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A Review of Digital Image Watermarking based on Firefly Algorithm

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Abstract: ***Recent years Nature-inspired algorithms (NIA) has gained more popularity in the problems, based on the optimizations. Many new NIAs has been developed in the recent years like Genetic algorithms (GA), Cuckoo search (CS), Particle swarm optimization (PSO), Firefly Algorithm (FA), Ant Colony Optimization (ACO). A survey of the firefly algorithm that is used for digital image watermarking is presented in this paper. Like other NIAs, Firefly algorithm is widely used in the digital image watermarking, for finding the optimal pixel value position in the host image.***
Keywords: Firefly Algorithm (FA), Image watermarking, Frequency domain watermarking, Techniques for watermarking

I. INTRODUCTION

Nowadays, the use of the internet is growing rapidly, due to which the digital transformation through the internet is challenged in the aspect of the authorization and the copyright of the digital contents. This need challenges the researchers to develop more efficient methods to protect the digital contents. Digital image watermarking has evolved to solve, protecting the digital contents. In this process, the watermark is added to the host multimedia, so that the authenticity of that digital contents can be claimed by the original authors. The watermark is any logo images or secret images, words or sound clips.

Mainly there are two methods for the image watermarking i.e. spatial domain and frequency domain [1] watermarking. In the spatial domain of image watermarking, the pixel value of watermark image is inserted in the host image, where random selection of pixel values of the subpart of the image is considered. In the frequency domain of the image watermarking, first the image is transformed into the frequency domain and then modification of the image is done to embed the watermark. The frequency domain transformation can be done by discrete Cosine transform (DCT), discrete wavelet transforms (DWT), discrete Fourier transform (DFT) and Singular value decomposition (SVD) [2, 3].

Robustness, Invisibility, and security are the main purposes to develop different watermarking techniques. From the earlier research, it has been seen that robustness and invisibility can perform better in frequency transform domain than spatial domain.

There are several algorithms developed and they have achieved to solve difficult optimization problems [11]. In last few years a new optimization algorithm, firefly algorithm (FA) inspired by flashing behavior of firefly has been developed [12]. Different researchers from different fields have been applied FA for solving different problems and have found that it is better in solving optimization problems than other nature-inspired algorithms (NIA).

Firefly is the nature creatures. These creatures have flashing behavior. The firefly algorithm has several assumptions:

A. All fireflies are unisexual, so each firefly is attracted to one another.
B. Attractiveness is proportional to the brightness of the firefly, so the less bright firefly is attracted towards brighter firefly and the attraction decreases when the distance between two fireflies increases.
C. The brightness of the firefly is determined by the objective function.

As mentioned above, brightness and the attractiveness, the attractiveness is directly proportional to its brightness and inversely proportional to the distance between two fireflies. So we can define attractiveness of the firefly

$$\beta = \beta_0 e^{-\gamma r^2}$$

Where β_0 is the attraction at r = 0, r is the distance between two fireflies. γ is the light absorption coefficient of the medium.

For two fireflies, the movement of attraction of firefly i to j is defined by,

$$x_i^{t+1} = x_i^t + \beta\left(x_j^t - x_i^t\right) + \alpha\epsilon$$

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Where second term is due to the attraction, the third term is distribution term, α is the parameter controlling step size and ϵ is a vector of random number drawn from a Gaussians distribution or other distribution.

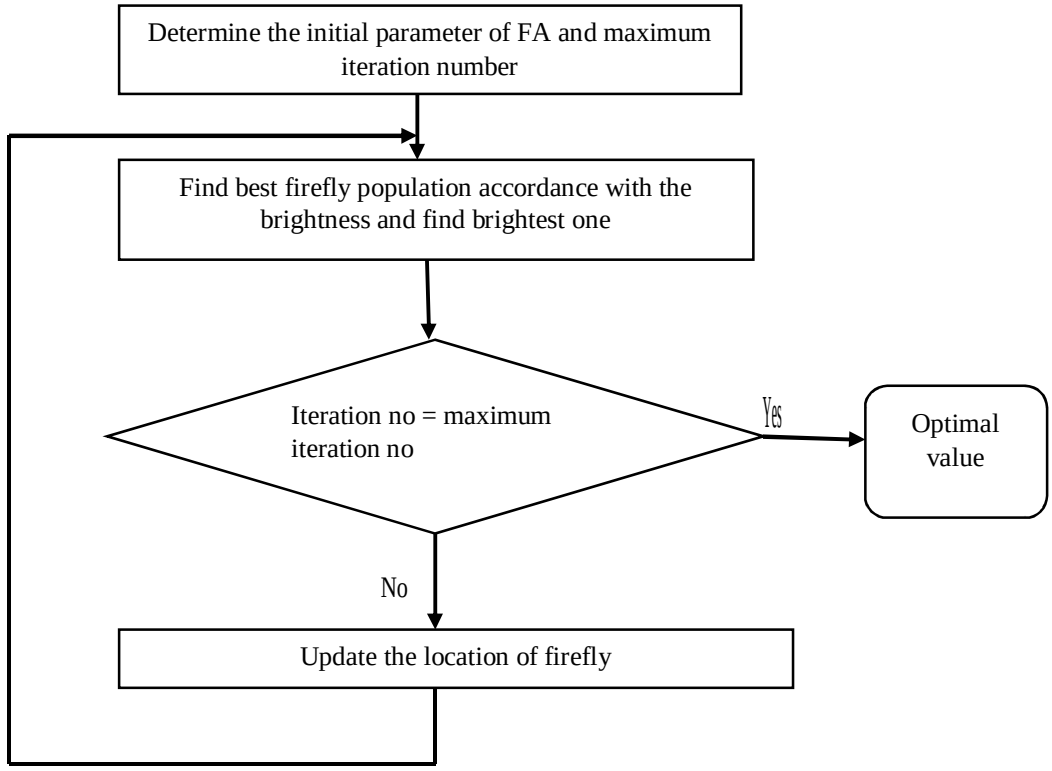

Fig 1: Firefly algorithm

II. WATERMARKING TECHNIQUES

Watermarking techniques are used to hide some secret information into the multimedia data using some algorithm. In this process, algorithm plays the crucial role. Better the algorithm, we can find more efficient and strong watermark embedded in the host image, so that the attacker cannot find the watermark information inside the host image. There are several algorithms developed to protect the watermark inside the host image. Mainly the algorithm comes into two domains spatial domain and Frequency domain.

A. Spatial Domain

In spatial domain digital watermarking, direct manipulation of the pixels of the image is considered. Direct manipulation of the pixels of the host image is done to hide the watermark. Some of the algorithm based on the spatial domain are as below:

1) *Least significant bit (LSB):* One of the simple and straightforward spatial domain technique. The watermark is embedded into the least significant bits of the host image. It has many drawbacks, so lots of improvements on LSB substitution has been proposed, like embedding the watermark in single bit rate, multi-bitrate or using some pseudo- random number generation method.
2) *Patchwork Technique:* It is a data hiding technique based on pseudorandom, statistical model. It inserts a watermark with a particular statistic using Gaussian distribution. A pseudo-randomly selection of two patches is carried out, where the first one is A and second one is B, patch A image data is brightened and the patch B is darkened.
3) *Correlation-Based Technique:* In this technique a pseudorandom noise (PN) pattern say W(x, y) is added to cover image I(x, y).

$$\boldsymbol{I_w(x,y) = I(x,y) - k^*W(x,y)}$$

Where K represents the gain factor, I_w represents watermarked image at any position x, y and I represent cover image.

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B. Frequency Domain

Frequency domain or transform domain methods are widely used in comparison to transform domain for image watermarking. In transform domain watermark is embedded in the spectral coefficient of the image. Mainly for frequency domain, we use Discrete Cosine Transform (DCT), Discrete Fourier transform (DFT), Discrete Wavelet Transform (DWT).

1) *Discrete Cosine Transform (DCT):* It represents the data in terms of frequency space rather than amplitude space. Watermarking techniques which are based on DCT are more robust than the watermarking techniques based on the spatial domain. These algorithms based techniques are robust against simple image processing operation like low pass filtering, brightness, and contrast adjustment. At the same time, they are weak against the geometric attack like rotation, scaling, cropping etc.
2) *Discrete Wavelet Transform (DWT):* This is a modern technique widely used in watermarking, compression etc. The transforms are based on small waves, called wavelets, of varying frequency and time duration. The main idea of DWT in image processing is to multi-differentiate decompose of the image into sub-image of the different spatial domain and independent frequency. The wavelet transform decomposes the image into three spatial domains, i.e. horizontal, diagonal and vertical. DWT is much preferred because it provides both a simultaneous spatial localization and a frequency spread of the watermark in the host image.
3) *Discrete Fourier transforms (DFT):* It transforms a continuous function into its frequency components. It has robustness against geometric attacks like rotation, scaling, cropping etc.

III. LITERATURE SURVEY

In this section, different proposed algorithm along with spatial or frequency domain using Firefly Algorithm is described.

In 2014, Charu Agarwal et al. [2] have discussed an optimized watermarking scheme based on discrete wavelet transform (DWT) and Singular value decomposition (SVD). The singular value of binary watermark is embedded in the singular value of LL3 sub-band coefficient of the host image by making the use of multiple scaling factors (MSFs). The MSFs are optimized using firefly algorithm.

This research focuses on optimizing the trade-off between the twin parameters of image watermarking i.e. imperceptibility and robustness. Eight different image processing operations as attacks are performed. Experimental results show that the proposed watermark embedding and extraction scheme outperforms another scheme for image processing except sharpening and cropping. Obtained PSNR valued indicated that the visual quality of the attacked image is good. In 2015, Huailin Dong et al.

proposed [3] optimized gray-scale image watermarking algorithm based on DWT-DCT-SVD and Firefly Algorithm. The result of multiplying the left singular vector and matrix with the singular value matrix of the binary watermark are embedded in the result of multiplying the left singular vector and matrix and the singular value matrix of the DCT matrix of the LL3 sub-band coefficient of the host image by making use of multiple scaling factor (MSFs).

The MSFs are optimized using firefly algorithm.

In 2015, A. Amsaveni. Efficient data hiding scheme in the spatial domain using firefly algorithm was proposed [4]. This experiment provides a reversible data hiding technique based on firefly algorithm. The histogram shifting technique is used to embed the secret data in the cover image.

The optimal location to hide the data is found by using firefly algorithm. The main objective of the proposed method was to minimize the bit error rate and maximize the SSIM index. In 2016, Ankita Kadu, Arun Kulkarni, Deepali Patil, presents new techniques in reversible data hiding techniques based on the robust firefly algorithm [5]. The optimal location to hide the secret data will be found by firefly algorithm. The image scrambling is applied in frameset Transform to prevent perceptual visibility of the embedded secret image.

The decomposition is done with Haar which is humble, symmetric and orthogonal wavelet. In 2017, Yong Guo, Bing-Zhao Li, Navdeep Goel, Presents Firefly algorithm [12], newly developed nature-inspired optimization algorithm, inspired by the flashing behavior of fireflies that a firefly tends to be attracted towards other fireflies with higher brightness.

A novel image watermarking method based on Firefly algorithm in discrete wavelet transform (DWT)-QR decomposition domain is proposed [6].

Structural similarity index measure and bit error rate are used in the objective function to trade-off invisibility and robustness. The experiment results show that the proposed image watermarking method not only meet the need of invisibility but also has better or comparable robustness as compared with some related methods.

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IV. COMPARISON TABLE

No.	Authors	Year	Techniques	Features
[1]	Yong Guo, et al.	2017	Firefly Algorithm, DWT-QR	Better or comparable robustness as compared to previous methods of watermarking.
[2]	Ansari, et al.	2016	Ant Bee Colony(ABC)	Visible improvement in performance and to find out the ownership.
[3]	Rampal Singh, et al.	2016	OSELM, DWT	Proposed watermarking scheme is imperceptible, transparent and robust against image processing and attacks.
[4]	Nikita kashyap, et al.	2012	3- level DWT	3- Level DWT provides better performance than 1- level and 2- level DWT.
[5]	Saini, et al.	2012	SVD-DWT and Back propagation neural network	Efficient watermarking with neural network based optimization technique.
[6]	Surya Pratap Singh, et al.	2012	DCT- DWT	Watermarked for colored and grayscale both images.
[7]	Xiaohong Yu, et al.	2013	DWT- SVD	Able to withstand with various types of geometric attacks.
[8]	Cai Yanhong, et al.	2012	JPW, DWT	Good quality watermarked image.
[9]	Ali al Haj	2007	DWT-DCT	Improved the performance of the watermarking algorithm that are based solely on the DWT algorithm.
[10]	Chun shien Lu, et al.	2001	Masking threshold units.	Two complementary watermarks are embedded using cocktail watermarking and they can be blindly extracted.

Table 1: Comparison of various techniques

V. CONCLUSION

The watermarking techniques are being developed using various algorithms. The main motive of these different techniques is to get better in the performance of the robustness and invisibility of the embedded watermark. In this paper, we discussed the

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watermarking techniques based on firefly algorithm (FA) and also show the comparison of different techniques for watermarking. So in the near future, we will evaluate using hybrid transform domain technique using machine learning algorithm.

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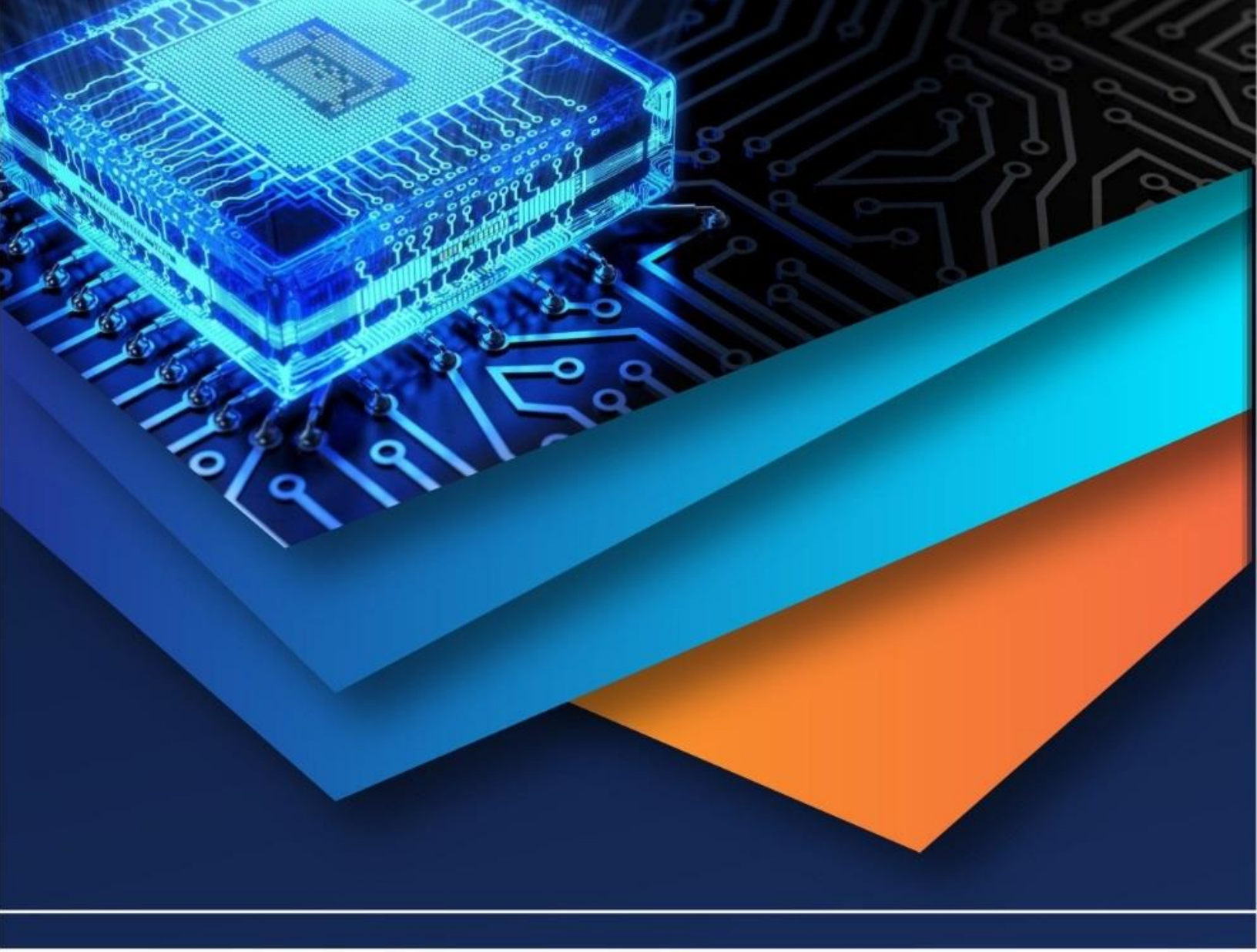

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