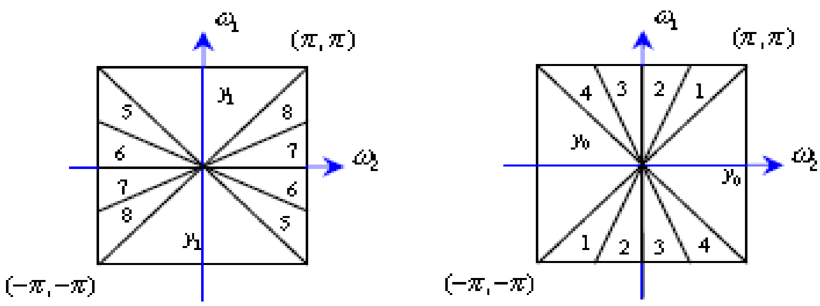

Fig 2. (a) An example of the *vertical* directional filter banks.
(b) An example of the *horizontal* directional filter banks.

III. HYBRID WAVELETS AND DIRECTIONAL FILTER BANKS (HWD)

Here we develop the image transform family of Hybrid Wavelets and Directional filter banks (HWD). For HWD, similar to the WBCT, we consider the wavelet transform as the multiresolution subband decomposition. Wavelets have already shown their good nonlinear approximation property for piece-wise smooth signals [6]; thus, we expect that by adding the feature of directionality in an appropriate manner we could improve the nonlinear approximation results yielded from wavelets. There are efficient algorithms developed for image processing applications such as image coding; therefore, one could properly adapt these algorithm to HWD, Similar adaptive schemes such as those used for wavelet packets can be developed for this new family.

For the WBCT scheme, we apply the DFB to all wavelet detail subbands in such a way to comply the anisotropy scaling law [4]. Because the WBCT coding scheme introduces visible artifacts in the smooth regions of images. These artifacts are mainly introduced by the DFB when we set some transform coefficients to zero. 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_α , ($m_\alpha < L$, L is the number of wavelet levels) finest scales of the wavelet subbands. We propose the following two types of the HWD family basis functions:

1. HWD type 1
   a. apply the DFB to the m_α finest diagonal wavelet subbands (HH_i , $(1 \le i \le m_\alpha)$),
   b. apply the VDFB to the m_α finest vertical wavelet subbands (HL_i , $(1 \le i \le m_\alpha)$),
   c. apply the HDFB to the m_α finest horizontal wavelet subbands (LH_i , $(1 \le i \le m_\alpha)$).

2. HWD type 2
   a. apply the DFB to the m_α finest diagonal wavelet subbands (HH_i , $(1 \le i \le m_\alpha)$),
   b. apply the VDFB to the m_α finest horizontal wavelet subbands (LH_i , $(1 \le i \le m_\alpha)$),
   c. apply the HDFB to the m_α finest vertical wavelet subbands (HL_i , $(1 \le i \le m_\alpha)$).

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 subbands vertically and the vertical subbands horizontally.

Fig. 3 shows some basis functions of the HWD family as well as the wavelet transform and the WBCT. As seen, the wavelet basis functions are point-wise while those of the HWD family are both directional and point-wise. Note that the nondirectional basis functions of HWD2 are more similar to those of wavelets when compared with the HWD1. In the WBCT all basis functions are directional. The center basis function in these schemes is an instance from coarser scales, which is the same for wavelets and also HWD type 1 and 2. In contrast, for the WBCT it appears as a scattered directional basis function, which is a source of artifacts in this type.

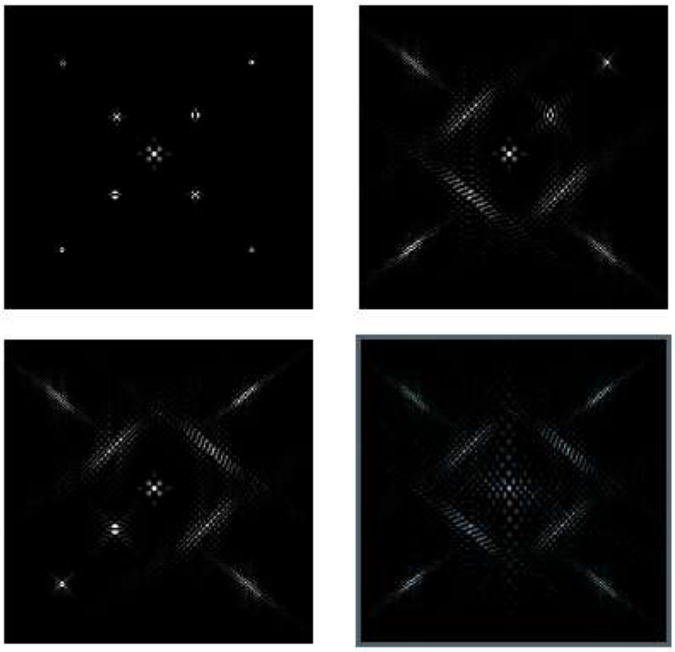

Fig 3. Some basis functions of the wavelets and HWD family.
From left to right, top to bottom: Wavelets, HWD1, HWD2, and WBCT.

IV. NON NEGATIVE MATRIX FACTORIZATION (NMF)

One major drawback of SVD is that the basis vectors may have both positive and negative components, and the data are represented as linear combinations of these vectors with positive and negative coefficients. In many applications, the negative components contradict physical realities. To address this problem, the NMF approach was proposed to search for a representative basis with only nonnegative vectors.

Given a cover image C of size $m \times m$, we can approximately factorize C into the product of two nonnegative matrices B and H with sizes $m \times r$ and $r \times m$ respectively, that is *the* $C = BH$; where $r \leq m$. The nonnegative matrix B contains the NMF basis vectors, and the nonnegative weight matrix H contains the associated coefficients (nonnegative weights). To measure the quality of the approximation factorization $C = BH$, a cost function between C and BH needs to be optimized subject to non-negativity constraints on B and H. This is done by minimizing the I-information divergence which is given by

$$I(C \| BH) = \sum_{ij} \left(C_{ij} \log \frac{C_{ij}}{(BH)_{ij}} - C_{ij} + (BH)_{ij} \right) \quad (1)$$

which yields the following multiplicative update rules

$$H_{kj} \leftarrow H_{kj} \frac{\sum_i B_{ik} C_{ij} / (BH)_{ij}}{\sum_i B_{ik}} \quad (2)$$

$$B_{ik} \leftarrow B_{ik} \frac{\sum_i H_{kj} C_{ij} / (BH)_{ij}}{\sum_i H_{kj}} \quad (3)$$

V. YUV COLOR COMPONENT

Since Pixel values in RGB color space are highly correlated, RGB color space is converted into YUV color space. RGB color space is used for many watermarking algorithms, but RGB color space is complex in describing the color pattern and has redundant information between each component [2]. Also, embedding watermark in RGB color space is less robust than YUV color space. Hence, RGB color space is converted into YUV Color space and then Watermark is embedded. Initially color image is read and R, G, B components of the original Cover Image are separated. Then they are converted into YUV color Space using following equations.

$$Y = 0.299 * R + 0.587 * G + 0.114 * B; \quad (4)$$

$$U = - 0.147 * R - 0.289 * G + 0.436 * B; \quad (5)$$

$$V = 0.615 * R - 0.515 * G - 0.100 * B; \quad (6)$$

VI. PROPOSED ALGORITHM

In proposed algorithm Y component is given to HWD which is used for extracting low frequency component from video frames. These components are pasteurized using NMF where we get two nonnegative matrices.Following are steps for embedding watermark in video frames.

1. Input color video which is divided into number of frames.
2. Extract Y component from video frames.
3. Apply HWD to frame for identifying low frequency part.
4. Input low frequency part for factorization into W1 & H1.
5. Factorize watermark image also using NMF into W2 & H2.
6. The W1 is normalized in between 0 and 1 and is termed as M1.
   M1[i]=(W1[i]-maximum(W1))/(minimum(W1))-(maximum(W1))
7. The weight matrix is obtained by Alpha=0.05*M1[i]
8. The embedding is performed as
   $W_{new}=W1+Alpha \otimes W2$ $\otimes$ --indicates element wise product.
9. After getting W_{new},using H1 the INMF results the watermarked coefficients of Y component.
10. Inverse HWD is applied to get back the watermarked Y component and these will combined with other color channels of Original video to get back the Watermarked video.

VII. CONCLUSION

This study represents drawbacks of Wavelet based Contourlet transform and give solution using Hybrid Wavelet Directional filter banks. The algorithm proposed used luminance part of video frames to insert watermark and low frequency part of frame results from HWD. Non negative matrix factorization avoid presence of negative entities involved in image which contradicts physical realities. This algorithm proposes new technique for video watermarking with the use of new & robust algorithms.

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