Application of Firefly Algorithm in Finding Optimal Parameters

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Abstract**—**Fireflies that attract all other fireflies or be attracted to other fireflies which are of higher brightness is the basis of the firefly algorithm. It is an optimization algorithm of calculating objective functional values. In this paper with the use of discrete wavelet transform the implementation of firefly algorithm is done and the experimental results of using certain number of initial and randomly allocated fireflies are used to calculate certain parameters which gives the ratio between the maximum signal power and maximum noise power, bit error rate(BER), coefficient measuring the degree of similarity(Corr), the normalized cross correlation(NC) between the watermarked image and original image. The mean objective functions are calculated using the parameters mentioned above.

Keywords**—***Firefly, dwt, haar, localization, optimization.*

INTRODUCTION

Swarm Intelligence (SI) is one of the topics under artificial intelligence (AI) which has become very popular in the last decade. The socialistic behaviour of bees, worms, bird groups, and flying ants were the major influence for SI.The fireflies flashing behaviour was the inspiration for Xin-She Yang and he proposed a metaheuristic firefly algorithm at Cambridge university. Many optimization problems can be solves easily using this algorithm. Luminary flashing activities like attracting the partners and risk warning for predators are the characteristics of this algorithm. This algorithm is mainly used for optimization of nonlinear functions. Attractiveness is assumed to be directly proportional to the brightness level of individual fireflies.

Particle Swarm Optimization mimics the flocking behaviour of birds and gives an optimum solution. Memetic Algorithm was inspired by Dawkin's theory of evolution where a set of memes are considered to form chromosomes. Shuffled frog leaping algorithm is inspired by leaping and shuffling behaviour of frogs to exchange information among them in order to search for food. Artificial Bee colony algorithm imitates the foraging behaviour of honeybees. The Biogeography based optimization algorithm is based on migrating behavior of species in habitat. Cuckoo search algorithm is inspired by breeding of cuckoo bird; they select their home nest by taking over the nest of some other birds. The fertilization process of flowers has inspired the flower pollination algorithm.

Two level transform of discrete wavelets using singular value decomposition(SVD) method is used to watermark the image using another cover image. DWT provides good spatial localization and multi resolution characteristics in digital image watermarking technique. A dwt is a transform in which there is direct sampling of wavelets.

LITERATURE REVIEW

A. Biological foundations

Fireflies are appealing insects. The flashing of light are the major characteristics of fireflies. Bioluminescence which is a biochemical process is the reason for flashing character. The mating of these fireflies are majorly characterised by the flashing light behaviour which serve as primary pursuit signals. Besides mating, the light may serve as warn off to their potential predators. The light is produced by their organ called lantern.

B. Discrete Wavelet Transform (DWT)

DWT is the type of transformation in which there is discrete sampling of the wavelets. The local information and frequency information both can be found out using DWT which one of the major positives of this transform. DWT is used to de-noise and provide good compression technique, they also provide information about the abrupt changes which can't be found out using Fourier transform. In this paper DWT transform is used with 'haar' wavelets, which was the first DWT invented. Assuming the size of the image to be K*L, the DWT transform method of watermarking will divide that image to 4 sub bands with size K/2*L/2

comprising of all the combination of low frequency and high frequency vertical and horizontal components. The working DWT based watermarking where the high frequency components are those redundant pixels in the image, hence these are neglected and image with minimal amount of information needed to define that image is placed on the cover image. Two levels of DWT is applied and SVD decomposition to each block is performed.

C. Assumptions

There are three main assumptions in firefly algorithm.

1. An individual firefly is considered to be unisexual so that they can be mingled with other fireflies and attract them.
2. As the gap between two fireflies becomes more and more, the attractiveness and brightness reduces. These parameters brightness and attractiveness are directly related to each other. The brighter firefly attracts the lighter firefly and there can be random movement if there is no difference in intensity levels.
3. The objective functions are those which determine the brightness parameter. The functional values of the objective functions are simplified to be the brightness of that particular firefly at that point.

METHODOLOGY

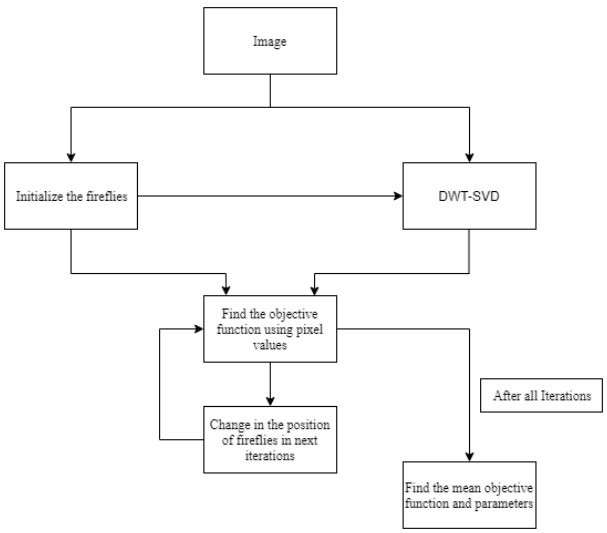

Fig (1) – Proposed methodology

The DWT-SVD method is used to watermark the Fig1 using Fig2 to get watermarked image Fig3.

Fig (2) –Original Image

Fig (3) – Image used for watermarking

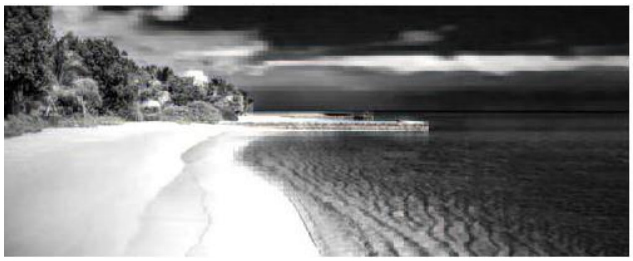

Fig (4) –Watermarked image.

The constants like randomness, absorption coefficient, and randomness reduction coefficient are initialized for better converging in case of functions. Converting to fig1 into binary image and allocating 'n' number of initial randomly allocated fireflies on the image, the same number of fireflies are allocated in random manner in watermarked image fig3 as well. The values of the points in which firefly is randomly allocated is taken between the regular and watermarked image and the performance parameters like PSNR, BER, NC, correlation coefficient is also calculated using the formulas.

By using these parameters f (PSNR, BER) and f (PSNR, NC) are calculated and tabulated. This procedure is repeated for 5 iterations for different values of initial number of fireflies allocated and the experimental results are tabulated.

$$PSNR(X,Y) = 10log_{10}\frac{MN \cdot \hat{X}_{max}^2}{\sum_{m=1}^{M}\sum_{n=1}^{N}[X(m,n)-Y(m,n)]^2} \quad (1)$$

$$NC(X,Y) = \frac{\sum_{m=1}^{M}\sum_{n=1}^{N}X(m,n)\cdot Y(m,n)}{\sqrt{\sum_{m=1}^{M}\sum_{n=1}^{N}[X(m,n)]^2}\cdot\sqrt{\sum_{m=1}^{M}\sum_{n=1}^{N}[Y(m,n)]^2}} \quad (2)$$

$$BER(X,Y) = \frac{\sum_{m=1}^{M}\sum_{n=1}^{N}X(m,n)\oplus Y(m,n)}{M\,X\,N} \quad (3)$$

$$f = PSNR(X,X^W) + 30\cdot\sum_{i=1}^{N}BER(w,w_i') \quad (4)$$

$$f = \frac{PSNR(X,X^W)}{100} + \sum_{i=1}^{N}NC(w,w_i') \quad (5)$$

Fig (5) – Formulas

APPLICATIONS

Firefly algorithm is used in many fields. It is used in satellite image classifications and to find faulty elements in array of sensors. This algorithm is also used for radiation pattern synthesis for linear array with non-uniformity in spacing between each antenna composed of isotropic antennas with isoflux distribution. Firefly algorithm is used in optimization of 3*3 planar antenna array. In medical field, this algorithm is used for watermarking of medical images. Owner identification, fingerprinting and copy protection can make use of this algorithm. In E-Commerce industry, watermarking can be used for transaction tracking and content archiving. Multimodal design problems along with many highly nonlinear design problems or equations can be solved using Firefly algorithm. Firefly algorithm takes least possible time for digital image compression.

EXPERIMENTAL RESULTS

Correlation coefficient used is 0.0185

Table 1 –Mean BER Values

Number of fireflies initialized	Iteration 1	Iteration 2	Iteration 3	Iteration 4	Iteration 5	Mean BER
10	$0.2*10^{-4}$	$0.4*10^{-4}$	$0.6*10^{-4}$	$0.7*10^{-4}$	$0.7*10^{-4}$	$0.52*10^{-4}$
50	$2.4*10^{-4}$	$2.5*10^{-4}$	$1.9*10^{-4}$	$2.7*10^{-4}$	$2.4*10^{-4}$	$2.38*10^{-4}$
100	$3.7*10^{-4}$	$3.7*10^{-4}$	$4.8*10^{-4}$	$4.3*10^{-4}$	$4.3*10^{-4}$	$4.16*10^{-4}$
1000	0.0046	0.0046	0.0046	0.0048	0.0046	0.0046
3000	0.0141	0.0137	0.0145	0.0141	0.0143	0.0141
5000	0.0235	0.0231	0.0236	0.0238	0.0233	0.0235

Table 2 – Mean PSNR Values

Number of fireflies initialized	Iteration 1	Iteration 2	Iteration 3	Iteration 4	Iteration 5	Mean PSNR
10	46.9897	43.9794	42.2185	41.5490	41.5490	43.2571
50	36.1979	36.0206	37.2125	35.6864	36.1979	36.2630
100	34.3180	34.3180	33.1876	33.6653	33.6653	33.8306
1000	23.3348	23.3819	23.4008	23.2057	23.3819	23.3410
3000	18.5171	18.6328	18.3803	18.5201	18.4406	18.4982
5000	16.2893	16.3601	16.2764	16.2288	16.3171	16.2943

Table 3 – Mean NC

Number of fireflies initialized	Iteration 1	Iteration 2	Iteration 3	Iteration 4	Iteration 5	Mean NC
10	0.8660	0.6761	0.5963	0.4629	0.3651	0.5933
50	0.6132	0.5804	0.7084	0.5593	0.6669	0.6256
100	0.7223	0.7218	0.6191	0.6331	0.6631	0.6719
1000	0.6358	0.6315	0.6354	0.6233	0.6316	0.6315
3000	0.6224	0.6452	0.6259	0.6260	0.6271	0.6293
5000	0.6334	0.6370	0.6241	0.6225	0.6319	0.6298

Table 4 – Mean of function of PSNR and BER

Number of fireflies initialized	Iteration 1	Iteration 2	Iteration 3	Iteration 4	Iteration 5	Mean f(PSNR,BER)
10	46.9903	43.9806	42.2203	41.5511	41.5511	43.2587
50	36.2051	36.0281	37.2182	35.6945	36.2051	36.2702
100	34.3291	34.3291	33.2020	33.6782	33.6782	33.8433
1000	23.4740	23.5196	23.5379	23.3491	23.5196	23.4800
3000	18.9392	19.0438	18.8159	18.9419	18.8702	18.9222
5000	16.9943	17.0537	16.9835	16.9437	17.0176	16.9986

Table 5 – Mean of function of PSNR and NC

Number of fireflies initialized	Iteration 1	Iteration 2	Iteration 3	Iteration 4	Iteration 5	Mean f(PSNR,NC)
10	1.3359	1.1159	1.0185	0.8784	0.7806	1.0259
50	0.9752	0.9406	1.0806	.9161	1.0289	0.9883
100	1.0655	1.0650	0.9510	0.9697	0.9997	1.0102
1000	0.8692	0.8653	0.8694	0.8553	0.8655	0.8649
3000	0.8075	0.8316	0.8097	0.8112	0.8115	0.8143
5000	0.7963	0.8006	0.7869	0.7848	0.7950	0.7927

CONCLUSION

In this paper, the performance metrics are evaluated between an image and watermarked image. Watermarking is done using discrete wavelet transform based on singular value decomposition. The performance parameter BER is directly proportional to the initial number of fireflies initiated and PSNR goes on decreasing with the number of fireflies initiated increases. The objective function values depend on initial number of fireflies and the performance parameters. The f(PSNR, BER) decreases with increase in the initial value of firefly but on the other hand f(PSNR,NC) depends more on the NC value in determining the functional value .With random allocation of positions of fireflies in the original image the function value for different iterations may vary ,hence the average values are also tabulated. The BER values obtained is better for the initial number of fireflies greater than 1000 as compared to [1]. PSNR values obtained are better when the number of fireflies initiated is low and those PSNR values are better compared to [1] for initial number of fireflies which are less than 50.It is difficult to obtain a high BER and a high PSNR at the same time, hence the number of fireflies initiated to be chosen based on the requirement of application.

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