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STEGANO HIDING WITH IMPROVED EMBEDDING CAPACITY USING LSB TECHNIQUES

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ABSTRACT

The increasing exchange of sensitive information through digital networks has intensified the need for effective and imperceptible information-hiding techniques. This study presents a Steganography Imaging System (SIS) designed to improve data embedding through the integration and automatic selection of multiple Least Significant Bit (LSB) techniques. The proposed system incorporates four embedding configurations, namely LSB1, LSB2, LSB3, and LSB4, to conceal textual information within digital images while preserving the visual characteristics of the cover image. The system performs both information embedding and retrieval and selects an appropriate LSB technique according to image and message requirements. The proposed approach was implemented in MATLAB and evaluated using a 120 × 120 image. Experimental results showed reported text-size values of 4,601 for LSB1, 4,861 for LSB2, 9,116 for LSB3, and 1,600 for LSB4. The findings demonstrate that embedding performance does not necessarily increase with a higher nominal LSB level, highlighting the importance of adaptive technique selection. Among the evaluated configurations, LSB3 achieved the highest reported embedding value, while LSB4 produced the lowest. The proposed SIS provides an integrated framework for comparing multiple LSB techniques and supports secure information hiding and retrieval while maintaining the perceptual quality of the resulting stego image. The study contributes to image steganography by emphasizing adaptive algorithm selection rather than reliance on a single fixed LSB configuration.

Keywords: Image Steganography, Least Significant Bit, LSB, Information Hiding, Embedding Capacity, Stego Image, Steganography Imaging System, Data Security.

I. INTRODUCTION

In the present era, where the use of the Internet to share information and data has bloomed, it has become a medium of communication as well as a means of sharing information. The information could sometimes be highly confidential or very personal. There is a need to secure that information, as well as data being transferred over the Internet. Since the Internet is a network of networks, there are millions of users with vast knowledge and tools to snoop on the information we transfer [1]. Hence, to reduce the misuse and disclosure of personal data or secrets, many conventional steganography approaches for hiding data within images have become outdated and exhibit poor perceptibility and accuracy. So, it is a dire need of the time to have a system to hide privacy and secrets within an image automatically, and to have a comparison of all the LSB (Least Significant Bit) techniques so that no one should know about the techniques used for hiding, as the SIS (Steganography Imaging System) is an automatic system [2]. The components of the Stegano hiding system are: the carrier file, which hides the information to be transferred; the prominent attributes that rely on it; and the type of cover LSB method used. Steganography provides a method for concealing secret information within an apparently ordinary digital medium, known as a cover file. In image steganography, the secret information is embedded into image data so that the resulting stego image remains visually similar to

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the original cover image. Unlike conventional approaches in which the existence of protected information may be apparent, steganography attempts to conceal the communication itself. The research presented in this paper uses images as carrier media and focuses on the use of LSB-based embedding techniques to conceal textual information while maintaining the visual characteristics of the image. The manuscript identifies the carrier image, its relevant attributes, the selected LSB method, and the resulting stego image as important components of the proposed hiding system.This method has gained eminent data rate accuracy. My results confirm that the proposed techniques identify the most efficient Algorithm for images based on their required text size. I further adopted similarity measures and performance evaluation strategies to maintain the privacy, confidentiality, availability, and accuracy of the data and images.

The rest of the paper is organized as follows: Section 2 discusses related approaches, and Section 3 presents the proposed Algorithm. In sections 4 and 5, I present experimental results for the proposed approach and compare them with those of available approaches, respectively. Section 6 concludes the paper.

II. RESEARCH GAP

The core issue in steganography is the vast amount of data the user wants to embed in the carrier image. One of the most common and efficient techniques is LSB; however, it is not easy to analyze the technique being used, which is a concern for all researchers around the globe. Based on the research motivation presented in the manuscript, the identified gap is the lack of an integrated system that brings multiple LSB configurations together and performs an automatic comparison and selection process. The proposed research therefore does not focus solely on developing another individual LSB substitution procedure. Instead, it combines four LSB alternatives—LSB1, LSB2, LSB3, and LSB4 within the Steganography Imaging System and uses the available image and text information to determine a suitable technique.

This distinction is important because the proposed contribution is centred on selection and integration. Rather than requiring a user to select LSB1, LSB2, LSB3, or LSB4 independently, the SIS framework is intended to evaluate the available alternatives and identify an appropriate method. The research consequently shifts the focus from the use of a single embedding technique toward an adaptive, multi-variant framework.Another problem is that if we increase the amount of data in the image, suspicious changes will appear, becoming clearly visible to the human eye. For instance, this research will face the challenge of hiding a large amount of data without affecting image quality. A few basic points need to be followed in the first place:

- Size of data that is hidden inside the image.
- Image Quality and the techniques applied should be applied to RGB images.
- Degree of data hiding and protection.

The new Algorithm improves the amount of data and the features in the new image. This research will elaborate on all the points by refining the existing method for hiding information in images using a vision system.

III. PROPOSED APPROACH.

The proposed approach section will contain the architecture of the proposed SIS (Steganography Imaging System). The suggested outlook builds on Ki-Hyun Jung's research. There were a few shortcomings that led us to suggest a revised steganography algorithm.

The main contribution of this paper is an automated comparison and selection of a suitable LSB-based algorithm for image steganography. In this research, four LSB algorithms based on the closest-matching criteria are proposed. This fundamentally makes the suggested steganography method more robust, more vigorous, and more resistant to Steganalysis. The least significant bit, the eighth bit, of a few or most of the bytes in an image is set to a bit of the secret message. In a 24-bit image, we can embed three bits of data in each pixel, one in each of the three LSB positions of the 8-bit values for the blue, green, and red components [8].

Broadening or shortening the word by changing the LSB does not change the apparent visibility of the picture; in fact, the resultant stego picture looks practically the same as the spread picture. In 8-bit pictures, one bit of data can be hidden. The components of the steganography hiding system are: the carrier files that

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hide the information to be transferred, the prominent attributes that rely on them, the type of cover LSB method used, and the stego-file, the final file obtained after information alteration and hiding [9]. The proposed research is the development of an intelligent application, the Steganography Imaging System (SIS), which combines algorithms for LSB1, LSB2, LSB3, and LSB4 to hide plain text within images. The receiver will use the same system to retrieve the plain text hidden inside the image. The selection of the Algorithm used should depend on the image and text sizes. This system will help utilize the visual content of the image. Selection of images in a large-scale image dataset can be based on a user's interests.

In this research, we implemented four algorithms for LSB steganography. The methods of SIS discussed in this research can filter images based on their data size and provide a better LSB algorithm that returns more accurate results. A steganography algorithm consists of two image embedding methods: hiding and retrieving data from the image. It will use a two-layer schema to hide the secret message within the stego message [10]. However, data or secret messages are protected from unauthorized access without revealing them. It maintains image quality and prevents data loss; the image is not affected by any algorithm (LSB1, LSB2, LSB3, and LSB4); image quality remains the same, and there is no data loss during hiding and retrieving an original or stego image and text [11]. The entire system is being performed in MATLAB. Further adopted similarity measures and performance evaluation strategies to maintain the privacy, confidentiality, availability, and accuracy of the data and images.

A. Research Motivation

The motivation for developing SIS arises from the need to improve flexibility in image-based information hiding. A system that incorporates multiple LSB configurations can potentially respond to different embedding requirements more effectively than a system restricted to one fixed configuration. The reported experimental results provide support for this motivation because the four tested configurations do not exhibit a straightforward increasing pattern in their reported text-size values. LSB3 produced the largest reported value of 9,116, while the reported LSB4 value was only 1,600.

Consequently, the proposed automatic selection mechanism is motivated by the observation that “higher LSB” should not automatically be interpreted as “better LSB.” Instead, the appropriate technique should be determined according to the characteristics and requirements of the embedding task. This forms the conceptual basis of the proposed SIS framework.

B. Research Contribution

The principal contribution of the study is the development of a Steganography Imaging System that integrates four LSB algorithms and provides an automated comparison and selection mechanism. The system incorporates both information hiding and information retrieval, allowing the secret text to be embedded into and subsequently recovered from the image. The manuscript further identifies the use of similarity and performance-evaluation strategies to assess the resulting images and hidden information.

The study therefore contributes in three main ways:

- Integration of multiple LSB techniques: LSB1, LSB2, LSB3, and LSB4 are incorporated into a single SIS framework.
- Automatic technique selection: The system is designed to select an appropriate LSB configuration based on image and text requirements.
- Embedding and retrieval: The framework provides both hiding and reverse retrieval processes for the concealed information.

IV. LITERATURE REVIEW

A. Background

i. History of Steganography

The idea of hiding information is too old, dating back to the 50’s, when people in prehistoric Greece hid their information by writing on wooden wax tablets. The first documented secret information was caught in the histories of Herodotus and Demerits by erasing the wax from tablet. One form of hiding information is the use of null ciphers, invisible ink, and unencrypted text messages. For example, by this method one could obscure a text within a paragraph of words, so that, by shuffling every 8th word, the secret data can be

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perceived [3]. Nowadays, digital steganography is in demand. Many embedding techniques use secret data that can be hidden in secret images, known as steganography. Jpeg, .bmp images, Wav audio file, of e- mail messages.

Different authors and scientists are using watermarking and copyrights to hide their secret mark in this way. Luckily, steganography has a very important part in detecting the communication among different terrorist groups around the world. In the last few years the most suspected attack that Osama Bin Laden has been posting images on a well-known website eBay with secret messages encrypted in images to convey messages to different terrorist groups [4].

Steganography, watermarking and cryptography all are related to the same type of hiding but objective and conditions are opposite. The applications of information hiding system are very vast for military, intelligence agencies, online elections, e-banking, medical images. One of the most well-known carrier or cover which can be utilized to transmit secret data and information is images. Digital water marking is a technique that can permanently hide secret data in to a digital media (audio, image, video, and text) that can be detached or extracted later. Watermarking is basically 'writing in hiding' it permanently resides in the host data. Only owner of the copyright can see the complete information. However, in cryptography, encryption and decryption are used; hidden message cannot be decoded without knowledge of the proper key [5]. While in steganography, the secret data itself could not be decoded, existence of the secret data is only known to sender and receiver without the third party involvement.

B. Least Significant Bit Embedding

ii. This technique is most accepted in hiding the information

Stegano hiding system use LSB technique, to embed the data in every bit of the image.

- In an image of 24 bit, 3 bytes are used for each individual pixel, so that each pixel could embed 3 bits of a secret data.
- The stego image would be same as the original image to the human eye.
- The most likely image is 256 colors where each pixel is of 1 byte.
- An image of 120×120 qualities would have the embedding capacity of 13 lac characters.
- For very large images one could hide small images inside image.
- Many applications are commercially using LSB embedding include white noise storm and S-Tools.

Common terms in Steganography Approach:

Stag analysis

The art of detecting a hidden message. Breaking of Steganography is called as steganolysis.

Stego-key

Stego-key is used for hiding the data into image.

Message

It is the information, which is to be kept hidden.

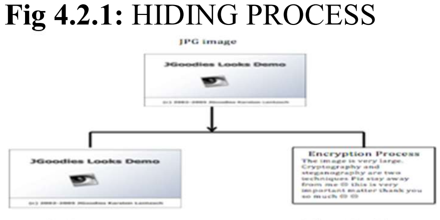
Stego medium

It is the medium, in which the information is hidden.

iii. Hiding Process

The information can be embedded in an image like [29].

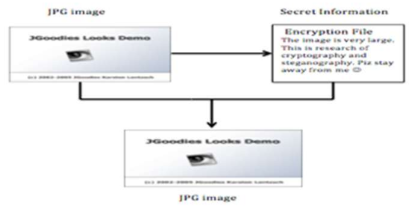
Fig 4.2.1: HIDING PROCESS



iv. Retrieving Process:

The information can be extracted from an image like:

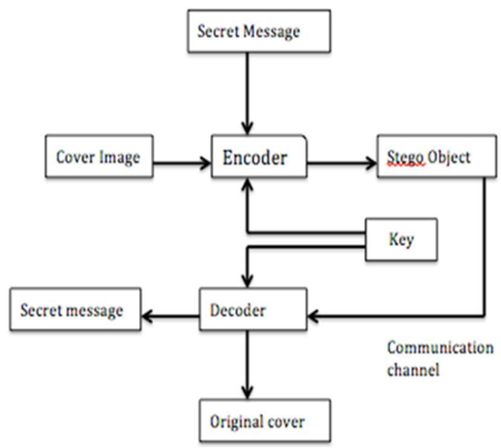
Fig 4.2.2: RETRIEVING PROCESS



C. Image Stag Analysis

Steganolysis is that the breaking of steganography and is the science of detecting hidden information. The main objective of steganolysis is to interrupt steganography and the detection of stego image. Almost all steganolysis algorithms rely on stenographic algorithms introducing applied math variations between cowl and stego image.

Fig 4.3 IMAGE STAG ANALYSIS



V. PROPOSED SOLUTION

The proposed SIS Steganography algorithms consist of 2 layers of security. A system named SIS has been developed for using the proposed Algorithm. This system can test many images of different sizes the normal size of any image 120×120 blocks. Image hiding is reliable and it is easy to decrypt the data from the image, like embedding and extracting of the data from the image. SIS system's important feature is that it uses the transform of least significant bit based hiding method to utilize the data from the image. SIS maintains privacy, confidentiality and accuracy of the data.

In this system, we have client side programming and server side programming as well.

Goal of the proposed SIS Steganography algorithms is consisting of two image embedding methods which are to hide, and to retrieve the data from the image. It will use two layers' schema to hide the secret message from stego message [24]. However, data or secreted message is protected from an unauthorized access without revealing this data. It maintains the image quality and data loss, image must not be effected by using any algorithm used, image quality remains same and there should be no data loss while hiding and retrieving an original or stego image and text.

A. LSB Technique

The Least significant bit (the eighth bit) of a few or the greater part of the bytes inside a picture is changed to a bit of the secret message. Digital pictures are basically of two sorts (I) 24 bit pictures and (ii) 8 bit pictures. In 24 bit pictures, we can embed three bits of data in every pixel, one in each LSB position of the three eight bit values. Of each of blue, red and green component. Expanding or diminishing the worth by changing the LSB does not change the presence of the picture much so the resultant stego picture looks

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practically same as the spread picture. In 8 bit pictures, one bit of data can be hidden. The image of 800x60 pixels can store 1,440,000 bits or 180,000 bytes of data.

VI. EXPERIMENTAL RESULTS

This is the main figure (GUI) of my research. In MATLAB, a figure can be invoked by entering the figure name and pressing enter. On this figure, we have two push buttons. The first button with the tag "Add Image", and by clicking on it another figure will be opened that will guide the user to add image. Second button having tag "Exit" will lead the user for exiting the SIS system.

Fig 6: MAIN FIG

A. Gui_Steg fig

When user first time setup this system, he/she need to insert the original image and text file and user must hide this text file in original image by pressing pushbutton of data hiding. Same process carried out for inserting or browsing stego image, secret text and data retrieving. I have created the following figure for this purpose.

Fig 6.1: INVOKING ADD IMAGE FIGURE FROM MAIN WINDOW

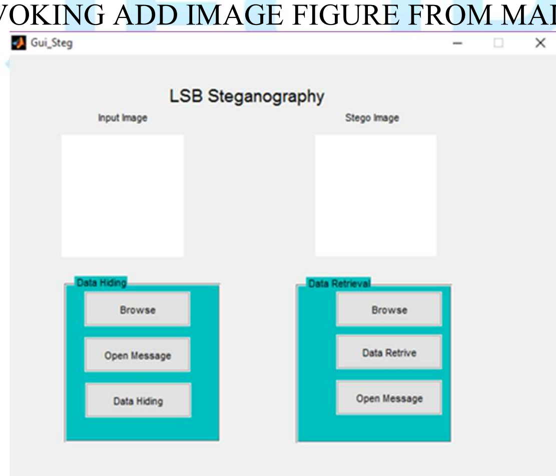

Fig 6.2: BROWSING SINGLE IMAGE FOR INSERTION

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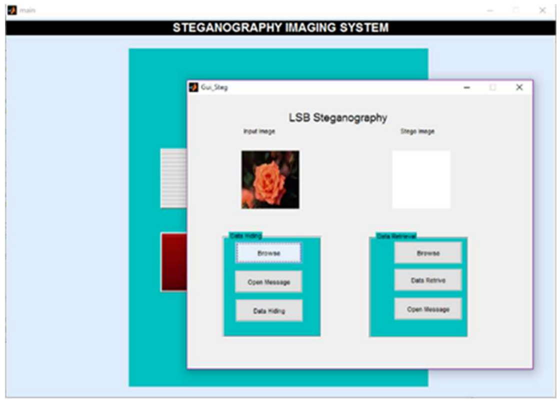


B. Lsb Steganography Algorithm:

i. **LSB Techniques**

LSB 1 Technique

Step 1 Convert the data from decimal numbers to binary numbers (using ASCII code).
Step 2 Read the cover image
Step 3 Convert the cover image from decimal numbers to binary number
Step 4 Break the bytes that are hidden into bits
Step 5 Take first 8 bits of the original data from the cover image.
Step 6 Replace the LSB by one bit of the data to be hidden
First byte of original information from the Cover image:
E.g.: 1 1 0 11 0 0 0
First bit of the data to be hidden:
1 Replace the LSB.

Fig 6.2.1: BIT SEQUENCE EXCHANGE FOR LSB 1

1	**1**	**0**	**1**	**1**	**0**	**0**	**0**

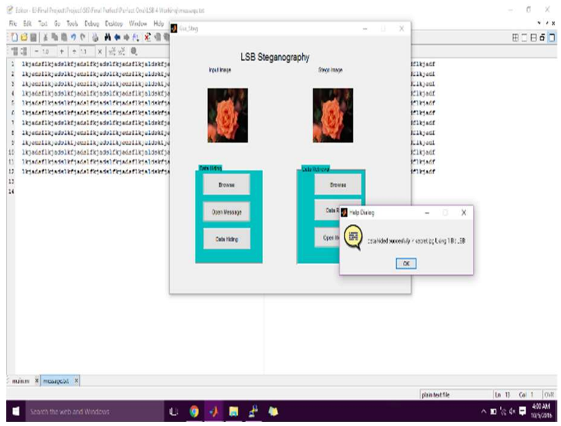
↓

1	**1**	**0**	**1**	**1**	**0**	**0**	**1**

This process will be continued for first 8 bits of data and conceal the first byte of data.

Step 7: Continue first 6 steps for all pixels.
After embedding data into images using LSB technique:

Fig 6.2.2: BROWSE IMAGE FOLDER SELECTION AND INSERTION OF MESSAGE FILE AND DATA HIDING BY USING LSB1 COMPLETION MESSAGE BOX.



Research Processing Details.
Image size: 120 ×120
Algorithm used: 1 Bit LSB
txt_size = 46.0100
method_mod_value = 1
txt_size = 4601
Width = 120
Method = 1
LSB 4 Not Found Trying LSB 4
LSB 3 Not Found Trying LSB 3
LSB 2 Not Found Trying LSB 2

ii. Lsb2 Technique

Step 1 Convert the data from decimal numbers to binary numbers (using ASCII code).
Step 2 Read cover image
Step 3 Convert the cover image from decimal numbers to binary number.
Step 4 Break the bytes that are hidden into bits.
Step 5 Take first 8 bits of the original data from the cover image.
Step 6 Replace the LSB by two bit of the data to be hidden
First byte of original information from the Cover image:
E.g. 1 1 0 11 0 0 0
First two bits of the data to be hidden:
1 Replace the LSB.

Fig 6.2.3: BIT SEQUENCE EXCHANGE FOR LSB 2

1	**1**	**0**	**1**	**1**	**0**	**0**	**0**

1	**1**	**0**	**1**	**1**	**0**	**1**	**1**

This process will be continued for first 8 bits of data and conceal the first byte of data.
Step 7: Continue first 6 steps for all pixels.
After embedding data into images using LSB technique:

Fig 6.2.4: INVOKING SEARCH OPTIONS FIGURE FROM MAIN WINDOW

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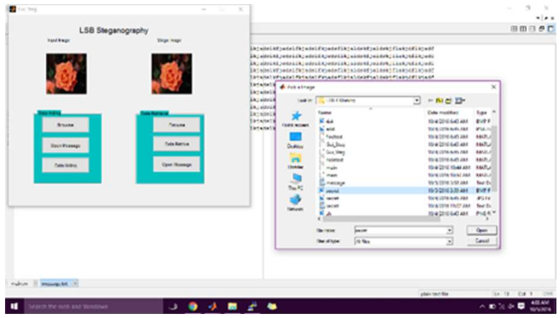
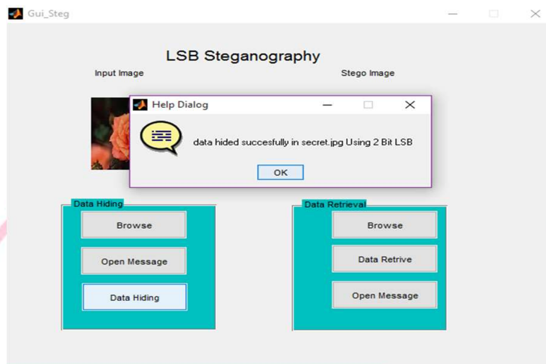


Fig 6.2.5: HIDING IMAGE INSIDE THE TEXT FILE BY USING LSB2 METHOD



Research Processing Details.
Image size: 120 ×120
Text Size: 4861
Algorithm used: 2 Bit LSB
Width = 120
Method = 2
4 Not Found Trying LSB 3
LSB 3 Not Found Trying LSB 2

iii. LSB3 Technique

Step 1 Convert the data from decimal numbers to binary numbers (using ASCII code).
Step 2 Read cover image
Step 3 Convert the cover image from decimal numbers to binary number
Step 4 Break the bytes that are hidden in bits
Step 5 Take first 8 bits of the original data from the cover image.
Step 6 Replace the LSB by three bit of the data to be hidden
First byte of original information from the Cover image:
E.g. 1 1 0 11 0 0 0
First three bits of the data to be hidden:
1 Replace the LSB

Fig 6.2.6: BIT SEQUENCE EXCHANGE FOR LSB 3

1	**1**	**0**	**1**	**1**	**0**	**0**	**0**

1	**1**	**0**	**1**	**1**	**1**	**1**	**1**

This process will be continued for first 8 bits of data and conceal the first byte of data.

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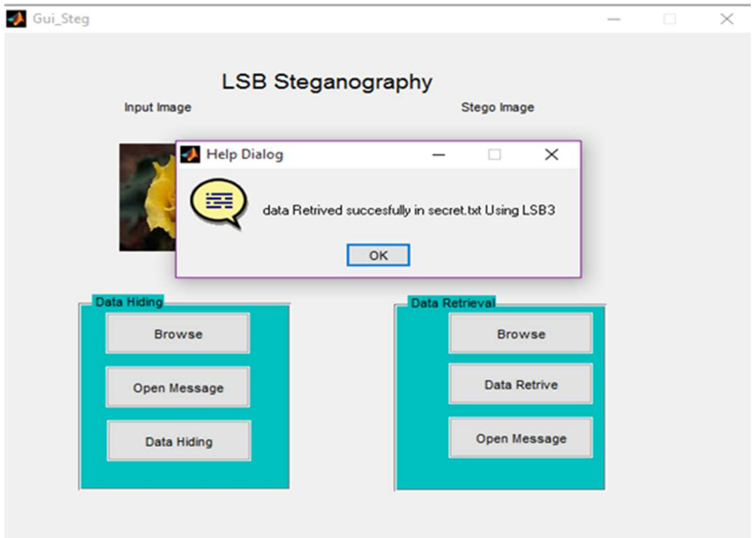
Step 7: Continue first 6 steps for all pixels.
After embedding data into images using LSB technique:
Fig 6.2.6: HIDING IMAGE INSIDE THE TEXT FILE BY USING LSB3 METHOD

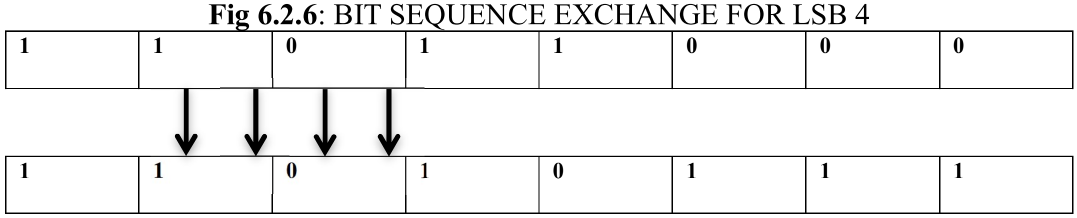


Research Processing Details.
Image size: 120 ×120
Text Size: 9116
Algorithm used: 3 Bit LSB
Txt_size= 9116
Width = 120
Method = 3
LSB 4 Not Found Trying LSB 3

iv. LSB 4 Technique

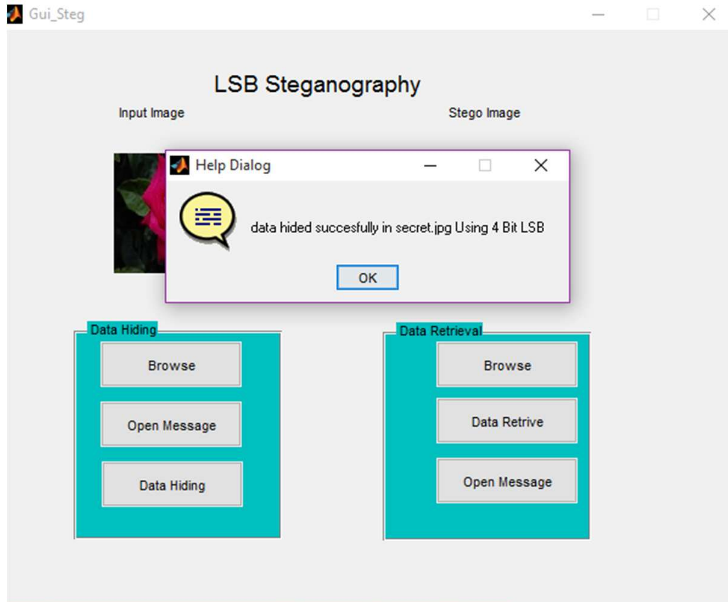
Step 1 Convert the data from decimal numbers to binary numbers (using ASCII code)
Step 2 Read cover image
Step 3 Convert the cover image from decimal numbers to binary number.
Step 4 Break the bytes that are hidden in bits
Step 5 Take first 8 bits of the original data from the cover image.
Step 6 Replace the LSB by four bits of the data to be hidden
First byte of original information from the Cover image:
E.g.   1 1 0 11 0 0 0
First bit of the data to be hidden: 1
Replace the LSB

Fig 6.2.6: BIT SEQUENCE EXCHANGE FOR LSB 4



This process will be continued for first 8 bits of data and conceal the first byte of data.
Step 7: Continue first 6 steps for all pixels.
After embedding data into images using LSB technique:

Fig 6.2.6: HIDING IMAGE INSIDE THE TEXT FILE BY USING LSB4 METHOD.



Research Processing Details
Image size: 120 ×120
Text Size: 1600
Algorithm used: 4 Bit LSB
Txt_size =1600
Width = 120
Method = 4

The proposed techniques for SIS is the most superior approach in all parameters than the all previous approaches as the result is shown in the research processing details. The research processing details for the auto selection of suitable LSB technique is giving most efficient, reliable and best results than the normal; LSB techniques [30]

VII. COMPARATIVE ANALYSIS OF THE LSB TECHNIQUES

A comparative analysis was performed using the experimental processing values reported for LSB1, LSB2, LSB3 and LSB4. All four reported tests used a 120 × 120 image. The reported text-size values were 4,601 for LSB1, 4,861 for LSB2, 9,116 for LSB3 and 1,600 for LSB4. These results demonstrate that the reported text-size value does not increase monotonically as the nominal LSB level increases.

Table 7.1: COMPARATIVE EXPERIMENTAL RESULTS

Technique	Image size	LSB level	Reported text size	Change vs. LSB1
LSB1	120 × 120	1 bit	4,601	0.00%
LSB2	120 × 120	2 bits	4,861	+5.65%
LSB3	120 × 120	3 bits	9,116	+98.13%
LSB4	120 × 120	4 bits	1,600	−65.22%

The comparison shows that LSB2 is approximately 5.65% higher than LSB1, while LSB3 is approximately 98.13% higher than LSB1. In contrast, LSB4 is approximately 65.22% lower than LSB1 and approximately 82.45% lower than LSB3. Therefore, the highest nominal LSB level does not correspond to the highest reported text-size value in these experimental records.

Fig 7.1: BAR-CHART COMPARISON OF THE REPORTED TEXT-SIZE VALUES FOR LSB1–LSB4.

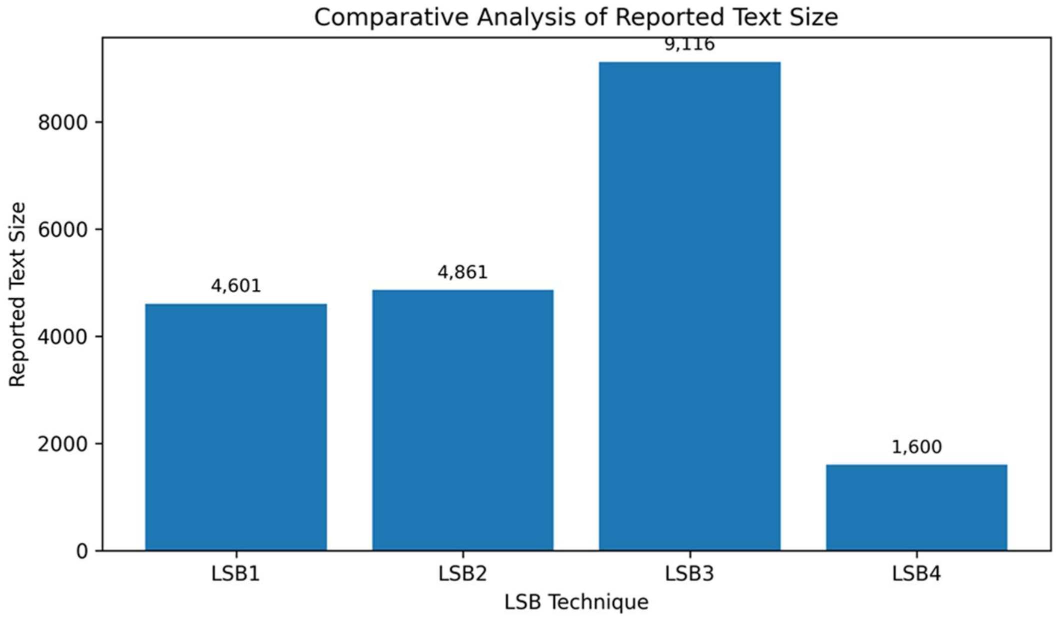
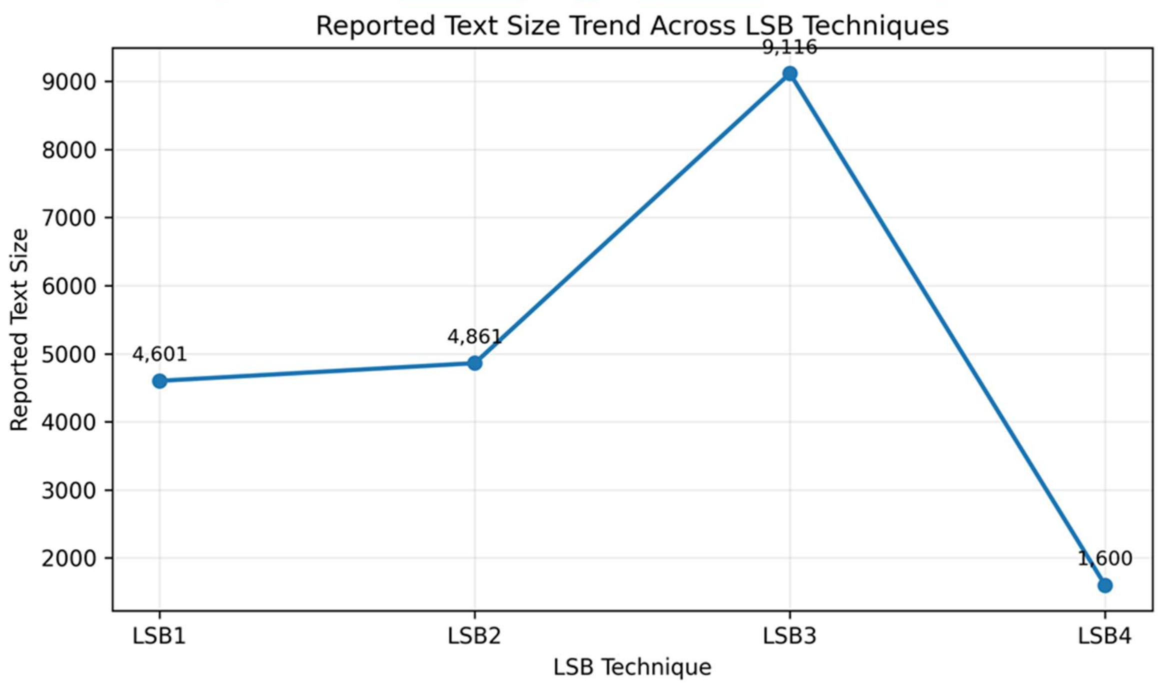


Fig 7.1 provides a direct visual comparison. LSB3 has the highest reported text-size value, whereas LSB4 has the lowest. This supports the rationale for an automatic selection mechanism that considers the image and message conditions rather than assuming that a higher LSB level will always produce the best result.

Fig 7.2: TREND GRAPH OF THE REPORTED TEXT-SIZE VALUES ACROSS THE FOUR LSB TECHNIQUES.



The trend graph highlights the non-linear behaviour of the reported results, with a substantial increase from LSB2 to LSB3 followed by a sharp decrease at LSB4. The manuscript does not provide standardized PSNR, SSIM, MSE, extraction accuracy, or execution-time measurements for all four techniques. Consequently, this comparison is limited to the reported text-size values and should not be presented as a complete proof of superiority in embedding capacity or visual quality. A stronger future evaluation should use the same cover images and identical payload sizes for every technique and report the same performance metrics for each method.

VIII. FUTURE WORK AND CONCLUSION

In this paper, a novel steganography LSB technique is presented. The new LSB technique embeds secret information in the cover image based on its pixel values. The motivation of proposed approach is that there isn't any steganography technique until yet into the best of my knowledge, that have combined Algorithm of all the LSB's [2]. The idea behind the research is to develop an intelligent application Steganography Imaging System which have combined algorithms for LSB1, LSB2, LSB3 and LSB4, the system is designed in such a way that will hide the plain text inside the image [30]. Which is the new implemented technique based on auto-selection of suitable LSB technique embeds the secret information in the cover image. The experimental results show that the proposed technique has the high perceptibility and compatibility.

Furthermore, none of the available techniques have been used to implement more than one LSB technique in one analysis. This proposed technique also, provides the reverse process of hiding algorithm. The stego images obtained by the proposed technique still have high visual quality and the hidden information is not perceptible to naked eye in any way.

IX. REFERENCES

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