European Journal of Applied Sciences 9 (1): 27-36, 2017
ISSN 2079-2077

DOI: 10.5829/idosi.ejas.2017.27.36

# Robust Reversible Watermarking Based on Normalized Correlation Combined with Cdma Techniques

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**Abstract:** In this paper, the Normalized Correlation based Quantization Index Modulation (NCQIM), Least Significant Bit (LSB) and Code Division Multiple Access (CDMA) techniques are combined for reversible watermarking. By using this method, the normalized correlation is calculated between the host signal and a random signal. Then the modulation is performed on generated normalized correlation by using codeword from the codebook associated with the embedded information. The codebooks are designed by using uniform quantizer for modulation. Then the LSB method is used. In this method, the LSB values of each pixel in the image are modified. Then CDMA technique is applied. Then watermark embedding is done through the above performed modulation. This watermark signal is used to produce minimum distortion in valumetric scaling and additive noise attacks. At decoder side, the watermark is extracted using the technique which is done at embedder side. The proposed method is simulated on different images and the watermark imperceptibility is achieved by using the parameter Peak Signal to Noise Ratio (PSNR). The robustness is increased by reducing Bit Error Rate (BER). This proposed technique achieves high embedding capacity in high noise environment, high robustness when compared to conventional Quantization Index Modulation (QIM) methods.

**Key words:** Bit Error Rate · Imperceptibility · Mean Square Error · Normalized correlation · Peak Signal to Noise Ratio · Uniform Quantizer

## INTRODUCTION

In the current trends of the world, due to the recent advancement, most of the individuals prefer to use the internet as the primary medium to transfer data from one region to another region across the whole world. The data transmission is made very simple, fast and accurate using the net facility. However, security is the main issue while sending data over the internet. The private content can be hacked in various ways. Therefore it becomes required to take data security into consideration. Data security means protection or safeguard of data from unauthorized users or hackers and providing high security to prevent data alteration. In order to overcome the problem of the security attacks in data transfers over the internet, digital image watermarking technique is used. It is one of the prominent methods to fulfill the gap between copyright issues and digital distribution of data content.

In addition to copyright protection, watermarking has many other applications, including authentication, access control, broadcast technology, communication lines. One of the most important technique proposed is Quantization Index Modulation (QIM), where watermark embedding is obtained by quantizing the host or input signal with a quantizer level chosen among a full set of quantizers that are each associated with a different message. The basic implementation method of QIM, is known as Dither Modulation (DM), adopts a large set of scalar and uniform quantizes. Later, the distortion compensation method was combined with the QIM method, resulting in the Distortion Compensated QIM (DC-QIM). DC-QIM follows Costa's procedures and closes the gap to capacity. The Scalar Costa Scheme (SCS) proposed in can be regarded as a special example of DC-QIM. The theoretical presentation of QIM methods has been extensively investigated. In these basic type algorithms, the amplitude

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values of one single pixel or of a set of pixels are straightforwardly quantized. Digital watermarking method can be observed as a communication issue with side information. The side information is knowledge of the host signal content, which is obtainable to the watermark embedder. The channel distortion level creates an unknown noise source. For this issue, an important result was given by Costa that the capacity of a channel with an additive Gaussian noise and some of the extra noise relevant known data to the encoder is the similar as that of the channel in that this extra noise is absent state.

The Logarithmic QIM (LQIM), performing a logarithmic transform method on the input signal before quantization. Due to the use of logarithmic transformation, LQIM method obtains non-uniform quantization step sizes for watermark embedding step, which makes it have perceptual benefits. Some gain invariant features have been utilized in quantization-based watermarking method with a particular significance on Volumetric Scaling Attack (VSA). Typically, the signal for quantization was constructed by the method of dividing the host signal value by its arithmetic mean in. The angle feature formed by the host signal vector was used for quantization in Angle QIM (AQIM). The idea of AQIM was also applied to improve the performance of STDM in. Normalized Correlation based Quantization Index Modulation (NCQIM) is the extension of QIM.

Normalized Correlation based Quantization Index Modulation (NCQIM) is the extension of QIM. In this paper, we refer to as Normalized Correlation based Quantization Index Modulation (NCQIM) Combined with Least Significant Bit (LSB) and Code Division Multiple Access (CDMA) techniques that is, in general, many specific situations optimal. Where the feature signals for modulation is the Normalized Correlation formed by the host signal and a random signal. To perform the information level modulation, the structured codebooks are designed using uniform quantizes. The watermarked signal is created by the embedding function in order to form the modulated NC with the random signal. The LSB and CDMA method is used before embedding the watermarked message. The watermark imperceptibility and robustness of this method is achieved using the parameters Peak Signal to Noise Ratio (PSNR) and Bit Error Rate (BER) respectively.

**Related Works:** In digital watermarking, the side information is knowledge of the host signal, which is available to the watermark embedded. I.J. Cox, M.L. Miller and A. McKellips suggested [1] that perceptual modeling had significant utility for watermarking. If a watermark is to be robust, i.e. survive, common signal processing that is routinely performed on the same content, then the watermark signal must be employed in the perceptually significant components of the content. They suggested that the watermark signal should be modified based on the perceptual properties of the content. A perceptual model is often used to increase the power of the signal while maintaining fidelity by amplifying the signal wherever the model's sensitivity is low.

Brian Chen and Gregory W. Wornell suggested [2] that a new class of embedding methods, termed QIM and Distortion Compensated QIM (DCQIM) Using deterministic models to evaluate digital watermarking methods, they show that QIM method is provably good against arbitrary bounded and fully informed attacks, which arise in several copyright secure applications, it achieves provably better rate distortion robustness tradeoffs than currently popular SS and Low Bit Modulation (LBM) methods. This method has purely additive function.

J.J. Eggers, R. Bauml, R. Tzschoppe and B. Girod, [3] give a complete performance analysis of the Scalar Costa Scheme (SCS), which is a suboptimal techniques using scalar embed and reception functions. Information theoretic bounds and simulation results with state of the art type coding techniques are compared. Further, reception after amplitude scaling attacks and the invertibility of SCS embedding are investigated. Thus, information embedding might be a more correct term than digital watermarking since the robustness requirement is weakened to robustness against AWGN.

F. Bartolini, M. Barni and A. Piva shows that, the performance of STDM watermarking [4] in the presence of two important classes of non-additive attacks, such as the gain attack with noise addition and the quantization attack are evaluated. More specifically, the gain attack properly models linear filtering and, to a lesser extent, histogram equalization or loudness changes and the quantization attack gives a good indication of the performance of STDM in the presence of lossy compression such as JPEG coding for the case of still images. The analysis is developed under the assumption that the host features are IID Gaussian random values and a minimum distance criterion is used to decode the hidden information.

F. Ourique, V. Licks, R. Jordan and F. Perez-Gonzalez shows that, AQIM [5] works by quantizing the angle formed by the host signal vector with the origin of a hyper spherical coordinate system. Hence, AQIM's invariance to amplitude scaling can be shown by construction. In addition to amplitude scaling robustness, AQIM's performance to AWGN attacks was assessed experimentally by means of Monte Carlo experts simulations. Experimental value results are presented for the bit error rate performance of AQIM under AWGN attacks. A new QIM scheme is provably insensitive to amplitude scaling attacks. It is shown that AQIM is robust against any amplitude scaling parameter.

F. Balado suggested that, a new geometric interpretation of additive and multiplicative SS watermarking [6] with repetition coding and decoding is used. The interpretation gives an intuitive rational on why the multiplicative scheme achieves better in additive independent attacks and it is also used to produce an original quantitative performance analysis. The geometric considerations, explain the advantages of multiplicative spread spectrum with repetition of the proposal of a novel side informed STDM like method, which is known as Sphere Hardening Dither Modulation. This method is the one side informed counterpart of multiplicative SS with repetition coding, in STDM is the side informed counterpart level of additive spread spectrum with repetition coding technique.

V.H. Mankar, T.S. Das and S.K. Sarkar solved the problem based on Angle Quantization Index Modulation (AQIM) within STDM framework [7]. AQIM method embeds the information by quantizing the angle formed by the host-signal vector with respect to the origin of a hyper spherical coordinate system as opposed to quantizing the amplitude of pixel values. The AQIM method, which keeps the amplitude value of pixels unchanged, is completely invariant to scaling distortion theoretically.

A new method for LQIM is proposed by N.K. Kalantari and S.M. Ahadi [8], in this a logarithmic function is first applied to the host or input signal. Then the transformed signal is quantized using uniform quantization as conventional QIM to embed watermark data within that. Finally using inverse transform the watermarked signal is achieved. The watermark extraction is done using minimum distance decoder. The optimum parameter for data embedding with minimum quantized distortion is derived. It is used for only vector quantization.

**Proposed Method:** In this paper, the NC-QIM, LSB and CDMA techniques are combined for embedding and extracting the watermarked message. This method is used to increase the robustness of the watermarked image. Most schemes require that the watermark be recovered even if the watermarked image is distorted and this distortion may be accidental or deliberate. So the watermarked image should be robust against any attacks. The host signal or input signal is transformed into the feature signal. In this transformation, the normalized correlation is calculated between the host signal and the random signal. Then the modulation is performed on the feature signal and watermark message. The LSB method is applied in this modulated signal. Then CDMA method is applied. Then the embedding function is performed to produce the watermarked signal. This watermarked signal goes through the channel. At decoder side, the received signal is transformed into feature signal by using NCQIM technique which is done at embedded side and LSB method is used. Then the watermarked message is extracted from feature signal.

**Normalized Correlation Based Quantization Index Modulation:** In the design methodology of the feature modulation watermarking method, a serious issue is to generate the feature signal from the host signal. For this purpose, the features should be selected by taking into account the properties of the utilized modulation technique. The feature signals are obtained by using PRNG seeded with the secret key. The host feature signal ($f_x$) by computing the normalized correlation of the host vector (x) and a random vector (u) is,

$$f_x = x^T u / \|x\| \, \|u\| \tag{1}$$

PRNG is an algorithm for creating a sequence of numbers whose properties almost equal to the properties of sequences of random numbers. It is completely calculated by a small set of initial values called the PRNG's seed. Pseudo random numbers are created by providing a random seed value to PRNG. Normalization is a process that changes the range of pixel intensity values. In watermarking, the normalized correlation is calculated between the host signal and random signal. The random signals are made by a PRNG seeded with the secret key and also used for the generation of host signals and watermarked signals. This increases the probability of correct detection [9-25].

**Quantization Index Modulation:** The QIM used to embedding information by modulating a set of indices with the embedded information and then quantizing the input value with the related sequence of quantizes. In this method the amplitude of single pixel (or) a vector of pixels is quantized using quantizes. Given the quantization step $\Delta$ and a dither value d □ $[-\Delta/4, \Delta/4]$, the sets $□_0$ and $□_1$ are respectively represented by,

$$□_0 = \{ k\Delta+d/k \, □ \, z\} \; n \; [-1, 1] \qquad (2)$$

$$□_1 = \{k\Delta+d+1/2\Delta|k \, □ \, z\} \; n \; [-1, 1] \qquad (3)$$

This is used for normalized correlation. The normalized correlation $f_x$ is then modulated with the hidden symbol m by selecting a code word $f_m$ from the corresponding codebook $□_m$ to replace $f_x$. This can be implemented by a quantization operation.

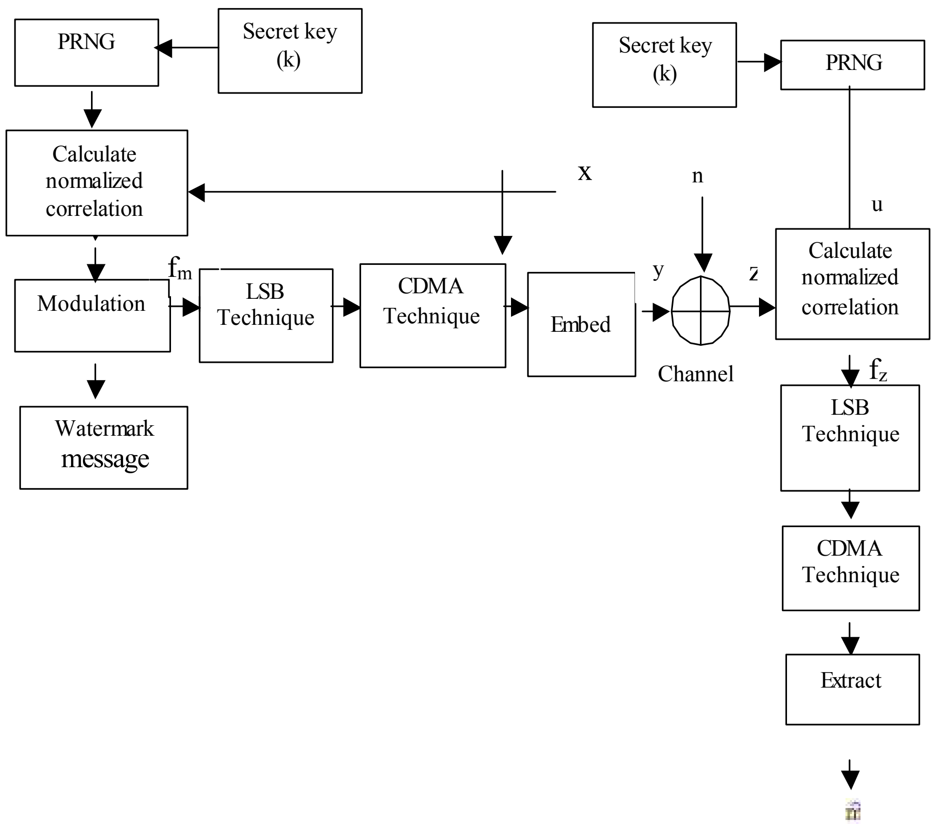



Fig. 1: Block diagram of the watermarking model

**Lsb Based Watermarking:** In this technique, the watermarking process is done in two methods: Watermarking Embedding techniques and Watermark Recovery techniques. In watermarking embedding the images are process in pixels and generate the watermark to cover original signal. In the embedding process, the size of the original image is obtained. Then the maximum message size to be embedded is determined based on the original image. Next the size of the key image is calculated. Then the watermark image is reshaped into vector. After this, the size of the watermark image is smaller than that of cover image. The watermark image is embedded into the cover image using LSB.Watermark extraction is done by the reverse process.

**Cdma Based Watermarking:** In this, we propose a CDMA based multiple-user sharing-channel watermarking technique which is useful for applications in multiple-user sharing copyright protection. Although there are many watermarking algorithms related to CDMA, these single watermarking algorithms only utilize the spread spectrum characteristic of CDMA to enhance the robustness of the algorithms and do not make full use of its potential peculiarity of supporting multiple-user sharing channel. To detect the watermark, each seed is used to generate its PN sequence, which is then correlated with the complete image. If the correlation level is high, that bit in the watermark is set to "1", otherwise a "0". The same method is then repeated for all the values of the watermark.

CDMA improves on the robustness of the watermark significantly, but requires several orders more of calculation.

In this, a novel approach based on the unconventional Random Encoding SS method is proposed for recovering the spreading sequence of watermark signal without any information from the transmitter. It is contribute a higher secure feature by using of the time varying random encoded spread spectrum.

**Watermark Embedding and Extraction Function:** The embedding function Em (.) is designed to produce a watermarked signal. In this model, the information modulation is not directly done on the input signal itself, but based on a feature signal transformed method from the host signal, which is quite different from the existing watermarking methods. The performance improvement can be brought about if an appropriate feature is utilized. The watermark signal is embedded in the original image after applying LSB technique. The watermarked signal goes through a particular channel, where it might be exposed to several common signal processing manipulations. The Gaussian noise is added in the channel to reduce the losses. This Gaussian noise is added in the channel to produce distorted watermarked signal.

The distorted watermarked signal can be written as,

$$z = y + n \tag{4}$$

Where,
z – Distorted watermarked signal,
Y–Watermarked signal,

**Watermark Extraction:** At the decoder side, the received signal z is first transformed into the feature signal $f_z$ as done at the embedded side. Then, a message $\hat{m}$ is extracted from $f_z$ according to the correspondence between the watermark content and the used the same feature level, which is established during the information modulation process and a message is extracted from $f_z$.

**Parameter Analysis**

**Watermark Imperceptibility:** Imperceptibility means that the watermarked content is perceptually indistinguishable from the original image. This property is related to the robustness of the watermark and hence an optimal balance between imperceptibility and robustness must be achieved by the watermarking scheme. Imperceptibility can be measured using Peak Signal to Noise Ratio (PSNR) between host and watermarked image and Root Mean Squared Error (RMSE). The PSNR value is calculated by using Mean Squared Error (MSE).

**Peak Signal to Noise Ratio:** The visual quality of the embedded images can also be measured using the PSNR.

It is the most easily defined by the Mean Squared Error (MSE). The PSNR is defined as

$$PSNR = 10\log_{10} (MAX^2/MSE) \text{ in decibels} \tag{5}$$

where,
MAX - Maximum pixel value of the frame,
MSE - Mean Squared Error

The MSE measures the statistical difference in the pixel values between the original and the reconstructed image. The MSE is defined as,

$$MSE(x,y) = \frac{1}{MN}\sum_{y=1}^{M}\sum_{x=1}^{N}[I(x,y) - I'(x,y)]^2 \tag{6}$$

where,
X - Original image,
Y - Watermarked image,
M, N - Size of the original image.

The RMSE is a quadratic scoring rule which measures the average magnitude of the error. It is calculated by using the formula,

$$RMSE = sqrt(MSE) \tag{7}$$

**Robustness:** The robustness can be achieved by using the parameter BER. Bit Error Rate is determined by Inverse of PSNR values.

$$BER = \frac{1}{PSNR} \tag{8}$$

The more is BER lesser will be the quality of the Watermarking technique. So BER is inversely proportional to PSNR. More the value of BER lesser will be PSNR value.

**Result Analysis:** In this paper the simulation process is implemented in MATLAB using different types of host images and watermark images. For analysis purpose gray scaled image is used. The opted host (original) and watermark images are as follows:

The performance evaluation can be analyzed by using the Peak Signal to Noise Ratio (PSNR). The following figures represent the extracted watermark images with several attacks of the proposed scheme. The different levels of values of PSNR & MSE for different images are listed in Table 2 and 3.

Table 1: The original image and corresponding watermarked images

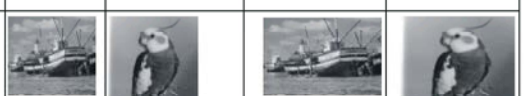
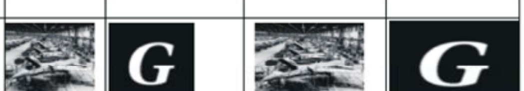
| S. no | Original Images | Original Watermark | Watermarked Images | Recovered Watermark |
|---|---|---|---|---|
| 1 |  | | | |
| 2 |  | | | |
| 3 |  | | | |
| 4 |  | | | |
| 5 |  | | | |
| 6 |  | | | |
| 7 |  | | | |
| 8 |  | | | |
| 9 |  | | | |
| 10 |  | | | |

Table 2: Comparison of PSNR value

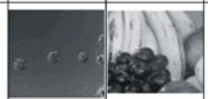
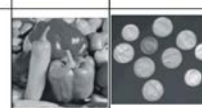
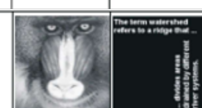
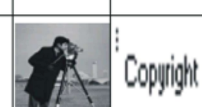
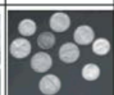
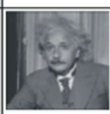
| S.no | Original Images | Watermark Images | PSNR value of NCQIM | PSNR value of NCQIM, LSB | PSNR value using NCQIM, LSB, CDMA |
|---|---|---|---|---|---|
| 1 |  | | 44.9600 | 45.6650 | 48.3650 |
| 2 |  | | 48.0021 | 48.6051 | 55.8901 |
| 3 |  | | 45.4116 | 45.9504 | 49.6891 |
| 4 |  | | 45.4745 | 45.9944 | 49.3075 |
| 5 |  | | 53.5258 | 53.7265 | 55.2681 |
| 6 |  | | 45.9297 | 46.2213 | 47.7285 |
| 7 |  | | 48.7510 | 49.2098 | 50.1713 |
| 8 |  | | 45.9314 | 46.1259 | 48.6234 |
| 9 |  | | 50.9812 | 51.7258 | 52.3651 |
| 10 |  | | 49.2315 | 49.7821 | 50.7268 |

Table 3: Comparison of Mean Squared Error

| S.no | Original Images | Watermark Images | MSE value of NCQIM | MSE value of NCQIM,LSB | MSE value of NCQIM, LSB, CDMA |
|---|---|---|---|---|---|
| 1 |  |  | 2.09 | 1.78 | 1.10 |
| 2 |  |  | 1.03 | 0.89 | 0.18 |
| 3 |  |  | 1.88 | 1.66 | 0.89 |
| 4 |  |  | 1.86 | 1.65 | 0.90 |
| 5 |  |  | 0.28 | 0.27 | 0.19 |
| 6 |  |   | 1.66 | 1.55 | 1.20 |
| 7 |  |  | 0.87 | 0.78 | 0.71 |
| 8 |  |  | 1.65 | 1.59 | 0.98 |
| 9 |  |   | 0.52 | 0.43 | 0.37 |
| 10 |  |   | 0.77 | 0.67 | 0.53 |

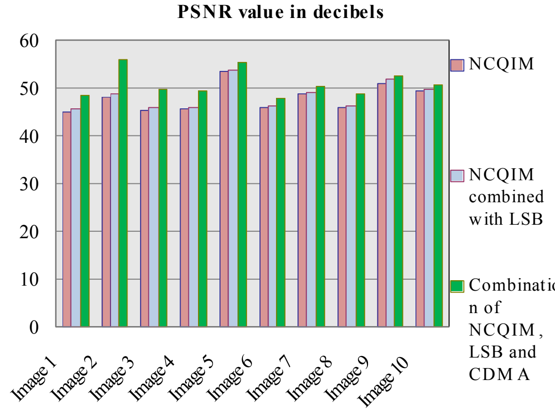



Fig. 2: PSNR performance of various images

Also for different images the values of RMSE and Bit Error Rate also changes. The different values of Root Mean Square Error and Bit Error Rate for different images have been listed in Table 4 and 5.

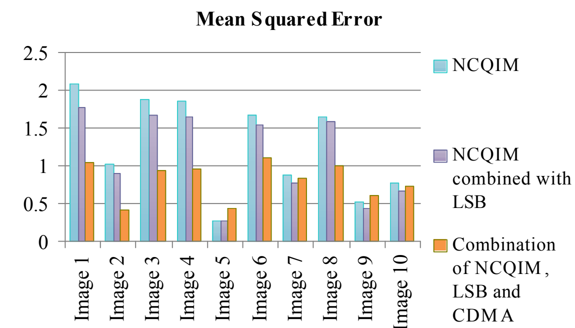
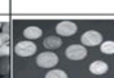



Fig. 3: MSE performance of various images

Table 4: Comparison of Root Mean Squared Error

| S.no | Original Images | Watermark Images | RMSE value of NCQIM | RMSE value of NCQIM ,LSB | RMSE value of NCQIM, LSB, CDMA |
|---|---|---|---|---|---|
| 1 |  |  | 1.4457 | 1.3342 | 1.0488 |
| 2 |  |  | 1.0149 | 0.9434 | 0.4242 |
| 3 |  |  | 1.3711 | 1.2884 | 0.9433 |
| 4 |  |  | 1.3638 | 1.2845 | 0.9486 |

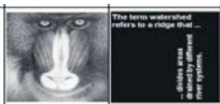
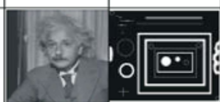
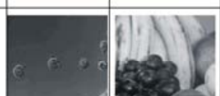
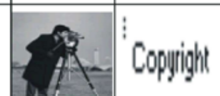
| | | | | | |
|---|---|---|---|---|---|
| 5 |  | | 0.5292 | 0.5196 | 0.4358 |
| 6 |  | | 1.2884 | 1.2449 | 1.0954 |
| 7 |  | | 0.9327 | 0.8832 | 0.8426 |
| 8 |  | | 1.2845 | 1.2609 | 0.9899 |
| 9 |  | | 0.7211 | 0.6557 | 0.6082 |
| 10 |  | | 0.8774 | 0.8185 | 0.7280 |

Table 5: Comparison of Bit Error Rate

| S.no | Original Images | Watermark Images | BER value of NCQIM | BER value of NCQIM, LSB | BER value of NCQIM, LSB, CDMA |
|---|---|---|---|---|---|
| 1 |  | | 0.0222 | 0.0219 | 0.0206 |
| 2 |  | | 0.0208 | 0.0206 | 0.0178 |
| 3 |  | | 0.0220 | 0.0218 | 0.0201 |
| 4 |  | | 0.0219 | 0.0217 | 0.0202 |
| 5 |  | | 0.0187 | 0.0186 | 0.0180 |
| 6 |  | | 0.0218 | 0.0216 | 0.0214 |
| 7 |  | | 0.0205 | 0.0203 | 0.0199 |
| 8 |  | | 0.0218 | 0.0217 | 0.0205 |
| 9 |  | | 0.0196 | 0.0193 | 0.0190 |
| 10 |  | | 0.0203 | 0.0200 | 0.0197 |

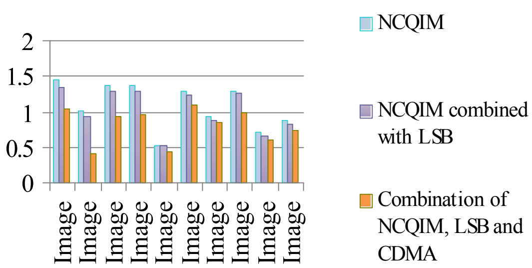



Fig. 4: RMSE performance of various images

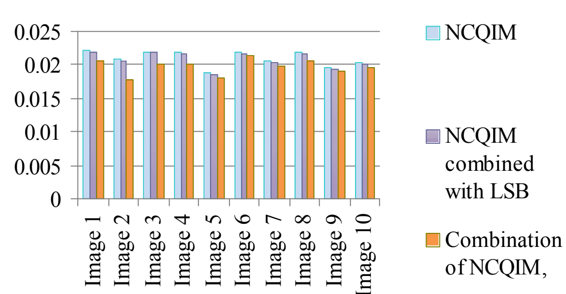



Fig. 5: BER performance of various images

## CONCLUSION

In this proposed method, the analysis of different host images like Lena, cameraman and baboon are taken for comparing the difference between PSNR, MSE, RMSE and BER values. In all the cases the value of PSNR is well above 47dB which shows the good quality level of embedding algorithm in comparison of all other techniques like LQIM, NCQIM, DWT watermarking and SVD watermarking. By embedding the watermark into the decomposition of host image, it provides better imperceptibility as well as reliability in the quality and recovery of image. The embedding distortion is a monotonically decreasing function of the quantization step. NCQIM combined with LSB and CDMA has been also extensively tested on the image and the Peak Signal to Noise Ratio (PSNR) was calculated and imperceptibility is achieved. The robustness is increased by reducing Bit Error Rate (BER). Therefore, the experimental results demonstrate that the proposed method yields superior robustness against a wide range of common image processing operations. This proposed method further can be extended with various embedding algorithm to enhance the robustness level.

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