Digital Watermarking Method Through GA and PSO Algorithm

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Abstract: Now a days there is increase in data exchange over digital media. As a result of that one multimedia data like audio, video, images transfer increases day by day. Watermarking is very famous now days due to security concern. There are many applications of watermarking with the help of which security can be increased in data. There are many areas where watermarking can be used such as copyright protection, fingerprint authentication, copy control etc. Among the well-known industries that use watermarking are digital media, communications, and computing technology. Watermarking is becoming more and more popular in cybersecurity and antivirus protection as the detection of unauthorized use of specific web resources and data protection become increasingly independent. The process of adding a signature, stamp, or other identifying feature to digital content in order to confirm its legitimacy and ownership is known as watermarking. The watermark could be anything private, such writing, a logo, or numbers. Algorithms can be used to increase imperceptibility and robustness applying to the cover image using block compression approach. Apply various attack types to the final picture. To decide degradation in image, compute the PSNR method. On the primary image, the Swarm-based Optimization and the Genotype are applicable. Highest trade-off of watermarking is between imperceptibility and robustness. Watermarks must be embedded sufficiently deep in the image so that standard attacks, such as compression, noise, or scaling, cannot be successful.

Keywords: Authentication, Copy control, algorithms, DCT, Robustness, Watermarking, GA, PSO.

Introduction

Since the 13th century, watermarking has been used. Initially, it was only used in the paper industry due to the transparency of watermarking, which helps to uniquely identify papers. Therefore, we can apply this technique for copyright and authentication. One design that can be applied to an entity is watermarking. When we add a watermark, it doesn't automatically alter any of the entity or structure's functions.

Digital entities like audio, video, computer programs and any data types for software / hardware like chips. Watermark is designed with main purpose to keep the authenticity and be secured from work attack as illegal distribution. Digital watermarking: A digital way of encoding data the thing with the images is that it was a form of 'watermark' on each image which would act as unique identifier or acting to protect ownership information [1] around the Pictures folks needed to mark in dusty material, but here now all's advanced so we're talking about 0100100 and some such making up entire files.

The methods we employ fall under the "transform domain." The watermark data is incorporated into the frequency domain coefficients of the images' HSV color space representation. This results in a high PSNR score and good imperceptibility by preserving the chromatic information. The discrete wavelet domain (DWT) and singular wavelet transform (SWT) methods are used in the frequency domain transform. Singular value decomposition (SVD) provides strong resistance to compression and Take note. False positives are the primary issue with singular value decomposition (SVD), and the strategies we are employing here to get over SVD's drawbacks are based on watermarking techniques. In this case, the extraction and embedding methods are being used. The PSNR value serves as the optimization criterion. The watermark's quality and resilience have been enhanced by the new robust algorithm. This is the paper's primary goal. Additionally, it enhances authentication.

Introduction to Knowledge Engineering in Watermarking

The primary task of the knowledge engineer is to gather information from human experts' to be put into a knowledge-based system (KBS).

On knowledge engineering relies on signal processing basics, which allow the development of effective watermarking systems. Engineers use their knowledge of various signal processing techniques, including picture, audio, and video compression, to create algorithms that can "smoothly" embed and remove watermarks from digital content. With this information, engineers can use signal processing methods designed to keep watermarks secret even from common interferences like geometric attacks and compression noise addition.

Watermarking techniques that can't be seen by the naked eye and cannot be accessed by signal processing methods might be developed by professional engineers. As a result of this, watermarking system efficiency can rise to greater heights. Knowledge engineering gives engineers ideas to make these algorithms.

When developing robust algorithms for different applications and constraints, knowledge engineering plays a crucial role. Engineers making watermarking algorithms take into account domain specific information that involves characteristic differences among various digital media types. For example, engineers designing watermarking algorithms tailored for specific areas such as image-processing applications like medical imaging or satellite images may incorporate domain-specific information about image-processing techniques and data formats particularly employed by those fields just mentioned above. Any other areas that use domain knowledge in the watermarking method are taken into account by such methodology which makes it to be meaningfully used with respect to certain requirements of a particular type like anticipated application class. Also, ethics and legal matters are incorporated into the design process for watermark systems through knowledge engineering. Developers can build watermarking technologies that follow the law, safeguard people's rights and privacy within this legal framework, moral values and industry rules.

. It is important for them to consider ethical issues and legality while developing reliable digital transactions and communication using this strategy.

Therefore, combining these ethics and knowing what is correct as per law would assist when it comes to respecting individual rights and having undisturbed digital content that is also secure. Also, dependant on knowledge engineering is watermarking research and innovation. In order to achieve this goal, they bring together the experts from different fields or disciplines. Such as computer science, electrical engineering and mathematics or psychology for engineers who are developing new techniques towards improving efficiency, effectiveness as well as robustness of watermarking algorithms/systems by integrating information from various sources.Through this interdisciplinary approach towards research and development, engineers can create watermarking technologies capable of addressing the ever-increasing needs of internet content protection during an Integration of Knowledge Engineering in Robust Watermarking Algorithms The ability to develop strong watermark algorithms necessitates knowledge engineering, so that the final produce can withstand different attacks and still conserve the integrity and privacy of digital materials. This happens through the contribution by experts in technical field as well as those in information theory and signal processing for combining with structural properties and insights of knowledge engineering in developing watermarking algorithms. Knowledge engineering is very important because it helps us to understand signal-processing-based solid watermarking methods which would otherwise be difficult to comprehend and use effectively. Engineers build on their understanding of techniques of digital signal processing like filtering, discrete cosine transform (DCT) and wavelet transforms to come up with algorithms that enable them seamlessly insert or remove watermarks from digital data. Employing knowledge engineering in creating such, computer scientists can design algorithms that evade common attacks such as compression, geometric transformations and noise addition but remain undetectable to human beings.

Signal Processing Techniques:

- **Understanding Signal Processing Principles:**
  Knowledge engineering is an excellent way of learning all these required signal-processing techniques for watermarking algorithms. Engineers should have expertise in digital signal processing including filtering, discrete cosine transforms and wavelet transforms. These algorithms also depend largely on this technology that can add and remove watermarks successfully. Now, let us assume signal processing theory and practice is well understood by engineers. In such situation, they might come up with techniques that would make detection of watermarks nearly impossible as well as untraceable from the typical attacks including geometric distortions , noise addition and compression [10].

- **Applying Signal Processing for Robustness:**
  To develop more robust watermarks against attacks, engineers design signal-processing-based watermarking strategies which make use of strong watermarking methods. With some knowledge engineering insight, these algorithms may balance between being imperceptible to human observers and being operationally resilient with respect to signal processing. For the purpose of rendering the watermark immune to compression and noise, engineers have adopted methodologies like quantization index modulation and spread spectrum modulation . To such as spread spectrum modulation or quantization index modulation. To guarantee safety of embedded watermarks and their authenticity, error correction coding is used in conjunction with other cryptographic mechanisms[11].

Integration of Domain Knowledge:

- **Addressing Unique Content Characteristics:**
  Watermarking algorithms require non-uniform information due to extensive functionalities as well as the set of different digital contents that each requires different types of intellectual property protection. The adaptation of watermarking algorithms by engineers is based on understanding what properties are possessed by digital data[12]. Medical imaging data formats and image processing knowledge can be used by engineers to develop watermarking algorithms specifically for these kinds of images. They can customize watermarking techniques using domain knowledge to meet the needs and overcome the restrictions of various application areas.
- **Customizing Algorithms for Diverse Domains:**
  Engineers may tailor watermarking techniques according to different application domain requirements. Engineers modify them based on the unique characteristics of different types of digital materials to improve algorithms' performance and applicability. Algorithms designed for satellite or medical images that would benefit from watermarking might differ greatly from those developed for multimedia content. Engineers may ensure that their watermarking approaches are universal through developing domain specific algorithms[13].

Ethical and Legal Considerations:

- **Compliance with Legal Frameworks:**
  From the inception and implementation stages, engineers employ knowledge engineering in order to consider ethical as well as legal aspects associated with water marking systems. Engineers refer to legal frameworks, industry standards and ethical conventions is to keep within the law in which they operate when embedding marks into digital images. Copyright laws, privacy requirements, and moral issues should be considered by engineers while creating watermarks for protection of digitally stored information. Inclusion of ethical and legal knowledge by engineers helps to ensure the responsible and ethical use of watermarking technology. This fosters accountability and trust in digital communication and transactions.[10]
- **Deploying Systems Responsibly:**

Engineers also make sure that watermarking system deployment is done in a responsible manner that meets regulatory requirements. It is necessary to think carefully about how watermarking technologies affect people's freedoms, privacy, etc. Engineers construct systems with measures that protect user data privacy right from the start. Some types of watermarking systems may enable users to control their own information while others can require opt-in permissions before collecting or sharing data with third parties. When they perform this role properly, engineers facilitate wider adoption and market acceptance of elimination strategy using water mark [14].

Interdisciplinary Collaboration and Innovation:

- **Fostering Collaboration Across Disciplines:**
  Watermarking technology experiences technical progress through knowledge engineering, which promotes interdisciplinary collaboration and information sharing. Watermark enhancement involves team work among engineers from fields such as; computer science, electrical engineering, mathematics' psychology among others. Engineers investigating new approaches and techniques that draw on concepts from many different areas may make watermarking algorithms and systems more efficient, effective, and resilient. By bringing together experts from different fields, engineers can draw from a wealth of information and perspectives, leading to more innovative and efficient watermarking solutions[15].
- **Exploring New Avenues for Improvement:**
  Engineers may improve watermarking methods and systems by drawing on knowledge from many areas. Engineers may use a combination of artificial intelligence (AI) and machine learning techniques to make watermarking systems more resistant to emerging threats [16]. Improved watermarking systems may be possible in the future as a result of new hardware technology, such as quantum computing. Engineers must always strive to be one step ahead of the competition regarding watermarking technology. Watermarking technologies should be able to embrace change if we are headed towards new directions of growth for digital asset protection.

Artificial Intelligence techniques basically remove the trade-off between two important factors robustness and imperceptibility of an image. Some important artificial intelligence techniques are:

In this diagram, every node is connected to every other node.

1. Each nodes had some weighing values. Different algorithms are used here like adaptive learning late method , conguate Gradient and quasi newton algorithm. Gradient' of performance method is used by all the algorithms. This gradient value is used by all the algorithms determined by performance computation in the network.

   Neural network can see as a weighted graph where the neurons come from the input nodes.

The association between the input neurons and output neurons can be seen as the directed weights. This network receives the input from outside in the form of some pattern Each input is multiplied with corresponding number of weights. Strength of neural network is the weights that are connected between neural network. If the some of weights is zero then the bias is added.

What is Genetic Algorithm- Genetic algorithms are used as optimization techniques. This is the searching algorithm. They are generally used to provide high quality methods for optimization problems and another search problem. Genetic Algorithm use population value it is made up of a collection of solutions that together represent the solution of all the systems.GA simulate the process of natural selection this means the species who are ready to adapt the changes in the outer are able to reproduce' and go to the other generation.

Methodology

Explanation of Embedding process in an image: -

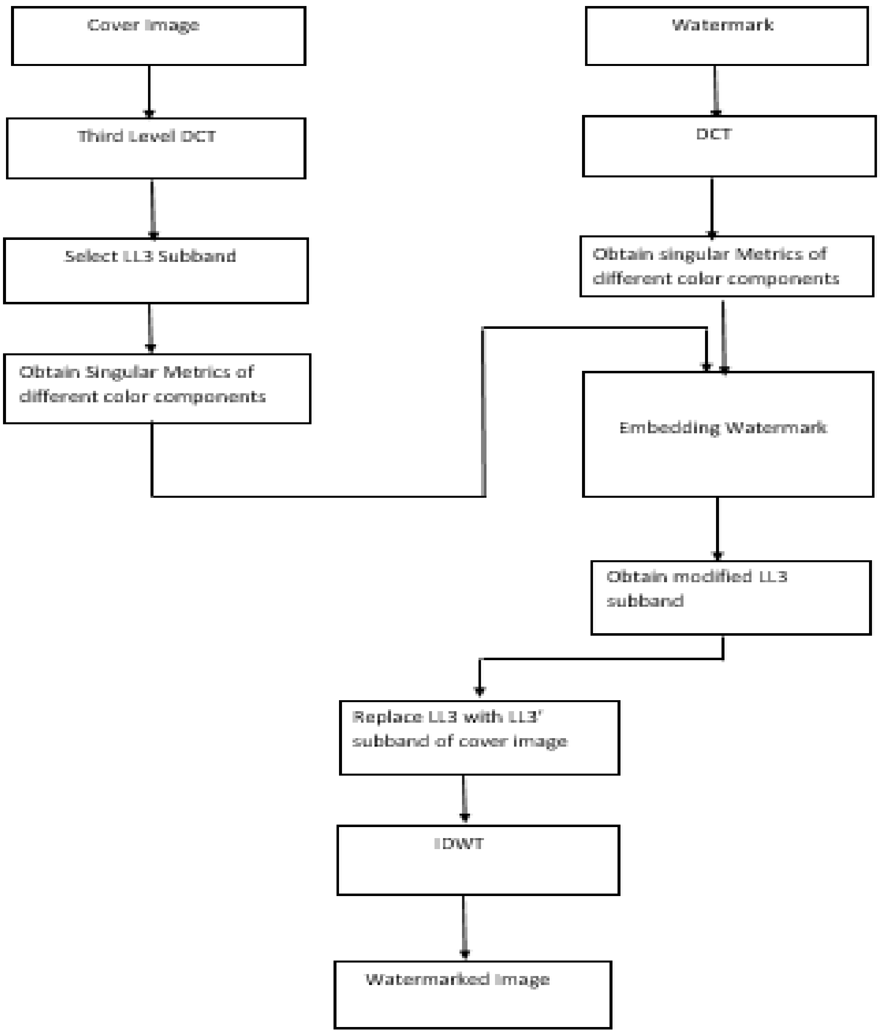

Figure 1.1

Steps:

1.Take the Cover picture.

2. Decomposed into sub bands using third level DCT transform.

3 Apply DCT to the elements on the front in shades of green, red, and blue picture after selecting the LL3 sub band.

$$Aci = Uci\ SciVci^{c}$$
$$i = R, G \& B \ldots\ldots\ldots\ldots\ldots\ldots..(i)$$

4. Get the matrices for the watermark image's red, green, and blue components by applying DCT to them.

$$Awi = UwiSwiVwi^{c}$$
$$i = R, G \& B \ldots\ldots\ldots\ldots\ldots\ldots..(ii)$$

5. Adjust the absolute values of various colour components. The cover image's LL3 subband containing the single values of the watermark image's various components.

$$Swati=Sci+N*Swi \ldots\ldots\ldots\ldots....(iii)$$

6.Use the following equations to get the updated LL3* sub band.

$$Awati = UciVciSwati^{c}\ldots\ldots(iv)$$

7.The arrays (Awatr, Awatg, Awatb) combine in three dimensions to produce an altered LL3* sub-band.

8. To get a watermarked picture, replace the Apply the inverse IDWT after modifying the LL3 * at the third level of the LL3 subband.

9. in order to test how well the suggested algorithm handles attacks and noise, apply them to the watermarked picture.

Explanation of Extraction process in an image :

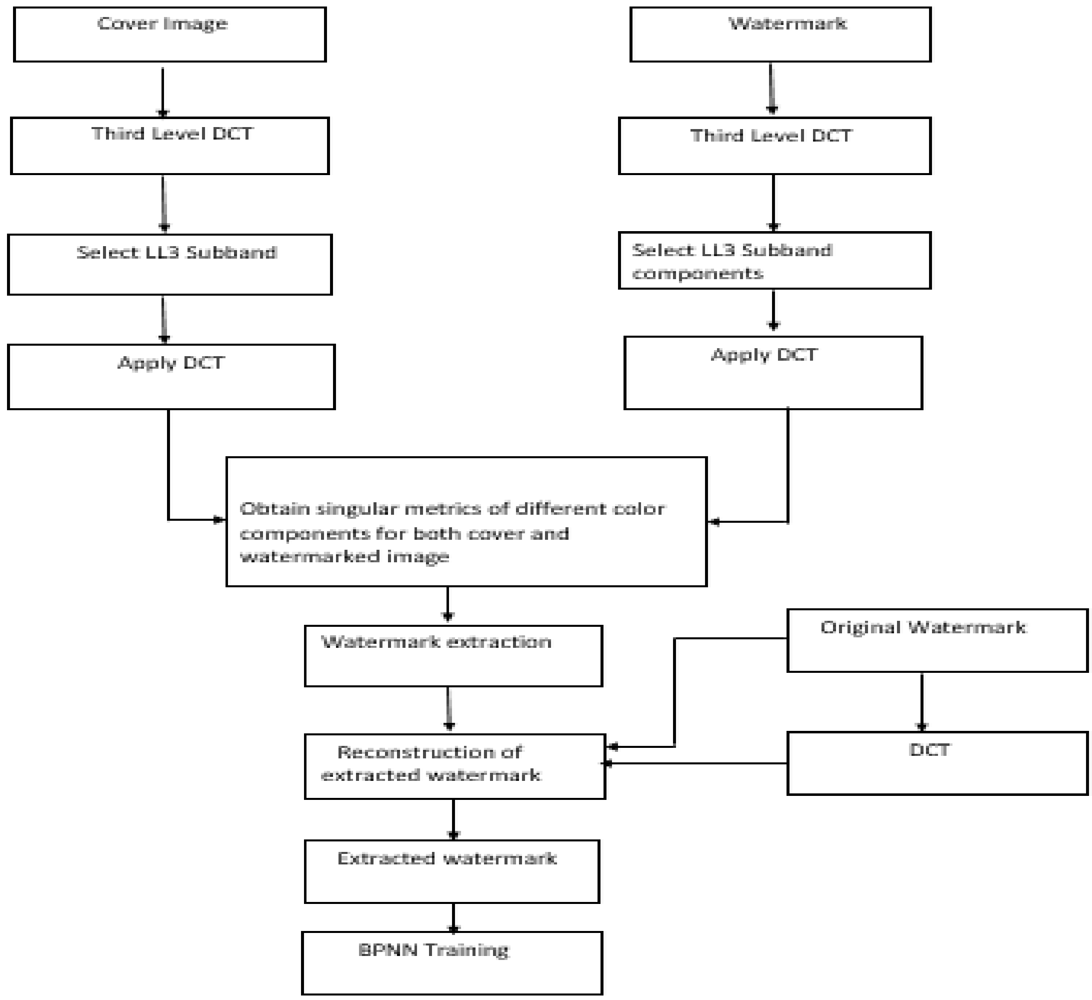

Figure 1.2

Steps:

1. Take the cover picture and use the third-level DCT transform to break it down into its component bands.

2. Choose the LL3 subband, then use DCT on the cover image's red, green, and blue components.

$$Aci = UciSciVci^{c}$$

i = G, R, and B……(i)

3. Run using DCT via the image's lime green, blue parts that make up the watermark.

$$Awi=UwiSwiVwi^{c}\ldots\ldots\ldots\ldots(ii)$$

4. In order to get the DCT matrices for the LL3 subaband, apply steps 1 and 2 on the watermark picture. When you plug in Uwati, Swati, and Vwati into Awati, you get T.

5. Images' watermarks' singular values, the cover picture's LL3 subband, and the watermark image itself should be obtained.

$$Swi^* = (Swati - Sci)/N \ldots\ldots\ldots\ldots\ldots\ldots (iii)$$

6. Use this equation to get the extracted watermark.
   $Uwi^* \; Swi^* \; Vwi^c = Aewi$ ……..(iv)

7. To make it more resilient, we use BPNN method to the extracted watermark.

What is PSO?

The computational optimization method known as Particle Swarm Optimization (PSO) was motivated by the social behavior of fish schools and flocks of birds. Kennedy and Eberhart first presented it in 1995. A popular population-based optimization technique for determining the best answer to optimization issues across a range of fields is PSO.

Each particle's location in the search space represents a potential solution, and the algorithm begins with a population of potential solutions represented as particles. Particles navigate the search space by rearranging their positions according to their own experiences as well as the experience of the population's top-performing particle, or "global best."
How the PSO algorithm works:

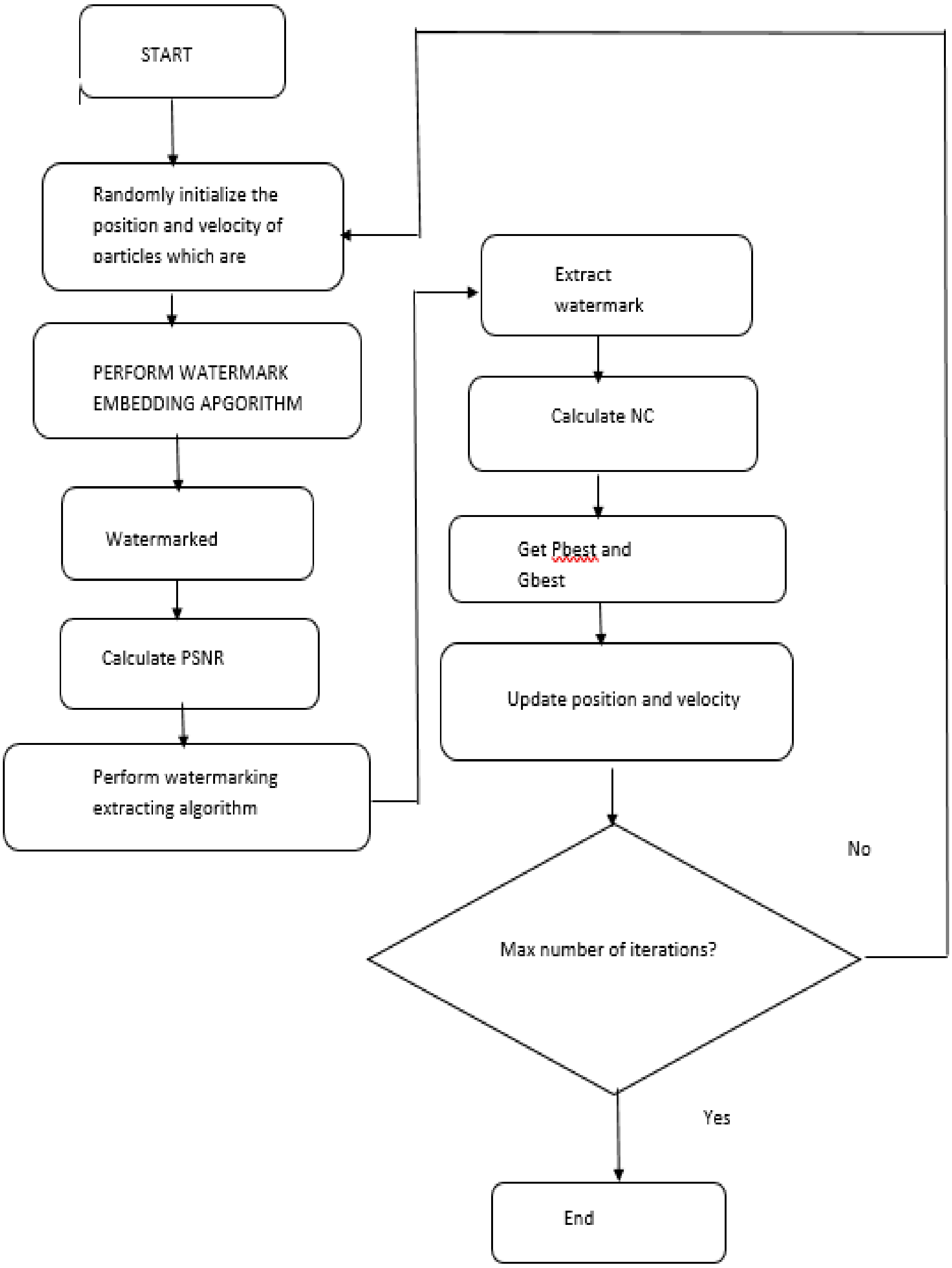

Figure 1.3

1Start by creating a population of particles in the search space with arbitrary locations and speeds. Each particle's velocity dictates how it travels through the space, and its position indicates a possible solution.

2. Evaluation: Determine each particle's position's fitness or objective function value. This function measures the quality of the optimization problem's solution.

3. Update Particle's Best Position (PBest): Based on its fitness value, each particle logs its best position(solution)todate.

4. Update Global Best (GBest): Using their fitness ratings, identify the particle that performs the bestoutofall the particles in the population (global best).
5. Update Velocity and Position: Use the following formulas to update each particle's velocity and position:
(Inertia Weight * Current Velocity) + (Cognitive Coefficient * Random Number * (PBest - Current Position)) + (Social Coefficient * Random Number * (GBest - Current Position)) = New Velocity(i)

Current Position + New Velocity = New Position(i)

The impact of the particle's current velocity is controlled by the inertia weight. The influence of the best particle in the population (GBest) and personal experience (PBest) are controlled by the social and cognitive coefficients, respectively. The algorithm is made more exploratory by introducing random numbers.
6. Termination: Until a termination condition is satisfied, the algorithm keeps repeating steps two through five. Reaching a maximum number of iterations or arriving at a good solution are examples of common termination criteria.

A straightforward and effective optimization technique, particle swarm optimization can be used for a variety of tasks, including neural network training, function optimization, engineering design, and data clustering. Its capacity to investigate and exploit the search space efficiently makes it popular in many optimization tasks.

Particle Swarm Optimization was used to optimize the watermark embedding algorithm.

Step 1- Decompose the picture into its component channels by reading it as a colour image. B1 R1 G1.
Step 2- Analyse the Watermark Picture by Dividing into the R1, G1, and B1 channels.
Step 3- change the host system's graphic to distinct discover the entropy value of the blocks. The scope of each block is (8×8).
Stage 4- Arrange each of the block in decreasing order of entropy value.
Step 5 – Then insert the watermarked blocks by applying a 2D DCT to the picture and choosing the DCT coefficients.
Step 6 –Then insert the watermark blocks that were computed using the Particle Swarm Optimisation approach into the selected main image blocks using the scale factor alpha1. This will optimise the final output and achieve a balance between imperceptibility and resilience. The watermark was embedded using the optimal alpha1 value produced by the particle swarm optimisation process, rather than a single scaling factor named alpha1. The following equation is used to conduct embedding:
Watermarked_block1 can be calculated as host_block1 + alpha *watermark_block…………..(1).
Step 7 – Next get the final watermark picture by using the inverse transform.
Step 8 - Finally, you may get a watermarked picture by combining all of the image's channels.

Particle Swarm Optimization was used to optimize the watermark extraction algorithm.

Step' 1 - Determine final picture's format additionally transform it into channels R1G1B1..
Step 2 - Figure out what the watermarked copy picture is R1G1B1 channels.
Step 3 - Examine the alpha1 worth determined by the method for particle swarm optimisation.
Step 4 – Modify the originating picture into an 8*8 block and then find the value of their entropy.
Step 5- Then Arrange the blocks in decreasing order of value.
Step 6 – Change divide the signed picture into blocks of size (8*8), and then rank them by entropy value, from highest to lowest.
Step 7 – Then finally use the value of alpha1 and equation (2) computed due to the swarm of particles optimisation process to extract the watermark from the first 1028 elements of the sorted block datasets.
Blocked watermark _extracted = (host_block - signed_block)/alpha1………………. (2)
Step 8 - Gather Obtain a hue watermarked picture for each R1G1B1 aircraft.

Results

All the Experiments are implemented on MATLAB R2017A.

Algorithm 1. Particle Swarm Optimization for watermarking

Step 1. Initialize the PSO parameters and particles.
Step 2. Define search space for block size and alpha.
Step 3. Define number of particles, max iterations, and other PSO parameters
Step 4. Initialize particle positions and velocities of particles.
Step 5: Establish the goal function.
Step 6: Define the objective function as the negative PSNR.
Step 7. Objective function takes particle's position (block size and alpha) as input value
Step 8. Take the main PSO loops.
Step 9. For iteration = 1 to max iterations do
Step 10: Perform
Step 11: Calculate the value of the objective function for each particle's position.
Step 12: Update the particles' best-known position if the objective function value is higher than Step 13.
Step 14. If the objective function value is greater than Step 13, update the particles' best-known position in Step 12.
Step 15. Update world-renowned position
Step 16. Close if
Step 17. Close if
Step 18. Update particle's velocity and position value using PSO equations
Step 19. Finish
Step 20. Come to an end for
Step 21.After PSO loop, global best position contains optimal block size and alpha

Step 22. Perform watermarking using optimal block size and alpha
Step 23. Calculate PSNR between original and watermarked images using optimal parameters
Step 24. Display or output optimal parameters and resulting PSNR value

Repetition 1 Best cost= 40.5396
Repetition 2 Best cost= 40.5382
Repetition 3 Best cost= 40.0051
Repetition 4 Best cost= 40.0051
Repetition 5 Best cost =40.0051
Repetition 6 Best cost= 40.0051
Repetition 7 Best cost= 40.0051

Algorithm 2: Genetic Algorithm For watermarking

Step 1. Initialize GA parameters and population.
Step2.Explainchromosome representation (block size and alpha)
Step 3. Explain population size, max generations, and other GA parameters
Step 4. Initialize random population of chromosomes
Step 5. Describe fitness function.
Step 6. Describe negative PSNR as fitness function
Step 7. Chromosomes provide the input for the fitness function, which outputs the fitness value.
Step 8.Using Main GA loop
Step 9. for generation = 1 to max generations do
Step10. Evaluate fitness of each chromosome in the population
Step 11. Select parents for crossover based on fitness (e.g., roulette wheel selection)
Step 12. Execute crossover to create new offspring
Step 13. Execute mutation on offspring with a certain probability
Step 14. Replace old population with new population (offspring)
Step 15. end for
Step 16. After GA loop, chromosome with best fitness contains optimal block size and alpha
Step 17. Execute watermarking using optimal block size and alpha
Step 18. Calculate PSNR between original and watermarked images using optimal parameters
Step 19. Display or output optimal parameters and resulting PSNR value

Repetition: 0
xmin:[9.51527771098767 0.00619082468072209] -- f(xmin): 40.0052

Repetition: 1
xmin:[9.5324092801984 0.00618115355322337] -- f(xmin): 40.0052

Repetition: 2
xmin:[9.5324092801984 0.00618115355322337] -- f(xmin): 40.0052

Repetition: 3
xmin:[9.5324092801984 0.00618115355322337] -- f(xmin): 40.0052

Repetition: 4
 xmin:[9.51633850039602 0.00619022584301544] -- f(xmin): 40.0052

Repetition: 5
 xmin:[9.51633850039602 0.00619022584301544] -- f(xmin): 40.0052

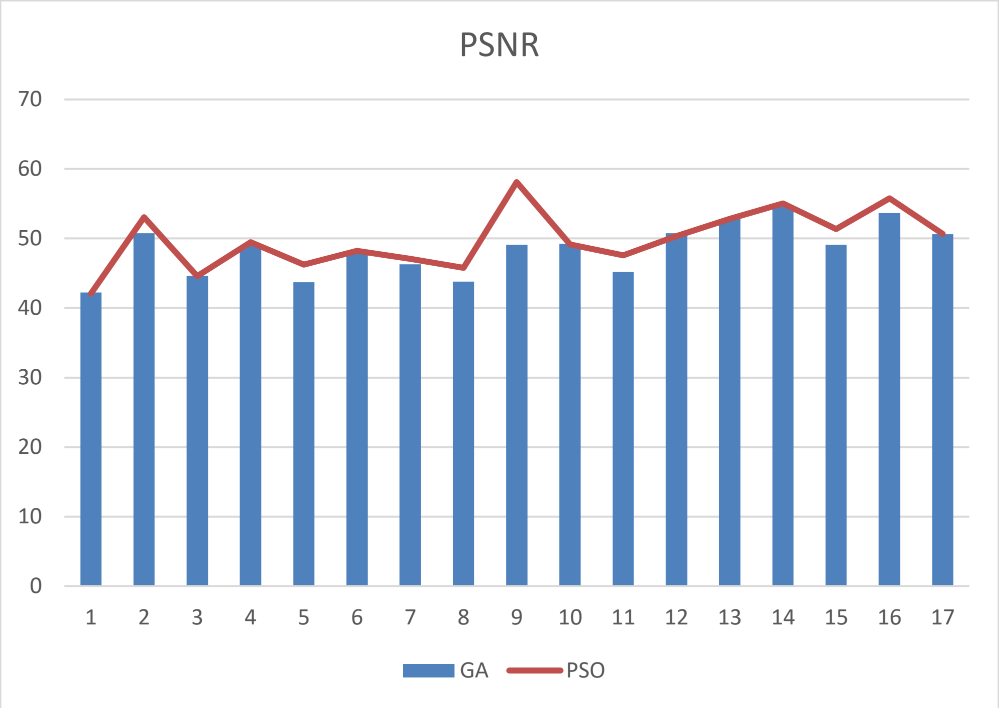

Chart 1.1

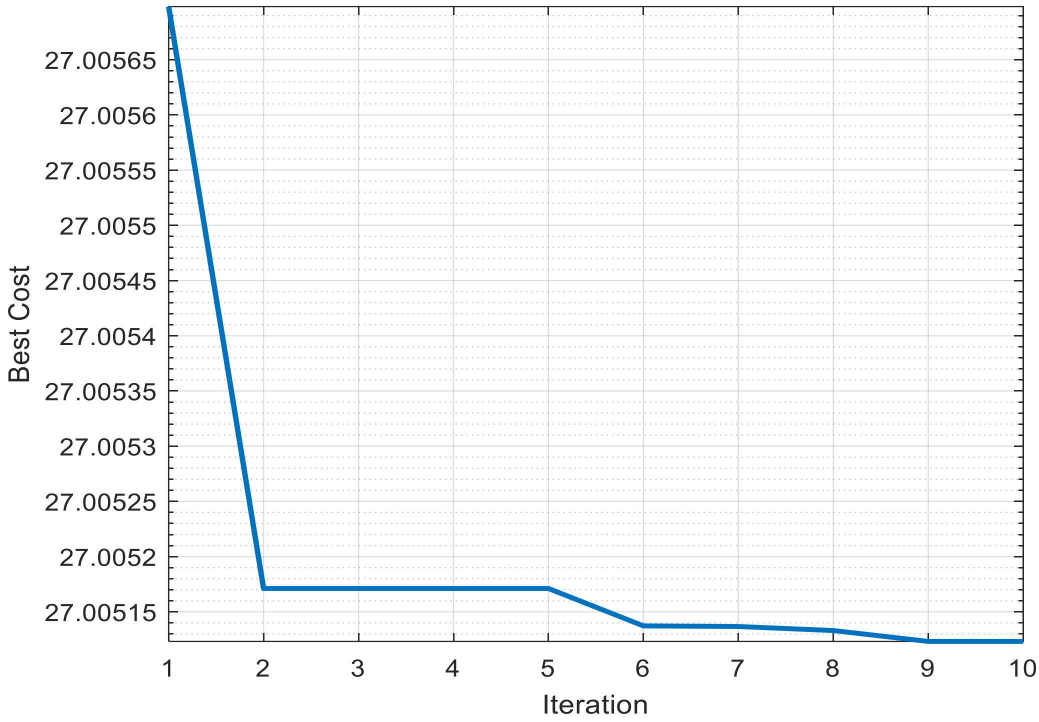

Chart 1.1

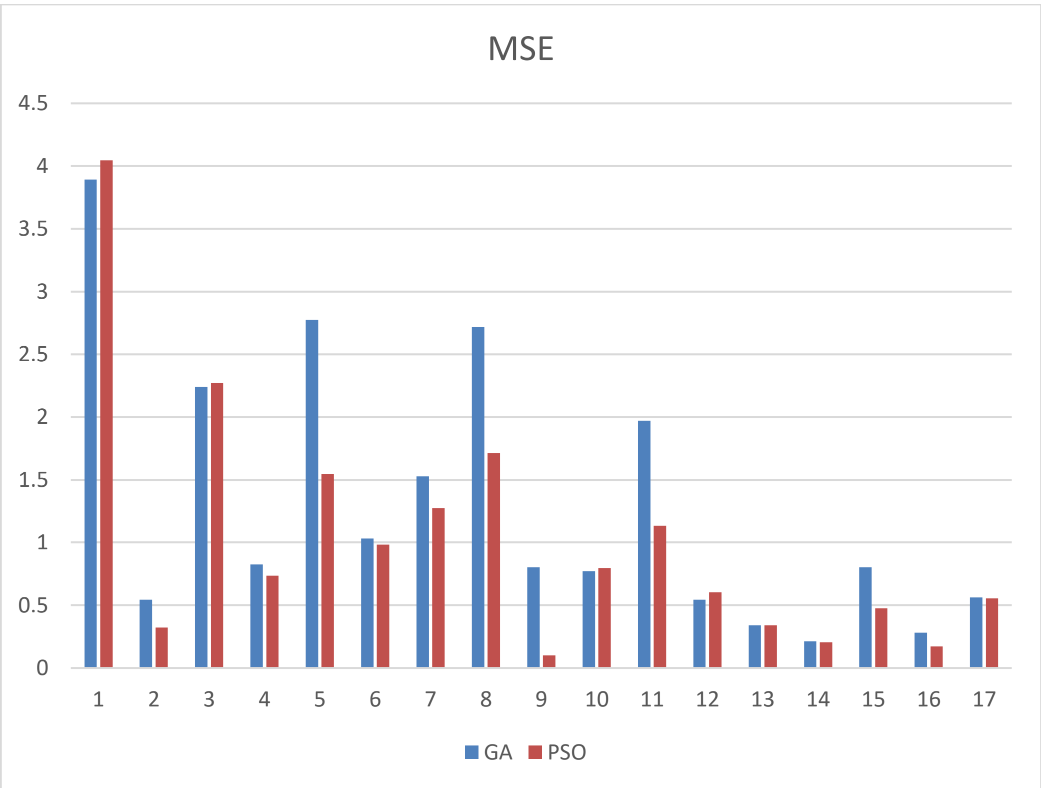

Chart 1.3

CONCLUSIONS

Here the proposed watermarking algorithm is implemented on matlab 7.0.PSO is utilized instead of GA as it's a better form of optimization for this case. Potential research areas would involve looking at alternative optimization techniques; broadening its scope to various types of media and improving its security against illegal extraction or editing.

REFERENCES

1. Provos, Niels, and Peter Honeyman, "Hide and seek: An introduction to steganography." Security & Privacy, IEEE, Vol. 1, No. 3, pp. 32-44, 2003.

2. A. Cheddad, J. Condell, K. Curran and P. McKevitt, “Digital Image Steganography: Survey and Analyses of Current Methods”. Signal Processing, Elsevier, Vol. 90, No. 3, pp. 727- 752, 2010.

3. P. Singh and R S Chadha, “A Survey of Digital Watermarking Techniques, Applications and Attacks”. International Journal of Engineering and Innovative Technology (IJEIT), Vol. 2, No. 9, pp. 165-175, 2013.

4. Amit Kumar Singh, Mayank Dave, and Anand Mohan, “Multilevel Encrypted Text Watermarking on Medical Images Using Spread-Spectrum in DWT Domain”. Wireless Personal Communications, pp.1-18, 2015.

5. W. Zhicheng, L. Hao, Dai Jufeng and W. Sashuang, “Image watermarking based on Genetic algorithm”. IEEE International Conference on Multimedia and Expo, ICME, pp. 1117-1120, 2006.

6. V. Aslantas, A. L. Dogan and Serkan Ozturk, “DWT-SVD based image watermarking using Particle Swarm Optimizer”. IEEE International Conference on Multimedia and Expo, ICME, pp. 241-244, 2008.

7. V. Aslantas, S. Ozer and S. Ozturk, “Improving the performance of DCT-based fragile watermarking using intelligent optimization algorithms”. Optics Communications, Elsevier, Vol. 282, No. 14, pp. 2806–2817, 2009.

8. N. Nilchi Ahmad R and T. Ayoub, “A new robust digital image watermarking technique based on the discrete cosine transformation and neural network”. IEEE International Symposium on Biometrics and Security Technologies, ISBAST, pp. 1-

9. C-T Yen and Y-J Huang, “Frequency domain digital watermark recognition using image code sequences with a back-propagation neural network”. Multimedia Tools and Applications, Springer, pp. 1-11, 2015.

10. T. S Tagare and S. Kuri, "Digital Image Watermarking -An Overview". International Journal of Computer Science Information Engineering Technologies, Vol. 1, No. 3, pp. 2277-4408. 2015.

11. R. Singh, "Digital Image Watermarking: An Overview". International Journal of Research (IJR), Vol. 2, Issue 05, pp. 1087-1094, 2015.

12. V. M. Potdar, S. Han and E. Chang,"A survey of digital image watermarking techniques." 3rd IEEE International Conference on Industrial Informatics (INDIN), pp. 709-716, 2005.

13. P. Parashar and R. K. Singh, "A Survey: Digital Image Watermarking Techniques". International Journal of Signal Processing, Image Processing and Pattern Recognition Vol. 7, No. 6, pp. 111-124, 2014.