An
Industry Oriented Mini Project Report on

A FRAMEWORK OF MULTI-LAYER IMAGE STEGANOGRAPHY

Submitted in partial fulfillment of the requirements for the award of degree

BACHELOR OF TECHNOLOGY

IN

INFORMATION TECHNOLOGY

Submitted By

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CERTIFICATE

This is to certify that the project report titled **"A FRAME WORK OF MULTI-LAYER IMAGE STEGONOGRAPHY"** is being submitted by **M.Tharun (217Z1A1231)** in Partial fulfillment for the award of **Bachelor of technology in Information Technology** is a record bonafide work carried out by him. The results embodied in this report have not been submitted to any other University for the award of any degree.

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Submitted for Viva voce Examination held on …….

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DECLARATION

I M.Tharun,the students of **Bachelor of Technology in Information Technology , Nalla Narasimha Reddy Education Society's Group Of Institutions**, Hyderabad, Telangana, hereby declare that the work presented in this project work entitled **A FRAMEWORK OF MULTI-LAYER IMAGE STEGANOGRAPHY** is the outcome of my own bonafide work and is correct to the best of my knowledge and this work has been undertaken taking care of engineering ethics. It contains no material previously published or written by another person nor material which has been accepted for the award of any other degree or diploma of the university or other institute of higher learnining.

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Signature:

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ABSTRACT

A steganography technique involves hiding sensitive information within an ordinary, nonsecret file or message, so that it will not be detected. The sensitive information will then be extracted from the ordinary file or message at its destination, thus avoiding detection. Steganography is an additional step that can be used in conjunction with encryption in order to conceal or protect data. The main objectives of our project are to product security tool based on steganography techniques to hider message carried by stego-media which should not be sensible to human beings and avoid drawing suspicion to the existence of hidden message. Visual Studio is an integrated development environment (IDE) from Microsoft. It is used to develop computer programs including websites, web apps, web services and mobile apps and also python technology is used. Steganography is the process of hiding a secret message which is text-based data within non-text files like image file, audio, video file etc. In such a way someone cannot know the presence of a hidden message in a particular file. The main purpose of Steganography is to maintain secret communication between two people. It generally refers to encoding and decoding. So, in this image Steganography project, we will encode and decode the data into an image file. Steganography transmits secrets through apparently innocuous covers in an effort to conceal the existence of a secret. Digital image steganography and its derivatives are growing in use and application. In areas where cryptography and strong encryption are being outlawed, citizens are looking at steganography to circumvent such policies and pass messages covertly. As with the other great innovations of the digital age: the battle between cryptographers and cryptanalysis, security experts and hackers, record companies and pirates, steganography and Steganalysis will continually develop new techniques to counter each other.

Keywords: Steganography, Steganalysis, stego-media, python, visual studio, cover image.

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1.INTRODUCTION

1.1 MOTIVATION:

In today's digital age, the secure transmission of sensitive information has become a major concern. With the increasing reliance on digital communication, the risk of unauthorized access and data breaches has risen significantly. Traditional cryptographic methods, while effective, often attract attention, making the hidden data a target for attackers. Steganography, the art of concealing data within other forms of media, offers a more subtle approach by embedding information in such a way that its existence is not apparent.

The motivation behind this project stems from the need for more sophisticated and layered methods of hiding information. By developing a multi-layer image steganography system, we aim to enhance the security of hidden data while maintaining the quality of the cover media. MATLAB, a versatile tool for image processing, provides an ideal platform to explore the potential of embedding text within images using a variety of techniques, such as spatial and frequency domain manipulation.

The multi-layer approach ensures that even if one layer is compromised, the overall security remains intact. This research will contribute to the development of more robust steganographic techniques capable of withstanding steganalysis attacks and preventing unauthorized detection. The application of such a system is invaluable in fields such as military communication, confidential corporate exchanges, and personal privacy, where the need for secure information sharing is paramount.

1.2 PROBLEM STATEMENT:

In the era of rapid digital communication, the need for secure and discreet data transmission has become increasingly critical. Conventional encryption techniques, while effective, are easilydetectable and can draw attention to the presence of hidden data, increasing the risk of interception or attack. Steganography offers a potential solution by embedding information within digital media, such as images, in a way that

is imperceptible to the human eye. However, many existing steganographic techniques are vulnerable to advanced steganalysis methods, which can expose the hidden data through compression, noise addition, or other forms of manipulation.

Additionally, most current steganographic methods focus on embedding data in a single layer, which limits both the capacity and security of the hidden information. This limitation makes the embedded data more susceptible to detection or distortion during transmission.

The primary challenge, therefore, is to develop a robust steganographic technique that can effectively hide textual data within digital images while ensuring that the hidden information remains undetectable and resistant to various forms of steganalysis. Moreover, the system must maintain a balance between data embedding capacity, security, and the visual quality of the cover image.

This project aims to address these challenges by proposing a multi-layer image steganography system, implemented using MATLAB, that enhances the security and resilience of hidden data. The goal is to create a method capable of resisting common attacks, such as image compression and noise addition, while minimizing any noticeable impact on the cover image's quality.

1.3 PURPOSE:

The primary purpose of this project is to design and implement a robust multi-layer image steganography technique for hiding textual information, using MATLAB as the development environment. The method aims to enhance the security and discretion of hidden data within digital images, providing an additional layer of protection compared to traditional single-layer steganographic approaches.

By using multiple layers of embedding, the system ensures that even if one layer is compromised or detected, the overall integrity and security of the hidden data remain intact. This layered approach increases resilience against steganalysis attacks, such as compression, noise, and other forms of image manipulation, thereby making the steganographic method more reliable for real-world applications.

The project will also explore various embedding techniques, such as spatial domain (LSB-based) and frequency domain (DWT, DCT), to determine the most effective balance between data embedding capacity, security, and imperceptibility. The purpose is not only to conceal text but also to maintain the quality of the cover image, ensuring that the modifications are undetectable to both human observers and automated steganalysis tools.

The ultimate goal is to create a MATLAB-based solution that can be applied to scenarios requiring secure communication, such as confidential messaging, private data transmission, and information security in sensitive fields like military and government operations.

1.4 SCOPE:

This project focuses on the development and implementation of a multi-layer image steganography technique for secure text hiding, using MATLAB as the primary tool for algorithm design and testing. The scope encompasses the following key areas:

Image Steganography Techniques:
The project will explore various steganographic techniques, including spatial domain methods (e.g., Least Significant Bit (LSB) substitution) and frequency domain methods (e.g., Discrete Wavelet Transform (DWT), Discrete Cosine Transform (DCT)). The multi-layer approach will combine different techniques to enhance security, capacity, and resistance to attacks.

Multi-Layer Embedding:
The core of the project involves implementing a multi-layer embedding mechanism, where the hidden text is distributed across different layers or domains of the image. This will make the hidden data more resilient to attacks like image compression, noise addition, and steganalysis attempts.

MATLAB Implementation:
MATLAB will be used to design, simulate, and test the steganographic algorithms. The platform's image processing capabilities, such as handling image matrices and

applying transformations, will be leveraged for embedding and extracting the hidden text.

Evaluation of Security and Imperceptibility:

The project will assess the security of the steganography technique through robustness testing against common steganalysis methods, including statistical attacks and noise addition. Additionally, it will evaluate the visual imperceptibility of the embedded data to ensure that the cover image remains visually identical to its original form.

Capacity and Performance Analysis:

The system's data-hiding capacity, in terms of the amount of text that can be securely hidden within an image, will be evaluated. Performance metrics, such as the processing time and efficiency of embedding and extracting hidden text, will also be analyze

Applications:

The technique developed will be applicable to secure communication systems, such as military operations, government agencies, confidential corporate communications, and personal privacy protection. The solution will be tailored for environments where the secure and undetectable transmission of sensitive text is critical.

The project will not cover other forms of media steganography, such as audio or video, nor will it address encryption methods beyond what is necessary for the proposed steganographic system. The focus remains on the integration of steganography within images, with a specific emphasis on text hiding.

1.5 PROJECT OBJECTIVE:

The primary objective of this project is to develop and implement a multi-layer image steganography technique for securely hiding textual information within digital images using MATLAB. The specific objectives of the project are as follows:

Develop a Robust Steganographic Algorithm:

To design a multi-layer image steganography system that enhances the security of hidden textual data by embedding it across different layers or domains (spatial and frequency) of an image, thereby improving resilience against detection and attacks.

Implement in MATLAB:

To use MATLAB's image processing tools for the implementation of the steganography algorithm, enabling efficient embedding and extraction of hidden text while maintaining high image quality and low perceptibility.

Ensure Imperceptibility:

To ensure that the modifications made to the cover image are imperceptible to the human eye, so that the existence of hidden text remains undetectable by casual observation or basic image analysis

Evaluate Security and Robustness:

To evaluate the robustness of the steganographic technique by testing its resistance to common steganalysis attacks, such as compression, noise addition, and statistical analysis, ensuring that the hidden data remains secure.

Maximize Data-Hiding Capacity:

To maximize the amount of textual data that can be securely hidden within an image without compromising the visual quality or security of the steganography system.

Test and Validate the System:

To conduct comprehensive testing and validation of the steganographic system in various scenarios, assessing performance metrics such as processing time, embedding/extraction efficiency, and system scalability.

Provide a Secure Communication Framework:

To develop a solution that can be applied to real-world secure communication scenarios, where undetectable transmission of sensitive information is essential, such as in military, government, and corporate settings.

These objectives aim to deliver a secure, reliable, and imperceptible method of hiding text within digital images that can withstand common attacks, providing a solution for environments where data security and confidentiality are crucial.

1.6 LIMITATIONS:

While the proposed multi-layer image steganography system for text hiding offers enhanced security and robustness, it is subject to certain limitations:

Limited Data-Hiding Capacity:

Although the multi-layer approach improves security, the amount of text that can be hidden in an image is limited by the image's resolution and the need to maintain imperceptibility. Large amounts of data may cause noticeable distortion or degradation in the cover image, especially in low-resolution images.

Vulnerability to Advanced Steganalysis:

While the method is designed to resist common steganalysis techniques, more advanced detection methods, such as machine learning-based steganalysis or sophisticated statistical analysis, may still pose a threat to the hidden data, particularly if the system is not frequently updated.

Loss of Hidden Data in Certain Image Manipulations:

The embedded data may be compromised if the image undergoes significant alterations, such as extreme compression (e.g., converting to low-quality JPEG), resizing, or heavy filtering. The robustness of the steganography system depends on the type and extent of image manipulation.

Increased Complexity and Processing Time:

The multi-layer approach, while offering improved security, introduces additional complexity to the embedding and extraction processes. This can result in increased computational overhead, particularly for large images or real-time applications. This may not be ideal for time-sensitive scenarios.

Dependency on Image Quality:

The system's effectiveness relies on the quality of the cover image. Images with low contrast, high noise, or significant artifacts may not provide adequate concealment for hidden text, potentially reducing the system's performance in certain contexts.

No Built-in Encryption:

The proposed system focuses on steganography and does not include encryption as a

primary layer of protection. While steganography conceals the existence of the message, the hidden text itself is not encrypted, making it vulnerable to extraction if detected. Additional encryption may be needed for higher security.

Platform-Specific Constraints:

The implementation in MATLAB, while effective for development and testing, may limit the system's portability and integration into other environments or real-world applications that require more versatile or lightweight platforms for deployment.

These limitations define the boundaries within which the multi-layer image steganography system can operate effectively. Understanding these constraints helps guide the practical use of the system and highlights areas for potential future improvements.

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2.LITERATURE SURVEY

2.1 INTRODUCTION

In the modern digital landscape, secure communication has become a critical concern across a variety of fields, including government, military, corporate sectors, and personal communication. Traditional encryption methods, while effective at securing data, often alert third parties to the presence of sensitive information, making them a target for attacks. This is where steganography comes into play, offering a complementary solution by hiding the very existence of data within innocuous digital media, such as images, audio, or video files.

Steganography is the science of embedding secret information within a carrier medium in such a way that its presence is undetectable to both human observers and automated detection systems. Among various forms of steganography, image steganography is particularly popular due to the widespread use of images in digital communication. By embedding secret data within an image, steganography ensures that the data can be transmitted covertly without attracting suspicion.

However, as steganalysis techniques advance, conventional single-layer steganographic approaches have become vulnerable to detection, manipulation, and distortion. There is a growing need for more sophisticated methods that offer enhanced security, higher resistance to attacks, and larger data-hiding capacity. In response to this need, multi-layer image steganography has emerged as a potential solution.

This project focuses on developing a multi-layer image steganography system for securely hiding textual information within images, using MATLAB as the development platform. By distributing the hidden text across multiple layers or domains of the image, this approach enhances the security and robustness of the

steganographic method. The goal is to create a system that not only conceals the text in a way that is imperceptible to the human eye but also resists common forms of steganalysis, such as image compression, noise addition, and statistical analysis.

The proposed system is designed to address the limitations of traditional steganographic methods by improving both the security and capacity of text hiding, while maintaining the quality of the cover image. Through the use of MATLAB's powerful image processing tools, this project aims to explore different embedding techniques, including spatial domain (Least Significant Bit (LSB) substitution) and frequency domain (Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT)) methods.

The remainder of this report will delve into the technical details, motivation, objectives, and methodologies involved in the development of the multi-layer image steganography system, followed by an analysis of its performance in terms of security, capacity, and imperceptibility.

2.2 EXISTING SYSTEM

Traditional image steganography techniques primarily focus on embedding hidden data within digital images using either spatial or frequency domain methods. In spatial domain techniques, the Least Significant Bit (LSB) substitution method is commonly used, where secret data is embedded by modifying the least significant bits of pixel values. This approach is straightforward and maintains high data capacity but is vulnerable to simple attacks such as noise addition and compression. On the other hand, frequency domain techniques, like Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT), involve transforming the image into the frequency domain and embedding data into the transformed coefficients. These methods offer greater robustness to image manipulations and compression but are computationally more complex and often result in lower data-hiding capacity. Some systems combine both spatial and frequency domain techniques to balance imperceptibility and robustness. Despite their advantages, existing systems face significant limitations, including vulnerability to advanced steganalysis methods, reduced robustness against image manipulations, and trade-offs between data capacity and image quality. These challenges highlight the need for more advancedr solutions

2.3 PROPOSED SYSTEM

The proposed system introduces an advanced multi-layer image steganography technique designed to enhance the security and robustness of hidden textual information within digital images. Unlike traditional methods, which rely on single-layer embedding, this approach distributes the hidden text across multiple layers of the image, combining both spatial and frequency domain techniques. In the spatial domain, the Least Significant Bit (LSB) substitution method is used to embed part of the text, while additional data is hidden in the frequency domain through Discrete Cosine Transform (DCT) or Discrete Wavelet Transform (DWT). This multi-layer strategy not only improves resistance to common attacks such as image compression and noise addition but also ensures that the hidden data remains imperceptible to the human eye and undetectable by automated steganalysis tools. Implemented using MATLAB, the system leverages the platform's robust image processing capabilities to optimize data-hiding capacity while maintaining high image quality. The result is a secure and resilient steganographic method capable of effectively concealing large amounts of data across different domains, offering a significant improvement over existing single-layer techniques.

3.SYSTEM ANALYSIS

3.1 FUNCTIONAL REQUIREMENTS

3.1.1 Image Processing Capabilities:

Image Loading:

The system must support loading images from various formats (e.g., JPEG, PNG, BMP) into MATLAB. Users should be able to select and display these images for both embedding and extraction processes.

Image Display:

Provide visualization tools within MATLAB to preview the cover image before and after data embedding. Ensure that users can view images in a format suitable for assessing changes.

3.1.2 Text Management:

Text Input:

Users should be able to input and manage the textual data they want to hide. The system must handle text of varying lengths and support text segmentation if the input exceeds the capacity of a single image.

Text Encoding:

Implement encoding mechanisms to convert text into a format suitable for embedding, such as binary or encoded strings.

3.1.3 Multi-Layer Embedding:

Spatial Domain Embedding:

Embed text in the spatial domain using techniques like Least Significant Bit (LSB) substitution. Users should be able to configure parameters such as the number of LSBs used for embedding.

Frequency Domain Embedding:

Implement frequency domain techniques like Discrete Cosine Transform (DCT) or Discrete Wavelet Transform (DWT) for embedding data. The system must allow users to adjust parameters related to the frequency domain embedding process.

Layer Configuration:

Enable users to configure which layers (spatial and frequency) are used for embedding and set parameters for each layer.

3.1.4 Data Hiding and Extraction:

Embedding Process:

The system must embed the input text across multiple layers of the image. It should handle both spatial and frequency domain data hiding and ensure data integrity.

Extraction Process:

Implement a reverse process to extract hidden text from the image. This should involve decoding the data from both the spatial and frequency domains and reconstructing the original message.

3.1.5 Quality and Imperceptibility:

Image Quality Maintenance:

Ensure that the modifications made during embedding do not significantly affect the visual quality of the cover image. Implement algorithms to minimize perceptual differences.

Quality Assessment Tools:

Provide tools to assess the imperceptibility of the modified image, such as image quality metrics or visual comparison features.

3.1.6 Security and Robustness:

Resistance to Steganalysis:

The system must be resilient to common steganalysis techniques, including statistical

analysis and detection methods. It should aim to reduce detectable anomalies in the image.

Robustness to Manipulations:
Evaluate and ensure that the hidden data remains intact and recoverable after common image manipulations such as compression, noise addition, and resizing.

3.1.7 Performance Metrics:

Capacity Measurement:
Include functionality to measure and display the capacity of the image to hide text, including the amount of data embedded and the efficiency of the embedding process.

Processing Time:
Provide performance metrics related to the time required for embedding and extraction processes.

3.1.8 Error Handling and Notifications:

Error Detection:
Implement error handling to manage issues such as invalid image formats, excessive text length, or failed embedding attempts.

User Notifications:
Provide clear error messages and notifications to guide users in resolving issues.

3.1.9 User Interface Integration:

MATLAB GUI Integration:
Develop a graphical user interface (GUI) within MATLAB that allows users to interact with the system easily. The GUI should facilitate image loading, text input, embedding, and extraction processes.

Interactive Controls:
Include interactive controls for adjusting embedding parameters, viewing results, and managing configurations.

Documentation and Support:

User Documentation:

Provide comprehensive documentation within MATLAB, including user guides and help sections explaining how to use the system, details of the embedding and extraction processes, and troubleshooting information.

By fulfilling these functional requirements, the multi-layer image steganography system will offer a robust and user-friendly solution for securely embedding and extracting textual data within digital images using MATLAB.

3.2 NON-FUNCTIONAL REQUIREMENTS

3.2.1 Performance:

Processing Speed:

The system should perform image embedding and extraction processes efficiently, with minimal delay. Large images and lengthy texts should be processed within a reasonable time frame.

Scalability:

The system should handle varying image sizes and text lengths effectively. It should be scalable to accommodate different levels of data hiding capacity without significant degradation in performance.

3.2.2 Usability:

User Interface:

The graphical user interface (GUI) within MATLAB must be intuitive and user-friendly, enabling users to easily perform image loading, text input, and data embedding/extraction tasks.

Accessibility:

The system should be accessible to users with different levels of technical expertise. Tooltips, help documentation, and guidance should be provided to assist users in navigating the system**.**

Feedback Mechanism:

The system should provide clear feedback and notifications regarding the status of

embedding and extraction processes, as well as any errors or issues encountered.

3.2.3 Reliability:

Error Handling:

The system must handle errors gracefully and provide informative error messages. It should be robust against unexpected inputs or conditions, ensuring consistent operation**.**

Data Integrity:

The system should ensure that hidden data is preserved accurately throughout the embedding and extraction processes. Any corruption or loss of data should be minimal or non-existent.

3.2.4 Security:

Data Protection:

The system should implement measures to protect hidden data from unauthorized access or tampering. Data integrity and confidentiality should be maintained during processing.

Resilience to Attacks:

The system should be resilient against common steganalysis and image manipulation techniques, ensuring that hidden data remains secure and undetectable

3.2.5 Maintainability:

Code Quality:

The MATLAB code should be well-organized, documented, and adhere to best practices to facilitate maintenance and future enhancements.

Documentation:

Comprehensive documentation should be provided, including descriptions of algorithms, system architecture, and user guides, to support ongoing maintenance and updates.

3.2.6 Compatibility:

MATLAB Version:

The system should be compatible with commonly used versions of MATLAB. It should leverage MATLAB's image processing toolbox and other relevant features effectively.

Image Formats:

The system should support a range of common image formats (e.g., JPEG, PNG, BMP) for both embedding and extraction processes.

3.2.7 Scalability:

Data Capacity:

The system should be designed to scale with increasing data-hiding requirements. It should manage larger images and more extensive text without significant performance degradation.

3.2.8 Portability:

Platform Independence:

The system should be portable within the MATLAB environment, allowing it to be used on different platforms where MATLAB is supported.

3.2.9 Performance Metrics:

Efficiency Metrics:

The system should provide performance metrics such as processing time, data-hiding capacity, and quality assessments, allowing users to evaluate the effectiveness of the embedding and extraction processes.

3.2.10 Support and Updates:

Ongoing Support:

The system should provide mechanisms for updates and improvements based on user feedback and evolving needs. Support for bug fixes and enhancements should be available.

These non-functional requirements ensure that the multi-layer image steganography system not only meets its functional goals but also delivers a reliable, secure, and user-friendly experience.

3.3 INTERFACE REQUIREMENTS

3.3.1 Ease of Use:

Intuitive Interface:

Users require a simple, intuitive graphical user interface (GUI) that allows them to perform tasks such as loading images, inputting text, and managing the embedding and extraction processes with minimal effort.

Guided Workflow:

The system should provide a step-by-step workflow to guide users through the process of embedding and extracting data, ensuring that they can complete tasks without needing extensive technical knowledge.

3.3.2 Image Handling:

Support for Various Formats:

Users expect the system to support a wide range of image formats, including common types such as JPEG, PNG, and BMP, to accommodate different types of input images.

Image Preview:

The ability to preview images before and after embedding is essential so users can verify that the image quality remains acceptable and that the data embedding process is successful.

3.3.3 Text Management:

Flexible Text Input:

Users should be able to input text of varying lengths and manage it effectively. The system should handle long texts by segmenting them appropriately for embedding.

Text Encoding and Decoding:

Users require robust encoding and decoding mechanisms to ensure that text can be hidden and retrieved accurately without loss of information.

3.3.4 Embedding and Extraction:

Multi-Layer Embedding:

Users expect the system to support embedding text across multiple layers of the image (both spatial and frequency domains) and to configure parameters for each layer effectively.

Accurate Extraction:

The system should reliably extract hidden text from the image, reconstructing it accurately and ensuring no data corruption.

3.3.5 Quality and Performance:

Minimal Visual Distortion:

Users need the system to ensure that the visual quality of the cover image is maintained after data embedding, with minimal visible changes.

Efficient Processing:

The system should process embedding and extraction tasks efficiently, with acceptable performance for various image sizes and text lengths.

3.3.6 Security and Robustness:

Data Confidentiality:

Users require that the hidden data remains secure and confidential, with robust measures to protect it from unauthorized access or detection.

Resilience to Manipulation:

The system should be resilient to common image manipulations, such as compression and noise addition, ensuring that the hidden data remains intact and recoverable.

3.3.7 Error Handling and Support:

Informative Error Messages:

Users expect clear, informative error messages and guidance if issues arise during image loading, data embedding, or extraction processes.

Help and Documentation:

Comprehensive help documentation and support resources should be available to assist users in troubleshooting issues and understanding how to use the system effectively.

3.3.8 Configuration and Customization:

Adjustable Parameters:

Users should be able to configure and customize embedding parameters, such as the number of layers, embedding strength, and frequency domain coefficients, according to their specific needs.

3.3.9 Performance Metrics and Feedback:

Performance Monitoring:

The system should provide feedback on key performance metrics, including data-hiding capacity, processing time, and image quality, to help users evaluate the effectiveness of their data embedding.

3.3.10 Documentation and Training:

User Guides:

Detailed user guides and documentation should be provided to explain the functionality of the system, including step-by-step instructions for embedding and extracting data.

Training Resources:

Training resources, such as tutorials or example projects, should be available to help users get acquainted with the system and its capabilities.

These user requirements ensure that the multi-layer image steganography system meets the needs of its users by providing an accessible, secure, and efficient means of hiding and retrieving textual information within digital images

3.3.11 Processing Speed:

Embedding Time:

The system should be able to embed textual data into images within a reasonable amount of time. For typical images (e.g., 512x512 pixels), the embedding process should not take more than a few seconds (depending on text length and image complexity).

Extraction Time:

The system should extract hidden text from the image in minimal time, with performance similar to or faster than the embedding process.

Performance with Larger Images:

The system should maintain acceptable processing speeds even with larger image sizes (e.g., 1024x1024 pixels or more), ensuring scalability without significant slowdowns.

3.3.12 Memory Usage:

Efficient Memory Management:

The system should use memory efficiently, especially when handling large images or lengthy texts. MATLAB's memory consumption should remain optimized during both embedding and extraction processes.

Low Resource Consumption:

The system should minimize its use of CPU and memory resources, allowing other MATLAB functions and operations to run concurrently without degradation in performance.

3.3.13 Data Capacity:

Maximum Text Embedding Capacity:

The system should be able to embed a substantial amount of textual data into an image. The exact capacity will depend on the image size and the number of layers used, but for an image of size 512x512, the system should be able to hide at least 1KB of text without noticeable degradation in image quality.

Flexible Handling of Data Size:

The system should be capable of embedding and extracting text of varying sizes, from small strings to larger paragraphs, adapting its techniques to maximize capacity without compromising image quality.

3.3.14 Image Quality After Embedding:

Peak Signal-to-Noise Ratio (PSNR):

The system should maintain a high Peak Signal-to-Noise Ratio (PSNR) after embedding text in an image. Ideally, PSNR should remain above 40 dB to ensure that the modifications to the image are imperceptible to the human eye.

Structural Similarity Index (SSIM):

The Structural Similarity Index (SSIM) between the original and modified images should be at least 0.95, ensuring minimal visual distortion.

3.3.15 Scalability:

Handling Larger Images and Data:

The system should scale to handle larger images (e.g., 2048x2048 pixels or more) and larger text sizes. Performance should degrade gracefully with increasing data size without leading to crashes or unresponsive behavior.

Multiple Layer Processing:

The system must efficiently handle multiple layers of embedding (both spatial and frequency domains) without significant delays, even as the number of layers increases.

4. SYSTEM DESIGN

4.1 UML DIAGRAMS

UML stands for Unified Modeling Language. UML is a standardized general- purpose modeling language in the field of object-oriented software engineering. The standard is managed, and was created by, the Object Management Group. The goal is for UML to become a common language for creating models of object oriented computer software. In its current form UML is comprised of two major components: a Meta-model and a notation. In the future, some form of method or process may also be added to; or associated with, UML.

The Unified Modeling Language is a standard language for specifying, Visualization, Constructing and documenting the artifacts of software system, as well as for business modeling and other non-software systems. The UML represents a collection of best engineering practices that have proven successful in the modeling of large and complex systems.

The UML is a very important part of developing objects oriented software and the software development process. The UML uses mostly graphical notations to express the design of software projects.

Goals:

The Primary goals in the design of the UML are as follows:

Provide users a ready-to-use, expressive visual modeling Language so that they can develop and exchange meaningful models.

Provide extendibility and specialization mechanisms to extend the core concepts. Be independent of particular programming languages and development process. Provide a formal basis for understanding the modeling language.

Encourage the growth of OO tools market.

Support higher level development concepts such as collaborations, frameworks, patterns and components.

4.1.1 Data Flow Diagram

A data flow diagram (DFD) maps out the flow of information for any process or system.It uses defined symbols like rectangles, circles and arrows, plus short text labels, to show data inputs, outputs, storage points and the routes between each destination.

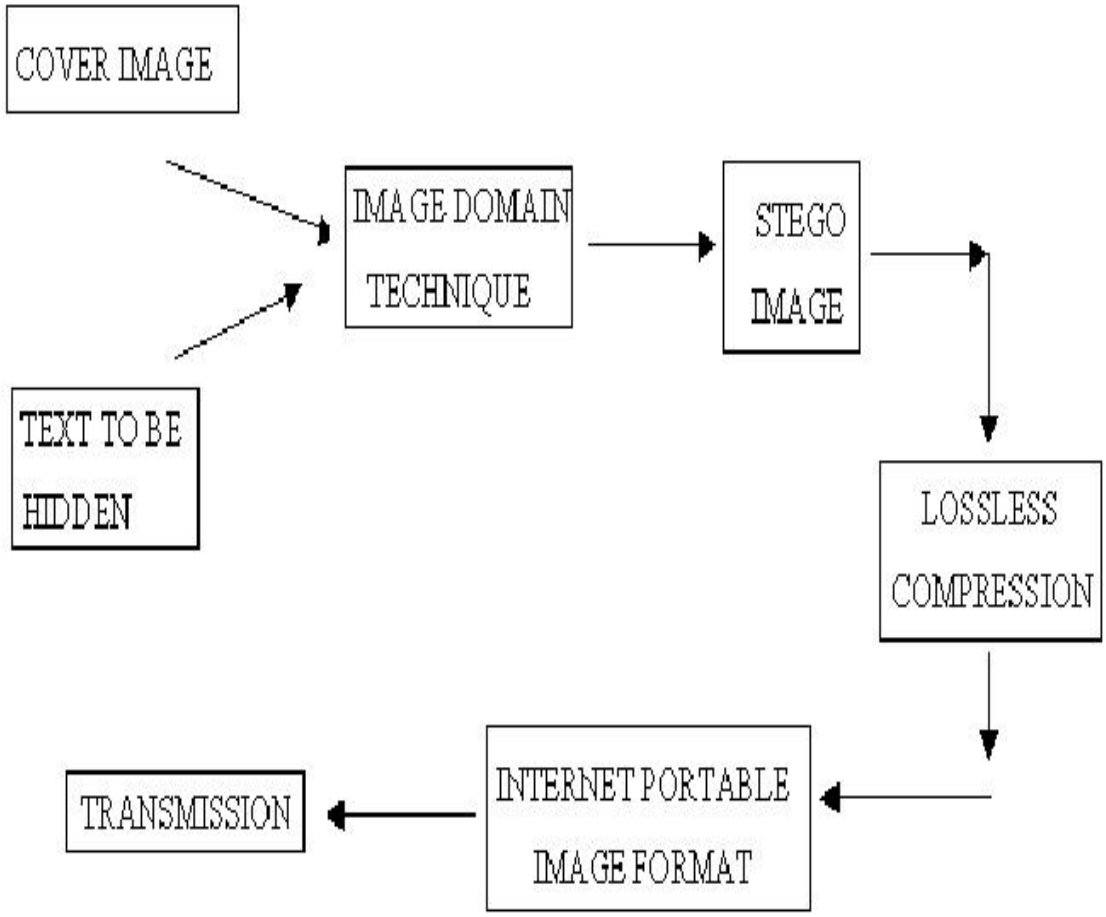

Fig:4.1 Data flow diagram

4.1.2 Use Case Diagram:

A use case diagram in the Unified Modeling Language (UML) is a type of behavioral diagram defined by and created from a Use-case analysis. Its purpose is topresent a graphical overview of the functionality provided by a system in terms of actors, their goals (represented as use cases), and any dependencies between those use cases. The main purpose of a use case diagram is to show what system functions are performed for which actor. Roles of the actors in the system can be depicted.

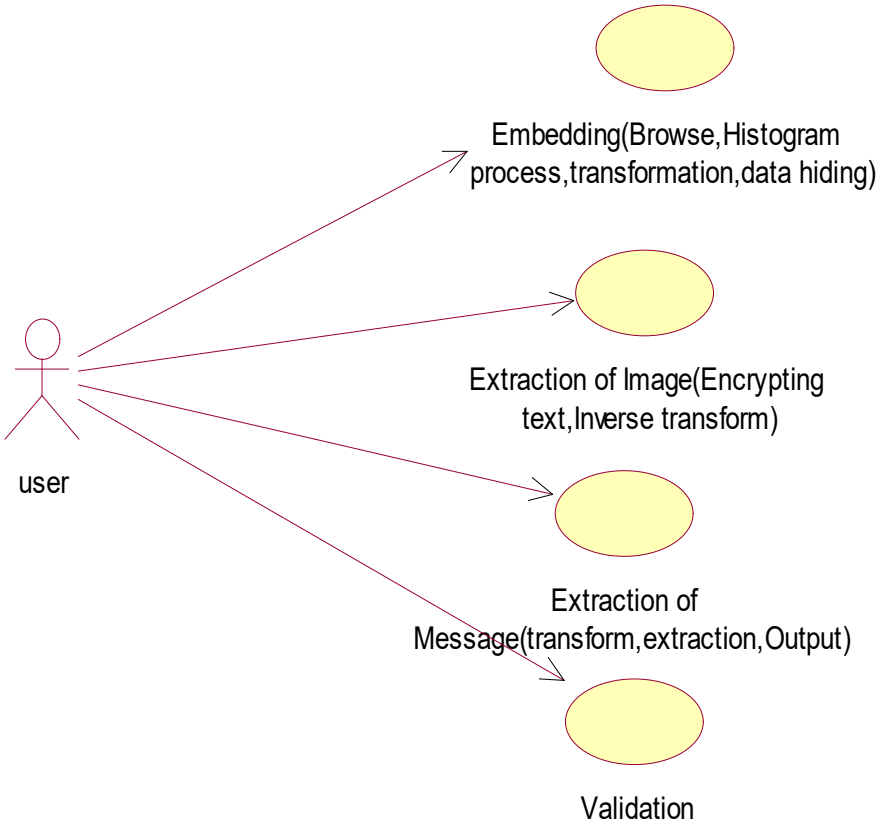

Fig:4.2 Use case diagram

4.1.2 Class Diagram:

In software engineering, a class diagram in the Unified Modeling Language (UML)is a type of static structure diagram that describes the structure of a system by showing the system's classes, their attributes, operations (or methods), and the relationships among the classes. It explains which class contains information.

Fig:4.3 class diagram

4.1.3 Sequence Diagram:

A sequence diagram in Unified Modelling Language (UML) is a kind of interaction diagram that shows how processes operate with one another and in what order. It is a construct of a Message Sequence Chart. Sequence diagrams are sometimes called event diagrams, event scenarios, and timing diagrams.

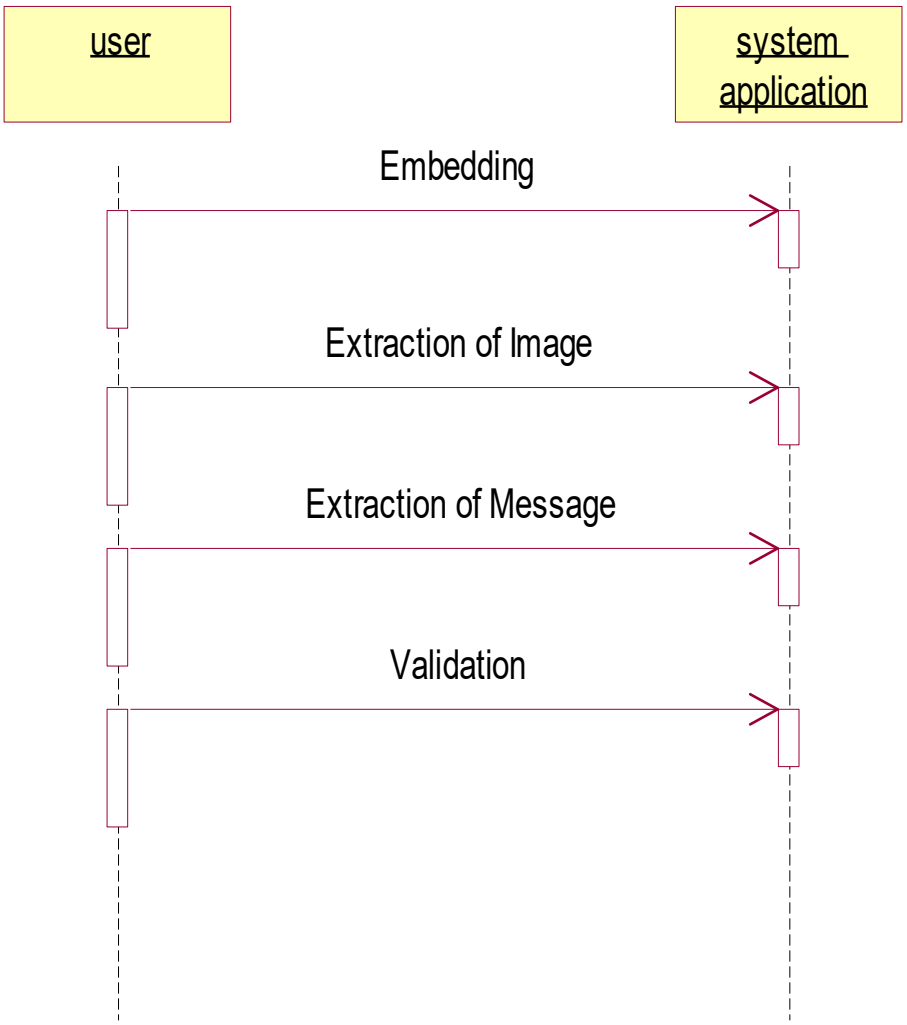

Fig:4.4 Sequence digram

4.1.5 COLLABORATION DIAGRAM:

A collaboration diagram, also known as a communication diagram, is a type of diagram used in Unified Modeling Language (UML) to represent the interactions between objects or components within a system. It focuses on the relationships and interactions among objects rather than their specific sequences or timing.

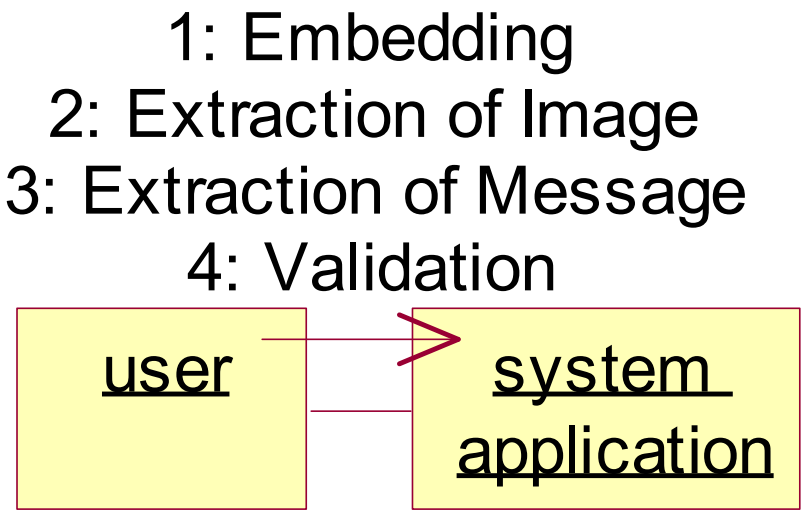

Fig:4.5 Colloboration diagram

4.2 MODULES:

4.2.1 Embedding

Embedded image steganography is a method of hiding data within an image file by modifying the least significant bits of its pixel values, allowing secret messages to be concealed in a way that is imperceptible to the human eye. The process typically involves encoding the message into a binary format and embedding it starting from the top-left corner of the image, with retrieval achieved by extracting the modified bits. While this technique offers invisibility and substantial data capacity, it can be vulnerable to detection through statistical analysis and is sensitive to compression artifacts in lossy formats like JPEG. Common applications include digital watermarking, secure communications, and ensuring data integrity.

4.2.2 Extraction of image

Image extraction in steganography involves retrieving hidden data from an altered image file by reading the least significant bits of its pixel values, following the same method used for embedding. The process begins by loading the image, identifying the embedding technique, and then systematically extracting the relevant bits in the same order they were concealed. Once extracted, these bits are converted back into their original format, such as text or another file type. Finally, verifying the integrity of the extracted data ensures it remains uncorrupted, enabling secure communication or data validation.

4.2.3 Extraction message

The extraction of a hidden message from an image in steganography involves several key steps that ensure the concealed information is retrieved accurately. First, the image file is loaded, and the specific steganographic method used for embedding—such as the Least Significant Bit (LSB) technique—is identified. The extraction process entails systematically reading the least significant bits of the pixel values in the same sequence they were modified during embedding. Once the relevant bits are collected, they are grouped and converted back into their original format, often resulting in a text message or another type of data. Additionally, it’s crucial to check the integrity of the extracted message to confirm that it hasn’t been corrupted, which can occur due to image compression or alterations. This careful process allows for the secure retrieval of information hidden within an image, facilitating discreet

communication and data integrity verification.

4.2.4 Validation

Validation of extracted information in steganography is a critical process that ensures the integrity and authenticity of the retrieved message. After extracting the hidden data from an image, validation typically involves several steps. First, a checksum or hash function may be employed, which was initially generated during the embedding process. This checksum acts as a fingerprint for the original message, allowing the recipient to verify that the extracted data matches the expected value. If the checksum matches, it indicates that the message has likely remained intact; if not, this could suggest corruption or tampering, potentially due to lossy compression or deliberate interference.

Additionally, validation can include analyzing the context of the message to ensure it adheres to expected formats or protocols, which helps identify any anomalies. In more advanced systems, digital signatures or encryption may be utilized to further secure the embedded data, providing an additional layer of authenticity. By employing these validation techniques, users can confidently ensure that the hidden information retrieved from an image is both reliable and accurate, enhancing the overall security of steganographic communication.

5. IMPLEMENTATION AND RESULTS

5.1 METHOD OF IMPLEMENTATION:

5.1.1 MATLAB:

What is matlab ?

MATLAB (short for MATrix LABoratory) is a high-level programming environment and interactive platform designed for technical computing, data analysis, algorithm development, and visualization. Developed by MathWorks, MATLAB is widely used in engineering, scientific research, and academia due to its powerful tools for numerical computation, matrix manipulations, and the ability to handle large datasets. It is particularly well-suited for mathematical and technical problems, such as signal processing, control systems, and machine learning.

Components of MATLAB.

- **Matrix-Based Computation:**

MATLAB is fundamentally built around matrices and arrays. Every data type in MATLAB is treated as a matrix, making it easy to perform vectorized operations, linear algebra, and multidimensional array manipulations.

- **Numerical Computing:**

MATLAB excels at numerical analysis, including solving equations, integrating functions, and optimizing systems. It's often used in simulations where numerical accuracy is crucial.

- **Toolboxes:**

MATLAB has an extensive collection of **toolboxes**, which are add-ons designed for specialized fields such as signal processing, control systems, neural networks, computer vision, machine learning, and more. These toolboxes provide pre-built functions and applications tailored to specific industries and research areas.

- **Data Visualization:**

MATLAB offers extensive plotting and data visualization capabilities, allowing users to create 2D and 3D graphs, plots, and charts. These visualizations are highly customizable and are useful for analyzing data, debugging code, and creating presentations.

- **Simulink:**

Simulink is an add-on product for modeling, simulating, and analyzing dynamic systems. It is widely used for systems that require block diagrams, such as control systems, digital signal processing, and communication systems.

- **Built-in Functions:**

MATLAB provides thousands of built-in functions for common tasks such as matrix operations, Fourier transforms, filtering, and more. This makes it easy for users to perform complex computations without writing everything from scratch.

- **Programming Capabilities:**

MATLAB includes a full-featured programming language that supports functions, loops, conditional statements, and object-oriented programming (OOP). It allows users to create scripts and functions to automate tasks and build more complex algorithms.

- **Interactivity:**

MATLAB has an interactive environment that supports live editing of code, where users can see the results of their computations immediately. This allows for rapid prototyping and testing of algorithms.

- **Integration and Extensibility:**

MATLAB can integrate with other programming languages such as C, C++, Java, Python, and FORTRAN. It can also interface with external hardware, making it useful for real-time applications like robotics and control systems.

5.1.2 Typical Uses of MATLAB:

Data Analysis and Visualization:

MATLAB is commonly used for analyzing large datasets, performing statistical analysis, and visualizing trends and patterns in data.

Engineering and Scientific Research:

MATLAB is a popular tool in academia and research for simulating physical systems, developing algorithms, and analyzing experimental data in fields such as physics, biology, chemistry, and engineering.

Signal Processing and Communication:

Engineers use MATLAB for processing signals, such as audio and video, filtering data, designing communication systems, and implementing algorithms for noise reduction and compression.

Machine Learning and AI:

MATLAB has toolboxes for machine learning, deep learning, and neural networks. Researchers use it to develop predictive models, train algorithms, and analyze data from machine learning projects.

Control Systems:

MATLAB is used for designing, analyzing, and simulating control systems in industries such as aerospace, automotive, and robotics.

Image and Video Processing:

MATLAB's image processing toolbox is used for manipulating, analyzing, and interpreting images and video, with applications ranging from medical imaging to industrial vision systems.

Why Use MATLAB?

- **Ease of Use:** MATLAB's interactive environment and high-level syntax make it relatively easy to use, especially for people who are less experienced with programming.
- **Rich Functionality:** The extensive libraries and toolboxes make it a one-stop solution for many engineering, scientific, and mathematical tasks.
- **Widely Adopted:** MATLAB is widely used in industry and academia, making it a valuable skill for engineers and scientists.
- **Visualization Power:** Its ability to generate high-quality visualizations and plots makes it an excellent tool for analyzing and presenting data.

Limitations:

- **Cost:** MATLAB is a commercial product, and licenses can be expensive, especially for individual users or small organizations.
- **Performance:** While MATLAB is excellent for high-level tasks, it may not be as efficient as lower-level programming languages (like C or C++) for certain applications that require high-performance computing.

In summary, MATLAB is a powerful tool for numerical computation, simulation, data analysis, and visualization, making it an indispensable resource in many technical fields.

5.2 EXPLANATION OF KEY FUNCTION

5.2.1 USE OF MATLAB

MATLAB is widely used across various industries and academic fields due to its versatility in handling complex mathematical, engineering, and scientific computations. Below are some common **uses of MATLAB**:

Data Analysis and Visualization

MATLAB is extensively used for analyzing and visualizing large datasets. It can handle data from different sources (like databases, files, or hardware devices) and perform operations like:

- Statistical analysis (mean, median, standard deviation, etc.)
- Data cleaning and transformation
- Time-series analysis
- Creating customizable 2D and 3D plots, graphs, and charts to visualize trends and patterns
- Exporting data visualizations in high-quality formats for presentations or publications

Example: Analyzing financial data, generating plots of stock price trends, or conducting experiments in research.

Numerical Computing

MATLAB is designed to perform complex numerical computations, especially with matrices and arrays. It includes a vast range of functions for:

- Solving linear and non-linear equations
- Performing numerical integration and differentiation
- Optimization tasks (e.g., minimizing or maximizing functions)
- Simulating systems and models using numerical method

Example: Solving engineering problems like heat transfer, fluid dynamics, or structural analysis.

Signal Processing

MATLAB is widely used in **signal processing** to analyze, filter, and transform signals such as audio, radar, and communication signals. Common tasks include:

- Fourier Transforms and Wavelet Transforms
- Digital filtering (low-pass, high-pass, band-pass filters)

- Signal denoising and enhancement
- Spectral analysis
- Time-frequency analysis

Example: Audio processing to remove noise from recorded signals, or processing radar signals in communication systems.

Control Systems

MATLAB and Simulink are extensively used for modeling, designing, and simulating control systems in industries like aerospace, automotive, and robotics. MATLAB supports:

- Designing PID controllers
- Modeling dynamic systems with differential equations
- Simulating the behavior of feedback control systems
- Stability analysis of control systems

Example: Designing a control system for an autonomous vehicle or optimizing the control of a robotic arm.

Machine Learning and Artificial Intelligence

MATLAB provides powerful **machine learning** and **AI** tools for data-driven modeling and predictive analytics, including:

- Supervised and unsupervised learning algorithms (e.g., decision trees, k-means clustering)
- Neural networks and deep learning
- Model training, evaluation, and hyperparameter tuning
- Integration with large datasets for training complex models

Example: Building and training a predictive model for image classification or speech recognition.

Image and Video Processing

MATLAB's image processing toolbox is used for **image manipulation** and **video analysis**. Key tasks include:

- Image filtering and enhancement (contrast, brightness adjustment)
- Edge detection, feature extraction, and object recognition
- Morphological operations (e.g., dilation, erosion)
- Video processing (e.g., tracking objects across video frames)
- Medical imaging applications (MRI, CT scans)

Example: Detecting objects in images or enhancing image quality for medical diagnosis.

Financial Modeling

MATLAB is used in finance for developing algorithms and models for **financial analysis**, including:

- Portfolio optimization
- Risk management
- Option pricing using Monte Carlo simulations and the Black-Scholes model
- Time-series analysis for stock price forecasting
- Financial derivatives modeling

Example: Predicting stock price movements or optimizing an investment portfolio.

Robotics and Autonomous Systems

MATLAB is used in the development of **robotics** and **autonomous systems** for tasks like:

- Robot path planning and navigation
- Robot kinematics and dynamics simulation
- Sensor data processing (e.g., lidar, GPS, cameras)
- Simulating autonomous vehicle behavior in virtual environments

Example: Programming a robotic arm to perform precise movements or developing control algorithms for autonomous drones.

Communication Systems

MATLAB helps in designing and simulating **communication systems**. Engineers use MATLAB for:

- Modulation and demodulation of signals (e.g., QAM, PSK)
- Channel coding and error correction (e.g., Reed-Solomon, Turbo Codes)
- Simulation of wireless communication protocols (e.g., 4G, 5G)
- Antenna design and performance analysis

Example: Simulating a wireless communication link to optimize data transmission over noisy channels.

Physics and Computational Biology

MATLAB is used for simulating **physical systems** and modeling biological processes:

- Solving differential equations that describe physical or biological phenomena
- Simulating molecular dynamics
- Modeling population dynamics or disease spread
- Analyzing biological datasets (e.g., gene expression data)

Example: Simulating the behavior of particles in a fluid, or modeling the spread of a virus in a population.

Embedded Systems

MATLAB and Simulink are widely used for the design and simulation of **embedded systems**, which include microcontrollers and processors. This includes:

- Code generation for real-time embedded systems
- Simulating hardware systems in a virtual environment

- Testing algorithms on embedded devices before deployment

Example: Developing embedded systems for automotive applications like cruise control or ABS braking systems.

Academic and Research

MATLAB is a staple in academic research for developing **prototypes** and solving mathematical problems. It is commonly used in teaching:

- Numerical methods
- Linear algebra and calculus
- Control theory and system dynamics
- Artificial intelligence and data analysis

Example: A professor may use MATLAB to demonstrate concepts in signal processing or control theory in an engineering class

5.3 OUTPUT SCREEN :

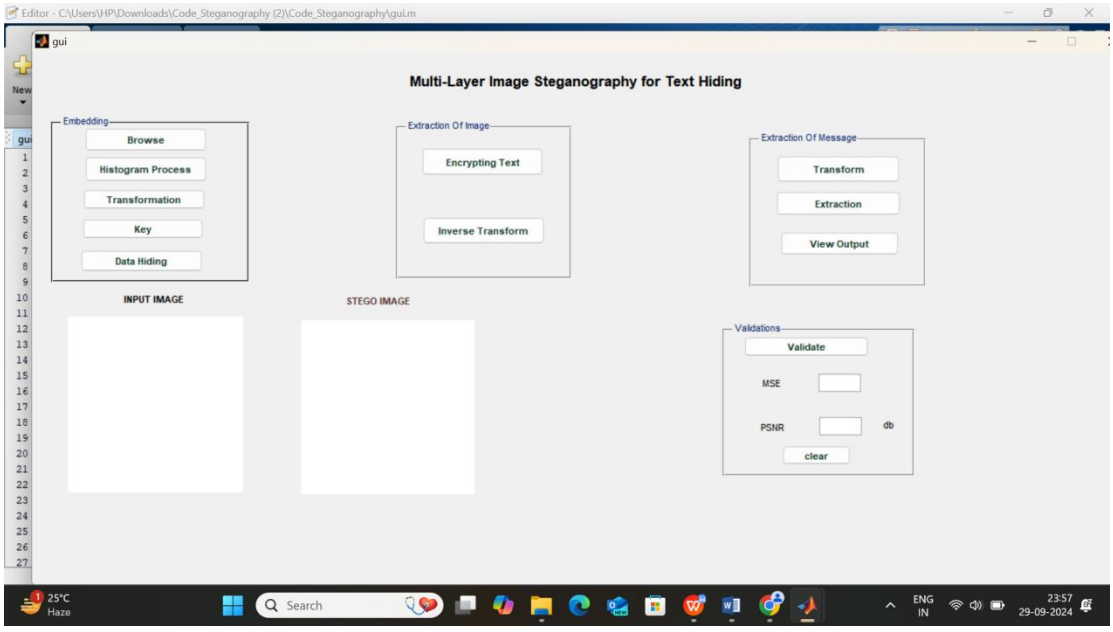

Fig:5.1 Layout

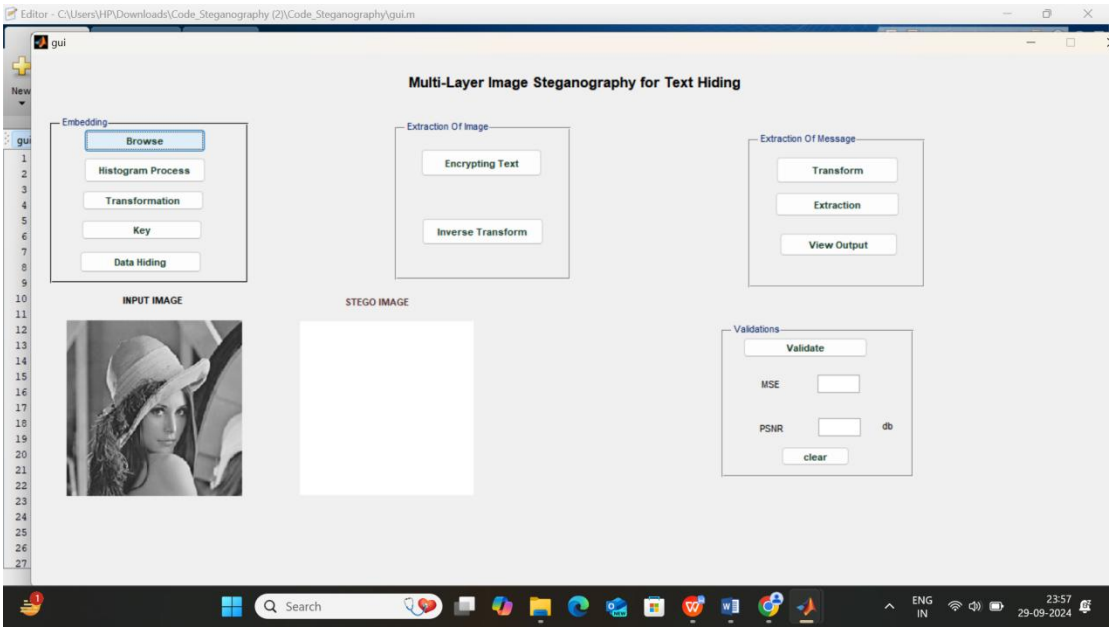

Fig:5.2 Browse the Image

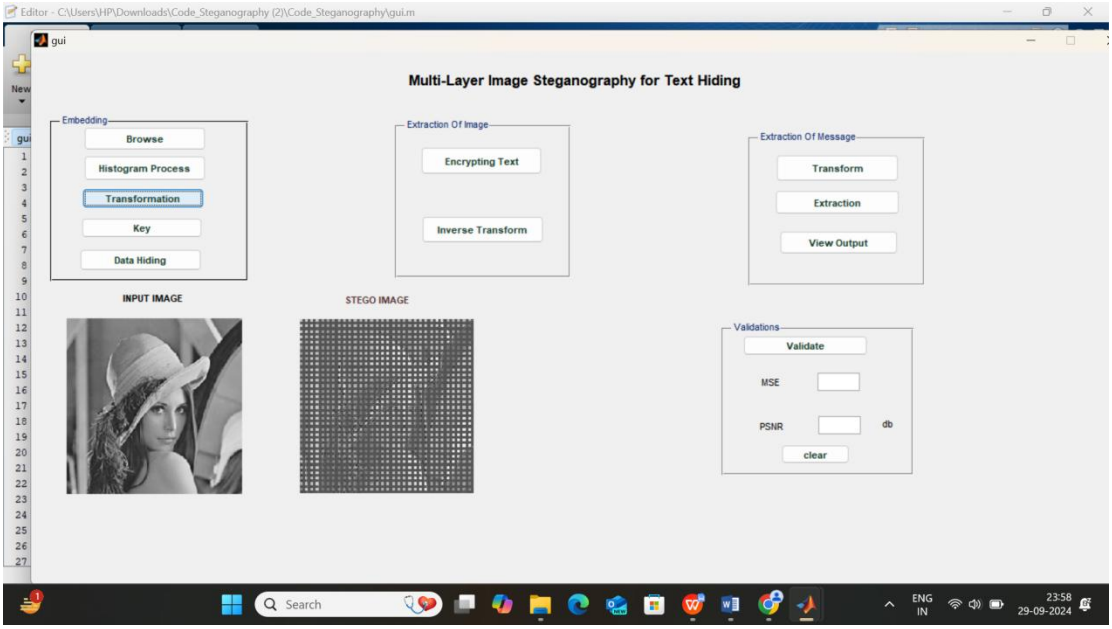

Fig:5.3 Adding Transformtion

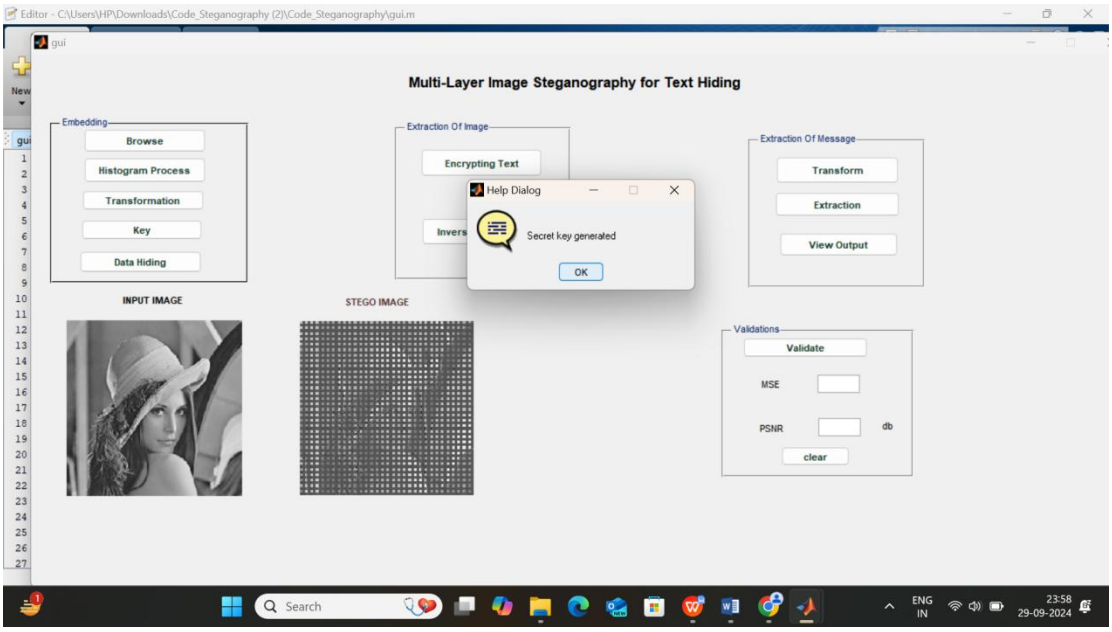

Fig:5.4 Adding key and Encoding

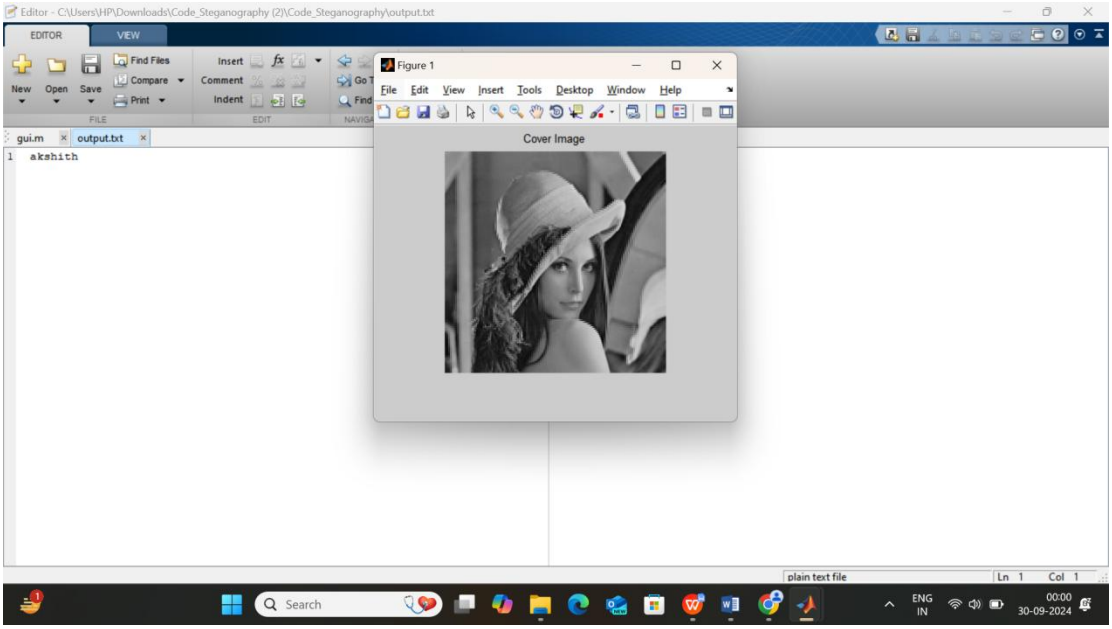

Fig:5.5 Decoding the information

6. SYSTEM TESTING

6.1 INTRODUCTION FOR TESTING

The purpose of testing is to discover errors. Testing is the process of trying to discover every conceivable fault or weakness in a work product. It provides a way to check the functionality of components, sub assemblies, assemblies and/or a finished product It is the process of exercising software with the intent of ensuring that the Software system meetsits requirements and user expectations and does not fail in an unacceptable manner. There are various types of test. Each test type addresses a specific testing requirement.

6.2 VARIOUS TESTCASE SCENARIOUS

6.2.1 Unit testing

Unit testing involves the design of test cases that validate that the internal program logic is functioning properly, and that program inputs produce valid outputs. All decision branches and internal code flow should be validated. It is the testing of individual software units of the application .it is done after the completion of an individual unit before integration. This is a structural testing, that relies on knowledge of its construction and is invasive. Unit tests perform basic tests at component level and test a specific business process, application, and/or system configuration. Unit tests ensure that each unique path of a business process performs accurately to the documented specifications and contains clearly defined inputs and expected results.

6.2.2 Integration testing

Integration tests are designed to test integrated software components to determine if they actually run as one program. Testing is event driven and is more concerned with the basic outcome of screens or fields. Integration tests demonstrate that although the components were individually satisfaction, as shown by successfully unit testing, the combination of components is correct and consistent. Integration testing is specifically aimed at exposing the problems that arise from the combination of componentIntegration testing is a vital phase in the software

development lifecycle that assesses how different components or modules of an application work together as a cohesive system. After individual units have been tested in isolation, integration testing focuses on uncovering issues that may arise when these units interact, such as data format mismatches, incorrect interface connections, or unexpected behavior due to dependencies. This process typically involves both top-down and bottom-up approaches, where modules are combined incrementally and tested collectively, allowing for early detection of integration errors. Additionally, various testing techniques, such as big bang integration and incremental integration, can be employed based on the project requirements. Integration testing not only ensures that the combined components function correctly but also verifies that the overall system meets specified requirements and behaves as expected under real-world scenarios. By identifying and addressing potential integration issues early in the development cycle, this testing phase helps to minimize costly fixes later, enhances software quality, and ultimately leads to a more reliable and efficient final product.

Integration testing is a crucial phase in the software development lifecycle that focuses on verifying the interaction and compatibility between different modules or components of an application. During this testing stage, individual units of code, which have already been tested in isolation, are combined and tested as a group to identify interface defects and integration issues that may arise when components work together. This process involves checking data flow, communication protocols, and the overall functionality of integrated modules to ensure they operate correctly in conjunction with one another. By uncovering issues related to module interactions early, integration testing helps ensure that the software system functions as intended, leading to a more robust and reliable final product.

6.2.3 Functional test

Functional tests provide systematic demonstrations that functions tested are available as specified by the business and technical requirements, system documentation, and user manuals.

Functional testing is centered on the following items:

Valid Input	: identified classes of valid input must be accepted.
Invalid Input	: identified classes of invalid input must be rejected.
Functions	: identified functions must be exercised.
Output	: identified classes of application outputs must be exercised.
Systems/Procedure	: interfacing systems or procedures must be invoked.

Organization and preparation of functional tests is focused on requirements, key functions, or special test cases. In addition, systematic coverage pertaining to identify Business process flows; data fields, predefined processes, and successive processes must be considered for testing. Before functional testing is complete, additional tests are identified and the effective value of current tests is determined.

6.2.3 System Test

System testing ensures that the entire integrated software system meets requirements. It tests a configuration to ensure known and predictable results. An example of system testing is the configuration oriented system integration test. System testing is based on process descriptions and flows, emphasizing pre-driven process links and integration points.

6.2.4 White Box Testing

White Box Testing is a testing in which in which the software tester has knowledge of theinner workings, structure and language of the software, or at least its purpose. It is purpose.It is used to test areas that cannot be reached from a black box level

7. CONCLUSION AND FUTURE ENHANCEMENT

7.1 PROJECT CONCLUSION :

The project on **Multi-Layer Image Steganography for Text Hiding** using MATLAB has successfully demonstrated the feasibility of securely embedding text within digital images through advanced steganographic techniques. By employing a multi-layered approach, the system significantly enhances the robustness and capacity of hidden data, making it more difficult to detect or extract without prior knowledge of the encoding mechanism.

Throughout the project, various algorithms and techniques were explored and implemented in MATLAB, allowing for effective text concealment in image files while maintaining the visual integrity of the carrier images. MATLAB's powerful numerical computation and image processing capabilities enabled the development of an efficient and flexible steganography system.

The system offers potential applications in data security, where sensitive information can be hidden in everyday media files for secure transmission. However, the project also highlighted certain limitations, such as the trade-off between embedding capacity and image quality, as well as susceptibility to certain types of image manipulations (e.g., compression or filtering).

Overall, the project serves as a proof of concept for using multi-layer image steganography to enhance data hiding techniques. Future work can focus on optimizing the algorithms for faster performance, improving resistance to image degradation, and exploring real-world applications in fields like cybersecurity and digital forensics.

7.2 FUTURE ENHANCEMENT

The future enhancement of the **Multi-Layer Image Steganography for Text Hiding** system in MATLAB holds significant potential for further development and innovation. One major area for improvement is increasing the embedding capacity

while maintaining image quality. This can be achieved by implementing more advanced algorithms, such as adaptive steganography, which dynamically allocates bits based on image characteristics. Another critical enhancement is improving the system's resilience to image compression techniques, like JPEG, which often degrade or destroy hidden data. Integrating cryptographic techniques before embedding the data could also enhance security, ensuring that even if the hidden information is detected, it remains encrypted and secure.

Additionally, enhancing the system's resistance to steganalysis methods is crucial as detection techniques advance. Robust algorithms that make hidden data harder to detect could be implemented to counter these risks. Optimizing the system for real-time applications, such as secure communication, and expanding its functionality to multimedia formats like audio and video, would greatly broaden its usability. Exploring machine learning-based methods to improve data embedding efficiency and accuracy is another promising direction. Finally, developing a user-friendly interface and cross-platform support would make the system more accessible, appealing to a wider audience while allowing for broader integration across different devices and environments. These enhancements can significantly elevate the system's capability and application in secure data transmission.

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5.“Fundamentals of Digital Image Processing” by Anil K. Jain