A Survey Paper on Image Adaptive Watermarking Techniques

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Abstract— A digital image watermark is a signal permanently embedded into a digital image that can be detected or extracted later by means of some operations for authentication purposes. This paper discusses the results of evaluating three conventional image watermarking algorithms for performance and robustness. The findings are based on experiments on a standard LENA image and thus a comparative analysis between the algorithms becomes apparent and very clear. Three algorithms namely LSB (Least Significant Bit), DCT (Discrete Cosine Transform) and DWT (Discrete Wavelet Transform) were implemented in MATLAB and various results were collected with respect to performance and robustness. LSB embedded watermarks were easily removed using techniques that do not visually degrade the image to the point of being noticeable. Cosine transform algorithm was good in both performance and robustness. The wavelet domain proved to be highly resistant to both compression and noise, with minimal amounts of visual degradation but the original image was significantly affected by the embedding. The numeric data included in the paper make this comparison more formal.

Key words: DCT, MATLAB

I. DISCRETE COSINE TRANSFORM

In spread spectrum, DCT is used. DCT is preferred for watermarking because of its higher imperceptibility and that they are more robust to image manipulations. DCT represents an image as a sum of sinusoidal varying magnitude and frequency. DCT result images have higher visual quality than the spatial domain (Flipping). Therefore, DCT methods are normally selected for gray and color image watermarking even though their algorithms are computationally complex.

A bit present in the information is encoded in a block using the relationship between the three quantized DCT that is available in Zaho and Koch (1995). Bors and Pitas (1996) developed the method to modify the DCT coefficient to fulfill the block selection constraint. Sequence of real number isused as a mark (Key) to embed the data in DCT domain is explained in Coxet al (1996 a) and Swanson et al (1996) and its results are proved that these watermarks are more robust in JPEG compression. Threshold technique is used to generate bidirectional coding, which acts as a private key for DCT domain watermarking is described by O'Ruanaidh et al (1996).

DCT is used to embed the watermark image in middle band frequency range is explained in (Weili and Aoki 1997). Adaptive watermarking technique in DCT is described by Dickinson and Tao (1997). Arranging the DCT coefficient in a zigzag order and adding them in mid 20 frequency range to preserve perceptual invisibility is explained by Barni et al (1998). The blocks chosen for embedding the watermark are selected based on gaussian network classifier and then linear DCT constraints are embedded in selected blocks which are clearly explained in (Bors and Pitas 1998).

DCT coefficient is calculated according to the analysis of noise sensitivity of every pixel based on the local region content (texture, edges and luminance) and is clearly explained in Kankanhalli and Ramakrishan (1998). A blind technique, to transform an image based on the table lookup method in the frequency domain watermarking is explained in (Wu and Liu 1998). Public watermarking technique is used to embed a signature into image in Chae and Manjunath (1999).

DCT with variable block-size (Hyung et al 1999) and fixed block size algorithms (Hsu and Wu 1999) are developed to embed the image watermark; the results proved that the technique successfully survives the image processing operations, image cropping and JPEG lossy compression.

DCT domain visible image watermarking technique for gray and colour images are described by Mohanty et al (2000) and Mohanty et al (1999).

A. Advantages of DCT:

1) Computational complexity of DCT is less compared to DWT.

II. DISCRETE FOURIER TRANSFORM

DFT technique is required for watermarking to satisfy the important property of translation in variants. Circularly symmetric watermark embedding in Two Dimensional Discrete Fourier Transform (2D-DFT) is explained in (Solachidis and Pitas 1999), which is more robust to rotation and scaling attacks. The entire watermark is modulated by a binary pseudo-noise matrix and then modulated watermark is embedded into FT of cover image described by Kim et al (1999a). Watermark is added to a template in the FT domain to obtain more robustness than in the case of Linear Transformation (LT) is discussed in Pereira and Pun (2000). Fourier Mellin Wavelet (FMW) performs log-polar map (LPM) on DFT domain and needs an interpolation of 21 two dimensional Discrete Fourier Transform (2D-DFT) magnitude with large dynamic range of neighboring coefficients pointed out by Langelaar et al (2007) and improved FMW scheme described by Lin et al (2001).

A. Advantages of DFT:

1) DFT is rotation, scaling and translation (RST) invariant. Hence it can be used to recover from geometric distortions, whereas the spatial domain, DCT and the DWT are not RST invariant and hence it is difficult to overcome from geometric distortions.

III. DISCRETE WAVELET TRANSFORM

DWT has been used over a long period of time in digital image water marking, due to its time/frequency decomposition characteristics. This resembles the theoretical

model of HVS. In wavelet transform, an image is decomposed into a set of band limited component, which can be reassembled to reconstruct the original image without error. DWT has the advantages of being closer to HVS and have a higher compression ratio than DCT. First level discrete wavelet decomposition of watermark is available in Kundur and Hatzinakos (1997). Multi-resolution private watermark for digital image using DWT is described by Xia et al (1997) and Kundur and Hatzinakos (1998). DWT based public digital watermarking scheme uses binary code (Inoue et al 1999), Embedded Zero tree Wavelet (EZW) (Shoapiro 1993), pseudo-random sequence (Barni et al 1999) to embed a watermark image. Tree level wavelet based multi-resolution watermark is introduced by Kim et al (1999 b) and improved wavelet based watermark technique is explained by Barni et al (2001). DWT is a hierarchical sub-band system, where the sub-bands are logarithmically spaced in frequency. DWT can be implemented using digital filters and downsamplers are in literature (Gonzalez and Woods 2002). Wavelet based watermarking algorithm for ownership verification of digital images using private key are explained in Wang et al (2002). Composite image watermark on DWT and DFT is described by Xiangui Kang et al (2003). Zero location watermarking in Z-transform and wavelet domain watermarking in JPEG compression are the various embedding techniques used in biomedical images, mentioned in Anthony et al (2004). It provides good space of 22 frequency locations for analyzing the image features such as edges or textured areas.

A robust watermarking scheme using best tree wavelet packet transform is explained by Rawat et al (2009). The prominent watermarking techniques available for still images are DCT (Mohanty et al 2000) and DWTand Image Adaptive Discrete Wavelet Transform (IADWT) (Franco and Del 2008). Robust video DWT domain watermarking technique is described in Rini (2011). In this scheme the quantization model used for quantizing the wavelet coefficient is based on the characteristics of HVS. Some of other transforms used to embed watermarks are multiresolution transform and complex HT (Falkowski and Lip-San 2000), normalization based watermark (Alghoniemy and Tewfik 2000), Karhunen Loeve (KL) transform (Moulin and Ivanovic 2003), probability based watermark (Nasir et al 2007), quantization index modulation and distortioncompensated (Chen and Wornell 2001) and discrete pascal transform (Mahmoud et al 2008).

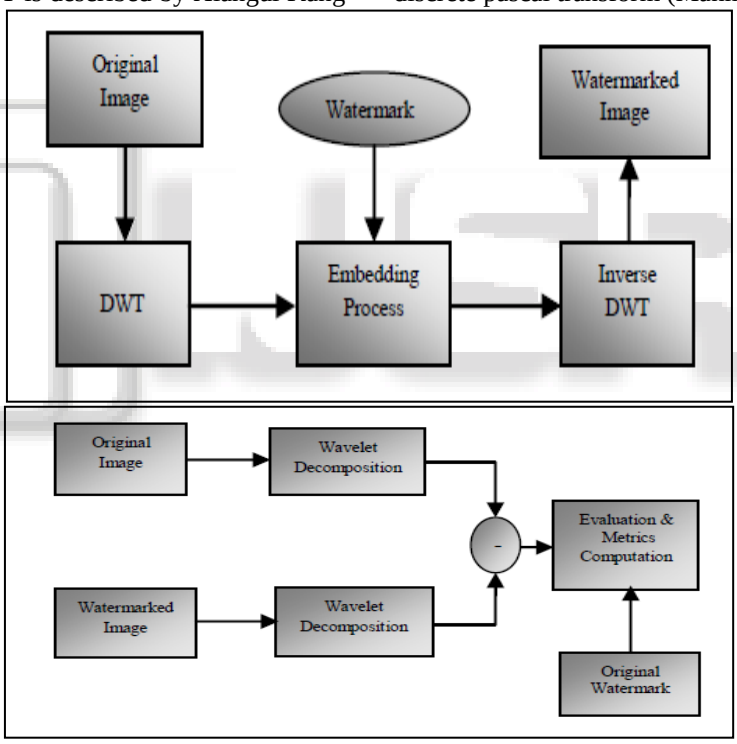

Fig. 1: Image Watermarking Using DWT

A. Advantages of DWT:

1) Wavelet transform understands the HVS more closely than the DCT.
2) Wavelet coded image is a multi-resolution description of image. Hence an image can be shown at different levels of resolution and can be sequentially processed from low resolution to high resolution.
3) Visual artifacts introduced by wavelet coded images are less evident compared to DCT because wavelet transform doesn't decompose the image into blocks for processing. At high compression ratios blocking artifacts are noticeable in DCI; however, in wavelet coded images it is much clearer.

TITLE	DCT	DWT
PSNR	*30.39*	*30.35*
MSE	*61.86*	*61.84*
COMPRESSION RATIO	*65.463*	*57.929*

Fig. 2:

IV. CONCLUSIONS & FUTURE WORK

In this paper a novel watermarking algorithm for colour images is proposed. The novelty of the algorithm is in the adaptation of the watermark in the colour channels. This adaptability gives the freedom to embed watermark with maximum strength, while keeping the PSNR in between an acceptable range. It is found that linear and uncorrelated colour transforms are most suitable for watermarking. Detection is oblivious and watermark strength is not required.

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