Effective Multiple Image Watermarking based on Dither Quantization

Vijendra Rai¹, Jaishree Rai² and Manoj Rana³

¹CSE Department, College of Engineering & Rural Technology Meerut, U.P., INDIA
²CSE Department, Vidyasagar College of Engineering Meerut, U.P., INDIA
³CSE Department, College of Engineering & Rural Technology Meerut, U.P., INDIA

vijendrarail@gmail.com¹, raijaishree@gmail.com² and manoj_rana121@yahoo.co.in³

ABSTRACT

Multiple watermarking is used for embedding multiple watermarks into the host single multimedia object (image) to provide authentication without bearing on the optical quality of the image. It is an embranchment of digital watermarking, which gives some particular applications, such as transaction tracking. Some digital watermarking techniques ensure the host-signal noise while associating the watermark in chronological sequence on experienced image data. The cover work is projected to multiple orthogonal projection vectors to be sure that different watermark signals do not mutually interfere in which they are embedded.

KEYWORDS

Discrete cosine transform (DCT), Invisible watermarking, Dither Quantization.

1. INTRODUCTION

Watermarking is defined as the practice of imperceptibly altering a work to embed a message about the work [1]. Hiding watermark information in image data files is one method of enhancing security and protecting patient privacy. Data hiding in multimedia signals has been an active research area in recent years. The objective of digital image watermarking is the insertion of a hidden message within the body of an image. This message can be extracted by receiver to prove ownership, identify if an image has been altered, and highlight the location of any alterations. One approach to solving this problem would be to use a digital image watermarking system where an imaging specialist could open a tampered image and receive a warning message that part of the image has been altered. The availability of digital data such as multimedia services on the internet leads to exponential growth of multimedia traffic (image, text, audio, video, etc). Watermarks added to digital content serve a variety of purposes. The most common among them are ownership assertion, fingerprinting, authentication and integrity verification, content labeling, usage control, control protection, etc. Digital watermarking has been proposed as a generic technique to solve various problems associated in the area of Digital Right Management (DRM) and multimedia security. In this paper we use a new method for invisible watermarking gray-scale images. This method is intended for use in image verification applications, where one is interested in knowing whether the content of an image has been altered since some earlier time. If we embed more than one watermark in the cover image to increase the robustness, then it is also termed as multiple watermarking techniques [2,3]. These are broadly classified as composite, segmented and Re-watermarking. In this paper we focus on jointly enhancing the robustness and security of core embedding mechanisms that can be used as building blocks for authentication. To achieve the robustness in large range of images one might embed multiple watermarks into same image for example, one can embed first watermark to convey ownership information, second watermark to verify content integrity and third watermark to convey a caption that might describe the content of image. The data-embedding mechanism for these authentication applications should be secure enough to prevent an adversary from forging the embedded data. In addition, semi-fragileness is often preferred to allow for distinguishing content changes versus non content changes.

Re-watermarking is a straight forward method of embedding. It places one watermark on the top of another and the watermark signal is detected by using former watermarked signal as the original image. Segmented watermarking partition the space available for watermarking into blocks and allocate each block to a different watermark. Composite watermark builds a single composite watermark from a collection of watermarks. Composite watermark will be separable if the watermarking patterns are orthogonal. To achieve this property of embedding cover vectors are extracted from the original cover image by using DCT. In this paper Spread Transform technique which is based on dither modulation is used to embed additional information data into a host signal. The rest of this paper is organized as follows: section II gives the terminology used in the paper. Section III explains the Spread Transform Dither Modulation technique in detail. Section IV gives watermarking embedding and extraction method. The experimental results are given in the section V. The paper is concluded in section VI followed by the references.

2. TERMINOLOGY

A new method for inserting invisible watermark into a digital image uses two layers of orthogonal transforms, pseudorandom data shuffling and a dither modulation technique. Neither the original host image nor the inserted data string is needed in extraction of the watermark. Watermark is a digital code
embedded imperceptibly and robustly into digital media such as still image and audio signals. Various orthogonal transforms such as DCT, DFT and Spread Spectrum have been used. In order to achieve different performances and meet various application requirements, watermark may be embedded into different parts of the host signal and using different embedding strategies such as coefficient replacement, adjustment, and addition.

Presently, the quantization-based watermarking has received attention and the most important method proposed so far is quantization index modulation (QIM) [5]. Quantization index modulation (QIM) methods are a class of watermarking methods that achieve provably good rate-distortion robustness performance while spread-spectrum techniques have been widely used to embed a small number of bits robustly in multimedia signals [4]. Quantization-based embedding is more common for such high-rate data-hiding applications as authentication. Quantization Index Modulation (QIM) refers to embedding information by first modulating an index or sequence of indices with the embedded information and then quantizing the host signal with the associated quantizer or sequence of quantizers [5]. An efficient implementation and low complexity realization of QIM is called dither modulation (DM), where the embedded information modulates the dither signal of a dithered quantizer, which have the property that the quantization cells and the reconstruction points of any given quantizer in the ensemble are shifted versions of the quantization cells and reconstruction points of any other quantizer in the ensemble. The shifts typically correspond to pseudorandom vectors called dither vectors [5]. For information embedding purposes, the dither vector can be modulated with the embedded signal: each possible embedded signal maps uniquely onto a different dither vector d(m). For example, for binary data there are d(0) and d(1). The host signal is quantized with the resulting dithered quantizer to form the composite signal. Specifically we start with some selected quantizer q(.) and the embedding function is:

\[ S(x, m) = q(x + d(m)) - d(m) \]  

(1)

Where x is some host signal vector in which some information m has to be embedded. Both the x and m can be represented by real values. We call this type of information embedding as dither modulation.

3. SPREAD TRANSFORM DITHER MODULATION BASED WATERMARKING TECHNIQUE

Current techniques for watermarking can be classified into two groups. The first group is based on spatial domain techniques, which embed the watermark by directly modifying the pixel values in the image. The second group comprises of transform domain methods, which embed the watermark by modulating the transform domain coefficients of the data. Spread transform dither modulation method is a transform domain method. The transform methods are more complex, but more robust than the spatial methods. The watermark is inserted into the cover image in a spread-spectrum fashion in the spectral domain, thereby making it robust against signal processing operations.

In this case, the feature vector extraction process can be seen as an extension of the spread–transform technique (a more general method of spreading watermark information over a host signal than spread–spectrum) that is frequently employed on multimedia [4]. To this feature vector a quantization based watermarking algorithm is used. A popular technique, often known as odd–even embedding [6] or dithered modulation [5], is to choose a quantization step size and round a feature, which can be a sample or a coefficient of the host signal, to the closest even multiples of to embed a “0” and to odd multiples to embed a “1”.

For quantization firstly transformation is done by dividing each of the original image pixels in 8x8 blocks of pixels by taking DCT of each block then divide each DCT coefficient by its corresponding quantizer step size, followed by rounding to the nearest integer: In this step the less important DCT coefficients are wiped out. This (lossy) transformation is done by dividing each of the coefficients in the 8x8 DCT matrices by a weight taken from a quantization table. If all weights are equal the transformation does nothing but if they increase sharply from origin, higher spatial frequencies are dropped quickly. The values in the quantization table are not the part of JPEG standards. Each application must supply its own, allowing it to control the loss compression tradeoff. Most existing compressors start from a sample table developed by the ISO JPEG committee [11]. Subjective experiments involving the human visual system have resulted in the JPEG standard quantization matrix. With a quality level of 50, the matrix renders both high compression and excellent decompressed image quality [10].

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If however, another level of quality and compression is desired, scalar multiplies of the JPEG Standard quantization matrix (QM) may be used. For a quality level greater than 50 (less compression and higher image quality), the standard QM is multiplied by (100-quality level)/50. For a quality less than 50 (more compression, lower image quality), the standard QM is multiplied by 50/quality level. The scaled QM is then rounded and clipped to have positive integer values ranging from 1 to 255. For example, the following QM yields quality levels of 10 and 90.
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Quantizers can be used to identity functions to embed the watermark information. The number of possible values of watermark $W_i$ determines the number of required quantizers. Index is $i$ that select the quantizer. For the case $i = 2$ we have a binary quantizer. To embed one bit $i$, $i \in \{0,1\}$, and image pixel is mapped to the nearest reconstruction point representing the information of $i$.

4. WATERMARK EMBEDDING AND EXTRACTION METHOD

In this paper, a new method of multiple watermarking based on spread transform is proposed, which has good performances in validity and capacity. This section presents a multiple watermarking method based on spread transform, in which the watermark is embedded in the DCT block based on orthogonal projection vectors. The watermarking techniques in which the information is embedded onto the LSB of the image pixel values are unlikely to produce visual artifacts in the image. If an image is altered, the LSB is likely to be changed such that the verification will be able to determine the modification. Such LSB manipulation, however, is not secure against malicious attacks: it is relatively easy to create a system that alters the visual content of an image without changing the LSB of every pixel value, to a degree that the whole image can be modified while the LSB is kept intact. To increase the robustness, watermark is embedded in middle frequency band of quantize coefficients. The term robustness implies here the ability of quality access control through self-noise submission after various signal processing operation [13].

4.1 EMBEDDING OF WATERMARK

- Read the input image to be watermarked.
- Extract the cover vectors from the cover (original) image by first dividing the image into blocks of 8 × 8 pixels and compute DCT for each block.

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- Now, quantize the DCT coefficients with the quantization table of quality factor 75 by dividing each DCT coefficient with the weighting factor of the quantization table and rounding to nearest integer. Quantization table of quality factor 75 is given as:

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<td>25 32 39 44 52 61 60 51</td>
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<td>36 46 48 49 56 50 52 50</td>
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- For extracting the cover vectors, the quantized coefficient in each block is scanned in zigzag order.

Thus converting a 8x8 squared array of quantized DCT coefficients to a 1-D string of 64 elements with the first left representing the DC component and the others 63 representing AC elements called cover vector, because most of the block energy is packed into only a few top-left coefficients, through quantizing so we left DC coefficient for embedding.

- After getting the cover vectors, select the vectors which are orthogonal to each other for getting the different orientation where watermark is to be embed so that different watermark do not mutually interfere. The cover image intensity value is projected to these orthogonal projection vectors to get the different orientations in which the different watermark signals are embedded.

- Consider the binary watermark, add dither $d(w)$ to this watermark using random dithering is also called dither modulation or dither quantization. Dither is an intentionally applied form of noise used to randomize quantization error. Random Dithering is a method of dithering which produces monochrome (black and white) images. Random Dithering works by choosing a
different random value for each pixel in the image which depends on step size Δ. In General, a smaller Δ results in less visibility and poorer robustness while a larger Δ leads to higher visibility and better robustness [11]. If the pixel is more intense (usually a higher number) than the random value becomes white, if not, it becomes black.

- After extracting the vectors, we let quantization step size Δ. So, the watermark signal can be modified by:

\[
W_i = \begin{cases} 
W_i + \Delta/2, & \text{if } V_i \geq 0 \\
W_i - \Delta/2, & \text{if } V_i < 0 
\end{cases}
\]

- A sequence of cover vectors \(V_i = V_1, ..., V_n\) is extracted from each quantized block. Then binary watermark \(W_i\) is then inserted into the \(n\) highest magnitude coefficients of orthogonal vectors excluding the DC component and results in \(V'_i = V_1', ..., V_n'\).

\[
V'_i = V_i + \alpha V_i, \quad W_i = V_i(1 + \alpha W) \quad (2)
\]

Where \(W\) is the corresponding watermark component and \(\alpha\) is the scaling factor to control the strength of watermark (e.g., \(\alpha = 0.1\)).

4.2 EXTRACTION OF WATERMARK

- The coefficients of \(V'_i\) are reversely scanned to extract the cover vectors.
- Then cover vectors are multiplied by JPEG quantization matrix to obtain DCT matrix of 8×8 block.
- Inverse DCT of each block yields the hidden image intensity values for that block.
- Apply DM with the same quantization step Δ on extracted watermark to get the original watermark.

5. EXPERIMENTAL RESULTS

The multiple watermarking method based on spread transform is implemented in which the watermark is embedded in the DCT block based on dither modulation method. Grayscale images are used as the cover works, and binary images are used as the watermark signals. For simplicity, we had used the size of the cover work as 256×256. The two watermarks namely watermark 1 and watermark 2 are used as it is multiple watermarking. Both the watermarks are the binary images of size 32×32.

Firstly, the DCT is applied in the blocks of 8×8 pixels of cover image. Then quantize each DCT coefficient and scan each block coefficients by row in zigzag order to get cover vectors. If the size of the cover image is 256×256, then we can obtain 1024 cover vectors \(V[k] \ (k \in \{1, 2, ..., 1024\})\), where each block has 64 elements. Now we select two orthogonal vectors randomly to embed two watermarks in different orientation so that there is no interference between the two. Finally, different watermark information is embedded into the corresponding orthogonal vectors.

In our experiment we consider the Lena image as our cover image and take two watermark images which are binary images as shown in Fig. 2. A measure of robustness is done for a given bit-error rate at a given distortion level and embedding rate. We experimentally determined achievable better rate-distortion-robustness by implementing STDM. As the embedding strength of watermarking algorithm is increased, there will be a corresponding decrease in the BER when the watermark is extracted as shown in Fig.3. Experimental results also show that the presented method can avoid the interference of one watermark signal with another very well, which is one of the most important and difficult problems for a multiple watermarking algorithm.

Fig 3. Bit Error Ratio of both Watermarks against Quality factor

After some signal processing operation extracted Lena Image and watermarks are shown in Fig. 4. This scheme can extract the watermark effectively and based on the extracted watermark the scheme suppress self noise that results in the improvement of the quality.
CONCLUSION
The convenient structure of dither modulation, which is easily combined with error-correction coding, allows the system designer to achieve different rate distortion–robustness tradeoffs by tuning parameters such as the quantization step size. A great work is the use of QIM techniques in watermarking applications, and indeed these represent some especially interesting design challenges. The proposed method is superior in terms of embedding capacity, PSNR and survival to number of image attacks. The experimental results show that our scheme is robust against various image processing operations such as, filtering, lossy jpeg compression and noise addition leading to the access of better quality of the image by the authorized users. The scheme is simple, fast, cost effective and easy to implement. Future work should focuses on the design of extraction function and synchronization schemes against the geometric attacks.

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