How to Cite:
Abdulrahman, A. A., Mustafa, M. A., & Tahir, F. S. (2022). Novel Watermarking efficiency using New Discrete Laguerre Wavelets Transform (NDLWT). *International Journal of Health Sciences*, *6*(S9), 3399–3409. https://doi.org/10.53730/ijhs.v6nS9.13334

Novel watermarking efficiency using New Discrete Laguerre Wavelets Transform (NDLWT)

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***Abstract*---**Watermarking in protecting brands from possible counterfeiting is considered one of the methods of processing digital and color images. This technique requires the discovery of advanced methods to obtain the best results by discovering a new filter instead of the standard filters that were used without reaching the peak of the required and optimal values through which the images are analyzed. Colored with the proposed watermark in the process of immersion and separation the new filter is derived from Laguerre polynomials and using mathematical methods to derive the filter. And using it in analyzing the image to reach the best results, and through the proposed New Discrete Laguerre Wavelets Transform NDLWT for watermark algorithms it becomes clear the efficiency of the proposed theory in reading the most important criteria for the quality of the extracted image. The program or language that was used in this work is the MATLAB language in analyzing and compressing the cover image, where five attacks were directed on the image from the gray scale in which the watermark was immersed, and the proposed filter was used in this work and to reach the best results and calculate Peak signal-to-noise ratio (PSNR) and normal correlation (NC) illustrated The efficiency of this method.

***Keywords*---**New discrete Laguerre wavelets transform (NDLWT), Watermarking, Peak signal-to-noise ratio (PSNR), normal correlation (NC), quick response code (QR code)

Manuscript submitted: 9 May 2022, Manuscript revised: 18 July 2022, Accepted for publication: 27 August 2022

1 Introduction

Image processing technology has taken an important role in the rapid growth of wireless media and the preservation of image data that is prone to loss, which has led to the mandatory use of image processing technologies in broad and important fields in medicine, industry and academia, The spatial frequency domain, which has a role in immersing the watermark in the image pixels, but when directing attacks and noise, the spatial frequency is weak in the face of these attacks, but using transformations such as Discrete Fourier Transform (DFT) which is a relative strength in the face of these attacks and the introduction of the watermark [1],[2]. Also electronic technologies, especially in the conditions of COVID-19, which led to the need to exchange and transfer data and in order to preserve copyright by placing a watermark on digital images whose effectiveness is very clear, such as including a picture or logo within the image [3], [4].

Watermark immersed in the digital image from the fields of digital image processing to preserve data to maintain the confidentiality of military and medical information which are difficult to extract. When the watermark is immersed in the image data, it leads to the loss and deterioration of some of this data, and the usefulness of these watermarks after the extraction process is restored, which outperforms the encryption process.[5]. Image transformations using discrete cosine transform (DCT) to show low-frequency encoding information to add watermark to preserve product data and confidentiality.

One of the problems facing medical products or other industrial products and in order to avoid counterfeiting or imitation of original products is the rapid growth in the multimedia system, and among these developments is the emergence of digital watermarks for their effective role in solving problems to maintain data security and copyright, In [6] RGB and YUV method were used to analyze the image with the use of Matlab software to immerse two watermarks for the purpose of optimization.

Safety and security of institutions in information technology and in order to reduce the fears of intrusion of confidential information, it was proposed to separate waveform transformation with (SVD) in the fourth level so that the location of the watermark is the first quadrant LL, a nd by using the inverse of the separate waveform transformation, the watermark is extracted [7] In order to obtain good results, the firefly algorithm was used to maintain the security of the digital image data. Arnold was used to immerse the watermark and then extract it and obtain the values of the extracted image quality standards [8],[9], [10]

Discrete cosine transform (DCT) is an example of one of the techniques in dealing with watermarks to lead to information efficiency with blind and semi-blind extraction process [11],[12], [13]. Also, basic discrete wavelets transform (DWT) such as Haar, debauchees wavelet [14], [15], [16].

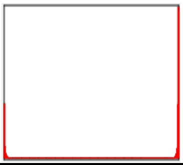
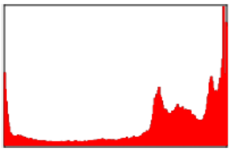
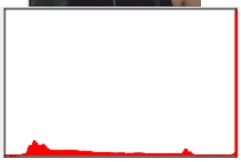
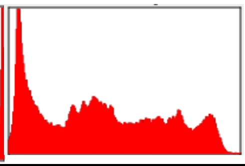
And the many Levitation Wavelet Transformation (LWT), Constant Wavelet Transformation (SWT), Contour Transformation and How to Deal with Watermark Pros and Cons [17], [18], [19], [20], [21]. Single value decomposition (SVD) leads to wavelet interference with the image matrix [22], [23], [24]. To improve the performance of QR investigation Madhu . is discussed, [25], [26], [27] [28], [29], [30].

The most powerful attacks are JPEG compression, salt and pepper, Gaussian blur and other attacks to reach values for the maximum Peak signal-to-noise ratio (PSNR) and also Arnold transform (AT) with SVD to flood watermarks in addition to using the sine matrix due to the strength of the attacks [31], [32],[33]

In this work, new discrete Laguerre wavelets transform derived from Lacier polynomials are proposed and used quick response code (QR code) in image analysis and compression in order to reduce the image data for watermark immersion and to reach the most significant results based on PSNR and normal correlation (NC) values.

Where a quick algorithm was proposed using the Matlab program to process the image, and 4 samples of the color images in the table (1) were used to be processed with the new filter to immerse the watermark, and the results that were reached prove the efficiency of the proposed theory in this work.

Table 1: Samples of the color images processed with watermark

	Watermark	Image a	Image b	Image c	Image d
Origenal image					
Histgram image					

2. Method of Research

The most important information, important equations, research steps and research objectives will be explained in this section

2.1 Discrete Wavelet Transform

The coefficients (r,s) are responsible for the wavelet movement, expansion and contraction, represented by the equation (1) which is called the mother wavelet through which the wavelets proposed in this work are derived to extract the vector that contains a basis consisting of small functions in (2).

$$W_{r,s}(x) = |r|^{-\frac{1}{2}} W\left(\frac{t-s}{r}\right) \qquad r, s \in R, \ R \neq 0 \tag{1}$$

$$[W_0(x), W_1(x), \dots, W_{M-1}(x)]^T \tag{2}$$

2.2. New Discrete Wavelets Transform (NDWT)

In this section, new wavelets derived from (1) will be constructed with the help of Laguerre polynomials and through equation (3) the wavelets are divided into Scaling function $\theta(x)$ belong V_n space and Laguerre wavelet $\varphi(x)$ belong W_n space $\varphi_{c,d}(x) = \varphi_{x,c,d,l}$ $l = 1,2$ $c = 1,2,\dots,2^{l-1}$, d is order of the proposed polynomials, x is the variable of function. The operator responsible for the contraction of the new wavelet is r which is transformed by $r = 2^{-(l-1)}$, for the stretching, it will be of help $s = 2^{-(l+1)}(2c-1)$ for transform , $t = 2^{-(l-1)}(2^l x)$ for using equation (1) transform to New Discrete Laguerre Wavelets Transform (NDLWT)

$$\varphi_{c,d}(x) = 2^{-(l+1)}\tilde{\varphi}_{c,d}\left(\frac{2^{-(l+1)}(2^l x) - 2^{-(l+1)}(2c-1)}{2^{-(l+1)}}\right) \quad (3)$$

Will be get (4)

$$\varphi_{c,d}(x) = \begin{cases} 2^{\frac{l+1}{2}}\tilde{\varphi}_{c,d}(2^l x - 2c + 1) & \frac{c-1}{2^{l-1}} \le x \le \frac{c}{2^{l-1}} \\ 0 & otherwise \end{cases} \qquad \tilde{\varphi}_d = \frac{1}{d!}\,\varphi_d \quad (4)$$

Equation (5) the polynomials of Laguerre for d=0,1,2,...

$$\varphi_0(t) = 1, \varphi_1(t) = 1 - t \quad \dots\dots \; \varphi_{d+1}(t) = (2d + 1 - t)\varphi_d(t) - d^2\varphi_{d-1}(t) \quad (5)$$

The following based functions for c=1,2 and d=0,1,2 for M=3

$$\left.\begin{aligned} \varphi_{1,0}(x) &= 2\sqrt{2} \\ \varphi_{1,1}(x) &= 2\sqrt{2}\,(2 - 4x) \\ \varphi_{1,2}(x) &= 2\sqrt{2}\,(16x^2 - 24x + 7) \end{aligned}\right\} x \in \left[0, \tfrac{1}{2}\right)$$
$$\left.\begin{aligned} \varphi_{1,0}(x) &= 2\sqrt{2} \\ \varphi_{1,1}(x) &= 2\sqrt{2}\,(4 - 4x) \\ \varphi_{1,2}(x) &= 2\sqrt{2}\,(16x^2 - 40x + 23) \end{aligned}\right\} x \in \left[\tfrac{1}{2}, 1\right) \quad (6)$$

The function approximate $F(x) \in L_2(0,1]$

$$F(x) = \sum_{c=1}^{2^l}\sum_{d=0}^{M-1} A_{c,d}\,\varphi_{c,d}(x) = A^T\varphi(x) \quad (7)$$

The two matrices , φ and by $2^l M \times 1$

$$A = \left[A_{10}, A_{11}, \dots, A_{1(M-1)}, A_{20}, \dots, A_{2(M-1)}, \dots, A_{2^l}, \dots, A_{2^l M-1}\right]^T \quad (8)$$

$$\varphi(x) = \left[\varphi_{1,0}(x), \varphi_{1,1}(x), \dots, \varphi_{1,M-1}(x), \varphi_{2,0}(x), \dots, \varphi_{2^k,M-1}(x), \dots \varphi_{2^k,0}(x), \dots \varphi_{2^k M-1}(x)\right]^T \quad (9)$$

the scalar function for NDLWT

$$\theta(x) = \begin{cases} 1 & if\ 0 \le x \le 1 \\ 0 & otherwise \end{cases}$$

(10)

The signal S with the coefficients of NDLWT $\alpha_{c,d}, \beta_{c,d}$ for the $A = \langle F,\varphi\rangle$ for wavelet function and $A = \langle F,\theta\rangle$ for scalar function in equation (11) the details coefficients and (12) the Approximate coefficients

$$\alpha_{c,d} = \int S(x)\varphi_{c,d}(x)dx \quad in\ R \tag{11}$$
$$\beta_{c,d} = \int S(x)\theta_{c,d}(x)dx \quad in\ R \tag{12}$$

The new filter of NDLWT for $c = 0,1,2$ and $d = 0,1,2,\dots,2^c - 1$
$c = 0,\ \theta_{0,0}(x) = \varphi_0(x) = 1 \subset V_0$, $c = 1,\ \varphi_{1,0}(x) = \frac{1}{\sqrt{2}}\varphi_0(2x) = \frac{1}{\sqrt{2}} \subset W1$ $\varphi_{1,1}(x) = \frac{1}{\sqrt{2}}\varphi_1(2x-1) = \frac{1}{\sqrt{2}}[1-(2x-1)] \subset W1$ same processed for $d = 2,\dots,2^c - 1$ will be reached the NDLWT filter for scalar function

Low pass filter $\begin{bmatrix} \frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} \end{bmatrix}$ and high pass filter $\begin{bmatrix} \frac{-1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} \end{bmatrix}$ after add NDLWT in MATLAB program by add NDLWT in MATLAB algorithm

2.3 compression color image with NDLWT

processing the original Image that has been compressed using the new filter, the image has been analyzed on the image matrix rows and image matrix columns, the coefficients will be divided into two parts, the approximate coefficients and details coefficients which in turn is divided into horizontal, vertical and diagonal , so that the image is divided into four parts, namely: LL, HL, LH, and HH, with reconstructed analyses image by invers new filter INDLWT reached to Syntheses Image In figure.1 The Decomposition at level 1

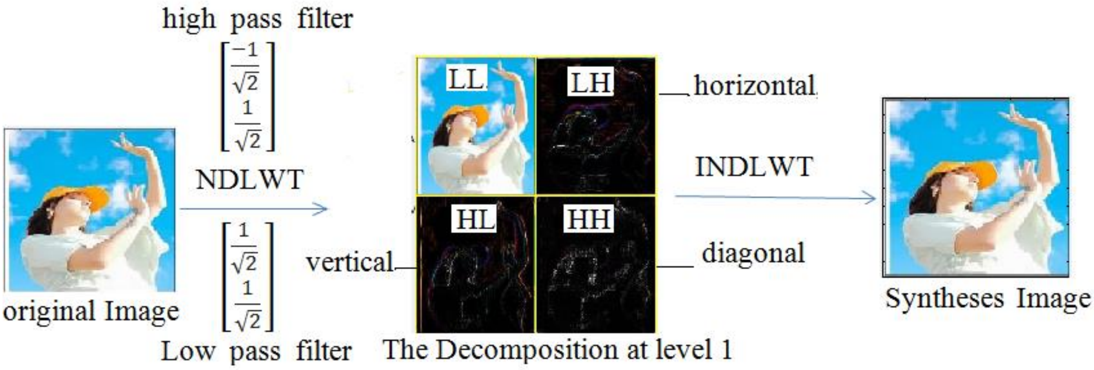


Figure.1 Color image analysis using NDLWT

The samples in Table (1) were processed after using the new discrete transformation And the quality standards for the color image were recorded. Table (2) shows the values of these following standards

1- Mean Squared Error (MSE) $MSE = \frac{1}{IJ}\sum_{m=1}^{I}\sum_{n=1}^{J}(x_{ij} - y_{ji})^2$
2- Peak signal-to-noise ratio (PSN R) $PSNS = 10log_{10}\left(\frac{255^2}{MSE}\right)$
3- bits per pixel ratio (BPP)

$$BPP = \frac{\text{Compressed image size in bits}}{\text{The sum of the pixels of an image}}$$

4- compressed ratio (CR) $CR = \left(1 - \frac{I}{J}\right) \times 100$

Table 2: Effect NDLWT on image quality in level 8

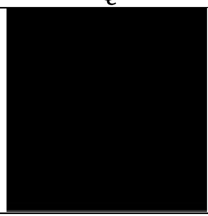
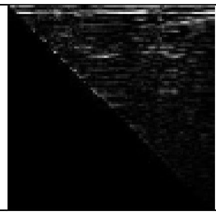
Original Image	MES	PSNR	BPP	CR
Image a	0.1193	57.36	19.6086	81.70 %
Image b	0.1242	57.19	17.9229	74.68 %
Image c	0.125	57.16	17.2825	72.01 %
Image d	0.1251	57.16	17.1943	71.64 %
Watermark	0.2251	57.16	17.2064	71.69 %

The proposed algorithm in this work that will prove the efficiency of the new filter to deal with the watermark after analyzing the QR matrix to be analyzed into the wavelet vector W and scalar vector V where the two vectors are projected to be $Q^T A = Q^T(QR) = IR = R$ where The stability of the matrix QR in the LH quadrant is the effect of the proposed new wavelets NDLWT to reach good results so that the watermark does not affect the image quality.

Table 3 shows the decomposition of the image with the effect of a second-order polynomial to show the rapid response in equation (13) depends on the two values z and $\log n_0$

$x_{n+1} = z x_n (1 - x_n)$ where $x_n \in (0,1)$

Table 3 Effect of QR parameter on color image analysis

Image	Gray	Q	R
			

The main role of new wavelets NDLWT in the algorithm proposed in this work with directing attacks on the image after immersing the watermark in the color image to settle in the second quadrant of the decomposed image using new wavelets NDLWT

2.4 Algorithm NDLWT for watermark

In this algorithm, the steps for embedding the watermark in the color image are done using NDLWT after entering the color image

Step 1: The first step involves entering the cover image in size $L \times L$ and then it will be converted to the gray scale image

Step 2: The watermark is analyzed used NDLWT

Step 3: The part (LH2) of size (2 x 2) that turns into volume sections $R \times R$

Step 4: The role the chaotic function (logistic map). appears to return the parts to their original

Location in equation (14)

$$n + 1 = z(1 - x_n) \quad (14)$$

Equations (15-18) show the process of inclusion and separation

$$\mathrm{L}(2,2) = \mathrm{L}(2,2) - \mathrm{L}(2,2)(\mathrm{mod.n}) + F_1 \text{ if n=1} \quad (15)$$

$$\mathrm{L}(2,2) = \mathrm{L}(2,2) - \mathrm{L}(2,2)(\mathrm{mod.n}) + F_2 \text{ if n=0} \quad (16)$$

The strength and efficiency of the watermark is affected by a factor r = 20.532 represented by, $F_1 = 0.75S, F_2 = 0.25S$ and Logistics map using QR.

$$n = 0 \; if \; (F_1 + F_2)/2 \; < \; \text{mod (L (2,2))} \quad (17)$$

$$n = 1 \; if \; (F_1 + F_2)/2 \; \geq \; \text{mod (L (2,2))} \quad (18)$$

Mathematical equation (19) that shows the correlation of the original water image before extraction and after extraction, where the two images are similar

$$NC = \frac{\sum_l \sum_k C(l,k)C\prime(l,k)}{\sqrt{\sum_l C(l,k)}\sqrt{\sum_l C\prime(l,k)}} \quad (19)$$

3. Work results and discussion

The technique that was used in this work is the new transformation NDLWT and its effect on image processing and analysis, where a new algorithm for watermarking was proposed and the image was used in size 512 x 512 in gray scale to divide the image into four quarters, each quarter with a size of 64 x 64 equal to the size of the watermark proved The results that were reached The power of the algorithm and the method used with the help of NDLWT after the cover image was exposed to image noise attacks and after the extraction process, a PSNR reading was reached and NC whose optimum value is 1 to show the efficiency of the image watermark, Where this value was reached after exposure to an attack JPEGCompression in addition to a value that is the best value see Figure 2 and Figure 3

Table (4): The most important results of the water image after being exposed to some attacks

	attacks	PSNR image a	NC image a	PSNR image b	NC image b	PSNR image c	NC image c	PSNR image d	NC image d
1	Salt and Pepper %1	37.098	0.9999	26.6076	0.9999	26.5350	0.9999	27.4456	0.9999
2	Salt and Pepper %5	32.6621	0.9999	22.3249	0.9999	22.0151	0.9999	22.9029	0.9999
3	JPEGCompression	60.0931	1.0000	61.0418	1.0000	60.8413	1.0000	60.5980	1.0000
4	Gaussian noise	38.6577	0.9999	37.6711	0.9999	37.6772	0.9999	37.6689	0.9999
5	Histequalization	34.0572	0.9988	34.0825	0.9988	34.9025	0.9988	34.4756	0.9988

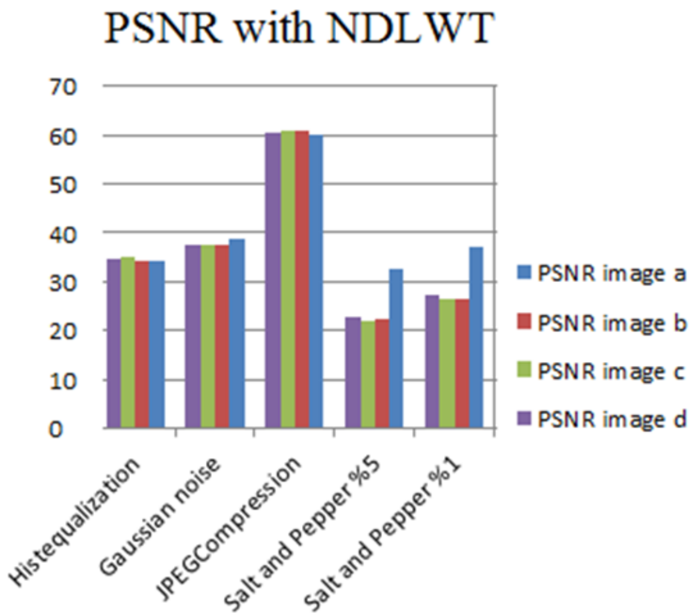


Figure 2. Effect NDLWT on PSNR

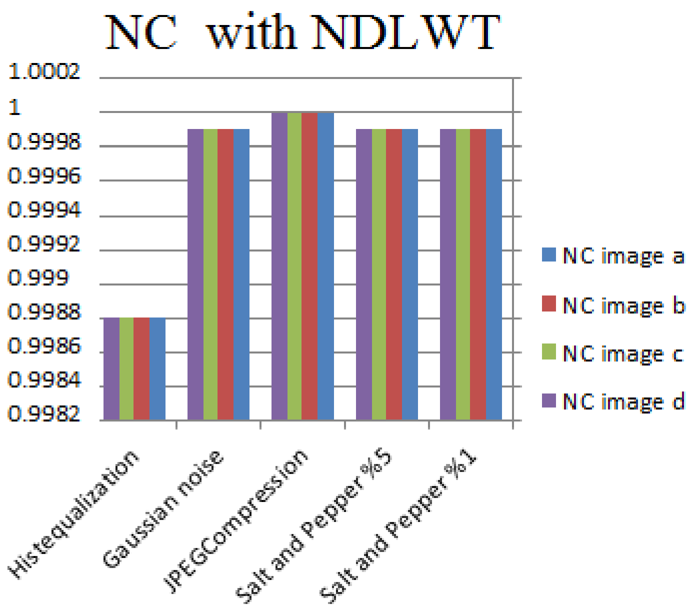


Figure 3. Effect NDLWT on NC

4. Conclusion

The proposed technique in this work showed the effect of separate wavelets on protecting the product and information and maintaining the confidentiality of the product by using watermarks using the MATLAB program in analyzing and compressing the cover image to control the size of the large and huge data of the image. The beginning of the work and after the watermark was immersed with the help of the new filter derived from NDLWT and exposed to five comparison attacks before extraction and after extraction, the extracted watermark did not lose from the information carried by the watermark and the best results were recorded and reached PSNR and CN when exposed to the attack JPEGCompression.

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