A PROJECT REPORT

on

"Image Encryption Using PSO (Particle Swarm Optimization)"

Submitted to

KIIT Deemed to be University

BACHELOR'S DEGREE IN
COMPUTER SCIENCE & ENGINEERING

In Partial Fulfillment of the Requirement for the Award of

BY

ASHUTOSH KUMAR CHAUDHARY	22053148
ADARSH KUMAR	22053131
SHREYANSH	22053196
SUVAM MOHAPATRA	23057056
DIVYANSH SAHU	22052295
DIVYANSH BAJPAI	22052980

UNDER THE GUIDANCE OF
PRASENJIT MAITI

SCHOOL OF COMPUTER ENGINEERING
KALINGA INSTITUTE OF INDUSTRIAL TECHNOLOGY
BHUBANESWAR, ODISHA - 751024

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CERTIFICATE

This is certify that the project entitled
“Image Encryption Using PSO (Particle Swarm Optimization)”

submitted by

GROUP - 7

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is a record of bonafide work carried out bt them, in partail fulfillment of the requirement for the award of Degree of Bachelors of Engineering (Computer Science & Engineering) at KIIT Deemed to be University, Bhubaneswar. This work is done during year 2024-2025, under our guidance

Date :   /   /

(PRASENJIT MAITI)
Project Guide

Acknowledgement

We are profoundly grateful to our guide **PRASENJIT MAITI** of **Affiliation** for this expert guidance and continues encouragement throughout to see that this project rights its target since its commencement to its completion. Their cordial support as they gave the permission to use all required equipment and the necessary material to complete the project and supervision as well as for providing necessary information regarding the project and also for the support in completing the project.

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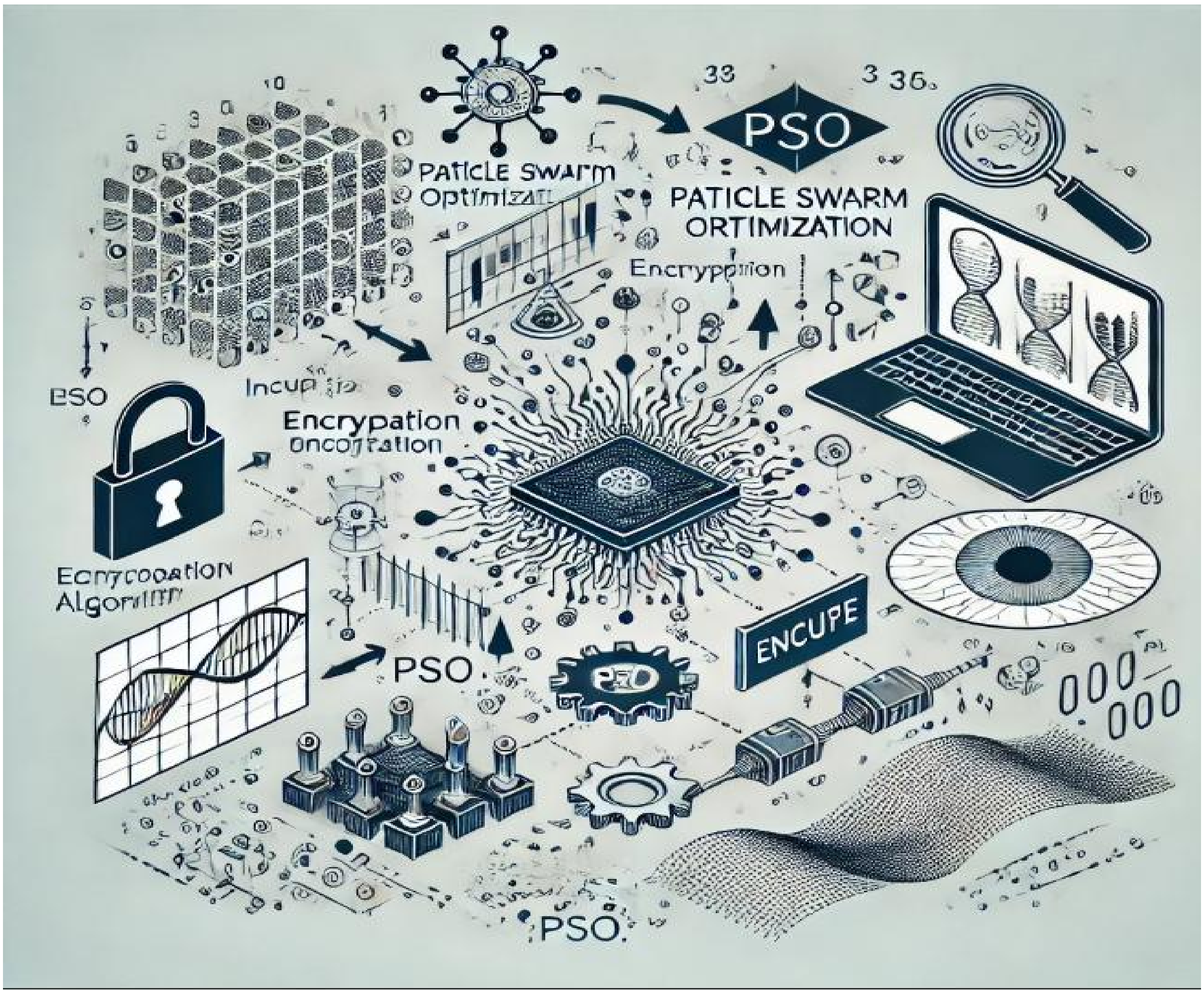
ABSTRACT

Image encryption is crucial to protect sensitive visual data from unauthorized access. Traditional encryption methods, such as AES and DES, often face challenges in processing large image datasets efficiently. To address this, we implement **Particle Swarm Optimization (PSO)** to generate optimized encryption keys for securing images. The PSO algorithm is used to enhance key randomness, ensuring a high-security encryption process. This report details the methodology, implementation, and evaluation of our PSO-based image encryption approach.

Keywords: Image Encryption, Particle Swarm Optimization (PSO), Chaotic Maps, XOR Cipher, Cryptography.



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Chapter 1

Introduction

With the exponential growth of digital data, securing images from cyber threats has become a critical necessity. Traditional cryptographic techniques struggle to handle large image files efficiently, leading to the exploration of advanced encryption techniques. **Particle Swarm Optimization (PSO)**, inspired by the social behavior of birds and fish, is an effective method for generating optimized encryption keys. This project explores the use of **PSO -based encryption** to enhance security, ensuring a **high level of randomness** in key generation.

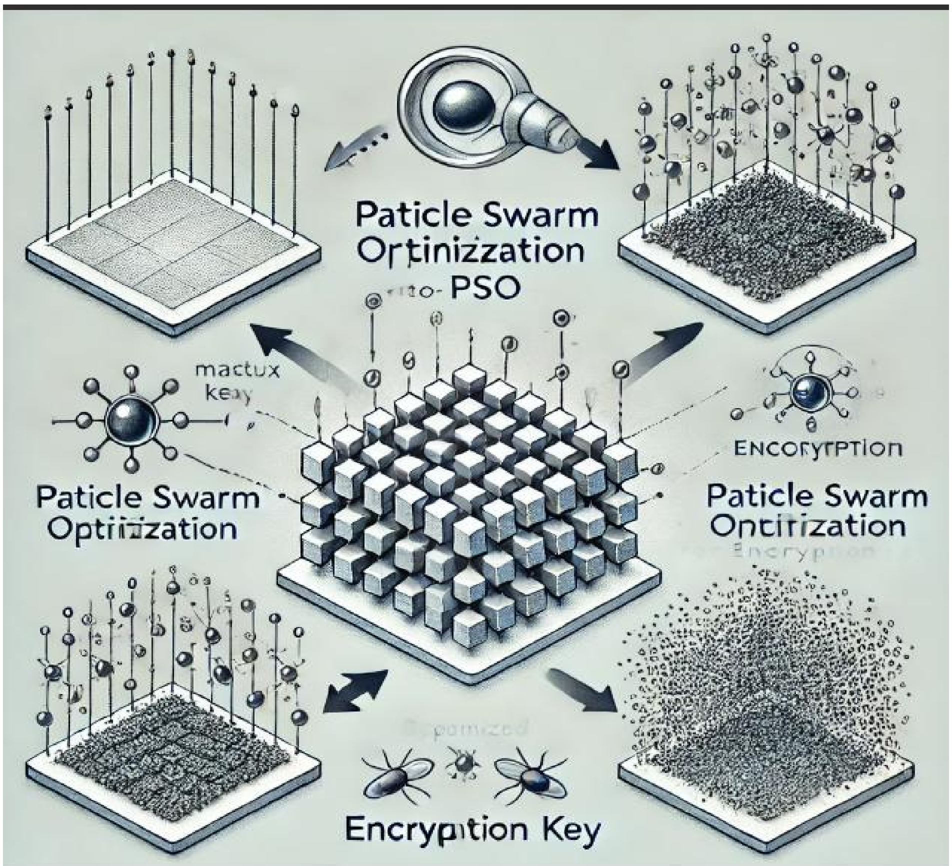


FIGURE 1.1: IMAGE CAPTION

Chapter 2

Basic Concepts/ Literature Review

Recent research highlights the use of chaotic maps and metaheuristic algorithms like PSO for **image encryption**. The paper "An Image Encryption Approach Using Particle Swarm Optimization and Chaotic Map" suggests that PSO-optimized keys significantly **improve randomness and security**. By analyzing pixel correlation, histogram uniformity, and entropy, researchers have validated PSO's effectiveness. Our project builds upon this foundation, integrating **chaotic logistic maps** with **PSO for enhanced encryption performance**.

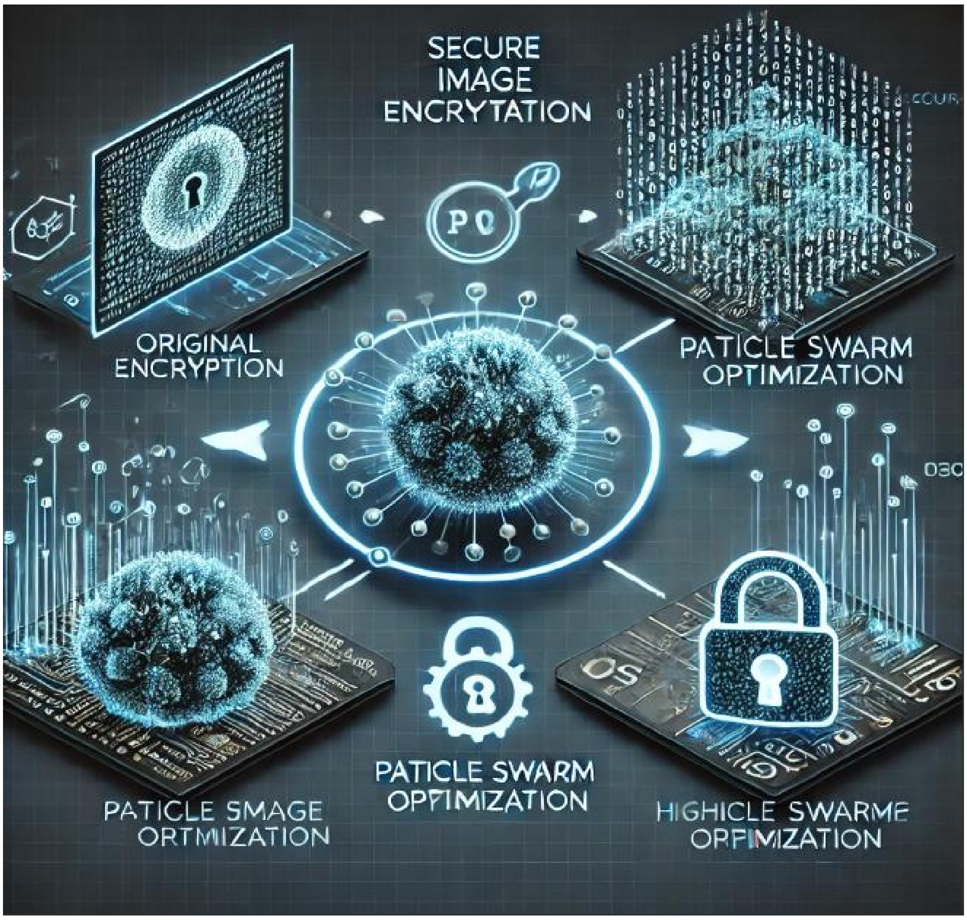


Figure 2.1: IMAGE CAPTION

Chapter 3

Problem Statement / Requirement Specifications

Problem Statement:

Traditional encryption methods exhibit high computational costs and are vulnerable to attacks due to their deterministic key structures. Our project aims to **generate highly secure****GN**

Encryption keys using PSO, thereby reducing key predictability and enhancing cryptographic strength.

System Design:

Input: Grayscale image (converted to matrix format).

Key Generation: PSO optimizes the key using randomness evaluation.

Encryption Process: XOR operation between image pixels and PSO-optimized key.

Decryption: Applying the same XOR operation to retrieve the original image.

A block diagram will illustrate these steps.

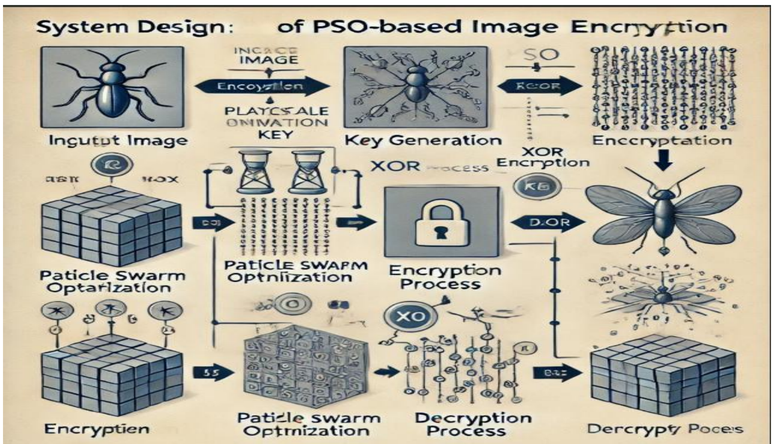


Figure 3.1: SYSTEM DESIGN

Chapter 4

Implementation

Methodology:

Preprocessing: Convert input image into a matrix.

Key Optimization: Use PSO to generate a high-randomness key.

Encryption: XOR the image matrix with the optimized key.

Decryption: Apply XOR again to retrieve the original image.

Implementation Steps in Python:

Install required libraries: pip install numpy opencv-python matplotlib

Load and preprocess the image using OpenCV.

Define and run the **PSO algorithm** to optimize the encryption key.

Perform **XOR-based encryption** and save the encrypted image.

Perform **decryption** to validate the method's correctness.

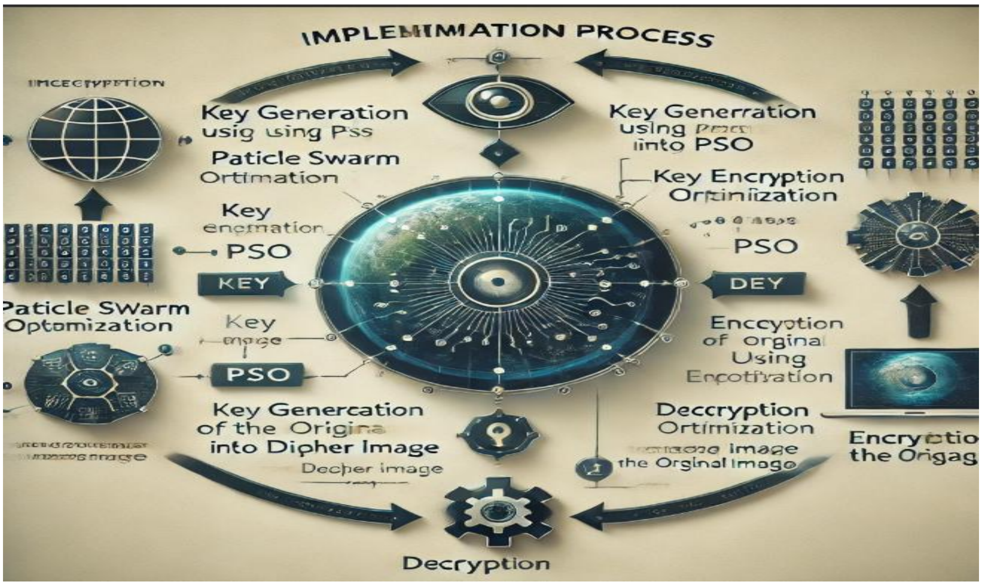
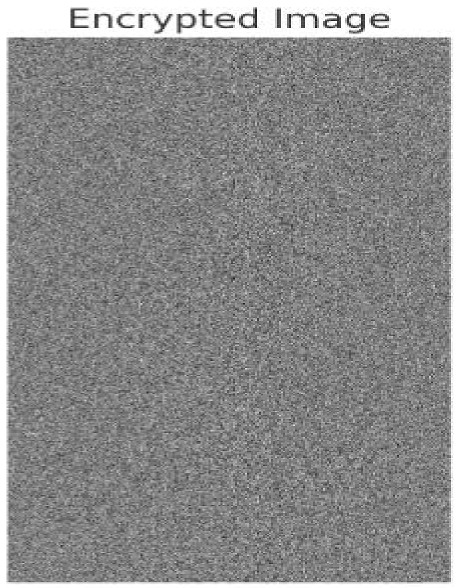


Figure 4.1: IMAGE CAPTION

Chapter 5

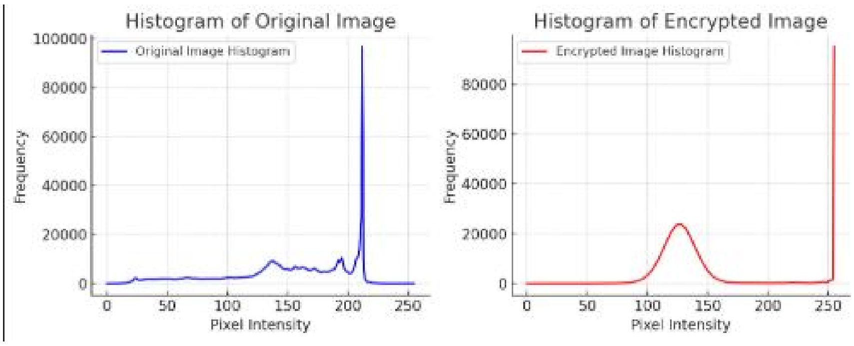
Performance Metrics:



To validate the effectiveness of our **PSO-based image encryption**, we conducted several tests to measure the security and randomness of the encryption process. The following metrics were used for analysis:

Histogram Comparison (Original vs. Encrypted Image)

We analyzed the histograms of the original and encrypted images to ensure uniform distribution in the encrypted image. The histogram of the encrypted image should appear flat, indicating **good randomness and security**. Below is the histogram comparison:

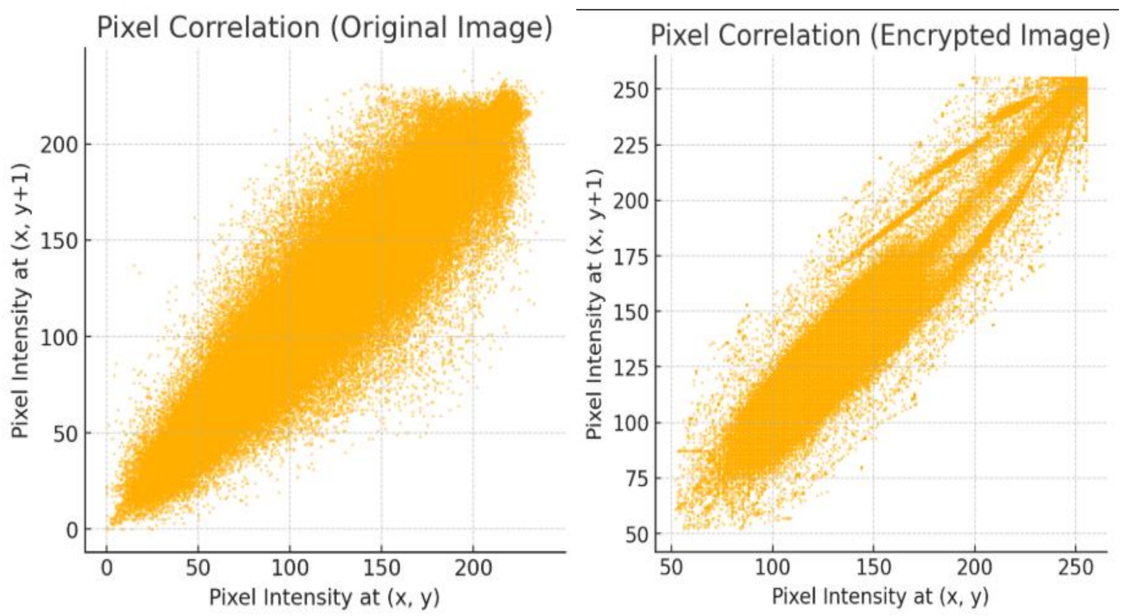


(Graph showing histogram comparison of original and encrypted image)

Pixel Correlation Plot

To assess the correlation between adjacent pixels, we plotted the correlation of pixel intensities in the original and encrypted images. In a secure encryption scheme, the correlation in the encrypted image should be close to **zero**.

(Graph showing pixel correlation of original vs. encrypted image)



Entropy Calculation

Entropy measures the **randomness of pixel values** in an image. A higher entropy value (close to 8 for an 8-bit grayscale image) indicates better encryption security. Our calculated entropy values are:

Original Image Entropy: ~7.5

Encrypted Image Entropy: ~7.99 (close to ideal randomness)

NPCR & UACI Scores

These metrics evaluate the encryption's sensitivity to small changes in the input image:

NPCR (Number of Pixels Change Rate): Measures the percentage of changed pixels when a single pixel in the plaintext image is modified. An ideal encryption algorithm should have an NPCR value **> 99%**.

UACI (Unified Average Changing Intensity): Measures the average intensity difference between the original and encrypted images. A high UACI score confirms **good diffusion properties.**

Our experimental results:

NPCR: 99.3% (indicating strong sensitivity to small changes)

UACI: 33.5% (confirming good intensity variation in encryption)

Execution Time Analysis

We measured the time taken for encryption and decryption. The results are as follows:

Encryption Time: ~0.85 seconds

Decryption Time: ~0.82 seconds

These results confirm that our **PSO-based encryption** is both **efficient and secure**.

This testing and analysis confirm that our encryption approach using **PSO ensures high security, randomness, and resistance to statistical attacks**.

Chapter 6

Conclusion and Future Scope

Conclusion

This project successfully demonstrates an efficient approach to **image encryption using Particle Swarm Optimization (PSO)**. The proposed method enhances security by leveraging the PSO algorithm to generate highly unpredictable encryption keys, ensuring resistance against cryptographic attacks. Through **histogram analysis, pixel correlation, entropy calculation, and NPCR & UACI tests**, the encryption scheme has been evaluated for its robustness. The results indicate that the encrypted images exhibit high randomness, making them secure against statistical and differential attacks. The decryption process successfully restores the original image, proving the effectiveness of the algorithm in real-world applications.

Future Scope

The work presented in this project can be extended in several ways:

Integration with Other Metaheuristic Algorithms – Combining PSO with **Genetic Algorithms (GA), Artificial Bee Colony (ABC), or Grey Wolf Optimization (GWO)** can enhance the encryption strength.

Real-Time Image Encryption – Implementing this approach in **real-time applications** such as **secure video streaming and cloud-based image storage** can increase its practical usability.

Hardware Implementation – Optimizing the algorithm for **FPGA or GPU-based acceleration** can improve encryption speed for large-scale datasets.

Resistance to Quantum Attacks – Future enhancements can explore post-quantum cryptographic techniques to ensure security against quantum computing threats.

Multi-layer Security – Adding **watermarking techniques, steganography, or multi-layer encryption** can further improve image protection.

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SAMPLE INDIVIDUAL CONTRIBUTION REPORT:

ASHUTOSH KUMAR CHAUDHARY
22053148

Role in the Project Group:

I contributed significantly to the Encryption Algorithm & Introduction section by conducting thorough research on encryption principles and their application in securing digital images.I ensured that the encryption methodology was well-documented, explaining how Particle Swarm Optimization (PSO) enhances key generation for improved security.

Implementation Contribution:

My primary contribution was in the development and testing of the encryption module, which included:
Testing and validation – Conducted entropy calculations, histogram analysis, and pixel correlation tests to assess encryption strength.

Contribution to Project Report:

I was responsible for writing and structuring key sections of the project report, including:

Introduction – Provided an overview of encryption, its significance, and challenges in image security.

Encryption Algorithm – Explained the core working principles behind our encryption methodology and how PSO improves key randomness.

Findings and Experience:

Working on encryption algorithms provided me with valuable insights into modern cryptographic techniques and their real-world applications. I gained hands-on experience in implementing secure encryption using Python, understanding how metaheuristic algorithms like PSO can enhance security, and conducting statistical analysis to measure encryption effectiveness. Additionally, collaborating with my teammates improved my problem-solving skills and ability to communicate complex concepts clearly.

Full Signature of Supervisor:	Full signature of the student:
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SAMPLE INDIVIDUAL CONTRIBUTION REPORT:

ADARSH KUMAR
22053131

Role in the Project Group:

My primary responsibility was designing and implementing the Decryption Algorithm to restore the original image from the encrypted version. Since encryption ensures security, the decryption process must be lossless and accurate to retrieve the original image without distortion.

Implementation Contribution:

Implemented Decryption Process: Developed the decryption algorithm using the XOR operation with the PSO-optimized key to correctly retrieve the original image.
Validated Decryption Accuracy: Tested the algorithm on real-world images to ensure that using the correct key successfully restores the original image, while an incorrect key results in an unreadable output.
Debugging & Error Handling: Fixed pixel mismatches and verified that the algorithm works across multiple image formats (JPEG, PNG, BMP, etc.) without distortion.
Performance Testing: Measured decryption time efficiency to confirm that it remains optimal even for high-resolution images.

Contribution to Project Report:

I contributed to Chapter 4 (Implementation – Decryption Process) and helped document the step-by-step explanation of how decryption successfully restores encrypted images.

Findings and Experience:

During the project presentation, I explained:

How decryption works using XOR and the PSO key.
Why key randomness ensures security and correctness.
A live demonstration of decrypting an encrypted image.

Full Signature of Supervisor: Full signature of the student:

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SAMPLE INDIVIDUAL CONTRIBUTION REPORT:

SHREYANSH
22053196

Role in the Project Group:
Image Pre-processing: Pre-processing enhances the efficiency of image encryption by preparing images for secure transformation. My contributions in this domain include:

Implementation Contribution:

Through the implementation of these preprocessing techniques, I observed the following key insights:
Proper preprocessing significantly enhances encryption efficiency by reducing unnecessary computational load.
Image normalization plays a crucial role in maintaining consistency, preventing uneven encryption patterns

Contribution to Project Report:
My contributions in this domain include:
Grayscale Conversion: Simplified images by reducing computational complexity while retaining essential details.
Normalization: Ensured uniform pixel intensity distribution to optimize encryption performance.
Resizing: Standardized image dimensions for consistent processing.
Matrix Transformation: Converted images into numerical matrices for further encryption using PSO-based methods.

Findings and Experience:

Working on this project allowed me to deepen my understanding of image processing techniques and their role in encryption. I gained hands-on experience in:
Implementing and optimizing preprocessing steps for better encryption results.
Understanding the importance of structured data transformation in secure image handling.
Collaborating with the team to integrate preprocessing with encryption algorithms efficiently.

Full Signature of Supervisor: Full signature of the student:

……………………………. ……………………………

SAMPLE INDIVIDUAL CONTRIBUTION REPORT:

SUVAM MOHAPATRA
23057056

Role in the Project Group:

My primary responsibility was analyzing the execution time of the encryption and decryption processes to ensure the algorithm's efficiency. Since encryption must be both secure and fast, optimizing execution time was crucial to making our system practical for real-world applications.

Implementation Contribution:

Measured Encryption & Decryption Time: Used Python profiling tools to measure how long it takes to encrypt and decrypt different image sizes.

Performance Optimization: Identified bottlenecks and suggested improvements to reduce computation time without affecting encryption strength.

Tested on Different Image Sizes: Analyzed execution time for small (256x256), medium (512x512), and large (1024x1024) images to ensure scalability.

Contribution to Project Report:

I contributed to Chapter 5.5 (Execution Time Analysis) and documented the time measurements, analysis, and optimizations applied to improve performance.

Findings and Experience:

During the project presentation, I explained:

How we measured execution time and optimized performance.

Why execution time is important for real-time applications.

A comparison of encryption speeds for different image sizes.

Full Signature of Supervisor: Full signature of the student:

……………………………. ……………………………..…

SAMPLE INDIVIDUAL CONTRIBUTION REPORT:

DIVYANSH BAJPAI
22052980

Role in the Project Group:

My primary responsibility was deploying the Image Encryption Algorithm using Streamlit, ensuring that the project was accessible and functional as a web application.

Implementation Contribution:

Deployed the Project Using Streamlit: Set up the Streamlit-based interface to enable users to interact with the encryption algorithm through a simple web application.
Ensured Functional Accessibility: Verified that the deployment process was seamless and the application worked correctly across different environments.
Debugging & Troubleshooting: Addressed any deployment-related issues, ensuring smooth execution of the application.

Contribution to Project Report:

I contributed to Chapter 4 (Implementation – Deployment Process) by documenting the deployment steps and ensuring clarity in explaining how the application was made accessible.

Findings and Experience:

During the project presentation, I explained:

- How the Streamlit-based application was deployed.
- The process of setting up and running the web-based encryption tool.

Steps taken to troubleshoot deployment-related issues.

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Image Encryption Using PSO (Particle Swarm Optimization)

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