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Robust Reversible Watermarking Using Logarithmic Quantization Index Modulation Techniques

M.Subbulakshmi[1], M.Vijayaraj2
[1]Department of ECE, National College of Engineering, Maruthakulam-627151, Tamilnadu, India.
Email: subbu_june23@yahoo.co.in
[2]Department of ECE, Government College of Engineering, Tirunelveli -627007, Tamilnadu, India.
Email: m_vijayaraj@yahoo.com

Abstract

In this paper, the logarithmic function is first applied to the host signal then the transformed signal is quantized by Quantization Index Modulation (QIM) technique for embedding the watermarking data with in an image. This is a visually better way to embed data within a message signal. Then the pseudo noise is mixed for transmission purpose. The embedded watermarked signal is retrieved using inverse transform to the extraction is done by Minimum distance decoder technique. There after the calculation of optimum parameter for the data embedding with minimum quantization distortion is derived and the probability of error is to be analytically and graphically calculated. Finally the system is designed to obtain, maximizing the information embedding rate, minimizing the distortion between host and watermarked signal & improving the robustness of embedding.

Keywords: Inverse Transform, LQIM, Minimum Distance Decoder, QIM, Robust Reversible Watermarking.

Introduction

A number of applications have emerged recently that require the design of systems for embedding one signal known as “embedded signal” or “watermark” within another signal, known as host signal. This paper specify methods in terms of the efficiency with which are trade off rate, distortion level and robustness. For demonstration, some minimum amount of embedding rate requirement and maximum acceptable level of embedding rete, the most effective embedding method is the higher the robustness that can be achieved. After quantizing the host signal, it change the quantization value to embed information.

According to QIM, the watermark data is embedded by quantizing the host (original) signal, a feature using a set of quantization. In that each quantization is associated with a different message. A simple logarithm function has been used for quantization. Thus, the quantization distortion due to this cannot be controlled and minimized regarding the host (or) message signal embedding. In this work, inspired by a standard usually used in the Processing of speech signals called μ-Law and A Law (companding law), and propose a new technique for this text.

In [3], the host signal features are transformed using a logarithmic function and then quantized uniformly regarding the watermark data. The watermarked data is obtained by applying inverse transform to the quantized data. Then using Minimum distance decoder method the watermark data is extracted. The optimum value of μ *and A* produces the results in minimum quantization distortion is obtained analytically according to the host signal distribution. In [1], the quantization algorithm based on DFT domain is researched. The principle and performances of this algorithm are analyzed theoretically, and its disadvantages of fixed quantization step and susceptible to amplitude scale and resampling attacks are noted out. The expressions of embedding distortion level and BER against AWGN and amplitude scale attacks are deduced. These expressions supply us with theoretical method to evaluate the performances of transparency and robustness.

Chen and Wornell (2001) was proposed [2], the problem of embedding one signal .i.e. digital watermark within another host signal to form a composite signal. The embedding process is proposed to obtain efficient tradeoffs among the three conflicting goals of maximizing the message signal embedding rate, reducing the distortion between the host signal and composite signal of also maximizing the robustness of the embedding message signal. In this paper, a new classes of embedding methods namely quantization index modulation (QIM) and distortion-compensated Quantization Index Modulation .i.e. DC-QIM, and develop convenient realizations in the form of dither modulation. Using deterministic methods to calculate Robust Reversible Watermarking methods in that QIM is “provably good” against arbitrary bounded and fully informed security attacks, which improves several copyright applications. It achieves provably better rate distortion–robustness tradeoffs than currently popular spread-spectrum and low-bit(s) modulation methods.

Kalantari and Ahadi (2009) were proposed a method, for logarithmic Quantization Index Modulation is proposed. In this way a logarithmic function is first applied to the host signal. Then the transformed signal is quantized using uniform quantization as conventional QIM to embed watermark data within host signal. Finally using inverse transform the watermarked signal is obtained. The watermark extraction is performed using minimum distance decoder in [3]. The optimum parameter for data embedding signal with minimum quantization error rate is derived and also the probability of error is calculated and verified by simulation. Furthermore data hiding using secret key is proposed and the Probability of error is obtained. μ - Law is used for companding purpose in this method.

S.Moulin and Koetter was proposed [4] a method, a class of information embedding methods called quantization index modulation (QIM) along with several low complexity realizations based on dither modulation and uniform scalar quantization. This type of methods can also be combined with suitable preprocessing and post processing steps such as distortion compensation. In this paper we have determined information embedding capacities in the case of Gaussian host signals and additive Gaussian noise with arbitrary statistics values. The statistics capacities in these cases equal that of the white host signal and white noise. When applied this to multimedia applications such as hybrid transmission and embedding of authentication signals, these results imply a capacity of about 1/3 b/s for every Hertz of host signal bandwidth and dB drop in received host signal quality. QIM methods exist that achieve performance within 1.6 dB level of these capacities, and even this small gap can be removed with distortion compensation.

In [4], Tan proposed a Quantization index modulation which is one of the popular digital audio watermarking methods. The main aim of the algorithm is analyzed firstly then embedding and extracting techniques of less computational complexity are evaluated. The performance of this algorithm is based on DFT (discrete Fourier transform) coefficients and its disadvantages are pointed out. Firstly, the embedding distortion (defined as mean square error) is minimized. The conclusions that transparency is in proportion to the square of quantization step and small DFT coefficient leads to bad transparency are reached and then based on the equation, the bit error rate expressions under additive white Gaussian noise and amplitude scale values are reduced. In the same time, the influence of re-sampling perturbation is investigated. As a result, the robustness to additive white Gaussian noise only relates to the quantization step and the algorithm is susceptible to amplitude scale and re sampling attacks.

The main aim of this paper is to achieve, Maximizing information embedding route, Minimizing distortion between host & composite signal, &Maximizing robustness of embedding.

Quantization Index Modulation

One class of embedding methods that achieves very well, and in some cases optimal, rate-distortion robustness trade-offs are so-called quantization index modulation (QIM) methods. In this section, describe the basic principles behind this type of methods, some low-complexity realizations, and noted some known attractive performance features of these methods

Basic Principles

One can view the embedding function **s**(x, m) as a function of x, in that each function in the pointed out by m .Here denote the functions in this ensemble value as **s**(x, m) to point out this view. If the embedding produced distortion is to be very small, then each and every function in the ensemble must be close to an identity function in some form. If all of these approximate identity functions are quantizes in time, then the type of embedding method is called QIM method. Thus, the quantization index modulation method 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 quantizes or sequence of quantizes.

Logarithmic Quantization Index Modulation

The proposed method called logarithmic quantization by which stronger watermark can be inserted that introduces less distortion to the host signal. The rational thing behind the logarithmic quantization is that since signal's amplitudes are more concentrated around zero, more step sizes should be devoted to quantizing smaller amplitudes and less should be associated to the larger amplitudes.

General Information About Embedding

Problem Model

The information about embedding problem is generally described by Figure 1

In this figure, there is a host-signal vector $x \in R^n$ into which some information u is going to embed. The embedding must be at a rate of R_u bits per dimension (host-signal sample) [3].

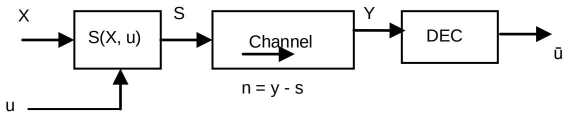

Figure 1: General Information Embedding Problem Model

A message m is embedded in the host-signal vector X using some embedding function S(X, u). A perturbation vector n corrupts the combination of host and watermarked signal i.e. composite signal s. The decoder extracts an estimate of m from the noisy channel output y. An embedding function maps the host signal x embedded information m a composite signal $s \in R^n$ subject to some distortion constraint.

The different embedding techniques are used for comparision purpose such as CDMA, LSB and DCT. The composite signal s is subjected to various common signal processing manipulations such as lossy compression, random noise and resampling as well as the attempts to remove the embedded information from that. These performance level occur in some channel, which produces an output signal $y \in R^n$. A decoder extracts a calculation of the embedded information based on the channel output [4].

The different images are used for embedding function and the watermarked image PSNR rates are,

Table 1: Watermarked Image PSNR And MSE Value Using CDMA

NO	IMAGE	PSNR value	MSE value
1	Lena	29.3009	72.2451
2	Cameraman	29.5934	71.4065
3	Moon	31.1010	50.4636
4	Coins	29.5757	71.6979
5	Lifting body	29.5961	71.3629

Table 2: Watermarked image PSNR and MSE value using DCT

NO	IMAGE	PSNR value	MSE value
1	Lena	42.4016	3.3967
2	Cameraman	41.3854	5.0494
3	Moon	46.5056	1.6396
4	Coins	42.3168	4.1439
5	Lifting body	46.2246	1.8723

Table 3: Watermarked image PSNR and MSE value using LSB

NO	IMAGE	PSNR value	MSE value
1	Lena	50.6787	0.5009
2	Cameraman	51.0593	0.4976
3	Moon	50.9952	0.5050
4	Coins	51.1345	0.5008
5	Lifting body	51.1345	0.5008

Logarithmic Quantization Index

Modulation Using M Law

A number of applications have emerged recently [1] that require the design of systems for embedding one signal, sometimes called an “embedded signal” or “watermark,” within another signal, and is known as a host signal. The embedding is obtained such that the embedded signal is “hidden,” i.e., causes no high level disturbances to its original. At the same time, the embedding must be robust to common degradations of the watermarked signal. This also leads to a more uniform signal-to-quantization error ratio for different amplitudes

Compression Function

In order to perform logarithmic quantization, the combination of host and watermarked i.e. composite signal must be transformed using the following compression function:

$$c = \ln (1 + \mu |x| Xmax) /\ln (1 + \mu) \tag{1}$$

Where μ is used to mention the compression level and $Xmax$ is the maximum value of the host signal features. These values should be known to the decoder. Since the maximum value in the host signal may be disorderly large, the maximum value should be defined regarding the probability density function of the host signal. When μ tends toward infinity, the compression function can be proved to reduce to a simple logarithm function.

Expansion Function

The transformed signal is then used for data embedding the quantized data is then expanded, in order to recover the watermarked signals as follow:

$$\mathbf{y = sgn(x)\ Xmax\ \mu\ [(1 + \mu)\ z - 1]} \qquad \mathbf{(2)}$$

Where sgn $(\cdot)$ is the sign function and z is the quantized signal. In order to extract the watermark data, the minimum distance decoder is involved. The Minimum distance decoder can be implemented in the original domain or the transformed domain. Finally, this research work analyzed both analytically and experimentally, that the implementation in the original domain results in better robustness.

Logarithmic Quantization Index

Modulation Using A Law

The use of a non-uniform quantizer is equivalent to passing the base band signal through a compressor and then applying the compressed signal to a uniform quantizer. The process of uniform quantization corresponds to A=1.This techniques also produces a more accurate uniform signal-to-quantization error ratio for different amplitudes

Compression Function

This also leads to a more uniform signal-to-quantization error ratio for different amplitudes. In order to perform logarithmic quantization, the host signal must be transformed using the following compression function:

$$V=A|M|/1+\mathrm{Log}A,\ 0<=|M|<=1/A \qquad (3)$$

$$V=1+\mathrm{Log}\ (A|M|)/\ 1+\mathrm{Log}\ A,\ 1/A<=\ |M|<=1 \qquad (4)$$

Expansion Function

To restore the signal samples to its correct relative level, use a device in the receiver with a characteristic complementary to the compressor, such a block called an expander. Then the Transformed signal is then used for data embedding the quantized data is then expanded to obtain the watermarked signals follow:

$$F^{-1}(y) = \mathrm{sgn}\ (y)\ (|y|(1+\ln\ (A))) \qquad (5)$$

For values $|y|<1/1+\ln\ (A)$

$$F^{-1}(y) = \mathrm{sgn}\ (y)\ (exp|y|(1+\ln\ (A))-1)/A \qquad (6)$$

For values $1/1+\ln\ (A) \leq |y|<1$

Watermark Extraction

The original watermarked signal is extracted from the expansion signal. The reverse process of embedding is called Watermark Extraction. The original watermark signal is obtained by this process. The message signal is also named as watermark signal.

Experimental results and discussions

Simulations are conducted with two datasets of natural images.

Figure 2: Lena 512(host image) **Figure 3:** watermark

Figure 4: Watermarked Image

Companding Method

In that method, the various μ and A value were taken and apply the transformation function and finally compare the PSNR values.

Figure 5: μ-law compressed image **Figure 6:** A-law compressed image

Figure 7: μ-law expansion image **Figure 8:** A-law expansion image

Table PSNR Value of Compression and Expansion Using CDMA with μ value

NO	μ-law value	Compression PSNR value	Expansion PSNR value
1	0.1	29.1335	-42.4667
2	10	12.5923	-42.4659
3	100	9.0392	-42.4637
4	200	8.5060	-42.4631
5	256	8.3489	-42.4643

Table The PSNR Value with A value using CDMA

NO	A-law value	Compression PSNR value	Expansion PSNR value
1	0.1	5.0062	-27.1082
2	10	11.1556	18.4906
3	100	8.3391	7.5808
4	200	7.9612	6.7263
5	256	7.8496	6.5240

Table PSNR Value of Compression and Expansion using DCT with μ value

NO	μ-law value	Compression PSNR value	Expansion PSNR value
1	0.1	37.8268	-42.4479
2	10	12.6144	-42.4470
3	100	9.0256	-42.4470
4	200	8.4935	-42.4480
5	256	8.3369	-42.4479

Table PSNR value with A value using DCT

NO	A-law value	Compression PSNR value	Expansion PSNR value
1	2	21.9774	21.7136
2	5	13.5252	14.7672
3	10	11.1507	18.5048
4	25	9.5544	12.0632
5	50	8.8346	9.1370

Table PSNR values of compression and expansion using LSB with μ value

NO	μ-law value	Compression PSNR value	Expansion PSNR value
1	0.1	40.6271	-42.4200
2	10	12.6643	-42.4235
3	100	9.0468	-42.4230
4	200	8.5111	-42.4000
5	256	8.3534	-42.4235

Table PSN R value with A value Using LSB

NO	A-law value	Compression PSNR value	Expansion PSNR value
1	0.5	9.7321	51.1332
2	0.7	27.0401	51.1332
3	1.0	51.1332	51.1332
4	1.1	52.0627	42.4246

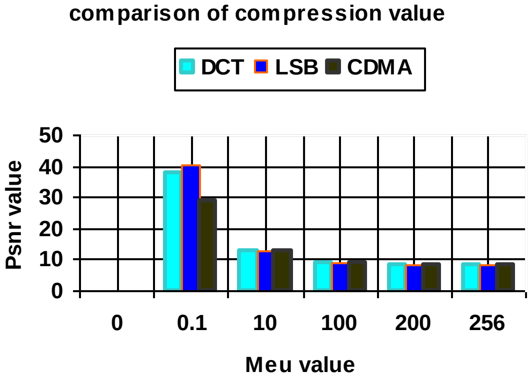

Figure 9: Comparison of three techniques using PSNR value and μ value

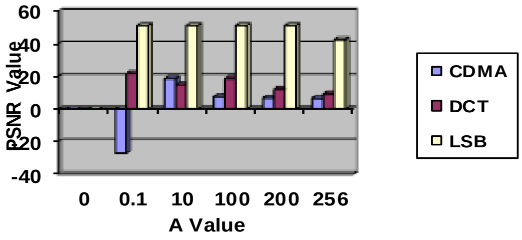

Figure 10: Comparison of three techniques using PSNR value and A value

Performance Analysis

Performance Analysis The performance of this watermarking algorithm is evaluated in terms of peak signal-to-noise ratio (PSNR) and Mean squared error (MSE) values. Watermarking the image lightly degrades the original images as far as peak signal to noise ratio (PSNR) is noted. But it is good within the visual perception and it does not readily visualize the watermark and the degradation level. The visual quality of the watermarked image is calculated in terms of PSNR.

$$\text{PSNR} = 20\log_{10}(\text{MAX}^2/\text{MSE}) \tag{7}$$

The mean square error (MSE) indicates the difference between the original image and the watermarked image.

$$\text{MSE}(x,y) = \frac{1}{MN}\sum_{y=1}^{M}\sum_{x=1}^{N}\left[I(x,y) - I'(x,y)\right]^2 \tag{8}$$

Where X-original image and Y-watermarked image
N-size of the original image.

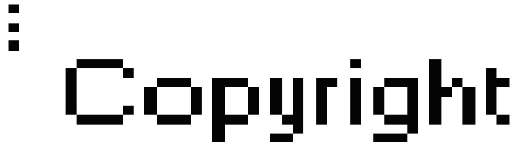

Figure 11: Recovered Watermark

Conclusion

In the Proposed method a novel quantizer arrangement for quantization-based data hiding called LQIM, was proposed. In this regard, a new technique similar to the μ-law standard is used to transform the host signal and quantize the data in the transformed domain and A-Law standard also used. Optimum μ and A law was also found which results in introducing minimum distortion to the host signal. Using this technique, stronger watermark can be inserted in the host signal in comparison with UQIM with the same quality of Watermarked data. For both the μ and A-law, the dynamic range capability of the compander improves with increasing μ and A respectively. This technique can be used in military and all government level sector works. The PSNR for low level signals increases at the expense of the PSNR for high range of signals. To accommodate these two contradiction requirements, a compromise is usually initiated in choosing the value of parameter μ for the law and parameter A for the A law.

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