Reversible Data Hiding with Improved Capacity Based on Directional Interpolation and Difference Expansion

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Abstract: Using reversible data hiding (RDH) we can hide our secret data into a cover image and the receiver can restore both the secret data and the original image. It has wide application in medical imagery, military imagery where no distortion of original cover is allowed. In this paper we proposed a RDH scheme based on interpolation and Difference Expansion. In their scheme reference pixels are not used for data embedding which leads to low capacity. And THIS IS proposed a high capacity RDH scheme in which prediction errors are used for data embedding. In this paper we propose a further modification to the scheme of directional interpolation. Directional interpolation yields a better approximation to the original pixel which improves the capacity of embedding. The effectiveness of the proposed scheme is tested using standard test images and the proposed scheme gives better results in terms of embedding capacity and visual quality compared to other scheme.

Keywords: RDH scheme, Directional interpolation, interpolation, Difference Expansion

1. Introduction

Now a day's protection of data transmitted over the Internet is a challenging research area. Data hiding is an approach that conceals secret data into a cover image. Embedding process will change the original cover image but the distortion is imperceptible to the human visual system. Data hiding techniques are commonly classified into two categories namely reversible and irreversible. As the name indicates, in reversible data hiding receiver can restore both the secret data and the original image. So that sometimes this technique is called loss-less data hiding. Images in many applications like medical imagery, military imagery and satellite imagery allow no distortion. Quality of the stego image and the payload capacity are the two parameters deciding the performance of an RDH scheme. When the embedding rate is high then the quality of the stego image will be less and vice versa.

Lately, several RDH schemes have been developed. Most of the schemes are based on difference expansion (DE) and histogram shifting. Data hiding scheme 1 based upon DE. In his method difference between two adjacent pixels are computed and this difference is doubled, so that the secret bit can be embedded in to the even value. Visual quality of scheme 1 is high but capacity is less. The scheme is based on integer transform and their capacity is high. RDH technique based on bilinear interpolation and difference expansion. In their scheme, in a single cover pixel, two secret bits can be embedded. Histogram modification is another technique used for data hiding. In data hiding method 4 based on histogram modification. In their scheme maximum change made to a pixel is 1, so that quality of the stego image is high but the hiding capacity is less. The reversible data hiding based on interpolation and histogram modification 5. In their scheme, cover image is divided into complex block and smooth block. Smooth block is only used for data embedding so that it produces a high quality stego image.

In this paper we propose an enhanced hiding scheme to improve scheme where prediction errors are utilized for data embedding. Data is embedded in a pixel if the prediction error is less than a predetermined threshold. We use directional interpolation for a more accurate prediction reducing the prediction error and thereby finding more embeddable number of pixels. Hence, the capacity of the proposed scheme is high. To test the effectiveness of the proposed scheme, we used some standard test images like Lena, Boats etc and the proposed scheme gives better results.

2. Proposed RDH scheme

In the proposed scheme, the pixels in a cover image C sized N × N are classified into two types namely reference pixels and embeddable pixels. Prediction value of all embeddable pixels is computed from its neighboring reference pixels. Data is embedded in a pixel if the prediction error is less than a predetermined threshold. Otherwise, the scheme performs a histogram shift operation. In order to increase the payload capacity, the proposed scheme embeds secret bits into the reference pixels too.

The proposed scheme has two phases- the data embedding phase and the secret extraction and image recovery phase, which have been explained in the following subsection.

2.1. Data embedding phase

In this scheme, the pixels in a cover image are classified into two categories namely reference pixels (RP), and embeddable pixels (EP) as shown in Fig.1. The following pseudo-code is used for the classification of pixels into EPs and RPs.

RP_1	EP_1	RP_2	EP_2
EP_3	EP_4	EP_5	EP_6
RP_3	EP_7	RP_4	EP_8
EP_9	EP_{10}	EP_{11}	EP_{12}

Fig.1. Classification

for i = 1 : N do

if i is even then select all pixels in the i^{th} row of C as embeddable pixel (EP)

if i is odd then

for j = 1 : N do

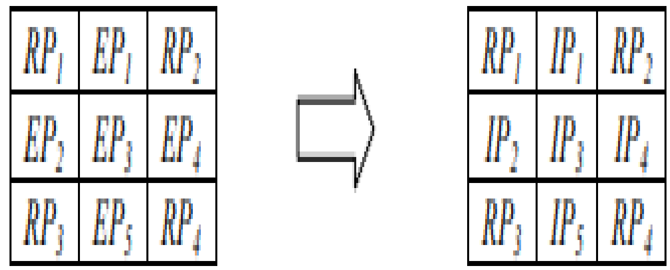
if j is even then select C(i,j) as embeddable pixel (EP)

else select C(i,j) as reference pixel (RP)

end

end

After determining the RPs and EPs, perform the interpolation operation and compute the interpolated values (IPs). Prediction value of all embeddable pixels is computed from its neighboring reference pixels in a 3×3 block as shown in Fig.2.



$$IP1 = (RP1 + RP2) / 2$$

$$IP2 = (RP1 + RP3) / 2$$

$$IP4 = (RP2 + RP4) / 2$$

$$IP5 = (RP3 + RP4) / 2$$

Fig.2. Interpolation

In this method the prediction value is calculated as a weighted sum of two directional interpolation values along 450 diagonal and 1350 diagonal as shown in Fig.3. The weights are determined to minimize the mean squared error between the original pixel and its interpolated value.

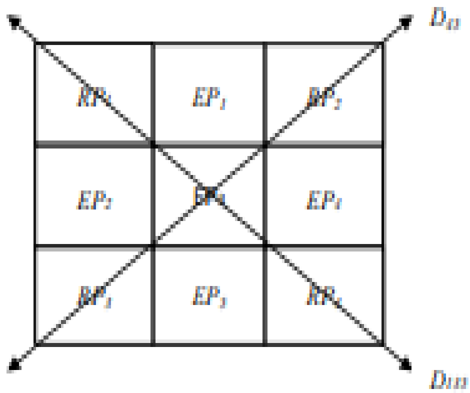


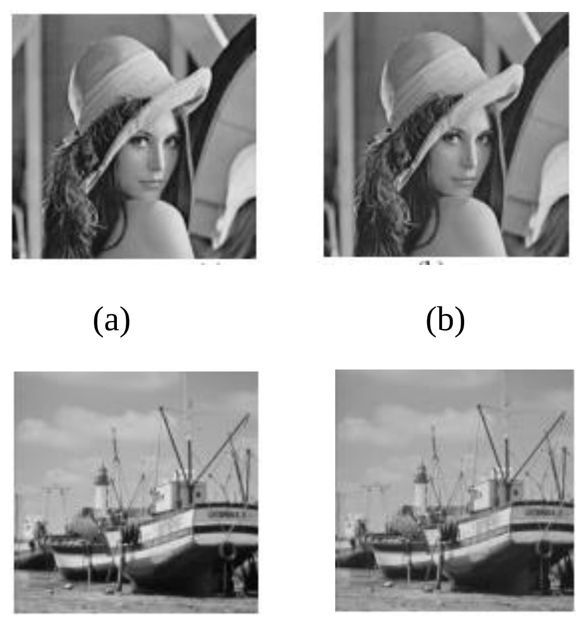
Fig.3. Directional Interpolation

2.2. Extra data for underflow/overflow

Original pixels having grayscale values in the range [0, T] and [255-T, 255] may generate an overflow or underflow. To avoid an underflow original pixels less than T+1 is modified as T+1 and to avoid overflow original pixel is larger than 255- (T+1) is modified as 255-(T+1). We need to record the position (location) information of these modified pixels and the last bits of the original pixel. This extra information is also embedded into the cover image.

3. Experimental results

Four standard grayscale images (Lena, sailboat, airplane, boat) of size 512 ×512 are used to test the effectiveness of the proposed scheme. Secret data composed of bits '0' and '1' are randomly generated by MATLAB function. The Peak Signal-to-noise ratio (PSNR) and the structural similarity index (SSIM) are the two metrics used to assess the stego image quality. It can be observed that the proposed method provides a higher embedding capacity for all cases and it can also be noted that PSNR and SSIM values are improved slightly. Fig.4. shows the original cover images and its stego images (Lena and Boat), their PSNR values are higher than 30 dB. Normally the image degradation between the cover and stego images cannot be observed by the human eye when the PSNR value crosses 30 dB.

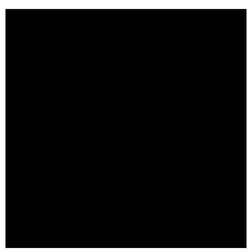


(a) (b) (c) (d)

Fig.4. (a) cover image (b) stego image with capacity 250,343 bits and PSNR 34.096 dB (c) cover image (d) stego image with capacity 233,918 bits and PSNR 31.604 dB

The proposed scheme is completely reversible as shown in Fig.5. We are taking the difference of original cover image and its recovered image, Fig.5(c) shows a complete black image which means both the images are same.

(a)



(b) (c)

Fig.5. (a) Cover image (b) Recovered image (c) Difference between the original and recovered image.

4. Conclusion

This paper proposes a new RDH technique based on directional interpolation and difference expansion. Directional interpolation reduces the prediction error so that number of embeddable pixels is increased. Hence the embedding capacity of the proposed scheme is very high. After extracting the secret data restoration of the original image is done without any distortion. The embedding capacity and visual quality our method gives better results than other technique.

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