A Novel Approach to Audio Watermarking with Improved Robustness against Geometric and Signal Processing Attacks

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Abstract

In tandem with the development of technology for audio watermarking, the scope of assaults that are directed at these systems has also seen expansion. Desynchronization attacks, which involve manipulating aspects such as amplitude fluctuation, pitch shifting, and time-scale change, and traditional signal processing techniques, such as MP3 compression, low-pass filtering, and noise addition, are two methods that can be used to attack audio watermarking systems. In general, there are two ways that these systems can be attacked. The intensity of the watermark is diminished by conventional signal processing; nevertheless, desynchronization assaults during the detection process might result in synchronization issues between the watermark that is recovered and the watermark that was originally present. Desynchronization assaults have only been addressed by a small number of specialized watermarking approaches, despite the fact that the majority of the audio watermarking strategies that have been used in the past have demonstrated resilience to typical signal processing attacks.

Keywords: Robust Audio Watermarking , Geometric Attacks, Multimedia Security, DCT-SVD Domain

1. Introduction

In order to improve the performance of a traditional encryption system, digital watermarking is an extra component that may be utilized. Most modern digital watermarking algorithms are resistant to standard signal processing techniques, including compression, low-pass filtering, and augmentation. We use these techniques to manipulate digital watermarks. However, their effectiveness tends to diminish when subjected to geometric alterations like rotation, scaling, translation, and cropping. The identification of watermarks in images that are not the originals is difficult for us. As audio watermarking technology advances, the range of attacks targeting these systems has also expanded. Desynchronisation attacks, which involve manipulating aspects such as amplitude fluctuations,

One way to get around audio watermarking systems is to change the pitch or time scale or use standard signal processing methods like MP3 compression, low-pass filtering, and noise addition. Generally, there are two ways to attack these systems. The intensity of the watermark is diminished by conventional signal processing; nevertheless, desynchronisation assaults during the detection process might result in synchronisation issues between the watermark that is recovered and the watermark that was originally present. Desynchronisation assaults have only been addressed by a small number of specialised watermarking approaches, despite the fact that the majority of the audio watermarking strategies that have been used in the past have demonstrated resilience to typical signal processing attacks. The synchronisation code, the all-list search, and combinations of spread spectrum and spread spectrum codes that make use of the basic self-synchronisation technique of original digital audio are the three categories that may be used to classify these.

2. Removal Attacks and Manipulations

Right present, there are three primary ideas that may be used to address the problem: The process involves embedding watermarks using geometric invariant domains. It has been suggested by O'Ruanaidh that the Fourier-Mellin transform domain be utilized. As part of its scope, the Fourier-Mellin transform incorporates watermarking into its operations. It is possible to get satisfactory results with the RST (rotation, scaling, and transformation) function. Through the utilisation of a two-dimensional Code Division Multiple Access (CDMA) watermark, *Kundur* [11] is able to disguise the multi-bit message. The Discrete Fourier Transform (DFT) is the method that

Cox [9] uses geometric transformations to create a domain that remains unchanged. It is important to note that the image contains additional info that assists us in synchronizing. In order to provide us with assistance in predicting geometric transformations, Pereira makes use of a template. Fleet's colour images contain data that is not visible to the human eye. Bas will place the embedded watermark on the image based on its features. Bas extracts the feature points using a Harris detector. On the other hand, the stability of the Harris feature point is insufficient in some circumstances, such as scaling. Scaling down the image reduces the efficacy of the watermarking procedure. In order to determine the feature points present in the image, Tang makes use of the Mexican Hat wavelet. The next step involves adding a watermark to a circular zone surrounding each feature point. On the other hand, the fact that the radius is always the same makes it impossible to defend against hypothetical scaling assaults. Ghanbari [12] uses the Scale-Invariant Feature Transform (SIFT) technique to extract feature points from their paper. There are, without a doubt, enhancement strategies available.

Low [8] presents the SIFT concept to the audience. This particular piece of writing incorporates the watermarking technique within its specific area of interest. The feature region is defined by a SIFT point, which is responsible for its creation. Each SIFT point encompasses two parameters: the scale and main orientation. In reality, the feature region is square, despite the fact that it appears to be round. Within this section, particular papers make use of the circular area. On the other hand, that is not entirely appropriate. Because the majority of watermarking algorithms embed watermarks in square regions, it is required to transform circular areas into square areas by padding them with zeros. This is done in order to ensure that the watermarks are embedded correctly. We will see an increase in our agricultural output as a consequence of this. There is a square region that we make use of in our activity. The results that it produces are remarkable. Digital files can incorporate watermarks in various locations. Any site may exhibit the presence of watermarks. For the purpose of achieving superior results, our paper makes use of an improved methodology. We make use of carefully chosen feature zones. The selection of feature areas significantly influences the robustness of the method. In this study, we select additional zones of interest from a photograph. Following that, we make use of an all-encompassing search strategy in order to locate feature areas that include embedded watermarks. The functionality of the method improves the watermark's resistance to assaults that are geometric in nature.

Getting rid of a watermark is a straightforward approach to dealing with the issue. Even without prior knowledge of the approach, an attacker can introduce distortions if they are aware that the majority of watermarks will be of low quality. The operations that are carried out during the process of data preparation in some applications might result in the inadvertent removal of watermarks. When applying the DFT, DCT, and DWT algorithms to a watermarking method, Asmara [1] examined their differences and similarities.

3. Literature Review

Natgunanathan [2] introduced a patchwork-based technique for watermarking stereo audio signals. The discrete Fourier transform (DFT) is the domain in which this approach operates, and it makes use of the similarities that exist between the two audio channels of stereo signals. We devised this approach to protect the stereo signals from potential damage. Despite the fact that its payload capacity was not very great, this algorithm showed a significant level of resistance when it was attempted to defend itself against a variety of standard attacks.

Megias [3] is responsible for the development of an algorithm for blind watermarking. Through the utilisation of the rapid Fourier transform, this approach prevents the chance of self-synchronisation occurring in audio signals. The use of the method allows for the incorporation of synchronisation signals into the time domain, as well as the introduction of watermarks into the frequency domain. One of the vulnerabilities of the code that was responsible for self-synchronisation in the temporal domain was that it was susceptible to specific assaults, which would result in the watermark becoming unsustainable.

Tewari [4] has revealed the existence of an algorithm for digital audio watermarking. It was through the modification of the middle frequency region of the DCT coefficients that this approach was able to insert the watermarks.

Using patchwork as the foundation, Natgunanathan [2] came up with yet another way for watermarking audio recordings. It was also necessary to change the mean values of some pieces in the DCT domain in order to embed and extract watermark bits inside a multilayer structure. We did this to achieve the previously mentioned goals. When it came to hauling the maximum amount of paper, the truck was unable to accommodate it.

In addition to disclosing a technique for adding a high-capacity audio watermark, Hu [5] developed a method for perceptual masking inside the DCT region. Hu was the one who came up with both of these methods. The authors said that their method's payload capacity reached 848.08 bits per second. It was because they used three separate DCT coefficients, each with its own unique set of parameters, to include the watermarks. The watermarks' simultaneous integration into those three DCT coefficients, however, did not prove the method's efficacy on its own. Many different audio watermarking methods have analysed the signal's frequency components using the discrete wavelet transform (DWT). The program's flexibility in accommodating different screen sizes allowed it to do this. We executed this activity with the aim of improving the algorithm's overall performance. Researchers came up with a method they call variable-dimensional vector modulation (VDVM) after their examination. The payload capacity was increased because it was possible to maximise the efficacy of the norm-space DWT-based audio watermarking technology. We were able to pull this off even though it wasn't very resilient in comparison to other approaches.

In order to improve the method's robustness and audio quality, Kumsawat [6] used a genetic strategy to find the optimal quantisation step. Because of this, he was able to accomplish his goals. The method in question has excellent defences against most assaults (except low-pass filtering), but it can only carry a small amount of data. Li [7] presented a solution for localised audio watermarking that is content-dependent, which prevents time-scale manipulation and arbitrary cropping. Adding the watermark bits to the stable, high-energy local sites increased their resilience, according to Gruhl [13]. We did this so that things may get better.

4. Objectives of the Study

This section presents the resilient watermarking approach known as DPC-CKGSA. This method makes use of CKGSA inside the DCT-SVD domain. There are three steps to make up the proposed watermarking technique. These stages include the embedding phase, the extraction phase, and the optimisation of the embedded variables.

The algorithm for embedding watermarks

This procedure combines the primary component of the cover image with the major component of the watermarked picture. Peinado [10], utilising the most ideal combination of embedding elements that is possibly attainable, is the means by which this objective is realized. In order to better understand the embedding process, the following is a list of the steps involved:

i. Select the cover picture (C) with dimensions of 512 × 512 pixels and the watermark image (W) with dimensions of 64 × 64 pixels.

ii. Partition the cover image into eight 8 × 8 square blocks. Next, do the discrete cosine transform (DCT) on each block, using the Arnold transform, resulting in a matrix (Cd) with constant values (DC).

iii. To lower the chance of getting false positives, do Singular Value Decomposition (SVD) operations on the matrix (Cd) and find the principal component (Cpd).

The right and left orthogonal matrices are denoted as Su and Xu, respectively, while the rectangular diagonal matrix Su includes non-negative real values.

iv. The Arnold chaotic map is used to convert a watermark image (W) into a scrambled watermark image (Ws) in order to increase security and durability.

v. It is necessary to determine the image's primary component after applying the Singular Value Decomposition (SVD) algorithm on the encrypted watermark picture.

$$W_s = U_W S_W V_W^T \tag{3}$$

$$W_{pc}^{*} = \ddot{U}_W \ddot{\times} \ddot{S}_W^{\prime\prime} \tag{4}$$

vi. The CKGSA algorithm is used to determine the ideal values of the embedding factors (α).

vii. Use the found embedding factors ($\mathbf{\Omega}$) on the main part of the cover image ($\mathbf{L}Mc$) to combine it with the main part of the scrambled watermark (UMc).$CPc\ Pc$).

$$PC_1 = C_{pc} + \alpha \cdot W_{pc} \tag{5}$$

8. Acquire the updated matrix ($P\ Cm$)

$$PC_m = U_C PC_1 V_C^T \tag{6}$$

Algorithm for extracting watermarks

On the other hand, the watermarking process uses the opposite extraction method, the embedding technique. Ko [14]: Instead of the cover picture, the side information is what is necessary in order to finally finish the extraction process. Because of this, the technique that has been supplied is a semi-blind method, and in order to extract the watermark image, the steps that are listed below are necessary to be completed.

Using CKGSA to determine the ideal set of embedding factors

Choosing the embedding settings in the most effective way possible is absolutely necessary in order to achieve a balance between robustness and imperceptibility, as Kim [15] says. After the correct embedding settings have been chosen, the watermark is included into the cover photo by utilising the procedure that is advised. The technique that has been suggested makes use of CKGSA, a metaheuristic algorithm that was created not too long ago, in order to achieve the same goal.

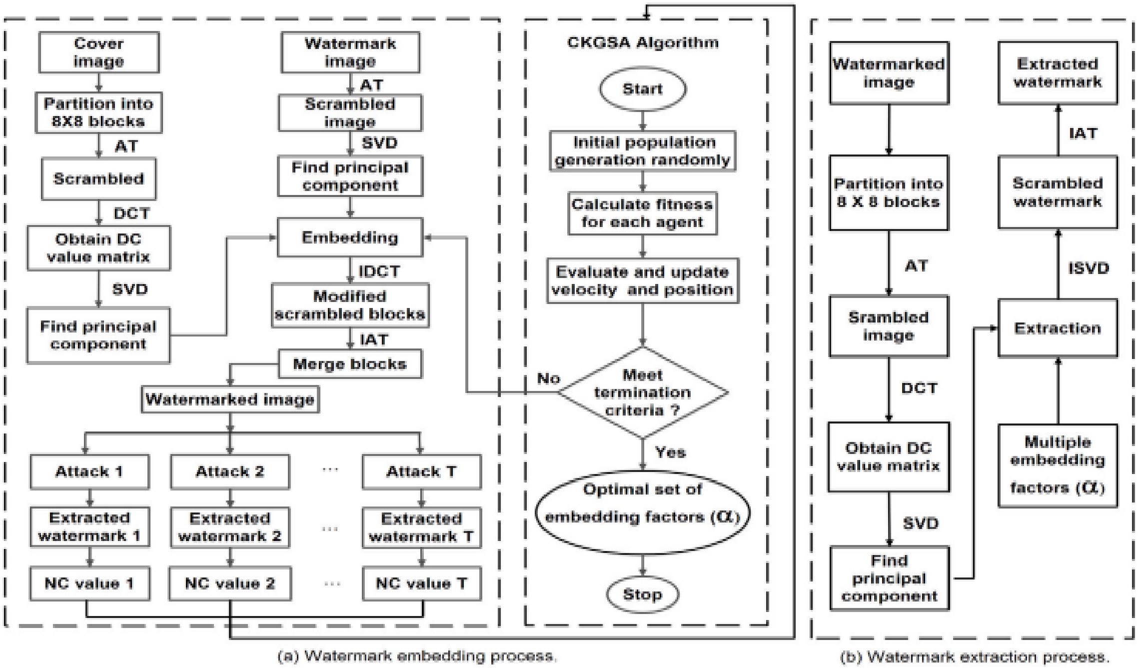


Figure 1. Here is the schematic for the DPC-CKGSA watermarking method that is suggested

Complexity of computation

The experiment uses a desktop PC with 8 GB of RAM and a Core i5 CPU. The method proposed as DPC-CKGSA mainly makes use of the following operations: Discrete Cosine Transform (DCT), Inverse Discrete Cosine Transform (IDCT), Singular Value Decomposition (SVD), Inverse Singular Value Decomposition (ISVD), and Arnold transform. A considerable amount of time is required for these processes (see Figure 1). The cost of computing each operation for an image of $R \times R$ dimensions is determined using the following formula in section 5.

5. Results

This section presents the empirical examination of the suggested (DPCCKGSA) approach. The study evaluated six cutting-edge watermarking techniques to assess the effectiveness of the suggested method. (i) (i) We utilised the Discrete Wavelet Transform (DWT) for the Geometrically Shaped Array (GSA); DWT, DCT, and SVD for Particle Swarm Optimisation (DDS-PSO); DWT, DCT, and SVD for Differential Evolution (DE); DWT, DCT, and SVD for PSO (DS-PSO); and DCT for Teaching-Learning-Based Optimisation (TLBO).

For each and every meta-heuristic algorithm, the population size is predetermined to be fifty, and the maximum number of iterations is established to be two hundred. However, the values of the parameters (p, c, and d) for the Arnold transform are determined According to the available literature, the numbers are 10, 1, and 1, respectively.

Evaluation of image quality and resilience

We use NC and PSNR to test the original watermark image (W) and the extracted watermark image (W) for resilience. Simultaneously, we evaluate the watermarked picture's quality using two measures: PSNR and SSIM. We compare the cover image (X) and the watermarked picture (X) using these measurements. We are taking the following metrics into consideration: One way to find the Peak Signal-to-Noise Ratio (PSNR) in mathematics is to use the following equation.

$$PSNR(C, W^{\star}) = 10\log_{10}\left(\frac{I_{peak}^2}{MSE}\right) \tag{7}$$

It follows that $Jkeak$ is 1 for pictures of the double data type and uint 8 data type, respectively. The equation is used to find the mean squared error (MSE) between the cover image ($\mathbf{O}$) and the watermarked picture. $(Y\star)$.

$$MSE(C, W^{\star}) = \frac{1}{R^2}\sum_{a=1}^{R}\sum_{b=1}^{R}(C(a,b) - W^{\star}(a,b))^2 \tag{8}$$

Equation expresses SSIM.

$$SSIM(C, W^{\star}) = \frac{(2\mu_C\mu_{W^{\star}} + c_1)(2\sigma_C\sigma_{W^{\star}} + c_2)}{(\mu_C^2 + \mu_{W^{\star}}^2 + c_1)(\sigma_C^2 + \sigma_{W^{\star}}^2 + c_2)} \tag{9}$$

The symbols μC and σC, which represent the mean and standard deviation of the cover picture, respectively, are used to represent these mathematical quantities. In a manner that is analogous, the watermarked image is computed by using the variables $\boldsymbol{\Theta}W$ and σW, which represent the mean and standard deviation of the watermarked picture, respectively. Through the utilisation of constants $c1$ and $c2$, NC is able to avoid the occurrence of the condition $0*0$ from taking place.

Examining imperceptibility

One way to determine the watermarked picture's quality is to compare it to the cover image and use the perceptual difference—also called visual

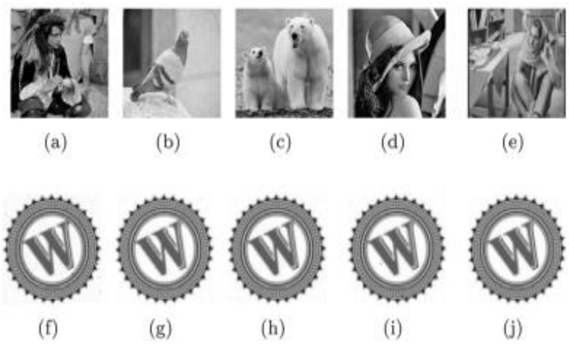


Figure 2. Photographs of a guy, pigeon, bear, Lena, and Barbara with watermarks

Figure 2. Photographs of a guy, pigeon, bear, Lena, and Barbara with watermarks and photographs of the same subjects without watermarks are also included.

Discernibility—to your advantage. When the imperceptibility grade is higher in perspective, cover photographs and watermarked images are more likely to appear similar. Qualitative and quantitative analyses were also considered in order to conduct an evaluation. Figure 2 illustrates the quality of the watermarked photographs for assessing qualitative aspects. These pictures bear a striking resemblance to the cover pictures depicted in Figure 2. You can use quantitative analysis to look into it. The Peak Signal-to-Noise Ratio (PSNR) and the Structural Similarity Index (SSIM), which are shown in Table 1, are two ways to measure this. If the PSNR and SSIM values of a watermarked picture are more than 35 dB and 0.93 respectively, then the image is deemed to be of good quality, as stated in the published literature. The analysis of all the photos is shown in Table 3. It shows that the suggested method produced the highest Peak Signal-to-Noise Ratio (PSNR), which was between 42.37 and 41.01. In spite of this, every single technology that is now being utilised has Peak Signal-to-Noise Ratio (PSNR) values that are higher than 35 decibels. The capacity to compare and visualize data is improved by the bar chart that is displayed in Figure 5. The results in Table 3 show that the DPC-CKGSA method worked to get the best SSIM values, which were 1, 0.9999, 0.9874, 0.9997, and 1 for the pictures of Man, Pigeon, Bear, Lena, and Barbara, in that order. Therefore, the presented DPC-CKGSA methodology proves to be an efficient method for embedding..

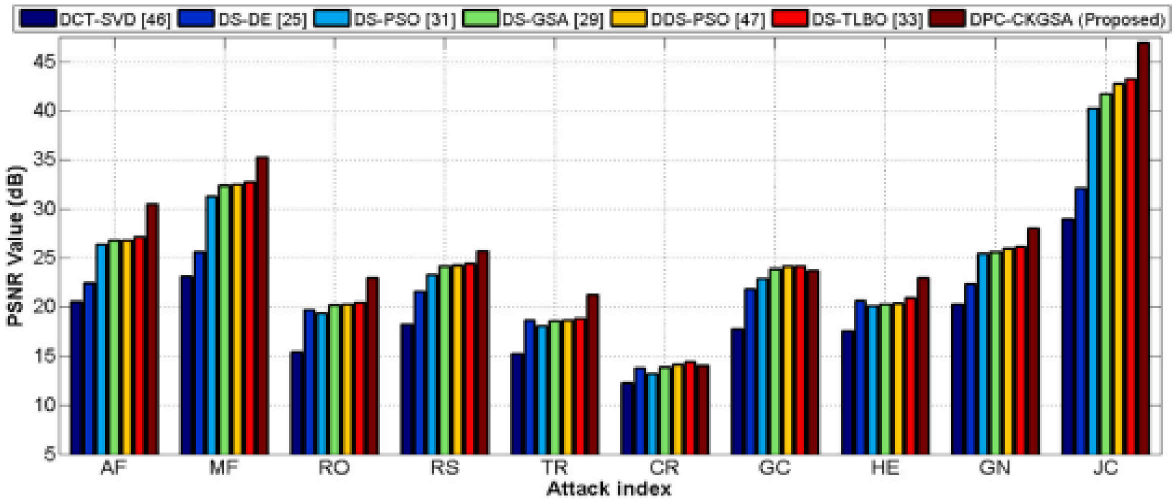
Table 1. The results of the proposed technique for different cover and watermark image sizes in terms of PSNR, SSIM, and NC when no attack is present

Cover image	. Image size	Watermark image size	Watermarked image		Extracted watermark
			PSNR	SSIM	NC
	512 x 512	64 x 64	42.37	1.0000	1.0000
Man	256 x 256	32 x 32	38.79	0.9846	0.9989
	128 x 128	16 x 16	35.44	0.9808	0.9977
	512 x 512	64 x 64	41.70	0.9999	1.0000
Pigeon	256 x 256	32 x 32	38.81	0.9807	0.9765
	128 x 128	16 x 16	36.05	0.9783	0.9672
	512 x 512	64 x 64	41.01	0.9874	1.0000
Bear	256 x 256	32 x 32	37.73	0.9761	0.9972
	128 x 128	16 x 16	35.40	0.9742	0.9776
	512 x 512	64 x 64	41.12	0.9997	1.0000
Lena	256 x 256	32 x 32	37.45	0.9837	0.9997
	128 x 128	16 x 16	36.58	0.9705	0.9862
	512 x 512	64 x 64	41.24	1.0000	1.0000
Barbara	256 x 256	32 x 32	37.66	0.9890	0.9908
	128 x 128	16 x 16	35.31	0.9684	0.9853

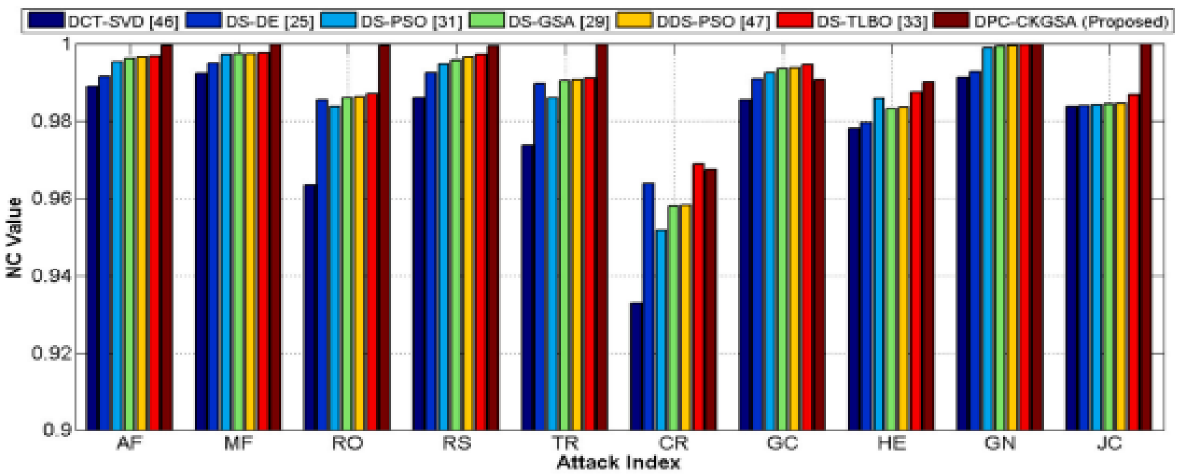
Examination of resilience

By evaluating the peak signal-to-noise ratio (PSNR) and normalised correlation (NC) between the original watermark photographs and the derived pictures, the robustness of the watermark extraction method can be assessed. We conduct 10 different attacks on the watermarked image to examine its resilience. Five different types of attacks can use these watermarking holes. They are geometric, noise-based, compression-based, filtering-based, and contrast-based attacks. Table 2 provides a brief description of each category of image assaults. Additionally, qualitative and quantitative evaluations were performed to determine the longevity of the submitted approach. When doing the quantitative analysis for each assault, both the NC and PSNR measurements were utilized. The attacks' classification determined the selection of these measures.

Using both the NC metric (defined in Equation 10) and the PSNR metric (shown in Equation 11), we can judge how good the watermark is that has been extracted. NC values near 1 indicate a strong resemblance between the recovered watermark and Kirovski's [17]. The next subsections will evaluate the resilience of the system by putting it through five different attacks. In Table 3, you can see the matched attacked watermarked photos for each of the Man, Pigeon, Bear, Lena, and Barbara images, along with the visual fidelity of the acquired watermark photos for each of those images. The following table provides evidence that the suggested method is effective in retrieving the high-quality watermark in spite of all of the assaults that were taken into consideration.



(a) PSNR values



(b) NC values

Figure 3. A comparison of the performance of several algorithms for the Man picture under different assaults, using "(a) PSNR values and (b) NC values"

Table 2 Evaluation of the proposed method's imperceptibility (PSNR and SSIM) in comparison to the many existing approaches for different types of cover photographs

Parameter	Cover images	DCT-SVD	DS-DE	DS•PSO	DS-GSA	DDS-PSO	DS-TLBO	DPC-CICGSA
PSNR	Pigeon	35.89	36.22	36.37	36.94	37.24	37.78	42.37
	Lear	35.82	36.15	36.34	36.67	36.87	37.74	41.70
	Lena	34.86	35.17	35.67	35.98	36.07	36.47	41.01
	Barbara	34.93	35.31	35.75	36.23	36.14	36.53	41.12
SSIM	Man	35.75	35.98	36.12	36.61	36.79	37.63	41.24
	Pigeon	0.9787	0.9881	0.9885	0.9889	0.9907	0.9939	0.9935
	Lear	0.9782	0.9879	0.9883	0.9885	0.9897	0.9936	0.9937
	Lena	0.9692	0.9695	0.9754	0.9776	0.9823	0.9883	0.9882
		0.9725	0.9742	0.9764	0.9785	0.9829	0.9888	
	Barbara	0.9774	0.9873	0.9875	0.9882	0.9890	0.9929	
								0.9925

Table 3. Using filtering attacks, the suggested technique's resilience in terms of NC is compared to other methods currently in use

Image for the cover	Attack index	Classica l (CL) DCr-SVD	Using a meta-heuristic (MH) to improve upon (')							
			DS-DE	DS-PSO	DS-GSA	DOS-PSO	DS-TI-BO (1·I1	DPC-CKGSA	CL	MH
Man	AF	0.9889	0.9889	0.9955	0.9889	0.9965	0.9968	0.9996	1.08	0.28
	MF	0.9924	0.9924	0.9973	0.9924	0.9977	0.9977	0.9999	0.75	0.22
Pigeon	AF	0.9879	0.9879	0.9947	0.9879	0.9968	0.9963	0.9995	1.17	0.32
	MF	0.9918	0.9918	0.9968	0.9918	0.9971	0.9977	0.9998	0.81	0.21
Bear	AF	0.9864	0.9864	0.9937	0.9864	0.9947	0.9947	0.9991	1.29	0.44
	MF	0.9905	0.9905	0.9957	0.9905	0.9963 0.9963	0.9963	0.9994	0.90	0.31
Lena	AF	0.9876	0.9876	0.9949	0.9876	0.9959	0.9959	0.9992	1.17	0.33
	ME	0.9917	0.9917	0.9969	0.9917	0.9975	0.9975	0.9997	0S1	0.22
Barbara	AF	0.9887	0.9887	0.9953	0.9887	0.9965	0.9965	0.9990	1.04	0.25
	MF	0.9922	0.9922	0.9971		0.9977	0.9977	0.9999	037	0.22

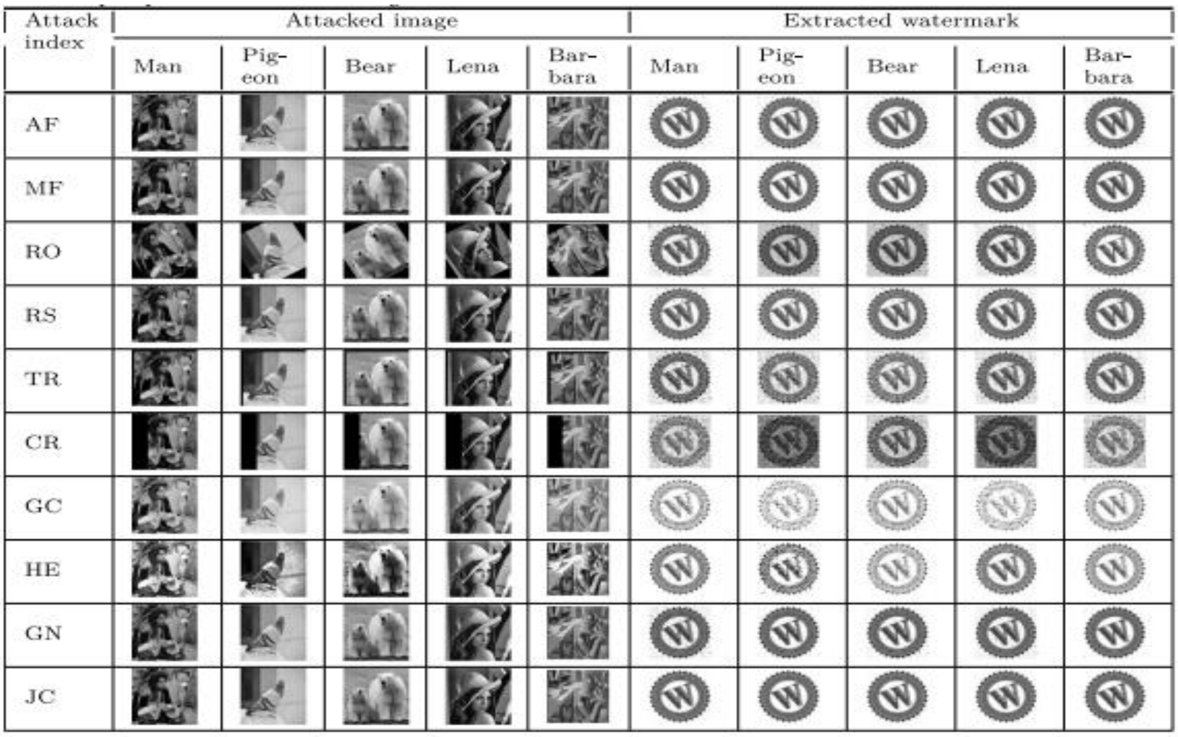
Resilience to filtering attacks

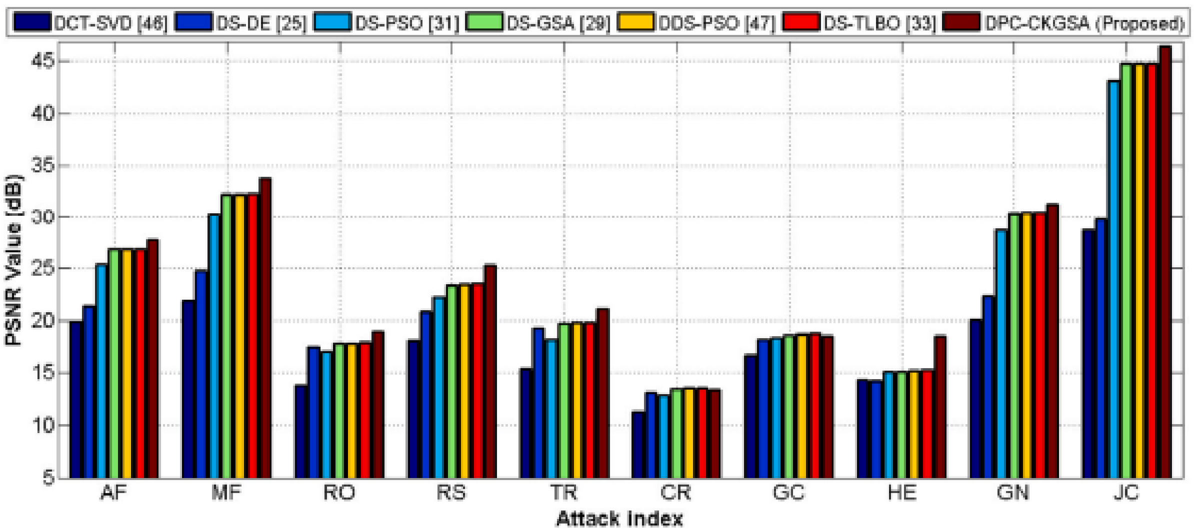
Applying a filtering image processing technology can reduce the noise levels of a watermarked image and enhance its smoothness. You can test how well the method holds up by running it over a watermarked image with two different filters: the median filter (MF) and the average filter (AF). Both filters utilise a 3 x 3 filter mask. To eliminate local oscillations and minimise noise, we may simply replace the value of the core pixel with the median and average of all the surrounding pixels.

We evaluate traditional and meta-heuristic watermarking methods using the PSNR and NC values after we filter attacks. You can see the results in Table 3. The tables also display the percentage benefits gained by the proposed technique when compared to the best and traditional methods in meta-heuristic-based watermarking approaches. Also, the two tables show that the proposed method works better than the others and gets a 39% success rate after median and average filtering attacks are used. Enhancement, compared to the DCT-SVD method for All the observed images have been analysed.

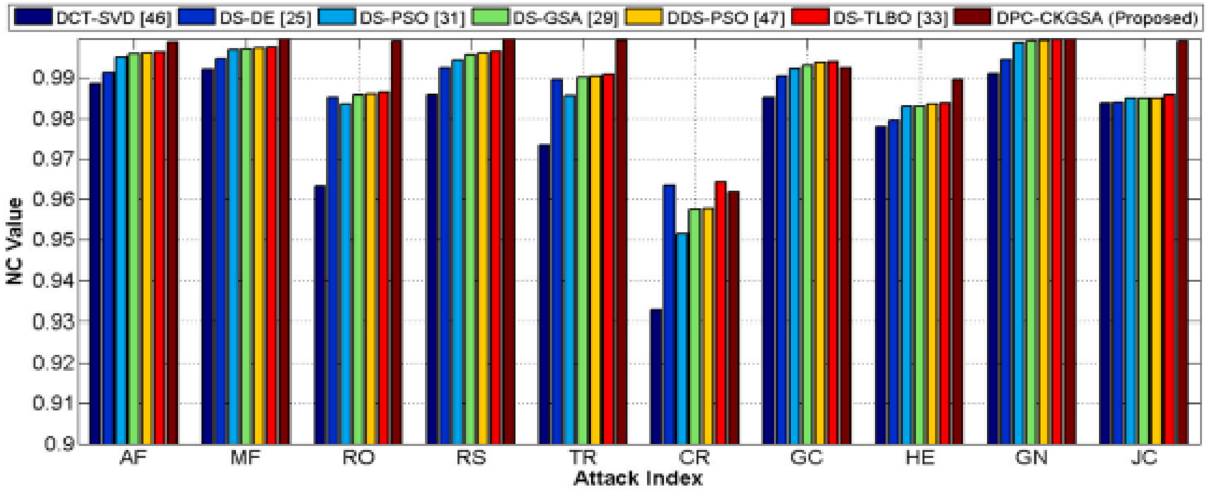
Furthermore, the DPCCKGSA The methodology outperforms competing approaches that rely on meta-heuristics. In comparison to the average filter, the median filter keeps the picture's edges intact, making it the better choice by Malvar [18]. The median filter, in contrast to average filtering, drastically reduces the amount of noise in the watermarked image. Median filtering outperforms average filtering when considering PSNR values (see Table 3).

Table 4. The watermarked image's visual quality and the watermark's extraction quality under different attacks





(a) PSNR



(b) NC values

Figure 4. Analyzing the Barbara picture and comparing various approaches' performance under various assaults using (a) PSNR values and (b) NC values

Table 5. The proposed method's NC resistance is evaluated in comparison to existing approaches that are currently in use through the usage of a compression attack

Cover image	Attack index	Classical (CL) DCT-SVD	Meta-heurisdc (MH)					Proposed Improvement from (%)		
			DS-DE	DS-PSO	DS-GSA	DDS-PSO	DS-7120	DPC-CKGSA	CI.	MH
Man	JC	0.9841	0.9841	0.9841	0.9845	0.9848	0.9870	1.0000	1.63	1.32
Pigeon	JC	0.9836	0.9836	0.9836	0.9842	0.9844	0.9848	0.9997	1.70	1.51
Bear	JC	0.9829	0.9829	0.9829	0.9837	0.9837	0.9842	0.9997	1.80	1.57
Lena	JC	0.9841	0.9841	0.9841	0.9849	0.9849	0.9855	0.9996	1.67	1.43
Barbara	JC	0.9840	0.9840	0.9840	0.9850	0.9850	0.9860	0.9992	1.56	1.34

Resilience to compression assaults

An image is compressed by the use of a JPEG compression attack, which is carried out on the picture in order to generate the compressed image. According to Chen [19], it is possible to significantly cut down on the amount of bandwidth needed for the transmission and storage of photos by making use of JPEG compression. The presence of an image that has a higher quality factor score provides more proof that the image is of a better quality, and vice versa. Through the utilization of a quality factor (QF) of fifty, the compression of the watermarked photos is successfully performed. These findings, which are provided in Tables 4 and 5, offer proof that the technique that was proposed is extremely robust to the assault that was described.

6. Discussion

Table 4 displays the results of the qualitative analysis. There are parts of these results that deal with the quality of the watermarked picture that was attacked and the quality of the watermarked image that was extracted after each attack that was watched. It is seen in the table that the method that was described is capable of successfully extracting watermark photographs that are quite equivalent to the original watermark image. This holds true for all the attacks examined. Cropping and gamma correction are the only two practices that deviate from this rule. The bar charts that display the PSNR and NC values produced from each of the approaches that were evaluated are an additional point of interest that should be taken into consideration. Additionally, Table 4 provides a comparison between the DPC-CKGSA approach and the copyright protection measures that are currently being utilized. We present this comparison as an additional point of interest. DCT-SVD, DSGSA, DDS-PSO, DS-DE, DS-PSO, and DS-TLBO are some of the methods that fall under this category. In terms of robustness and imperceptibility, the comparison reveals that the strategy that was recommended performs far better than the solutions that are currently being used.

7. Conclusion

With the help of this study, we want to develop a watermarking technique that is both optimised and resilient; we call it DPC-CKGSA. By utilising CKGSA, which is founded on DCT and SVD domains, this approach is able to successfully strike a balance between imperceptibility and robustness. This is accomplished in order to prevent false positives. We compared the efficacy of the suggested technique with the most advanced watermarking methods currently available. These methods are based on PSNR, SSIM, and NC values. They were taken into consideration in the comparison.

8. Future Scope

The results of the experiments demonstrate that DPC-CKGSA is superior and does not include FPP. There is a potential for the approach that has been presented to be utilised in the future for audio, video, and colour pictures.

9. References

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