Reversible Data Hiding Using Enhanced Prediction for Progressive Image Transmission

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Abstract

We propose the reversible data hiding algorithm for progressive image transmission in this paper. With the alteration of difference values between original and predicted images, reversible data hiding can be applicable to progressive image transmission. For assessing parameters including the reversibility, embedding capacity, and image quality, with our algorithm, we observe the generally better performances with simulations over existing methods.

Keywords: Reversible data hiding, difference histogram, capacity, image quality.

1. Introduction

Progressive image transmission (PIT) can be commonly encountered when using the browsers. With the vast amounts of image contents on the Internet, copyright protection of progressively transmitted media has become the practical issue. Data hiding is an effective means for copyright protection [1]–[3], and reversible data hiding has attracted attention in recent years. Performance assessments include the following.

➢ Reversibility. Original image and secret information should be perfectly separated from marked image, like reversible process in thermodynamics.

➢ Embedding capacity, implying the ratio between the numbers of bits for hiding over the size of original image. Larger capacity would be more favorable.

➢ Marked image should look as resemble as the original image, i.e., differences need be small.

2. Proposed method and enhancements

By utilizing the difference histogram between original and predicted images, data embedding can be achieved. By following the concepts from hierarchical coding in [1], and those in [2] and [3], we generate the predicted image first and calculate the difference between predicted and original images. Prediction is performed by employing the weighted averages between neighboring pixels in horizontal and vertical directions, and it differs from the counterparts in [2] and [3] with the enhancements in prediction. Next, difference values between original and predicted images in the base- and enhancement-layers are prepared. Data embedding can be performed accordingly as follows.

Step 1. Generate the difference histogram between original and predicted images in each layer.

Step 2. Choose the embedding level (EL). It is a positive integer, noting portions for intentionally modifying the histogram. Larger EL leads to larger capacity for embedding. We move the positive part to the right, and the negative part to the left with EL. Empty bins are reserved for embedding.

Step 3. Embed secret bits in empty bins of difference histogram. We follow the procedures in [3].

Step 4. Reconstruct the output image with PIT by adding the difference value back to the previous layer. The base layer is constructed first, and then the enhancement layers are produced consequently.

Correspondingly, at the decoder, secret bits extraction and original recovery follow the reverse procedures.

Step 1. Generate the histogram of difference values of progressively received image.

Step 2. Extract secret bits sequentially, layer by layer, with EL. Difference histograms with empty bins are produced for the recovery of original image.

Step 3. Obtain the original difference histogram, and recover original image by adding the difference back to the base and enhancement layers.

3. Simulation Results

We have conducted simulations with three test images, Airplane, F16, and Lena, with sizes of 512×512, to check the effectiveness in Fig. 1, and have made comparisons between our method and that in [2] and [3]. There are five curves, where the blue curve denotes performances of proposed method, the red curve means that of [2], and remaining three imply three schemes, or MSE (mean square error), BL (bilinear), and NN (nearest neighbor), from [3]. We observe the trend when embedding more bits, denoted by bit per pixel (bpp), marked image quality, denoted by peak signal-to-noise ratio (PSNR), gets degraded.

From Fig. 1, with our algorithm, the largest capacities can be observed, with 1.2539 bpp at 30.64 dB for Airplane, 1.2217 bpp at 29.74 dB for F16, and 1.2228 bpp at 29.07 dB for Lena, respectively. It leads to the average enhancement of 27.94% in maximal capacity over those in [2] and [3]. However, an average degradation of 2.10 dB of marked image can also be watched. Larger capacity leads to more alteration to difference histogram, hence the degradation of marked images.

As reported in [3], among the MSE, BL, and NN schemes, MSE reaches the best, and NN performs poorly. We also observe the curve in [2] outperforms all the three curves in [3] in Fig. 1. With proposed method, it performs well at high embedding capacity regions, where capacities of larger than 1.0 bpp can easily be reached. However, it has a bit inferior representation at low embedding capacity regions. Even so, it still performs better than the NN scheme in [3]. From the observations above, proposed algorithm has the advantages of hiding more secret bits with better qualities for the copyright protection of progressively transmitted images.

4. Conclusions

We propose a reversible data hiding algorithm with enhanced prediction for producing difference histogram, which is suitable for progressive image transmission. Reversibility of proposed algorithm is guaranteed. Simulations have presented the better performances at high embedding capacities, and comparable results at mid- to low-capacities regions. Our algorithm is easy for implementation, and it is applicable to progressive image transmission.
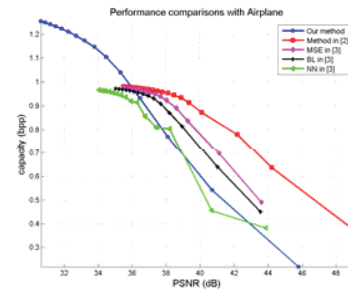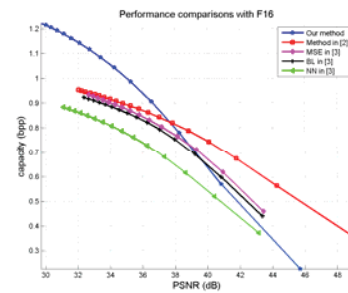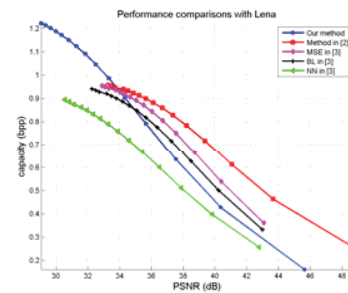
Fig. 1   Comparisons of capacity and quality of test images between our scheme and the method in [2] and [3]. (a) Airplane. (b) F16. (c) Lena.

Acknowledgements

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