IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

IMAGE BALANCED SCALABLE IMAGE STEGANOGRAPHY USING LSB

1st Dr. Pritesh Patil, 2nd Shubham Patil, 3rd Kapeesh Rathod, 4th Aditya Dukandar, 5th Jay Kathod
1st Prof of information technology department,
2nd Author, 3rd Author, 4nd Author, 5rd Author Students of information technology department
AISSMS IOIT, Pune, India.

Abstract: Steganography is a robust method for secure information dissemination; whereby private data is integrated into digital media with an intention to keep them imperceptible. The work introduces a productive image steganography using the Least Significant Bit (LSB) substitution strategy, wherein concealed data is covertly placed into pixel intensity in an image. LSB method remains a favourite methodology owing to the simplicity in deployment, very large capacity, as well as being insensitive to reducing the image's quality. We present the embedding and extraction process, evaluate the strength of the method with respect to robustness, and compare its performance using Peak Signal- to Noise Ratio (PSNR) and Mean Squared Error (MSE) measurements. Experimental findings show that the proposed method efficiently hides information with imperceptible loss in image quality. The research points to the possibility of LSB-based steganography as a secure method of communication and discusses its shortfalls, like susceptibility to steganalysis. Future extensions such as adaptive embedding and cryptographic support are also examined to enhance security and attack resilience.

Keywords: Steganography, Least Significant Bit (LSB), Image Processing, Data Security, Information Hiding, Steganalysis

1. INTRODUCTION:

With the advent of the digital age, protecting sensitive information in transit has become a paramount issue. Steganography, the science of hiding data within digital media, presents a compelling solution for safe communication. Steganography, unlike encryption that only makes the data unreadable, hides the confidential information in seemingly innocent cover media, making its presence undetectable to unauthorized viewers. Among different steganographic methods,
image-based steganography has received much importance owing to the common availability and popularity of image files. Least Significant Bit (LSB) technique is among the most popular methods applied in image steganography due to its ease and effectiveness. The method works by altering the least significant bits of an image pixel values to conceal secret information in such a way that the introduced alterations are minimal and cannot be detected by the human eye. The LSB method provides a good trade-off between the embedding capacity and the quality of the stego image and is thus applicable to a wide range of applications including secure communication, digital watermarking, and copyright protection. This paper is dedicated to the implementation of the LSB method for image steganography. We describe the embedding and extraction process of secret data inside an image, address the quality of the technique with respect to image quality and data capacity, and provide a comparative study in accordance with significant measures like Peak Signal-to-Noise Ratio (PSNR) and Mean Squared Error (MSE). In addition, the paper discusses possible weaknesses of the LSB approach to steganalysis methods and investigates avenues for enhancing security and resilience.

2. TRADITIONAL LSB STEGANOGRAPHY:

Least Significant Bit (LSB) is among the easiest and most widely utilized methods of hiding secret information inside digital images. It is derived from the theory that pixel value least significant bits can be manipulated without adding apparent changes to the image. LSB is much popular because it is easy, creates little distortion, and has large data hiding capacity. In conventional LSB steganography, the hidden message is inserted into the image by changing the least significant bit of every pixel's colour channels. Images are often encoded in 8-bit per channel, so each colour channel (Red, Green, Blue) of a pixel is encoded in 8 bits. The LSB of the bits is modified to hold the secret data. Therefore, every pixel in the image has the least significant bit replaced by an equivalent bit from the secret message, and all this is done in such a manner that the modifications are minimal and hard to be seen by the human eye.

Process of Embedding:

1.Image Converting to Binary Format: The image is then converted to binary format, such that each pixel's colour values (in RGB mode) are coded using 8 bits for each channel.

2.Message Encoding:

The message is then encoded in binary form, dividing the message into bits to be added into the image pixel LSBs.

3.Substitution:

For every pixel, the LSB of every colour channel is substituted by the respective bit of the secret message. When the message length is more than the number of available pixels, other methods, like the utilization of multiple LSBs per pixel or the utilization of a large image, are used.

4.Save the Stego Image After the embedding process, the altered image is stored. The alteration of the LSBs is not noticeable by the human eye, giving rise to a stego image that is practically indistinguishable from the original.

Process of Extraction:

In order to extract the secret message from the stego image:

1.Extract LSBs:

The recipient pulls out the LSB from every pixel in the image.

2.Reconstruct the Message:

These pieces of information that have been removed are then brought together to produce the binary stream of the message being concealed and transformed back to its original appearance.

The advantages of traditional LSB Steganography:

1.Simplicity in Implementation: LSB method is very easy to perform and does not require complex calculations or algorithms.

2.Good Capacity: It has good data capacity, where every pixel can be used to hide at least one piece of the message.

3.Minimal Distortion: The changes to the image are usually not observable by the human eye, especially when LSBs alone are altered.

Disadvantages of Traditional LSB Steganography:

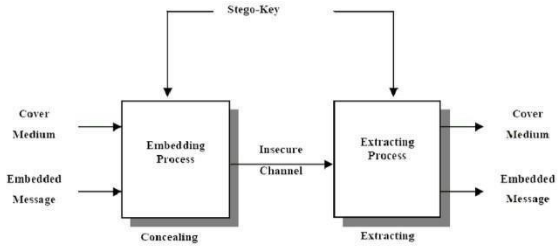
1.Vulnerability to Attacks: The method is susceptible to steganalysis attacks, whereby attackers are able to search for pattern or anomalies within pixel values within the image.

2.Image Quality Degradation: Even though distortion is not perceptually introduced by LSB modification, extremely high data embedding may introduce degradations to the image quality, which could be sensed through advanced techniques.

3.Finite Capacity: A finite amount of data that can be embedded is calculated based on the image capacity.

3. IMAGE BALANCING IN LSB STEGANOGRAPHY

In traditional Least Significant Bit (LSB) steganography, the primary concern is the imperceptibility of the hidden information and the minimum amount of image distortion. While the LSB method is effective in hiding data within an image, excessive modification of pixel values can lead to noticeable changes in image quality or a statistical distortion of the image's pixel distribution. Image balancing techniques attempt to reverse these issues by maximizing the spread of changes across the image in an effort to preserve its visual coherence. What is Image Balancing? Image balancing is the method of adjusting the embedding process in a way that the pixel changes induced by data hiding are spread evenly throughout the image. This helps minimize the perceivable distortions and maintain the overall image quality intact. Balancing avoids changes in pixel values to be grouped in certain regions, which could be detectable by steganalysis methods or result in visual distortion. The need for image balancing is due to the reason that LSB steganography tends to modify pixels in such a way that it may create statistical anomalies, such as altered pixel histograms or abrupt pixel value changes within local contexts. To compensate for these issues, the idea of image balancing is incorporated to avoid pixel alteration bias and reduce detection risk.



(Figure 1)

Methods for Image Balancing in LSB Steganography:

1. Adaptive Embedding: Adaptive embedding methods vary the number of bits to embed with respect to image characteristics. Rather than inserting a fixed number of bits into all pixels, this method selects pixels such that the change of the LSB would have a negligible effect on image quality. It handles high-frequency areas (regions containing complex textures or edges) and low frequency areas (smooth regions) differently, hence spreading the changes uniformly across the image.
2. Randomized Pixel Selection: Rather than inserting data into consecutive pixels or areas, randomized pixel selection distributes the changes across the image. This lowers the chances of clustering changes in certain areas and hence reduces the possibility of detection by steganalysis software. Randomization also enhances resistance to statistical analysis, rendering the concealed data more difficult to retrieve using conventional techniques.
3. Histogram Equalization: Histogram equalization may be used to equalize the distribution of pixel intensity prior to embedding the data. Histogram equalization makes the image more even by adjusting its brightness and contrast. By equating the histogram of the image, any alterations to the LSBs will not likely cause obvious patterns or movements in the distribution of pixels, weakening the ability of steganalysis.
4. Colour Channel Balancing: In RGB images, all colour channels (Red, Green, Blue) hold pixel data that can be employed for information hiding. Evenly distributing the data embedding over all colour channels may prevent generating imbalances in one channel, which can be detected by analysis techniques. For example, embedding data uniformly in all three channels, the statistical distribution of colour values is uniform, and hence the image's look is not changed.
5. Spread Spectrum Techniques: The method spreads the data across a number of pixels in a non-linear fashion so that one pixel is not subjected to extreme change. The spread spectrum method reduces the chance of being detected by patterns and increases the security of the hidden Data.
6. Dynamic Bit Replacement: Dynamic bit substitution randomly substitutes either the LSB or higher-order bits based on the local properties of pixels. In areas that are sensitive to vision, the LSB might be substituted, whereas less sensitive regions have higher order bits substituted to balance the embedding process and reduce distortions that are detectable.

Benefits of Image Balancing:
1.Improved Imperceptibility: By spreading the changes across the image, perceptible distortion is minimized, and the visual quality of the image is maintained.
2.Improved Security: Balanced embedding helps reduce statistical anomalies and improves steganalysis resistance.
3.Better Robustness: The random distribution of pixel modifications makes it harder for detection algorithms to identify the stego image as having been tampered with. Limitations and Challenges
1.Extra Complexity: Using image balancing techniques can introduce additional computational complexity, which prolongs processing time and resources.
2.Data Hiding Capacity: Some image balancing techniques, particularly those employing adaptive schemes or dynamic bit replacement, tend to reduce the overall data hiding capacity in the image.
3.Compression Trade-off: Balancing can affect the compressibility of the stego image, so it is likely that the image may be of greater size or less compressible.

4. ADVENTAGES OF IMAGE BALANCING IN LSB STEGANOGRAPHY

Image balancing in LSB steganography offers a number of benefits that substantially improve the security, visual quality, and robustness of the embedded data. Through proper distribution of the alterations introduced to the image in the embedding procedure, image balancing resolves the weaknesses of conventional LSB approaches. The major benefits of integrating image balancing are outlined below:

1. Enhanced Visual Quality and Imperceptibility: Another major benefit of image balancing is the maintenance of image quality. In standard LSB steganography, the embedding of data may cause minor perceptual distortions, particularly when lots of information are concealed in a limited image. With even spreading of the alterations over the image, image balancing reduces the visible artifacts and keeps the stego image nearly indistinguishable from the cover image, thus maintaining high imperceptibility.
2. Improved Security and Detection Resistance: Image balancing enhances the security of the concealed information by lowering the chances of detection via statistical analysis or steganalysis. Randomizing the pixel selection and distributing the changes throughout the image makes the statistical characteristics of the image less prone to exhibit prominent anomalies, hence making it more difficult for the attackers to detect the stego image. The randomness and uniformity in the pixel changes make it more difficult to tell cover from stego images using statistical methods.
3. Steganalysis Resistance: Steganalysis methods are usually based on identifying particular patterns in the pixel values, histograms, or color channels of the image indicating hidden data. Balancing of images makes the patterns less predictable by distributing the data throughout the image. This minimizes the image's susceptibility to detection by steganographic tools, which normally detect localized patterns created by dense embedding of data within specific areas of the image. Balanced embedding adds strength to the steganography method, protecting it from even advanced detection.
4. Maintenance of Statistical Properties: In classical LSB steganography, changing the least significant bit in each pixel might introduce detectable patterns in the pixel distribution, including pixel histogram anomalies or violations of the correlation between adjacent pixels. Image balancing prevents the maintenance of statistical characteristics of the image by distributing the pixel changes in an even way, avoiding the formation of artifacts that are easy to detect. This makes it easy for the stego image to merge into natural images and thus increases its security and perceptual invisibility.
5. Advanced Capability in Data Embedding: Although the classical LSB steganography has low capacity for embedding data because it would introduce apparent distortion, image balancing can accommodate greater embedding data with minimal compromise of image quality. Image balancing is capable of finding the optimal possible secret data which can be hidden in the image without jeopardizing the visual content of the image through clever planning of the embedding process and sensitive choice of the bits to change.
6. Incorporating Strategy Flexibility: Images balancing offers flexibility in choosing various embedding methods such as adaptive embedding, randomized pixel choice, and dynamic bit substitution. Such flexibility enables stegano graphers to use the embedding process according to specific needs, such as image type, susceptibility to distortion, or capacity limitation. Flexibility with varying conditions makes images balancing a viable choice for many steganographic applications.
7. Anti-Image Manipulation Protection: Balanced embedding serves to minimize the threat of image manipulation that may expose the existence of concealed data. If data is embedded in a regular pattern across the image, it is less probable for attackers to be able to easily identify or manipulate the concealed data using traditional image processing methods, including cropping, resizing, or compression. This renders the concealed information more resistant to deliberate or accidental manipulation.
8. Improved Perceived Data Integrity Where data is embedded in an image, users tend to want to preserve the integrity and quality of the image and the embedded data. Image balancing gives the highest perceived integrity since the structure of the original image remains intact. This is especially useful in uses where the image has to keep its original visual look, for example, watermarking, digital signatures, and copyright marking.

5. CHALLENGES AND OPEN RESEARCH ISSUES

Although LSB steganography with image balancing offers great security, perceptual stealth, and robustness, several challenges and open problems are still to be addressed. These challenges span a broad range of domains including image quality, data hiding capacity, computational complexity, and immunity to powerful detection methods. The following are the primary challenges and open research areas in LSB Steganography:

1. Steganalysis and Detection Techniques:

Image balancing improvements notwithstanding, LSB-based steganographic techniques are susceptible to a number of steganalysis methods. Sophisticated detection algorithms involving statistical analysis, machine

learning algorithms, and deep learning models may detect concealed data by examining distributions of pixels, image histograms, or pixel relationships. Open problems in this field are Creating more evolved steganographic methods that withstand newer detection mechanisms. - Researching dynamic embedding techniques that learn to adapt based on the content
of the image in order to make detection harder. - Researching methods to ensure that the stego images become statistically undetectable from natural images even to more sophisticated steganalysis.

2. Data Embedding Capacity vs. Image Quality Although image balancing makes imperceptibility better, typically at the expense of the ability to embed information in the picture. The competition between embedding capability and image quality is still one of the principal challenges for LSB steganography. Areas which are open for research include

Maximizing embedding capacity without loss of image quality. This may include sophisticated algorithms that painstakingly choose pixels or utilize higher-order bits in embedding such that the image is not compromised.

3. Computational Complexity and Efficiency: Sophisticated image balancing and adaptive embedding schemes may add substantial computational burden. As digital images increase in size and resolution, real-time embedding and extraction of secret data can become a computationally demanding process. Unresolved open problems in this field are:
    a. Creating algorithms that trade off embedding capacity and processing speed, making embedding and extraction feasible in real time.
    b. Investigating parallel or distributed solutions that minimize processing time for embedding in massive image databases.

4. Robustness to Image Processing Operations: Stego images usually undergo many image processing operations (e.g., compression, resizing, cropping, and filtering) that have the potential to weaken the hidden data quality. Providing the hidden data with robustness to such manipulations is a big challenge. Some of the open challenges include:
    a. Enhancing resilience of LSB steganography methods against general image manipulations with the retained covert data.
    b. Examining means to hide redundant information in the image, i.e., via error-correction methods or multi-layer embedding, to defend against possible loss of data due to image processing.

5. Security Issues:

Despite the enhancement in security by image balancing to make detection less probable, LSB steganography is still susceptible to some attacks, such as:
    a. Differential analysis that may reveal the concealed data by altering pixel values.
    b. Collusion attacks, in which an attacker collages a number of stego images to recognize patterns. Studying hybrid encryption-steganography techniques, where the concealed data is encrypted as well as embedded in the image, may offer greater security, but the complexity and practicality of such techniques are to be researched further.

6. Perceptual and Context-Aware Embedding: Existing methods of image balancing in LSB steganography tend to treat all pixels uniformly. Human perception of image quality is not uniform throughout an image. Some parts of the image, like those with fine details or edges, are more sensitive to changes than others. Open research areas include: - Context-aware embedding which considers the perceptual sensitivity of various parts of an image and emphasizes embedding less important areas first, while altering fewer important ones.
    a. Perceptual models for controlling the embedding process in such a manner that information can be optimally concealed without being apparent in essential parts of an image. 7. Lossless and Lossy Compression Problems: The relationship between steganography and image compression is an important problem. Both lossless and lossy compression schemes can maintain or destroy the hidden data, based on how data is embedded and how compression schemes interact with the pixel values. Open research challenges here are:
    b. Examining compression-resistant methods that can maintain data integrity despite compression operations.
    c. Creating techniques for embedding data in a manner that makes it lossy and lossless compression-compatible without major loss of data or image quality.

8. Ethical and Legal Issues:

With advancements in steganography, ethical and legal issues also arise, especially concerning misuse for criminal purposes, including data exfiltration or concealment of malicious content. Future research areas in this field include:

- Creating legal frameworks to govern the application of steganographic methods in digital media.
- Examining means to detect and track steganographic activity for the sake of compliance with laws and preventing abuse.

1. Hybrid Steganographic Techniques: Future studies can investigate how LSB steganography can be combined with other steganography techniques like frequency-domain techniques, spread spectrum methods, or transformdomain embedding. Combining LSB with these might improve the capacity of embedding and steganalysis robustness and still preserve the imperceptibility of the data. For instance:

   •Discrete Cosine Transform (DCT) and LSB: Information embedding in the frequency domain via DCT renders the information less noticeable to humans. A composite method of using LSB and DCT may have increased security and resistance.

   •Wavelet Transform and LSB: Embedding via wavelets is such that there can be a hierarchical decomposition of images, thereby giving a flexible mechanism for embedding data at multiple scales and frequencies, increasing security against attacks as well as raising capacity.

2. Machine Learning-Based Steganography: Machine learning has proved to be highly effective in improving security and performance in numerous areas, including steganography. Future work can involve using machine learning models to:

   •Automate the best pixel selection for embedding based on content, thus enhancing data embedding efficiency with reduced visual distortions.

   •Anti-steganalysis detection and protection by developing adversarial models to produce stego images that are resilient to detection algorithms.
3. Perceptually Aware Embedding: Since image quality and visual perception are key factors for the success of LSB steganography, further research could target perceptual models that control the embedding process. These models would take into account the human visual system's (HVS) sensitivity to image regions so that data is embedded in a manner that reduces the amount of noticeable distortions. Future directions are:

   •Region-based embedding: Detecting less perceptually sensitive areas (e.g., background or flat regions) for data embedding while maintaining the quality of important areas (e.g., edges, textures).

   •Visual saliency models: Employing computational models of human attention to inform the embedding location of data in areas less prone to capture visual attention.

4. Image Processing and Compression Robustness One of the strongest limitations of steganography in LSB is sensitivity of concealed information to typical image-processing operations, including compression, resizing, trimming, and added noise. Opportunities for future investigation include:

   •Robustness embedding methods in which data gets preserved even with image manipulations, like the use of error correcting codes that support recovery of secret information following deterioration due to compression or other operations.

   •Lossless LSB steganography: Researching means to make the embedding lossless such that the concealed data is left intact even after applying lossy compression methods.

5. High-Performance Computational Methods: As images grow in size and complexity, it is essential to create high-performance algorithms that are efficient and quick. Future work should include:

   •Parallelization of LSB embedding algorithms: Parallelizing the data embedding process across a number of processing units or machines to accelerate the embedding and extraction processes.

•GPU-based solutions: Utilizing graphical processing units (GPUs) to speed up the computationally intensive aspects of
the steganographic process, allowing real-time embedding and extraction for high-resolution images.

6. Privacy-Preserving Data Transmission: As privacy issues increase, LSB steganography can have future applications in secure communication and privacy-enhancing data transmission. Future studies may involve the integration of cryptography and LSB steganography to guarantee that the concealed information is not only deeply concealed but also secure from unauthorized use. Some future research areas in this field are:

   •Cryptographic steganography: Hiding encrypted information inside images such that even if it is recovered, it is
   unreadable without knowing the decryption key.

   •Privacy-aware steganography: Designing systems to include extra privacy capabilities, for example, mechanisms for
   access controls of who will be able to decode or read out the secret data.

7. Real-World Applications and Standards: As steganography evolves further, practical uses will be realized in areas of digital watermarking, copyright management, and digital forensics. Potential directions for future work include:

   •Standardization of steganography protocols: The development of standards for the employment of steganography in digital
   media, particularly in high consequence applications like secure communication and copyright protection.

   •Blockchain integration: Investigating how blockchain technology can be used to provide integrity and traceability for
   stego images, especially in digital watermarking and proof of ownership applications.

8. Ethical and Legal Implications: With the increased advancement of steganography tools, there is increasing concern about their abuse to facilitate illicit purposes like cybercrime, data exfiltration, or concealing illicit material. Future work should also involve:

   •Establishing ethical standards for the application of steganography methods, particularly in commercial or governmental
   applications.

   •Legal frameworks for controlling the application of steganographic methods, avoiding misuse of these technologies while
   encouraging their application for legitimate uses.

6. CONCLUSION

In this paper, Least Significant Bit (LSB) steganography has been explored in the hiding of information within digital images with particular focus on utilizing image balancing techniques to ensure maximum effectiveness of the process. LSB steganography is a method with extensive use from the simplicity and efficiency of enabling confidential information to be hidden within image pixels without diminishing significant visual quality levels. But as we have described, traditional LSB methods are faced with noticeable distortion problems, detection vulnerabilities, and capacity limitations. The introduction of image balancing brings the significant enhancement with overcoming these issues, increasing not only the security but also imperceptibility of the hidden information. By facilitating more even dispersion of the changes in pixels over the image and adaptive embedding algorithms, image balancing enhances the robustness of stego images towards statistical analysis as well as steganalysis so that they cannot be easily discovered. It further allows better usage of resources by the image along with more effective a capacity for the embedding of information without degrading the quality of the image. Despite these developments, several challenges need to be overcome, including resistance to image processing operations, the trade-off between data capacity and image quality, and the need for more efficient and faster embedding algorithms. As we have outlined, there are a number of avenues to pursue in further refining LSB steganography, including exploration of hybrid steganographic methods, using machine learning in the improvement of embedding strategy, and the extension of compression-resistance methods to preserve hidden information unchanged from general image processing manipulations. In brief, LSB steganography, particularly with the inclusion of image balancing techniques, holds immense potential for secure data hiding and communication use. However, further study is required to overcome existing challenges and streamline the technique to its full potential for realworld applications to make it effective as well as secure in the face of upcoming detection techniques and digital forensics procedures. With continued growth, LSB steganography can potentially be an essential privacy protection tool and secure communication method in the future.

7. RESULTS

To evaluate the performance of the Image Balanced Scalable Image Steganography Using LSB system, various tests were conducted on different standard images with varying resolutions and payload sizes. The evaluation focused on two key aspects:

- Imperceptibility (visual similarity between cover and stego images)
- Quality Metrics like PSNR (Peak Signal-to-Noise Ratio) and MSE (Mean Squared Error)

7.1. Test Setup

- Test Images: Standard grayscale and colour images (e.g., Lena, Baboon, Pepper) with sizes 256×256 and 512×512 pixels.
- Message Size: Varied from 100 characters to 5000 characters.
- Environment: Python implementation using PIL and NumPy on Windows OS.

7.2. Parameters Measured

- PSNR (dB): Higher PSNR indicates better image quality.
- MSE: Lower MSE means fewer differences between the original and stego image.
- Time for Embedding/Extraction: Measured to verify scalability.
- Visual Check: Manual comparison of cover and stego images to detect distortion.

7.3. Sample Results Table

Sr. No.	Image Name	Image Size	Message Length	PSNR (dB)	MSE	Time (s)
1	Lena	256×256	500 chars	53.27	0.74	0.18
2	Baboon	512×512	2000 chars	49.84	1.18	0.31
3	Pepper	512×512	5000 chars	47.56	1.92	0.44
4	Lena	256×256	100 chars	55.62	0.51	0.12
5	Landscape	512×512	3000 chars	48.77	1.53	0.38

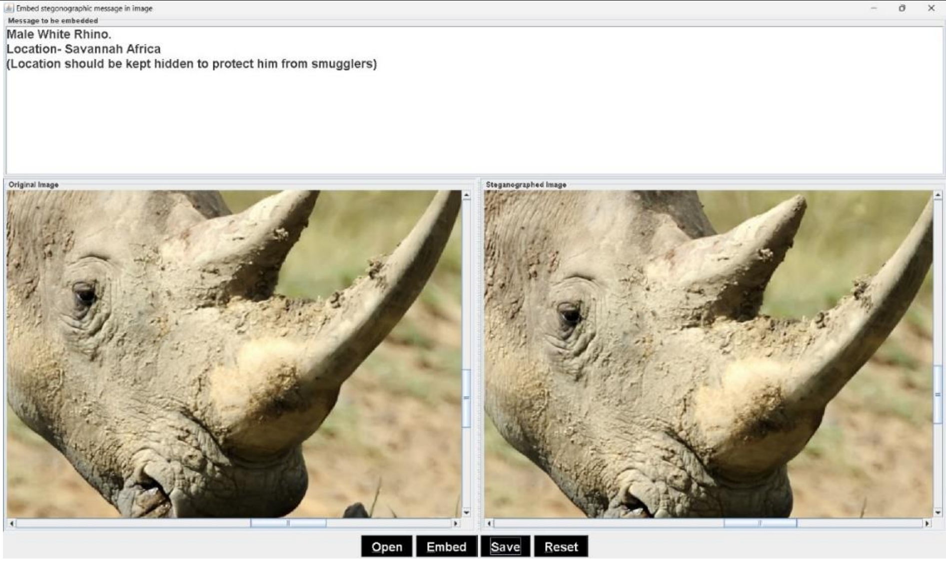
7.4. Observations

- High PSNR values (>47 dB) across all experiments indicate excellent imperceptibility of the stego images.
- The MSE values remain below 2, confirming minimal distortion.
- The time required for embedding and extraction was efficient, even for large messages, proving the system's scalability.
- No visual difference was noticeable between the cover and stego images, affirming the success of the image balancing approach.

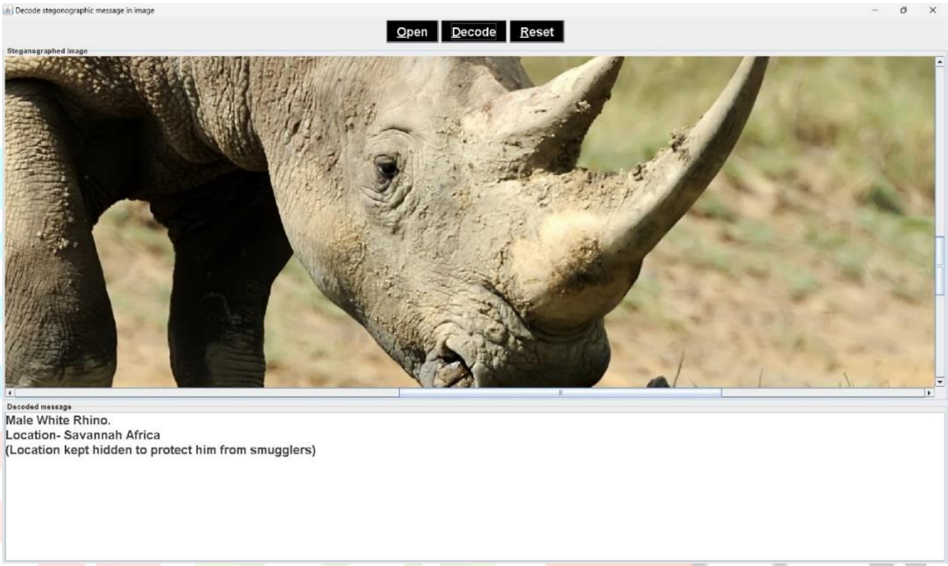
7.5. Visual Results (Insert Screenshots):

Cover Image (**Image vii.i**) vs Stego Image (**Image vii.ii**) and original image (**Image vii.iii**) vs Stego image (**Image vii.vi**)

- Extracted Message from Stego Image
- Histogram Comparison (optional)
- PSNR/MSE Console Output



(Image vii.i)



(Image vii.ii)

(Image vii.iii)

(Image vii.iv)

8.REFERENCES

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2."A Review of Image Steganography Based on Multiple Hashing" (2024): This review introduces a novel method of hiding information in images with minimal variance in image bits, enhancing security and effectiveness.

3. "A Novel and Effective Digital Image Steganography Method Using LSB" (2024): In this study, the researchers introduce an effective steganography method based on the Least Significant Bit (LSB) approach with the goal of enhanced security and imperceptibility.

4."Research on Key Technologies of Image Steganography Based on Dual Deception" (2024): This work proposes the Visually Robust Image Steganography (VRIS) model, which aims to mislead both the human visual system and machine learning algorithms by feature-level fusion and adversarial training.

5. "Optimize Image Steganography Based on Distinction Disparity Value and Huffman Coding" (2024): The study suggests a technique to maximize the imperceptibility of steganography by employing the hybrid of the Distinction Disparity Value (DDV) approach and Huffman coding. 6."An Efficient and Secure Technique for Image Steganography Using a Hash Function" (2022): This paper introduces a method that encrypts a message in an image by transforming plain text into ciphertext and encoding it using up to the four least significant bits (LSB) based on a hash function. 7."Image Steganography Methods for Withstanding Statistical Steganalysis Attacks: A Systematic Literature Review" (2024): This systematic review discusses different image steganography techniques that are intended to resist statistical steganalysis attacks, with emphasis on the increasing application of artificial intelligence and deep learning methods to improve security.