Research on Blind Image Restoration Based on Two Dimensional Constant Modulus Algorithm

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Abstract. Aiming at the defects of existing image restoration algorithms, the image restoration algorithm based on two dimensional constant mo.dulus blind equalization algorithms is proposed. In this proposed algorithm, the constant modulus blind equalization algorithm with fast convergence and small mean square error is extended from one-dimension to two-dimension, it is applied to two-dimension image blind restoration, and its convergence speed is independent of the initial condition. After the degraded imagas of pollution or the fuzzy images are processed by the proposed algorithm, the image quality is greatly improved. The simulation tests show that the proposed algorithm is better than one-dimensional CMA in image blind restoration.

Introduction

Because of the basic and important status of image restoration in digital image process, many researchers have focused on researching image restoration technique, a series of classic image restoration algorithms such as inverse filter, Wiener filter, constrained least squares algorithm, and maximum entropy restoration method, and so on, were proposed under the assumption that the point spread function (PSF) is known [1-3].However, the PSF of the real image system is often unknown, so we can recover the image only relying on the image observation data and prior knowledge of the imaging system, the original image, and the noise. This method is called as blind image restoration algorithm. In other words, the blind image restoration technique restores the specific PSF and the specific original image only based on the "specific" image observation data. Obviously, blind image restoration algorithm is an image recovery method with more practical [4, 5].In recent years, with popularity of computers and computer networks, blind image restoration research has gained unprecedented attention as a popular topic in signal processing. New techniques and methods such as parameter estimation method [6, 7], non-parametric estimation method [8, 9], and fast algorithm [10] were proposed.

In order to further improve the performance of the blind image restoration, two-dimensional constant modulus algorithm based blind image restoration method is proposed. This proposed method can eliminate the distortion and inter symbol interference caused by communication channels, has low calculation load and high robustness, faster recovery speed, and higher image restoration quality.

Two-dimensional Blind Equalization Algorithm

System Model. The model of two-dimensional constant modulus blind equalization algorithm (TDCMA) is shown as Fig. 1. In Figure 1, $a(k_1,k_2)$ represents two-dimensional signal, $h(k_1,k_2)$ is two-dimensional impulse response of the channel called as PSF, $s(k_1,k_2)$ is the two-dimensional signal of channel output, an additive white Gaussian noise is represented by $n(k_1,k_2)$, $x(k_1,k_2)$ denotes

two-dimensional noisy signal or of equalizer input, $w(k_1,k_2)$ represents two-dimensional weight coefficient of the equalizer, $y(k_1,k_2)$ is the output signal of equalizer and $e(k_1,k_2)$ is the error signal of equalizer.

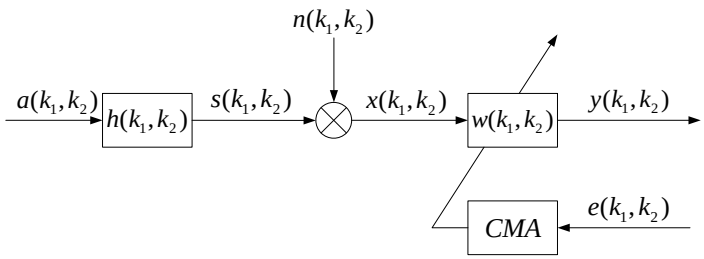

Figure 1. The model of two-dimensional blind equalization algorithm

The Working Principle of Two-dimensional Blind Equalizer. According to Fig. 1, we have

$$x(k_1,k_2)=a(k_1,k_2)\otimes h(k_1,k_2)+n(k_1,k_2) \tag{1}$$

Where, $\otimes$ denotes convolution. When $x(k_1,\ k_2)$ and $a(k_1,\ k_2)$ are known, $h(k_1,\ k_2)$ can be obtained; when $a(k_1,\ k_2)$ is unknown, it is quite difficult to obtain $h(k_1,k_2)$. So it is necessary to use the blind equalization technique without prior information of the signals. Under these circumstances, the cost function is defined as

$$J(W)=E\{R_{CM}\text{-}|y(k_1,k_2)|^2\} \tag{2}$$

Where

$$y(k_1,k_2)=\sum_{m=0}^{N-1}\sum_{n=0}^{N-1}W_j(m,n)x(k_1-m,k_2-n) \tag{3}$$

So we have

$$W_{j+1}(m,n)=W_j(m,n)+2\mu e_j x(k_1-m,k_2-n)y(k_1,k_2) \tag{4}$$

where μ denotes the step-size, $W_{j+1}(m,\ n)$ is two-dimensional equalizer weighted matrix, m and n respectively represent the row vector and the column vector of right matrix, k_1 and k_2 represent the row vector and the column vector corresponding to the pixel points of the image,and $x(k_1-m,k_2-n)$ is the input signal of the equalizer, as well as $e_j=R_{CM}-|y(k_1,k_2)|^2$.

Blind Image Restoration Algorithm Based on TDCMA

Steps of Algorithm. The steps of blind image restoration algorithm based on TDCMA are given as follows:

Step 1. Select a gray image called as “cameraman”.

Step 2. Obtain the degraded images according to Eq.1.

Step 3. Obtain equalizer output according to Eq.3.

Step 4: Update the weighted matrix of the two-dimensional equalizer according to Eq.4.

Simulation Experiment. To test the validity of the TDCMA algorithm, simulation experiments were carried out and compared with one–dimensional CMA based on dimension reduction. As shown in the Fig.2(a), an 256×256 original image, first, we use the 20×20 Gaussian Blur PSF to degrade the original image, then, the white Gaussian noise has been attached to this image, finally,we obtained the degraded image shown in Fig.2(b). The algorithm parameters of the one–dimensional CMA algorithm were set as follows: the noise was 20dB, the iterative step-size μ was set to 0.0005 and the number of iterations was set to 500. Fig.2(c) shows the restored image after iteration. In the TDCMA algorithm, the noise level was adjusted with a variance σ^2 of 0.03, and the iterative μ is 0.005, the number of iterations is 500. The simulation results are shown in Fig.2 and Table 1.

(a)Original image

(b)Blurred images with noise

(c) Restored image based on CMA

(d) Restored image based on TDCMA

Figure 2. Experimental results

Table 1 Comparison of PSNR

Algorithm	CMA	TDCMA
PSNR	17.6332	23.5463

As shown in the above results, we can see that the performance of the TDCMA is better than one-dimensional CMA for image restoration. Despite the complexity of the proposed TDCMA algorithm is increased, there is no need to reduce dimensionality to the image signals. Although the speed of the proposed algorithm is decrease, the effect of the restored image is better. The PSNR is an objective measurement of evaluating the image quality, the larger the value of PSNR, the less the distortion. Table 1 shows the values of the PSNR, which shows that the perforacne of two-dimensional CMA has good in comparison with one-dimensional CMA, which indicate that the effect of two-dimensional CMA is much better than one-dimensional CMA.

Conclusions

In this study, a blind image restoration technique based on two-dimensional constant modulus blind equalization algorithm (TDCMA) is proposed. The implementation process of this proposed algorithm has no any matrix operations, average and differential, and its convergence speed is independent of the initial conditions. The proposed algorithm has shown good performance of stability and can overcome information loss caused by image dimensionality reduction. After the two-dimensional image is dialed with constant modulus equalization algorithm, the image quality is greatly improved and the restoration effect is better. So the proposed algorithm is of practical value.

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