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Optimal Pixel Adjustment Based Reversible Steganography

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Abstract—**A novel prediction-based reversible steganographic scheme based on image in-painting is used to embed the secret information. First, reference pixels are chosen adaptively according to the distribution characteristics of the image content. Then, the image in-painting technique based on partial differential equations (PDE) was introduced to generate a prediction image that has similar structural and geometric information as the cover image. Finally, by using the two selected groups of peak points and zero points, the histogram of the prediction error is shifted to embed the secret bits reversibly[1]. Since the same reference pixels can be exploited in the extraction procedure, the embedded secret bits can be extracted from the stego image correctly, and the restoration of the cover image is lossless. Through, the use of the adaptive strategy for choosing reference pixels and the in-painting predictor, the more embeddable pixels are acquired.However, PDE based in-painting algorithm is computationally complex and requires more execution time. Also, the quality of the stego image is not considered in the in-painting algorithm.**

To improve the visual quality of the stego image Optimal Pixel Adjustment algorithm (OPA) can be used. The OPA is applied after embedding the message. The frequency domain is employed to increase the robustness of the steganography method. OPA algorithm is to minimize the error difference between the original coefficient value and the altered value by checking the right next bit to the modified LSBs so that the resulted change will be minimal. This research work uses OPA to obtain an optimal mapping function to reduce the difference error between the cover and the stego-image which increases the hiding capacity with low distortions and Peak Signal to Noise Ratio (PSNR).

Keywords: **PSNR, Reversible Data Hiding, DCT coefficient, Inpainting Algorithm, OPA**

I. INTRODUCTION

Steganography means "Covered Writing" which is derived from the Greek language. The main purpose of Steganography is to send secret or confidential message under the cover of a carrier signal. Two main properties of any Steganography technique[2] are good imperceptibility and sufficient data capacity. Good imperceptibility ensures that the embedded message is difficult to detect. Steganography and cryptography are mainly used for security, but both are different. The main goal of cryptography is to communicate securely by changing the data into a form that an attacker cannot understand. The Steganography techniques are used to hide the presence of the message and make it difficult for attackers to find the occurrence of the message.

The research on Steganography concentrates on images, audio, and video as cover media. An image in which data is embedded is called as a cover image and the image which is used for carrying secret data is termed as stego image. A good data hiding method should be capable of evading visual and statistical detection while providing an adjustable payload. Impossibilities of data hiding is commonly achieved by exploiting the weakness of the human auditory and visual systems, using the techniques, for example changing the least-significant bits of pixels of cover image to embed information, or shifting lines, words, or characters by a small amount in an image containing text. Other works hide information by adding redundant data, or making use of alternative representations of electronic data. For example hidden information can be added in a text document by adding tabs and spaces at the end of the line. The different combinations of the color palette entries in a GIF image can be used to embed secret data into the image file. Sometimes the cover media will experience some distortion due to data hiding and cannot be inverted back to the original media. That is, after the hidden data have been extracted out

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some permanent distortion has been occurred to the cover media.

Reversible Steganography scheme has the ability to embed the secret data into a host image and then recover the host image without losing any information when the secret data is extracted. This should be overcome by using some techniques. Reversible Steganography is also known as reversible data hiding. No modification is done in the digital representation of the cover image when reversible data hiding method[6] is used. The Reversible data hiding is used in the field of medical, military, legal applications etc.

Reversible Steganography can also be called as reversible data hiding, which means that the original form of the image, before the secret bits were embedded, can be recovered completely after the embedded bits are extracted. Reversible data hiding can be used for medical, military, and legal applications, which do not allow any modification in the digital representation of the cover image due to the risk of misinterpretations.

II. PROPOSED SCHEME

To improve the visual quality of the stego image OPA algorithm can be used. The OPA is applied after embedding the message. The frequency domain is employed to increase the robustness of the Steganography method.

This research work uses OPA to obtain an optimal mapping function to reduce the difference error between the cover and the stego-image which increases the hiding capacity with low distortions and Peak Signal to Noise Ratio (PSNR). The main idea of applying OPA is to minimize the error between the cover and the stego image.

A. Embedding System

Embedding system is to embed the Secret information within an image and produce the stego image(fig 1).

Initially select the cover image in which the secret information are to be embed. Once when the cover image is selected, it is processed.

- ✓ Now select the Secret Information(i.e., Text File)
- ✓ Find the pixel co - efficient value and also find reference pixel to which the data is to be embedded.
- ✓ Embed the secret information using Least Significant Bit (LSB) embedding techniques.
- ✓ The error difference between the original coefficient value and the altered value by checking the right next bit to the modified LSBs can be minimized using the OPA algorithm.
- ✓ By minimizing the error difference between the original co-efficient value and the altered value, the quality of the stego image can be maintained.

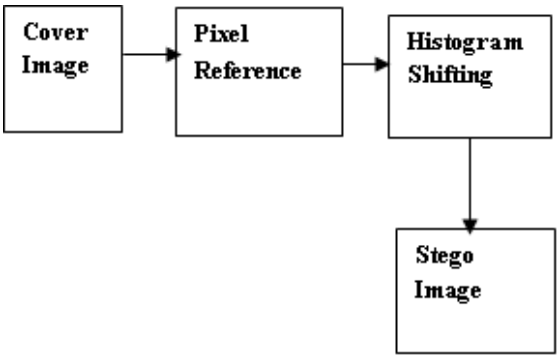

Fig1. Embedding Process

Fig2.Stego images for Lena with corresponding parameters in Fig. 2. (a)PSNR = 51.04 dB. (b) PSNR = 49.96 dB. (c) PSNR = 49.49 dB. (d) PSNR= 49.22 dB.

B. Optimal Pixel Adjustment:

The Optimal Pixel Adjustment (OPA) is applied after embedding the message. The main idea of applying OPA is to minimize the error between the cover and the stego image. For example if the pixel number of the cover is 10000 (decimal number16) and the message vector for 4 bits is 1111, then the pixel number will change to 11111 (decimal number 31) and the embedding error will be IS, while after applying OPAP algorithm the fifth bit will be changed from 1 to 0, and the embedding error is reduced to 1.

OPA Process:

- ➢ Consider $\mathbf{P_{xi}}$, $\mathbf{P_{xi}'}$, $\mathbf{P_{xi}''}$ represent pixel values at i^{th}pixel in the host image H, stego image S.

  Let,

  $$\delta_i = P_{xi}' - P_{xi}$$

  Where, δ_i = embedding error
- ➢ Cover or host image of M*N pixels is represented as

  $$H = x_{ij} E \{0, 1...255\}$$
- ➢ Secret message **m** in K secret bit is

  $$m = \{m_i \mid 0 \leq i < n, m_i \in \{0, 1\}\}$$

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- To convert P_{xi}' to P_{xi}'' i.e. original pixel to stego pixel three cases are defined.

Case 1: $(2^{k-1} < \delta i < 2^k)$

$\mathbf{P_{xi}'' = P_{xi}' - 2^k; P_{xi}' \geq 2^k}$

$\mathbf{= P_{xi}'; otherwise}$

Case 2: $(-2^{k-1} \leq \delta_i \leq 2^{k-1})$

$\mathbf{P_{xi}'' = P_{xi}'; for\ all}$

Case 3: $(-2^k < \delta_i < -2^{k-1})$

$\mathbf{P_{xi}'' = P_{xi}' + 2^k; P_{xi}' < 256 - 2^k}$

$\mathbf{= P_{xi}'; otherwise}$

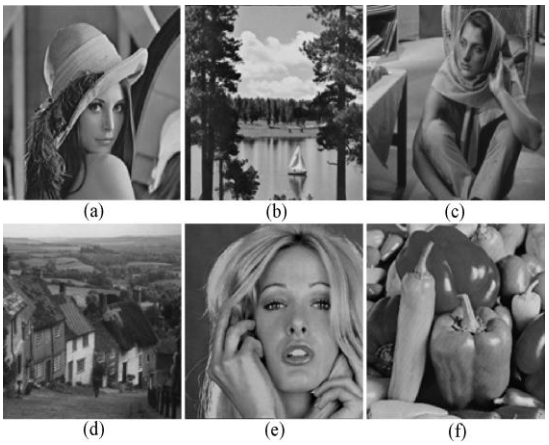

Fig3. Six standard test images. (a) *Lena*. (b) *Lake*. (c) *Barbara*.(d) *Gold hill*. (e) *Tiffany*. (f) *Peppers*.

C. *Extraction System:*

The following steps are to be followed for extraction of the secret Information

- ✓ Take the stego image i.e., the image in which the secret data is embedded.
- ✓ Now using any of the extracting technique the secret information is extracted from the stego image.
- ✓ After extraction process(Fig4), the secret information can be extracted from the cover image with the better quality.

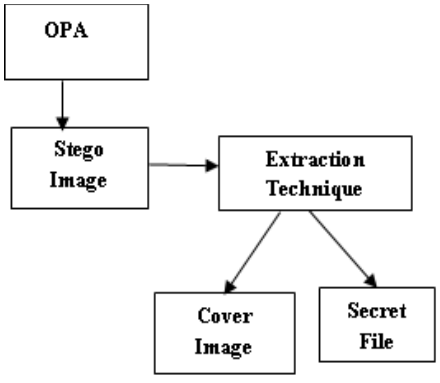

Fig4. Extraction Process

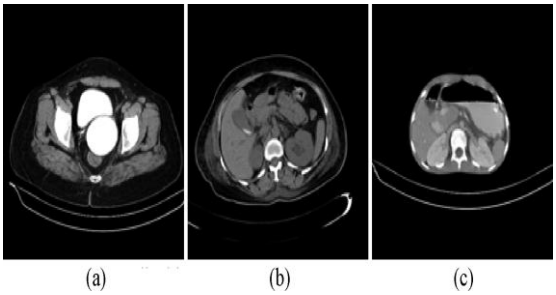

Fig5. Three medical cover images. (a) Medical image 1. (b) Medical image 2. (c) Medical image 3.

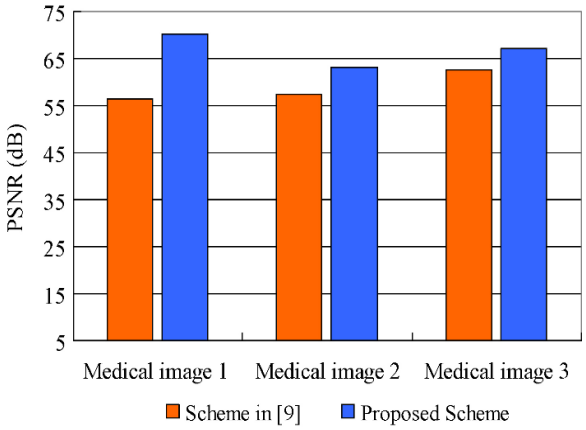

Fig6. Comparison of medical images between the proposed scheme and the scheme

CONCLUSION

Image Inpainting based on partial differential equations (PDE) is introduced to complete the prediction process by the reference pixels. By using the two selected groups of peak points and zero points, the histogram of the prediction error is shifted to embed the secret bits reversibly. During the extraction procedure, the same reference pixels can be exploited to conduct the prediction, which guarantees the lossless recovery of the cover image. Hence visual quality for stego images is not maintained. To improve the visual quality of the stego image OPA algorithm can be used. The Optimal Pixel Adjustment (OPA) is applied after embedding the message. This research work uses OPA to obtain an optimal mapping function to reduce the difference error between the cover and the stego-image which increases the hiding capacity with low distortions and Peak Signal to Noise Ratio (PSNR). The main idea of applying OPA is to minimize the error between the cover and the stego image. Future work is to improve the hiding capacity along with image quality.

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