Vol.2 No.3 July 2019

Multimedia Research

Received 20 April, Revised 24 June, Accepted 9 July

Enhanced Whale Optimization Algorithm and Wavelet Transform for Image Steganography

Nipanikar S I
PVPIT
Pune, Maharashtra, India
nipanikar.si@gmail.com

Hima Deepthi V
Vel Tech University
Chennai, Tamil Nadu, India

Abstract: In the interactive environment, information security is considered as the main issue with the development of information technology. Here, there is no protection for the messages transmitted to and from the receiver. A method called image steganography is used, which assures security to the concealed communication and protection of the information. In some of the receiver images, image steganography conceals the secret message and transmits the secret message so that the message is noticeable only to the transmitter and the receiver. Hence, this paper presents an algorithm for image steganography by exploiting sparse representation, and a method called Enhanced Whale Optimization Algorithm (WOA) in order to effectual selection of the pixels in order to embed the secret audio signal in the image. Enhanced WOA based pixel chosen process exploits a fitness function that is on the basis of the cost function. In order to evaluate the fitness, cost function computes the entropy, edge, and pixel intensity. Experimentation has been performed and a comparison of the proposed algorithm with the conventional algorithms regarding the PSNR and MSE. Moreover, it decides the proposed Enhanced WOA, as an effectual algorithm.

Keywords: Steganography; Secret Message; Cover Image; PSNR; MSE

1. Introduction

In public channels, digital multimedia data is transmitted with the quick growth of computer networks and multimedia technology. Hence, a great deal of interest is paid for the security of public channel transmission. Moreover, cryptography is exploited to secure multimedia data in the previous phases. Nevertheless, subsequent to the decryption, the security will be disabled. Therefore, information hiding is developed to overcome the disadvantages. Information hiding like watermarking and steganography is a method that sets in data into digital media for covert communication or copyright protection [6]. Moreover, the multimedia data can be unnoticeably transferred to the receiver evaluated with cryptography [8]. The multimedia data is considered as the cover of information hiding that comprises text, audio, image, video, and so forth. In applications, an image is considered an important medium, great deal importance has on image steganography [7].

Generally, steganography is considered as modern embedding secret messages interested in digital multimedia also no others apart from the transmitter and receiver can be attentive to the concealed messages [20] [21]. Recently, in our daily life steganography plays a more and more important role in binary images as it can be observed all over the place, such as handwriting, signatures, CAD graphs and so forth. On the other hand, the pixel's values are just zero or one in the binary image whereas those in colorful images, and grayscale images, encompass a superior range. Consequently, it is enormous confronts to embed messages into binary images and sustain large quality and security of stego images [13].

In image steganography, there are two techniques, such as spatial techniques and frequency-domain techniques correspondingly. Generally, in JPEG encoding, the frequency-domain algorithms handle with Discrete Cosine Transform (DCT) coefficients [13]. In hiding data, to operate DCT coefficients, Jsteg, F3, F4, and F5 methods are the steganography encoding methods. In the frequency domain, the steganography algorithms demonstrate typically the minimum capacity to conceal data and maximum distortion of stego-images. Conversely, the spatial algorithms encompass higher data ability and superior visual quality of stego-images. By the human examination, the limited alteration of every pixel is not clear. In particular, to embed the information image steganography exploiting Least Significant Bit (LSB) [14] manipulation is to modify the LSBs of pixels. In the information image, the bits of a pixel are partitioned into two bits and that is embedded into the LSBs for cover image pixels. Hence, the visual difference among stego-image and an uncontaminated cover image is not clear [15].

In recent times, several image steganography algorithms were developed [9] and [10]. A number of image steganography algorithms are in the spatial domain, in that a few pixels in the cover image are replaced using few bits to conceal (secret bits). An easy approach of this algorithm is called LSB steganography that comprises concealing secret bits on the LSB of a few pixels for the cover image. The main advantage of this algorithm is attaining maximum embedding ability. On the other hand, the LSB-based method suffers from several attacks and steganalysis as demonstrated in [11] and [12]. The secret object must be encrypted previous to embed it into the cover image to shun this lack. Hence, in steganography algorithms, the security of secret images is of supreme significance. By integrating steganography methods security could be attained with ciphering algorithms, for instance, in order to encrypt the secret object previous to embedding it into the host image. The extracted object is decrypted to extract the secret data.

The main contribution of this paper is to propose an enhanced WOA algorithm based pixel selection in order to evaluate the fitness. Moreover, the foremost intention of this paper is to choose the location of the optimum pixel for the embedding procedure. For the selection of the pixel location, this work presents the cost function for the enhanced WOA method. The proposed cost function based upon the entropy, edge, and intensity of the seed points. The computation of the entropy, edge, and intensity based upon the mean of the neighboring seed points of the particle. The DWT is considered as another objective of this paper to symbolize the image in the spatial domain into the frequency domain within the minimum and maximum-frequency coefficients.

2. Literature Review

In 2019, Junhong Zhang et al [1] presented a type of distortion measurement which was not only on the basis of the inequity effects subsequent to flipping the pixels. Nevertheless, it was based on the visual effects of flipping equivalent pixels that were known as joint distortion measurement. Here, subsequently, utilize the syndrome-trellis code to reduce the embedding distortion and obtain messages embedded rather than choosing appropriate locations to embed secret messages. In addition to investigational outcomes had shown that the developed distortion measurement encompasses superior performance, and the steganography method, which can attain higher statistical security with the maximum ability and image quality.

In 2019, Inas Jawad Kadhim et al [2] worked on the implementation of digital image steganography. Here, the important confront in modeling a steganographic scheme was to uphold a fair trade-off among security, robustness, imperceptibility and superior bit embedding rate. Moreover, this work presents a methodical evaluation of conventional kinds of image steganography and the new contributions in every group in multiple modalities. Moreover, this work presents an absolute outline of image steganography such as requirements, broad operation, different features, and estimate their performance. Various performance evaluation measures for analyzing steganographic model were also conferred. Furthermore, the scheme to choose various cover media was discussed for several applications and some modern steganalysis systems.

In 2019, Ahmed A. Abd EL-Latif et al [3] exploited the advantages of quantum walks to develop a new method in order to construct substitution boxes (S-boxes) on the basis of the Quantum Walks (QWs). By the S-box evaluation criterion, the performance of the proposed QWs S-box model was analyzed. Moreover, the outcome shows the constructed S-box, which had fundamental qualities for feasible applications for security reasons. Moreover, a novel model for image steganography was modeled. For the embedded data, to attain superior security, the developed model was an incorporated model among quantum walks and classical data hiding. Using QWs S-box, the extraction and embedding procedures were controlled. The enclosure of cryptographic QWs S-box assures the security of both extraction and embedding stages.

In 2019, XiaotianWu and Ching-NungYang [4], worked on Secret Image Sharing (SIS) methods with steganography and authentication for uncompressed images. To compressed the domain, they cannot be used. This model was not relapse distorted stego image into its original model while the cover image was of importance. In order to resolve the aforesaid issues, a (k, n) threshold partial reversible Absolute Moment Block Truncation Coding (AMBTC) on the basis of the SIS model with authentication and steganography was developed. Using the polynomial on the basis of the SIS in GF (28), a secret image was partition into n noise-similar to shares. They were hidden into the AMBTC cover image with parity bits using the developed embedding methods, and n meaningful stego images were modeled in order to competently deal with the shares. Authentication was used as a result that the reliability of stego image was confirmed. Adequate stego images can completely restructure the secret.

In 2018, Kumar Gaurav and Umesh Ghanekar [5], proposed a new steganography method on the basis of the local reference edge detection model and exclusive disjunction (XOR) property. In the sharp edge area, human eyes were fewer sensitive towards intensity changes evaluated to the uniform area of the image. By bit plane dependent XOR coding model, the embedding approach enhanced regarding security and capacity in LSB bits of edge pixels, which creates minimum probable alterations. The conventional edge-based steganography model present better imperceptibility however relatively limits the embedding ability. Moreover, the proposed algorithm competently enhances the embedding capability with a satisfactory range of robustness and imperceptibility.

3. Proposed Methodology

In this section, the proposed algorithm is presented for image steganography, which exploits the sparse algorithm. In the image, the image steganography is considered as concealing the secret messages and in this work, the secret message is a speech signal. The major contribution of the image steganography is that it presents good security and the ability in securing the secret messages from hacking or tracking. Here, it needs the secret speech signal and the cover image. By exploiting the Discrete Wavelet Transform (DWT), cover image experiences wavelet transform [16] in the frequency domain which authorizes the depiction of the cover image. Subsequently, it chooses the necessitate pixel to embed the concealed speech signal by exploiting the enhanced WOA-based pixel selection. In the best location, the concealed message acquires embedded. After the completion of the embedding process, IDWT is exploited in the spatial domain, which indicates the embedded image. Then, the extraction of the concealed speech signal process takes place at first it transforms the embedded image in the spatial domain into the frequency domain. Later, the extraction of the sparse signal takes place that is utilized to extract the concealed speech signal. Fig. 1 demonstrates the schematic illustration of the proposed methodology.

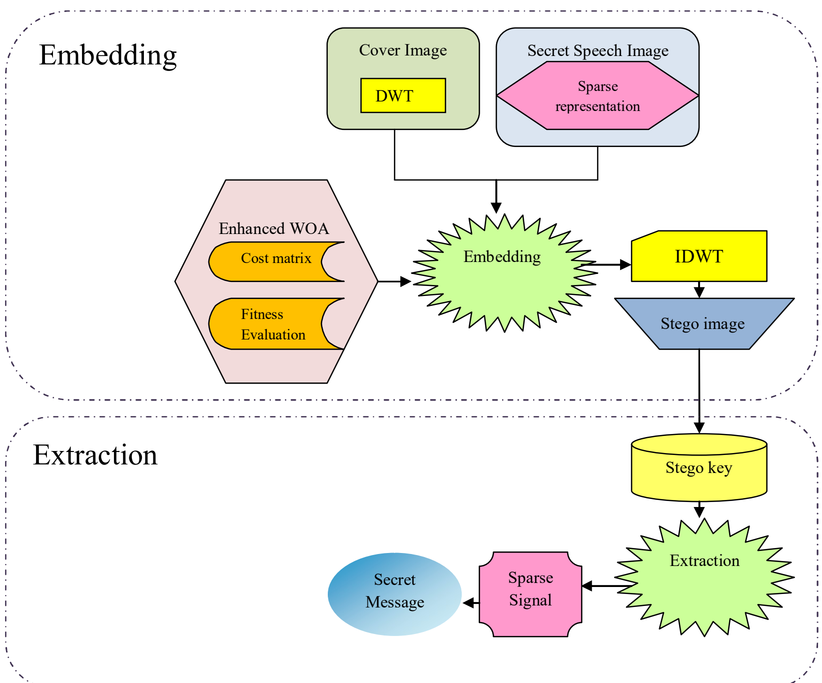

Fig. 1. *Schematic diagram of the proposed methodology*

3.1 Embedding Process Model

In this section, the step by step process is presented, which elaborates on the embedding process in the image. The following steps are used in the embedding process, at first; the concealed speech signal and the cover image are attained and record the concealed speech signal length. Subsequently, the DWT is performed in order to extract the wavelets of high and low frequency. From the extracted wavelets, choose any of the wavelet coefficients, and subsequently choose any of the pixels so that it can be suitable for embedding. To carry out the embedding process, the optimal position is decided by exploiting the enhanced WOA-based pixel selection process that chooses the ideal pixel to embed the audio message. Subsequently, the concealed speech message acquires embedded into the improved coefficients and later integrated with the unenhanced coefficients. The last phase is the creation of the stego image, it uses the IDWT. Fig 2 demonstrates the diagrammatic representation of embedding process.

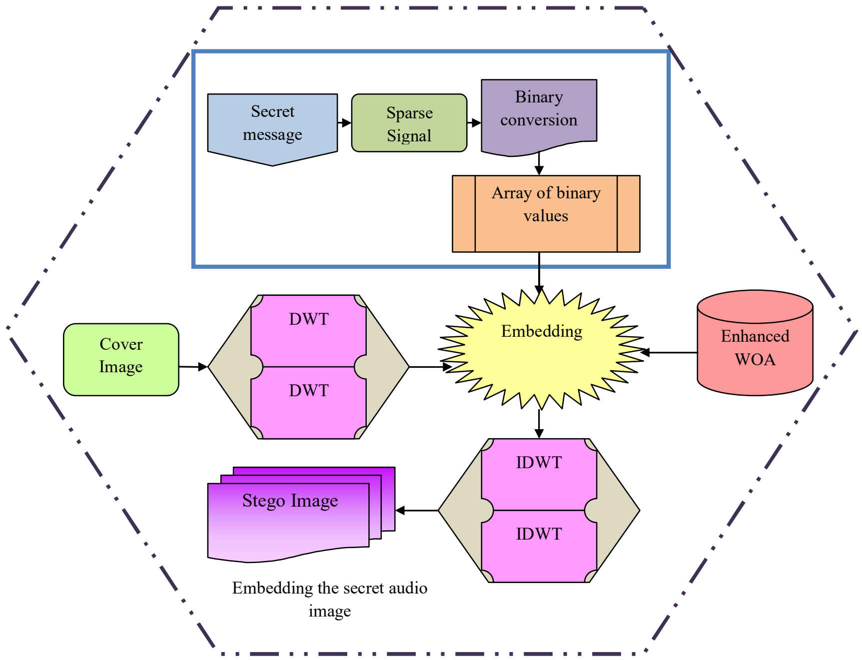

Fig. 2. *Diagrammatic representation of the embedding process*

a)Cover Image representation:

The cover image is considered as the indigenous image, here the speech signal is embedded. In the cover image, the embedding procedure carries on without any alteration in the statistical properties of the cover image. Let us assume the cover image as I with the dimension $L \times M$. The cover image is basically in the spatial domain, and hence, DWT is used to indicate the cover image with low and high-frequency coefficients in the frequency domain. In the frequency domain, to indicate the cover image, the cover image experiences DWT and sub-sampling that presents a superior degree of robustness. The band's coefficients attained as a consequence of DWT and sub-sampling are stated in eq. (1).

$$[I_1 \quad I_2 \quad I_3 \quad I_4] = DWT(I) \tag{1}$$

In eq. (1), I_1 indicates the lesser frequency bands coefficient, which conveys all the important information of the image that is the estimated band, I_2, I_3, and I_4 are the unimportant wavelet coefficients which convey the information such as the edge and texture of the image that is the maximum-frequency bands. Every extracted sample is of dimension $i \times j$ correspondingly.

Furthermore, the bands chosen for the procedure are I_1 and I_4, that are the lesser and greater frequency bands coefficients. Use DWT to I_1 and I_4, the sub-bands coefficient extracted from I_1 and I_4 is stated in eq. (2) and (3).

$$[I_1^{LL} \quad I_1^{LH} \quad I_1^{HL} \quad I_1^{HH}] = DWT(I_1) \tag{2}$$

$$[I_4^{LL} \quad I_4^{LH} \quad I_4^{HL} \quad I_4^{HH}] = DWT(I_4) \tag{3}$$

In eq. (2), I_1^{LL} and I_4^{LL} indicates the coefficients of lesser frequency subbands for the band I_1 and I_4 correspondingly, $I_1^{LH}, I_1^{HL}, I_1^{HH}$ indicates the superior frequency sub-bands of I_1, and $I_4^{LH}, I_4^{HL}, I_4^{HH}$ indicates the superior frequency sub-bands produced from I_4. It is obvious that the lesser frequency bands present all the important image information and the superior frequency bands produce the edge and the texture of the image information. Each sub-bands dimension produced from the bands I_1 and I_4 is $\left(\frac{i}{2} \times \frac{j}{2}\right)$. By exploiting the DWT, the extraction of band coefficients as it allows pixel-wise extraction of the high and low-frequency bands and, DWT presents the need resolution.

b) Secret speech signal using sparse representation

For embedding, the message exploited is the speech signal. The indication for the concealed message, that is the speech signal is P^s, and the speech signal dimension is $N \times 1$. P^r indicates the arbitrarily produced sparse matrix within the dimension $N \times N$ which evidently states that the sparse matrix is a square matrix. Eq. (4) states the sparse representation for the speech signal.

$$P_{N\times 1} = \left\lfloor P^s_{N\times 1} \times P^r_{N\times N} \right\rfloor \tag{4}$$

In eq. (4), $P^r_{N\times N}$ indicates the arbitrarily produced sparse square matrix within the dimension $N \times N$, $P^s_{N\times 1}$ indicates the speech message within the dimension $N \times 1$, and $P_{N\times 1}$ indicates the sparse indication for the speech signal that is the product of the speech message and the arbitrarily produced sparse square matrix. Hence, the sparse signal dimension is $N \times 1$. The sparsely indicated speech signal is transformed into binary, and it pursues the 11-bit representation so that the final bit is the signed MSB. If the signal is the positive signal then the MSB=0, and if the signal is the negative signal then the MSB=1. The representation of the binary converted signal is P^{bn}, and the binary converted sparse signal dimension is $(N \times 1) \times 1$. The binary sparse signal is partitioned into 8 submatrices of size $n_1 \times n_2$ and it is stated in eq. (5).

$$P_{bn} \cong P_i\ ;\ 1 \le k \le 8\ . \tag{5}$$

In eq. (5), P_k indicates the k^{th} sub-matrix, P^{bn} indicates the binary converted the sparse signal. There are 8 sub-matrices of value range among one and eight.

c) Embedding:

Subsequent to the embedding, stego image is the ultimate image that attained the secret speech message into the cover image. The statistical property of the stego image is the same as that of the cover image. In an initial phase, in the stego image model, choose the bands to experience alteration by the augmentation of the sparse signal and the best possible location. The enhanced signal is stated in eq. (6) and (7).

$$I_1^{*i} = I_1^i + \left(P_k \bullet S_{opt} \bullet \alpha\right) \tag{6}$$

$$I_4^{\bullet i} = I_4^i + \left(P_k \bullet S_{opt} \bullet \alpha\right) \tag{7}$$

In eq. (6), $i = \{LL, LH, HL, HH\};\ 1 \le k \le 8\ j$ indicates the higher and lower frequency sub-bands of I_1 and I_4 correspondingly, S_{opt} indicates the optimal location to do embedding, P_i indicates the sparse speech signal, α indicates the constant. In the frequency domain the sub-bands are present; hence to indicate the image backward in the spatial domain it needs IDWT. The outcomes from IDWT is stated in eq. (8) and (9).

$$I_1^* = IDWT\left(I_1^{*LL}, I_1^{*LH}, I_1^{*HL}, I_1^{*HH}\right) \tag{8}$$

$$I_4^* = IDWT\left(I_4^{*LL}, I_4^{*LH}, I_4^{*HL}, I_4^{*HH}\right) \tag{9}$$

Hence, the embedded signal within the enhanced bands I_1 and I_4 is indicated as eq. (10).

$$I^* = IDWT\left(I_1^*, I_2, I_3, I_4^*\right) \tag{10}$$

3.2 Extraction of Secret Audio Message

The objective of the extraction procedure is to effectively extract the concealed message from the stego image, which is in the representation of a concealed speech signal. In the embedding procedure, the stego image is considered as the input, which occurs on the receiver side. Convert the spatial representation of the stego image into the frequency domain the stego image experiences DWT. Subsequently, from the stego image, the sparse signal is extracted that is an alteration to the binary form, and at last the concealed image is extracted.

Stego image is considered as the input for the extraction process, and it is indicated as I^{*E} and this is in the spatial domain. Hence, DWT is exploited in the frequency domain which indicates the stego image with low and high-frequency bands. Eq. (11) represents the coefficients of the bands produced consequently to the DWT.

$$\left\lfloor I_1^{*E} \quad I_2^{*E} \quad I_3^{*E} \quad I_4^{*E} \right\rfloor = DWT\left(I^{*E}\right) \tag{11}$$

In eq. (11) I_1^{*E}, I_2^{*E}, I_3^{*E}, and I_4^{*E} represents the band's coefficients produced exploiting DWT and I^{*E} is the stego image that is the concealed speech message embedded in the cover image. The enhanced bands are I_1^{*E} and I_4^{*E}, hence the sub-bands are produced from these bands. The eq. (12) and (13) indicate the sub-bands coefficients produced.

$$\left[I_1^{LL^*_E} \quad I_1^{LH^*_E} \quad I_1^{HL^*_E} \quad I_1^{HH^*_E} \right] = DWT\left(I_1^{*E}\right) \tag{12}$$

$$\left[I_4^{LL^*_E} \quad I_4^{LH^*_E} \quad I_4^{HL^*_E} \quad I_4^{HH^*_E} \right] = DWT\left(I_4^{*E}\right) \tag{13}$$

From the generated sub-bands, the subsequent phase is the extraction of the sparse signal. From the sub-bands for the stego image, the subtraction of the sub-bands of the cover image presents the sparse signal of the concealed message. Hence, the outcome is,

$$P_m^* = I_1^{K^*_E} - I_1^K \ ; \ 1 \le m \le 4 \tag{14}$$

$$P_l^* = I_4^{K^*_E} - I_4^K \ ; \ 5 \le l \le 8 \tag{15}$$

In eq. (14), $K = \{LL, LH, HL, HH\}$, $I_1^{K^*_E}$ indicates the sub-bands of enhanced coefficients, I_1^{*E} of the stego image, $I_4^{K^*_E}$ indicates the enhanced sub-band coefficients, I_4^{*E} of the stego image, I_1^K indicates the coefficient of sub-band for the stego image and I_4^K indicates the coefficient of the sub-band for the cover image. The stego image is in the binary model and therefore, all the bands the coefficients, and sub-bands, are binary. Hence, decimal conversion phases and the sparse signal produced in the aforesaid phase experience decimal conversion. The decimally transformed sparse signal is P^d. Hence, the dimension of the decimal sparse signal is $1 \times N$. At last, the extraction of the concealed speech message is done by the partition of the arbitrarily produced sparse square matrix from the decimally transformed sparse signal. The extracted speech message is P^{*s}.

$$P^{*s} = \frac{P_{1\times N}^{*d}}{P_{N\times N}^{r}} \tag{16}$$

In eq. (16), $P_{1\times N}^{*d}$ indicates the decimally transformed sparse signal produced from the stego image and $P_{N\times N}^{r}$ indicates the arbitrarily produced sparse matrix.

4. Enhanced Whale Optimization Algorithm

In this paper, the optimum location of the pixel is achieved by the enhanced WOA method [18]. This paper derives the proposed cost function to evaluate the fitness of each pixel location. The proposed cost function based upon the intensity, entropy, and edge.

Recently, the application and advancements of Machine Learning (ML) and optimization algorithms are acquiring quickly in the various domains. In conventional WOA [17], the current optimal solution is contemplated as the contribution of other search specialists. Then, all prey endeavors to alter their circumstances to nearby the optimal agent, and the flowchart of the proposed method is demonstrated in Fig 3. Since the region of the optimal hunt, space is not recognized from the previous; this process of update might outcome in being caught in neighborhood optimal for the cost function and the fitness function is considered for the paper is stated in eq. (17).

Fitness function based upon the cost matrix that conveys all the initial population which is randomly selected. The dimension of the cost function is $\left(\frac{i}{2} \times \frac{j}{2}\right)$. Consider the population Pl_{ij} and the fitness function of Pl_{ij} is,

$$Ft_{ik} = \sum_{i=1}^{n} \sum_{k=1}^{n} Pl_{ik} * Cf_{ik} \tag{17}$$

In eq. (17), Cf_{ik} represents the cost function for the population, Pl_{ik} represents the cost function depends on three parameters, such as the brightness, intensity, and the edge of the individual search agent available in Pl_{ik}. Eq. (18) indicates the cost function.

$$Cf_{ik} = \frac{1}{3}\left[It_{ik} + En_{ik} + Ed_{ik}\right] \tag{18}$$

In eq. (18), En_{ik} represents the entropy in the i^{th} row and k^{th} column of the cost matrix, It_{ik} represents the intensity in the i^{th} row and k^{th} column of the cost matrix, Ed_{ik} represents the edge of the seed point in the i^{th} row and k^{th} column of the cost matrix. The eq. (19) denotes the formulation of deciding the entropy, intensity, and edge of the search agent.

$$It_{ik} = \frac{1}{8}\sum_{j=1}^{8} I_{ik}^{j} \; ; \; E_{ik} = \frac{1}{8}\sum_{j=1}^{8} E_{ik}^{j} \; ; \; B_{ik} = \frac{1}{8}\sum_{j=1}^{8} B_{ik}^{j} \tag{19}$$

In the i^{th} row and k^{th} column the entropy, intensity, and edge of the search agent are computed by deciding the mean value of the 8 adjacent values. The personal optimal solution of each search agent is decided using an easy comparison. The present location of the search agent is evaluated with the fitness function, and the optimal values get updated as the optimal location of the individual search agent, Pl_{best}. Likewise, the optimal location for the entire search agent gets updated.

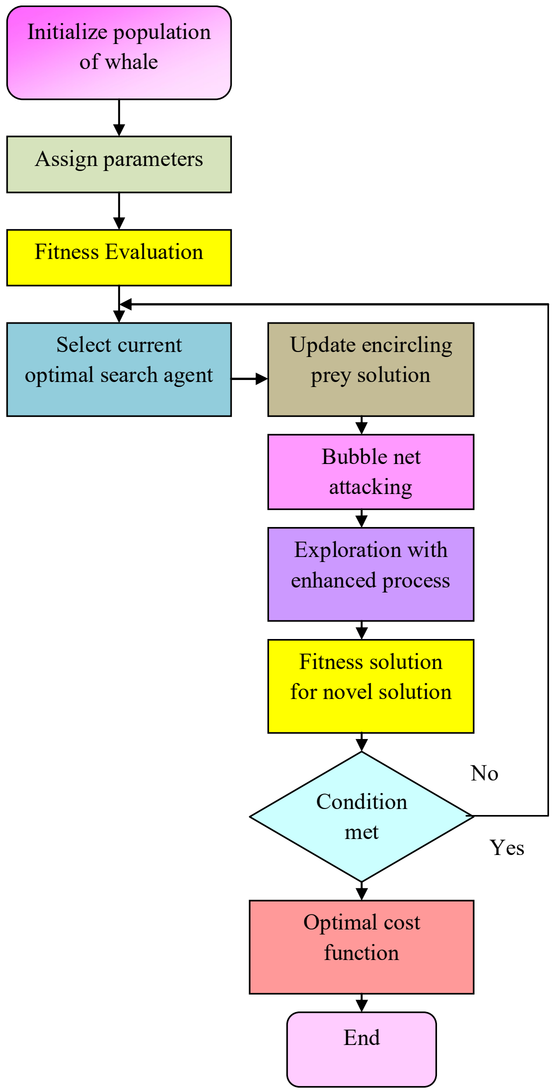

Fig. 3. *Flow chart of the enhanced whale optimization algorithm*

4.1 Procedure of Whale Updation

In encircling prey, the humpback whale includes the prey i.e., small fishes through subsequently revitalize its circumstances towards the best course of action all during an expanding number of iteration from preliminary to the optimal number of iteration and it is stated in eq. (20).

$$F = \left|\vec{x} \cdot \overline{P}^{*}(t) - \overline{P}(t)\right| \tag{20}$$

$$P(t+1) = P^{best}(t) - G \cdot x\,\vec{l} \tag{21}$$

In eq. (21) t current iteration is G and $\bar{x}$ are coefficient vectors, $\vec{P}$ represents the location on a vector of the optimal deal obtained in this manner, $*$ represents the location vector, and $\bullet$ represents the element by element mod function and multiplication. Eq. (22) used to calculate the coefficient.

$$x\overline{1} = 2x\overline{2} \cdot \vec{a} - x\overline{2} \quad \text{and} \quad x = \overline{2} \cdot a \tag{22}$$

Eq. (22) $x\overline{2}$ linearly minimized from 2 to 0 during iterations $\vec{a}$ represents a random vector in (0, 1).

i). Shrinking encircling model: This procedure is used through minimizing linearly the value of $x2$ from 0 to 2; the arbitrary value of vector i ranges among −1 and 1.

ii) Spiral updating location:

A spiral circumstance is subsequently done among the condition of prey and whale to duplicate the helix shaped enhancement of humpback whales as gets after.

$$\overline{P}(t+1) = \vec{G} \cdot e^{bt} \cdot \cos(2\Pi s) + \vec{P}(t) \tag{23}$$

Eq. (23) exhibits the division procedure of i^{th} prey and b as the steady state logarithmic spiral. In order to exhibit, therefore, there is a probability of selection for a partially between both the surrounding constricting system and the spiral model to remodel the circumstances of whales at the time of upgrade. The form gets following using eq. (24).

$$\overline{P}(t+1) = \begin{cases} \overline{P}(t+1) - x\overline{1} \cdot \vec{G} & \text{if } j < 0.5 \\ \vec{G} \cdot e^{bs} \cdot \cos(2\pi s) + \overline{P}(t) & \text{f } j \geq 0.5 \end{cases} \tag{24}$$

In eq. (24) s represents an arbitrary value among −1 and 1, $b \to$ constant, and $j \to 0, 1]$. To show this synchronous behavior, there is a probability of partially to select among both the pervasive constricting structure and the spiral model to simulate the circumstances of whales in the middle of improvement.

iii) Search for prey exploration stages: enhanced procedure

The alike method specified the variety of the $x1$ vector can be exploited to seem for prey (examination). Certainly, humpback whales appear random as shown using the location of each other [19].

$$\vec{G} = \frac{\left| x \cdot \vec{P}_{rand} - \vec{P} \right| \text{ and } P(t+1) = P_{rand} - x1 \cdot \vec{G}}{\text{correlation}} \tag{25}$$

This approach and $\left| x\overline{1} \right| > 1$ highlights exploration and permits the WOA to do a global optimum and $\left| x\overline{1} \right| < 1$ for updating the position of the search agents. To discover the search space competently the correction factor creates the whales move in a few steps towards the prey.

iv)Termination criteria

The update process of Enhanced WOA will be repeated until obtaining the best outcomes. Consequently, it enables any investigation operator to update its circumstances in the region of the current optimal understanding and imitates encircling the prey all the more effectual.

5. Results and Discussions

5.1 Simulation Procedure

In this section, the simulation outcomes of the proposed enhanced WOA and its evaluation with other methods, namely GA, PSO, and wavelet regarding the PSNR and MSE was presented. It stated an obvious insight against the benefits of the proposed algorithms with the other methods. Moreover, this section shows the 2 parameters, which were taken for evaluation, such as the MSE and the PSNR. These 2 parameters decide the image quality. The analysis of the quality of the stego image based upon these parameters.

5.2 Performance Analysis

The performance analysis of the proposed algorithm demonstrated in this section. The one speech signals 1 and 2 speech signals are chosen as the input for the image steganography.

In the cover image, the input signals are embedded and send, and subsequently, the signal is extracted at the receiver side. It assures the concealed message is called only to the transmitter and the receiver. For the embedding and the extraction procedure the cover image is exploited and that both the input signals are similar.

In Fig 4 and 5, the explanation of the proposed Enhanced WOA regarding PSNR and MSE by varying the speech signal without noise, filter value, and Gaussian noise salt and pepper noise, and the outcomes are analyzed over the conventional methods, such as wavelet, PSO, and GA.

From Fig 4, it is shown that the proposed enhanced WOA has a higher PSNR while the noise signals are not affected by the noise. Moreover, by analyzing the outcomes, the proposed method is superior to the other conventional methods. Fig 5 exhibits the performance of the presented enhanced WOA with the conventional methods for the overture of the noise in the speech signal. The overture of the noise in the speech signal, the MSE is observed and it increases a bit, however, it is minimum while comparing with the MSE values of the conventional techniques like the wavelet, PSO and GA.

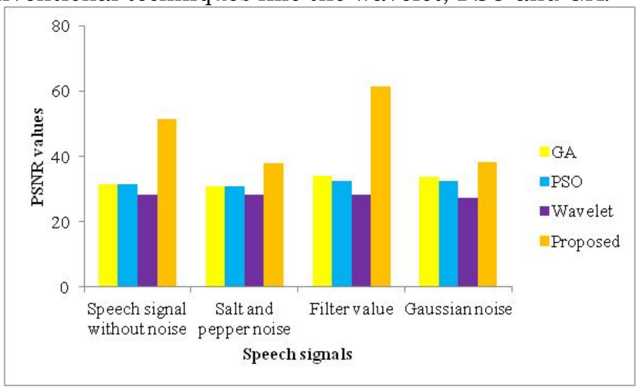

Fig. 4. *Comparative analysis of the proposed technique with respect to PSNR*

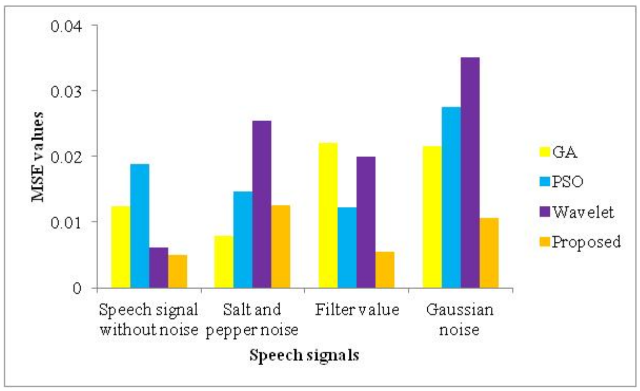

Fig. 5. *Comparative analysis of the proposed technique with respect to MSE*

6. Conclusion

This paper presented the image steganography, which had been attained by exploiting the enhanced WOA-based pixel chosen. In the cover image, the secret speech message was concealed that was the receiver in this method. The secret speech message was obtainable only to the transmitter and the receiver, and by exploiting the image steganography hacking acquires disenabled because of the security presented. In the cover image to embed the speech signal the proposed enhanced WOA-based pixel chosen assures the chosen of a suitable pixel. Moreover, the proposed algorithm exploits a competent fitness calculation, which was based upon the cost matrix. Finally, the simulation was done with two input speech signals, and the performance evaluation was performed by exploiting the experimentation outcomes were attained. Moreover, the evaluation of the proposed enhanced WOA regarding PSNR and MSE decides the efficiency of the method and it evaluated with conventional methods such as GA, wavelet, and PSO.

Compliance with Ethical Standards

Conflicts of interest: Authors declared that they have no conflict of interest.

Human participants: The conducted research follows the ethical standards and the authors ensured that they have not conducted any studies with human participants or animals.

References

[1] Zhang, Junhong & Wei, Zhuo & Yin, Xiaolin & Liu, Wanteng & Yeung, Yuileong. (2018). Binary Image Steganography Based on Joint Distortion Measurement. Journal of Visual Communication and Image Representation.

[2] Inas Jawad Kadhim, Prashan Premaratne, Peter James Vial, Brendan Halloran,"Comprehensive survey of image steganography: Techniques, Evaluations, and trends in future research", Neurocomputing, Volume 335, 28 March 2019, Pages 299-326.

[3] Ahmed A. Abd EL-Latif, Bassem Abd-El-Atty, Salvador E. Venegas-Andraca,"A novel image steganography technique based on quantum substitution boxes", Optics & Laser Technology, Volume 116, August 2019, Pages 92-102.

[4] Xiaotian Wu, Ching-Nung Yang,"Partial reversible AMBTC-based secret image sharing with steganography", Digital Signal Processing, Volume 93, October 2019, Pages 22-33.

[5] Kumar Gaurav, Umesh Ghanekar,"Image steganography based on Canny edge detection, dilation operator and hybrid coding", Journal of Information Security and Applications, Volume 41, August 2018, Pages 41-51.

[6] X. Zhang, F. Peng and M. Long, "Robust Coverless Image Steganography Based on DCT and LDA Topic Classification," IEEE Transactions on Multimedia, vol. 20, no. 12, pp. 3223-3238, Dec. 2018.

[7] C. R. Kim, S. H. Lee, J. H. Lee and J. -. Park, "Blind decoding of image steganography using entropy model," Electronics Letters, vol. 54, no. 10, pp. 626-628, 17 5 2018.

[8] Y. Zhang, X. Luo, Y. Guo, C. Qin and F. Liu, "Zernike Moment-Based Spatial Image Steganography Resisting Scaling Attack and Statistic Detection," IEEE Access, vol. 7, pp. 24282-24289, 2019.

[9] P.-Y. Chen, H.-J. Lin, et al., A dwt based approach for image steganography, Int. J. Appl. Sci. Eng. 4 (3) (2006) 275–290.

[10] X. Zhang, F. Peng, M. Long, Robust coverless image steganography based on dct and lda topic classification, IEEE Trans. Multimedia 20 (12) (2018) 3223–3238.

[11] Y. Su, C. Zhang, C. Zhang, A video steganalytic algorithm against motion-vectorbased steganography, Signal Process. 91 (8) (2011) 1901–1909.

[12] X. Li, B. Li, X. Luo, B. Yang, R. Zhu, Steganalysis of a PVD-based content adaptive image steganography, Signal Process. 93 (9) (2013) 2529–2538.

[13] Upham, D.: ‘Steganographic algorithm jsteg’. Available at http://zooid. org/~paul/crypto/jsteg(1993)

[14] Andreas, W.: ‘F5-a steganographic algorithm’. Int. Workshop on Information Hiding, Pittsburgh, PA, USA, 2001

[15] Swain, G.: ‘A steganographic method combining LSB substitution and PVD in a block’. Proc. Int. Conf. on Computational Modelling and Security, Bengaluru, India, February 2016, pp. 39–44.

[16] Mansi S. Subhedar, Vijay H. Mankar, Image steganography using redundant discrete wavelet transform and QR factorization, Comput. Electr. Eng. 54 (2016) 406–422.

[17] X. Wu, S. Zhang, W. Xiao and Y. Yin, "The Exploration/Exploitation Tradeoff in Whale Optimization Algorithm," in IEEE Access, vol. 7, pp. 125919-125928, 2019.

[18] Y. Li, T. Han, H. Zhao and H. Gao, "An Adaptive Whale Optimization Algorithm Using Gaussian Distribution Strategies and Its Application in Heterogeneous UCAVs Task Allocation," in IEEE Access, vol. 7, pp. 110138-110158, 2019.

[19] Y. Ling, Y. Zhou and Q. Luo, "Lévy Flight Trajectory-Based Whale Optimization Algorithm for Global Optimization," in IEEE Access, vol. 5, pp. 6168-6186, 2017.

[20] Vinolin V and Vinusha S,"Edge-based Image Steganography using Edge Least Significant Bit (ELSB) Technique",Multimedia Research, Volume 1, Issue 1, October 2018.

[21] Vinusha S,"Secret Image Sharing and Steganography Using Haar Wavelet Transform",Multimedia Research, Volume 2, Issue 2, April 2019.