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A Hybrid & Robust Wavelet Based Video Watermarking Schemes for Copyright Protection Using Optimization Based Techniques

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Abstract:-*Watermarking is a component of inserting data into the multimedia, for example, image, audio or video. This paper propose a method for video watermarking using hybrid DWT-SVD to protect the copy right of images. In order to improve the efficiency of video watermarking two main processes are used namely watermark embedding process and watermark extraction process. Before embedding process the input video sequence convert into number of frames. Here singular value decomposition (SVD) transforms using Firefly Algorithm provides this objective of an optimal robust watermarking technique. Multiple scaling factors are used to embed the watermark image into the host by multiplying these scaling factors with the Singular Values (SV) of the host image. Firefly Algorithm is used to optimize the modified host image to achieve the highest possible robustness and transparency. The result obtain from the watermark embedding process is the watermark video sequence. Next watermark extraction process is carried out. It is the reverse process of watermark embedding. Thus, protection from copyright infringement is a challenging task and hence requires techniques that provide the security to the digital information. Cryptography, Stenography and watermarking have been developed as emerging fields to face the challenges. In watermark extraction process, it extracts the watermark image from the watermark video sequence.*

Keywords: *Watermarking, Singular value decomposition, discrete wavelet transform, Bandelet Transform , Spread Spectrum, Stenography Firefly Algorithm*

I. INTRODUCTION

The rapid growth of multimedia content in digital form has increased the need to develop secure methods for legal distribution of the digital content. With the speedy growth of the Internet and multimedia systems in distributed environments, it is easier for digital data owners to transfer multimedia documents across the Internet. Therefore, there is an increase in the concern over copyright protection of digital content [1], [2]. Security of digital data has become more and more important with the omnipresence of internet. The advent of image processing tools has increased the vulnerability for illicit copying, modifications, and dispersion of digital images. Against this background, the data hiding technologies for digital data such as digital watermarking have got a lot of attention recently [3]. Digital watermarking is put into practice to prevent unauthorized replication or exploitation of digital data [4], [5]. Digital watermarking is a technique that provides a way to protect digital images from illicit copying and manipulation. Watermarking is the process of embedding data into a multimedia element such as image, audio or video. This embedded data can later be extracted from, or detected in, the multimedia element for different purposes such as copyright protection, access control, and broadcast monitoring [12].

A digital watermark is an imperceptible signal added to digital data, called cover work, which can be detected later for buyer/seller identification, ownership proof, and so forth [12]. It plays the role of a digital signature, providing the image with a sense of ownership or authenticity. The primary benefit of watermarking is that the content is not separable from the watermark. A watermark is capable of exhibiting numerous significant characteristics. These comprise that the watermark is hard to perceive, endures common distortions, resists malicious attacks, carries numerous bits of information, is capable of coexisting with other watermarks, and demands little computation to insert or detect [13]. In order for a watermark to be useful it must be robust to a variety of possible attacks by pirates. These include robustness against compression such as JPEG, scaling and aspect ratio changes, rotation, cropping, row and column removal, addition of noise, filtering, cryptographic and statistical attacks, as well as insertion of other watermarks [14].

Digital watermarking technology has wide range of potential applications. The application areas are: copyright protection, authentication, image fingerprinting, hidden annotation, Broadcast Monitoring, Concealed Communication and more [7], [8].

Watermarks and watermarking techniques can be divided into various categories in various ways. According to the range of application, digital watermarking can be classified into image watermarking, video watermarking and audio watermarking [6]. Visible or invisible watermarks can be embedded into multimedia data by the process of watermarking. Visible watermarks are undoubtedly detectable in nature and a human observer can intentionally percept them. In order to prevent unauthorized access to an image visible watermarking is used [9]. In contrast, the owner or the origin of the host image can be identified using the invisible watermarking that can also be employed to identify a customer or to prove ownership by the detection of any unauthorized image copies [10] [11]. Invisible watermarking can be classified into two parts, robust and fragile watermarks.

II. REVIEW OF RECENT RESEARCHES

A handful of watermarking schemes, which employs the robustness schemes for improved performance, have been presented in the literature for protecting the copyrights of digital videos. A brief review of some recent researches is presented here.

Yan Liua and Jiying Zhao [21] have proposed a 1D DFT (one-dimensional discrete Fourier transform) and Radon transform based video watermarking algorithm. An ideal domain which obtains the temporal information without losing the spatial information has been generated by the 1D DFT for a video sequence. A fence-shaped watermark pattern has been embedded in the Radon transform domain of the frames with highest temporal frequencies which they have selected with comprehensive analysis and calculation. The adaptive embedding strength for diverse locations has preserved the reliability of the watermarked video.

Reyes R. *et al.* [22] have presented a public video watermarking algorithm, a visibly identifiable binary pattern, such as owner's logotype has been embedded by their method. After separating the video sequences into distinct scenes, the scene blocks have been selected at random and the binary watermark pattern has been embedded into their Discrete Wavelet Transform (DWT) domain. The binary watermark pattern has been mapped to a noise like binary pattern by employing a chaotic mixing method to improve he security of their proposed method. The watermark has been proved to be invisible and robust to several attacks by means of simulation results.

Kareem Ahmed *et al.* [23] have proposed a 2-level Discrete Wavelet Transform decomposition of each RGB video frame component dependant video watermarking method. Independent watermarks have been embedded into separate shots by their method. The shots have been matched to watermarks by means of a genetic algorithm. Based on a key, any one of the HL1 of red, green or blue components of each frame has been selected by their proposed method and the error correcting code has been embedded into it.

Yun Ye *et al.* [27] proposed an efficient video watermarking scheme through modifying the third decoded luminance differential DC component in each selected macro block. The modification was implemented by binary dither modulation with adaptive quantization step. The scheme was based on the observation that luminance differential DC components inside one macro block are generally space correlated, so the quantization step can be adjusted according to adjacent differential components, to utilize properties of human visual system (HVS). The method was very robust to gain attacks since amplitude scaling will have the same effect on differential components and the quantization step. Experimental results showed that it can be implemented in real time with better visual quality than uniform-quantizing scheme.

Zhaowan Sun *et al.* [29] have proposed a video watermarking scheme based on motion location. In the scheme, independent component analysis was used to extract a dynamic frame from two successive frames of original video, and the motion is located by using the variance of 8×8 block in the extracted dynamic frame. According to the located motion, they choose a corresponding region in the former frame of the two successive frames, where watermark is embedded by using the quantization index modulation algorithm. The procedure above was repeated until each frame of the video (excluding the last one) was watermarked. The simulations showed that the proposed scheme has a good performance to resist Gaussian noising, MPEG2 compression, frame dropping, frame cropping and more.

Bandelet transform is a major self-adaptive multiscale geometric analysis method which utilizes known geometric information of images to improve the approximation ability. Compared with the other widely used non adaptive multiscale geometric analysis algorithms such as curvelet transform (Leung et al 2009) and contourlet transform (Sirvan et al 2010), the bandelet transform not only has the characteristics of multiscale analysis, time frequency localization, directionality and anisotropy, but also offers particular properties of strict sampling and adaptability which are very important for image representation. Owing to its merits, the bandelet transform can achieve asymptotically optimal representation of images, especially for those with geometric structures.

III. PROBLEM DEFINITION

- The main motive of our proposed work is to solve the problems arising like copyright protection, copy protection, fingerprinting, authentication and data hiding.
- To improve the security.
- The demerits such as low PSNR and less correlation coefficient were also to be considered.
- Discrete Wavelet Transform is found to be an important tool in decomposing the images.
- The project implemented to extract the image having a good quality of data.
- To test the reliability of attacks such as removal, interference, geometric, cryptographic and protocol attacks.

The problem of resistance to video attacks, it is known that robustness is the critical issue affecting the practicability of any watermarking method.

IV . PROPOSED METHOD

There is an insistent require for copyright protection against pirating in quick growth of network distributions of images and video. To address this matter of ownership identification different digital image and video watermarking schemes have been suggested. This research suggests a competent scheme for video watermarking scheme by means of discrete wavelet transform to guard the copyright of digital images. The competence of the suggested video watermarking technique is achieved by two main steps:

1) Watermark embedding process   2) Watermark extraction process

Using shot segmentation the input video sequence segment into shots before the embedding process. Next, the segmented video shots are divided into number of frames for the embedding process. Below, the detailed process proposed method is elucidated and the block diagram of the proposed method is demonstrated in beneath,

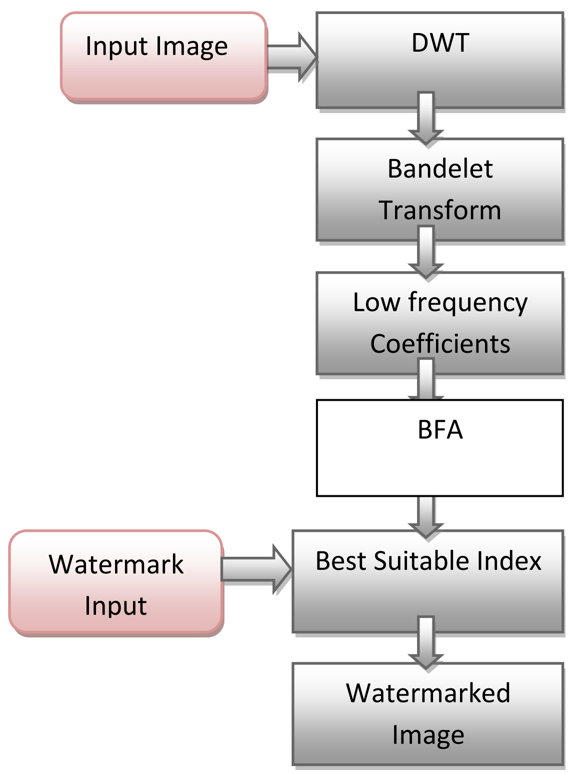


Fig.1 Block diagram of proposed method

4.1 Motion estimation

Motion estimation is the process of finding out the motion vector that explains the transformation from one 2D image to another; usually from adjacent frames in a video sequence. Then by comparing each nearest frames for finding image quality the mean square error (MSE) is computed. If the mean square error value is greater than the threshold value then choose that frame as the best frame.

$$MSE= \text{Distance between two frames} \quad (1)$$

If MSE > threshold, then select that frame as the best frame for embedding process. Here the threshold value is optimized using Improved Artificial Bee Colony Algorithm.

4.2 Biogeography Firefly Algorithm

Biogeography Firefly Algorithm (BFA) is a population-based algorithm to find the global optima of objective functions based on swarm intelligence (Yang 2008).It simulates the flash pattern and characteristics of fireflies. Each firefly is attracted by the brighter glow of the other neighboring
fireflies. When a couple of fireflies are farther away, the attractiveness is decreasing.

In BFA, there are three idealized rules defined by Yang
1.Each firefly will be attracted to the other fireflies regardless of their sex.
2. Attractiveness is proportional to their brightness. Thus, for any two fireflies, the less bright one will move towards the brighter one. If there is no firefly brighter than a particular firefly, it will move randomly.
3. The brightness of a firefly corresponds to the objective function. For a maximization problem, the brightness can simply be proportional to the value of the objective function.
In the proposed application of BFA, the objective function of the given watermarking problem is modified based on difference in intensity of the pixels. In FA based watermarking, the total number of population is the total number of pixels of the image. The size of the input image is 512× 512.It is divided into 8×8 blocks. The bandelet transform is applied for reducing the redundancy of the given image. After the FA function is called for process, a Gaussian distribution is used for random number generation for the purpose of modifying the intensity of the pixel. With a high contrast block, the intensity of the pixel is modified. If the block has a low contrast, then the intensity of the pixel is tuned to achieve good quality of the image. Maximum, minimum and average intensities of each block are computed and are stored in an array. All the coefficients of the blocks are sorted in descending order so that the optimum value can be identified effectively. Based on the light intensity, the embedding block will be selected.

4.3 Watermarking

Watermarking is the sheltered methodology of embedding information into the data, for instance, audio or video and images. This procedure needs different properties depending on the real world applications, for example, robustness against attacks such as frame dropping, frame averaging attack. In proposed watermarking process initially read the watermark image next use the singular value decomposition (SVD) and discrete wavelet transform (DWT). It contains the subsequent steps the detailed procedure is elucidated below,

- singular value decomposition (SVD)
- discrete wavelet transform (DWT)

4.3.1 Singular Value Decomposition

In order to improve the robustness, Singular Value Decomposition (SVD) has been employed in watermark methods. This method decays a matrix in three matrices P, Q, R. The equation of the matrices shown in below,

$$X = PQR^T \quad (2)$$

Where X is the original matrix, Q is the diagonal matrix of the eigenvalues of X. These diagonal values are as well called as singular values. P is orthogonal matrices and the transpose of an orthogonal matrix R. P columns are called left singular vector and the Q columns are called right singular vectors of X. The basic design behind SVD technique of watermarking is to find out the SVD of image and the differing singular values to implant the watermark.

4.3.2 An Overview Of Bandelet Transform

(Le Pennac & Mallat 2005) introduced a new method called bandeletization. In this approach, the DWT image reliability is obtained along with geometric flow. The bandeletization modifies a warped wavelet by transformation of scaling function into wavelet transform and redundancy is
removed from the warped wavelet transform. Standard Orthogonal Wavelet Transform (SOWT) is used for second generation.

4.4 Watermark embedding steps

1. Input the video clip V.
2. Divide the video clip into video scenes Vsi
3. Select Apply DWT on the frames of each Vsi using DWT, Firefly algorithm, and Schur as described in steps 4 - 12.
4. Convert the color matrix format from RGB to YUV for every video frame F
5. For the Y (luminance) matrix in each frame F, compute the 2-level DWT. This operation generates seven DWT sub- bands [LL1, LL2, HL2, LH2, HH2, LH1, HH1].
7. Apply Fireflies algorithm to find the location of DWT block with large texture for embedding the watermark. This secures the transparency.
8. Rescale the watermark image so that the size of the watermark will match the size of the HL2 sub-band which will be used for embedding.
10. Apply the inverse Schur operator on the modified S′ HL2 matrix to get a modified coefficient matrix HL2′ . The inverse Schur operation
11. Apply the inverse DWT on the modified coefficient matrix HL2′. This operation produces the final watermarked Video frame F'.
12. Convert the video frames f' from YUV to RGB color matrix.
13. Reconstruct frames into the final watermarked Video scene F'. 14. Reconstruct watermarked scenes to get the final watermarked video clip V’

4.5 Watermark extraction steps

1. Input the watermarked Video clip V′.
2. Split the watermarked Video clip V′ into watermarked scenes
3. Vsi'.
4. Convert the video frame F′ from RGB color matrix to YUV.
5. Perform the DWT and Schur decomposition on the watermarked frames of each watermarked video scene as described in steps 5 - 7.
6. Apply the Schur operator on the wHL2 sub-band. The Schur operator decomposes the sub-band's coefficient matrix into two independent matrices
7. Extract the embedded watermark from the diagonal matrix wHL2
8. Construct the image watermark WVsi by cascading all watermark bits extracted from all frames.
9. Repeat the same procedure for all video scenes. The above proposed watermarking extraction procedure is illustrated in the block diagram shown in Figure 4.

V. EXPERIMENTAL RESULTS

The experimental result of the proposed video watermarking using hybrid DWT-PCA is explained below. In this paper efficiently embedded the watermark image into input video sequence and extract back from the watermark video sequence. The output of the proposed video watermarking has been calculated by PSNR and NC (Normalized cross Correlation). The visual quality is evaluated by the PSNR criterion for watermarked video. The extracting fidelity is computed by the NC value between the original watermark image and the extracted watermark image. The performance of the proposed watermarking method is evaluated by using two video sample sequences namely Akiyo and Hall. The result of the Akiyo video sequence of the watermark image is shown in Fig. 2 and 3.

Fig.2 (a) input Akiyo video sequence

(b) watermark video sequence

(c) watermark image (d) extracted watermark image

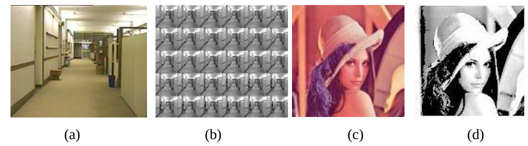


Fig.3 (a) input Hall video sequence

(b) watermark video sequence (c) watermark image

(d) extracted watermark image.

A. Evaluation Metrics

The quality of the system is evaluated using the quality metrics. The quality metrics calculated in our proposed methodology are:

B. ZSNR *Evaluation Metrics*

The quality of the system is evaluated using the quality metrics. The quality metrics calculated in our proposed methodology are:

- PSNR
- NC

(i) PSNR (Peak Signal to Noise Ratio)

PSNR is the logarithmic value of ratio between signal and noise. It is expressed in decibels. The PSNR value is calculated using the following equation. It's shown in below,

$$PSNR = 20\log_{10}\left(\frac{MAX_i}{\sqrt{MSE}}\right) \qquad (3)$$

Where,

MSE = Mean square error

MAX_i is the maximum possible pixel value of the image.

Table 1 and Table 2 represent the PSNR values of the both input Akiyo and hall video sequence with and without optimization.

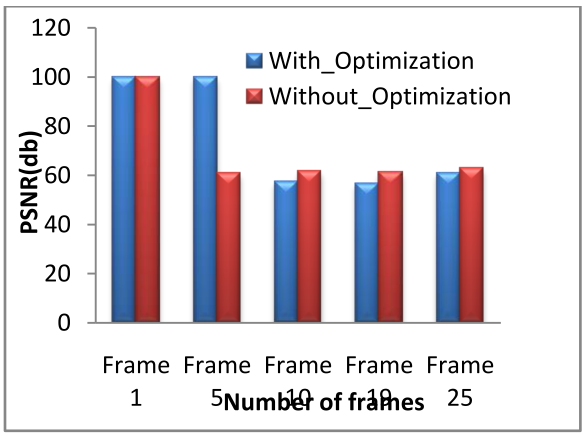
Table 1: PSNR values for Akiyo with and without optimization

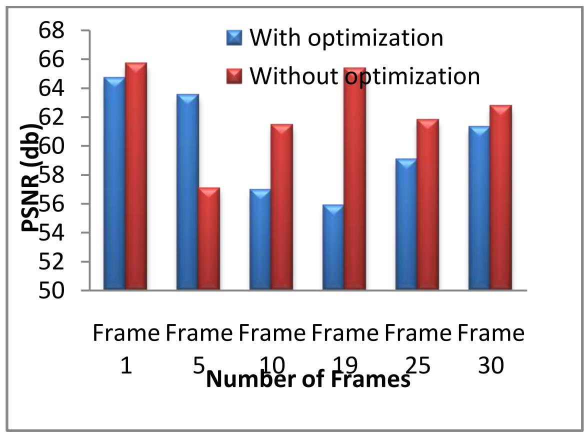
Frames	PSNR Values for Akiyo video	
	With optimization	Without optimization
Frame 1	100	100
Frame 5	100	61.7257
Frame 10	59.5058	64.5039
Frame 19	57.8744	62.1754
Frame 25	63.0699	63.8404

Table 2: PSNR values for Hall with and without optimization

Frames	PSNR Values for Akiyo video	
	With optimization	Without optimization
Frame 1	65.7276	65.9964
Frame 5	64.8782	58.0952
Frame 10	59.9368	60.4369
Frame 19	55.8458	67.5615
Frame 25	59.0570	63.7655

Graph 1 and Graph 2 represent the PSNR values by varying the frame number for both Akiyo and Hall video sequence. It's shown in below,





Graph 1: PSNR values by varying the frame number for Akiyo **Graph 2:** PSNR values by varying the frame number for Hall

(i) *NC (Normalized cross Correlation)*

The Normalized Cross-Correlation (NC) is calculated using the following equation. It's shown in below

$$NC = \frac{\sum_{i=1}^{i=n-1}\sum_{j=1}^{j=n-1} w(i,j).w'(i,j)}{\sqrt{\sum_{i=1}^{i=n-1}\sum_{j=1}^{j=n-1}(w(i,j))^2}.\sqrt{\sum_{i=1}^{i=n-1}\sum_{j=1}^{j=n-1}(w'(i,j))^2}} \quad (4)$$

Where,

W (i,j) = Pixel values of the original watermark
W' (i,j) = Pixel values of the detected watermark
Table 2 and Table 3 represent the NC values of the both input Akiyo and hall video sequence with and without optimization.

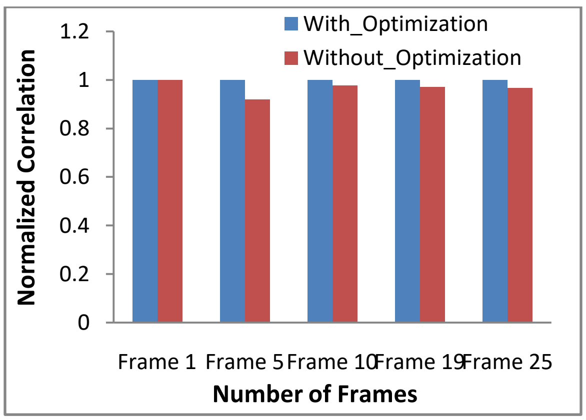
Table 3: NC values for Akiyo with and without optimization

Frames	PSNR Values for Akiyo video	
	With optimization	Without optimization
Frame 1	1.0000	1.0000
Frame 5	1.0000	0.9598
Frame 10	0.9859	0.9669
Frame 19	0.9945	0.9107
Frame 25	0.9988	0.9964

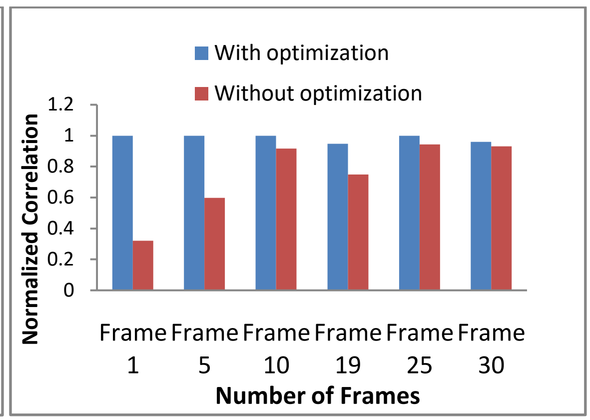
Table 4: NC values for Hall with and without optimization

Frames	PSNR Values for Hall video	
	With optimization	Without optimization
Frame 1	1.0000	0.3211
Frame 5	1.0000	0.7977
Frame 10	1.0000	0.9171
Frame 19	0.9481	0.9488
Frame 25	0.8956	0.9428
Frame 30	0.9704	0.9817

Graph 3: NC values by varying the frame number for Akiyo

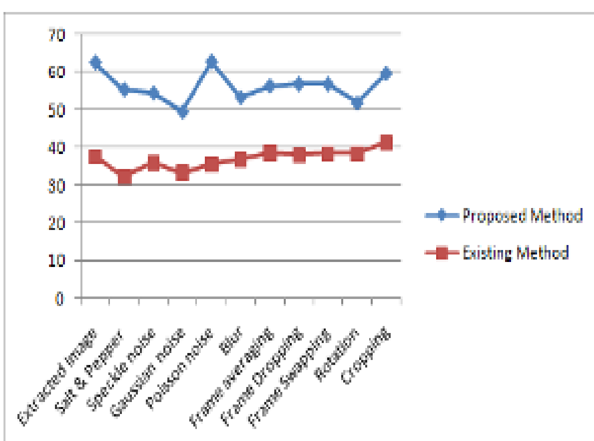


Graph 4: NC values by varying the frame number for Hall

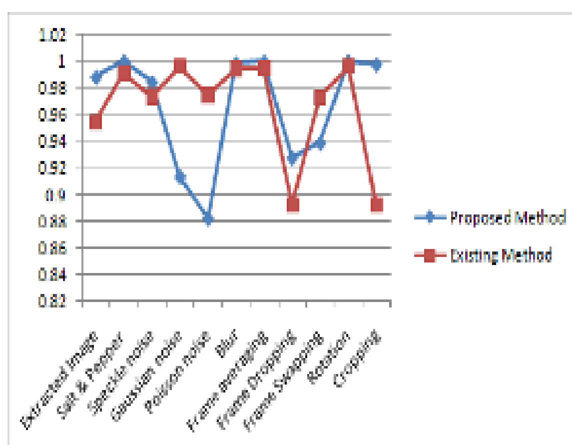


Some other experimental results of watermarking and scan based encryption method in DWT-SVD domain are shown in table. The original video sample consists of about 300 frames of size 262x262.

Table 5: Comparison during attacks for Rhinos Video



Graph 5: PSNR value for watermark image applying different types of attacks



based on different attacks such as Salt and Pepper noise attack and Intensity attack etc.

This is a new optimal method of robust image watermarking based on SVD using Modified Firefly Algorithm. Modified Firefly Algorithm is used to employ optimize function that was defined by two conflicting requirements of watermarking i.e. visibility and robustness. The watermark image is embedded into the host image by modifying the singular values of the image. To achieve maximum robustness without losing transparency, modifications are to be done using multiple scaling factors obtained by Modified Firefly Algorithm.

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