AN INNOVATIVE METHOD TO ENHANCE THE DISTORTION MEASURE OF IMAGE STEGANOGRAPHY BY GENETIC ALGORITHM(GA) BY COMPARING IT WITH THE OPENCV ALGORITHM TO ACHIEVE PEAK SIGNAL TO NOISE RATIO.

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Abstract

Aim: To enhance the distortion measure of encoded images in the process of Image steganography using a Genetic Algorithm(GA) by comparison with the OpenCV Algorithm.
Methods and Materials: The two different groups are OpenCV Algorithm (N=10) and Genetic Algorithm (N=10). G-power is computed for two different groups, alpha (0.05), power (80%).
Results: The Peak Signal to Noise Ratio value is used to measure distortion, and the value for the Genetic Algorithm is 54. The independent sample T-Test (α = .001) value ($p<0.05$) with a confidence level of 95% is statistically fulfilled for the two techniques Genetic and OpenCV Algorithms.
Conclusion: Compared to OpenCV Algorithm, the distortion measure seems to be better in the Genetic Algorithm.

Keywords: Innovative Method, Distortion Measure, Algorithm, Data, Genetic Algorithm(GA), PSNR, Steganography, OpenCV, Image Steganography.

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1. Introduction

Image Steganography is the process of binding information that is text into a cover image. It is a type of art where invisible or secret communication will take place (Pradhan et al. 2016). The information hidden in the images is not visible to human eyes. Text Steganography, Image Steganography, Audio Steganography, and Video Steganography are the four different types of Steganography. In this paper, the major discussion is based on Image Steganography. In Image steganography, there are two different approaches that are Transform Domain Techniques and Spatial Domain Techniques. LSB substitution and pixel value differencing(PVD) are the Spatial domain Techniques. Whereas, DCT and DWT are Transform Domain Techniques. Here, the paper will discuss and compare two methods which are Genetic and OpenCV algorithms. The method of Image Steganography enables two parties to interact in a hidden and secret manner. In today's scenario, data hiding is important as data is used in all industries. The type of data which is important to hide is sensitive data, confidential data, private and personal data, and trade secrets. This data hiding helps to prevent data exploitation, data loss that isn't intended, human mistake, data erasure by accident, financial gain, extortion, and the concealment of criminal activity (Хорев and Сергеев 2020). Moreover, there are applications like confidential communication and secret data storage (Fridrich 2010). It also provides for digital file copyright protection by employing the message as a watermark. Security for modification of data, a system of access control for digital content distribution, and database systems of media (Sharma and Madhusudan 2015).

More than 20 related publications were published in IEEE, while another 25 plus related articles were published in Google Scholar such as ResearchGate and Sciencedirect. Some of the most cited articles and their findings are, (Arun and Murugan 2017) For improving security, the author used the Least Significant Bit XOR Substitution method as an approach to construct Image Steganography. A unique 8-bit cipher key is employed here, which is originally XOR with RGB colors. Indeed, the storage capacity in the image for data sharing is also improved. (Jaradat, Taqieddin, and Mowafi 2021) the article aimed to implement Image Steganography using chaotic maps and the PSO algorithm seeking to locate the optimal pixel location for the message to be embedded. Here, the photo is divided into 4 blocks. In this paper, the final result has improved the distortion to a minimal value. In addition, the Peak Signal to Noise Ratio value has been increased to 64. (Elharrouss, Almaadeed, and Al-Maadeed 2020) the research introduced an innovative Image Steganography algorithm based on K-Least Significant Bit. A text message is embedded in a cover image using the last three Significant Bits. A method to improve image quality is added to the process after decoding the messaging from the image. This results in Peak Signal to Noise Ratio value of 33, which is extremely low. (Swain 2014) the author implemented an update to the Least Significant Bit approach and used nine-pixel differencing to develop Image Steganography. Here, the image has been separated into chunks of 3*3 non-overlapping blocks. The PSNR results as an average value of 42. Among all the papers, in my opinion, the best technique is implementing image steganography using chaotic maps and PSO algorithm as it results in a very high PSNR value, which leads to maximum minimizing distortion. Our team has extensive knowledge and research experience that has translated into high quality publications(K. Mohan et al. 2022; Vivek et al. 2022; Sathish et al. 2022; Kotteeswaran et al. 2022; Yaashikaa, Keerthana Devi, and Senthil Kumar 2022; Yaashikaa, Senthil Kumar, and Karishma 2022; Saravanan et al. 2022; Jayabal et al. 2022; Krishnan et al. 2022; Jayakodi et al. 2022; H. Mohan et al. 2022)

Communicating through a secret path must always be confidential with a good efficiency process. The problems that have to be improved are minimal distortion, high quality, and embedding capacity of encoded images. The current trend in this sector has prompted the improvement of the existing system. Steganography is different from Cryptography where the aim is to hide the data in Steganography whereas in Cryptography the data will be converted to an encrypted form with a key. The advantages of using Steganography over Cryptography are that the hidden data is hard to detect and it is not susceptible to attacks such as rotation and translation. The value of the Peak Signal to Noise Ratio value must be high to improve the image quality using distortion measure as a parameter. The goal of the research is to improve distortion measure utilizing the parameters Peak Signal to Noise Ratio and Mean Square Error(MSE).

2. Methods and Materials

The innovative work is done in the Object Oriented Analysis and Design Laboratory, Department of Computer Science and Engineering, Saveetha School of Engineering, SIMATS. There were two groups. The first group is the Genetic algorithm(N=10) and the second group is the OpenCV algorithm(N=10). Among the two groups, group 1 is the innovative model, and group 2 is an existing model. The results were calculated (Kang 2021) using G* power software the minimum power of the analysis is set to 0.8 and the maximum tolerated error is set to 0.5 with a threshold value of 0.05% and the Confidence Interval is 95%.

As the amount of pixels in each image is the most important element in this analysis, different images get the different Peak Signal to Noise Ratio values. Also, various formats of photos like jpg, png, jpeg, bmp, etc can be used with different resolutions to check for a change in image capacity, distortion, and image quality using Peak Signal to Noise Ratio value.

OpenCV

(Singh 2019) OpenCV algorithm is the easiest and simplest method to perform Image Steganography. This method gives a low Peak Signal to Noise Ratio value when compared to Genetic Algorithm, Discrete Cosine Transformation, and Least Significant Bit Algorithm too. The current methodology comprises additional data using encrypted data, which drastically affects the image's visual representation. By raising the bandwidth of the original message or by modifying the file format, the disguised message is transmitted. Also, using OpenCV the Image Steganography is difficult to detect.

Pseudo Code for OpenCV

The algorithm steps in OpenCV Algorithm are:

1. Here, the Tkinter dialog box is used.

2. Open the file in the dialog box using the Tkinter file dialog library.
3. Retrieve the path of the image.
4. Using the Tkinter thumbnail function, load the image into the GUI.
5. For smoother computation, load the image as a NumPy array and change the type to unsigned int.
6. Divide the image into levels of characters.
7. Now, put the characters in ASCII format.
8. Encode the text.
9. Then, Decode it.
10. Join all the bits to form letters.
11. Also, Join all the letters to form messages.
12. After calculating the Peak Signal to Noise Ratio value, print it together with the encrypted image.

Genetic Algorithm(GA)

Under the natural selection process, the Genetic Algorithm(GA) uses a unique approach for tackling both constrained and unconstrained optimization problems. The basic idea behind the Genetic Algorithm begins with a random selection from the population P. Then undergoes the process of crossover and mutation to produce the new population that is offspring. This process will survive to the next generation. The process is repeated to generate maximum value. Genetic Algorithm is used in many different fields and applications due to its effectiveness and efficient performance in solving optimization problems. Fig. 1, represents the flowchart of the Genetic Algorithm.

Pseudocode for GA

The basic operations of the Genetic Algorithm

1. Initialization
2. Evaluation - Using evaluation function f(x).
3. New Generation - Repeat the steps to the end until the maximum is reached.
4. Selection - Choose the selection process randomly.
5. Crossover - Select two chromosomes for mutation, offspring will be the copy of those chromosomes.
6. Mutation - Use evaluation function to the offspring.
7. Replacement - Replace the old population with the new population.
8. Test - check if the maximum value is reached else go to step 3.

For comparing both the models, different images like a set of 10 images for each algorithm are used for calculating MSE, PSNR values. Finally, choose the algorithm which has higher values of PSNR and lower error of MSE. The Peak Signal to Noise Ratio value is inversely proportional to the Mean Square Error.

The system configuration is used for the algorithm to run in a 64-bit Operating System, 4GB RAM PC, Python 3.8, Windows 10, Google Colab, SPSS tool, and Microsoft Office for software specification.

The study examines the Peak Signal to Noise Ratio and Mean Square Error-values to determine which algorithm performs best. The Peak Signal to Noise Ratio value is inversely proportional to the Mean Square Error. This also indicates the image quality as well as the amount of data that may be stored in the image.

3. Results

The Peak Signal to Noise Ratio value will fluctuate when the phots and their formats change. The Peak Signal to Noise Ratio values for the data collection of sample size(N=10) has been derived from Table 1. In comparison to the OpenCV Algorithm, the paper concludes that the Genetic Algorithm has a higher Peak Signal to Noise Ratio value. Moreover, this could also be concluded as Genetic Algorithm has the higher image quality and embedding capacity as it has got better values than OpenCV. Also, the distortion is minimal in the Genetic Algorithm. Table 1 shows the data collection of image samples where N=10, in order to improve image quality and embedding capacity(%) by increasing the Peak Signal to Noise Ratio and lowering the Mean Square Root(%). ("Peak Signal-to-Noise Ratio" n.d.) here, the formula is used to calculate Mean Square Root which gives us a lead to calculate the Peak Signal to Noise Ratio value. Also, there is a formula to calculate PSNR from MSE. The narrower the Mean Square Error, the broader the Peak Signal to Noise Ratio value will result. The IBM SPSS version 21 statistical software is used for the study. The autonomous variables are the pixel values and the reliant variables are PSNR, MSE, image quality, and embedding capacity in the study, Image Steganography. In SPSS, the data is collected of sample size N=10 for both OpenCV and Genetic Algorithm. PSNR is used as a testing variable, whereas GroupID is used as a grouping variable. GroupID is given as 1 for OpenCV and 2 for Genetic Algorithm. Group Statistics is applied for the Statistical Package for the Social Sciences (SPSS) collected data and shown in Table 2. By performing the statistical analysis group statistics represents the comparison of the PSNR of OpenCV and Genetic Algorithm. The Genetic Algorithm has the highest value of PSNR as 54.84 and the lowest is 51.745 in Table 2. This concludes that image quality and embedding capacity is better in the Genetic Algorithm in comparison to the OpenCV algorithm. Figure 2, symbolizes the comparison chart for the Genetic Algorithm(GA) and OpenCV algorithm using Peak Signal to Noise Ratio value for different sets of 10 images. The Independent Sample T-Test is used for the sample collection in Table 3, with a threshold significance of 0.005 and a confidence interval of 95%. After applying the SPSS calculation, the Genetic Algorithm has accepted a statistically significant value($p<0.05$). Figure 3, represents a simple graph where the X-axis is OpenCV vs Genetic Algorithm(GA) and the Y-axis is the Mean of Peak Signal to Noise Ratio value detection which results in +/- 1SD.

4. Discussion

The overall study showed that the Peak Signal to Noise Ratio values varied, which increased the image quality and embedding capability. This demonstrates that the Genetic algorithm, with a Peak Signal to Noise Ratio value of 54, outperforms the OpenCV algorithm, which has a Peak Signal to Noise Ratio value of 46. There is a statistically significant difference in Image Steganography PSNR values of the two algorithms having a significant accuracy value of 0.001($p<0.005$ Independent sample T-Test).

(Uruma et al. 2019) this paper offered a subtle way to the Image Steganography Algorithm using Image

Colorization as a novel method. The technique inserted data in the colorization matrix. Using the colorization matrix, a huge amount of data can be incorporated into the image. The results of this paper proved that the capacity of image storage for data hiding is improved. (Darbani, AlyanNezhadi, and Forghani 2019) the author devised an Image Steganography method for storing text messages, especially in JPEG images. In this paper, the quantity of hidden information encoded into the image is larger. In addition, the visual quality is nearly identical to that of the original image. Here, two adjacent pixels are considered where two less significant bits of each pixel are used for embedding. This is another approach that is used for Image Steganography. (Jaradat, Taqieddin, and Mowafi 2021) the article represents the Image Steganography which has been developed in this paper is based on chaotic maps and the PSA algorithm. The Peak Signal to Noise Ratio value is improved drastically in this article, which is significant. Using this algorithm, the best pixel location is found and the data is embedded here for data hiding. The main motive of this paper was to improve the PSNR value, image quality, embedding capacity, and minimal distortion. (Velmurugan and Hemavathi 2019) in this paper, Audio Steganography is implemented but here it is implemented with an advanced and innovative algorithm. The algorithm used here is Neural Networks using a hash function to increase security. The key reason for employing this approach is that decoding the steg-object is challenging. (Nandi and Ghanti 2017) this paper aims to implement image Steganography using unique steps. The process is that firstly the text is encoded using the steps and then embedded into the image.

Similarly, the decoding process is done in the reverse process. So, the three steps are reversing, swapping, and circular right shifting for encoding whereas for decoding the steps are left circular shifting, swapping then reversing. The paper declares that using this method the data embedded in the image will not be lost. (Jangid and Sharma 2017) this author uses the MLC(Multi-level clustering) technique to implement Video Steganography. The cover frame is clustered using K-means clustering in this approach. As a consequence, the Peak Signal to Noise Ratio improves, and MSE values decrease. The primary goal of this paper was to raise the PSNR value. (Jangid and Sharma 2017; Rajput, Adhiya, and Patnaik 2017) audio Steganography is another type of Steganography that is being used to embed data for data hiding. The Least Significant Bit(LSB) algorithm is employed in this article. The paper aimed to increase storage capacity and security. The data embedded in the audio file is not embedded sequentially in a particular place, the data is embedded at specific points of the audio file. The proposed algorithm was better than the existing algorithm.

In the Genetic Algorithm(GA), the Peak Signal to Noise Ratio value is better than the OpenCV algorithm. There was variation in the values but not significantly high. Indeed, the Genetic Algorithm has many steps to be followed and an old method too. Using a different technique will improve Peak Signal to Noise Ratio value significantly.

The comparison ratio must be improved to get better results. Also, it must be able to use all the different types of image formats. This tells us that the improvement in Steganography algorithms is important and necessary. Finally, once the aforesaid requirements are met, image quality, embedding capacity, and Peak Signal to Noise Ratio value will all automatically improve.

5. Conclusion

The goal of this study is to design an innovative method for Image Steganography with a negligible amount of distortion. The Genetic Algorithm(GA) surpasses the OpenCV algorithm since the Peak Signal to Noise Ratio value is greater in the Genetic Algorithm. In the Genetic Algorithm(GA) and OpenCV Algorithm, the Peak Signal to Noise Ratio values are 54 and 46, respectively. Image quality and embedding capacity improve, as the Peak Signal to Noise Ratio value rises. This leads to minimizing distortion. Therefore, the distortion is reduced to minimal using the innovative model.

Declarations

Conflict of Interests

No conflicts of interest in this manuscript.

Authors Contributions

Author ABL was involved in conceptualization, data collection, data analysis, manuscript writing. Author KM was involved in conceptualization, guidance, and critical review of the manuscript.

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TABLES AND FIGURES

Table 1. Data gathering from an N=10 sample of images in order to improve image quality and embedding capacity by increasing the Peak Signal to Noise Ratio and lowering the Mean Square Root.

DataSet Sample (Different Images)	**PSNR (OpenCV Algorithm)**	**PSNR (Genetic Algorithm)**
1	46.5	54.39
2	47.19	54.43
3	48.1	52.77
4	46	51.745
5	47	54
6	46	54.84
7	48	52.58
8	48.1	53.5
9	47.3	53.1
10	46.8	54.2

Table 2. This is group statistics for both algorithms. The Peak Signal to Noise Ratio values of OpenCV and Genetic Algorithm are compared. The highest PSNR value of OpenCV is (48.1) and the lowest is (46). The highest PSNR value of the Genetic Algorithm is (54.84) and the lowest is (51.745).

	Groups	**N**	**Mean**	**Std.Deviation**	**Std.Error Mean**
PSNR	**OpenCV**	10	47.0990	0.79848	0.25250
	Genetic	10	53.5555	0.98777	0.31236

Table 3. Independent Samples T-Test was applied for the sample collections by fixing the level of significance as 0.05 with a confidence interval of 95%. After applying the SPSS calculation, the Genetic Algorithm has accepted a statistically significant value($p<0.05$).

	Levene's Test for Equality of Variances		**T-Test for Equality of Means**					
	F	**Sig.**	**T**	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std.Error Difference**	**95% Confidence Interval of the Difference**

									Lower	**Upper**
PSNR	**Equal Variances assumed**	0.752	0.397	-16.075	18	0	-6.4565	0.40165	-7.30034	-5.61266
	Equal Variances not assumed			-16.075	17.243	0	-6.4565	0.40165	-7.30301	-5.60999

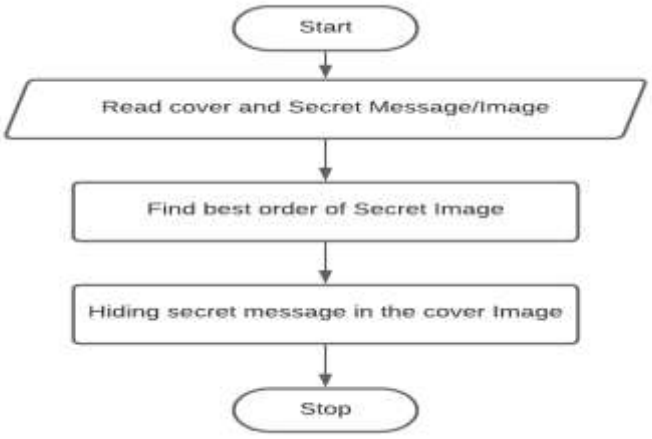

Fig. 1. Flowchart of Genetic Algorithm

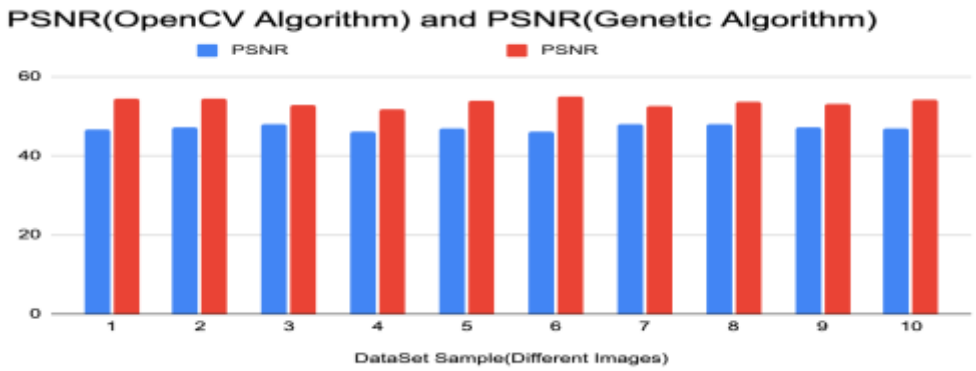

Fig. 2. A comparison chart of Peak Signal to Noise Ratio values for Genetic Algorithm and OpenCV algorithm.

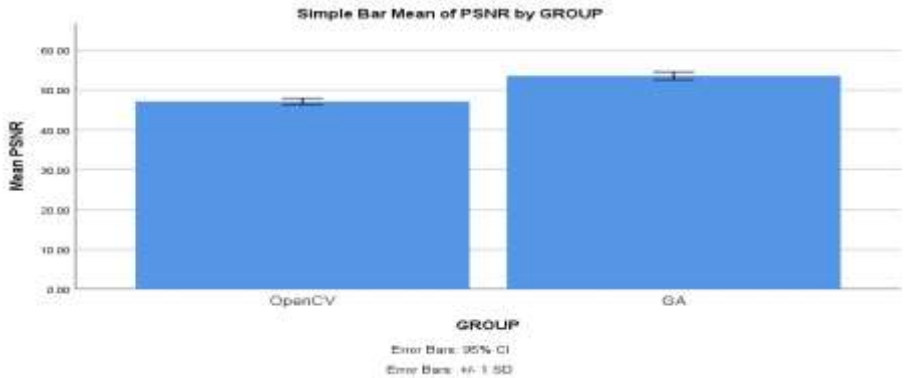

Fig. 3. Bar graph between OpenCV and Genetic Algorithm(GA). Comparison of OpenCV and GA in terms of PSNR values. The PSNR values of the Genetic Algorithm are better than OpenCV. X-Axis: OpenCV vs Genetic Algorithm(GA) Y-Axis: Mean of Peak Signal to Noise Ratio detection is +/- 1SD.