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An Extensive Analysis Through Literature Survey on Image Watermarking Technique

Amisha Mishra[1], Prof. Nagendra Patel[2]

M-Tech Research Scholar[1], Research Guide[2]

Department of Computer Science Engineering, Rewa Institute of Technology

Abstract: In recent years, digital multimedia technology has shown a significant progress. This technology offers so many new advantages compared to the old analog counterpart. The advantages during the transmission of data, easy editing any part of the digital content, capability to copy a digital content without any loss in the quality of the content and many other advantages in DSP, VLSI and communication applications have made the digital technology superior to the analog systems. The distribution and use of multimedia data is much easier and faster with the great success of Internet. The great explosion in this technology has also brought some problems beside its advantages. However, abuses of these facilities and technologies pose pressing threats to multimedia security management in general, and multimedia copyright protection and content integrity verification in particular. Although cryptography has a long history of application to information and multimedia security, the undesirable characteristic of providing no protection to the media once decrypted has limited the feasibility of its widespread use. Digital watermark may be comprised of copyright or authentication codes, or a legend essential for signal interpretation. The existence of these watermarks with in a multimedia signal goes unnoticed except when passed through an appropriate detector. Common types of signals to watermark are still images, audio, and digital video.

Keywords—Digital Image Watermarking, DWT, Chirp z-transform (CZT), Entropy, SVD, QR.

I. INTRODUCTION

In this work has been carried out on digital watermarking. Throughout the rest of the report, watermarking refers to digital watermarking. To avoid the unauthorized distribution of images or other multimedia property, various solutions has been proposed. Most of them make unobservable modifications to images that can be detected afterwards. Such image changes are called watermarks. Watermarking is defined as adding (embedding) a watermark signal to the host signal. The watermark can be detected or extracted later to make an assertion about the object. A general scheme for digital watermarking is given in Figure 1.1. The watermark message can be a logo picture, sometimes a visually recognizable binary picture or it can be binary bit stream. A watermark is embedded to the host data by using a secret key at the embedder.

Definition of Watermarking

Embedding a digital signal such as audio, video or image with information which cannot be easily removed is called digital watermarking. Watermark is also a digital signal, pattern, image or text inserted into a multimedia object to protect the ownership right. The multimedia object may be an image, audio, video, software or hardware.

General Watermarking System

Digital image watermarking is value-added technique providing copyright protection and authentication features by hiding appropriate ownership information in digital images . The generalized blo ck diagram of typical image watermarking system is shown in Figure 1.1.

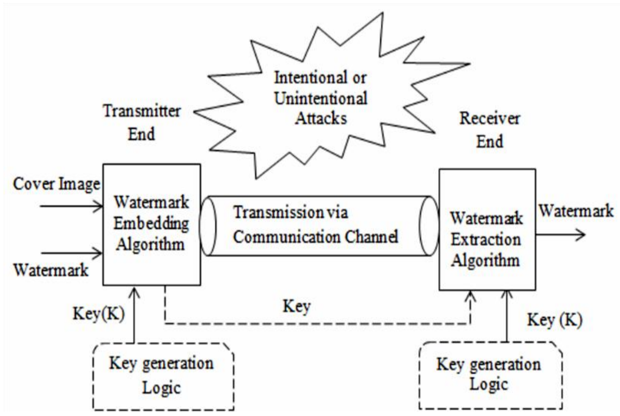

Figure 1.1: Generalized block diagram of typical image watermarking system

Key Terms of Watermarking

This study provides an overview of digital watermarking and it covers some basic terms. The list below contains the meaning of standard terms used throughout this proposal

a. Cover image: the original image used in watermarking.
b. Stego image: the cover image following watermark embedding
c. Test image: the possibly modified stego image from which the watermark is to be extracted

d. Reference image: the image used to assist watermark detection, and also it could be a cover image, stego image, or a test image.
e. Watermark: can be a simple signal consists of pseudo-random binary sequence, or a multi-bit message encoded in a transform domain.
f. Watermark embedding: the process of encoding a watermark signal (i.e. the watermark into an image).

Digital Watermark Formulation

The diagrams below show the basic theories about Digital watermark technique.

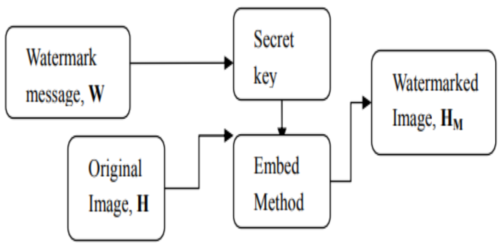

Figure 1.2 Watermark Embed Process

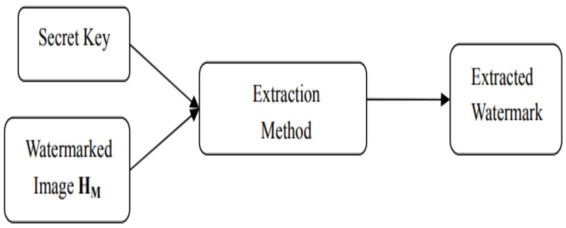

Figure 1.3 Watermark Extraction Process

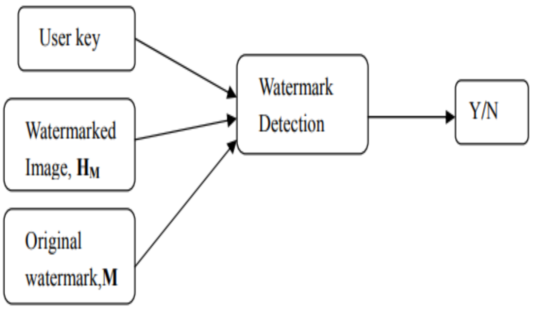

Figure 1.4 Watermark Detection Process

Where Iw denotes watermarked image, which should be considered identical by the human observer. I denotes original image, f is the watermark algorithm, function f may be arbitrary, but the robustness of the watermark algorithm depends on which algorithm is chosen.

Terminology of Digital Watermark

In the literature review, there are numbers of items of pivotal watermark knowledge which should be specified for the reader to understand. Hereby, before further investigation of digital watermark techniques, those technologies are named and explained to reduce the confusion for the un-professional reader and watermark beginner.

Watermarking techniques have a very close relationship with some other techniques such as steganography and information hiding, but these techniques are still different from watermarking. These three fields have a great deal of overlap and share many technical approaches. However, there are fundamental philosophical differences that affect the requirements, and thus the design, of a technical solution.

Properties of Digital Watermark

- Perceptually invisible
- Robustness
- Cost
- Capacity
- Recoverable ¾ Reversible
- Undetectable
- Able to determine the true owner
- High bit rate

Discrete Wavelet Transform (DWT) domain

The wavelet domain method transforms both the image and watermark into the discrete wavelet domain. This method uses a multi-resolution wavelet decomposition of both the original image and the watermark. It is based on the Human Vision System. When the image is decompose by wavelet transformation, its components are separated into bands scale, much like the retina of the eye splits an image into several components. The Discrete wavelet transform will allow the independent processing of the resulting components much like the human eyes. The low –frequency components have to be modified in order to embed the information in a reliable and robust way. DWT has high robustness of the approach to JPG compression and additive noise and linear filtering.

Many other transforms had been also considered for digital watermark technique. For example, the discrete Fourier transform (DFT), the Fast Fourier Transform (FFT) andFourier-Mellin transform and fractal transform.

Singular Value Decomposition (SVD)

Recently watermarking schemes based on Singular Value decomposition (SVD) have gained popularity due to its simplicity in implementation and some attractive mathematical features of SVD. Here a brief description of SVD and its role in the watermarking schemes have been presented.

SVD is an effective numerical analysis tool used to analyze matrices. In SVD transformation, a matrix can be decomposed into three matrices that are of the same size as the original matrix. From the view point of linear algebra, an image is an array of nonnegative scalar entries that can be regarded as a matrix. Without loss of generality, if *A* is a square image, denoted as $A \in Rn \times n$, where *R* represents the real number domain, then SVD of *A* is defined as

$$A=USV^T$$

where $U \in R^{n\times n}$ and $V \in R^{n\times n}$ are orthogonal matrices, and $S \in R^{n\times n}$ is a diagonal matrix, as

$$S = \begin{bmatrix} \sigma_1 & & & \\ & \sigma_2 & & \\ & & \ddots & \\ & & & \sigma_n \end{bmatrix}$$

Here diagonal elements i.e. σ' s are singular values and satisfy

$$\sigma 1 \geq \sigma 2 \geq \ldots \sigma r \geq \sigma r{+}1 \geq = \ldots\ldots = \sigma n{=}0$$

It is noticeable that the unique property of the SVD transform is that the potential *N*2 degrees of freedom or samples in the original image now get mapped into

$S \Rightarrow N$ Degrees of freedom

$U \Rightarrow N(N -1) / 2$ Degrees of freedom

$V \Rightarrow N(N -1) / 2$ Degrees of freedom

totaling *N2* degrees of freedom.

SVD is an optimal matrix decomposition technique in a least square sense that it packs the maximum signal energy into as few coefficients as possible. It has the ability to adapt to the variations in local statistics of an image.

Properties of SVD

Generally a real matrix *A* has many SVs, some of which are very small, and the number of SVs which are non-zero equals the rank of matrix *A*. SVD has many good mathematical characteristics. Using SVD in digital image processing has some advantages:

- The size of the matrices from SVD transformation is not fixed and can be a square or a rectangle.
- The SVs (Singular Values) of an image have very good stability, i.e. when a small perturbation is added to an image, its SVs do not vary rapidly;
- SVs represent algebraic image properties which are intrinsic and not visual

Typical Image Coder

A typical lossy image compression system is consists of three closely connected components namely (a) Source Encoder (b) Quantizer, and (c) Entropy Encoder. Compression is accomplished by applying a linear transform to decorrelate the image data, quantizing the resulting transform coefficients, and entropy coding the quantized values.

Source Encoder (or Linear Transformer)

Over the years, a variety of linear transforms have been developed which include Discrete Fourier Transform (DFT), Discrete Cosine Transform (DCT) , Discrete Wavelet Transform (DWT) and many more, each with its own advantages and disadvantages.

Quantizer

A quantizer simply reduces the number of bits needed to store the transformed coefficients by reducing the precision of those values. Since this is a many-to-one mapping, it is a lossy process and is the main source of compression in an encoder. Quantization can be performed on each individual coefficient, which is known as Scalar Quantization (SQ). Quantization can also be performed on a group of coefficients together, and this is known as Vector Quantization (VQ) [6] . Both uniform and non-uniform quantizers can be used depending on the problem at hand. .

Entropy Encoder

An entropy encoder further compresses the quantized values losslessly to give better overall compression. It uses a model to accurately determine the probabilities for each quantized value and produces an appropriate code based on these probabilities so that the resultant output code stream will be smaller than the input stream. The most commonly used entropy encoders are the Huffman encoder and the arithmetic encoder, although for applications requiring fast execution, simple run-length encoding (RLE) has proven very effective [6]. It is important to note that a properly designed quantizer and entropy encoder are absolutely necessary along with optimum signal transformation to get the best possible compression.

QR Decomposition

The QR decomposition (also called the QR factorization) of a matrix is a decomposition of the matrix into an orthogonal matrix and a triangular matrix. A QR decomposition of a real square matrix A is a decomposition of A as A = QR, where Q is an orthogonal matrix (i.e. QTQ = I) and R is an upper triangular matrix. If A is nonsingular, then this Decomposition is unique.

The resulting QR Decomposition is

$$A = \left[\mathbf{a}_1 \,\middle|\, \mathbf{a}_2 \,\middle|\, \cdots \,\middle|\, \mathbf{a}_n \right] = \left[\mathbf{e}_1 \,\middle|\, \mathbf{e}_2 \,\middle|\, \cdots \,\middle|\, \mathbf{e}_n \right] \begin{bmatrix} \mathbf{a}_1\cdot\mathbf{e}_1 & \mathbf{a}_2\cdot\mathbf{e}_1 & \cdots & \mathbf{a}_n\cdot\mathbf{e}_1 \\ 0 & \mathbf{a}_2\cdot\mathbf{e}_2 & \cdots & \mathbf{a}_n\cdot\mathbf{e}_2 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \mathbf{a}_n\cdot\mathbf{e}_n \end{bmatrix} = QR.$$

Note that once we find e1, . . . , en, it is not hard to write the QR Decomposition

Chirp z-Transform Algorithm

A computational algorithm for numerically evaluating the z-transforrn of a sequence of N time samples was presented. This algorithm, entitled the chirp z~transform algorithm, enables the evaluation of the z-transform at M equi-angularly spaced points on contours which spiral in or out (circles being a special case) from an arbitrary starting point in the z-plane. In the s-plane the equivalent contour is an arbitrary straight line. The CZT algorithm has great flexibility in that neither N or M need be composite numbers; the output point spacing is arbitrary; the contour is fairly general and N need not be the same as M. The flexibility of the CZT algorithm is due to being able to express the z-transform on the above contours as a convolution, permitting the use of well-known high-speed convolution techniques to evaluate the convolution.

Applications of the CZT algorithm

Applications of the CZT algorithm include enhancement of poles for use in spectral analysis; high resolution, narrowband frequency analysis; and time interpolation of data from one sampling rate to any other sampling rate. These applications are explained in detail elsewhere. The CZT algorithm also permits use of a radix-2 FFT program or device to compute the DFT of an arbitrary number of samples. Examples illustrating how the CZT algorithm is used in specific cases are included elsewhere. It is anticipated that other applications of the CZT algorithm will be found.

This algorithm has been named the chirp z-transform (CZT) algorithm. Using the CZT algorithm one can efficiently evaluate the z-transform at M points in the z-plane 'which lie on circular or spiral contours beginning at any arbitrary point in the z-plane. The angular spacing of the points is an arbitrary constant, and M and N are arbitrary integers. The algorithm is based on the fact that the values of the z-transform on a circular or spiral contour can be expressed as a discrete convolution. Thus one can use well-known high-speed convolution techniques to evaluate the transform efficiently.

Applications of Digital Watermarking

Watermarking systems can be characterized by a number of properties to get the activeness of watermark. In this study, the most common properties of a digital watermarking scheme are highlighted such astransparency, robustness, capacity and security

Copyright protection is one of the most commonly proposed applications of digital watermarking. A watermarking scheme can provide copyright protection in two ways: as a tool for identification of unauthorized copies and as a mechanism for demonstration of ownership. In the first scenario, the watermarking scheme should have an efficient decoder which can be used by a web-crawler to quickly track down unauthorized copies of watermarked images. In the second case, the scheme should be blind, private, and non-invertible

Image authentication is another popular watermarking application. Authentication watermarks are used to detect image tampering visible to the human eye. As a result, any intentional modification of the image should break an authentication watermark. However, image processing operations that preserve perceptual similarity (e.g. file format conversion) should not interfere with watermark detection.

Digital watermarking techniques can also be used for image fingerprinting (insertion of product identification codes) and steganography (data hiding). These applications place different requirements on a watermarking scheme's robustness and embedding capacity. A scheme designed for steganographic purposes should be able to embed the maximum possible amount of information into an image without introducing any perceptible distortions. The robustness of such a scheme is irrelevant. On the other hand, watermarking schemes used for fingerprinting need not have high capacity but must be robust to both intentional and unintentional attacks.

- *IPR Protection*
- *Demonstration of rightful ownership*
- *Authentication*
- *Labeling for data retrieval*
- *Covert communication*

II. LITERATURE REVIEW

P. Rasti, G. Anbarjafari and H. Demirel, [1] In this work, a new image watermarking algorithm on colour images is proposed. The proposed algorithm divides a cover image into three colour bands of red, green and blue. Then the following tasks are done on all three channels separately. First, each colour band is divided into patches of small sizes then the entropy of each patch is calculated. At this step a threshold is found based on the average entropy of all patches and following is applied to all patches which have entropy lower than the threshold. A wavelet representation of each patch are given by applying a discrete wavelet transform. Then Singular value decomposition, orthogonal-triangular decomposition, and a chirp z-transform are used to embed a watermark on the cover image. Several signal processing attacks are applied on watermarked images in order to robustness of the algorithm. The Proposed algorithm is compared with one conventional and two state-of-the-art algorithms. Experimental results show superiority of the proposed algorithm compare with other algorithm in the area of image watermarking.

Khalil Zebbiche, Fouad Khelifi [2] In this study, a robust wavelet-based fingerprint image watermarking scheme using an efficient just perceptual weighting (JPW) model has been proposed. The JPW model exploits three human visual system characteristics, namely: spatial frequency sensitivity, local brightness masking and texture masking, to compute a weight for each wavelet coefficient, which is then used to control the amplitude of the inserted watermark. The idea is motivated by the fact that fingerprint images perceptually differ from natural images and a JPW model adapted to such images would further enhance the robustness of the watermarking scheme. Experimental results show that the proposed model significantly improves the performance of the conventional watermarking technique in terms of robustness while maintaining the same imperceptibility of the watermark. Finally, the proposed technique has shown a clear superiority over a number of related state-of-the-art masking techniques.

Table of Literature Review

SR. NO.	TITLE	AUTHORS	YEAR	APPROACH
1	"Colour image watermarking based on wavelet and QR decomposition,"	P. Rasti, G. Anbarjafari and H. Demirel	2017	A new image watermarking algorithm on colour images.
2	"Efficient wavelet-based perceptual watermark masking for robust fingerprint image watermarking"	Khalil Zebbiche, Fouad Khelifi	2013	A robust wavelet-based fingerprint image watermarking scheme using just perceptual weighting (JPW)
3	"Yli Sezimine Dayali Glibli Gri Dlieyi Damgalama Teknigi Robust Grayscale Watermarking Technique Based on Face Detection"	Lauri Laur , Morteza Daneshmand , Mary Agoyi , Gholamreza Anbarjafari	2015	Robust grayscale watermarking technique based on face detection
4.	"Discrete Wavelet TransformsBased Self-Embedding Watermarking,"	R. Gupta and M. Ramaiya	2015	A novel DWT based self-embedding color image watermarking scheme
5.	"A perception based color image adaptive watermarking scheme in YCbCr space,"	A. Roy, A. K. Maiti and K. Ghosh	2015	Discrete Wavelet transform and Singular Value Decomposition (DWT-SVD) based color image watermarking scheme in YCbCr color space
6	"Novel blind colour image watermarking technique using Hessenberg decomposition,"	Q. Su, In this study	2016	A novel blind image watermarking technique using Hessenberg decomposition
7	"Block-based discrete wavelet transform-singular value decomposition image watermarking scheme using human visual system characteristics,"	N. M. Makbol, B. E. Khoo and T. H. Rassem	2016	A robust block-based image watermarking scheme based on the singular value decomposition (SVD)
8	"HDR Image Watermarking based on Bracketing zecomposition"	Vassilios Solachidis, Emanuele Maiorana, Patrizio Campisi	2013	A novel watermarking scheme specifically designed for high dynamic range (HDR) images

Lauri Laur , Morteza Daneshmand, Mary Agoyi, Gholamreza Anbarjafari [3] Due to increase of usage of digital media distributed over the Internet, concerns about security and piracy have emerged. The amount of digital media reproduction has brought a need for content watermarking. In this paper robust grayscale watermarking technique based on face detection is proposed. Face detection algorithm is used to fid a face on host image and this part of image is transformed into frequency domain using Discrete Wavelet Transform. Chirp z-transform is applied on low-frequency subband from previous step and LU decomposition is used on the outcome. Diagonal matrix from LU decomposition is further decomposed using Singular Value Decomposition and watermark is embedded into singular values. Numerous experiments are run on that algorithm and results are compared with novel and state-of-the-art techniques. The results show that proposed method has good imperceptibility and robustness characteristics.

R. Gupta and M. Ramaiya [4] Digital watermarking is a technology that hidesinformation in image to provide authentication. Information hiding is done by the tempering content of the image. The embedding process has to be such that the tempering of the media are invisible. The proposed work presents a novel DWT based self-embedding color image watermarking scheme by using cubic interpolation of mean difference matrices of the image and used it as a watermark. Cubic interpolation is used for up-sampling the image. Proposed scheme assure the self-embedding of original image and also assure extraction of watermark information with satisfied visual criteria. Two level DWT decomposition of original for embedding watermark information ensure Robustness of proposed scheme. Experimental results show that the proposed scheme is more efficient and robust.

A. Roy, A. K. Maiti and K. Ghosh,[5] Copyright protection has now become a challenging domain in real life scenario. Digital watermarking scheme is an important tool for copyright protection technique. A good quality watermarking scheme should have high perceptual transparency, and should also be robust enough against possible attacks. A well-known (Lewis-Barni) Human Visual System (HVS) based watermarking model is fairly successful with respect to the first mentioned criterion, though its effectiveness in color images has not been claimed. Furthermore, it is true that although several watermarking schemes are available in literature for grayscale images, relatively few works have been done in color image watermarking, and the little that have been done, have mostly been tested in RGB, YUV, YIQ color spaces. Thus the question remains that, which is the optimal color space for color image watermarking and whether this HVS model is applicable for that color space. There are two main contributions of the present work with respect to the above. First, it claims that for color image watermarking, the YCbCr space can be used as the perceptually optimum color space, the Cb component being the optimal color channel here. Second, it also tests the effectiveness of the above-mentioned HVS model in that color space. These have been achieved by using the HVS model to propose a new non-blind (original image and the watermark logo image both are needed for extraction) image adaptive Discrete Wavelet transform and Singular Value Decomposition (DWT-SVD) based color image watermarking scheme in YCbCr color space. The multi-resolution property of DWT and stability of SVD additionally makes the scheme robust against attacks, while the Arnold scrambling, of the watermark, enhances the security in our method. The experimental results support the superiority of our scheme over the existing methods.

Q. Su, In this study,[6] a novel blind image watermarking technique using Hessenberg decomposition is proposed to embed colour watermark image into colour host image. In the process of embedding watermark, the watermark information of colour image is embedded into the second row of the second column element and the third row of the second column element in the orthogonal matrix obtained by Hessenberg decomposition. In the process of extracting watermark, neither the original host image nor the original watermark image is needed and it is impossible to retrieve them without the authorised keys. Experimental results show that the proposed colour image watermarking technique based on Hessenberg decomposition outperforms other watermarking methods and it is robust to resist a wide range of attacks, e.g. image compression, filtering, cropping, rotation, adding noise, blurring, scaling, sharpening and rotation and so on. Especially, the proposed method has lower computational complexity than other methods based on singular value decomposition or QR decomposition.

N. M. Makbol, B. E. Khoo and T. H. Rassem,[7] Digital watermarking has been suggested as a way to achieve digital protection. The aim of digital watermarking is to insert the secret data into the image without significantly affecting the visual quality. This study presents a robust block-based image watermarking scheme based on the singular value decomposition (SVD) and human visual system in the discrete wavelet transform (DWT) domain. The proposed method is considered to be a block-based scheme that utilises the entropy and edge entropy as HVS characteristics for the selection of significant blocks to embed the watermark, which is a binary watermark logo. The blocks of the lowest entropy values and edge entropy values are selected as the best regions to insert the watermark. After the first level of DWT decomposition, the SVD is performed on the low-low sub-band to modify several elements in its *U* matrix according to predefined conditions. The experimental results of the proposed scheme showed high imperceptibility and high robustness against all image processing attacks and several geometrical attacks using examples of standard and real images. Furthermore, the proposed scheme outperformed several previous schemes in terms of imperceptibility and robustness. The security issue is improved by encrypting a portion of the important information using Advanced Standard Encryption a key size of 192-bits (AES-192).

Vassilios Solachidis, Emanuele Maiorana, Patrizio Campisi [8] The present paper proposes a novel watermarking scheme specifically designed for high dynamic range (HDR) images. The employed embedding strategy is based on a decomposition of the original HDR representation into multiple low dynamic range (LDR) images by means of a bracketing process. After having inserted the selected watermark into each LDR component, the final output is generated by combining the available contributions into a single HDR object. By exploiting some of the well studied properties of digital watermarking for standard LDR images, our approach is able to generate a watermarked HDR image visually equivalent to the original one, while allowing to detect the embedded information in both the marked HDR image and in its LDR counterpart, obtained through tone-mapping operators or by extracting a specific luminance range of interest from it. Several results obtained from an extensive set of experimental tests are reported to testify the effectiveness of the proposed scheme.

III. PROPOSED WORK

There are different types of digital watermark, such as fragile watermark, blind watermark and etc. Hence, it can be applied watermarking to a wider range of exercises. Digital watermarking techniques can be applied to image, audio and video. This study emphasizes the robust features of digital image watermarking. The evaluation selects some representative methods from existing research and development. To maintain an impartial and scientific manner, the testing images for each method were identical. Similarly, the image distortion will be selected by using the same attack method. Least Signification bit also called the least visible bit. This is one of the most simple and straightforward methods. This is the first method started with to learn about this field. The idea is to replace the least significant bits of the image directly with the watermark message. In contrast, embedding in perceptually significant coefficients method may have strong robustness but is directly opposed to imperceptible requirement. So to make a watermark imperceptible, we will be expected to put the watermark message into the perceptually least signification coefficients. LSB method has an large capacity of utilizing the whole host image to participate in this transaction method. But the disadvantage of this method is that the robustness of the watermark is very weak. Most of the watermark will be lost after the some attacks take place such as JPEG compression and Gaussian noise.

IV. CONCLUSION AND FUTURE SCOPE

The domain of digital watermarking and the domain of digital data hiding are two close, but distinct research areas. In both areas the main goal is to embed information in a digital medium. The main difference between them is the scope of the application. In data hiding the medium-carrier is of no importance, while in digital watermarking the medium is of crucial importance as well as the message hidden within. Therefore research in both areas is very proximate and certain embedding techniques are shared in both fields. A reversible watermarking scheme resistant to geometrical attacks. The original image for extracting the watermark, shows robustness against geometrical attacks while maintaining low computational cost. Nevertheless the watermarked images are not robust against compression and filtering attacks. An image quality metric especially for watermarking and data hiding is to be developed. PSNR, and sometimes do not give credible measurements for watermarked images. This metric should take account the special features of the Human Visual System (HVS) as well as the effects of information embedding in an image. A series of images should pass objective evaluation and by comparing the objective and the quality metric’s the quality metric could be fine-tuned in order to simulate HVS criterions. This metric would be very useful in chaotic watermarking scheme presented.

REFERENCES

[1] P. Rasti, G. Anbarjafari and H. Demirel, "Colour image watermarking based on wavelet and QR decomposition," *2017 25th Signal Processing and Communications Applications Conference (SIU)*, Antalya, 2017, pp. 1-4.

[2] Khalil Zebbiche1, Fouad Khelifi2, Belfast BT7 1NN, UK, “Efficient wavelet-based perceptual watermark masking for robust fingerprint image watermarking” Published in IET Image Processing doi: 10.1049/iet-ipr.2013.0055.

[3] Lauri Laur , Morteza Daneshmand , Mary Agoyi , Gholamreza Anbarjafari “Yli Sezimine Dayali Glibli Gri Dlieyi Damgalama Teknigi Robust Grayscale Watermarking Technique Based on Face Detection” 2015 1EEE.

[4] R. Gupta and M. Ramaiya, "Discrete Wavelet TransformsBased Self-Embedding Watermarking," *2015 Fifth International Conference on Communication Systems and Network Technologies*, Gwalior, 2015, pp. 689-692.

[5] Roy, A. K. Maiti and K. Ghosh, "A perception based color image adaptive watermarking scheme in YCbCr

space," *2015 2nd International Conference on Signal Processing and Integrated Networks (SPIN)*, Noida, 2015, pp. 537-543.

[6] Q. Su, "Novel blind colour image watermarking technique using Hessenberg decomposition," in *IET Image Processing*, vol. 10, no. 11, pp. 817-829, 11 2016.

[7] N. M. Makbol, B. E. Khoo and T. H. Rassem, "Block-based discrete wavelet transform-singular value decomposition image watermarking scheme using human visual system characteristics," in *IET Image Processing*, vol. 10, no. 1, pp. 34-52, 1 2016.

[8] V. Solachidis, E. Maiorana, P. Campisi, and F. Banterle, "HDR image watermarking based on bracketing decomposition," in Digital Signal Processing (DSP), 2013 18th International Conference on, pp. 1–6, IEEE, 2013.

[9] F. Guerrini, M. Okuda, N. Adami, and R. Leonardi, "High dynamic range image watermarking robust against tone-mapping operators," Information Forensics and Security, IEEE Transactions on, vol. 6, no. 2, pp. 283–295, 2011.

[10] X. Xue, M. Okuda, and S. Goto, "μ-law based watermarking for HDR image robust to tone mapping," 2011. H. Park, S. H. Lee, and Y. S. Moon, "Adaptive video watermarking utilizing video characteristics in 3d-dct domain," in Digital Watermarking, pp. 397–406, Springer, 2006.

[11] K. Zebbiche and F. Khelifi, "Efficient wavelet-based perceptual water- mark masking for robust fingerprint image watermarking," IET Image Processing, vol. 8, no. 1, pp. 23–32, 2014.

[12] L. Laur, M. Daneshmand, M. Agoyi, and G. Anbarjafari, "Robust grayscale watermarking technique based on face detection," in Signal Processing and Communications Applications Conference (SIU), 2015 23th, pp. 471–475, IEEE, 2015.

[13] P. A. Hernandez-Avalos, C. Feregrino-Uribe, and R. Cumplido, "Water- marking using similarities based on fractal codification," Digital Signal Processing, vol. 22, no. 2, pp. 324–336, 2012.

[14] P. Rasti, S. Samiei, M. Agoyi, S. Escalera, and G. Anbarjafari, "Robust non-blind color video watermarking using qr decomposition and entropy analysis," Journal of Visual Communication and Image Representation, vol. 38, pp. 838–847, 2016.