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Design and Development of BFO Based Robust Watermarking Algorithm for Digital Image

Priyanka*, Charu Jain** and Geet Sandhu***
**M. Tech. Scholar (CSE), Computer Science & Engineering, Amity University, Gurgaon, India*
***Sr. Lecturer, Computer Science & Engineering, Amity University, Gurgaon, India*
****Lecturer, Computer Science & Engineering, Amity University, Gurgaon, India*

(Corresponding author: Priyanka)
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ABSTRACT: The rapid increase of digitized media because of the proliferation of networked multimedia has created many issues like related to copyright protection, easily copying and transmitting the digital data. This has created the need for various techniques which helps to protect the digital media over the internet. Digital watermarking is one of the solutions. Digital watermarking is a technique which is used to hide the ownership information in the digital media. In this paper, we have implemented a technique based on Bacterial Foraging Optimization (BFO) for watermarking the digital image. The work has been implemented in the MATLAB and the results show its robustness against the various attacks. The quality parameters such as PSNR, MSE and Similarity Ratio are also being used to check the quality of watermarked image which provides the satisfactory results.

Keywords: Digital watermarking, Bacterial Foraging Optimization, BFO, PSNR, MSE

I. INTRODUCTION

With the fast development of Internet, the transmitting the digital media which is available in the form of text, audio, video, image has become easy [1]. But copying, modifying and transmitting these media illegally has become a major issue. To face all these problems, it is necessary to develop strong techniques. For protecting the digital media, the digital watermarking is used as a technique. Digital watermarking is a branch of information hiding which is used to hide proprietary information in digital media like photographs, digital music, or digital video [2].

The basic process of watermarking involves the two steps, embedding the watermark and extracting the watermark. For embedding the watermark, we need the cover image in which the watermark (secret information) can be embedded [3].

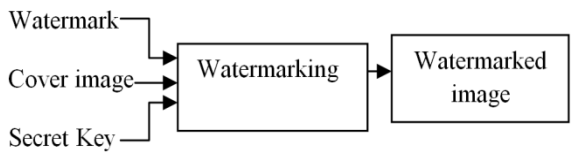


Fig. 1. Basic watermark embedding process.

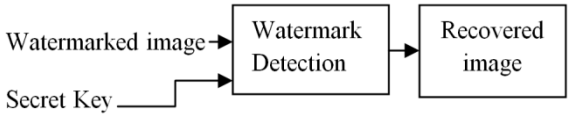


Fig. 2. Basic watermark recovery process.

As shown above, a secret key is used in the embedding and extracting watermark from the image. The secret key is used to enforce the security and it can be a private or public. Many techniques for watermarking have been proposed by various researchers in the after the start of watermarking era in 1993 [3].

Basically two domains are there which are spatial and transform domain. The spatial domain is easy to implement and simple but weak against the attacks while the frequency domain watermarking are more robust to attacks, however, they are more complex as compared to spatial domain [2].

In this paper, we have proposed a digital watermarking technique based on Bacterial Foraging Optimization (BFO) for the digital images.

The rest of the paper has been organized as below. Section II describes the literature review of various techniques, Section III describes the Proposed Scheme for digital watermarking based on BFO, Section IV shows the performance evaluation for the proposed scheme and finally Section V provides the conclusion and future scope.

II. LITERATURE SURVEY

The concept of digital watermarking came into 1990 [4-5] and 1993. Tirkel *et al* [6] coined the word water mark which later became watermark.

There are three main steps in the watermarking which are watermark signal design, watermark embedding and extracting of the watermark but mostly the watermark signal design and embedding are considered as one step and extracting the watermark as second step [7-9].

Many approaches have been published for the digital watermarking which are robust to the attacks. We also have used the high frequency areas to store the watermark so we here discuss only the approach of transform domain in DCT, DWT and DFT domain and BFO.

The DCT approach is robust to image processing operation but weak against the geometric attacks. At the same time, the DCT based approach is difficult to design.

DCT approach is classified under the Global and Block Based watermarking [2]. Cox *et al* [10] used firstly the DCT based watermarking algorithm to embed a robust watermark in the perceptually significant portion of the Human Visual System.

DWT approach was introduced in [11] which uses the same procedure as the DCT but the transformation of the image into its transform domain is different which makes the difference. DWT approach performs more robust than DCT in various applications [2].

DFT approach was studied because it proved its robustness against the geometric attacks. There are two types of DFT based watermarking techniques, one in which the watermark is directly embedded and other in which the watermark is template based embedding [2].

Bacteria Foraging Optimization (BFO) Algorithm was proposed by Passino. It is a newcomer in the nature-inspired optimization algorithms. From the last five decades, optimization algorithms like Genetic Algorithms, Evolutionary Programming, Evolutionary Strategies (ES), have been dominating the realm of optimization algorithms which draw their inspiration from evolution and natural genetics [12].

Bacterial Foraging Optimization Algorithm (BFOA) is inspired by the pattern exhibited by the foraging behavior of *E. coli* bacterium. A bacterium searches for nutrients by moving small steps is known as chemotaxis and mimicking chemotactic movement of virtual bacteria in the problem search space is the basis of the BFOA [12].

We have implemented the BFO algorithm for the watermarking of digital image and BFO is used to find the high frequency areas of the image where the watermark will be inserted.

III. BFO BASED DIGITAL WATERMARKING TECHNIQUE

We have defined a BFO based algorithm that is being used to hide the input data secretly in an image. As the name suggest the approach is based on the basic to bacterial movement. To perform the data encoding, ADAPTIVE algorithm is applied over the image. In this work, we have defined a BFO based approach to identify the high frequency areas where the data will be stored. The basic steps of the algorithms are mentioned as follows:

Step 1. Get the Cover Image and Hidden Image as input.

Step 2. Initialize BFO parameters respective to the image.

Step 3. Set image pixels as initial population set.

Step 4. Read each pixel of population set respective to the bacteria S for chemo tactic step and find the cost of location in image

Step 5. Perform the bacterial movement respective to swimming and tumbling.

Step 6. Implement the swarming process so that the bacterial patterns can be observed and estimated. It will also perform the similar patterns in a group

Step 7. Perform the reproduction by performing the bacterial splition and place them in same location with same feature vectors.

Step 8. Identify the group of dead bacteria and eliminate them

Step 9. Collect the result pixel and form watermarking on identified image.

The basic model can be described as under:

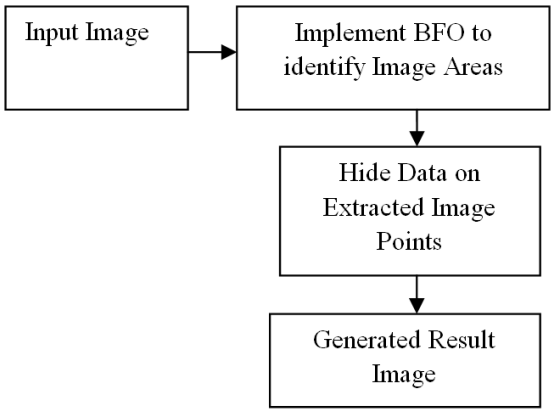


Fig. 3. Basic Model.

IV. EXPERIMENTAL RESULTS

The evaluation parameters have been used to check the quality of the image and to find the error between the watermarked and input original image.

We have used the PSNR (Peak Signal to Noise Ratio), MSE (Mean Squared Error) and SSIM (Structured Similarity Index Measure) and the performance has also been checked under the various attacks like Salt and Pepper and Gaussian Filter.

A. Mean Square Error (MSE)

It is defined as the square of errors between cover image and watermarked image. The distortion in the image can be measured by MSE [13].

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]\ 2 \quad \text{(i)}$$

Where:

I(i,j) is the value of the pixel in the cover image.

K(i,j) is the value of the pixel in the watermark image.

m, n: rows and columns of image.

B. Peak Signal to Noise Ratio (PSNR)

It is the measure of quality of the image by comparing the cover image with the watermark image[13]. It is calculated as :

$$PSNR = 10 * \log\left(\frac{255}{MSE}\right)$$

Where 255 is the peak signal for the image

C. Structured Similarity Index Measure (SSIM)

SSIM is a image quality metric that assesses the visual impact of three characteristics of an image: luminance, contrast and structure.

Fig. 4. ((a)-(f) are the cover images and (g) Secret Image).

SSIM measure the similarity between the two images, in our case between the original and watermarked image. The SSIM value lies between 0 to 1. If the value is 1 then it means the images are identical [13].

For our proposed work, we have used the 6 cover images named Baboon, Cameraman, peppers , boat and Lena of size 256×256 and a payload named copyright of size 50×20 is embedded in these cover images.

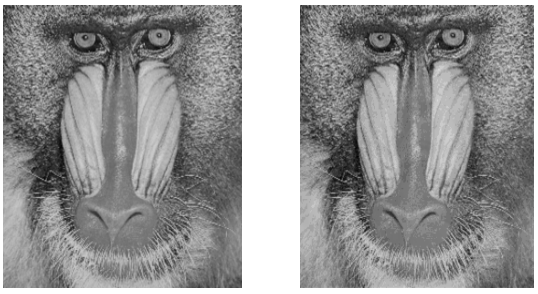
D. PSNR and MSE Analysis

The PSNR and MSE results for various images are provided as a result of implementation of the scheme based on BFO as:

Original image watermarked image

PSNR for boat image : 33.2978

MSE for boat image : 30.4298



Original image watermarked image

PSNR for baboon image : 31.2168

MSE for baboon image : 49.1362

Original image

Watermarked image

PSNR for Lena Image: 33.2769
MSE for Lena image: 29.3185

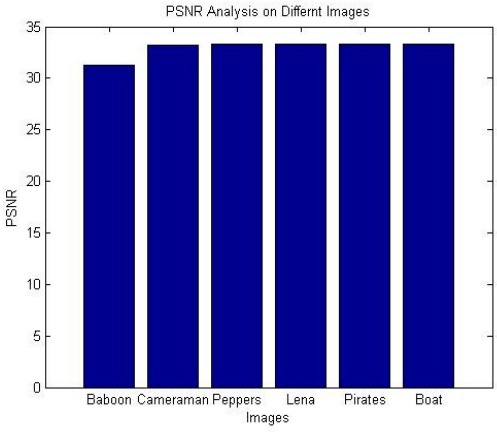
Below a table showing the PSNR, MSE and Similarity ratio results for various images as:

Table 1: MSE, PSNR, Similarity Ratio Comparison.

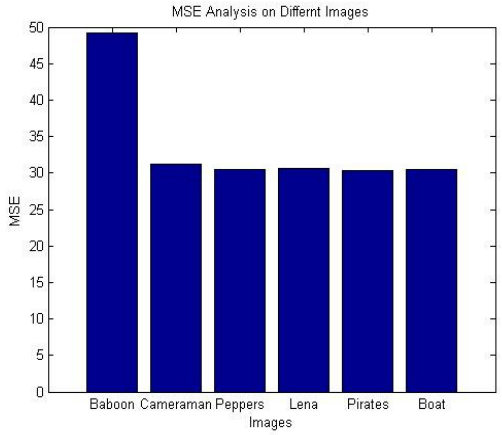
Cover Image 256×256	Payload 50×20	MSE	PSNR	Similarity Ratio
Baboon	Copyright	49.1362	31.2168	0.4721
Cameraman	Copyright	31.2375	33.1840	0.6995
Peppers	Copyright	30.4333	33.2973	0.6810
Lena	Copyright	29.3185	33.2769	0.5874
Pirate	Copyright	30.2942	33.3172	0.6622
Boat	Copyright	30.4298	33.2978	0.5513

V. RESULTS ANALYSIS

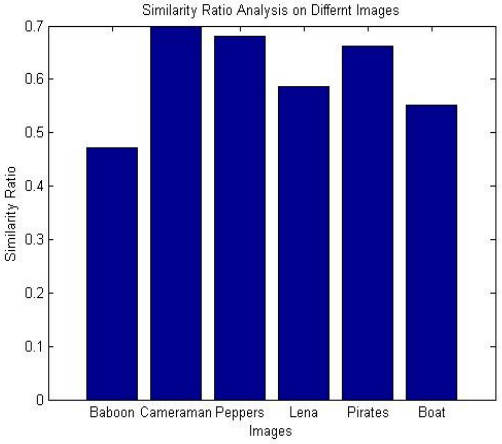
Results Analysis for the PSNR on various images has been given as:



Results Analysis for the MSE on various images has been given as:

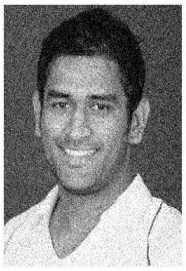


Results Analysis for the Similarity Ratio on various images has been given as:

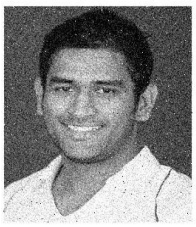


A. Performance Analysis under Attacks

The work has been analysed under the Gaussian attack and Salt and Pepper attacks as shown the below:



Watermarked image After Gaussian Noise



Watermarked After Salt and Pepper Noise Image

VI. CONCLUSION AND FUTURE SCOPE

The presented work was divided in three main layers. In first stage, the data encoding is performed using ADAPTIVE algorithm. In first layer, the BFO is applied over the image to identify the valid areas where data can be stored effectively. Once the areas are identified, the embedding of data over the cover image is performed. The presented work was implemented in MATLAB environment. The results show the significant results in terms of data storage and successful retrieval. The work is also tested under different kind of attacks. The results show the robustness of proposed work under these attacks.

We have implemented the watermarking in the digital images using BFO approach. Watermarking can be deployed in following areas such as Encoding Secret Messages in Text, Images and Audio.

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