An Efficient Technique for Information Recovery of Erroneous Medical Image Blocks Transmitting Over Error Prone Networks

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Abstract

Imperfect transmission of block-coded images often causes lost blocks. These blocks may contain very important information of image. In this paper, an efficient method of error concealment scheme is proposed for restoring lost blocks and lines in medical images that are transmitted over error prone network such as the internet and wireless networks. It adopted the idea of data hiding that can be implemented in the DCT domain. The algorithm determines the most important information in each block of original image and rotated one by 90^0 clockwise and embeds this information into another block that is not adjacent to it, since adjacent blocks have high probability to be lost at the same time. Simulation results show that the visual quality and the PSNR evaluation of a reconstructed image are significantly improved using the proposed scheme with respect to other techniques.

Keywords: error recovery, medical images, DCT transforms.

طريقة كفوءة لاستعادة المعلومات من القطع المفقودة للصور الطبية المرسلة عبر الشبكات المعرضة للخطأ

الخلاصة

الارسال الردئ للصور ذات التشفير المقطع غالباً ما يسبب فقدان هذه القطع، وهـذه القطع ربما تحتوي على معلومات مهمة جدا في الصورة. في هذا البحث، تم اقتراح طريقة كفوءة لاستعادة القطع والخطوط المفقودة في الصور الطبيـة المرسـلة عبـر الشـبكات المعرضة للخطأ، مثل الانترنت والشبكات اللاسلكية وقد اعتمدت هذه الطريقة على فكـرة اخفاء البيانات التي يمكن بنائها في مجال DCT . تضمنت هـذه الخوارزميـة تحديـد المعلومات المهمة في كل قطعة للصورة الاصلية والصورة المدورة بمقـدار 90 باتجـاه عقارب الساعة واخفاء هذه المعلومات في قطعة أخرى ليست مجاورة لهـا ، لأن القطـع المتجاورة لها احتمالية كبيرة أن تُفقد في نفس الوقت. وتبين النتائج المستخلصة ان جـودة الرؤية وقيم الـ PSNR للصور المستعادة ان هناك تحسـن كبيـر باسـتخدام الطريقـة المقترحة مقارنة مع التقنيات الاخرى.

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1. Introduction

In recent years, Internet and wireless communication have grown astronomically. However, un-reliable wireless channels may inject errors into the transmitted bitsream. Since wireless multimedia will have much wider application in the future, error resilience issue has become a necessity for image/video transmission [1].

The distortion can range from momentary degradation to a completely unusable image or video signal. Hence, it is necessary for the receiver to perform error concealment to minimize the observed distortion. Error concealment (EC) is a post-processing technique employed at the receiver side to recover the lost data from received images by exploiting some important information [2]. A number of error concealment approaches have been proposed in recent years, and can be applied either on spatial domain or frequency domain. Frequency domain techniques are often used in practice. While the spatial approaches are usually less time-consuming, but it cannot be always applied; therefore spatial error concealment is an invaluable resource [3].

Shuiming et al [4] presented a novel spatial content-based image error detection and error concealment algorithm to improve the image quality. The damaged image blocks are detected by exploring the contextual information in images. The statistical characteristics of missing blocks are then estimated based on the types of their surrounding blocks. Agrafiotis et al [5] describe a spatial error concealment method that uses edge related information for concealing missing blocks in a way that not only preserves existing edges but also avoids introducing new strong ones. The method relies on a novel-switching algorithm, which uses the directional entropy of neighboring edges for choosing between two interpolation methods, a directional interpolation to ensure edge preservation or a bilinear interpolation to avoid the creation of false strong edges. Joost [6] introduced a novel locally adaptive interpolation method for the reconstruction of lost low frequency wavelet coefficients. The main idea is the estimation of the optimal interpolation direction from the energy of the corresponding coefficients in the high frequency subbands. By locally adapting the interpolation, edges are reconstructed more accurately than in the case of constant interpolation weights.

Data hiding technology has been widely studied and presented over last decade. Data hiding aims at embedding a secondary data (referred to as signature) into an original digital media (referred to as host) with no visible distortions. Usually, a data-hiding algorithm should satisfy both the two requirements of robustness and imperceptibility. In another word, the signature hidden in the host could not be perceptually observed and not so easily be got rid of. Great success of data hiding has been achieved when it is applied to copyright protection and image authentication [7].

In this paper, an efficient error concealment scheme for medical images in Discrete Cosine Transform (DCT) is proposed. It is based on data hiding techniques to reconstruct missing image blocks. Different from the existing data hiding technologies, the scheme presented here does not embed a secondary media into a given one, but tries to embed the host itself back to the host instead.

2. A Proposal Method for Error Concealment Scheme

The block diagram of the proposed scheme is illustrated in figure (1). In this scheme, the host image and its rotated are converted from spatial domain into the frequency domain. The purpose from using the rotated image is to preserve the data information if any error it happened during transmission. Then, some significant feature information is extracted from given images and embedded back into these images themselves and transmitted.

In the receiver side, the embedded data are reconstructed and the original host image is reconstructed based on the restored hidden data in both images along with some other post processing methods. It is obvious that the more information of the missing data is at hand, the more perfect reconstruction of the missing data can be achieved. Motivated by such a simple principle, a new strategy can be proposed to implement error concealment using information hiding techniques. A new feature of such a strategy is that it advances a new application for information hiding, and at the same time, it presents the possibility to further improve the performance of error concealment.

2.1 Data Embedding Technique

The main idea behind the proposed scheme is based on the method used to embed the data into the image. Firstly, The original and rotated image are transformed from spatial domain into the frequency domain by dividing them into 8×8 pixel block and applying two dimensional DCT on each block, which removes the redundancy of image pixels on the spatial domain and compacts the energy into a small number of coefficients. Then, DCT coefficients are quantized using quantization table. In order to make the quantized coefficients in the positive range, these coefficients are scaled by appropriate scaling factor. After scaling, each quantized coefficient can be represented by 8 bits.

From each block, 8 quantized coefficients are selected in zigzag order, which represent the more important information in the block and ignore the others since the remaining coefficients are nearest to zero. The 8 selected coefficients have 64 bits since each coefficient can be represented as 8 bits. It can be inserted the 8 coefficients from each block in the Least Significant Bit (LSB) bit plane of other block in the image. The size of LSB bit plane in the 8×8 pixel block is also 64 bits.

Because adjacent blocks have high probability to be lost at the same time, the selected coefficients of each block are not inserted into the LSB bit plane of the adjacent block. For example, in figure (2) the quantized coefficients of block (a1) are inserted into the LSB bit plane of block (c1).

2.2 Damaged Block Recovery

In order to reconstruct damaged block (a1), the block (c1) is identified which contains the 8 quantized coefficients of the damaged block (a1) as shown in figure (2) By retrieving the LSB bit plane of the block (c1), it may be able to extract the 64 bits which represent the 8 quantized coefficients of the 8×8 DCT block (a1).

To reconstruct the damaged block, the 8 selected coefficients are rescaled then dequantized. Finally, the 8 dequzantized coefficients are placed in the block (a1) in zigzag order while the other coefficients are zero and applied inverse 2D-DCT. In order to improve the perceptual quality of the reconstructed image, the image and its rotated are combined by averaging the corresponding pixel values of these two images within 2×2 window. But when two blocks (a1 and c1) are broken at the same time, it is impossible to restore the loss of block (a1) from (c1). The reason is that block (c1) contained the 8 quantized coefficients of block (a1). In such cases, it can be applied a spatial interpolation using nearest neighborhood pixels [8] to restore the loss of the block (a1).

3. Results and Discussion

Error concealment technique is very important in medical applications.Forexample, transmitting images of sick person to the professional doctor for diagnosis especially in accidentally. The proposed method is tested using two medical images of size 512×512 pixels with 8 bits grayscale. To simulate the loss of image blocks during image transmission, several image blocks and lines were removed randomly depending on the loss rate: 5%, 10%, 15%, 20%, and 25%. The objective quality of reconstructed images can be measured using Peak Signal to Noise Ratio (PSNR). The measured PSNR value is computed between original images and reconstructed images as follows:

$$PSNR = 10\log_{10}\frac{255^2}{\frac{1}{M\times N}\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}|X(i,j)-X'(i,j)|^2} \quad \text{... (1)}$$

Where, M×N are the image dimension, X(i,j) is the original image pixel, and $X'(i,j)$ is the reconstructed image pixel. Tables (1) and (2) show the values of PSNR for the reconstructed images by the proposed method with and without rotated image, and spatial interpolation technique. In most of the loss rates, the proposed method outperformed the other technique. Also, the PSNR values of the proposed method are more improved as the missing block rate increases.

Figures (3) and (4) show the visual quality assessment of reconstructed images. It can easily be seen that the spatial interpolation technique is able to restore missing blocks only, but it is impossible to restore missing lines since there is no information available in the neighboring pixels belong to the missing lines. Also, the perceptual quality of the image is degraded by the proposed method without rotated image. While, the proposed method with rotated image can successfully restore the missing lines and blocks in images. Since, the information about the missing lines and blocks exist in the other blocks of the image. Moreover, the reconstructed images are similar to the original image using the proposed method with rotated image. Although the spatial interpolation technique achieved appropriate PSNR values but interpolated lines could easily be noticeable by the native eye. Consequently, the proposed method with rotated image outperforms other techniques both objectively and subjectively.

4. Conclusions

This paper presented a successful application of information hiding for error concealment of medical images that are transmitted over error prone networks. The scheme has strong capability to restore missing lines, block, and image edges. Simulation results showed that the proposed scheme provides both subjective and objective quality improvement than that of the spatial interpolation technique. Furthermore, the performance of this scheme is significantly improved as the number of missing blocks increases.

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Table (1) PSNR values of reconstructed MRI-1 image

Missing rate	Spatial interpolation PSNR (db)	Proposed method without rotated image PSNR (db)	Proposed method with rotated image PSNR (db)
5%	24.5665	15.8792	27.2365
10%	21.5587	16.0211	27.2949
15%	21.5544	16.0855	27.3015
20%	20.5890	16.2310	27.3559
25%	23.5170	16.4529	27.4225

Table (2) PSNR values of reconstructed MRI-2 image

Missing rate	Spatial interpolation PSNR (db)	Proposed method without rotated image PSNR (db)	Proposed method with rotated image PSNR (db)
5%	31.6275	16.4835	29.8058
10%	29.6030	16.6077	29.8783
15%	27.9026	16.6644	29.9125
20%	26.2767	16. 8408	30.0087
25%	23.5170	17.0757	30.1720

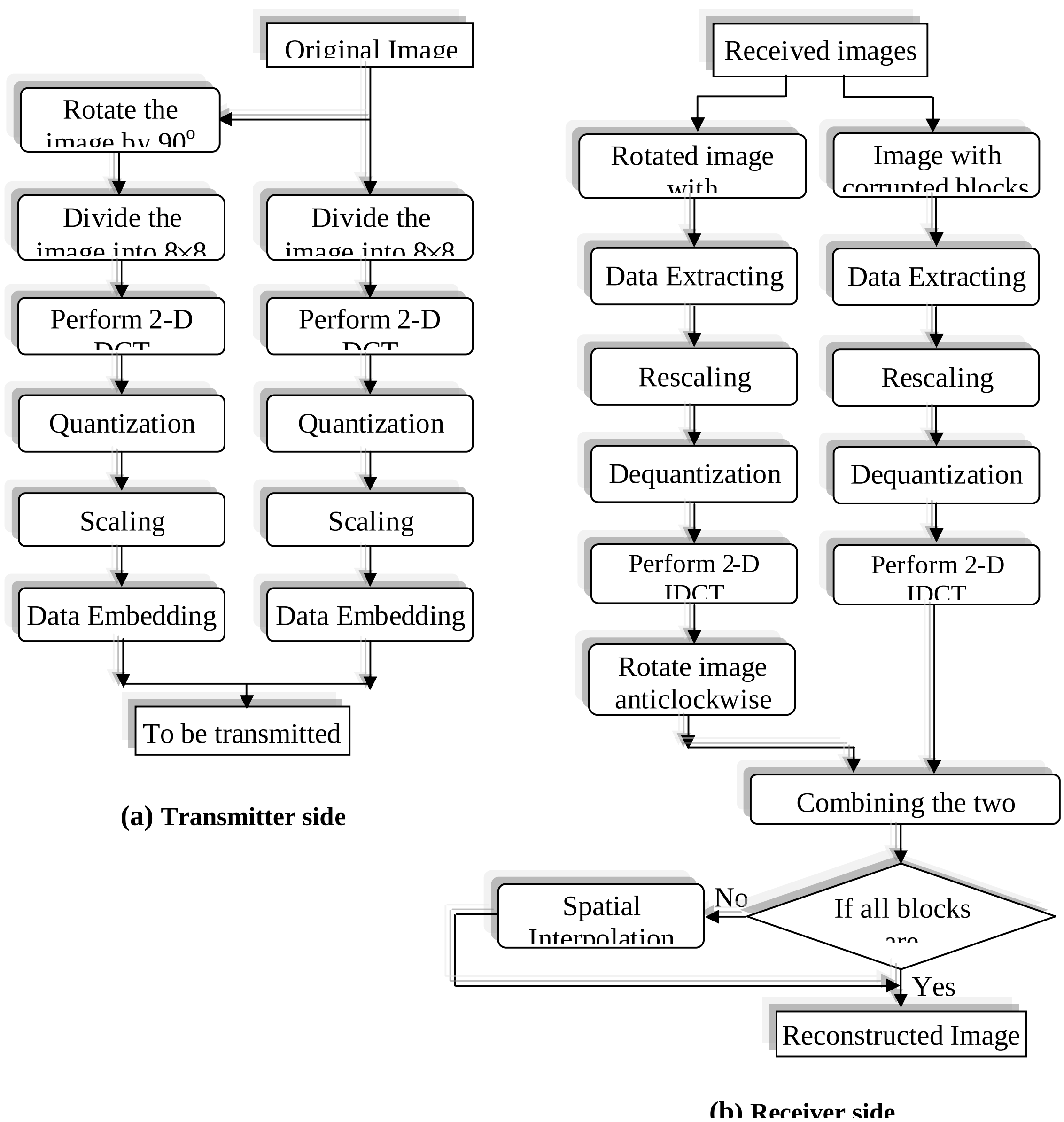


Figure (1): Block diagram of the proposal method

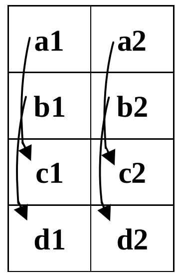


Figure (2): Data embedding process

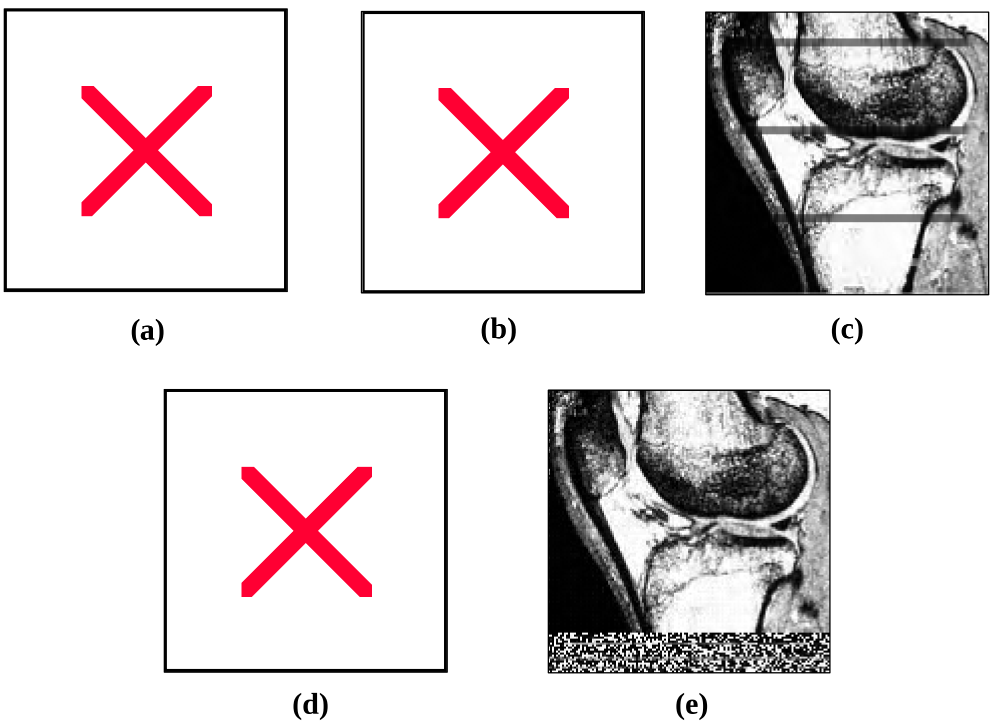
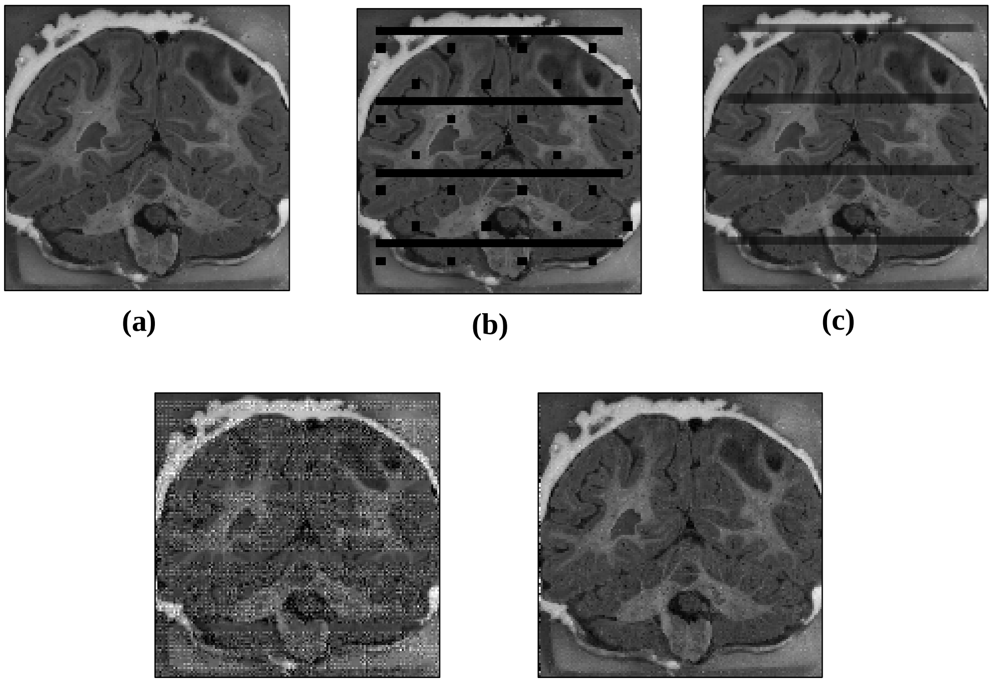


Figure (3): (a) Original MRI-1 image, (b) distorted image (25%), (c) reconstructed by spatial interpolation, (d) reconstructed by proposed method without rotated image, and (e) reconstructed by proposed method with rotated image



(a) **(b)** **(c)**

(d) **(e)**

Figure (4): (a) Original MRI-2 image, (b) distorted image (25%), (c) reconstructed by spatial interpolation, (d) reconstructed by proposed method without rotated image, and (e) reconstructed by proposed method with Rotated image.