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Reversible data embedding using difference expansion scheme for watermarking

Shriya Tatachar
shriyatatachar.te17@rvce.edu.in
RV College of Engineering, Bengaluru, Karnataka

Rakesh K. R.
rakeshkr@rvce.edu.in
RV College of Engineering, Bengaluru, Karnataka

G. R. Namita
grnamita.te17@rvce.edu.in
RV College of Engineering, Bengaluru, Karnataka

Rohit Kulkarni
rohitkulkarni.te17@rvce.edu.in
RV College of Engineering, Bengaluru, Karnataka

ABSTRACT

Reversible Data Embedding is a lossless reversible data embedding technique which embeds invisible data known as payload into the input image and uses Difference Expansion (DE) technique. This paper uses a DE based reversible scheme to reduce the amount of auxiliary information embedded and to increase the watermark length. The key concepts discussed in this paper are: Reversible Embedding, Extraction and Restoration of the original dataset with minimal distortion. By observing redundancy, reversibility can be explored. Payload, PSNR and Watermark Length have been used to assess the effectiveness of DE. Four data sets have been used - Lena, Boat, Airplane and APC. For Lena the payload obtained is 31.14 and payload was found to be 0.76 implying that more information can be embedded in an image than in the standard methods.

Keywords: *Data Embedding, Difference Expansion, DE, Reversible Data Embedding, Watermarking, PSNR, Payload*

1. INTRODUCTION

Data Embedding has gained popularity over the years in various fields. It is a technique where digital sets of data are combined. In this technique, the noise components of the host are used to insert information without modifying its statistical properties. Since the receiver has to recover the data as well, reversible data embedding is used where the original data can be restored.

DE uses the pixel pair information of the changeable difference. This difference is calculated and selected based on the conditions mentioned. The original image information, message code, and additional information are embedded into the difference values.

DE is used to implement an efficient watermarking scheme. The information about these expandable differences is stored in a location map with the goal to minimize the information being embedded on the original data set. In this method, there is a rearrangement of row and column indices in order to enable higher composition rate and preserve edge information through location maps.

2. LITERATURE REVIEW

DE based techniques are used in reversibly embedding the data into cover content. Many DE based reversible embedding schemes aim in reducing the amount of auxiliary information to be embedded in the input images. The auxiliary information generated is to prevent underflow and overflow. [1]

The Difference Expansion based reversible embedding algorithm's performance is assessed by the Payload Capacity, Visual quality and the complexity of the algorithm. The general approach of a high-capacity reversible embedding by choosing an area of the input image and embedding both the original pixel values and the payload into the area. [2]

In general, DE based algorithms use expandable differences in the current pixel pair before moving on to the next, which can cause distortion in the watermarked image and in the layer embedding limit. Hence, such a scheme cannot perform very smoothly. An algorithm using two embedding directions and to overcome the mentioned problems. [3]

This embedding scheme indistinguishably hides data in an image in a reversible manner to protect the data. It can then extract the embedded data and recover the original image. DE can be determined through the relationship between the threshold value and adjacent pixel differences. Enhancement of embedding quality can be achieved by removal of location map. [6]

3. DESIGN THEORY

There are 2 steps involved in implementing watermarking scheme. They are: 1) Embedding 2) Extraction and Restoration. It can be shown in Fig-1.

Embedding: Input Image I is fed to a preprocessor which calculates the Integer Average and the Difference for all pixel pairs according to DE technique and the information to be watermarked W, is also sent. The information to be watermarked is converted into a bit stream B which is appended to the watermarked differences to obtain the modified pixel pairs and to achieve embedding.

Extraction and Restoration: At the receiver end, the embedded data is retrieved as bit stream B. The bit stream is processed to avoid overflow and to obtain the original watermark W. The original image is restored by ensuring minimum distortion to obtain a high PSNR value. This method of reversible data embedding achieves a high payload value which enables the sender to embed larger data onto the original carrier image.

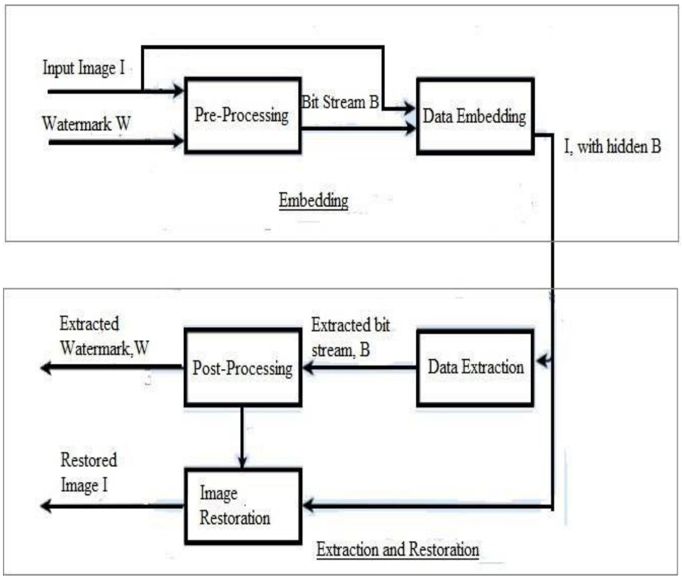

Fig. 1: Watermarking Scheme

In DE, pixels of the original image are paired to calculate the Integer Averages and the Differences.

Integer Average (l), Difference (h).

$$l = [x + y] / 2; \; h = x - y; \qquad - (1)$$

$$x = l + [h + 1] / 2; \; y = l - [h / 2]; \qquad - (2)$$

Watermarked difference (h^{l}): $h^{l} = 2 \times h + b$ - (3)

Fig. 2: Equations

Using equation (1) in Fig-2, the Integer Average and Difference can be found. Using equation (2) from Fig-1, the original pixel pair can be retrieved from (l) and (h), proving that DE is invertible. On using equation (3), Watermarked Difference (h^{l}) can be obtained by appending b to h.

$$x^{l} = l + [h^{l} + 1] / 2; \; y^{l} = l - [h^{l} / 2]; \qquad - (4)$$

$$l^{l} = [x^{l} + y^{l}] / 2; \; h^{l} = x^{l} - y^{l} \qquad - (5)$$

$$b = \mathrm{LSB}(h^{l}) \qquad - (6)$$

Embedded bit (b) is obtained using equation (6)

Fig. 3: Equations

The modified pixel pair can be obtained using equation (4) in Fig-3. During extraction and restoration, (l) and (h) are obtained using equation (5) and the embedded bit can be retrieved using equation (6).

$$0 \le l + |[h+1]/2| \le 255 \text{ and } 0 \le l - |h/2| \le 255 \qquad - (7)$$

Since l and h are integers

$$|h| \le 2(255 - l) \text{ and } |h| \le 2l + 1 \qquad - (8)$$

$$|h| \le 2(255 - l) \text{ if } 128 \le l \le 255 \text{ and } |h| \le 2l + 1 \text{ if } 0 \le l \le 127$$

Fig. 4: Equations

The pixel pair is restricted to [0,255] to prevent underflow and overflow problems. Subsequently, the conditions for h and l are given by equation (7) and (8) in Fig-4.

In order to observe changeability, the following conditions have to be met in Fig-5, Fig-6.

Definition 1 Difference value h is expandable under the integer average l,
if $|2 \times h + b| \le min\,(2\,(255 - l), (2l + 1))$ and for both $b = 0,1$

Fig. 5: Definition 1

Definition 2 We say a difference value h is changeable under the integer average value if
$|2 \times [h / 2] + b| \le min\,(2\,(255 - l), (2l + 1))$ for both $b = 0,1$

Fig. 6: Definition 2

4. RESULTS AND ANALYSIS

For the purposes of this paper, the standard datasets which were used to implement watermarking scheme are: Boat, Lena, Airplane and APC. In addition to the visual quality assessment, the parameters which were calculated and compiled for all the data sets were: PSNR, Payload (bpp) and Watermark Length (W) shown in Table-1. Fig-7 and Fig-8 show the Original Image and Watermarked Image for the dataset "Boat".

Fig. 7: Original Image for Boat

Fig. 8: Watermarked Image for Boat

Since DE uses a large location map, the capacity is low and the obtained payload values are ~0.5.

The obtained PSNR values lie between 30 dB and 50 dB; therefore, we can confirm that DE is a lossless scheme.

Table 1: Results

Data Set	PSNR	Payload (bpp)	Watermarked Length (W)
Boat	29.82	0.66	19763
Lena	31.14	0.76	21817
Airplane	34.42	0.88	27306
APC	31.63	0.86	26385

5. CONCLUSION

A method using DE based on reversible embedding has been presented. The reason to choose reversible data hiding over general steganography methods is that it allows in embedding large amounts of data into the input image so that the original image can be reconstructed from the watermarked image. Hence it is suitable where the metadata has to be stored in the input image and must be recovered after extraction.

The algorithm used for implementing reversible data hiding on difference expansion scheme, where the data is embedded into LSBs of the expanded differences between the adjacent pixel pairs. The algorithm is an easy and efficient method and it reduces the redundancy in the digital image to obtain the results which show that the modified DE process using two embedding directions is able to achieve an ideal capacity (payload). To improve the embedding capacity, payload independent location maps can be developed.

6. REFERENCES

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