A Framework for Data Security using Cryptography and Image Steganography

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ABSTRACT Cryptography and steganography are the two research areas which are popular for data confidentiality, data hiding respectively. Steganography hides the data in various multimedia cover files like image, audio and video. This paper handles images for steganography, which have high redundant pixels. In this paper, Least Significant Bit (LSB) method hides the secret message bits in least significant bits of each pixel. The performance metrics MSE and PSNR are used to check the strength of the proposed algorithm. The proposed algorithm also checks payload capacity, image quality and security of the confidential data by applying cryptography and steganography algorithms and various parameters.

Keywords: Pixel, MSE, PSNR, LSB, distortion

I. INTRODUCTION

Audio, video and images are mainly used for data hiding and is called steganography. Digital images are more preferable media for hiding the information, because it is able to hide more data. Till now, various researchers are being worked on steganography algorithms using different image formats for hiding more data. The strength of any steganography algorithm can be measured by hiding capacity, distortion and security. The hiding capacity is nothing but maximum number of bits per pixel hiding in image/audio/video. Measuring the distortion is used to check the performance of steganography algorithm. The distortion of image can be calculated by PSNR, Mean square error (MSE), Root mean square error (RMSE) etc.

II. LITERATURE SURVEY

In digital era, the data can be transferred in different ways between sender and receiver through internet. But more threats are existing for confidential data like medical diagnostics, financial, credentials and military data. In order to provide the data security, cryptography is one technique which scrambles the content. Similarly steganography is also provides the data security through data hiding. Steganography uses a cover medium to hide the secret information [2]. For enhancing the data security, there is a need to combine steganography and cryptography. Image steganography can be hiding the unnatural secret message within a carrier image, so the carrier image quality will have a small change, thus no one cannot recognize it [1]. In steganography, vulnerability is more when least significant bit substitution methods are used for data hiding [3]. The LSB bits of all the pixels can be formed as LSB array and can be used to hide the secret binary words which enhances the security [4].

Similarly, the bits from four LSB planes can form four LSB arrays that are used to store four parts of the binary message at minimum distortion locations [5]. The three LSB planes can be investigated for increasing the hiding capacity. But it able to hide two bits only from the secret message [6,7]. LSB Steganography method replaces the least significant bits with secret message bits [8]. After insertion of the secret message bits, the values of pixels can be changed up to +1/-1[9]. In LSB methods, the message was present at LSB, and by only picking LSBs, the intruder can access the data.

In image steganographic techniques evaluation, the following parameters plays a vital role that are shown in Fig.1. Those are (i) hiding capacity, (ii) distortion measure and (iii) security check.

Hiding Capacity: The hiding capacity can be measured by the following two parameters:

- Maximum hiding capacity, is the total bits can be hidden in cover image
- Bit-rate, is the capacity of each pixel can hide how many number bits

Distortion Measurement: The distortion should not be noticed by the public. The distortion can be measured by various parameters. Peak signal-to-noise Ratio (PSNR), Root Mean Square Error (RMSE), Mean Square Error (MSE) are the parameters play an important role in assessing the performance of the steganography algorithms. The mean-squared error (MSE) The MSE between the original image (I1 (m,n)) and the stegoimage (I2(m,n)).

\[ \text{MSE} = \frac{1}{m \times n} \sum_{i=1}^{m} \sum_{j=1}^{n} (p_{ij} - q_{ij})^2 \]

Where the image contains M number of rows and N number of columns. The p and q are the carrier image pixel and the stego-image pixel value at row and column respectively. The MSE value of any algorithm indicates that when both the carrier and
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the distorted-image are equal then MSE is 0.
Peak signal-to-noise Ratio (PSNR)
The following formula is for calculating PSNR value for the
given image:

\[
\text{PSNR} = 10 \times \log_{10} \frac{255 \times 255}{\text{MSE}}
\]

It is a good indicator for comparing the restoration results of
the same image but meaningless across images. According
to different studies, PSNR is ranked as follows: up to 40 dB =
very good; 30 to 40 dB = acceptable; < 30 dB = not
acceptable.

III. PROPOSED SYSTEM

Least Significant bit substitution (LSB) method

The LSB substitution technique stores the secret message
bits in the least significant bits of the cover file. The cover
file could be audio, video or image file.

Least significant bit (LSB) in PNG

As we know, the Graphics Interchange Format (GIF) has
only eight (8) bits depth, so, the information hiding capacity
is lower compared to BMP. The hiding of information using

LSB has the same result in both GIF and BMP. The LSB
approach is considered as most effective for embedding a
reasonable capacity of information. In the GIF image, the
colors used are stored in a palette because it is an indexed
image. The use of a GIF image as a carrier for

steganography requires some levels of carefulness because of
the issue with the palette scheme. The use of a GIF image
with an altered LSB as a palette scheme may give different
colors due to the change in the color palette index.

Whenever there are different neighboring palette entries,
there is a remarkable image change, but when there is a
similar neighboring palette entry, the change is not
remarkable [11]. Generality, applications that deploy LSB
approaches on GIF image are characterized with low
security due to the possibility of detecting even an average
change in the image. Such issues can be solved thus:

- The palette must be isolated if there is a reduced
difference between sequential colors.

- An 8-bit grayscale GIF image comprising of 256
gray shades must be used; else, there will be a
gradual alteration of the colors.

At the sender-end

Step 1: Apply DRDP method for shuffling the data
Step 2: Convert all pixels in the original image row by row
into binary form and put it in image array
Step 3: Length of the message is stored in first pixel
Step 4: Take two characters (16-bits)/UTF-16 UNCODE
character and convert it into binary form
Step 5: The step-5 16-bit binary data is stored in next 3
pixels in the following:
- 3-bits in LSB of red component of 1st pixel
- 2-bits in LSB of green component of 1st pixel
- 3-bits in LSB of red component of 2nd pixel
- 2-bits in LSB of green component of 2nd pixel
- 3-bits in LSB of red component of 3rd pixel
- 2-bits in LSB of green component of 3rd pixel
- 1-bit in LSB of blue component of 3rd pixel
Step 6: Repeat Step 4, Step 5 for next pixels till all the bits
of secret message are embedded in the image.
Step 7: Set the image with the new values and save it.
Step 8: End

At the receiver-end

Step 3: Next three pixel gives the 2-character (16-bits)/UTF-
16 UNCODE character data in the following:
- 3-bits in LSB of red component of 1st pixel
- 2-bits in LSB of green component of 1st pixel
- 3-bits in LSB of red component of 2nd pixel
- 2-bits in LSB of green component of 2nd pixel
- 3-bits in LSB of red component of 3rd pixel
- 2-bits in LSB of green component of 3rd pixel
- 1-bit in LSB of blue component of 3rd pixel
Step 4: Repeat Step-3 for next pixels in the stego-image
Step 5: Decode all the extracted bits using DRDP method to
get the plain message.
Step 6: End

Using encoding algorithm, the stego-image can be prepared
which hides the given message, transfer the stego-image to
the destination. In destination end, the hidden message can
be extracted and decoded using DRDP method. Then the
original message can be shown to the user.
IV. RESULTS AND DISCUSSION

The performance of the proposed system can be measured with two parameters PSNR and MSE. The proposed algorithm has been applied on the following 256X256 pixel grayscale images for 2KB, 4KB, 6KB, 8KB, 10KB and 12KB data.

The proposed algorithm hides 2KB data using above grayscale images and the results are shown in Table-1.

Table 1: The results of the proposed method using (256×256) image for 2KB data

| Image name          | PSNR     | MSE          |
|---------------------|----------|--------------|
| Lena.png            | 52.02567405554823 | 0.40786172839506174 |
| Lady.png            | 52.10998923428396  | 0.40001975308641974  |
| Baboon.png          | 52.01873862476182  | 0.4085135802469136  |
| Mother_baby.png     | 52.04316683245441  | 0.4062222222222222  |
| Photographer.png    | 52.08070772173965  | 0.40272592952592593  |
| Mountains.png       | 52.352312640282996 | 0.3783111111111111 |

The proposed algorithm hides 4KB data using above grayscale images and the results are shown in Table-2.

Table 2: The results of the proposed method using (256×256) image for 4KB data

| Image name          | PSNR     | MSE          |
|---------------------|----------|--------------|
| Lena.png            | 50.4794738257217 | 0.5822814814814815 |
| Lady.png            | 50.55723923383845 | 0.572532098765322  |
| Baboon.png          | 50.59096536679627  | 0.566479012345679  |
| Mother_baby.png     | 50.64984257765515  | 0.5598814814814815  |
| Photographer.png    | 50.44089830107775  | 0.587465432098765   |
| Mountains.png       | 50.90267753089074  | 0.5282172839506173  |

The proposed algorithm hides 6KB data using above grayscale images and the results are shown in Table-3.
The proposed algorithm hides 8KB data using above grayscale images and the results are shown in Table-4.

Table 4: The results of the proposed method using (256*256) image for 8KB data

| Image Name     | PSNR     | MSE       |
|---------------|----------|-----------|
| Lena.png      | 49.373   | 0.7511111111111111 |
| Lady.png      | 49.45317609213536 | 0.7375012345679013 |
| Baboon.png    | 49.47615192875395 | 0.7360987654320909 |
| Mother_baby.png | 49.53075274575315 | 0.7244444444444444 |
| Photographer.png | 49.127118833681834 | 0.7950024691358024 |
| Mountains.png | 49.78105789120015 | 0.6838761049382716 |

The proposed algorithm hides 8KB data using above grayscale images and the results are compared with existing techniques like Classic LSB method, SSC method, PIR, FMM and CST methods. The comparative results are shown in Table-7.

Table 7: The performance comparison of proposed and existing methods through PSNR\textsuperscript{12} by hiding 8KB of data in images of resolution (256*256)

| Image Name     | Classic LSB method | SSC method | PIR method | FMM | CST | Proposed Method |
|---------------|--------------------|------------|------------|-----|-----|-----------------|
| Lena.png      | 42.51               | 42.60      | 42.30      | 43.57 | 55.92 | 48.57           |
| Baboon.png    | 54.73               | 47.97      | 46.89      | 44.55 | 48.95 | 48.57           |
| House.png     | 52.04               | 52.89      | 51.07      | 67.55 | 51.17 | 48.57           |
| Couple.png    | 48.40               | 47.91      | 46.58      | 46.25 | 55.91 | 48.65           |
| Tree.png      | 56.27               | 49.76      | 48.60      | 46.12 | 38.54 | 48.37           |
| Moon.png      | 56.02               | 47.26      | 46.39      | 45.82 | 47.49 | 48.90           |

The results of the parameters PSNR and MSE of the proposed system are shown in Table-7. These values are compared with existing methods. The Table-7 shows the comparison of PSNR value of the proposed system and the existing algorithms [13]. The proposed method tries to overcome the drawbacks of all these methods.

V. CONCLUSION

In cryptography and steganography, various algorithms have been designed by many researchers in the world. Many algorithms are able to handle ASCII data only and steganography algorithms are based on LSB technique using images. Very few algorithms are using DRDP method for shuffling the data with simple mathematical operations. When we observe the performance analysis, the Encryption-Time and Decryption-Time are same. The encoded data can be hidden in to the cover file using LSB steganography technique. In the proposed system, the original image and stego-image are looking similar and distortion is also very less. It is proved by two parameters like MSE and PSNR. These values are better than the existing methods.

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