Literature Survey on multiple image watermarking Techniques with Genetic Algorithm

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ABSTRACT
Digital image watermarking is an important and useful technology for protecting the copyright of the content. Digital watermarking has been widely applied to solve copyright protection of digital media relating to illegal use of distributions. Multiple watermarks can be used to address multiple applications or one application may be addressed several times. Based on the watermark embedding, the multiple watermarking techniques can be classified into three techniques such as successive, segmented and composite watermarking. It also provides a comprehensive review of the existing literature available on image watermarking methods using optimization techniques. The genetic algorithm is relatively a new optimization technique to improve the performance of imperceptibility on the watermarked image in terms of peak signal to noise ratio and robustness of extracting watermark in terms of normalized correlation. This paper, discusses the theories and survey on multiple watermarking techniques for images using genetic algorithms.

KEYWORDS: Composite Watermarking, Genetic algorithm, Multiple Image Watermarking, Segmented Watermarking.

INTRODUCTION
Watermarks are identifying marks produced during the handmade paper making process and the watermarks first appeared in Fabriano (Italy) during the 13th century. In 1992, Andrew Tirkel and Charles Osborne first coined the term of digital watermark [1].

Mintzer et al. [2] discussed “If one watermark is good, or more better?”. In this converse, the multiple watermarks are employed to convey multiple sets of information into image. Multiple watermarks can be used to address multiple applications or one application may be addressed several times.

Digital watermarking is to embed a message into cover media to prove ownership. In 1975, Holland developed a methodology for studying natural adaptive systems and designing artificial adaptive systems [3]. Genetic Algorithm (GA) is based on the concept of natural genetics and random search technique. Genetic algorithm is one of the optimization techniques for improving the performance of watermarking.

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Watermarking:

Watermarking is the process of embedding watermark into a multimedia object (audio, image, video and text) such that watermark can be detected or extracted later to make an assertion about the multimedia object [4].

The classification of watermarking is shown in Figure 1.

Watermarking Types:

According to human perception, the digital watermarks can be divided into visible and invisible types as follows,

1.1.1 Visible Watermark:

Invisible watermark the watermark appears, information is visible to a viewer in video or documents only on careful inspection. The logo displayed in one corner of different television channels is an example of visible watermarking. Braudaway et al. [5] described the technical goals for watermarking include applying a readily visible mark to the image that clearly identifies its ownership, permitting all image detail to be visible through the watermark, and making the watermark difficult to remove.

1.1.2 Invisible Watermark:

The invisible watermark is completely imperceptible and the advantage of such type of watermarking includes high perceptual quality and a large number of application areas.

1.1.2.1 Invisible-Robust:

The invisible-robust watermark is embedded in such a way that alterations made to the pixel value are perceptually not noticeable and can be recovered only with the appropriate decoding mechanism (including image compression, linear or nonlinear filtering, cropping, resampling, rotation and printing). Resolving rightful ownerships with invisible robust watermarking techniques are implicated in [6].

1.1.2.2 Invisible-Fragile:

The invisible-fragile watermark is embedded in such a way that any manipulation or modification of the image would alter or destroy the watermark. Chen et al. [7] presented a new fragile watermarking scheme based on integral wavelet transform. The preliminary experimental results indicate that their proposed method conforms to the human perception characteristics and provides a perceptually invisible fragile watermark with fewer image data modified.

1.1.3 Dual Watermark:

The dual watermark is a combination of a visible and an invisible watermark. Suthar et al. [8] Combined visible and invisible, secure digital image. Their proposed method improves the robustness using turbo coding algorithm.

Watermarking Domains:

Spatial Domain:

The spatial-domain techniques directly modify the intensity values of some selected pixels in an image to hide the watermark image. Robust spatial-domain watermarking algorithms for image copyright protection are described in [9]. Their proposed algorithm is robust against compression, filtering, cropping and scaling.

Frequency Domain:

The watermarking systems modify the frequency transforms of data elements to hide the watermark data and finally the inverse transform is applied to obtain the marked image. The frequency domain based watermarking techniques are more robust as compared to simple spatial domain watermarking techniques. The classifications of frequency domain techniques [10] as follows,

Discrete Cosine Transform:

A discrete cosine transform (DCT) expresses a finite sequence of data points in terms of a sum of cosine functions oscillating at different frequencies. DCT coefficients are real-valued. DCT domain watermarking can be classified into Global DCT watermarking and Block based DCT watermarking. The block based DCT, the image is first partitioned into a number of blocks and DCT transform is applied to each block before watermark embedding. Jialing Han et al. [11] presented a new watermarking algorithm of DCT domain based on host image analysis. The watermark is embedded in the insensitive areas of human eyes, which are selected by host...
image analysis. It has greatly improved the invisibility of watermarking system, or has improved the amount of embedded watermark with the same visual effect.

**Discrete Fourier Transform:**

The discrete Fourier transform (DFT) converts a finite list of equally spaced samples of a function into the list of coefficients of a finite combination of complex sinusoids, ordered by their frequencies, that has those same sample values. A novel design of a DFT-based digital watermarking system for images is proposed in [12]. Experimental results show that their proposed method is robust against the common image processing operations.

**Discrete Wavelet Transform:**

The transformation product is set of coefficients organized in the way that enables not only spectrum analyses of the signal, but also spectral behaviour of the signal in time. This is achieved by decomposing signal, breaking it into two components, each caring information about source signal. Filters from the filter bank used for decomposition pairs are low pass and high pass filter. The filtering is succeeded by down sampling. Low pass filtered signal contains information about slow changing component of the signal, looking very similar to the original signal, only two times shorter in term of number of samples. High pass filtered signal contains information about fast changing component of the signal. Filters from the filter bank are called "wavelets". Watermarks can be embedded in a file using wavelet domain as it improves robustness and also watermark remains imperceptible [13]. A multiple watermarking scheme based on discrete wavelet transform is presented for the analysis of imperceptibility and robustness [14]. The watermarks are embedded into the detail sub-bands using genetic algorithms for the optimisation to improve the performance of imperceptibility on the watermarked image in terms of peak signal to noise ratio and robustness of extracting watermark in term normalised correlation.

**Hybrid Domain:**

The Hybrid domain technique is intermediate between spatial and transform domain techniques, it is a combination of both spatial and frequency domain techniques. David Asatryan et al. [15] proposed a novel watermarking algorithm, based on combining of spatial domain watermarking approach and an embedding procedure, which uses the DCT pattern instead of required original watermark. The proposed algorithm is robustness under JPEG attacks and also useful for image tamper detection.

**Watermarking Applications:**

**Copy Protection:**

Copy protection mechanism disallows unauthorized copying of the media. Copy protection is very difficult to achieve in open systems, it is feasible to achieve closed or proprietary systems. DolleyShukla et al. [16] reviewed various copy protection literatures for digital image and video watermarking.

**Copyright Protection:**

Copyright protection objective is to embed information about the source and thus typically the copyright owner of the data in order to prevent other parties for claiming the copyright on the data. The application requires a very high level of robustness and the watermarks are used to resolve rightful ownership. Shankar Thawkar [17] presented an invisible image watermarking scheme for copyright protection. Their technique provides high capacity and minimum computations.

**Fingerprinting:**

An impression on a surface is formed by the ridges on a fingertip, especially such an impression made in ink and used for identification. The recovery of fingerprints from a crime scene is an important method of forensic science. Fingerprints are easily deposited on suitable surfaces (such as glass or metal or polished stone). Yiwei Wang et al. [18] discussed the requirements for a fingerprinting system for intelligence images. Their experimental results demonstrate the effectiveness of the algorithm.

**Authentication:**

With the advance of computer tools available for digital signal processing, modifying a digital document is becoming easier while detecting that the content is modified becomes harder. The authorized source knows the valid key for encryption, an adversary who tries to change the message cannot create a corresponding valid signature for the modified message. Christian Rey et al. [19] introduced the notion of image content authentication and the features required to design an effective authentication scheme. A brief survey of the main watermarking based authentication techniques is presented and the requirements that an authentication algorithm should satisfy for video surveillance application are discussed in [20].
Data Hiding: Data hiding is a method of hiding the existence of a message and this allows communication using often enciphered messages without attracting the attention of a third party. Minya Chen et al. [21] discussed important issues such as robustness and data hiding of the different techniques.

Broadcast Monitoring: Broadcast monitoring is the process of receiving and reviewing media that is transmitted on a broadcast channel to determine if a particular media item has or has not been broadcasted. Broadcast monitoring may be performed to ensure an advertisement has been inserted on a broadcast television system as defined in an advertising agreement or broadcast monitoring may be used to ensure some media is not broadcast (e.g. licensed content). In [22] to automate broadcast monitoring, which is typified by the verification of the transmission of the material ID code of a commercial message (CM) or program, the authors propose a watermarking scheme without reference images, which does not require a reference image when the watermark sequence is extracted.

Medical Safety: Embedding the date and the patient’s name in medical images could be a useful safety measure. This is very important these days when telemedicine is getting wider application. Claims made by bodies on serious health condition of a personality must be authenticated with the usage of watermarking protecting the person imputed. Comparison of multiple-watermarking techniques based on Discrete Wavelet Transform and Singular Value Decomposition using Genetic algorithm for medical images in [23]. Their research elaborates the three main categories of multiple watermarking techniques such as successive, segmented and composite watermarking. The optimization is to maximize the performance of peak signal to noise ratio and normalized correlation in multiple watermarking techniques using genetic algorithms.

Covert Communication: The watermark can be embedded imperceptibly to the digital image to communicate information from the sender to the intended receiver while maintaining low probability of intercept by other unintended receivers. Now a day, covert communication is one of the most important aspects of internet. When you want to hide the data from intruders, you can use different methods for covert communication [24].

Watermarking Requirements: An image watermarking process needs to satisfy the following requirements [25, 26].

Imperceptibility: A digital watermark is called imperceptible if the original cover signal and the marked signal are perceptually indistinguishable.

Security: Watermarks should survive deliberate attempts to remove them. Ideally, a watermark should remain readable up to the point where the content becomes modified enough to be of low value.

Robustness: The watermark should be reliably detectable after alterations to the marked document. It must be difficult (ideally impossible) to defeat a watermark without degrading the marked document.

Capacity: Image watermarking capacity is an evaluation of how much information can be hidden within a digital image.

Unambiguous: The extracted watermark should be clear enough to determine the ownership problem.

Multiple Watermarks: It may also be desirable to embed multiple watermarks in a document.

Multiple Watermarking Techniques: In multiple watermarking techniques more than one watermarks are embedded into the original image. The classification of multiple watermarking techniques is shown in figure 2.
Table 1 shows the multiple watermarking techniques in different domains. There has been many works in the literature related to multiple image watermarking techniques using different transform and some of them are discussed below.

Giakuomaki et al. [27] proposed a wavelet-based watermarking scheme to embed multiple watermarks in medical images. Although the scheme offers medical confidentiality and record integrity, the visual quality of watermarked images can be improved to achieve higher PSNR values. Peter et al. [28] has proposed three novel blind watermarking schemes (single, multiple and iterative watermark embedding) to embed watermarks into digital images. Experimental results show that their watermarking algorithms give watermarked images with good visual quality. An optimal wavelet based watermarking algorithm the watermarks are embedded with variable scaling factor in different sub-bands. The scaling factor is high for the LL sub-band and it is low for other three sub-bands [29].

Yuan Yuan et al. [30] proposed a multiple watermarking technique by adopting integer wavelet transform. Their method is robust to a wide variety of attacks. A novel image watermarking technique in the wavelet domain is suggested and tested in [31]. Their method to achieve more security and robustness, their techniques relies on using two nested watermarks that are embedded into the image to be watermarked. A novel robust multiple watermarking techniques for color images in spatial domain are proposed in [32]. Their method the host image is divided into four different regions. Yuancheng Li et al. [33] proposed a novel multiple watermarking algorithm which embedded two watermarks into original image in different frequency by using bandelet transform. Experimental results demonstrate that their watermarking algorithm based on bandelet has a good performance both in invisibility and robustness. An invisible watermarking technique is proposed in [34], to embed multiple binary watermarks into digital images based on the concept of Visual Cryptography (VC).

Effective multiple image watermarking based on dither quantization is presented in [35]. Their method is superior in terms of embedding capacity, PSNR and survival to number of image attacks. Sergey Anfinogenov et al. [36] proposed a multiple robust digital watermarking system for still images. Their method shows the results is resistant to cyclic shifts, cropping, row and column removal, addition of noise and JPEG transforms. A review of multiple watermarking for text documents is presented [37]. Their multiple watermarking approach increase the watermarking capacity and tamperproof performance and also increases the security, robustness and invisibility. A new image watermarking algorithm that is robust against various attacks is presented in [38]. Discrete Wavelet Transform and Singular Value Decomposition have been used to embed two watermarks in the HL and LH bands of the host image. Simulation evaluation demonstrates that their technique withstand various attacks.

Mohananthini and Yamuna [39] proposed the multiple watermarking scheme based on discrete wavelet transform for color images. The multiple watermarks are embedded in original image, to achieve better visual quality on watermarked image. The advantage of their proposed method has preferable performance of imperceptibility and used as the various color images. Yuanning Liu et al. [40] presented a novel robust multiple watermarking methods for regional attacks of digital images. Experimental results demonstrated good visual imperceptibility and robustness of their proposed method against traditional regional attacks, accidental attacks and joint attacks, which are performed by Stirmark or Adobe Photoshop CS5. Exploring DWT–SVD–DCT feature parameters for robust multiple watermarking is presented in [41]. Their proposed method is robust against JPEG and JPEG2000 compression.

The three main categories of multiple watermarking techniques are successive, segmented and composite watermarking.

**Successive watermarking:**

In successive watermarking technique, the watermarks are embedded one after the other, from the watermarked images the watermarks are extracted from one after another. This approach is also denoted Re-watermarking in literature. Fig. 3 shows the block diagram of multiple successive watermarking by using two watermarks.

The first watermark is embedded into the original image by the following equation

\[ WI_1(i, j) = I(i, j) + \alpha w_1(i, j) \]  

Where,  
WI1 = Watermarked Image1  
W1 = First Watermark  
I = Original Image and  
\( \alpha \) = Scaling factor which determine the strength of Watermark

Similarly, the second watermark is embedded into the watermarked image by the following equation

\[ WI_2(i, j) = WI_1(i, j) + \alpha w_2(i, j) \]  

Where,  
WI2 = Watermarked Image2  
W2 = Second Watermark
W2 = Second Watermark

Review of multiple successive watermarking techniques is presented below.

Sheppard et al. [42] distinguished the three main categories of multiple watermarking techniques such as composite watermarking, segmented watermarking and successive watermarking. The use of classical single watermarking scheme in a multiple re-watermarking scenario is discussed in [43]. Their method focused on a comparison of blind and non-blind algorithms. Shieh et al. [44] proposed a new algorithm for embedding several watermarks into the same original source. Simulation results show that their method robustness for surviving intentional attacks and their effectiveness in protecting copyrights. Daniel Mark et al. [45] demonstrated that watermark interference in multiple re-watermarking applications. Their method is to embed several watermarks as compared with different embedding domains. Jutta Hammerle – Uhl et al. [46] demonstrated that watermark interference in wavelet based multiple re-watermarking algorithms can be controlled in principle by using wavelet packet sub-band structures exhibiting a certain amount of dissimilarity.

**Segmented watermarking:**

In the segmented watermarking method, the original image is partitioned into disjoint segments a priori and each watermark is embedded into its specific share. Fig. 4 shows the block diagram of multiple segmented watermarking by using line and points. Fig. 4 (a) shows one watermark is embedded into odd-numbered rows noticeable in straight lines and another watermark is embedded into even-numbered rows noticeable in dot lines. Fig. 4 (b) shows one watermark is embedded into odd-numbered columns noticeable in straight lines and another watermark is embedded into even-numbered columns noticeable in dot lines. The Fig. 4 (a) and (b) line segmented watermarking by using two watermarks. The Fig. 4 (c) shows point segmented watermarking by using two watermarks. One watermark is embedded into plaque shape and another watermark is embedded into circle shape.

The first watermark is embedded into odd-numbered rows image and the second watermark is embedded into even-numbered rows image, by the following equation

\[ I_{W_1}(i, j) = I_{odd}(i, j) + \alpha \times W_1(i, j) \]  
\[ I_{W_2}(i, j) = I_{even}(i, j) + \alpha \times W_2(i, j) \]

Where,

- \( I_{odd} \) = Odd watermarked Image
- \( I_{even} \) = Even watermarked Image
- \( W_1 \) = Watermark1
- \( W_2 \) = Watermark2
- \( I_{odd} \) = Odd-numbered rows image
- \( I_{even} \) = Even-numbered rows image
- \( \alpha \) = Scaling factor which determine the Strength of Watermark.

Review of multiple segmented watermarking techniques is presented below.

Glen E. Wheeler et al. [47] proposed weighted segmented watermarking of still images in which segments are formed by dividing the image into square blocks, each of which contains one contributor’s watermark. If a watermark is present in one or more segments of the work, the owner of that watermark is reported to be an owner of the work as a whole by an arbiter. Hamed Dehghan et al. [48] presented a new wavelet-based image watermarking technique which is suitable for image copyright protection. Their method the host image was segmented into small blocks and the watermark data were embedded in the low pass wavelet coefficients of each block. Their simulation results show that the imperceptibility of the watermarked image and the robustness of watermark against several attacks. Nantha Priya et al. [49] proposed the segmented image is modeled as mixture generalized Gaussian distribution and their model is the basis of mathematical analysis of various aspects of the watermarking process such as probability of error and embedding strength adjustment. The experimental results show that their algorithm performed well against rotation, scaling, and other attacks. A set of schemes and their analysis for multiple watermark placements that maximizes resilience to the above mentioned cropping attack proposed in [50].

**Composite watermarking:**

In composite watermarking, all watermarks are combined into a single watermark which is subsequently embedded in one single embedding step. For example the two watermarks are combined into composite watermark is given below

\[ w(i, j) = w_1(i, j) + w_2(i, j) \]

The composite watermark is embedded into the original image by the following equation

\[ w(i, j) = w_1(i, j) + w_2(i, j) \]
\[ WI(i, j) = I(i, j) + \alpha W(i, j) \]  \( (6) \)

Where,
\( WI = \) Watermarked Image
\( W1 = \) First Watermark
\( W2 = \) Second Watermark
\( W = \) Composite Watermark
\( I = \) Original Image and
\( \alpha = \) Scaling factor which determine the strength of Watermark

Review of multiple composite watermarking techniques is presented below.

Mina Deng et al [51] proposed an efficient buyer seller watermarking protocol based on homomorphic public-key cryptosystem and composite signal representation in the encrypted domain. The proposed composite embedding can be performed in the encrypted domain by simply using an additively homomorphic cryptosystem. Farid Ahmed et al. [52] proposed composite signature based watermarking for fingerprint authentication. A new singular value decomposition-discrete wavelet transform (SVD-DWT) composite image watermarking algorithm that is robust against affine transformation and ordinary image processing is presented in [53].

Applications of Multiple Watermarking:

The multiple watermarks are intended to satisfy the different applications, the order in which the watermarks are applied is very important. The applications are discussed below,

Ownership information:

In this application two ownership watermarks are used to identify both the owner and the recipient. A new color image watermarking scheme for copyright protection is proposed [54]. Multiple watermark bits are embedded into the luminance component or the blue component of a color image using discrete wavelet domain. Experimental results show that their proposed scheme successfully makes the watermark perceptually invisible as well as robust to common signal processing and some geometric attacks.

Integrity verification:

In this application multiple verification watermarks are used in image to increase verification security. The multiple persons have the own key, if any one of the person forged a watermark on a fake image using his own key, the remaining persons would still be able to detect the alteration using his own key.

Captioning:

The object specific information is called captions. The multiple captioning watermarks are used to apply multiple captions a recipient wants to add supplemental captioning to an object. The recipient extract the original caption with attach an additional caption, to get the expanded caption. Mintzer et al. [55] discussed three types of watermarking applications in the context of multiple watermarking and identify different ways how to employ and to interpret multiple watermarking. Multiple watermarks can be used to address multiple applications or one application may be addressed several times. For example, a first watermark can be used to embed ownership information, a second one for integrity verification, and a third one for captioning. On the other hand, there can be multiple copyright watermarks, multiple verification watermarks, or multiple watermarks for multiple captions.

Document tracing:

The insertion of multiple watermarks to trace a document is the possibility of directly detecting from the document who was the creator, who had access to the data after its creation, how the property of the document is shared among different users, allowing not only the document tracing also connected to a legal prosecution. Boato et al. [56] presented a novel watermarking scheme, which allows inserting and reliably detecting multiple watermarks sequentially embedded into a digital image, as it is required by challenging the applications are confidential data tracing and shared property handling. Radharani and Valarmathi [57] have proposed a multiple watermarking technique which has been combined wavelets based on texture properties to watermark copyright and authentication information inside a cover image. Experimental results proved that their proposed algorithm is efficient in terms of quality and storing watermarks using texture properties provides more robustness.

Medical safeties:

The medical safety application of the multiple watermarking techniques ensures that each doctor inserts his diagnosis in the medical image without degrading it. With any new diagnosis insertion, the image must always keep its clarity and its characteristics. Giakoumaki et al. [58] applied multiple watermarking in medical images
the physician's digital signature, patient's personal and examination data, keywords for image retrieval, and a reference watermark for the purpose of data integrity control. Their experimental results demonstrate the efficiency and transparency of the watermarking scheme, which conforms to the strict limitations that apply to regions of diagnostic significance.

**Genetic Algorithm:**

Genetic Algorithms is one of the best optimization tools and the process can be described on five functional units such as random number generation, fitness function, selection (reproduction), crossover and mutation operators. In genetic algorithms each individuals are linked with chromosomes, then a set of chromosomes form a population. Genetic algorithms starts with some randomly selected population are called the first generation and then each individual in the population corresponding with a solution is to the problem domain.

**Fitness Function:**

The fitness function is formed by combining two metrics are peak signal to noise ratio (PSNR) and normalized correlation (NC) [59]. The fitness function is also known as objective function is used to evaluate all the individuals in the population and the best individual along with the corresponding fitness value are evaluated. The selection of fitness function is based on the imperceptibility and robustness as follows,

\[
\text{Fitness Function} = \text{PSNR} + (100 \times \text{NC})
\]

The robustness value increases as the fitness value also increases, so optimization of robustness takes place for a given value of imperceptibility.

\[
\text{Fitness Function} = \text{NC} + (100 \times \text{PSNR})
\]

The imperceptibility value increases as the fitness value also increases, so optimization of imperceptibility takes place for a given value of robustness.

**Selection Operator:**

The selection operator works for a genetic algorithm which maximizes its objective function. The selection process is defined as the best individuals are favoured. The selection process is high; the genetic algorithms should be able to identify optimal or nearly optimal solutions. The selection process is low, the genetic algorithms to take a longer time to find the optimal solution. The selection schemes are proportionate-based selection and ordinal-based selection described as follows,

**Roulette Wheel Selection:**

The roulette wheel selection scheme as described by Goldberg [60] for different outcome can occur with different probabilities. The roulette wheel selection is a proportionate-based selection. Each member of the pool is assigned space on a roulette wheel proportional to the individual fitness. The maximum fitness of the members has the higher probabilities of selection. A new Genetic Algorithm based on center of mass selection operator has been proposed in [61]. The experimental results show that their algorithm performs better solutions than the standard roulette wheel based genetic algorithm. The comparison between the hybrid watermarking using genetic algorithm and the pure hybrid DCT-SVD is presented in [62]. Their experimental results show that the extracted watermark quality of the hybrid using genetic algorithm is better than the pure hybrid DCT-SVD by using the roulette-wheel method. A robust digital image watermarking scheme based on singular value decomposition (SVD) and a tiny genetic algorithm is proposed in [63]. Their method used the tiny genetic algorithm to search the proper values in order to improve the visual quality of the watermarked image and the robustness of the watermark.

**Linear Rank Selection:**

In 1989, Baker [64] first suggested a ranking selection is to eliminate the serious disadvantages of proportionate selection. The individuals in the population are ranked according to their fitness values and a new fitness score is calculated from the rank of an individual. The rank based selection scheme behaves in a more robust manner than proportional based selection and to prevent too quick convergence. Tsai et al. [65] proposed a robust watermarking in wavelet domain using rank order and genetic algorithm for image authorization. Experimental results illustrate that their performances of the robust watermarking and the genetic robust watermarking techniques. Tsai et al. [66] presented wavelet based image watermarking using rank order and genetic algorithm. The experimental results show that their techniques to achieve better performance.

**Tournament Selection:**

The tournament selection is similar to rank selection, but computationally more efficient. In tournament selection scheme, a small group of individuals is sampled from the population and the individual with best fitness is select for reproduction. The tournament selection is applicable when the fitness function is in implicit form that is a comparison of two individuals finds out which one is better. Sachin Goyal et al. [67] proposed
Crossover:
Crossover is a genetic operator that combines two chromosomes (parents) to produce a new chromosome (offspring). Crossover occurs during evolution according to a user-definable crossover probability. The crossover methods as follows,

N-point crossover:
A single point crossover operator that randomly selects a crossover point within a chromosome then interchanges the two parent chromosomes at this point to produce two new offspring. A two point crossover operator that randomly selects two crossover points within a chromosome then interchanges the two parent chromosomes between these points to produce two new offspring.

Segmented crossover:
The segmented crossover is similar to N-point crossover with the difference being that the number of breaking points can varied.

Uniform crossover:
In the uniform crossover operator individual bits in the string are compared between two parents and the bits are swapped with a fixed probability of 0.5.

Shuffle crossover:
In shuffle crossover first a randomly variation is applied to the two parents and then N-point crossover is applied to the shuffle parents. Finally the shuffle children are transformed back with the inverse variation.

Mutation:
Mutation operator occurs during evolution according to a user-definable mutation probability. Mutation functions make small random changes in the individuals in the population, which provide genetic diversity and enable the genetic algorithm to search a broader space. The probability should usually be set fairly low; otherwise the search will turn into a primitive random search.

Genetic Algorithm based Image Watermarking:
The block diagram of image watermarking by using genetic algorithm is shown in Figure 5. Watermark embedding and extraction is the image watermarking process and optimization is the genetic algorithm process. The image watermarking and genetic algorithm process is discussed bellows,

Image watermarking process:
The image watermarking process is based embedding and extraction. The watermark used for embedding logo image, which is small compared with the size of the original image. The watermark extraction processes are the inverse process of watermark embedding. The steps for watermark embedding and extraction process are briefly listed as follows,

The watermark is embedded to the original image to get the watermarked image. The watermarked image can be obtained by different embedding methods (additive, multiplicative and quantization).

The performance of watermarking technique can be evaluated by peak signal to noise Ratio (PSNR). The PSNR is used to measure the imperceptibility of watermarked image, which is given by

\[
PSNR(dB) = 10 \log_{10} \frac{255^2}{MSE}
\]  

The watermark can be extracted from the watermarked image and original image.

Normalized Correlation (NC) is used to measure the robustness of watermark after extraction. The NC between the extracted watermark \( W'(I, j) \) and the embedded watermark \( W(I, j) \) is defined as

\[
NC = \frac{\sum_{i=1}^{H} \sum_{j=1}^{L} W(i, j) \times W'(i, j)}{\sqrt{\sum_{i=1}^{H} \sum_{j=1}^{L} [W(i, j)]^2 \times \sum_{i=1}^{H} \sum_{j=1}^{L} [W'(i, j)]^2}}
\]
**Genetic algorithm process:**

The genetic algorithm process is the optimization of imperceptibility and robustness are briefly listed as follows.

1. **Initialize** the parameters are crossover rate, number of variables, mutation rate, initial population size and number of iterations.
2. **Generate** the initial population randomly specified by performing the image watermarking process, as the watermarked image is generated for each individual.
3. **Evaluate** the best fitness function is based on the imperceptibility and robustness as in equation (7) and (8).
4. **Select** the best fitness value and the best individuals.
5. **Generate** the new population randomly specified by performing the crossover, mutation functions on the selected individuals.
6. **Repeat** the steps 2-5 until a predefined iteration is reached.

A handful of watermarking method, which use Genetic algorithm for improved performance, have been presented in the literature for protecting the copyrights of digital images. Recently, incorporating Genetic algorithm into watermarking method to improve its performance and effectiveness has received a great deal of attention among watermarking researchers. A brief literature survey of some recent researches is presented here.

**Survey of image watermarking technique in spatial domain using genetic algorithm** is given in Table 2.

Ran-Zan Wang et al. [70] proposed image hiding by optimal LSB substitution and genetic algorithm. Their improved hiding technique is developed to obtain a high-quality embedding result. A real-coded generic algorithm for optimized digital watermarking embedding in time-domain technique is proposed in [71]. Their algorithm improved the invisibility and the operating precision of images and reduces the operating complexity.

Anwar et al. [72] introduced a new method of adaptive blind digital image watermarking in spatial domain. Their method proposed increasing the payload two times, to achieve better imperceptibility. Masoumehkhodaei et al. [73] proposed a new image hiding by using genetic algorithm and LSB substitution. The experimental results show that their method has enhanced both the quality and the security of stego-image by using LSB substitution.

Cauvery et al. [74] presented a secure algorithm for watermarking images, and a methodology for digital watermarking that may be generalized to video data. Their method demonstrated the utility of genetic algorithm in the area of improving the fidelity and robustness of digital watermarking. Marghny Mohamed et al. [75] proposed a data hiding by LSB substitution using genetic optimal key-permutation. Their experimental results show that their method provides good image quality and large message capacity as well as increase in the system immunity.

Survey of image watermarking technique in discrete cosine transform domain using genetic algorithm is given in Table 3. Watermark optimization technique based on genetic algorithms is proposed in [76]. The experimental result shows that their proposed approach can effectively improve the quality of the watermarked image and the robustness of the embedded watermark against various attacks. Chin-Shiu-Shieh et al. [77] proposed genetic watermarking based on transform-domain techniques. Their results show the robustness under attacks and the improvement in watermarked image quality with genetic algorithm.

A robust algorithm for DCT-based GA spread spectrum watermarking has been presented in [78]. Their scheme got better-watermarked image qualities and more robust to the attacks. Promcharoen et al. [79] proposed a new approach for digital image watermarking in DCT domain. The genetic algorithms (GAs) are performed to find out the optimal parameters for watermark embedding, independently for each region type. The experimental results show that their approach yields a watermark that is invisible to human eyes and robust to various image manipulations. The comparison between the hybrid watermarking using genetic algorithm and the pure hybrid DCT-SVD (Discrete Cosine Transform-Singular Value Decomposition) is presented in [80].

Their results show that the extracted watermark quality of the hybrid using genetic algorithm is better than the extracted watermark quality of pure hybrid DCT-SVD. The watermarking robust against the cropping attack and with good imperceptibility is introduced in [81]. After sorting the cover image blocks, the multi-objective genetic algorithm is used for finding the best coefficients in each sorted blocks. Their results show improvement in the watermarking robustness and imperceptibility.

Survey of image watermarking technique in discrete wavelet transform using genetic algorithm is given in Table 4. Prayothkumsawat et al. [82] developed a technique for optimizing the image watermarking using genetic algorithm. Their method genetic algorithm is applied to the wavelet domain to improve the quality of the watermarked image and the robustness of the watermark. Prayothkumsawat et al. [83] proposed the spread spectrum image watermarking algorithm using the discrete multi wavelet transform. The experimental result shows that their proposed algorithm yields a watermark that is invisible to human eyes and robust to various image manipulations. Ali al-haj and Aymenab-errub [84] optimized DWT based image watermarking that can simultaneously provide perceptual transparency and robustness. These two watermarking requirements are conflicting, they applied genetic algorithms in order to reach the optimal performance. Masayoshi nakamoto et al. [85] proposed using genetic algorithm for optimization of key sequence. The robustness of the watermark
is strong. Hamid amiri and Mansour jamzad [86] determined the variation of coefficients using Multi Objective Genetic Algorithm (MOGA). The MOGA provided a good balance between the robustness and the fidelity requirements.

Chen yongqianget al. [87] proposed to select the fit wavelet coefficients by using genetic algorithm to embed the watermarking bit into the host gray image and the extracted watermark can be identified expediently through the synergetic neural network (SNN). The experimental result shows these schemes have preferable performance of security, imperceptibility and robustness. Surekha and Sumathi [88] proposed a new optimization method for digital images the genetic algorithm is used to optimize the watermark amplification factor in DWT sub-band. Their approach proved to be secure and robust. The genetic algorithm is used for parameter optimization in [89]. Their optimization is to maximize the values of Peak Signal to Noise Ratio (PSNR) of the watermarked image and Normalized Cross correlation (NCC) of the extracted watermark.

The digital image watermarking in DWT domain based on genetic algorithm proposed in [90]. The watermark amplification factor is calculated based on the HVS properties of the image. The values PSNR and NC are increased as the number of iterations increased showing that genetic algorithms improves the image imperceptibility and robustness of watermarked images even after performing attacks.

A novel invisible robust watermarking scheme for embedding and extracting a digital watermark in an image is presented [91]. The novelty lies in determining perceptually important coefficients of transform in the host image using simple Haar Wavelet Transform (HWT) and Genetic Algorithm (GA)-Particle Swarm Optimization(PSO) based hybrid optimization. Their proposed method is highly imperceptible and robust against different attacks like gaussian filter, median filters, blurring, contrast, JPEG compression and SPHIT compression. Abduljabarshaamala et al. [92] proposed watermarking based on genetic algorithm and studied the effect of DWT and DCT embedding domain on robustness of watermarking. Attacks based on numerical correlation (NC) is analysed through the DWT results showed more robustness than DCT in watermarking based on genetic algorithm.

Singular value decomposition (SVD) is an effective numerical analysis tool and mathematical technique used to extract algebraic features from an image. The SVD-based approaches is to apply the SVD to the whole cover image or, alternatively, to small blocks of cover image, and then modify the singular values to embed the watermark. Survey of singular value decomposition based image watermarking technique using genetic algorithm is given in Table 5. An image watermarking scheme based on singular-value decomposition (SVD) using genetic algorithm (GA) is presented in [93]. Their experimental result shows both the significant improvement in transparency and the robustness under attacks. Chih-Chin Lai et al. [94] introduced a novel image watermarking scheme using singular value decomposition (SVD) and micro-genetic algorithm (micro-GA). Their method proper values of scaling factors are optimized and obtained efficiently by means of the micro-GA. A digital watermarking scheme based on singular value decomposition and micro-genetic algorithm is proposed in [95]. Experimental results show that their approach has good performance against several attacks. Heechul Jung et al. [96] proposed an enhanced SVD based watermarking with genetic algorithm.

Their method to found optimal scaling factors in their algorithm satisfies both robustness and high quality of the watermarked image.

Jagadeeshet al. [97] proposed a genetic algorithm based oblivious image watermarking scheme using singular value decomposition. Their algorithm is more secure and robust to various attacks, such as low pass filtering, median filtering, JPEG compression, resizing, row-column blanking, row-column copying. A robust digital image watermarking scheme based on singular value decomposition (SVD) and a tiny genetic algorithm is proposed in [98]. They used the tiny genetic algorithm to search the proper values in order to improve the visual quality of the watermarked image and the robustness of the watermark. Poonam et al. [99] proposed image watermarking based genetic algorithm using DWT-SVD techniques. They found the transparency and robustness of watermark under various attacks.

Genetic algorithm approach for singular value decomposition and quantization based digital image watermarking is presented in [100]. Their scheme is based on quantization step size optimization using the Genetic Algorithm to improve the quality of watermarked image and robustness of the watermark. Khaled Loukaoukha et al. [101] proposed the security of digital watermarking scheme based on SVD and Tiny-GA. They demonstrated that their watermarking algorithm is fundamentally flawed and has a very high probability of false positive detection of watermarks. Roshan Jahan [102] proposed a new digital image security scheme is applied which incorporates watermarking algorithm using DWT-SVD and optimized chaotic based image encryption obtained through genetic algorithm with high level of robustness and security.

**Attacks:**

Every attack that aims at removing the embedded watermark by modifying the pixel values of the watermarked image; should make it difficult to detect the presence of the watermark. Fig. 6 shows the block diagram of multiple watermarks embedding and extraction with attacks. The four classes of attacks are removal, cryptographic, geometric and protocol attacks [103-106]. Table 6 lists their performance of image watermarking.
technique using genetic algorithm against these attacks such as Salt & Pepper Noise, Gaussian Noise, Low pass Filtering, Average filtering, Median Filtering, Wiener Filtering, Gaussian Filtering, Scaling, Cropping, Rotation, JPEG Compression, Sharpening, Histogram Equalization, Resizing, Gamma correction, Row-Column blanking and Row-Column copying.

Salt & Pepper Noise:
To test the robustness against adding noise, the watermarked image is degraded by adding salt and pepper noise randomly. Here, the noise is caused by errors in the data transmission. The watermarked image is corrupted with salt and pepper noise at the density ranging from 0.01 to 0.1. Unaffected pixels always remain unchanged. The noise is usually quantified by the percentage of pixels which are corrupted.

Gaussian Noise:
The watermarked image corrupted with Gaussian noise of zero mean and varying the variance of the noise ranging from 0.01 to 0.1. In telecommunications and computer networking, communication channels can be affected by wideband Gaussian noise coming from many natural sources, such as the thermal vibrations of atoms in conductors, shot noise, black body radiation from the earth and other warm objects and from celestial sources such as the Sun.

Low pass Filtering:
Low pass Filtering includes linear and non-linear filters. To perform the image filtering to watermarked image as low-pass filtering. The watermarked images are attacked by low-pass filtering. Low-pass filters exist in many different forms, including electronic circuits, anti-aliasing filters for conditioning signals prior to analog-to-digital conversion, digital filters for smoothing sets of data, acoustic barriers, blurring of images, and so on. Low-pass filters provide a smoother form of a signal, removing the short-term fluctuations and leaving the longer-term trend.

Average filtering:
The average filtering techniques with varying mask sizes are applied to analyse the performance of the watermarked image during the optimization process of genetic algorithm to evaluate the robustness measure. Average filtering removes the high frequency components present in the image acting like a low pass filter.

Median Filtering:
Median filtering is a nonlinear operation often used in image processing to reduce high frequency noise in an image. Each output pixel contains the median value in the m-by-n neighbourhood around the corresponding pixel in the input image. The watermarked image is passed through median filter. Median filtering is very widely used in digital image processing because, under certain conditions, it preserves edges while removing noise.

Wiener Filtering:
Wiener method based on statistics estimated from a local neighbourhood of each pixel. To perform the image filtering to watermarked image as wiener filtering. This filter is used to produce an estimate of a desired or target random process by linear time-invariant filtering an observed noisy process, assuming known stationary signal and noise spectra and additive noise. The Wiener filter minimizes the mean square error between the estimated random process and the desired process.

Gaussian Filtering:
The use of linear filtering to remove certain types of noise as Gaussian filters. The Gaussian filter attack with varying a window size is applied with zero mean and unit variance. Gaussian filters have no overshoot to a step function input while minimizing the rise and fall time. This behaviour is closely connected to the fact that the Gaussian filter has the minimum possible group delay. These properties are important in areas such as oscilloscopes and digital telecommunication systems.

Scaling:
The scaling factors are selected the robustness of the extracted watermark is invisibility and quality, usually higher in the low frequency band and lower in the high frequency band. The watermarked image is scaled by varying a factor and rescaled back to its original size of image using bilinear interpolation before watermark detection.
Cropping:
The cropping is a geometrical attack where a small portion of the watermarked image is cut or removed as an attempt to remove the significant portion of the image to remove the watermark. Depending on the application, this may be performed on a physical photograph, artwork or film footage or achieved digitally using image editing software. The term is common to the film, broadcasting, photographic, graphic design and printing industries.

Rotation:
The rotation is used to realign horizontal features of an image. Rotation is tested by rotating the image in counter-clockwise direction and then back to the original position through bilinear interpolation before watermark detection.

JPEG Compression:
The JPEG is one of the most used image compression technique, and is often an unintentional attack. The watermarked images are compressed using different quality factor ranging from 0 to 100. JPEG compression is used in a number of image file formats.

Sharpening:
Sharpening operations are used to enhance the subjective quality. A sharp image includes small components, the fine detail, down to the limit of vision. Thus, it is the size of the finest details that also contributes to our perception of sharpness. An image that contains both high acutance (edge contrast) and small details is considered sharp. A high acutance image that does not contain fine details might be considered sharp by some viewers but the image will pale in comparison to the same scene that also contains the fine details.

Histogram Equalization:
The Histogram Equalization block enhances the contrast of images by transforming the values in an intensity image so that the histogram of the output image approximately matches a specified histogram. The method is useful in images with backgrounds and foregrounds that are both bright or both dark. In particular, the method can lead to better views of bone structure in x-ray images and to better detail in photographs that are over or under-exposed.

Resizing:
Resizing operation first reduces or increases the size of the image and then generates the original image by using an interpolation technique. This operation is a lossy operation and hence the watermarked image also loses some watermark information.

Gamma correction:
The gamma correction is very frequently used operation to enhance images or adapt images for display.

Row-Column blanking:
In row-column blanking attack, a set of rows and columns are deleted.

Row-Column copying:
In row-column copy attack, a set of rows and columns are copied to the adjacent or random locations.

Fig. 1: Classification of Watermarking
Fig. 2: Multiple Watermarking Techniques

Fig. 3: Multiple successive watermarking technique.

Fig. 4: Multiple segmented watermarking technique

Fig. 5: Block diagram of image watermarking by using genetic algorithm
Fig. 6: Block diagram of embedding and extraction with attacks

Table 1: Multiple watermarking techniques in different domains

<table>
<thead>
<tr>
<th>Authors</th>
<th>Year</th>
<th>Transform</th>
<th>Performance</th>
</tr>
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<tbody>
<tr>
<td>Giakuomaki et al. [24]</td>
<td>2003</td>
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<td>Tao et al. [26]</td>
<td>2006</td>
<td>Integer Wavelet Transform</td>
<td>Robust and Good visual quality</td>
</tr>
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<td>Yuan Yuan et al. [27]</td>
<td>2007</td>
<td>Discrete Wavelet Transform</td>
<td>Robust</td>
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<tr>
<td>Maha Sharkas et al. [28]</td>
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<td>Discrete Wavelet Transform</td>
<td>Security and robustness</td>
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<tr>
<td>Ibrahim Nasir et al. [29]</td>
<td>2009</td>
<td>Spatial Transform</td>
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<tr>
<td>Yuanqiu et al. [30]</td>
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<td>Invisibility and robustness</td>
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<td>Surekha et al. [31]</td>
<td></td>
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<td>Robust</td>
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<tr>
<td>Sergey Afinigenov et al. [33]</td>
<td>2012</td>
<td>Discrete Fourier Transform</td>
<td>Robust</td>
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<td>Jaiswal et al. [34]</td>
<td>2013</td>
<td>Discrete Wavelet Transform</td>
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<td>Mohanad O. et al. [35]</td>
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<tr>
<td>Yuanning et al. [36]</td>
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<td>Robust</td>
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<tr>
<td>Hwai-Tsu Hu and Ling-Yuan Hsu</td>
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<td>Robust</td>
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Table 2: Image watermarking technique in spatial domain using genetic algorithm

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<tr>
<td>Ran-Zan Wang et al. [37]</td>
<td>2001</td>
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<td>Li Xiaoni et al. [38]</td>
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<td>Anwar et al. [39]</td>
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<tr>
<td>Masoumehkhodaei et al. [40]</td>
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<td>Cauvery et al. [41]</td>
<td>2011</td>
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<td>Marghny Mohamed et al. [42]</td>
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<td>Quality and capacity</td>
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Table 3: Image watermarking techniques in discrete cosine transform using genetic algorithm

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<th>Achievements</th>
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<tr>
<td>Huang et al. [43]</td>
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<td>Shushle et al. [44]</td>
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<td>Zhicheng Wei et al. [45]</td>
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<td>Quality and Robustness</td>
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<td>Promcharen et al. [46]</td>
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<td>Invisible and Robust</td>
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<td>DidiRosiyadi et al. [47]</td>
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<td>Quality</td>
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<tr>
<td>SeyedSahandMohammadiZiabari [48]</td>
<td>2014</td>
<td>Robustness and Imperceptibility</td>
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</tbody>
</table>

Table 4: Image watermarking techniques in discrete wavelet transform using genetic algorithm

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<tr>
<td>Prayothkumsawat et al. [49]</td>
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<td>Ali al-haj and Aymenabu-errub</td>
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<td>Perceptual transparency and Robustness</td>
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<td>Masayoshi nakamoto et al. [52]</td>
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<td>Hamid ami and Mansour jamzad</td>
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<td>Robustness and Fidelity</td>
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<td>Chen yongqiang et al. [54]</td>
<td>2009</td>
<td>Security, Imperceptibility and Robustness</td>
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<tr>
<td>Surekha and Sumathi [55]</td>
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<td>C.C.Lai et al. [56]</td>
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<td>Sridevi et al. [57]</td>
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<td>Abduljabbarshaamala et al. [59]</td>
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<td>Robustness</td>
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<td>VeyeriAslantas [60]</td>
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<td>Chih-Chin Lai et al. [61]</td>
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<td>Chih-Chin Lai et al. [62]</td>
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Table 6: Image watermarking technique using genetic algorithm with attacks

<table>
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<tr>
<td>Salt and pepper noise</td>
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<td>Gaussian noise</td>
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<td>Median filtering</td>
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<td>Gaussian filtering</td>
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<td>Scaling</td>
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<td>Row-column blanking</td>
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<tr>
<td>Row-column copying</td>
<td>[56 and 67]</td>
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</table>

Discussion:

The discussion of multiple watermarking techniques, composite watermarking technique as having good imperceptibility and segmented watermarking technique as achieving more robustness. The selection of multiple watermarking techniques can be preferred depending on the applications for superior result. The medical safety needs more imperceptibility, since the information is essential. However, for the best visual quality the composite watermarking technique can be preferred. The watermarking application of rightful ownership requires a very high level of robustness. Segmented watermarking is used for fingerprint application which requires a high robustness against standard data processing attacks.

Conclusion:

The various researchers from different fields are focusing multiple watermarking techniques to develop imperceptibility and robust watermarking. This paper emphasizes multiple watermarking for various domains, techniques, application and analysis for the various attacks. During the embedding and extraction process, the image watermarking technique simultaneously provides perceptual transparency and robustness. Since these two watermarking requirements are conflicting, this can be solved by optimization techniques. This paper presents a literature survey on multiple image watermarking using genetic algorithm for various domains which will be useful for researchers to implement the effective image watermarking using genetic algorithm.

REFERENCES


