



Image Steganography Using Pixel Value Differencing (PVD) Technique Based on Firefly Algorithm

**Oluwaseun M. Alade^{1*}, Elizabeth A. Amusan¹, Oluyinka T. Adedeji²
and Oluwaseun O. Alo²**

¹*Department of Cyber Security Science, Faculty of Computing and Informatics, Ladoke Akintola University of Technology, Ogbomoso, Nigeria.*

²*Department of information Systems, Faculty of Computing and Informatics, Ladoke Akintola University of Technology, Ogbomoso, Nigeria.*

Authors' contributions

This work was carried out in collaboration among all Authors. Author OMA formulated the firefly algorithm and wrote the first draft of the manuscript. Author EAA obtain the cover image. Authors OTA and OOA managed the literature searches, references and does the final manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Steganography deals with the ways of hiding communicated data in such a way that it remains confidential. Finding best position inside cover image to embed text message, maintaining a reasonable trade-off between security, robustness, higher bit embedding rate and imperceptibility are some of the challenges of steganography system. Hence, this paper presents firefly algorithm for finding best positions inside cover image in order to embed text message into cover image using Pixel Value Differencing (PVD) technique. Four different cover image was used. Experimental result showed the cover image with selected location using firefly algorithm as well as the stego image using PVD technique. The stego image was evaluated using Peak Signal to Noise Ratio (PSNR) and Mean square Error (MSE). Firefly Algorithm with PVD technique produced a promising result for image steganography.

*Corresponding author: E-mail: oolade75@lutech.edu.ng;

Email: eaadewusi@lutech.edu.ng, otadedeji@lutech.edu.ng, oolalo@lutech.edu.ng;

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1. INTRODUCTION

Steganography deals with the ways of hiding communicated data in such a way that it remains confidential. It upholds secrecy between two communicating parties. In image steganography, secrecy is achieved by embedding data into cover image and generating a stego - image. Image Steganography techniques are grouped under the two domains. The two domains are spatial domain and transform domain steganography. The secret information is directly inserted in spatial domain technique. The concept of hiding information in spatial domain is simple and its computational complexity is low. The capability level for hiding text is high with easy retrieval mode. Examples are least significant bit (LSB), most significant bit (MSB) and Pixel Value Differencing (PVD) to mention a few. Transform domain method is used for hiding a huge amount of data. How image or file transformed was executed is as a result of secret data hidden within the coefficients [1].

Steganography techniques can be evaluated using Imperceptibility, robustness and capacity as some of the performance metrics. Capability to elude detection (failure to discover the existence of a hidden message) is called Imperceptibility. Robustness is how fit a steganography technique can resist the extraction of hidden data [2]. The maximum number of information that can be securely entrenched and retrieved in a work without being statistically detectable is called the Payload Capacity. Steganography requires appropriate embedding capacity [3].

Swarm Intelligence (SI) (part of artificial intelligence) is based on the study of joint behavior in decentralized and self-organized systems [4]. Systems found in nature, such as ant colonies, bird flocking to mention a few described the major knowledge of SI. Swarm Intelligence systems are made up of a population of agents relating locally with one another and with their environment and local interactions among such nodes frequently lead to the occurrence of a global behavior [5]. Examples of Swarm intelligence search technique that can be used in finding best steganographic positions in a cover image are ant colony optimization, artificial bee colony, particle swarm optimization and Firefly algorithm to mention a few.

2. RELATED WORKS

An algorithm was proposed by [6] using pixel-value differencing. The original image was divided into non-overlapping sets of two consecutive pixels. The range interval was selected using the human vision sensitivity to gray value variations from smoothness to contrast. The result produced more imperceptible than those produced by least significant bit replacement method. Without making reference to the method of the original cover image, the secret message embedded can be extracted from the resulting stego-image.

Chen et al. [7] altered a method suggested by [8] using the side match process and data was secreted in the edge portions of the image. Based on demands of individual users, the embedding capacity can also be adjusted. The proposed method provided a respectable security in addition to the improvement on image quality.

Akinola et al. [9] worked on LSB, MSB and combined LSB-MSB algorithms based on their image quality and encoding times using digital images. Mean-Squared Error (MSE), Peak Signal-to-Noise Ratio (PSNR) and the encoding time of the three algorithms (the proposed algorithm, LSB and MSB) after embedding in digital images was calculated.

Ziyad et al. [10] used firefly and particle swarm optimization (PSO) algorithms for finding best positions inside image cover separately then used LSB to embed text message inside the stego image. A comparison between these two algorithms was given. Other spatial technique apart from LSB was suggested to embed text message inside cover image in order to improve its security.

In this paper firefly algorithm was used for finding best positions inside image cover and PVD technique was used to embed text message. PVD technique was used to improve the security of the stego image against steganalysis attacks, to increase the capacity of hidden data into host image without causing any statistically significant modification.

3. STEGANOGRAPHY USING FIREFLY ALGORITHM WITH PVD TECHNIQUE

The firefly algorithm is an optimization algorithm that simulates the features and flash pattern of

fireflies. The rules are summarized as given: all fireflies are unisex, irrespective of their gender, one firefly is enticed to other fireflies. Also, for any two flashing fireflies, the less bright one will move towards the brighter one because attractiveness is proportional to their brightness. The firefly move randomly if there was no one that is brighter than a precise firefly [10]. The basic steps of the firefly algorithm (FA) as adopted by [10,11] can be summarized as follows.

Step 1: Initialize algorithm parameters

Max Gen: the maximal number of generations
 γ : the light absorption coefficient.
 r : the particular distance from the light source
 d : the domain space

Step 2: Define Objective function $f(x)$, $x = (x_1, \dots, x_d)^T$

Step 3: Generate initial population of fireflies x_i ($i = 1, 2, \dots, n$)

Step 4: Determine Light intensity I_i at x_i by $f(x_i)$

Step 5: Define light absorption coefficient

while ($t < \text{MaxGeneration}$)
 for $i = 1:n$ all n fireflies
 for $j = 1:n$ all n fireflies
 if ($I_j > I_i$) Move firefly i towards j in d -dimension; end if

Step 6: Attractiveness varies with distance r via $\exp[-r]$

Step 7: Evaluate new solutions and update light intensity, end for j ; end for i

Step 8: Rank the fireflies and find the current best, end while

Step 9: Post process results and visualization

The peak signal to noise ratio (PSNR) measured in dB was calculated using equation 1.

$$PSNR = 10 \log_{10} \left(\frac{MAX^2}{MSE} \right) \quad (1)$$

Where MAX is the maximum pixel value, 255 for 8 bit images.

MSE is the mean square error as given by equation 2

$$MSE = \frac{1}{M * N} \sum_{i=0}^{M-1} \sum_{j=0}^{N-1} [I(i, j) - I_o(i, j)]^2 \quad (2)$$

Where I_o is the cover image before embedding, I is the stego – image after embedding and $M \times N$ represents the size of these images.

Fig. 1 show the block diagram of hiding text message inside image cover image using firefly algorithm with Pixel Value Differencing (PVD) technique. At receiver stage; stego image is received, and text message is extracted. The first step is applying firefly algorithm on stego image (as shown in Fig. (2)), in order to find hiding locations pixels). Pixel Value Differencing algorithm was used to hide messages into image pixels by converting messages into RGB hexadecimal shapes and replacing pixel values in images with hexadecimal RGB message values.

Table 1. Result of quality metrics of MSE and PSNR value using Firefly with PVD

Cover Images (512 x 512)	Firefly with PVD	
	MSE (%)	PSNR (dB)
Village Boy	0.006	50.25
Peppers	0.0065	49.20
Baboon	0.007	46.25
Lena	0.0062	49.65

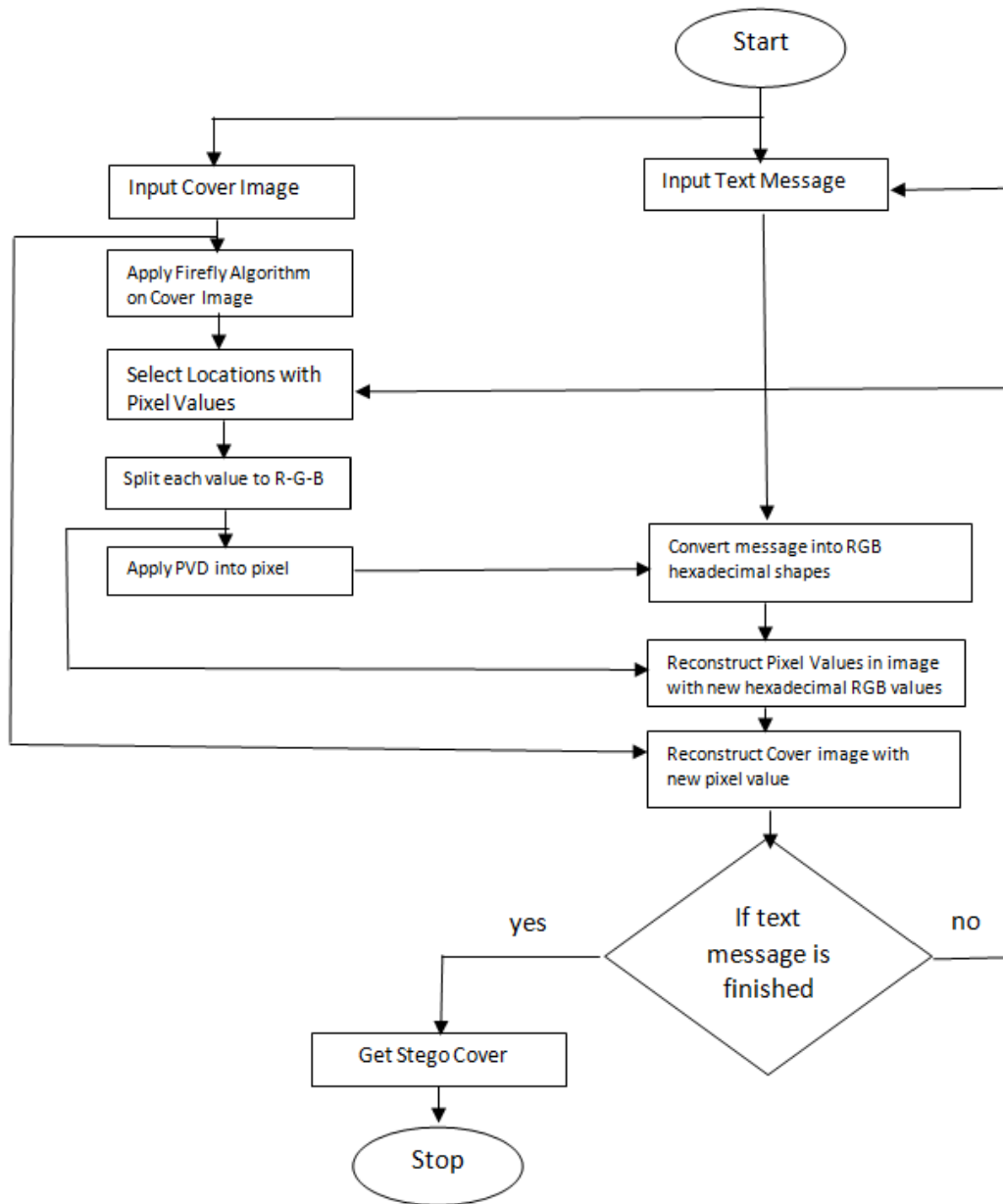


Fig. 1. Block Diagram of Hiding text message inside cover image using Firefly Algorithm with PVD Technique

4. RESULT AND DISCUSSION

Fig. 3 showed four cover images (VillageBoy, Peppers, Baboon and Lena represented as A,B,C, D respectively) without selected location by firefly. Fig. 4 showed cover image with the location that are selected by firefly algorithms. The selected locations are specified by red colour. Fig. 5 showed the stego image with firefly algorithm with PVD technique. The MSE and

PSNR are calculated between the cover images and the stego images and the results of the quality metrics of the stego image are shown in Table 1.

From Table 1, the experimental results have a good PSNR value and a better MSE value than those of the theoretical analysis. Firefly algorithm selects the best hiding positions which are deployed all over the cover images.

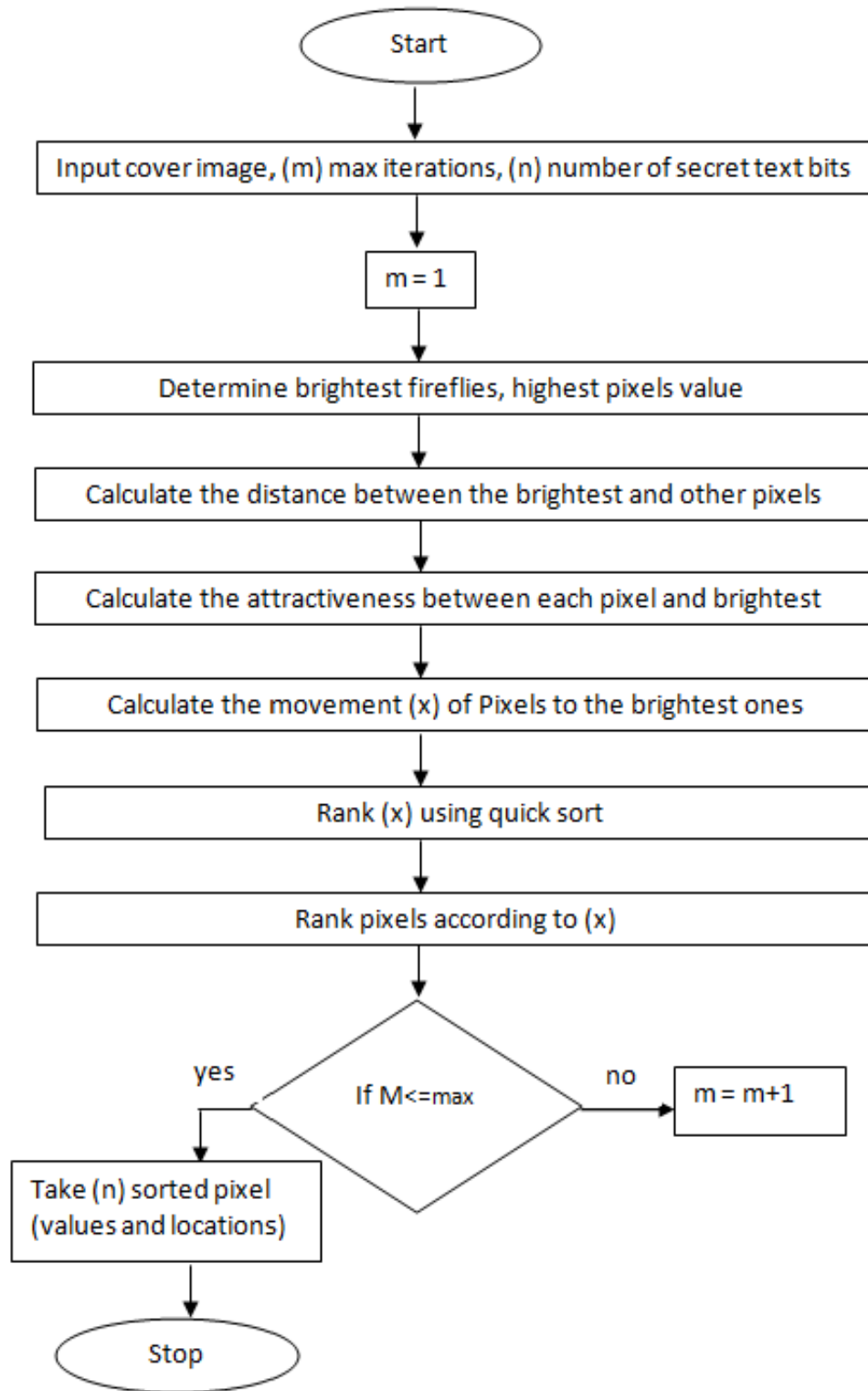


Fig. 2. Block Diagram of Firefly Algorithm for finding best hiding location in cover image

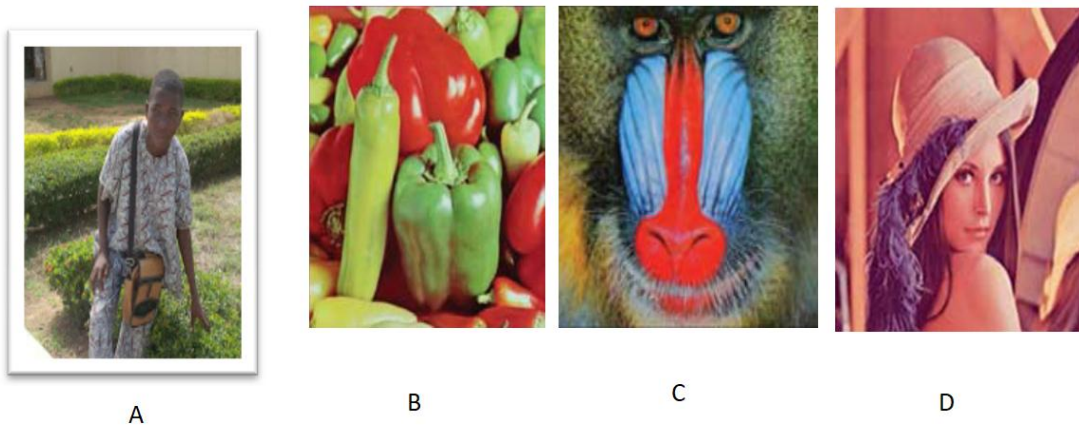


Fig. 3. Cover images without selected location

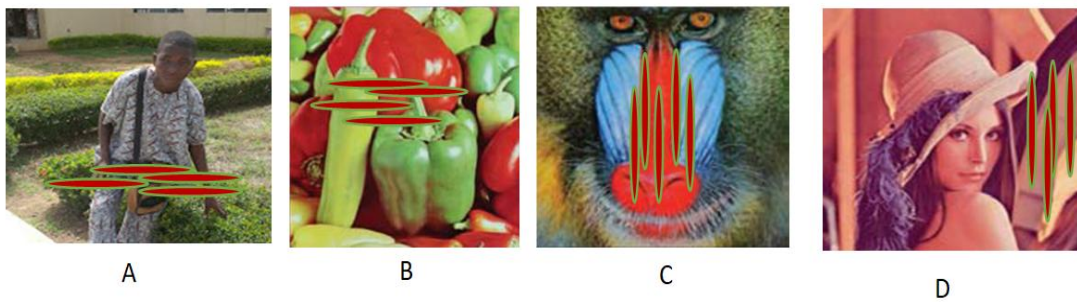


Fig. 4. Cover image with Firefly selected locations

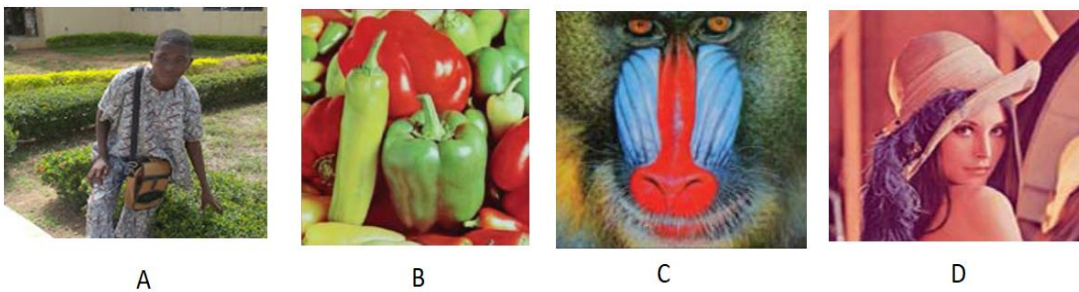


Fig. 5. Stego image for Firefly Algorithms with PVD technique

4. CONCLUSION

Firefly algorithm with PVD technique was successfully experimented on four different cover image. The result of this work show that firefly is a good searching technique. Firefly algorithm selects the best hiding positions which are deployed all over the cover images. Also firefly stego covers have better quality metrics.

5. FUTURE WORK

Future work may be geared towards experimenting it with other swarm intelligence algorithms, usage of other steganography techniques apart from pvd, also hybridizing of spatial domain technique with transform domain technique. Performance evaluation of some selected swarm intelligence algorithms can also

be carried out. Also effect of using different pixels dimension should also be investigated.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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