



# A Comprehensive Review On Optimization-Based Digital Image Watermarking Approaches For Copyright Protection

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**Abstract:** The watermark must be both invisible and long-lasting. The ability to properly restore a watermark from recovered relevant content—which may also include a range of noises and compression effects—explains how robust a watermark is. Since digital data is added to a digital signal, the process of digitally watermarking an image is incredibly accurate. Watermarking is the technique of adding records into digital media, including text, still photos, videos, and audio statistics, without lowering the quality of the digital media as a whole. Another name for watermarking is digital fingerprinting. This technique is less energy-intensive and aids in preventing unauthorized statistics copying from multimedia networks. Watermarking has numerous applications, two of which are copyright protection and authentication. An overview of the many theories and research efforts being carried out on the topic of image watermark authentication is given in this paper. The patchwork signal as well as the watermarked sign. The host signal is the transmission that will have the watermark added to it. When employing a watermarking device, there are three steps involved: detection, attack, and embeddedness. A set of rules must first evaluate the host computer and the data that will be on it in order to generate a watermarked signal. Embedding records—also referred to as digital signatures or watermarks—into a digital signature in a way that makes it challenging for the records to be deleted is the process of digital watermarking. Another name for this process is digital watermarking. Virtual watermarks can be used to confirm the authenticity or integrity of a service signal and can also be used to uncover the owners' identity.

**Index Terms - Digital Image Watermarking, DCT, DWT, LSB, PSNR, MSE, etc.**

## I. INTRODUCTION

It is now much simpler to copy, edit, duplicate, and distribute digital photos at a low cost and with approximately immediate delivery, all without any compromise in image quality. Image processing and the internet have made this process considerably simpler. This has been made feasible as a result of the integration of the two technologies. The growth and progress of network technology has had such a rapid pace that it creates a risk to the secrecy and safety of data. This risk is a result of the rapid rate at which it has occurred. Therefore, the authentication of content, the protection of copyrights, and the protection against duplication are all extremely important components in the process of overcoming the obstacles that are provided by dangers that are already present as well as those that will develop in the near future. The act of digitally watermarking a picture, which is also more commonly referred to as digital image watermarking, is an easy procedure that provides an alternate approach to ensuring tamper-resistance, the ownership of intellectual property, and the reinforcement of the safety of multimedia documents. Data can be concealed by any digital information, including but not limited to photos, sounds, and movies. It is possible for digital content to be

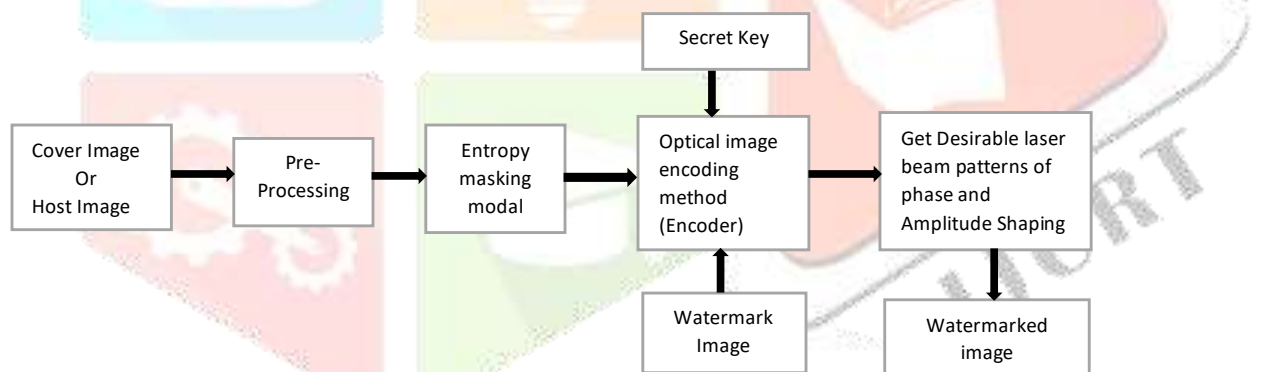
unlawfully collected, reproduced, and distributed through a physical transmission medium while it is being sent, processed, and stored. This is because digital content is susceptible to unauthorized access. In every single one of these three processes, this is a possibility. The process of digital picture watermarking begins with the insertion of watermark data into a multimedia product. This is then followed by the subsequent extraction of that data from the watermarked product or the detection of the data inside the watermarked product itself.

These methods guarantee that the image has not been altered in any way that it has been authenticated, that both its content and its integration have been confirmed, and that it has been integrated. It is not a particularly straightforward approach to remove a watermark, as it requires either displaying the content that has been watermarked or transferring it into different file types. After an attack, it is possible to acquire information about the alteration by looking at the watermark. This is because of the circumstance described above. One must be able to discriminate between digital watermarking and other methods such as encryption. This is an extremely important ability to have. The use of digital picture watermarking techniques makes it possible for a wide range of operations to be preserved, such as the transformation from digital to analogue, compression, alterations to the file format, re-encryption, and decryption. As a result of these responsibilities, it is capable of functioning either as an alternative to cryptography or as a supplement to it. Due to the fact that the information is hard-coded into the text, it is not possible to erase it using the standard method.

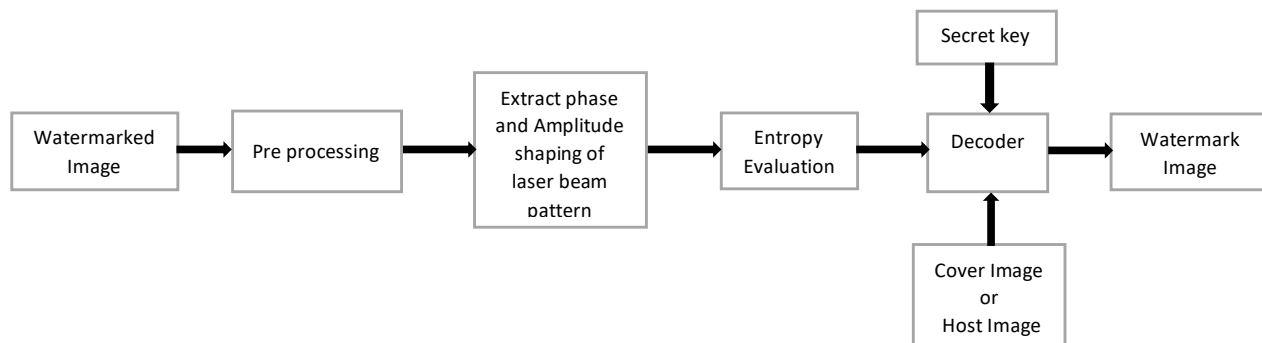
The word "steganography" originates from the Greek word "steganos," which is whence we got our word "steganography." For the purpose of concealing communication and altering an image in such a way that only the sender and the receiver to whom it is intended can recognize the message that has been conveyed, this method is utilized. Because of this strategy, detection becomes a more challenging endeavour. Steganography is an alternative means of protecting one's privacy and security that, rather than encrypting messages, can be used to hide them in other objects that appear to be harmless. Steganography is more difficult to detect than encryption. As a consequence of this, their existence will not be uncovered, and the aim of steganography will now have been accomplished. Steganography, on the other hand, is a technique that can be utilized for the purpose of information exchange as well as the planning of terrorist actions. The rapid development of the internet and computer networks is solely responsible for this phenomenon. However, the technique of watermarking inserts a message into the material that makes up a digital signal rather than the signal itself. Steganography is used to disguise the existence of a cover image, while watermarking is used to introduce a message into the material that makes up a digital signal. It is therefore difficult for an eavesdropper to remove or modify a message in order to gain an output message. This is because of the above-mentioned reason. In order to prevent unauthorized individuals from gaining access to the content, it is essential to incorporate information into the visual representation that was initially created. It is incredibly tough for unauthorized users to remove a digital image watermark because it is nearly impossible to detect with current technology. The technique has been implemented by a number of algorithms that utilize both the spatial and frequency domains. These algorithms have been using the method. Each of these particular domains comes with its own individual set of benefits and drawbacks. Beginning with the construction of a cover picture, also known as a host image, is the first step in the process of assuring the secure delivery of a message. You can think of the host picture as nothing more than noise, as noise together with some additional information, or as a multimedia message that needs to be sent. All of these interpretations are valid. It is necessary for the data that has been watermarked to be transmitted through a communication channel, which may be prone to data loss, noisy, or unreliable. As a result, the data that has been watermarked may be susceptible to various attacks, such as lossy compression, geometric distortion, signal processing operations, and signal conversion, to name a few; this means that there may be a discrepancy between the watermarked data that was originally sent and the data that was ultimately received. A watermark is the word used to describe the noise that is injected into an image due to the fact that it is transmitted over a communication channel. Because of this noise, the information entropy is increased to its maximum, which in turn increases the degree to which the average information that is contained inside an image is both unclear and ambiguous. Due to the fact that this is the only sort of image that satisfies the requirements, the employment of watermarking techniques is restricted to images that have a high level of information entropy, complex patterns, and a high resolution. For this reason, the encoded image needs to be processed in such a way that it will result in a trustworthy image reconstruction. This is necessary in order to increase security. This innovative approach of optical image encoding is able to obtain the encoded image by employing a random-phase encoding technique in both the input plane and the Fourier

plane. This allows for the encoded image to be produced. It is possible to substitute the two random phase plates that are located at the input and the Fourier planes with two deformable mirrors, respectively, when using this method. Because of this, the system is able to achieve arbitrary beam shaping in the information that pertains to the amplitude and phase of the image.

In order to watermark digital images, there are two parts involved in the process: the first stage entails embedding the watermark, and the second stage includes removing the watermark from the image. At the point in the process where the watermark is implanted, the cover picture must first be pre-processed, and then its entropy must be assessed in order to ascertain the information concerning the image's ability to integrate. This is done in order to ensure that the watermark is embedded correctly. After that, the encoder uses a secret key in conjunction with an optical image encoding method to insert a watermark picture into the high entropy value of the host image. This is done in order to protect the integrity of the image. Afterwards, the system is responsible for the generation of the watermarked image by obtaining the information regarding the amplitude and phase shape of a laser beam. In this way, the process is finished. The section of the process that is responsible for embedding the watermark is depicted in figure 1a. When the watermark extraction process is complete, the image that contains the watermark is pre-processed. This is the final stage of the method. Once that is complete, the system will proceed to extract the information that pertains to the amplitude and phase shaping of the laser beam patterns. Following that, an examination of the entropy of these beam patterns is carried out during the process. The watermark is extracted using a value that has a high entropy, which is selected when the time comes to do so. For the purpose of achieving the highest possible level of robustness and invisibility, this is done. It is possible for a decoder to detect the watermark image that was formed as an output from the watermarked image by using the same key, as demonstrated in figure 1b. The method demonstrates that it is simple, dependable, and undetectable to reconstruct the watermark image from the image that contains the watermark by making use of the watermarked image.



(a) Watermark Embedding



(b) Watermark Extraction

**Figure 1:** Image Watermarking System

## Types of Watermarking

Text, picture, audio, and video watermarking are the four different types of techniques that can be used for watermarking multimedia content; nevertheless, the majority of the time, watermarking is applied to still images.

**Text Watermarking:** Text watermarking is a procedure that involves embedding or concealing data into a piece of written text. Ding Huang and colleagues suggested an innovative method for text watermarking in which the interword spaces of various text lines are subtly altered. According to the results of their tests, spatial patterning of text documents may be a useful technique in digital watermarking.

**Image Watermarking:** Image watermarking refers to the process of secretly inserting information into an image file and saving it with that file. The paper presents a technique for the secure watermarking of images by applying the wavelet transform. The performance of their suggested method for watermarking can withstand a wide range of different kinds of assaults.

**Audio Watermarking:** Audio watermarking is a word that can be used to describe the process of embedding information into sound. The audio watermarking technique, in addition to its essential characteristics, is broken down in. In addition to this, it exhibits works produced using a variety of techniques for digital audio watermarking.

**Video Watermarking:** The process of embedding information into video can be termed as video watermarking. Hamid Shojanazeri et al. presented the state of the art in video watermarking techniques and provided a critical review on various available techniques. It addresses their main key performance indicators which include robustness, speed, capacity, fidelity, imperceptibility and computational complexity.

## Watermark Types

**Pseudo Random Number Sequence:** The Pseudo Random Number (PRN) sequence is produced by providing the generator with a secret seed and using the detector to determine whether or not a watermark is present. Using non maximum pseudorandom sequences, Kesidis et al. described a method that embeds the watermark message in randomly chosen coefficients along a ring in the frequency domain. The findings of their experiments indicate that their technique is resilient when subjected to a wide range of image processing processes and geometric modifications.

**Visual Watermark:** In this step, the visual watermark is recreated, and then the visual quality of the watermark is assessed. Initially, a primary watermark that takes the form of a PN sequence is implanted into an image (the secondary watermark), and then the primary watermark is incorporated into the host image. Two visual watermarks are inserted into the DWT domain by modifying the low and high frequency coefficients, as described in and provides further explanation of this process.

## Watermarking Perception

Digital watermarks can be classified into two categories: those that are visible to humans and those that are not visible to humans.

**Visible Watermark:** By using a visible watermark, the watermark itself is visible, but the information it contains is only discernible to a viewer of a video or image after close examination. Take, for instance, a television channel such as BBC, the emblem of which is obviously placed on the corner of the screen of most televisions.

**Invisible Watermark:** The invisible watermark is entirely undetectable by the human eye. The invisible-robust watermark is encoded in the image in such a way that any changes that are made to the pixel value are not perceptually noticeable and the watermark can only be recovered using the right decoding process. The invisible and fragile watermark is ingrained in the image in such a way that any manipulation or change of the image will result in the watermark being altered or destroyed.

**Dual Watermark:** The dual watermark is a combo of a visible and an invisible watermark that can be used to authenticate documents. The first step of their process involves adding a visible watermark to the source image. After that, an invisible watermark is placed to the image that has previously been visually watermarked. The dual watermarked image is the final watermarked image that will be used.

### Watermarking Domains

As will be demonstrated in the following section, watermarks can be inserted into either the spatial or the transform domain.

**Spatial Domain:** The intensity levels of certain pixels in the image are altered in a direct manner by the spatial-domain approaches. The authors present a new watermarking strategy for colour images that is based on the spatial domain probability. Their method was shown to be reliable when subjected to a variety of image processing tasks.

**i) Least Significant Bit (LSB):** The approach for spatial domain watermarking that is utilised the most frequently is known as least significant bit modification. In this section, the most significant bit (MSB) of one set of pixels can be hidden by changing the least significant bit (LSB) of randomly chosen pixels. It does so by employing a particular key in order to produce a random signal. The watermark is embedded in the host picture's least significant bits, and it may be extracted using the same technique as the host image. The host image can be processed using a variety of different methods. This particular kind of algorithm is straightforward and easy to put into practise. The least significant bits transmit information that is less important, and as a result, the quality of the host picture is not impacted in any way by this. It has a low influence on the host image while still providing a high level of perceived transparency.

**ii) Intermediate Significant Bit (ISB):** LSB techniques are the most frequent and straightforward advanced watermarking techniques in the spatial domain; nevertheless, the robustness of the data they watermark against attacks is not guaranteed by using these techniques. Because of this, many alternative methods, such as intermediate significant bit (ISB) methods, have been created in order to enhance the robustness of the watermarking system and maintain its quality. A number of studies have used a variety of computational approaches to build ISB methods. By locating the optimal pixel value anywhere in the range between the middle and the extremes of the range, one of these approaches can take the place of the more traditional LSB strategy. With this strategy, the watermarked image is shielded from a variety of attacks, and the likelihood of the image being altered is much reduced.

**Frequency or Transform Domain:** The method of watermarking that is based on the transform domains can be further subdivided into the discrete Fourier Transform (DFT), discrete Cosine Transform (DCT), and discrete Wavelet Transform (DWT) domain techniques.

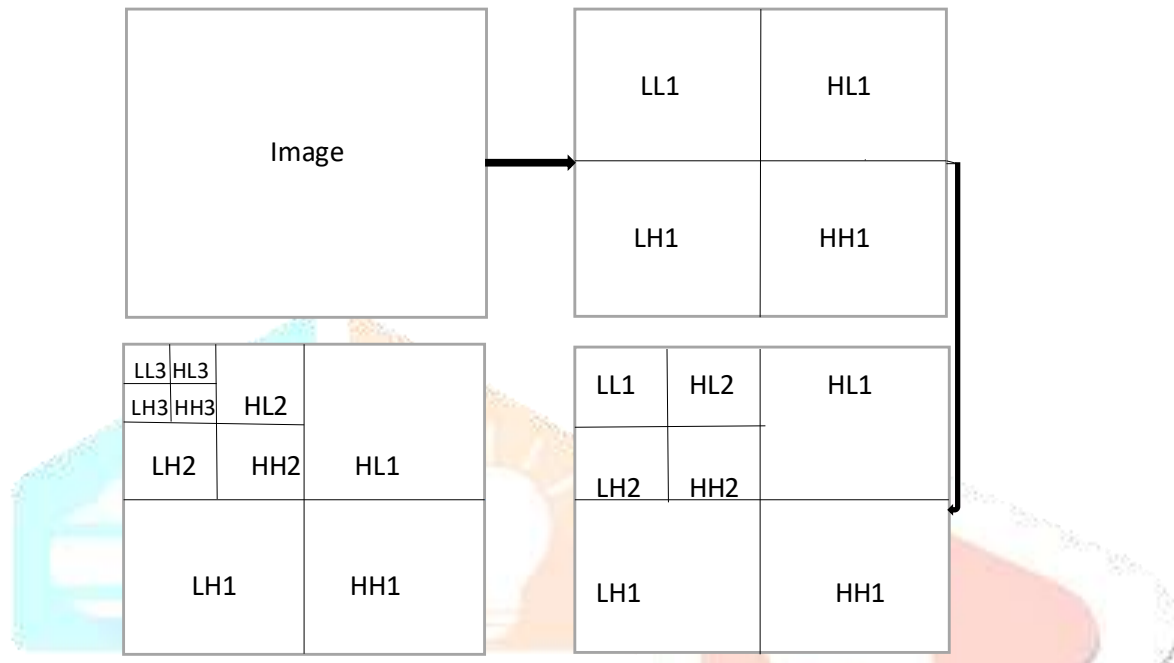
**i) Discrete Fourier Transform:** The discrete Fourier transform (DFT) transforms a finite list of samples of a function that are equally spaced into the list of coefficients of a finite combination of complex sinusoids that has those same sample values. These coefficients are ordered by the frequencies of the sinusoids in the combination. An approach that can watermark digital images in a way that is rotationally and dimensionally invariant was presented by Solachidis et al. The outcomes of their experiments remain unchanged regardless of whether they are subjected to compression, filtering, cropping, translation, or rotation.

**ii) Discrete Cosine Transform:** A discrete cosine transform, often known as a DCT, is a mathematical operation that describes a finite sequence of data points as the sum of cosine functions that oscillate at various frequencies. In, an examination of a technique for the copyright protection of still digital images using discrete cosine transform domain watermarking similar to spread spectrum is provided. In the same manner as the JPEG technique, the DCT is applied to blocks of 8 by 8 pixels.

**iii) Discrete Wavelet Transform:** The wavelet transform uses very small waves as its foundation. Wavelet analysis is built on top of multi resolution analysis as its foundation. In DWT with two dimensions, each level of decomposition results in the production of four bands of data. One of these bands corresponds to the low pass band (LL), while the other three correspond to the horizontal (HL), vertical (LH), and diagonal (HH) sub-bands, respectively. In reference, a method for the DWT-based image watermarking is proposed. The

findings of the simulation clearly demonstrated that their proposed method performed very well in terms of its imperceptibility and its robustness against attacks.

**iv) Hybrid Domain:** The method known as the hybrid domain serves as a bridge between the spatial domain and the transform domain; more specifically, it combines the spatial domain and the frequency domain. Dharm Singh and colleagues conducted research on a watermarking system based on the least significant bit (LSB) and the discrete cosine transform (DCT) in both the spatial and frequency domains. As comparison to the LSB domain, the results of their experiments showed that the DCT provided superior performance in terms of imperceptibility and robustness.



**Figure 3:** 3-Level LWT Decomposition

### Watermarking Techniques

The processes of watermarking can be categorised in a number of different ways. Watermarking can be divided into three categories: blind watermarking, non-blind watermarking, and semi-blind watermarking. These categories are based on whether the original image needs to be able to extract or detect the watermark.

**i) Blind Watermarking:** In blind watermarking, the only thing required to extract the information is a secret key. The blind watermarking method is less secure than other methods that don't involve blindness. The process of public watermarking is known as the blind watermarking method. Sahraee et al. introduced a resilient blind watermarking algorithm for the purpose of copyright protection. Their algorithm is based on the quantization of the distance between wavelet coefficients. The findings of their experiments indicate that their proposed strategy is extremely resistant to being attacked.

**ii) Non - Blind Watermarking:** Non-blind watermarking necessitates the use of the original image in addition to a hidden key for the purpose of the watermark detection process. Private watermarking refers to the process of adding a watermark that is visible to the user. Presents a DWT-SVD based non-blind watermarking system that is intended for use with colour images stored in RGB space. The use of combinations of DWT and SVD inside their design results in increased security, resilience, and imperceptibility.

**iii) Semi-Blind Watermarking:** In conclusion, semi-blind watermarking calls for the use of a secret key in addition to the watermark bit sequence in order to complete the extraction procedure. Semi - blind watermarking is termed as semi-private watermarking. A robust semi-blind watermarking approach based on DWT was presented by C-C-Chang et al. to disguise a grayscale watermark in a digital image for the purpose of image authentication. Their plan is resistant to the several kinds of attacks that could be mounted.

## Watermarking properties

The properties of digital watermarking are broken down further below.

**i) Effectiveness:** When an object that is fed into a detector produces a positive detection, the object has been found. With this definition of works that have been watermarked, the efficiency of a watermarking system can be measured by the likelihood that the output of the embedder will contain a watermark. To put it another way, the efficiency of the method can be measured by the probability of detection right after embedding.

**ii) Fidelity:** The degree to which the original and watermarked versions of the cover Image appear to be visually identical to one another is referred to as the fidelity of the watermarking technology. The degree of perceived similarity between an unwatermarked work and a watermarked work at the moment in time when both are offered to a consumer is referred to as the fidelity of a watermarking system.

**iii) Data Payload:** The phrase "data payload" refers to the total number of bits that a watermark encodes in a given amount of time or in a given Operation. The number of bits that are encoded within an image is what is meant by the term "data payload." An example of this would be an image. An N-bit watermark is a type of watermark that encodes N bits and has its own specific name. Embedding any one of 2<sup>N</sup> different messages is possible with the help of such a system. It's possible that various applications will call for significantly different data payloads.

**iv) Robustness:** The term "robustness" refers to the capability of locating the watermark after standard signal processing processes have been performed. The requirement for robustness to all potential signal processing procedures is not present in every watermarking application. Instead, a watermark just needs to be able to withstand the typical signal processing activities that are anticipated to take place between the time it is embedded and the time it is discovered.

**v) Security:** The ability of a watermark to withstand assaults from malicious parties is referred to as its "security." Any action that is taken with the intention of defeating the function of the watermark is referred to as a hostile attack.

**vi) Cost:** The rate at which embedding and detection operations need to be carried out, as well as the quantity of embedders and detectors that need to be deployed, are the two primary concerns that need to be addressed. Additional considerations include determining whether the detectors and embedders will be built as one-of-a-kind hardware devices, as software applications or plugins, or some combination of the two.

## II. MULTIPLE WATERMARKING

Multiple watermarks are applied to one another and then integrated into the reference image during the multiple watermarking process. The studies that have been published in the literature and are related to multiple image watermarking techniques are discussed below. A wavelet-based watermarking method that can include several watermarks in medical images is proposed in. Their method generates high-quality watermarked photos with better PSNR values while guaranteeing patient anonymity and the accuracy of medical data. A wavelet transform-based watermarking approach where the watermarks are injected using a configurable scaling factor into different subbands. For the LL subband, the scaling factor is rather significant, whereas it is quite low for the other three subbands. An integer wavelet transform-based multiple watermarking technique is described. They have an approach that can withstand a wide range of attacks. Maha Sharkas et al. assessed a recently created method for picture watermarking in the wavelet domain. Their methodology yields increased security and dependability. A number of watermarking techniques that can be used to color photographs in the spatial domain are proposed in. A unique multiple watermarking algorithm is presented in the publication, which embeds two watermarks at different frequencies into the original image. The bandelet transform is employed to do this. Their chosen watermarking algorithm performs well in terms of resilience and invisibility. An image watermarking technique is provided in to embed several binary watermarks into the original image, based on the concept of visual cryptography.

## III. RELATED WORK

It has been proved that the extraction of the watermark from inside the grayscale image is less difficult than the ways of vile really alteration, as stated by Ramana and Muruga (2009). This demonstrates that the watermark may be extracted from the grayscale image. They evaluate a number of PSNRs and MSEs in order to describe the digital watermarking approach for digital images that is based on the 931 toughness different

wavelet significantly alter. This method is discussed in the International Journal of Scientific Research in Science, Engineering, and Technology (ijrsrset.com).

DWT (discrete wavelet transform) milling between transform domains is supported by each and every one of the watermarking software packages that are discussed in MSE, PSNR, BER, Dharwadkar, and N. V. Amberker (2011). A number of businesses that rely only on extraction have disproved watermarking algorithms, including both blind and non-blind watermarking. Although original photos are still required for the extraction of non-blind watermarks, they are no longer required for the extraction of watermarks that are found to be inappropriate. The non-blind watermarking technique is utilized in it.

Discrete wavelet transformation was utilized by Antonis K. Mairgiotis and Nikolaos P. (2008) in order to develop the system for digital watermarking; however, the wave filter that we have available is a HAAR wavelet. For the same reason, this law establishes the robustness of the watermark when it is put to a digital image. When there is just a small amount of watermarking, this is extremely important because the most of it may be readily removed through the use of straightforward picture editing. It is possible that the invisibility of a watermark could prevent it from being used for malicious purposes.

A multiple picture watermarking technique that is based on dither quantization was reported by Vijendra Rai and colleagues in. In terms of attacks and embedding capabilities, their algorithm is superior than competing algorithms. He puts out a proposition for a digital watermarking system for still photographs that is multi-layered and dependable. The use of their methods reveals that the results are resistant against a wide variety of assaults. A comprehensive analysis of several watermarking techniques is presented for text documents. Their multiple watermarking method contributes to an increase in both the security and the robustness of the system.

#### **IV. OPTIMIZATION TECHNIQUES**

Utilizing optimization tactics with the goal of achieving the highest feasible levels of imperceptibility and robustness in performance is the objective of these strategies. When it comes to perfection, efficiency, and functionality, the objective of optimization is to attain the highest possible level of perfection. The utilization of systems in the most efficient manner feasible, taking into account the limits imposed by the parameters, to the greatest extent possible. There are a variety of optimization strategies that can be utilized, including neural networks, fuzzy systems, genetic algorithms, and particle swarm optimization.

##### **Neural Network**

A mathematical function that is conceived of as a straightforward model of a biological neural network could be referred to as an artificial neural network. The structure of the network, the strength of the connections, and the processing that is carried out at computing components or nodes are the factors that influence the function. A neural network's weights, thresholds, and activation function are the fundamental components that make up the network. Learning strategies in neural networks can be broken down into three primary categories: supervised learning, unsupervised learning, and reinforced learning. Reinforcement learning is the third technique. Neural Network Architecture refers to the connections that are made between neurons. There are several types of neural networks, including single layer feed forward, multilayer feed forward, fully recurrent network, competitive network, Jordan network, and simple recurrent network.

##### **Fuzzy systems**

Fuzzy systems include fuzzy logic and fuzzy set theory. The fuzzy logic is the logic underlying approximate, modes of reasoning as an extension of multi valued logic including truth, is a matter of degree. The fuzzy sets have been introduced in 1965 by Lotfi A. Zadeh as an extension of the classical notion of set. The fuzzy system elements are fuzzification, fuzzy rule base, membership function, fuzzy inferencing and defuzzification.

## Genetic algorithm

A genetic algorithm, often known as a GA, was first presented by John Holland in the middle of the 1970s. In order to tackle problems that require optimization, genetic algorithms are a strategy that can be utilized. In the realm of evolutionary computing and random search algorithms, genetic algorithms are classified as a subclass together. Charles Darwin's idea of evolution serves as the foundation for genetic algorithms. Using the Darwinian principle of natural selection and operations that are patterned after naturally occurring genetic operations, such as crossover and mutation, the genetic algorithm is a probabilistic search algorithm that iteratively transforms a set (called a population) of mathematical, each with an associated fitness value, into a new population of offspring objects. This is accomplished by transforming the population into a new population of offspring.

## V. ATTACKS

To showcase the resilience, the pictures are assessed for an array of distinct assaults. Attacks on watermarks must identify its flaws, provide suggestions for enhancements, and investigate how watermark is impacted by currently available technologies in order to be effective. The four types of assaults are removal attack, geometric attack, cryptographic attack, and protocol attack. The removal attacks are directed at the data that is contained in the watermark on the targeted object. The fact that the watermark is often an additive noise signal mixed in with the host signal gives rise to these types of attacks. Attacks that introduce more background noise into the watermarked object are known as interference attacks (including lossy compression, collusion, denoising, quantization, remodulation, and averaging). You can only use these geometric assaults on photos and movies. The geometric attacks modify the watermarked object in a way that prevents the detector from finding the watermark data; these manipulations include rotation, translation, scaling, Warping, line/column removal, and cropping. The watermark is not actually deleted by these attacks. The removal or geometric attacks do not jeopardize the security of the watermarking algorithm; on the other hand, the cryptographic attacks do address the possibility of the algorithm's security being jeopardized.

The watermarking concept has flaws that are exploited by the protocol assaults. It is feasible to create a counterfeit original object that, when run through the detector, produces readings identical to those of a real original object.

## VI. CONCLUSION

Embedding a single watermark is possible with the vast majority of watermarking techniques; nevertheless, when single watermarking approaches are tested in actual applications, there are important constraints that need be taken into consideration. When many users share the copyright on an object, for instance, this is an example of this; in this scenario, the watermarking technology must be able to allow numerous users to simultaneously insert their watermarks. This highlights how essential it is to make use of a number of different watermarker. According to this analysis, many watermarks are placed into the picture in order to achieve security, imperceptibility, embedding capacity, and robustness against a wide range of image processing procedures using a variety of methodologies. This is done in order to get the desired results. For the purpose of establishing watermarking methods that are both undetectable and dependable, researchers from a wide range of fields are focusing their efforts on developing a number of different approaches to watermarking. This page has a strong focus on multiple watermarking for a wide range of domains, methodology, applications, and analyses of assaults coming from a variety of different directions. Additionally included in this article is a discussion of optimization strategies that are utilized in the algorithms that are used for picture watermarking. Researchers who are interested in developing a variety of picture watermarking procedures that are both efficient and effective will find these techniques to be beneficial.

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