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Modification of FSE Method Based on Coefficients of Homogeneity

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Abstract:

In this paper a modification of frequency selective extrapolation (FSE) method is described. The FSE method is used for concealment of missing blocks in digital images. The modification of the method is based on missing block support area analysis with usage of Canny edge detection algorithm. In the result of the analysis, for each missing block a suboptimal support area size is selected, which is used in FSE method. The paper includes experimental results which are compared with the results of frequency FSE method.

1. Introduction

Image and video compression standards such as JPEG, MPEG, H.263 [1] are used for efficient dat transmission and representation over the internet. In these standards the data is coded by block-basec techniques. In case of JPEG the image is segmented into non-overlapping blocks. After segmentatior each block is compressed, then stored or transmitted over communication channels. The transmissior over the fading channels may lead to transmission errors. If the block is well compressed the error of one bit may cause a loss of the whole block. After such erroneous transmission the image may contain block losses. Concealing of block losses is an important problem in the image processing.

A powerful algorithm, based on signal extrapolation, is Frequency Selective Extrapolation [2] which operates in the Fourier domain and has a high extrapolation quality. The Frequency Selective Extrapolation algorithm conceals block losses by estimating lost areas from the correctly receivec adjacent areas.

In this paper an improved algorithm of Frequency Selective Extrapolation is described whicl analyses and defines suboptimal sizes for adjacent support areas before extrapolating them. The suppor areas are analyzed using Canny edge detection algorithm [4], which helps to define the coefficient o homogeneity of the adjacent areas. Based on the coefficient of homogeneity, the size of the support area which will be used in extrapolation, is defined.

The paper is organized as follows: in Section 2 the theory of frequency selective extrapolation i described shortly. Then, in Section 3 the algorithm of selective extrapolation is described. In Section 4 th proposed modification of selective extrapolation method is described and the results of experiments ar shown.

. Frequency Selective Extrapolation Overview

Fig. 1 schematically shows an example of the area Λ, which is a part of a digital image, where a missed block has occurred. Λ area is composed of dark grey area B (a missing block area), which has to be estimated by extrapolation of elements in light grey area A (a support area).

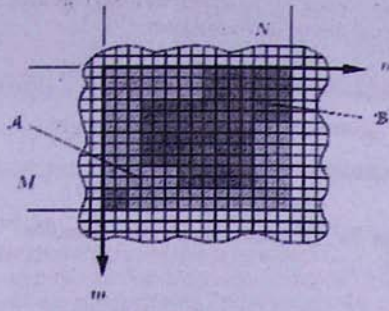


Fig.1. Part of digital image with missing area

The part of image, which is contained in the area Λ, we denote_ $F = \{f[m,n]\}$, where $m = 0,1,\dots,M-1$, $n = 0,1,\dots,N-1$. In order to extrapolate the observed area Λ, the elements of the known area are approximated by the parametric model $G = \{g[m,n]\}$, which is also defined in Λ.

The parametric model is a weighted liner combination of basis functions. In this algorithm 2D DFT functions are used as basis functions. The parametric model is generated successively, in each iteration we calculate

$$g^{(v)}[m,n] = \sum_{(k,l)\in K^v} c_{k,l}^{(v)} \varphi_{k,l}[m,n].$$

Where K^v represents a set of basis functions used for the expansion of the parametric model $g[m,n]$, before iteration v; $c_{k,l}^{(v)}$ is expansion coefficient which is calculated in iteration v; $\varphi_{k,l}[m,n]$ is DFT basis function which is defined in the entire area Λ.

$$\varphi_{k,l}[m,n] = e^{j\frac{2\pi}{M}mk} e^{j\frac{2\pi}{N}nl}.$$

For each iteration a residual error is calculated

$$r^{(v)}[m,n] = (f[m,n] - g^{(v)}[m,n])b[m,n],$$

where $b[m,n]$ is the window function

$$b[m,n] = \begin{cases} 1, (m,n)\in A \\ 0, (m,n)\in B \end{cases}.$$

In each iteration the residual error of support area is decreased by $\Delta g[m,n]$, which shows the change of parametric model between the iteration steps v and $v+1$, $\Delta g[m,n]$ is updated in each iteration. Then, the residual error is calculated in the following way:

$$r^{(v+1)}[m,n] = r^{(v)}[m,n] - \Delta g[m,n]b[m,n].$$

The $c_{k,l}^{(v)}$ expansion coefficient is calculated to minimize the weighted instantaneous residual error energy E_A (1). For iteration step $v+1$ the residual error energy is calculated in the following way:

$$E_A^{(v+1)} = \sum_{(m,n)\in\Lambda} w[m,n](r^{(v)}[m,n] - \Delta g[m,n])^2. \tag{1}$$

where

$$w[m,n]=\begin{cases}0,(m,n)\epsilon A\\ \text{positivi value},(m,n)\epsilon A.\end{cases}$$ positive

$\Delta g[m,n]$ is updated in the following way:

$$\Delta g[m,n]=\Delta c\,\varphi_{u,v}[m,n],$$

where the Δc is an optimal update of expansion coefficient in each iteration, see [2]. Thus th $c_{u,v}$ expansion coefficient is updated in the following way:

$$c_{u,v}^{(v+1)}=c_{u,v}^{(v)}+\Delta c \qquad (2)$$

The pair (u,v) is included in the set of basis functions K^{v+1}, if a function with such coefficient was not included before:

$$K^{(v+1)}=K^{(v)}\cup(u,v),\text{if }(u,v)\in K^{(v)}$$

The error energy is updated in the following way, see [2]:

$$E_A^{(v+1)}=E_A^{(v)}-\Delta E_A^{(v+1)} \qquad (3)$$

From equation (3) we see that $E_A^{(v+1)}$ has a minimum value, when $\Delta E_A^{(v+1)}$ has a maximum value. $(u,v)=\operatorname{argmax}\Delta E_A^{(v+1)}$

3. Description of Selective Extrapolation Algorithm

In this section we will describe the algorithm step by step. The algorithm is described for one block are and one color channel. The block includes a missed block and a support area. Since we use FFT transfon the size of the block area is increased by zero-padding to the size of power of 2. In the experiments th size of the missed block is 16px, the support area is from 1px to 16px. The size of the block area is 64x6 hence $f[m,n]$ and $g[m,n]$ have 64x64 size.

1. The algorithm is initialized with and the residual error equals to weighted original signal in th first iteration: $r_w^{(0)}[m,n]=w[m,n]f[m,n]$. Where,

$$w[m,n]=\begin{cases}074\sqrt{\left(m-\frac{M-1}{2}\right)^2+\left(n-\frac{N-1}{2}\right)^2},(m,n)\epsilon A\\ 0,(m,n)\epsilon B\end{cases}$$

   Then, we transform $w[m,n]$ and $r_w^{(0)}[m,n]$ into frequency domain by Fast Fourier Transfor Algorithm [3].
2. $\Delta E_A^{(v+1)}$ energy decrease computation.
3. Selection of basis functions with indexes (u,v).
4. $c_{u,v}^{(v+1)}$ coefficient update for Δc, see (2).
5. Check if the $\Delta E_A^{(v+1)}$ is less than the predefined E_{min}=15 threshold or if the number iterations is more than 11. If no go to step 2 else go to step 6.
6. The algorithm terminates and we get a parametric model by Inverse Discrete Transform $G^{(v)}[k,l]$:.
7. In the end the elements of the missed block of the input image are replaced with th corresponding elements of $g^{(v)}[m,n]$ parametric model.

The algorithm is implemented in Matlab. Fig. 2 shows the result of the selective extrapolation algorithm

(a) (b)

Fig. 2 (a). Input image with missing blocks; (b) Concealed image.

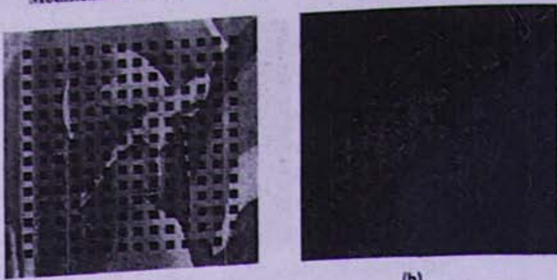
Modification of Selective Extrapolation Method

n the selective extrapolation algorithm the size of the support area for all blocks is fixed. We suppose at each block has a suboptimal size of support area. The suboptimal size will bring to a better result of trapolation in comparison to the fixed size of support area border width. We have implemented the llowing experiment. For each block of input image we have implemented the selective extrapolation gorithm with different sizes of support area borders (1px, 3px, 5px, 8px, 16px) and have calculated SNR value for all of them. The support area border size, corresponding to PSNR with maximum value is ed for current block in selective extrapolation algorithm. After repeating this process for all blocks, we lculate the final PSNR value. The final PSNR value of test method is higher in comparison to PSNR lue of images concealed with the fixed size of support area border for all blocks. The results are shown Table 1. This test method cannot be used in practice, because for calculating PSNR for each block, we e the original image. But, this method proved our assumption that there was a suboptimal size of pport area border.

Table 1. PSNR values for each color channel.

Support Area	PSNR R	PSNR G	PSNR B
Fixed 1px	34.91dB	31.72dB	31.70dB
Fixed 3px	35.53dB	31.71dB	32.08dB
Fixed 8px	34.07dB	32.44dB	32.24dB
Fixed 16px	35.15dB	32.73dB	33.09dB
Test method	38.15dB	33.82dB	33.81dB

In practice to define the suboptimal size of support area border, without having the original image, e implement content-aware analysis of each block area. The analysis is made with the help of Canny ge detection algorithm. It is easy to define the coefficient of homogeneity of the support area by alyzing the image, which was processed by Canny algorithm. We define the size of support area taking to account the coefficient of homogeneity; it should be less than a predefined threshold. The method is scribed below. At first we take the input image and apply Canny edge detection algorithm on it, see g. 2.



(a) (b)

Fig. 2 (a). Input image, (b). Copy of input image processed by Canny algorithm.

It is noticeable that only edges, which have white color, are left after the processing Fig. 2 (b). Th pixels values of processed image are 0-black pixels and 255-white pixels. In the processed image w make our analysis. We define the area of processed image which corresponds to the missing block area the input image. Then, we set the support area border 1px and calculate the coefficient of homogenei (COH).

$$COH = \frac{(number\ of\ white\ pixels)}{(\text{number of all pixels})} * 100$$

If the COH value is under 5%, we increase the number of support area border by 1px and calculate th COH again. We repeat this for each block until the COH is more than 5% or the border size reaches 16p The research showed that there was no efficiency when the support area border was larger than 16 pixel see [2]. The support area border size values for all blocks are recorded in an array. This array is used the selective extrapolation algorithm. The results of the experiment are shown in Table 2.

Table 2. The result of the proposed image, PSNR values for R, G, B color channels.

Support Area	PSNR R	PSNR G	PSNR B
1-16 Pixels (Proposed method)	36.01dB	32.58dB	32.39dB

5. Conclusion and Future Work

In this paper a modification method of frequency selective extrapolation was described. The modificati based on support area analyses is targeted to choosing the suboptimal size of the support area. The usa of Canny algorithm allows us easily to detect the edges of the input image, thus to calculate th coefficient of homogeneity.

The results of the experiments have shown that the method is effective. We have shown that th size of support area affects the quality of extrapolation. Each missing block has its suboptimal supp area size. In our future work we are going to improve the support area analysis technique. Moreover, the frequency selective extrapolation method the discrete Fourier transform (DFT) is used: we are goi to use other transformations such as Haar, discrete cosine transform (DCT) and Hadamard transform [5].

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ՀԸԷ մեթոդի վերափոխումը համասեռության գործակիցների հիման վրա

Գ. Կարապետյան

Ամփոփում

Այս աշխատանքում մշակված է հաճախական ընտրանքային էքստրապոլյացիայի ՀԸԷ) մեթոդի մի նոր տարբերակ: Նշենք, որ ՀԸԷ մեթոդն օգտագործվում է թվային պատկերներում բլոկային կորուստների քողարկման նպատակով: Վերջինիս մոդիֆիկացիան (վերափոխումը) հիմնված է աջակցող տիրույթի վերլուծության վրա՝ օգտագործելով Կանիի ալգորիթմը: Վերլուծության արդյունքում յուրաքանչյուր բլոկի համար ընտրվում է աջակցող տիրույթի ենթաօպտիմալ (suboptimal) չափ, որն այնուհետև օգտագործվում է ՀԸԷ ալգորիթմում: Աշխատանքում բերված են ՀԸԷ մեթոդի նոր տարբերակի փորձարկման արդյունքները, ինչպես նաև կատարված է համեմատական վերլուծություն ՀԸԷ մեթոդի արդյունքների հետ:

Модификация метода ЧВЭ на базе коэффициентов однородности

Г. Карапетян

Аннотация

Работа посвящена модификации метода частотной выборочной экстраполяции ЧВЭ). Метод используется для реконструкции блочных потерь в цифровых изображениях. Модификация метода ЧВЭ основана на анализе вспомогательной области с использованием алгоритма Кани. Вследствие анализа для каждого блока выбирается субоптимальный размер вспомогательной области, который далее используется в алгоритме ЧВЭ. В работе приведены результаты экспериментов, которые сравнены с результатами метода ЧВЭ.