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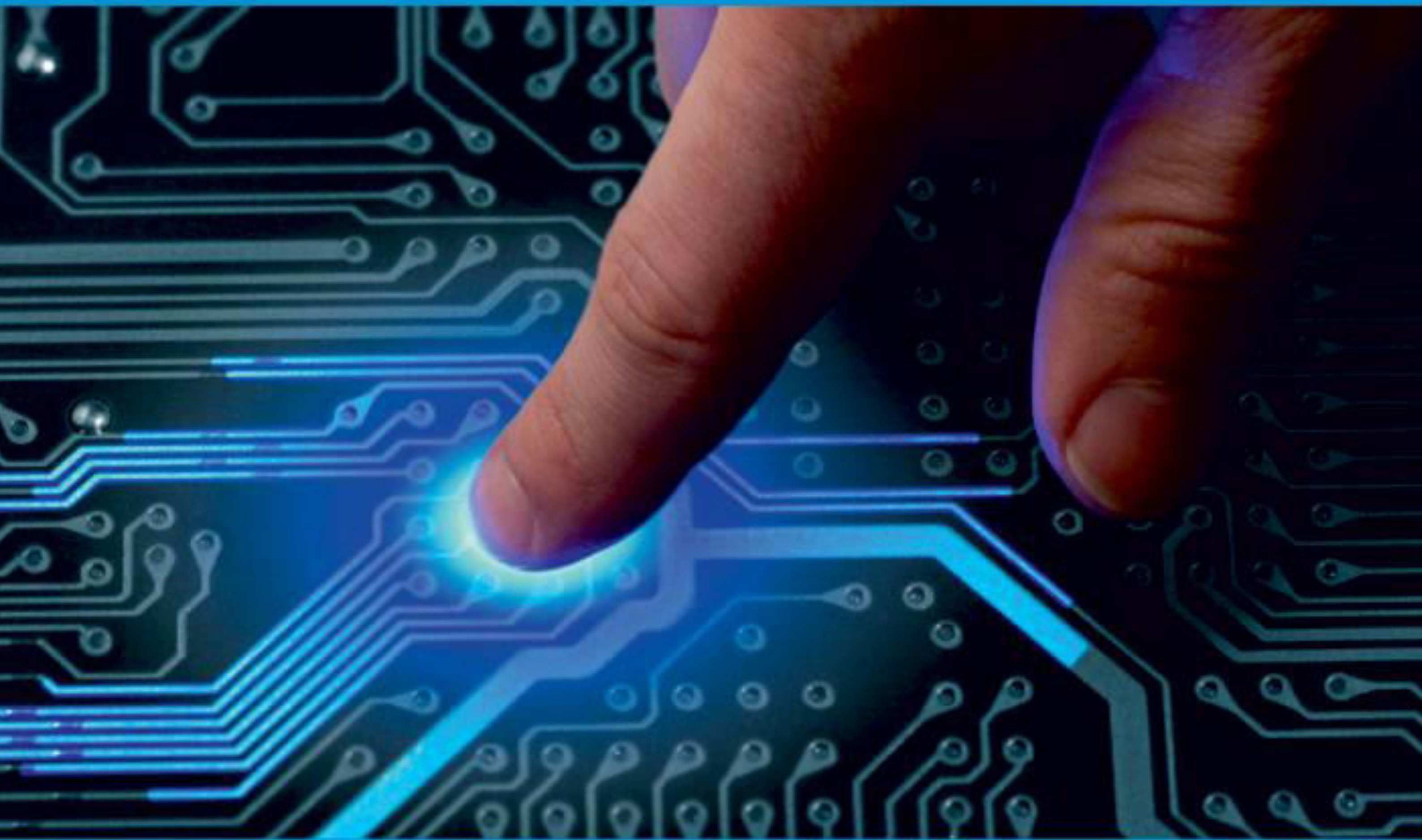

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Particle Swarm Optimization Based Blind Image Watermarking

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ABSTRACT: The significance of methods for copyright protection like the one described in this paper, "Particle Swarm Optimisation (PSO) based Blind Image Watermarking.". A host image is first decomposed using a discrete wavelet transform, and then the insensitive LH and HL subbands are removed using a discrete cosine transform (DCT) based on a human visual model. Then, to make the watermark more robust and easy to spot, a feature matrix is built out of the best frequency spectra in the DCT domain. Finally, The biggest unique values of a feature the matrix combination are rearranged to insert an unstable logistics track watermark image in the decomposition of the singular values domain. To choose the best DCT coefficients and estimate the strength of watermark embedding, a multi-dimensional optimisation is performed using an improved version of PSO, with consideration given to the substantial influence of imperceptibility and robustness. The proposed method is secure because of the way in which logistic maps are intertwined. Experimental results on standard test images demonstrate that the recommended watermarked method achieves better results than competing schemes in terms of both concealment and durability, and that PSO effective searches for ideal levels of a watermark adopting strength and for the most suitable DCT sub bands

KEYWORDS:. Particle Swarm Optimisation (PSO), Image Watermarking, discrete cosine transform (DCT), watermark embedding

I. INTRODUCTION

Digital watermarking is a technique that is employed to safeguard intellectual property rights and mitigate unauthorised replication. The methodology entails the incorporation or elimination of a digital data component, commonly referred to as a watermark, within a multimedia object. The inconspicuousness of the watermark poses a considerable challenge for unauthorised users seeking to eliminate it.[Cox et~al., 2007]. In the framework of client-server architecture, researchers have been looking into the prospect of completely doing away with the need for trusted intermediaries in the course of interactions involving the transfer of data between a client and a service provider. Techniques have been developed that can embed watermarks in the cloud in a secure and private manner while also allowing for their extraction. [Kumar, 2019]. Image owners can feel more confident about making their content accessible to the public when they upload it to social media platforms and send it over the internet in a networked arrangement where photos are communicated if they integrate copyright logos in the form of watermarks into their images. This is because the watermarks take the shape of copyright logos. To put it more succinctly, if you want to add a copyright logo to your image, you will need to make a watermarked image in order to conceal the logo within the original. If you do not generate a watermarked image, the logo will be visible.

Academic experts have suggested an alternative method for controlling the impact and effectiveness of a watermark. This approach entails employing various scaling factors with unique values that are ascertained based on the localised features of different segments within the image, instead of depending on a single, unchanging scaling factor. [Rajpal et~al., 2016]. It has been recommended that collaborative watermarking approaches, which make use of the Human Visual System, be employed in order to achieve increasing degrees of indiscernible in the watermarks that are placed on digital media. These techniques take using the evidence that to your opportunity humans have a good experience. The Human Visual System is made up of a number of essential properties, two of which are the graphic prediction error in addition to the edge probability, the two of which are responsible for selecting the optimal sites for embedding watermarks in an image. The graphic prediction error in addition to the edge probability, the two of which are responsible such as establishing the optimum sites for enhancing watermarks.

II. LITERATURE SURVEY

This chapter presents an in-depth analysis of the research that has been conducted on the many distinct types of digital watermarking that can be utilised for Blind images. In the following chapter, we will investigate many techniques that can be used to watermark data in the transform domain. We have selected a few of the research articles that have generated the most interest and attention. An investigation into the fundamental watermarking techniques, applications, and variants is carried out during the initial phase of the research project.

The field of multi-media signal processing has experienced a notable increase in the prevalence of digital watermarking among both academic researchers and industry practitioners. This area of research has attracted considerable interest from numerous academics. Despite some minor inconsistencies in the literature, the term "watermarking" generally relates to the actions involved in embedding a electronic signal or identifier through multimedia content in order to protect copyright or authenticate its origin. [Low and Maxemchuk, 1998] It would appear that this is the most common scenario. Watermarking is the process of subtly altering data in order to covertly add metadata. The term "watermarking" corresponds to this specific method. The watermarks are difficult, if not impossible, to identify. This graphic brings attention to two major traits that are typical of watermarking. When it is first completed, the process of incorporating data shouldn't have any discernible effect on the original image. In addition to this, the message should be appropriate for the medium that is being utilised in order to display the image. The methods that are utilised in the process of watermarking may be categorised as a type of the methods that are utilised in the process of concealing information. Situations that fall under the purview of this category include those in which the information that has been masked is not necessarily linked to the primary media. Having stated that, it is essential that I bring to your notice the fact that a lot of authors utilise the statement "watermarking" to make mention of the notion of information concealing that is the most all-encompassing and comprehensive.

Researchers in the field of watermarking immediately realised the necessity for strong theoretical underpinnings, despite the fact that heuristic approaches with little to no theoretical context and support first dominated the field. Researchers have investigated this field of study by conducting experiments and utilising successful techniques, fundamental concepts, and theoretical advances gleaned from a diverse range of scientific fields.

2.1 Particle Swarm Optimization

An iterative optimisation strategy that takes its cues from the workings of nature is known as the Particle Swarm Optimisation (PSO) method. In 1995, Eberhart and Kennedy were the ones who initially presented it. [Eberhart and Kennedy, 1995]. The phenomenon can be compared to the behaviour of birds while they are searching for food, where the individual birds act as stand-ins for the particles. A swarm is made up of a collection of separate entities acting together. The process starts with the random beginning of the swarm's particles. This is called the stochastic initialization. Each particle has a position and velocity that are entirely unique to themselves. To put it another way, A particle swarm is a group of potential alternatives to an optimization process that can move through to the check basis function as trajectories. This allows the particle swarm to find optimal solutions more quickly.

2.2 Lifting Wavelet Transform

The generation of bi-orthogonal wavelets was made possible by the development of a transform called the Lifting Wavelet Transform. Because of a restriction imposed by the traditional discrete wavelet transform, a new technique known as the Lifting Wavelet Transform had to be developed. This strategy makes use of direct evaluation within the integer domain, which ultimately resulting in a considerable drop in the level of complexity required to solve the reversibility problem. Lifting Wavelet Transform has quickly become a well-liked option within the realm of the processing of images as a result of its exceptional performance in both the temporal and spatial domains. This method has the potential to generate wavelets of a subsequent generation; all that needs to be done is make some adjustments to the lifting process[Daubechies and Sweldens, 1998].

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Split: Sets of odd and even signal samples that are kept separate from one another and do not overlap. $\Phi(a)$, calculated using equation 1.

$$\Phi_e = \Phi(3a) and \Phi_o = \Phi(3a+1) \quad (1)$$

Predict: The split samples can be used to forecast each other if they are associated with each other by first abstracting the difference between them. The equation that can be used to predict values can be found here. 2.

$$\Psi(a) = \Phi_o(a) - \Upsilon[\Phi_e(a)] \quad (2)$$

where $\Upsilon[\Phi_e(a)]$ and $\Psi(a)$ are predict operator & high frequency components respectively Which is a term that is used to characterise the distinction between the value of the initial sample and the value that was anticipated. [Chen et~al., 2000].

Update: After updating the even samples $\Phi_e(a)$ with the update operator $Updt(a)$, the low-frequency component $lfc(a)$ is represented by the abstract difference $\Psi(a)$, which is a rough approximation of the original signal $\Phi(a)$ defined in the following equation 3 [Chen et~al., 2000].

$$lfc(a) = \Phi_e(a) + Updt(G(a)) \quad (3)$$

2.3 Singular Value Decomposition

The application of a method within the realm of linear algebra The term for this conceptis singular value decomposition (SVD), which is capable of decomposing a single matrix into its three separate component matrices, is one way that a matrix can be split up into its component parts.

- the vectors on the left singular;
- a collection of individual values;
- vectors with a right singular.

According to the SVD theorem, if one is provided with a matrix, which will be represented by M, following that one can locate a decomposition of N in such a way that $C = RIA$. If one is given the letter N, one can accomplish this task [Mansouri et~al., 2009].

There is also the possibility of describing the SVD of a matrix by using geometric language as an alternative viable option. After increasing the values of the matrix (I), performing a rotation (R), and then finally performing a third rotation (A), the SVD indicates that it is possible to reconstruct the values of any matrix C by increasing the values of the matrix first, then performing a rotation (R), and finally performing a third rotation (A) [Smithies and Varga, 2009].

2.4 Arnold Transform

The Arnold Transform, also known as AT, would be utilised for scrambling the majority of the time. It is utilised in image processing to jumble the location of pixels in order to save room for storing things. [Sui and Gao, 2013]. A square matrix of A x A the measured values are as follows: $K = \{(\alpha,\beta)|\alpha,\beta = 1,2,3, \dots A-1\}$. The AT can be stated in the following manner:

$$\begin{pmatrix}\alpha_a\\ \beta_a\end{pmatrix} = \begin{pmatrix}2 & \alpha\\ \beta & \alpha\beta+2\end{pmatrix}\begin{pmatrix}\alpha_{a-1}\\ \beta_{a-1}\end{pmatrix} \text{modA} \quad (4)$$

The coordinates α_a and β_a are utilised to transform with regard to $\alpha_{(a-1)}$ and $\beta_{(a-1)}$ after m iterations, Both a and b are considered to be positive values, and the width and height of a square matrix are denoted by the letter A. When (α,β) is modified numerous times, the AT is iterative. It reverts to its former state.

2.5 Performance Metrics

It is possible to provide a numerical value that expresses to what extent something is the cover picture and the picture

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that contains the watermark can be distinguished one from the other. The calibre of the picture that appears on the cover is diminished whenever there is any modification made to the first picture that was taken, regardless of whether the picture is watermarked or whether another technique is used. As a result, evaluating its quality is essential [Kutter and Petitcolas, 1999]. The standard of an image used for a cover suffers whenever it's indeed subjected to watermarking or any other form of alteration. Therefore, conducting a quality assessment of it is essential. Through the utilisation of the formula for calculating the peak signal-to-noise ratio (PSNR), which is shown in equation 5.

$$\mathrm{PSNR} = 10 \times \log_{10}(\frac{155^2}{MSE}) \quad (5)$$

Mean squared error (MSE) is a metric that can be used to compare the original, unaltered version of an image to the version of the image that contains a watermark. This comparison can be used to measure the error. Utilising the equation as a point of reference, the MSE can be calculated. 6, such that O represents the first version, unmodified picture & MW represents finally modified, copyrighted version.

$$\mathrm{MSE} = \frac{1}{A \times B} \sum_{s=0}^{A-1} \sum_{t=0}^{B-1} (O(s,t) - MW(s,t))^2 \quad (6)$$

In order to conduct an accurate analysis of the effectiveness of the watermarking system, it is necessary to conduct a thorough assessment of the watermark retrieval quality. Academics typically use It is essential to employ both this same normalised correlation (NC) and also the structural similarity index measure when evaluating the accuracy of a watermarking system can be relied on. Both of these measurements can be found here (SSIM). Both of these units of measurement can be found in this particular location. [Wang et~al., 2017]. While NC evaluates the high level to which the version and the copyrighted duplicates share structural similarities, SSIM establishes the extent to which the source material and the watermark information copies share comparable levels of similarity. It is possible to obtain the NC and SSIM by solving their respective equations, which are designated as7 and 8.

$$\mathrm{NC} = \frac{\sum_{s=1}^{A} \sum_{t=1}^{B} w(s,t) \times w\prime(s,t)}{\sum_{s=1}^{A} \sum_{t=1}^{B} w^2(s,t)} \quad (7)$$

We use the symbols i and w', one representing the initial watermarked image (w) and the other for the collected watermarked image (iw'), respectively, in to make a distinction between the two.

$$\mathrm{SSIM} = \frac{(2\mu_w \mu_{w\prime} + C_1)(2\sigma_{ww\prime} + C_2)}{(\mu_w^2 + \mu_{w\prime}^2 + C_1)(\sigma_w^2 + \sigma_{w\prime}^2 + C_1)} \quad (8)$$

III. OUR APPROACH

In the following chapter, we will go into more detail about the methodology that was suggested for watermarking medical images. This strategy has been developed to be imperceptible by the visual system of a human being, and as a result, it will be covered in greater depth in the following chapter. The green channel of a digital image contains a bitwise watermark information that is implemented into to the channel that possesses colour in order to meet the standards for the image security and resilience of a watermarked image. These standards were developed to ensure that a watermarked image will not be altered. There is evidence of the colour in the green channel. In order to provide better understanding, the proposed strategy has been divided into sections. 3.1 and 3.2 respectively.

3.1 Process of Watermark Embedding

In this portion of the document, we went over the method involved for incorporating a watermark , and it was very straightforward. Algorithm I outlines the process that must be followed in order to successfully embed the watermark. The first step involves dissociating the colour components of the red, green, and blue elements of the host image, extracted from the image itself. During the second stage regarding the procedure, the green channel of the image of the host is subjected to LWT transformation in order to acquire the low-frequency sub-bands. (i.e. LL, LH, HL, HH). In the third stage, low-frequency sub-bands (LL) are converted into 3×3 block. To obtain the Q matrix, the fourth stage involves decomposing each block using the Hessenberg decomposition method. The watermark bits are encrypted with the Arnolod cat map encryption method during the fifth stage of the process. The sixth stage involves quantifying the marking bits into the Q matrix, after which the Q' matrix is obtained.

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Algorithm 1 Watermark Embedding Method

Require: Color Medical Image as CM_{img} and Watermark Image W_{img}

Ensure: Watermarked image CM_{img}

1: $[CM_{imgr}, CM_{imgg}, CM_{imgb}] = [Red(CM_{img}), Green(CM_{img}), Blue(CM_{img})]$

2: $[LL, LH, HL, HH] = lwt(CM_{imgg})$

3: $block_i = createBlock(LL, blk_n)$

4: $W'_{img} = \text{ArnoldTransform}(W_{img})$

5: $[S, V, D] = SVD(block_i)$

6: $S' = Q + \Delta * W_{imgi}$

7: $block'_i = ISVD(S', V, D)$

8: $LL' = ResetBlocks(LL, block'_i, blk_n)$

9: $CM'_{imgg} = ilwt\,(LL', LH, HL, HH)$

10: $CM'_{img} = [CM_{imgr}, CM'_{imgg}, CM_{imgb}]$

11: Obtained watermarked as CM_{img}

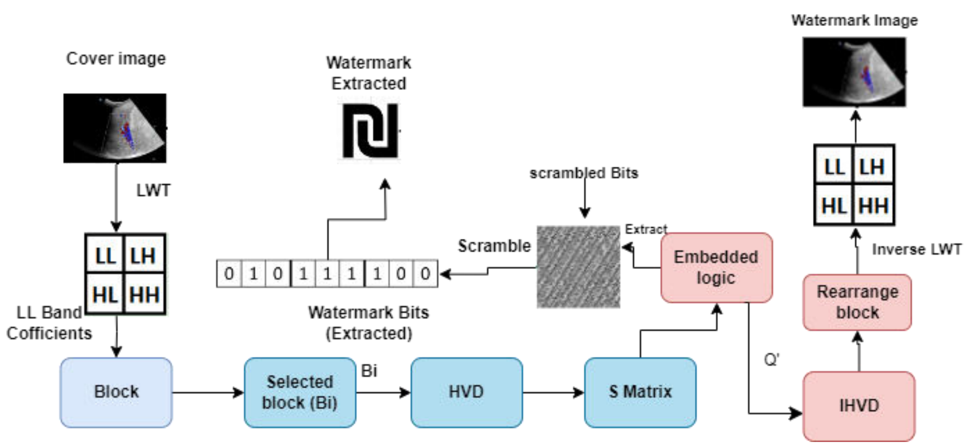

Figure 1: Watermark Embedding Procedure

3.2 Watermark Extraction Process

The following section provides an explanation of the procedure that was followed in order to retrieve the watermarks. Figure illustrates the process that was used to remove the watermark from the image. 2. The procedure for integrating the watermark is described in great detail in Algorithm III, which can be found here. This algorithm takes as its input a colour medical image with the attribute (H'), and the extracted watermark is what it returns as its output. During the first stage of the watermarking process, the chromatic channels of the image are separated into their respective red, green, and blue components. During the second stage, the low frequency sub-bands (LL) are obtained by first isolating the green channel of the watermarked image, and then applying a LWT transform to that channel. The sub-band that has a low frequency is divided into blocks of three times three during the third stage of the process. A zigzag pattern is used to select each of these blocks one at a time. In the fourth stage, the Hessenberg decomposition method is applied in order to acquire the Q matrix that contains the watermark bits. This is done in order to complete the process.

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Algorithm 2 Watermark Extraction Procedure

Require: Watermarked Medical Image CM'_{img}

Ensure: Extracted Watermark Image

$\left[CM'_{imgr}, CM'_{imgg}, CM'_{imgb}\right] = [Red(CM'_{img}), Green'(CM_{img}), Blue(CM'_{img})]$

2: $[LL, LH, HL, HH] = lwt(CM'_{imgg})$

$block_i = createBlock(LL, blk_n)$

4: $[S, V, D] = SVD(block_i)$

$W'_{img} = \begin{cases} 1, & \text{if } S + \Delta \leq \lambda \\ 0, & \text{Otherwise} \end{cases}$

6: $W'_{img} = IArnoldTransform(W'_{img})$

Extracted watermark Image as (W'_{img})

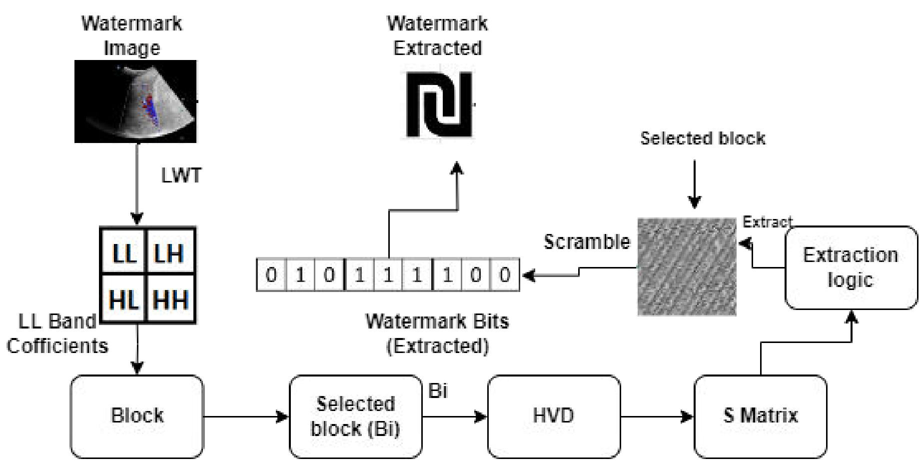

Figure 2: Watermark Extraction Method

IV. RESULT & DISCUSSION

In this section, the planned activity is dissected, and the outcome that is to be anticipated is talked about. In order to evaluate how well the proposed method works, we tested it with several different kinds of X-Ray pictures as well as binary watermark pictures. The cover photo that was chosen for the medical publication has a resolution of 700 by 600 pixels, whereas the image that was used for the watermark has an elimination of 64 by 64 pixel values. These measurements were utilised in the layout that was proposed. This investigation was conducted by the the National the library of Medicine. In order to acquire a deeper comprehension of the clinical condition that was the subject of this investigation, these photographs were utilised. The preliminary renditions of the clinical pictures, which are presented in the figures, are as follows: 2 - 7,in addition to the image that serves as the watermark, which is displayed in figure 9. In order to maintain the patient's privacy and ensure their well-being, the information about the patient has been omitted on purpose.

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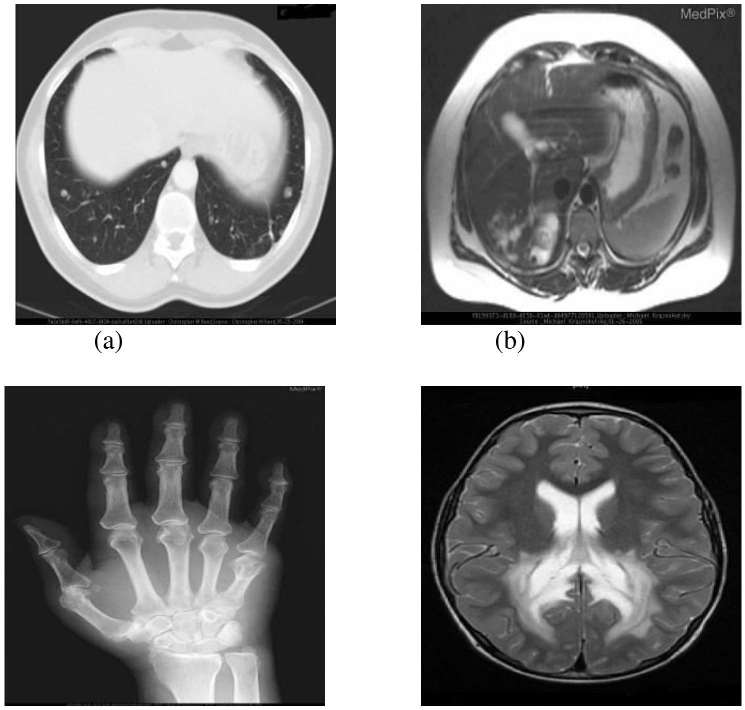
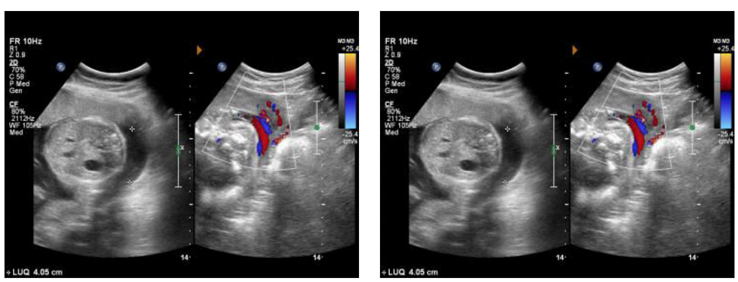


(a) (b)

(c) (d)

Figure 3: Pictures employed in order to purpose of experimentation.



(e) (f)

Figure 4: Images used for experimentation

Figure 5 : Watermark Image

In the following table, the qualities of the PSNR and SSIM of an extracted features that were derived from the watermark are presented. These values were obtained from the watermark. The watermark was extracted from the images, which allowed for the calculation of these values. 0, respectively. PSNR and SSIM both reached their highest possible values of 57.1245 and &1.00, respectively, when they were calculated. This is a perfect illustration of the extremely elevated status of confidentiality that a watermark possesses within an image that has been watermarked, as the watermark is almost impossible to spot once the image has been watermarked. In addition to this, the method used

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to get rid of the watermark works effectively when it is put into practise.

Table 1: Watermarked image & extracted watermark quality evaluation criteria

The Metrics of Evaluation	(a)	(b)	(c)	(d)	(e)	(f)	(g)
Embedded Image	PSNR	54.1246	54.4519	54.2419	54.8745	54.1429	57.5615
	SSIM	1.5000	1.5000	1.5000	1.5000	1.5000	1.5000
	NC	0.9678	0.9692	0.9697	0.9691	0.9698	0.9893
Extracted Image	SSIM	1.2000	1.2000	1.2000	1.2000	1.2000	1.2000
	NC	0.9585	0.9586	0.9588	0.9589	0.9568	0.9591

V. CONCLUSION

As a result, the aim of this study was to develop a grayscale image watermarking scheme for use with medical images. The contourlet transform and the slantlet transform form the foundation for the proposed scheme. The watermark is encrypted using the Arnold transform, which serves two purposes: first, it ensures the security of the system, and second, it ensures the system's continued viability in the long run. The low-pass band that contains the Contourlet transform is utilised in the proposed method, and the LL sub-band had been the one that was used for embedding the watermark in the image. Our investigation produced leads that were more successful to those generated by other methods, both in terms of the level of imagery they generated and their resilience to a variety of various kinds of assaults. Our results were superior both in terms of the pictures quality they produced as well as their opposition to a variety of a distinct types of assaults. Our experiment yielded these results, which produced results that were greater to those generated by other strategies. These outcomes were produced as a result of our experiment. In addition, our work can only be done with black-and-white or grayscale images.

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