A MODIFIED FIXED PHASE ITERATIVE RECOVERY ALGORITHM FOR RESTORATION OF COLOR BLURRED IMAGES

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Abstract

The applications of an Iterative method for the restoration of color blurred image is presented. The method is an enhanced modification of the fixed-Phase Iterative algorithm (FPIA). A blurred image is enhanced by Laplace operator during the FPIA method on eachiteration. This modification is originally supported theoretically by a derivation of some iterative deblurring methods that are based on the enhanced version of the blurred image instead of the blurred image itself only.

The modified fixed phase iterative algorithm (MFPIA) method is examined to restore some Gaussian- and motion-blurred color images. The restored images via this proposed method are compared with some standard iterative method called Richardson-Lucy method. From the comparison. It is appearant that the MFPIA method gives better values for signal to noise ratio (SNR) of the resuling image. The method is also better from human visual measurements point of viww with less number of iterations. In addition to that benefit the restoration by the other method result in images having shaded edges. Another advantage for the MFPIA method is that to restore a blurred image, the only thing required to be known is the blurred image itself; while a prior knowledge of the point spread function (PSF) with the original unblurred image is a must in the Richardson-Lucy methods. This makes the MFPIA method more powerful for practical applications.

الخلاصة

يقدم هذا البحث طريقة تكرارية معدلة لاسترجاع الصور الملونة المضببة مسبقا . صممت الخوارزمية المستخدمة على اساس خوارزمية استرجاع الصور بطريقة تكرارية مع ثبات الطور . ان التعديل الذى اجري على تلك الخوارزمية بني اساسا على تعزيز الصورة المسترجعة باستخدام معامل لابلاس (Lap lace Operator) حيث اصبحت عملية الاسترجاع تعتمد على نمط معزز من الصورة المضببة بدلا من اعتماد الطريقة على الصورة المضببة فقط .

لقد تم اختبار الخوارزمية على عدد من الصور الملونة المضببة بطريقتي (Gaussian & motion) و قورنت النتائج مع خوارزمية ريشاردسون لوسي (Richardson-Lucy) ، فأثبتت انها الاكفأ في أسترجاع الصور بنوعية جيدة وبأقل عدد من المحاولات التكرارية . بالاضافة الى ما تقدم فأن الخوارزمية المعدلة لاتحتاج الى معلومات مسبقة عن الصورة الاصلية ولا على التضبيب الذي تم عليها وعلى العكس من طريقة ريشاردسون لوسي هذا ماجعل الخوارزمية المعدلة أكثر ملائمة للتطبيقات العملية .

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1. Introduction

There are many techniques used to deal with blurred images. Some of them are used to reduce the blurring effect on an image by enhancing that image using edge enhancement technique [1] , while the other techniques aim to remove the blurring effect by making benefit of prior information about the original image and the blurring process (i.e. the point spread function (PSFor the frequency response H(u,v) ehich is convolved with the original unblurred image to produce the blurred image). Some of the frequency domain filters, e.g., inverse filter. Wiener filter or others [2] are examples of these techniques. On the other hand in practice when there is no information about the PSF (for example in remote sensing and space imaging the fluctuations in the PSF are difficult to be characterized as a random process, and there is a difficult in statistically modeling the original image . Some iterative techniques are used here to restore the blurred image. The degraded image can be modeled as [2, 3]

$$g(n_1,n_2) = f(n_1,n_2) * h(n_1,n_2) + n_0(n_1,n_2) \quad (1)$$

Where
F(n , n) is the original image function, h (n , n) is the impulse response function for blurring,
n (n , n) is the additive noise,
g (n ,n) is the degraded image , and n , n are the spatial domain coordinates (0 < n , n <N , where N is the number of pixels in each dimension for a square image) with the * denotes the convolution operator. Supposing that there is no noise effect,Eq.(1) can be reduced to[2]

$$g(n_1,n_2) = f(n_1,n_2) * h(n_1,n_2) \quad (2)$$

So that the purpose of all the restoration or deblurring techniques is to separate the convolution product in order to restore f (n ,n) from g (n ,n). In the absence of the prior information about the image and the blurring process the restoration process here is referred to as the blind deconvolution process [4, 5].

Practically an image can be blurred using Matlab6p 1 programming language. Images can either be Gaussian or motion blurred using special instructions. The Gaussian blur can be generated by the following filter response

$$h_g(n_1,n_2) + e^{-\left(n_1^2 + {}_2^2\right)/2\partial^2} \quad (3)$$

The number of selected pixels and the deviation sigma (Q) can be modified in order to control the Gaussian blurring degree on the image , while in motion blur, the number of selected pixels can be changed to be shifted with an angle of shifting ( ) that is called the shifting direction [6] .

Recently , new method for restoration of gray –scale blurred images called the modified fixed phase iterative recovery algorithm (MFPIA) is proposed [7] and compared with a well known method called the fixed phase iterative recovery algorithm (FPIA) [8]. The comparison proved that the new method is better from the complexity and the speed points of view of algorithm with a better correlation measures between the original and the restored images .This paoer proposes the same MFPIA method for restoration of color blurred imagees and gives a comparison with another known method called the R Richardson-Lucy iterative algorithm which will be described in section 2 of this paper . Section 3 presents the proposed method .A comparative study is given in section 4. Finally some discussion and conclusions are drawn in section5.

2. Iterative Richardson – Lucy deblurring algorithm

This iterative algorithm was introduced by Richardson –Lucy in 1972 [9]. The algorithm maximizes the likelihood at the resulting image, when convolved with the PSF. It also supposes the existence of the PSF.

Starting with an iterative form of Eq. (2), which can also be given as [10]

$$g_p(n_1,n_2) = h(n_1,n_2) * f_P(n_1,n_2) \qquad (4)$$

Where p is the iteration step number .It should be noted that the Richardson Lucy method supposes that

$$R_P(n_1,n_2) = g(n_1,n_2) - g_P(n_1,n_2) \qquad (5)$$

Or

$$g(n_1,n_2) = g_P(n_1,n_2) + R_P(n_1,n_2) \qquad (6)$$

while the Richardson-Lucy algorithm equation is given as

$$\hat{f}_{p+1}(n_1,n_2) = \hat{f}_P(n_1,n_2)\left[\frac{g_P(n_1,n_2)+R_P(n_1,n_2)}{g_P(n_1,n_2)} * h^*(n_1,n_2)\right] \qquad (7)$$

Where R (n ,n) is the Richardson-Lucy restoration filter and small * denotes a complex conjugation .An example on image restoration using Richardson-Lucy algorithm is shown in Fig.1.

3. The MFPIA method

In this section the MFPIA method will be presented. The basic idea of formulation depends on two concepts , one that is introduced by Zho Ren Feng and Zhou Hui in the fixed phase iterative recovery algorithm (FPIA) of blurred images [8] which states that the phase spectrum of the original clear image is the same as that for the blurred image . The other fact was presented in the derivation and analysis of Slepian method or Soundhi method [11],which states that the restoration of a blurred image can be implemented by using its derivative .

The proposed method combines these two concepts in a modified way in order to deblur the blurred image . That is why we call it the modified fixed phase iterative algorithm (MFPIA) . The algorithm supposesthat there is no noise effect n (n ,n) = 0 so that Eq.(2) can be used here . The algorithm is carried out by implementing the following steps:-

1. for the first iteration, set
   f (n , n) = g (n ,n)
2. suppose that p is the time of the iteration and for the sake of algorithm simplicity, f (n ,n) is converted initially to a one- dimensional form f (n) where 0< n <N by using vector transformation[12].
3. convert f (n) to its frequency domain representation F (k) i.e. magnitude & phase using the fast Fourier transform (FFT). The length of FFT and FFT must be greater than 2N to ensure that the recovery is done perfectly so

$$F_P(k) = \text{FFT}\,[f_p(n)] \text{ for } 0 \le k \le 2N^2 \qquad (8)$$

It should be noted here that for the I iteration, since

f (n , n) = g (n ,n), then the transformed version will be

$F_0(k)$ =G (k)=FFT[g(n)]for 0≤ k ≤ 2N^2 (9)

In magnitude and phase forms

$$F_p(k) = |F_p(k)| \exp[j\theta_{F_p}(k)] \quad (10)$$

and

$$G(k) = |G(k)| \exp[j\theta_G(k)] \quad (11)$$

4. the phase replacing process taking place here is given by
0 (k) ------ 0 (k)
For all p values then the new sequence F

$$F_{p+1}(k) = |F_p(k)| \exp[j\theta_G(k)]] \quad (12)$$

5. now applying FFT to F (k) , f (n) can be obtained , and since f (n) is a 2N - point length it must be truncated into N - point length. The resulting truncated sequence can be obtained by the following time truncation process:

$$\hat{f}_{p+1}(n) = \begin{cases} f_{p+1}(n) & 0 \le n \le N^2 - 1 \\ 0 & N^2 \le n \le 2N^2 - 1 \end{cases} \quad (13)$$

6. Using the inverse vector transform, the sequence f (n) can be back transformed to f (n , n)

7. then the derivative operation is performed by using an edge detection operator (e.g. Laplacian operator), thus f (n , n) is obtained .

8. The restored image at iteration p+I is obtains y adding the transformed sequence

f (n , n) and its derivative f (n ,n), Thus the final sequence is obtained as

$$f_{p+1}(n_1, n_2) = \hat{f}_{p+1}(n_1, n_2) + \hat{f}_{p+1}(n_1, n_2) \quad (14)$$

9. if the restored image quality is not good the algorithm is repeated from step 3.

Fig. 2 shows the MFPIA method flow chart. Fig. 3 shows an example on image restoration using this method.

4. A comparative study

For comparison, two color images are selected with 256 x 256 spatial resolution . The 1 st image (House) is blurred using Gaussian blurring with Q=2 and number of selected pixels =7 [see Eq. (3)], while the other image (Wcat) is blurred using motion blur the number of the shifted pixels =8 ,and a shifting angle 0=0,Fig.4& 5 show both application of the Richardson-Lucy algorithm and the MFPIA method on the Gaussian blurred and motion blurred images respectively . From these figures , it can be seen that the restored color images using MFPIA method are better than those restored using the Richardson-Lucy method. That's because the images restored using the Richardson-Lucy method appear with shaded edges which is not the case with the MFPIA method. The Signal to Noise Ratio (SNR) for the House image in Fig.4 is 32.848 dB for image restored with MFPIA and 32.791 dB for image restored with Richardson-Lucy method. For the weat image of Fig.5, the SNR is 34.107 dB for image restored with MFPIA and 31.632 dB for image restored with Richardson-Lucy method.

5. Discussions & Conclusions

A new application of MFPIA method on color image deblurring has been presented in this paper. The MFPIA method is a modification of the FPIA method it is called the modified fixed phase iterative algorithm (MPFIA). The modification is a mixed idea between the FPIA using the derivative of the blurred image that is used in the restoration of images by Slepian method. This has made the proposed method depend on an enhanced version of the blurred image instead of the original blurred one only. The algorithm for the MFPIA method is given. This method has been applied to color images that had been originally blurred by using two methods:- Gaussian blur method and Motion blur method. The Richardson-Lucy algorithm has been selected for comparison. It is evident from the results that the MFPIA method gives better performance than the Richardson-Lucy method. It should be noted that the restored image using Richardson-Lucy method has shaded edges; this undesired effect does not appear in this MFPIA method.

An important advantage of this MFPIA method is that all what we need to restore a blurred image is the blurred image itself, i.e., the prior knowledge of the PSF and the original unblurred image are not required here as in other methods such as Wiener method [2] and Richardson-Lucy method. This advantage makes the proposed method much more powerful in practical applications than those methods. The other advantage of the proposed method is that a final restored image of good quality can be achieved with less number of iterations as compared with Richardson- Lucy method and with the original FPIA method [7], which means the MFPIA method is better from the algorithm speed point of view.

6. References

[1] Gomes J. & Luiz V., **Image Processing for Computer Graphics** ,Rio De Janiero, Brazil, 1997.

[2] Umbaugh S.E., **Computer Vision and Image Processing**, Prentic-Hall, Inc., USA, 1998.

[3] Aggelos K.K., "**Iterative Image Restoration Algorithm** ", Optical Engineering, Vol.28, No.7p 735-748, July 1989 ftp3.itu.int/av-arch/video-site/9811http:// Sea/q15f23.ps-supplemental Result

[4] Deepa Kundur & DimitriosHatinakos, **"On the Use of Lyapanoy Criteria toAnalyze the Convergence of Blind Dec onvolution Algorithms",** IEEE Transactions on Signal Processing, Vol.46, No11, p2918-2925, Nov 1998. http://ee.tamu.edu/-deepa/pdf/sptiy.pdf

[5] Cabir Vural & William A.Sethares, "**Recursive Blind Image deconvolution Via Dispersion Minimization",** University of Wisconsin-Madison, 2002. http:// eceserv0.wise.edu/-Sethares/paperspdf/ICDSP02

[6] **Image Processing Toolbox on Matlab Help** "Version 6.1".

[7] Abdul-Jabbar J.M., "**A modified fixed phase iterative algorithm recovery of blurred images** ", To be published in the Basrah Journal of Engineering science (BJES), college of Engineering ,Basrah ,Iraq.

[8] Zho Ren F.& Zhou Hui , "**The Fixed-phase Iterative Algorithm Recovery of Blurred Image** : , ICSP , 2000 . http:// www. Ifip. Or .at /con 2000/icsp2000/icsp- Si241 .pdf

[9] Van Kempen P. & Van Vliet J., " **The Influence of the Regulariztion Parameter and the first Estimate on the Performance of Tikhony Non- Linear Image Restoration Algorithms " ,** Jornal of Microscopy , Vol.198, p 63-75 Apr 2000 . http:/www.ph.tn. tudelft.nl/-lucas/publications/2000/JoM2000GKLV/JoM2000GKLV. pdf

[10] Strack J. L. and Pantin E., "**Deconvolution in Astronomy: A Review".** 2002. http:// jstarck.free.fr/pasp02.pdf

[11] Xin Miao, "**Image restoration :Removal of Blur Caused by Uniform Linear Motion "** , University of California at Berkeley , 2000. http:// www.cnr.berkeley.edu/-miaoxin

[12] Pratt W. K., **Digital Image Processing,** Jhon Wiley & Sons, USA, _ 1978.