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Data Hiding For High Image Quality Based On Local Complexity and Interpolation

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Abstract:Steganography is the practice of hiding private or sensitive information within something in such a way that someone cannot know the presence or contents of the hidden message. The paper presents a reversible data hiding method in which the cover image as well as the hidden message can be extracted back at the receiver side. Image Interpolation and Histogram shifting techniques are used in this method. Even and Uneven areas of an image are identified with respect to its neighbor pixels and embedding is done only on the even regions. Interpolation is performed on the even region before embedding process. Embedding is done using histogram shifting technique and hence a high visual quality is obtained. This method obtains an average PSNR value of 50.1 db. At the receiver end the cover image as well as secret data are completely extracted out and hence private communication between two parties is made possible.

Keywords - Steganography, Image interpolation, Histogram shifting, reversible data hiding

I. INTRODUCTION

In this modern digital world Internet users frequently need to store, send, or receive private information’s. The most common way to do this is to transform the data into a different form. It can be retrieved only by those who know how to return it to its original form. This method of changing the form of information for security is known as encryption. A major drawback to encryption is that the existence of data is not hidden. Data that has been encrypted, although unreadable, still exists as data. If given enough time, someone could eventually decrypt the data. A solution to this problem is steganography. The ancient art of hiding messages so that they are not detectable. The hidden message is plain, but unsuspecting to the reader. Steganography's intent is to hide the existence of the message, while cryptography scrambles a message so that it cannot be understood.

Digital image steganography is mostly oriented toward tricking the human visual system into believing the perception of the image has not been manipulated in any way. Similar rules apply to the whole field of digital media steganography, whose primary function is to trick the observer to believe the crafted "forgery" is indeed genuine. General terms used in data hiding are:

- Cover Image: Original image in which the secret data is to be hide.
- Payload: Secret data to be hidden.
- Stego Image: The cover image containing the payload.

Usually steganography, the art and science of writing hidden messages uses various techniques for hiding the secret data. Generally every method should satisfy some basic rules or requirements. They include:

- The integrity of the secret data has to be maintained
- The stego image must be unchanged or almost unchanged to human visual system.
- We always assume that the attacker knows that their is hidden information inside the stego image.

Data hiding technology prevents information from being detected, stolen or damaged by unauthorized users. Data hiding can be reversible or irreversible. This method provides a reversible data hiding technique in which the original cover image as well as the secret data can be extracted at the receiver side. The method uses image interpolation technique and histogram shifting for hiding the secret data. Image interpolation can improve the embedding capacity of the cover image and histogram shifting is done for further improving the image quality. Image interpolation can be defined as the process of creating or generating new pixel values from already known or available values i.e. obtaining high resolution images from low resolution images. Here first the input image is interpolated using ENMI (Enhanced Neighbor Mean Interpolation) to obtain the cover image in which the data is to be hide. Now Even and Uneven surfaces of the image are detected based on neighboring pixel complexity and embedding is performed only on the even surfaces. The difference values of even surfaces are taken and embedding is done. Histogram shifting based data hiding improves the quality of the image as it shifts the pixel values left or right depending on the secret data values (0 or 1). During histogram shifting we take peak point and zero point depending on pixel intensity occurrence and embedding done on peak point shifting. Since we use shifting of values underflow or overflow problems can occur , to solve this problem Location map concept is used here.

In the extraction phase, the even surfaces identified are again revised and check for the pixel shifting if the pixel value is shifted right then 1 is extracted out and if pixel value is shifted left then 0 is extracted out. In order to maintain the visual quality all pixels except the peak value are shifted depending on the condition. Then reverse of the interpolation is done to obtain the original input pixel values. Hence at the receiver end secret data and input image are extracted out i.e. reversibility of the hiding is maintained.

II. Related Works

Reversible data hiding schemes in spatial domain are mainly based on difference expansion and histogram shifting. Generally, schemes based on difference expansion provide higher embedding capacity, whereas the schemes based on histogram shifting offer better visual quality of the stego-image. In past few years, various reversible data hiding schemes based on histogram shifting have been developed. . In 2011, Hong and Chen [8] combined the interpolation technique and a reference pixel distribution mechanism to enhance image quality instead of using Li et al.'s technique. Later, Zhao et al. [3] proposed a new reversible data hiding scheme based on histogram shifting and sequential recovery. The principle of their scheme was to shift the histogram constructed from the neighboring difference instead of shifting the histogram of the cover image. In this work at the first stage, a high-quality cover image is generated using the developed enhanced neighbor mean interpolation and then take the difference values from input and cover pixels as a carrier to embed secret data. In this stage, this scheme raises the image quality a lot due to the ENMI method. At the second stage, a histogram modification method is applied on the difference image to further increase the embedding capacity and preserve the image quality without distortion. Experimental results indicate that the method have better PSNR value of stego-image with improving 43 % on the average when compared the past key-studies.

Interpolation is the process by which a small image is resized or remapped to a larger one. Interpolation algorithms stretch the size of an image and generate pixels to fill in the blanks. Image interpolation is widely used in medical imaging, digital photos, film scanned images, and so forth. In image interpolation, limited information is used to calculate and predict other pixel values. The limited information, or the known pixels, are called reference pixels and will leave unchanged while interpolating. Some common interpolation algorithms including nearest neighbor interpolation, bilinear interpolation, cubic interpolation, bicubic interpolation etc.

Reversible data hiding method which shifts slightly the part of the histogram between the maximum point (also called the peak point) and the minimum one to the right side by one pixel value to create an empty bin besides the peak point for hiding the input message. The knowledge of the maximum point and the minimum point of the histogram is necessary for retrieving the hidden data and restoring the stego-image lossless to the original state. In addition, the coordinates of the pixels whose gray values are equal to the gray value of the minimum point b need be memorized as overhead information when the value of b is not zero. Reversible data hiding method based on histogram shifting was proposed in [10], which uses the information about peaks and zeros of the cover image histogram to perform a partial shift, leaving a gap to hide data. In the Ni et al.'s [10] method, the embedded secret data cannot be recovered when the knowledge of peak and zero point of histogram are not transmitted to the receiver.

III. PROPOSED WORK

A new reversible data hiding method is proposed here which provides better visual quality and embedding capacity than the existing method. In the existing work embedding is done on the entire cover image when interpolation is done first it makes a blurring effect on the uneven areas of the image and hence the stego- image in effect becomes blurred and the quality losses. Hence in the proposed method before embedding is performed the cover image is divided into even and uneven surfaces using neighboring pixel complexity and embedding is done only on the even surfaces and hence high embedding capacity as well as image quality is obtained.

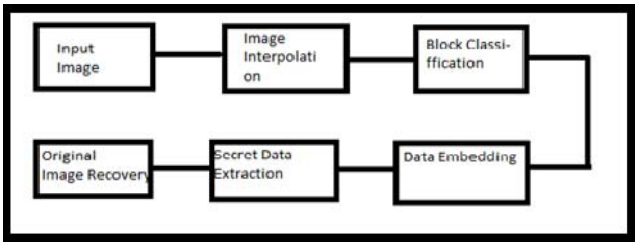


Fig1:Flowchart of proposed method

Image Interpolation

Interpolation is a method of constructing new data points within the range of a discrete set of known data points. Image resizing is required when you need to increase or decrease the total number of pixels in the image. It normally happens at almost every image at any of its phase of processing. The implemented enhanced neighbor mean interpolation (ENMI for short) is inspired from the JungYoo- scheme [4]. ENMI provides better image quality and embedding capacity than other already existing interpolation methods in literature such as Linear, Bilinear, Cubic etc in spatial domain. Figure 9 illustrates the procedure of our implemented scheme.

For an input image I sized of 512 * 512 pixels, define an image block, which is composed of four adjacent pixels, i.e., I(i,j), I(i +1,j), I(i,j+1), and I(i + 1,j +1). For each pixel I(i,j) ,the corresponding cover pixel, C(i,j) of a cover image C is defined by the algorithm of ENMI.

$$C(i,j)=\begin{cases} I(i,j) & \text{if } i \bmod 2=0 \text{ and } j \bmod 2=0 \\ I(i,j-1) & \text{if } j=N-1 \\ I(i-1,j) & \text{if } i=N-1 \\ \frac{I(i,j-1)+I(i,j+1)}{2} & \text{if } i \bmod 2=0 \text{ and } j \bmod 2=1 \\ \frac{I(i-1,j)+I(i+1,j)}{2} & \text{if } i \bmod 2=1 \text{ and } j \bmod 2=0 \\ \frac{I(i-1,j-1)+I(i-1,j+1)+I(i+1,j-1)+I(i+1,j+1)}{4} & \text{otherwise} \end{cases}.$$

Block Classification

In this work, the cover image I with the size of 512*512, is divided into non- overlapping blocks with sizes of 3* 3 pixels. For each block, the center pixel Ci is selected as the reference pixel, and other eight pixels are referred to as non-reference pixels. For the non-border block with the reference pixel Ci, there are other reference pixels, i.e., Cl, Cr, Cu ,Cd, which are located directly left, right, up above, and down below pixel Ci, respectively. These four reference pixels are defined as the satellite reference pixels of the reference pixel Ci.

The embedding capacity by using histogram shifting for smooth regions is significantly greater than the embedding capacity in the complex regions. Based on this property, to obtain higher embedding capacity while maintaining the quality of the stego-image, we use the local complexity measurement as shown above to classify image blocks into complex blocks or smooth blocks. For the complex blocks, all the pixels will be marked as reference pixels to prevent them from being modified in the embedding process.

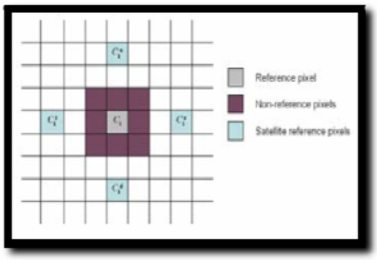


*Fig 3: A 3*3 block*

Fig 4: Even and Uneven regions of Lena Image

For a given block, based on its satellite reference pixels, its local complexity, is calculated using below equation, and is used to evaluate whether the pixels are located in a even or uneven region. Local Complexity (LC) is defined using a function called Range, where the Range function is defined as the absolute difference between the maximum and minimum values of the four satellite reference pixels, of the current processing block. If the complexity value is less than the threshold T, the current processing block likely is located in the smooth region. In this case, we obtain one or more pixels that can be used for carrying secret bits.

$$LC_i = Range(C_i^l, C_i^r, C_i^u, C_i^d).$$

Data Embedding and Retrieval

Step 1: The cover image I is partitioned into two areas, i.e., the embeddable area and the non-embeddable area. The non-embeddable area consists of the two lowest rows and the two right-most columns of the cover image.

Step 2: Process the original cover image I by scanning the entire cover image; then, record the positions of those pixels that have values of 0 and 255 into location map L. The location map L is concatenated with side information to generate the extra information that will be processed later during extraction. Then, pixels that have values of 0 and 255 are modified to 1 and 254, respectively. The modified cover image is denoted as I'.

Step 3: The embeddable area of the modified cover image I' is divided into blocks with sizes of 3*3 pixels. Then, the blocks are classified as even blocks (S-blocks) and uneven blocks (C-blocks) using complexity function.

Step 4: For each block Bi belongs to S-block, compute the difference values d*i* of the non-reference pixels in Bi.

Step 5: The difference histogram of the non-reference pixels is constructed. Then, a pair of peak point (PP) and zero point (ZP) is identified.

Step 6: Scan the difference values di sequentially. If di =PP, a secret bit s, extracted from the embedded data S, can be embedded by modifying the difference value di to di' using Equation. Otherwise, no secret bit can be embedded, and the scan difference value di has to be modified to di' using Equation below for attaining more stego quality.

$$d_i' = \begin{cases} d_i & \text{if } s=0 \\ d_i - 1 & \text{if } s=1 \text{ and } d_i = PP_1 \\ d_i + 1 & \text{if } s=1 \text{ and } d_i = PP_2 \end{cases}$$

$$d_i' = \begin{cases} d_i - 1 & \text{if } ZP_1 < d_i < PP_1 \\ d_i + 1 & \text{if } PP_2 < d_i < ZP_2 \\ d_i & \text{otherwise} \end{cases}$$

Step 7: Repeat Step 6 until the embedded data S are embedded completely.

Step 8: Construct the stego-image block Bi' by adding di' to Bi

During extraction also divide the stego-image into two areas, i.e., embeddable and non-embeddable areas, according to the rules mentioned in above subsection. Then, the embeddable area is partitioned into blocks that have sizes of 3*3 pixels. Since the reference pixels are preserved in the embedding process, the image block will be re-classified into smooth blocks or complex block in the same manner that was used in the data-embedding phase. Subsequently, the secret data can be extracted correctly, and the cover image I can be reconstructed by reversing the entire steps done above. The original difference value di can be reconstructed and it is used to extract secret data S as,

$$s = \begin{cases} 0 & \text{if } d_i' = PP_1 \text{ or } d_i' = PP_2 \\ 1 & \text{if } d_i' = PP_1 - 1 \text{ or } d_i' = PP_2 + 1 \end{cases}.$$

IV. Experimental Result

For the Experimental Analysis various four different 512 * 512 size grey scale images were used. This work mainly focuses on the quality of the stego image and here PSNR (The peak signal-to-noise ratio) was used to estimate the difference between the quality of the original cover image and its stego-image. A large PSNR value indicates that the visual quality of the stego-image is good because it means that a small amount of distortion has occurred. In contrast, a small PSNR value denotes that the stego-image has poor visual quality due to its large distortion. The equation for calculating PSNR is

$$PSNR = 10\log_{10}\left(\frac{255^2}{MSE}\right)$$

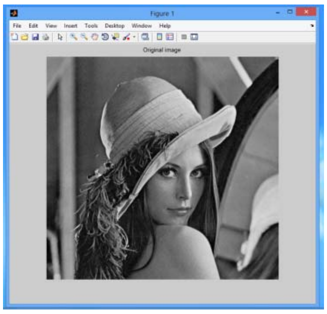
On analysis it is obtained that the implemented work provides a PSNR value of 50.1db on an average. That means it provide a better image quality with comparable embedding capacity. This is because the designs of the other our schemes which allow exploring the properties of the blocks while embedding data. In contrast, the proposed scheme uses the local complexity function to identify smooth blocks and also incorporated a new scan path for embedding data to get higher frequencies of the peak histogram bins for embedding data.

In addition, the complex blocks were excluded during the embedding process to maintain the high quality of the stego image. Here we divide image into different size pixel blocks, but as the size of the block increases the image quality decreases as the information available for comparison decreases. Hence we uses 3* 3 as the standard size for block divisioning.

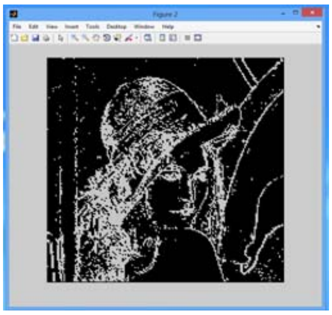
Threshold value used for pixel classification into even and uneven surfaces can also vary. Various threshold values were analyzed and T= 20 is taken as an example. As the threshold increases the pixel in the uneven region decreases and hence embedding capacity decreases. The PSNR value obtained for four input images at T=20 and its comparison with existing method is shown below:

Input Image	Existing Method	Implemented Method
Lena	48.9	50.1
Baboon	45.2	46.5
Women	47.0	47.4
Boat	48.0	48.6

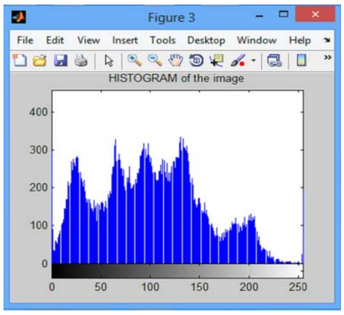
Fig 5: Comparison of previous method and proposed method



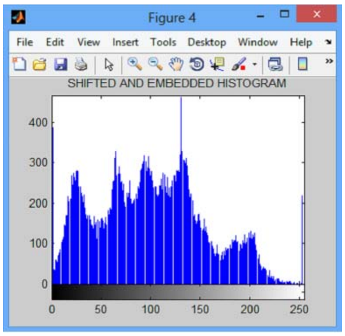
a)Cover Image



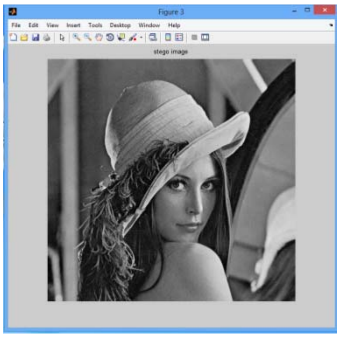
b)Block classification



c)Histogram of cover image



d)Histogram after embedding



e)Stego Image

V. Conclusion

In this work, a new reversible data hiding scheme was implemented by considering the reference pixels in the adjacent area to identify uneven image blocks and to design a new scan path. With the new scan path, a higher frequency of peak histogram values was obtained from the even blocks of the original cover image. A higher visual quality of the stego-image can be obtained by identifying complex blocks so they can be ignored during the process of embedding data. Location Map concept is used and hence underflow and overflow problems are avoided. Four standard test images and gray scale were used in the experiments to prove the performance of the proposed scheme in embedding capacity and image quality. In comparisons with other existing schemes, our proposed scheme provided better performance in both embedding capacity and image quality.

References

1. K. S. Kim, M. J Lee, H. Y. Lee, H. K. Lee, Reversible data hiding exploiting spatial correlation between sub sampled images, Pattern Recognition, vol. 42, no. 11,pp. 3083-3096, 2009.
2. Y. C. Li, C. M. Yeh, C. C. Chang, Data hiding based on the similarity between neighboring pixels with reversibility, Digital Signal Processing, vol. 20, no. 4, pp. 1116-1128, 2010.
3. W. Hong, and T. S. Chen, Reversible data hiding for high quality images using interpolation and reference pixel distribution mechanism, Journal of Visual Communication and Image Representation, vol. 22, pp. 131-140, 2011.
4. D. C. Lou, M. C. Hu, J. L. Liu, Multiple layer data hiding scheme for medical images, Computer Standards Interfaces, vol. 31, pp. 329-335, 2009.
5. H. Luo, F. X. Yu, H. Chen, Z. L. Huang, H. Li, and P. H. Wang, Reversible data hiding based on block median preservation, Information Sciences, Vol. 181, pp. 308328, 2011.
6. X. T. Wang, C. C. Chang, T. S., Nguyen, and M. C. Li, Reversible data hiding for high quality images exploiting interpolation and direction order mechanism, Digital Signal Processing, vol. 23, no. 2, pp. 569-577, 2013.
7. J. Tian, Reversible data hiding using difference expansion, IEEE Transactions on Circuits and Systems for Video Technology, vol. 13, pp. 890-896, 2003.
8. Z. Zhao, H. Luo, Z. M. Lu, J. S. Pan, Reversible data hiding based on multilevel histogram modification and sequential recovery, International Journal of Electronics and Communications, vol. 65, pp. 814-826, 2011.
9. H. Luo, F. X. Yu, H. Chen, Z. L. Huang, H. Li, and P. H. Wang, Reversible data hiding based on block median preservation, Information Sciences, Vol. 81, pp. 308328, 2011.
10. Ya-Ting Chang, Cheng-Ta Huang, Chin-Feng Lee, Shiuh-JengWang, "Image interpolating based data hiding in conjunction with pixel-shifting of histogram" Expansion embedding techniques for reversible watermarking, IEEE Transactions on Image Processing, vol. 16, pp.721-730, 2013.
11. Yang CH (2008) Inverted pattern approach to improve image quality of information hiding by LSB substitution. Pattern Recognition 41(8):26742683
12. Jung KH, Yoo KY (2009) Data hiding method using image interpolation. Computer Stand Interfaces 31(2):465470

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