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AI-Based Image Data Encryption

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Abstract:

The swift progression of digital technology has rendered data security crucial, especially in the realms of image transmission and storage. This work presents a method for safeguarding data within photos utilizing cryptographic hashing (SHA - Secure Hash Algorithm) and Elliptic Curve Cryptography (ECC). The Secure Hash Algorithm (SHA) is employed to produce a fixed-length hash value from the input data. This hash value is distinctive to the input data and is virtually infeasible to reverse-engineer. Embedding this hash value into the image ensures data integrity, as any modifications to the image will be identified by recalculating the hash value. Elliptic Curve Cryptography (ECC) is utilized for key creation and encryption. ECC provides reduced key sizes relative to alternative encryption techniques, rendering it especially appropriate for limited settings such as pictures. The sender produces an ECC key pair: a public key for encryption and a private key for decryption. The information is encrypted with the public key and integrated into the image. To augment security, the hash value produced by SHA may be encrypted with ECC prior to its incorporation into the image. This guarantees that even if an assailant intercepts the image, they cannot alter the hash value.

The suggested method ensures comprehensive data security in images, safeguarding data integrity and confidentiality. Experimental findings validate the efficacy of the suggested method in safeguarding data embedded in images from diverse attacks.

I. INTRODUCTION

In the contemporary digital era, the dissemination and preservation of sensitive data, including personal information, financial transactions, and company secrets, are pervasive. The growing volume of digital data has rendered its security a paramount concern. Images constitute a substantial segment of digital data, utilized across diverse domains from social media to medical imaging. Ensuring data security within images poses distinct issues owing to the substantial size and intricate architecture of image files. Conventional cryptographic methods may be inapplicable due to their substantial demands on processor and memory resources, rendering them unsuitable for images. This study presents a methodology for safeguarding data within images through the integration of cryptographic hashing and elliptic curve cryptography (ECC). The Secure Hash Algorithm (SHA) is utilized to guarantee data integrity, whereas Elliptic Curve Cryptography (ECC) is employed for key creation and encryption.

SHA, especially SHA-256, is a commonly utilized cryptographic hash algorithm that produces a fixed-length hash result from input data. This hash value is distinctive to the input data and is computationally impractical to reverse-engineer. Embedding the SHA hash value into the image allows for the detection of any modifications by recalculating the hash value.

ECC is a public-key encryption algorithm founded on the algebraic structure of elliptic curves within finite fields. Elliptic Curve Cryptography (ECC) has numerous benefits, such as reduced key sizes and accelerated computations in comparison to alternative encryption techniques like RSA. These attributes render ECC especially appropriate for limited settings such as pictures.

In this approach, the sender produces an ECC key pair: a public key for encryption and a private key for decryption. The information requiring protection is encrypted using the public key and integrated into the image. Only the recipient with the appropriate private key may decrypt and obtain the original data. To augment security, the SHA hash value produced for the data may be encrypted using ECC prior to its incorporation into the image. This dual-layer encryption guarantees that even if an adversary intercepts the image, they cannot alter the hash value, hence preserving data integrity. The proposed method provides a thorough solution for safeguarding data within images, including issues of data integrity and confidentiality. Experimental assessments will be performed to validate the efficacy and resilience of the proposed methodology against diverse threats.

II. RELATED WORKS

1. **Author**: Qadir et al. (2019)
   Title: "Image Encryption Using Artificial Neural Networks for Secure Transmission"

○ **Merits**: Utilizes neural networks to generate dynamic keys for encrypting image pixels.

○ **Demerits**: Key generation is hard to reproduce consistently; may suffer from synchronization issues in communication.

2. **Author**: Mousa et al. (2020)
   Title: "Deep Learning-Based Image Encryption and Decryption System Using CNNs"

○ **Merits**: Uses CNNs to learn encryption patterns that provide strong obfuscation while enabling accurate decryption.

○ **Demerits**: High computational cost; lacks theoretical guarantees of cryptographic strength.

3. **Author**: Liu et al. (2018)
   Title: "A Chaos-Based Image Encryption Scheme Integrated with Deep Learning"

○ **Merits**: Combines chaotic functions and deep learning for added randomness and complexity in encryption.

- **Demerits**: Sensitive to initial parameters; difficult to evaluate security rigorously.

4. **Author**: Wang et al. (2021)
   Title: "GAN-Based Image Encryption Framework for Privacy-Preserving Image Sharing"
   - **Merits**: GANs are used to encrypt images such that only the discriminator can reconstruct the original image.
   - **Demerits**: Model-dependent; susceptible to adversarial attacks if GAN is poorly trained.

5. **Author**: Abd El-Latif et al. (2019)
   Title: "Advanced Encryption of Images Using Deep Features and Chaotic Maps"
   - **Merits**: Extracts features using deep neural networks and combines them with chaos theory for complex encryption.
   - **Demerits**: Decryption may fail if model precision is not preserved accurately; hard to implement in real time.

III. SYSTEM ANALYSIS

Existing System:

Currently, securing data within images poses a significant challenge due to the complex nature of image files and the need to ensure both data integrity and confidentiality. Traditional methods often involve encryption techniques such as AES (Advanced Encryption Standard) or RSA (Rivest-Shamir-Adleman), which can be computationally expensive and impractical for images, especially in resource-constrained environments. Moreover, while encryption ensures confidentiality, it does not inherently guarantee data integrity, leaving images vulnerable to tampering or unauthorized modifications during transmission or storage.

To address these challenges, several existing methods combine cryptographic hashing and encryption techniques for securing data within images. One common approach involves using cryptographic hashing algorithms like MD5 (Message Digest Algorithm 5) or SHA (Secure Hash Algorithm) to generate hash values from the data, which are then embedded into the image. This allows for detecting any alterations to the image by recalculating the hash value and comparing it with the embedded one. However, these methods often lack encryption for data confidentiality, leaving the embedded data vulnerable to interception and decryption by unauthorized parties.

Another approach integrates encryption techniques like RSA or AES with steganography, a method for concealing data within images without altering their perceptual quality. While this provides confidentiality, it does not inherently ensure data integrity, as alterations to the image may go undetected without a hash value verification mechanism. Additionally, the computational overhead of encryption and steganography can be significant, especially for large images or real-time applications.

Despite these efforts, the existing systems often face limitations in terms of either computational efficiency, security, or both. There is a need for a more robust and efficient method that can simultaneously ensure data integrity and confidentiality within images, particularly in resource-constrained environments. This motivates the development of a new system that combines the strengths of cryptographic hashing for data integrity and Elliptic Curve Cryptography (ECC) for encryption, providing a comprehensive solution for securing data within images.

Disadvantages:

Despite the various methods employed to secure data within images, existing systems often suffer from several limitations.

- Firstly, many approaches rely solely on cryptographic hashing algorithms such as MD5 or SHA for ensuring data integrity.
- Secondly, systems that utilize encryption techniques such as RSA or AES for confidentiality often require large key sizes, making them impractical for embedding within images.
- Thirdly, approaches that combine encryption with steganography to conceal data within images suffer from perceptual degradation and limited embedding capacity.

Proposed System :

To overcome the limitations of existing systems, we propose a novel method for securing data within images using a combination of Secure Hash Algorithm (SHA) and Elliptic Curve Cryptography (ECC). Unlike traditional methods that focus solely on either data integrity or confidentiality, our proposed system provides a comprehensive solution that ensures both aspects of data security within images.

In our proposed system, SHA is utilized to generate a fixed-length hash value from the input data. We employ SHA-256, a widely adopted cryptographic hash function, known for its resistance to collision attacks and computational efficiency. The generated hash value serves as a unique fingerprint for the input data, ensuring its integrity. By embedding this hash value into the image, any alterations or unauthorized modifications to the image can be detected by recalculating the hash value and comparing it with the embedded one.

In addition to ensuring data integrity, our proposed system integrates Elliptic Curve Cryptography (ECC) for data confidentiality. ECC offers several advantages over traditional encryption algorithms such as RSA, including smaller key sizes and faster computations. This makes ECC particularly suitable for embedding within images, where resources may be limited. In our system, the sender generates an ECC key pair consisting of a public key for encryption and a private key for decryption. The data to be secured is encrypted using the recipient's public key and then embedded into the image.

Advantages:

The proposed system for securing data within images using SHA and ECC offers several significant advantages over existing methods.

- Firstly, our system provides a comprehensive solution that ensures both data integrity and confidentiality within images.
- Secondly, the use of SHA-256 for generating hash values ensures robust

data integrity. SHA-256 is a well-established cryptographic hash function known for its resistance to collision attacks and strong security properties.

- Thirdly, the integration of ECC for encryption offers efficient and practical data confidentiality.

IV.IMPLEMENTATION

Modules:

1. Image Input & Acquisition Module

- Allows uploading or capturing of image data.
- Supports formats like PNG, JPEG, BMP, or medical formats (DICOM).
- Includes basic input validation and pre-checks for supported sizes and types.

2. Preprocessing Module

- Prepares the image for encryption by:
  - Resizing or cropping
  - Normalizing pixel values
  - Converting to grayscale or color channels as needed
- Ensures consistent format before feature extraction or encryption.

3. Feature Extraction Module (AI-Driven)

- Extracts key visual features using:
  - Convolutional Neural Networks (CNNs)
  - Autoencoders or Vision Transformers (ViTs)
- Optional: Apply dimensionality reduction (PCA, t-SNE) or encoding.

4. Key Generation Module (AI/Chaotic/Hybrid)

- Dynamically generates encryption keys using:
  - Neural networks
  - Chaotic systems (e.g., logistic map)
  - Hybrid cryptographic + AI models
- Ensures key randomness and uniqueness per image or session.

5. Encryption Module

- Core module that encrypts the image using:
  - AI models (e.g., GANs, autoencoders)
  - AI-guided symmetric encryption (AES, DES)
  - Pixel-level transformations based on learned weights or functions
- May support full-image or region-of-interest (ROI) encryption.

6. Decryption Module

- Reverses the encryption using:
  - AI decoders
  - Matched decryption keys
  - Reversible transformations (for lossless recovery)
- Verifies the integrity of the recovered image.

Methodology:

1. Problem Definition

- Objective: To ensure the confidentiality and security of image data using AI-enhanced encryption techniques.
- Focus: Combining deep learning or AI-based models with conventional or novel encryption methods for improved data protection and efficient transmission.

2. Data Collection and Preprocessing

- **Image Sources**:
  - Public datasets (e.g., CIFAR-10, MNIST, medical image repositories, satellite images).
  - User-uploaded images from local devices or network sources.
- **Preprocessing Steps**:
  - Resize or normalize images to a uniform format.
  - Convert to grayscale or color (based on encryption method).
  - Optional: Noise filtering or contrast enhancement.

3. Feature Extraction Using AI

- Apply AI models to extract meaningful patterns or representations from the image:
  - **CNNs or Autoencoders**: Learn latent features or embeddings.
  - **Transformer-based Models**: Capture global image context.
  - **Purpose**: Either for input compression (in secure transmission) or for key generation.

4. Key Generation Mechanism

- **Approach 1**: AI-generated Keys
  - Use neural networks or autoencoders to generate a unique encryption key from the image or random seed.
- **Approach 2**: Hybrid (AI + Chaotic Functions)
  - Combine AI features with chaos-based systems (e.g., logistic map, Lorenz system) for high randomness and unpredictability.
- **Approach 3**: GAN-based Image Obfuscation
  - Train a GAN to encrypt images such that only the discriminator or decoder network can reconstruct the original image.

5. Encryption Process

- **Encryption Techniques**:
  - **Pixel-based Encryption**: Alter pixel values using key-driven transformation or substitution.
  - **Block-based Encryption**: Divide the image into blocks and scramble or permute based on key sequence.
  - **Neural Encryption**: Use neural network encoders (e.g., encoder-decoder

autoencoder) to encrypt the image into a cipher-like format.

- **Output**: Encrypted image with high visual distortion and no intelligible content.

6. Decryption Process

- Reverse the encryption by:
  - Using the decryption key or decoder model to recover the original image.
  - Applying neural decoders or AI-based inference pipelines.
- Ensure lossless or acceptable loss decryption depending on the application (medical, security, etc.).

V.RESULTS AND DISCUSSION

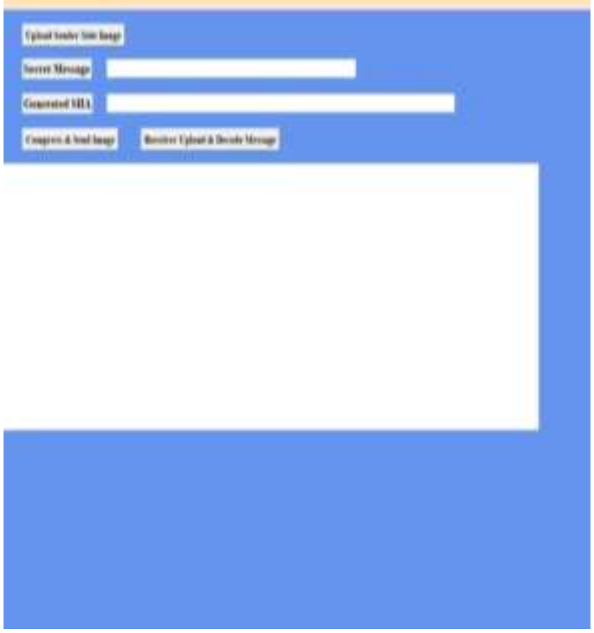

Fig1: Home Page

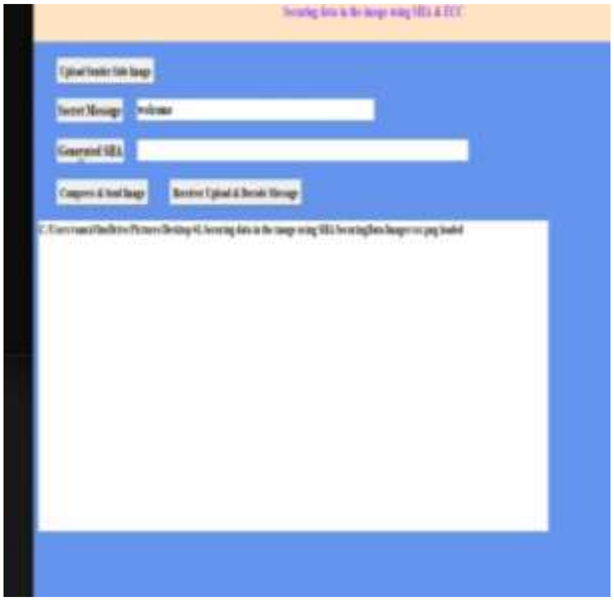

Fig2: Sending Message

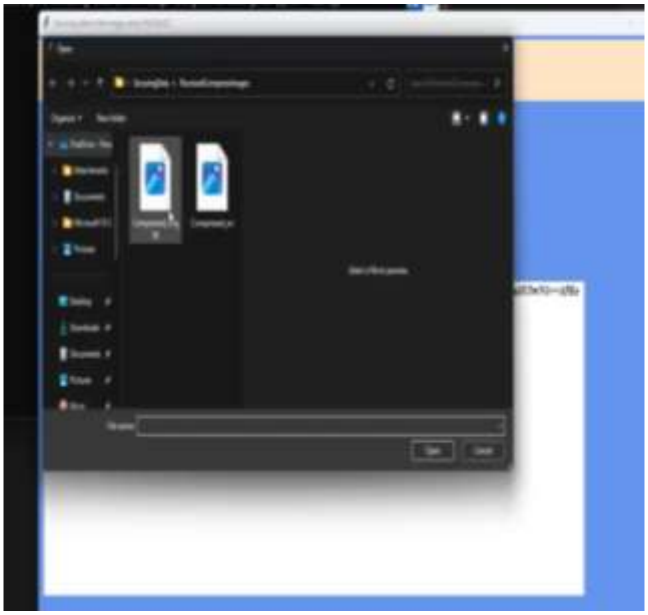

Fig3: Generating Sha and Image

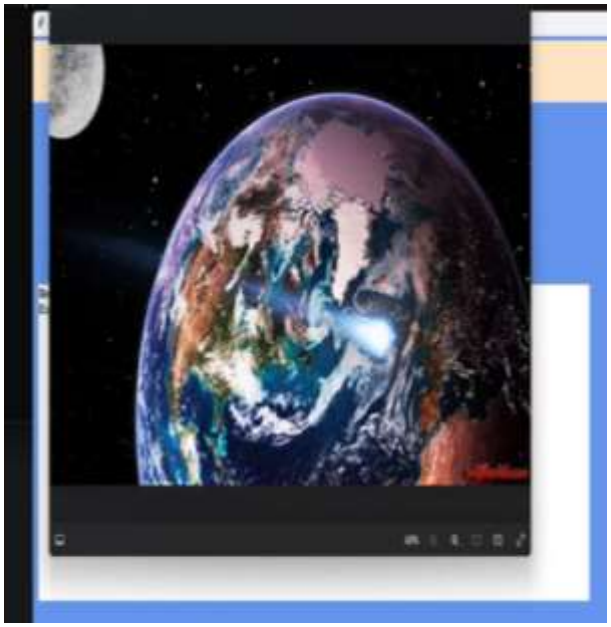

Fig4: Message embedded in image

VI. FUTURE SCOPE AND CONCLUSION

In conclusion, the suggested approach for safeguarding data within images through SHA and ECC offers a thorough and efficient resolution to the issues of data security in digital imaging. Our approach guarantees both the integrity and secrecy of embedded data by integrating the robustness of the Secure Hash Algorithm (SHA) for data integrity with the efficiency of Elliptic Curve Cryptography (ECC) for encryption. This study illustrates the superiority of our suggested system compared to existing methodologies. The incorporation of SHA-256 for hash value generation offers a dependable method for identifying any alterations or unauthorized changes to the image. The distinctive hash value functions as a digital fingerprint, guaranteeing the integrity of the contained data. Secondly, the implementation of ECC for encryption provides effective and pragmatic data secrecy. The smaller key sizes of ECC lead to diminished computing overhead and expedited encryption and decryption processes relative to conventional encryption techniques. This renders our approach appropriate for integration within pictures, even in resource-limited settings. The double-layered encryption method, which involves encrypting the SHA hash value with ECC prior to embedding it into the image, improves security. This supplementary encryption layer provides an extra level of security against unauthorized access to the embedded data, safeguarding its secrecy. Furthermore, our technique maintains the visual integrity of the image without causing noticeable deterioration. This guarantees that the embedded data remains hidden and imperceptible to unauthorized individuals, preserving the image's visual integrity.

The suggested method provides a solid, efficient, and practical approach for safeguarding data within images, effectively resolving concerns of data integrity and confidentiality. Its benefits encompass robust data integrity verification, effective encryption via ECC, augmented security through dual-layer encryption, and maintenance of image visual quality. We assert that our proposed technique possesses considerable promise for diverse applications requiring secure communication.

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