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Difference Expansion Based Reversible Data Hiding Scheme for Watermarking

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***Abstract*: Reversible Data Hiding is a lossless data embedding technique which embeds a message code into a digital image in a reversible method. Difference Expansion (DE) is used for reversible data embedding. In this paper, a DE based scheme is used to minimize the auxiliary information being embedded and to increase the length of the watermark. The concepts discussed in this paper are: Embedding, Extraction and Restoration of the embedded data with minimal distortion. The redundancy in the image has been explored to observe reversibility. PSNR, Watermark Length and Payload Capacity are the metrics used to analyze the performance. It was concluded that by using reversible data hiding, more data could be embedded with minimal loss in information compared to other methods.**

***Keywords*: difference expansion, DE, reversible data hiding, payload, PSNR, data embedding.**

1. Introduction

Data embedding is a technique for combining digital data sets. The noise components are employed in this technique to introduce information without changing its features. Because the receiver must also recover the data, reversible data embedding is utilized, which allows the original data to be restored with little data loss.

DE uses pixel pair information of the changeable differences. The original image, message code, any other additional information are embedded into these values.

It is utilized to develop a watermarking technique that is efficient and effective. With the purpose of minimizing the information embedded on the original data set, the information about these expandable differences is saved in a location map. The row and column indices are rearranged to allow for a higher composition rate while still preserving edge information.

2. Literature Survey

DE is used for reversibly embedding data into the image. Many DE based schemes aim to reduce the auxiliary information being embedded into the image. The auxiliary information generated is to prevent underflow and overflow [1].

It's performance is analyzed by using PSNR, Watermark Length, Visual Quality Assessment and Payload as the metrics. The method to perform reversible embedding at high capacity is to choose an area of the input image and embed the original pixels and the message bits [2].

Before moving on to the next pixel pair, it uses expandable differences in the current pixel pair, which might create distortion in the watermarked image and the layer embedding limit. As a result, such a design will not run smoothly. To solve the challenges highlighted, an algorithm with two embedding directions was developed [3].

To secure data, the lossless data embedding approach invisibly hides it in a reversible manner. It can recover the original image by removing the embedded data [4].

The disadvantage with current DE is that it performs only one-layer embedding. Ongoing to the next layer, all the present expandable differences are used up and the image quality is severely reduced. To solve this, advancements have been made in DE [5].

3. Design Theory

There are 2 stages: 1) Embedding Stage and 2) Extraction and Restoration Stage as shown in figure 1.

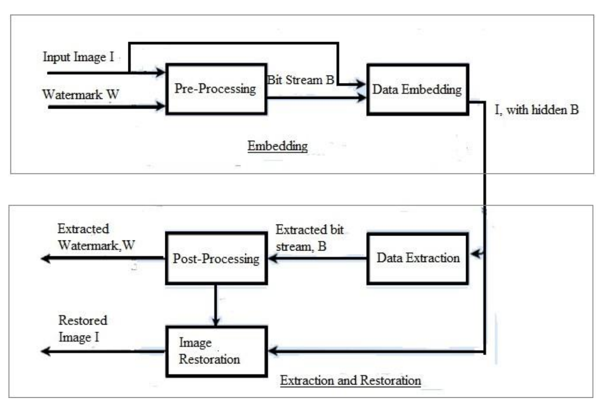

Fig. 1. Block diagram

1) Embedding Stage: A pre-processor receives the original image and calculates the Integer Average (l) and Difference (h) for all pixel pairings. To acquire the updated pixel pairings, the

*Corresponding author: rohitkulkarni.te17@rvce.edu.in message code is converted to a bit stream B, which is then appended to the LSB bits of h.

2) Extraction and Restoration Stage: The message that is embedded is retrieved as B. To get a high PSNR value, the original image is recreated with little distortion. This method achieves a high payload capacity, allowing huge data to be embedded onto the original carrier image.

Integer Average (l), Difference (h).

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

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

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

In DE, pixels of the image are paired to obtain l and h using eq. (1) The pixel pair is retrieved from l and h using eq. (2). The Watermarked Difference (hl) is obtained by appending b to h as seen in eq. (3).

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

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

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

The modified pixel pair (x^l, y^l) is obtained on using eq. (4). In the second stage, Integer Average and Changeable Differences are retrieved by using eq. (5) and b using eq. (6).

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

Since l and h are integers

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

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

To prevent overflow and underflow, the pixel pair values are restricted to [0, 255]. The criteria is seen eq. (7) and eq. (8).

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

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 $b = 0$ and 1.

4. Results and Analysis

Lena, Airplane, APC, and Boat are the datasets utilized to implement DE based watermarking. Peak Signal to Noise Ratio (PSNR), Payload Capacity (bpp), and Watermark Length (W) are the characteristics used to evaluate the performance for each dataset, as shown in table 1. The Original and Watermarked Image for "Lena" are shown in figures 2 and 3.

Since the location map size used is large, the payload capacity is good with values ~.75.

Fig. 2. Original Image – Lena

Fig. 3. Watermarked Image – Lena

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

This paper presents a method of Difference Expansion based for reversible data hiding. The key advantage of this method over other steganography methods is that it allows enormous amounts of data to be embedded in the input image, allowing the original image to be reconstructed from the watermarked image.

The data is embedded into LSBs of the expanded differences between the adjacent pixel pairs. The method is efficient as it reduces the minimizes the image redundancy to achieve the results.

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