A UNIFIED REVERSIBLE DATA EMBEDDING AND SCRAMBLING METHOD

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Abstract: Data embedding technique is maintaining at high-output image quality so that the difference between the original and the embedded images are imperceptible to the naked eye. A unified data embedding-scrambling technique called UES is proposed to achieve two objectives simultaneously. Namely, high payload and adaptive scalable quality degradation. Data embedding methods can be further classified into two methods. They are irreversible and reversible. The locations of the predicted pixels are vacated to embed information while degrading the image quality. The perceptual quality of the embedded-scrambled image can be controlled. The prediction errors are stored at a predetermined precision using the structure side information to perfectly reconstruct or approximate the original image. The precision of the stored prediction errors can be adjusted to control the perceptual quality of the reconstructed image. The prevalence of these technologies has led to serious security concerns and handling needs.

Keywords: Embedding, Scrambling, UES.

1. INTRODUCTION

Embedding is a method of Digital watermarking useful information into a digital work (especially, thus, audio, image, or video) for the purpose of copy control, content authentication, distribution tracking, broadcast monitoring, etc. The distortion introduced by embedding the data is often constrained so that the host and the watermarked work are perceptually equivalent. However, in some applications, especially in the medical, military, and legal domains, even the imperceptible distortion introduced in the watermarking process is unacceptable. This has led to an interest in reversible watermarking, where the embedding is done in such a way that the information content of the host is preserved. This enables the decoder to not only extract the watermark, but also perfectly reconstruct the original host signal from the watermarked work.

Another category of high-capacity reversible data-embedding algorithms may be classified as expansion-embedding approaches. A common feature of these approaches is the use of some de-correlating operator to create features with small magnitudes. The data embedding is done by expanding these features in order to create vacancies into which the data bits are embedded. The first algorithm in this category was proposed by Tian [1] and has been extended recently during the course of our work in the 1-D Haar wavelet transform is used to de-correlate the image. The resulting high-pass components are the differences of the adjacent pixel values; therefore, this technique is called difference-expansion (DE) embedding. The DE technique is able to embed significantly larger amounts of data than the other earlier approaches (as large as 2 bpp and close to 0.5 bpp in a single pass). The distortion introduced is also significantly less for comparable payload sizes. Alattar [2] has extended Tian's work by generalizing the DE technique for any integer transform. Kamstra et al. [3], [4] have also extended Tian's algorithm by using the information in the low-pass band to find suitable expandable differences in the high-pass band.

Traditionally, data embedding and scrambling are explored independently. However, the availability of contents in large number and the computational power to manipulate those leads to a growing interest in integrating the features from both fields to manage and handle the contents more efficiently. While imperceptibility and output image quality is a matter of interest in the conventional reversible data embedding methods, it is no longer a concern in the joint approach. However, due to the huge number of modifications in the structure of the original content, the reconstruction process is more technically challenging in the joint approach when compared to that of the conventional data embedding methods. Despite the possible obstacles, some new interesting applications can take the advantage of the integration of data embedding and scrambling, particularly for visual contents.

In general, a data hiding technique for digital content can be classified into two disciplines, namely data embedding and perceptual encryption. Data embedding aims to utilize a content (e.g., image) as a venue to host external information. On the contrary, purpose of perceptual encryption (hereinafter refer to scrambling) is to make a content imperceptible by converting it into a severely distorted or meaningless form [2].

Data embedding methods can be further classified into two main categories, namely, irreversible and reversible [5]. Conventionally, both irreversible and reversible embedding techniques try to maintain the perceptual quality of the output image (i.e., embedded with data) at the highest possible level while embedding as many external information as possible into the image. For irreversible techniques, the loss of information due to the embedding process is permanent and the original image is not completely recoverable. For reversible methods, in addition to above mentioned objectives, the method must be able to perfectly reconstruct the original image. Reversibility is an attractive and beneficial feature particularly for those applications dealing with crucial and sensitive information such as medical images, military images, forensic, and valuable artwork.

2. REVERSIBLE DATA EMBEDDING:

Reversible data embedding, which is also called lossless data embedding, embeds invisible data (which is called a payload) into a digital image in a reversible fashion. As a basic requirement, the quality degradation on the image after data embedding should be low. An intriguing feature of reversible data embedding is the reversibility, that is, one can remove the embedded data to restore the original image. From the information hiding point of view, reversible data embedding hides some information in a digital image in such a way that an authorized party could decode the hidden information and also restore the image to its original, pristine state. The performance of a reversible data-embedding algorithm can be measured by the following [6].

- Payload capacity limit: What is the maximal amount of information can be embedded?
- Visual quality: How is the visual quality on the embedded image?
- Complexity: What is the algorithm complexity? The motivation of reversible data embedding is distortion- free data embedding. Though imperceptible, embedding some data will inevitably change the original content. Even a very slight change in pixel values may not be desirable, especially in sensitive imagery, such as military data and medical data. In such a scenario, every bit of information is important. Any change will affect the intelligence of the image, and the access to the original, raw data is always required. From the application point of view, reversible data embedding can be used as an information carrier. Since the difference between the embedded image and original image is almost imperceptible from human eyes, reversible data embedding could be thought as a covert communication channel. By embedding its message authentication code, reversible data embedding provides a true self authentication scheme, without the use of metadata. In this paper, we present a high-capacity, high visual quality, reversible data-embedding method for digital images [14].

It can be applied to digital audio and video as well. We calculate the differences of neighboring pixel values, and select some difference values for the difference expansion (DE). The original content restoration information, a message authentication code, and additional data (which could be any data, such as date/time information, auxiliary data, etc.) will all be embedded into the difference values. In this paper we will consider gray scale images only.

For color images, there are several options.

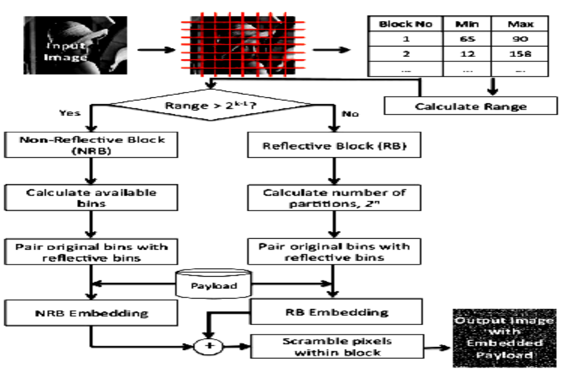


Figure1: Reversible Data Embedding

One can de-correlate the dependence among different color components by a reversible color conversion transform, and then reversibly embed the data in the de-correlated components. Or one can reversibly embed each color component individually. Please note that reversible data embedding is a fragile technique. When the embedded image is manipulated and/or lossy compressed, the decoder will find out it is not authentic and thus there will be no original content restoration.

3. DATA EMBEDDING:

The data embedding is achieved by directly replacing the pixel values by the external information. The proposed method consists of three main processes, namely, pixel value prediction, information embedding, and reconstruction. These processes are elaborated in the following sub-sections.

- Checkerboard Based Prediction (CBP)
- Unified Embedding-Scrambling (UES)
- Extraction and Reconstruction

For completion of discussion, we compare UES to the conventional reversible and irreversible methods. Note that the results for ε = 0 and 1 regardless of L reflect the performance of the proposed UES as a reversible data hiding method where the original host image can be perfectly reconstructed (because α = 2 ≥ _log2((2 × ε) + 1)_ =2). The rest of the cases (i.e., ε > 1) suggest the performance of the proposed UES as an irreversible method.

4. UES

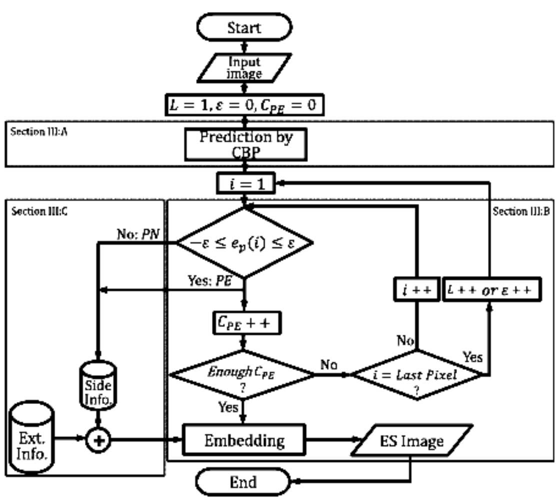


Figure 2: Embedding-Scrambling

The process flow of the proposed embedding-scrambling method is summarized in Fig.2. First, the proposed CBP is utilized to predict pixel values in the image [13]. Next, each prediction error, denoted as ep for the rest of the presentation, is computed as ep = x − x p where x and x p are the original and predicted value by CBP, respectively. Then, ep is analyzed to decide if the corresponding pixel location is suitable for data embedding [12].

The secret message is encrypted before embedding .the secret message is randomly permuted using the secret key [8],[9],[10]. The random permutation is carried out by using mat lab functions rand and rand perm. We classify all pixels in an image into three categories, namely, (a) not-predicted (NP), (b) predicted but not embedded (PN) and, predicted-and-embedded (PE). Here, the set of NP consists of all the reference points in every other column and row, which are utilized to predict the rest of the pixels using the proposed CBP method. Next, PN refers to a pixel whose eP fails the condition in Eq. (4). In other words, PN is a pixel that cannot be predicted accurately by the proposed CBP method, and it is not considered for data embedding. Thus, PN holds the original pixel value. Finally, PE refers to a pixel that satisfies Eq. (4), and it is utilized for data embedding. Here, the prediction errors ep are stored as side information to reconstruct the original image.

5. RESULTS

Two benchmark image datasets, namely: 7 images (each of dimension 512×512 pixels) from the USC-SIPI standard test image dataset [33] and 1338 uncompressed images (each of dimension 384×512 pixels and converted to gray scale) in UCID (An Uncompressed Color Image Database) [34] are considered for experimental purposes. It is verified by visual inspection that our method is able to severely degrade quality of the host image by embedding external information into it and the distortion level can be controlled by changing ε as well as L (i.e., level of processing). It is also verified that the embedded information can be completely extracted, and quality of the reconstructed image is controllable.

The image quality of the embedded-scrambled and reconstructed images are considered objectively using SSIM and subjectively by visual inspection [11]. The SSIM values of the embedded-scrambled images (denoted as ES) and the reconstructed images (denoted as R) from the USC-SIPI and UCID databases for various combinations of ε and L are reported.

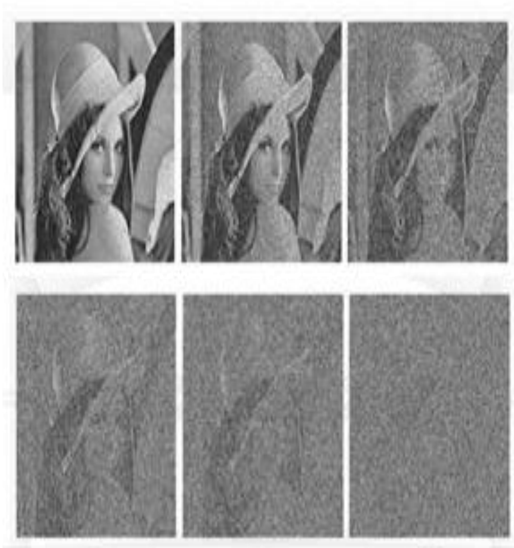
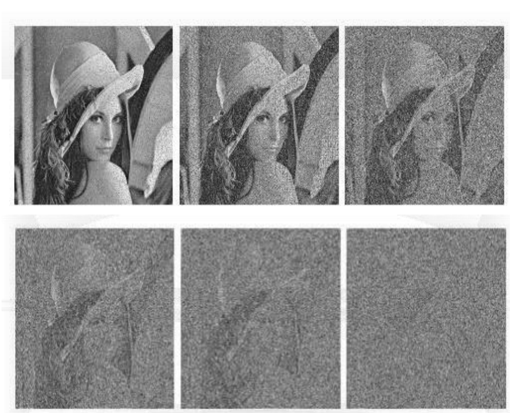


Figure 3: Embedded-scrambled image using UES

Figure 4: Reconstructed image using UES method



The reconstructed Lenna image for various combinations of ε and L. Although the SSIM decreases as ε and L increase, the perceptual quality of the reconstructed images are high and they appear identical regardless of the parameters in use. Note that the average SSIM of the reconstructed host image from the UCID dataset is always greater than 0.99 for all the combinations of parameter values considered.

6. CONCLUSION

In this paper proposed to unify reversible data are embedding and scrambling method. The unified reversible data is embedding and scrambling to payload, scalability and image quality. In the proposed system reversible data embedding method output is compared to existing method. In my proposed is unified data is reversible data embedding and scrambling to original image data. It is able to recover the host image after imposing severe degradation by embedding huge amount of external information, with an average reconstruction quality of SSIM $\geq$ 0.99 for the UCID image dataset. The image quality, scalability and payloads are proposed in this method.

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