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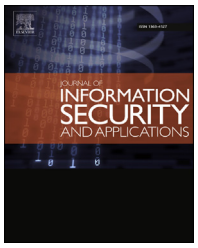

Binomial transform based fragile watermarking for image authentication

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ABSTRACT

In this paper, a novel Binomial transform based fragile watermarking technique has been proposed for color image authentication. Binomial transform (BT) is applied to convert each 2×2 sub-image block into transform domain in row major order. On average, two bits of authenticating watermark are fabricated on each transformed component starting from the least significant bit position (LSB-0). Inverse Binomial transform (IBT) is performed as post-embedding operation to convert each 2×2 transformed block back into the spatial domain. A delicate re-adjustment is performed on the first embedded component to keep the pixel components positive and less than or equal to 255 keeping the fabricated watermark unaltered. The watermark is extracted at the recipient end based on the reverse operation and is verified for authentication using a message digest. Experimental result ensures that the proposed technique obtain higher Payload and Peak Signal to Noise Ratio (PSNR) as compared to existing methods.

1. Introduction

In the field of information hiding, digital watermarking plays a vital role by incorporating useful information into various digital media like image, audio and video etc. for ownership evidence, fingerprinting, authentication and integrity verification. To ensure integrity and authentication, few trusted cryptographic techniques are used such as Hashing (MD5, SHA-1), Digital Signatures etc. (Paar et al, 2010). In the year 1997, Yeung and Mintzer had proposed a seemingly simple technique (Yeung and Mintzer, 1997) where a watermark (usually a binary logo or binary image) was embedded in the carrier image and the embedding procedure resulted a verification key. This verification key was used as a LUT (Look up Table) for extraction as well as verification of the watermark.

The basic idea of watermarking in transform domain is to convert the cover image using popular transformations such as quaternion Fourier transformation (QFT), discrete Cosine transformation (DCT), discrete Wavelet transformation (DWT), or discrete Fourier transform (DFT) to get transformed coefficients. Transformed coefficients are modified slightly to embed the secret watermark, and the watermarked image is obtained by inverting the modified transformed coefficients. Transform domain methods are widely used than spatial domain techniques due to its ability of fabricating bits in both negative and positive components which offers high robustness. Digital watermarking is basically classified into two domains: fragile and robust. In general, robust image watermarking techniques are used to protect ownership of the digital images. In contrast, the purpose of fragile image

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watermarking techniques is image authentication, that is, to ensure the integrity of the digital image. In this study, we are mainly concerned with fragile watermarking in transform domain.

In 1998, Wong (1998) proposed a public key cryptography based image watermarking technique. This method could be used not only to detect the hidden watermark rather it also provided the localization property i.e., the place where the modification done was also given. It used the private key to sign the watermark and embed it into the carrier image. In 2001, Fotopoulos et al. (2001) proposed a watermarking technique in the Gabor domain. The watermark used in this work is a pseudorandom Gaussian noise sequence and the seed of the generator is the watermarking key. Based on a well known multiplicative rule, all blocks of coefficients are altered, except the first one. In 2004, Shieh et al. (2004) presented optimization of a watermarking technique based on Genetic Algorithm (GA) to find the optimum frequency bands for watermark embedding into a DCT-based watermarking for better security, robustness, and the image quality of the watermarked image. In 2005 (Kumsawat et al., 2005), Kumsawat et al. proposed a spread spectrum image watermarking algorithm based on discrete multi-wavelet transform and GA. They also analyzed a threshold values for embedding strength to improve the visual quality and robustness of watermarked images. In 2007, Monzoy-Villuendas et al. (2007) proposed a fragile watermarking in YCrCb color space. The technique was very sensitive against small changes in the watermarked image and show robustness of the system against VQ attacks which is considered vulnerable against most of the existing fragile watermarking techniques. In 2008, Aslantas et al. (2008) proposed a novel fragile watermarking scheme based on discrete Cosine transform (DCT) where the watermark bits are fabricated in frequency domain by altering the least significant bits (LSBs) of the transformed coefficients. The transformation may generate rounding errors due to the conversion of real numbers into integers in the process of transformation. A population based stochastic optimization technique (PSO) is proposed to correct these rounding errors. In 2009, the Slantlet Transform (SLT) coefficients have been used instead of the wavelet transform coefficients for data embedding (Kumar and Muttoo, 2009). It has been confirmed through the experimental results that the application of the SLT gives better image quality of stego-images. In 2010, Varsaki et al. proposed a discrete Pascal transform (DPT) (Varsaki et al, 2010) based information embedding technique which offers an efficient idea of hiding watermark bits into the real frequency components. In 2012, Liu et al. (2012) had proposed a novel fragile watermarking algorithm based on the Fractional Fourier Transform (FRFT) where the chaotic sequence is converted to '0' or '1' to represent the watermark information. In the year 2012, Betancourth (2012), has proposed a wavelet based fragile watermarking technique for tamper region localization and detection of the modification. In this method, a small number of wavelet coefficients are watermarked but all are implicitly protected. As a result, the quality degradation is minimized without compromising the authentication process. In 2013, a separable discrete Hartley transform based invisible watermarking scheme has also been proposed by Mandal and Ghosal (2013) which exploits image authentication by fabricating the watermark data along with the message digest (which is obtained from watermark) into the carrier image. Moreover, the technique offers a minimal loss of quality and improved security whereas the security was improved by incorporating a secret key (K) dependent embedding/extracting algorithm. In 2013 Huang et al. (2013) also proposed a spherical coordinate system based fragile watermarking technique has been proposed. A 3D model is translated from the cartesian coordinate system to the spherical coordinate system where a quantization index modulation technique is used for fabrication of authenticating bits. In the same year, Botta et al. (2013) proposed a Karhunen-Loeve transform (KLT) based fragile watermarking where the transformed coefficients are modified according to the weighted-modulo sum and a genetic algorithm (GA). The technique achieves an excellent sensitivity against any kind of intentional/unintentional attack on the watermarked image. In 2014, Cheng et al. (2014) proposed a fragile watermarking technique based on discrete Cosine transform (DCT) for hologram authentication. The technique can also be used as an effective filter for blocking holograms and detecting errors in presence of high perceptual transparency. In the same year, Khalil et al. (2014) proposed a two layer fragile watermarking technique based on discrete Wavelet transform (DWT) on the Quran images for authentication. In this method, a blurring method has been introduced into the watermark bit stream based on a chaotic map to prevent local attacks. In 2014, Chen et al. (2014) proposed a novel watermarking based on 4-dimensional quaternion discrete Fourier transform for color images. The technique is an improved version of traditional QDFT based watermarking in terms of imperceptibility, capacity, quality and robustness.

To improve the payload and to reduce the degradation of the watermarked image, a novel fragile watermarking based on Binomial transform has been proposed where the authentication is achieved through a 128 bit message digest. The technique converts each 2×2 sub-image block into a transformed block consisting of four transformed components. The transformed components are used for embedding authenticating watermark bits. On embedding authenticating watermark message/image bits, inverse Binomial transformation (Borisov and Shkodrov, 2007; Falcon and Plaza, 2009) is applied to re-generate the watermarked image into spatial domain. The original pixel values are not preserved though embedded bits are intact, but, if we apply Binomial transform again, the transformed component values are not changed.

The Binomial transform (BT) is applied on a set of pixels $\{a_n\}$ to generate transformed components $\{s_n\}$ as given in Eq. (1).

$$s_n = \sum_{k=0}^{n} (-1)^k \binom{n}{k} a_k. \tag{1}$$

Similarly, the inverse Binomial transform (IBT) is used to convert transformed components back into spatial domain as given in Eq. (2).

$$a_n = \sum_{k=0}^{n} (-1)^k \binom{n}{k} s_k. \tag{2}$$

The proposed technique is emphasized on protection of secret watermark against unauthorized access. The proposed