ISSN: 0067-2904

Restoration of Digital Images Using an Iterative Filter Algorithm

Hala. K. Alkzai*, Ayad A. Alani
Department of Physics, College of Science, Al-Nahrain University, Baghdad, Iraq.

Abstract
Digital image started to including in various fields like, physics science, computer science, engineering science, chemistry science, biology science and medication science, to get from it some important information. But any images acquired by optical or electronic means is likely to be degraded by the sensing environment. In this paper, we will study and derive Iterative Tikhonov-Miller filter and Wiener filter by using criterion function. Then use the filters to restore the degraded image and show the Iterative Tikhonov-Miller filter has better performance when increasing the number of iteration To a certain limit then, the performs will be decrease. The performance of Iterative Tikhonov-Miller filter has better performance for less degradation parameters, with high SNR and Wiener filter has better performance for more degradation parameters, with low SNR.

Keywords: Gaussian blurring function, Gaussian noise function, Degraded image, Criterion function, Itrative Tikhonove _Miller filter, Stander deviation.

ترميم الصورة باستخدام خوارزمية مرشح تكراري

هاله كاظم الخزاعي* ، اياد عبد العزيز العاني
قسم الفيزياء، كلية العلوم ، جامعة النهرين ، بغداد، العراق.

الخلاصة:
بدأت الصورة الرقمية تدخل في عدة مجالات مثل علوم الفيزياء والحاسوب والهندسة والكيمياء والبيولوجيا والطب لاجل الحصول على معلومات مهمة منها. ولكن اي صورة نحصل عليها بطريقة بصرية او الكترونية معرضة للتشويه من قبل بيئة المتحسس. مجال ترميم الصورة هو احدى مجالات معالجة الصورة الرقمية الذي يهتم بتحسين الصورة المشوهة. في هذا البحث، سنقوم بدراسة واشتقاق مرشح تكنهوف–ميلير التكراري ومرشح وينر باستخدام الداله المعيارية. ثم استخدامنا الفلاتر لترميم الصور المشوهة ووجدنا ان مرشح تكنهوف–ميلير التكراري لديه افضل اداء عند زيادة عدد التكرارات الى حد معين ثم يبداء الاداء بالنقصان بعدها. ان افضل اداء لمرشح تكنهوف–ميلير عندما التشويه قليل مع نسبة الاشارة الى الضوضاء قليلة ومرشح وينر لديه افضل اداء عندما يكون التشويه عالي مع نسبة الاشارة الى الضوضاء ضوضاء قليلة.

Introduction

Concern in digital image process field started in 1920, at the point when digitized picture of world news events were 1st send by submarine cable among New York and London. A number of digital image process applications; like physics, pictures of experiments in such space as high-energy plasmas and electron microscopy habitually improved by pc techniques. And in medication applications, as an example, physicians are power-assisted by pc procedures that enhance the distinction or code the intensity levels into color for easier interpretation of x-rays, like process of X rays-chest and supersonic scanning, another example, medical image also used for detection of tumors or different

*Email: Halahala745@yahoo.com

malady in patient [1]. Image restoration is mention as an rising the image quality that is degraded by blurring and noise [2]. The degradation model used in the research consists of two portion, the blurring function and the noise function. In the case of additive noise, the degradation model in spatial domain is given by [1]:

$$g(x,y) = H(x,y)\, f(x,y) + n(x,y) \quad (1)$$

Where g(x,y) is degraded image, f(x,y) is original image, n(x,y) is additive noise, H(x,y) is circulant matrix of blurring function.

In general, most effect which distort the image as aberration, non-homogeneous media, motion between the object and camera [3]. Image Restoration kind are often divided into two kind: Blind restoration and Non-Blind restoration. Blind restoration, the one within which operation of blurred unknown factor, therefor we create an estimate of the blurring operator and so using that estimate we have to deblur the image. Non-Blind restoration is that the one within which the blurring operator is noted, then we will take away blur from the degraded image using the noted of blurring function [4]. Iterative Tikhonov-Miller filter and Wiener filter are constrained linear restoration techniques, to derive them, we should to found a criterion function by letting Q be a linear operator on f. Consider the least-squares restoration problem as one of minimizing functions of the form $\|Q\hat{f}\|^2$, subject to the constraint $\|g - H\hat{f}\|^2 = \|n\|^2$. This approach introduces considerable flexibility in the restoration process because it produces different solutions for different choices of Q [1]. The addition of an equality constraint in the minimization problem can be handled without difficulty by using the method of Lagrange multipliers. The procedure is to express the constraint in the form $\alpha(\|g - H\hat{f}\|^2 - \|n\|^2)$ and then append it to the function $\|Q\hat{f}\|^2$. In other words, we seek $\hat{f}$ that minimizes the criterion function **[1]**.

$$J(\hat{f}) = \|Q\hat{f}\|^2 + \alpha(\|g - H\hat{f}\|^2 = \|n\|^2) \quad (2)$$

Where α is a constant called the Lagrange multiplier and Q linear operator.

By differentiating Eq.(2) with respect to $\hat{f}$ and setting the result equal to the zero vector yields [1]:

$$\frac{\partial J(\hat{f})}{\partial \hat{f}} = 0 = 2\, \acute{Q}\, Q\, \hat{f} - 2\alpha\, \acute{H}(g - H\hat{f}) \quad (3)$$

The solution is obtained by solving eq.(3) for $\hat{f}$;that is [1]:

$$\hat{f} = (\acute{H}H + \gamma\, \acute{Q}Q)^{-1}\acute{H}g \quad (4)$$

Where $(\acute{H}H + \gamma\, \acute{Q}Q)^{-1}\acute{H}$ is Wiener filter equation, $\hat{f}$ is restored image and $\gamma = \frac{1}{\alpha}$.

The optimal solution is given by eq.(2) with Q $\approx C$ and we use the method of the steepest descent to minimize the objective function $J(\hat{f})$ in (2) gives the following iterations [5]:

$$\hat{f}_{k+1} = \hat{f}_k + \beta r_k = \hat{f}_k - \tfrac{1}{2}\beta \nabla_f J(f)|_{\hat{f}_k} = \hat{f}_k - \beta\left((H^T H + \alpha C^t C)\hat{f}_k - H^t g\right) \quad (5)$$

Where k is number of iteration, $\hat{f}_{k+1}$ is restored image after k+1 iterations, $\hat{f}_k$ is restored image after k iterations, β is control the convergence of the iterations and C is Laplacian operator. Eq.(5) is called Iterative Tikhonov-Miller equation. The advantage iterative procedures that are no matrix inverses need to be implemented, and the additional deterministic constraints can be incorporated into the solution algorithms [5]. There is several iterative method used [6-9].

Experimental Results

Bird image used are 256*256 pixels in size, convolved with Gaussian blurring function with different standards deviation values " σ " and degraded by additive Gaussian noise with different signal to noise level "SNR" to produce degraded image, Then restored with different filter, such as Iterative Tikhonov-Miller filter and Wiener filter.

Image Restoration Algorithm by using Matlab language

1. Read original image of size 256 × 256 type binary or RGB images .

2. Generating Gaussian function (size 256 × 256) with different standards deviation .
3. Generating random Gaussian noise with different noise level.
4. Convolve original image with Gaussian function to produce a blurred image.
5. Add Gaussian noise to blurred image to produce a degraded image.
6. Estimate original image using different restoration filter such as, Wiener filter, Tikhonov-Miller regularized restoration filter.
7. Calculate the Root mean square error (RMSE) from restored images obtained by filters.

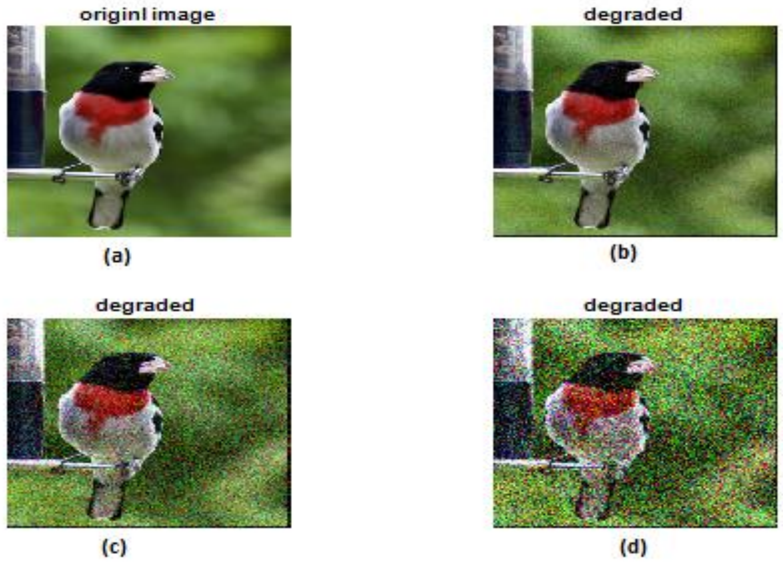


Figure 1- represent **(a)** original image**. (b), (d)** are degraded images, blurring with Gaussian function of σ = 1 and distorted with Gaussian noise with SNR = 20, 10 and 5 respectively

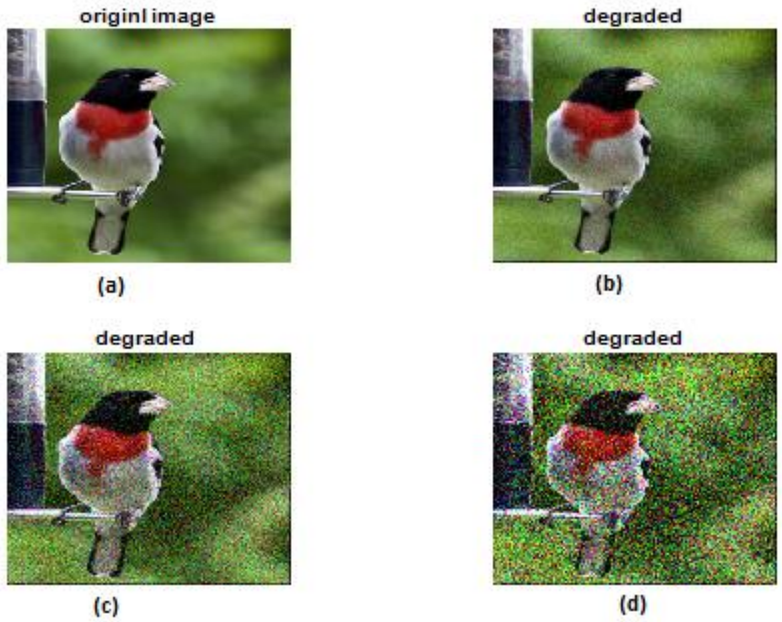


Figure 2- represent **(a)** original image. **(b),(d)** are degraded images, blurring with Gaussian function of σ = 2 and distorted with Gaussian noise with SNR = 20, 10 and 5 respectively

1. Wiener filter

Wiener filter used to restore the degraded bird image, blurring with Gaussian blurring function with different standards deviation values, and distorted with Gaussian noise with different noise level as will be shown in the following figures.

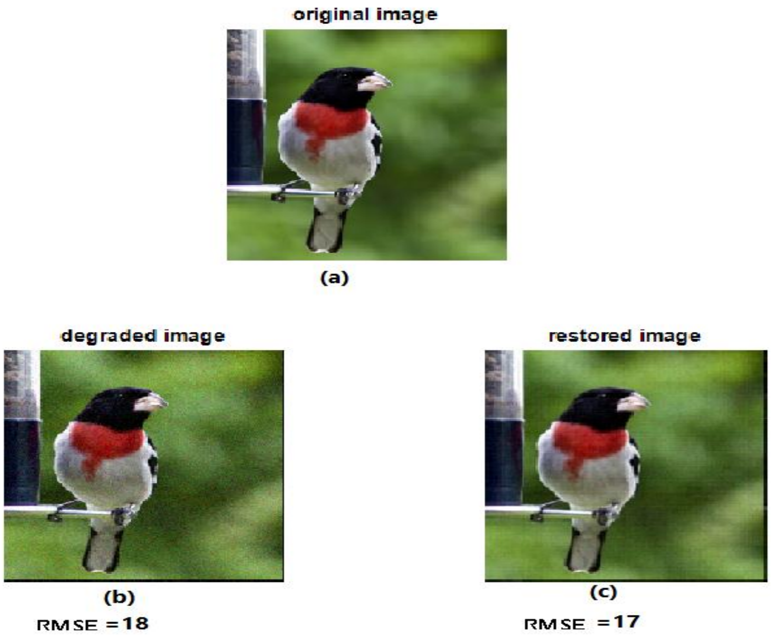


Figure 3- represent **(a)** original image. **(b)** degraded image, blurring with Gaussian function of σ = 1 and distorted with Gaussian noise of SNR = 20**. (c)** restored image using Wiener filter.

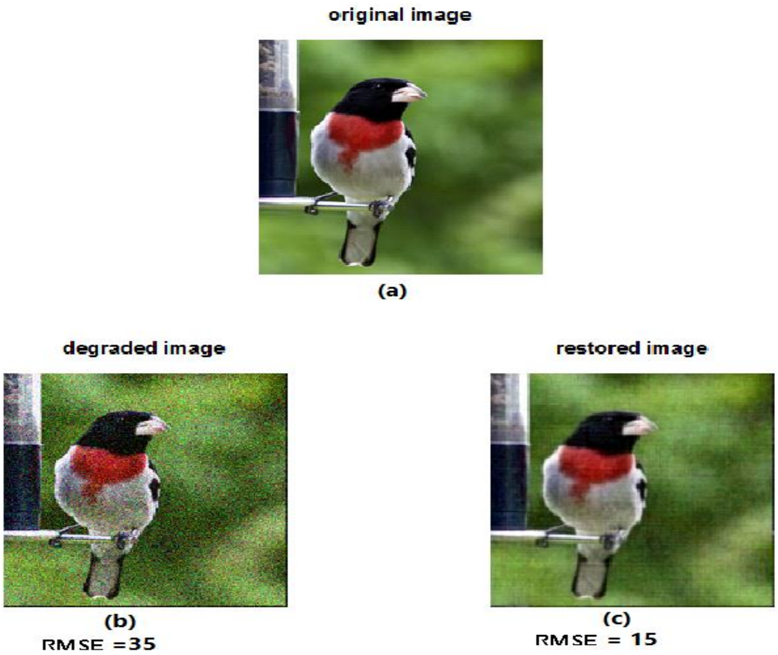


Figure 4- represent **(a)** original image**. (b)** degraded image, blurring with Gaussian function of σ = 1 and distorted with Gaussian noise of SNR = 10. **(c)** restored image using Wiener filter.

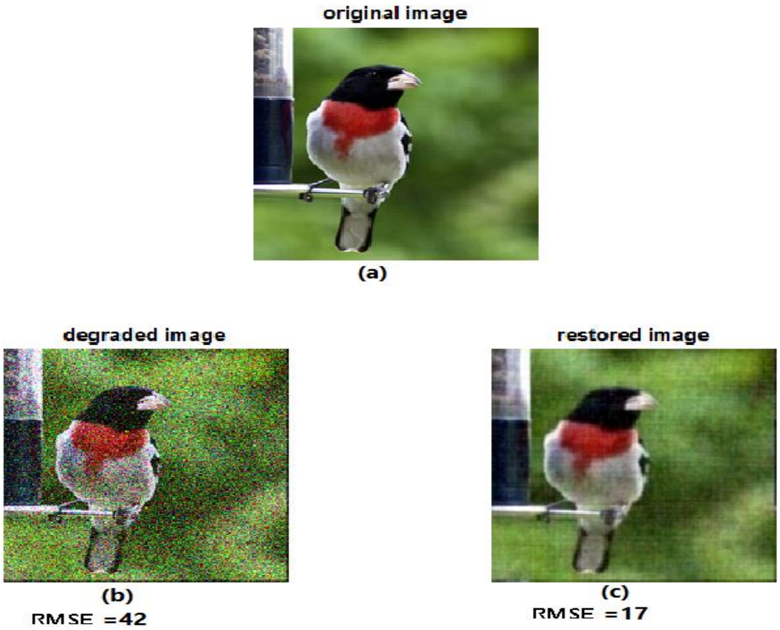


Figure 5- represent **(a)** original image. **(b)** degraded image, blurring with Gaussian function of σ = 1 and distorted with Gaussian noise of SNR = 5. **(c)** restored image using Wiener filter.

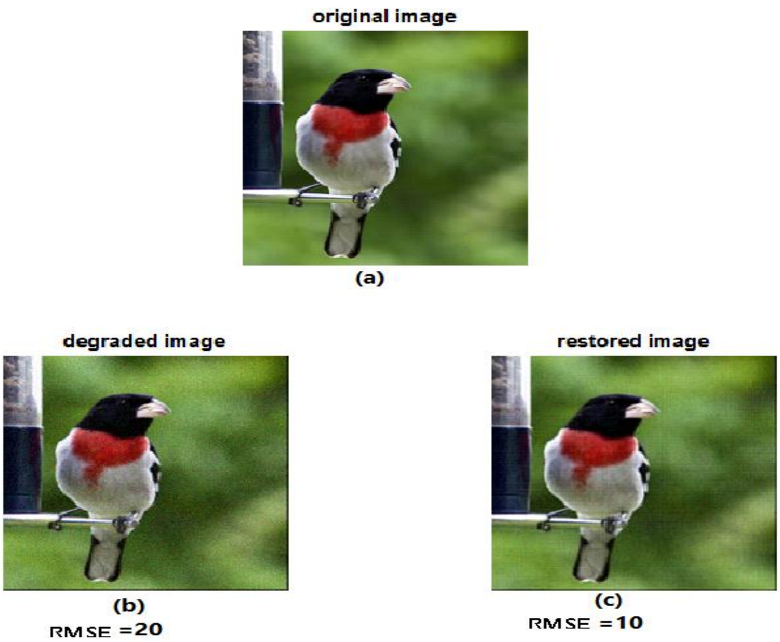


Figure 6- represent **(a)** original image. **(b)** degraded image, blurring with Gaussian function of σ = 2 and distorted with Gaussian noise of SNR = 20. **(c)** restored image using Wiener filter

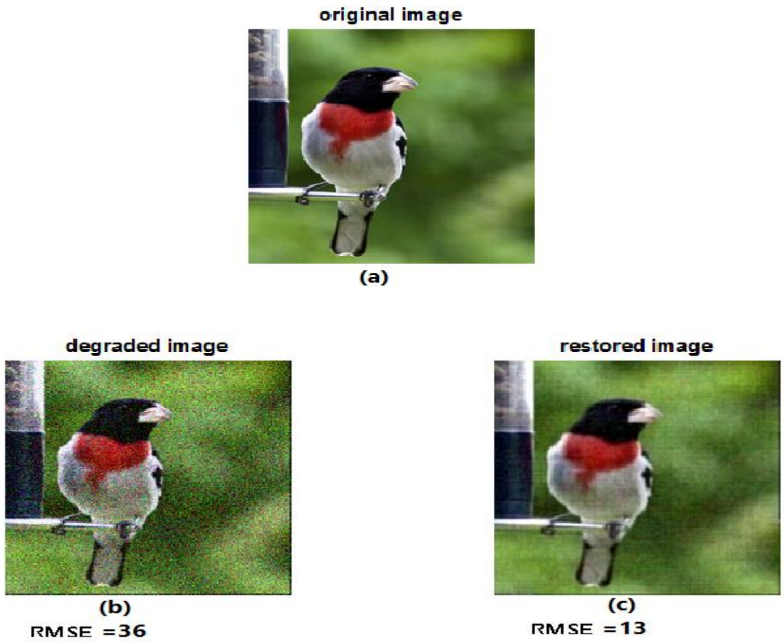


Figure 7-represent **(a)** original image. **(b)** degraded image, blurring with Gaussian function of σ = 2 and distorted with Gaussian noise of SNR = 10. **(c)** restored image using Wiener filter.

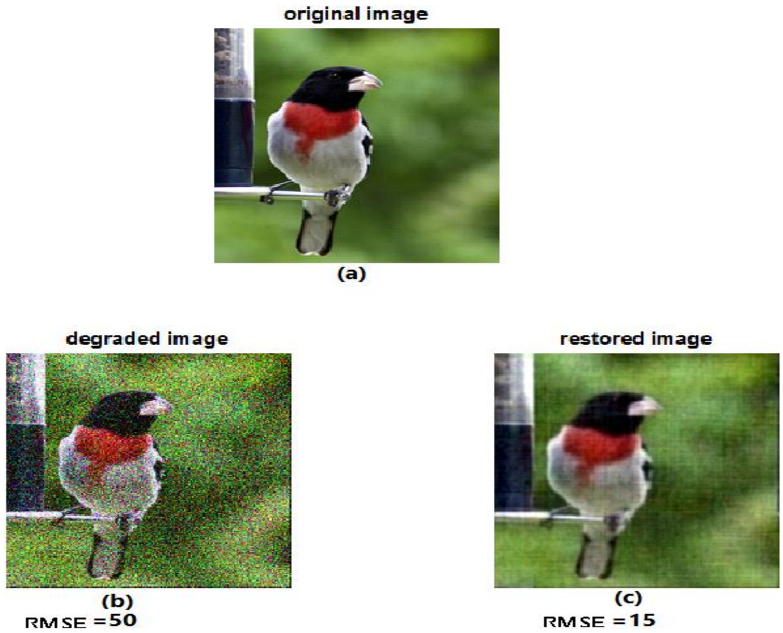


Figure 8- represent **(a)** original image. **(b)** degraded image, blurring with Gaussian function of σ = 2 and distorted with Gaussian noise of SNR = 5. **(c)** restored image using Wiener filter.

2. Iterative Tikhonov-Miller filter

Iterative Tikhonov-Miller filter used to restore the degraded bird image, blurring with Gaussian blurring function with different standards deviation values, and distorted with Gaussian noise with different noise level as will be shown in the following Figures.

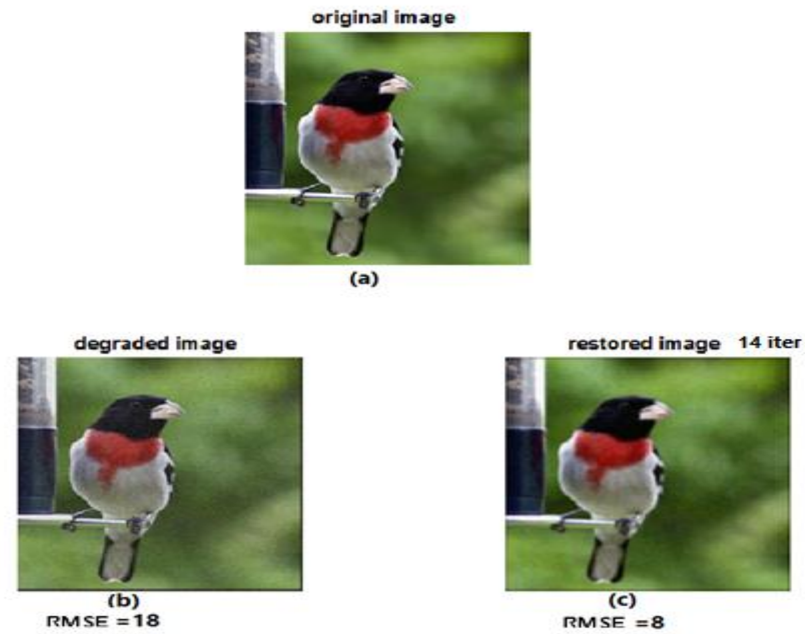


Figure 9- represent **(a)** original image. **(b)** degraded image, blurring with Gaussian function of σ = 1 and distorted with Gaussian noise of SNR = 20. **(c)** restored image using Iterative Tikhonov-Miller filter.

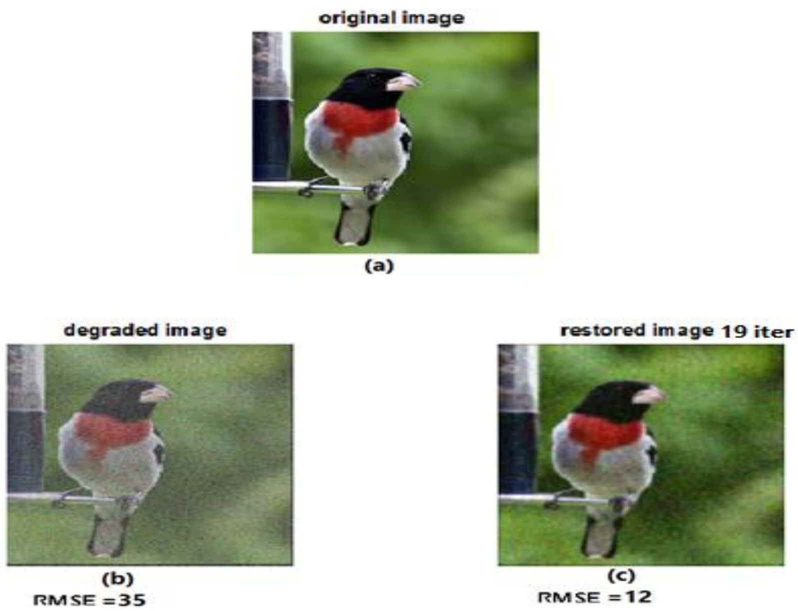


Figure 10- represent **(a)** original image. **(b)** degraded image, blurring with Gaussian function of σ = 1 and distorted with Gaussian noise of SNR = 10. (**c**) restored image using Iterative Tikhonov-Miller filter.

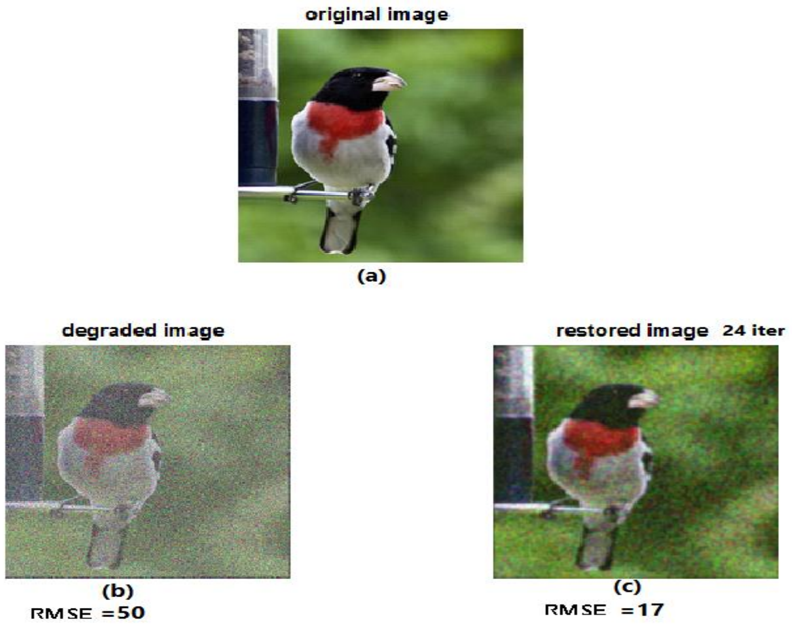


Figure 11- represent **(a**) original image. **(b)** degraded image, blurring with Gaussian function of σ = 1 and distorted with Gaussian noise of SNR = 5. **(c)** restored image using Iterative Tikhonov-Miller filter.

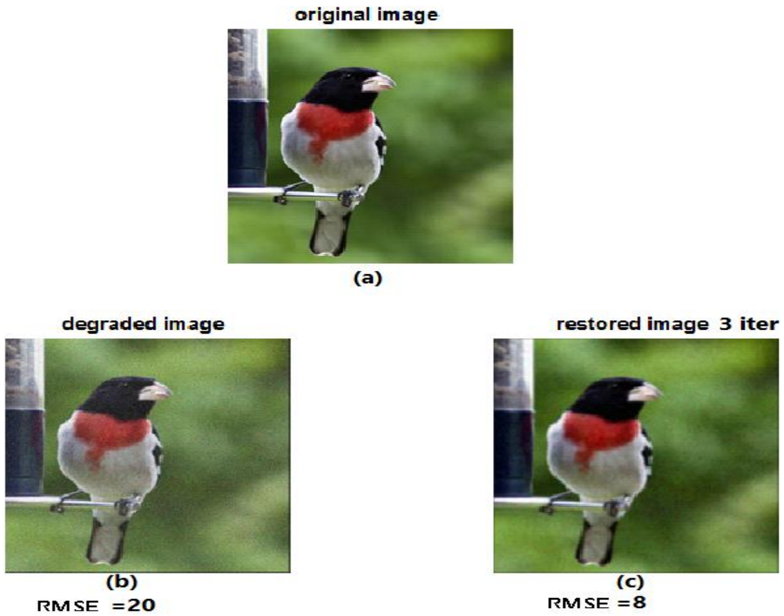


Figure 12- represent **(a)** original image. **(b)** degraded image, blurring with Gaussian function of σ = 2 and distorted with Gaussian noise of SNR = 20. **(c)** restored image using Iterative Tikhonov-Miller filter.

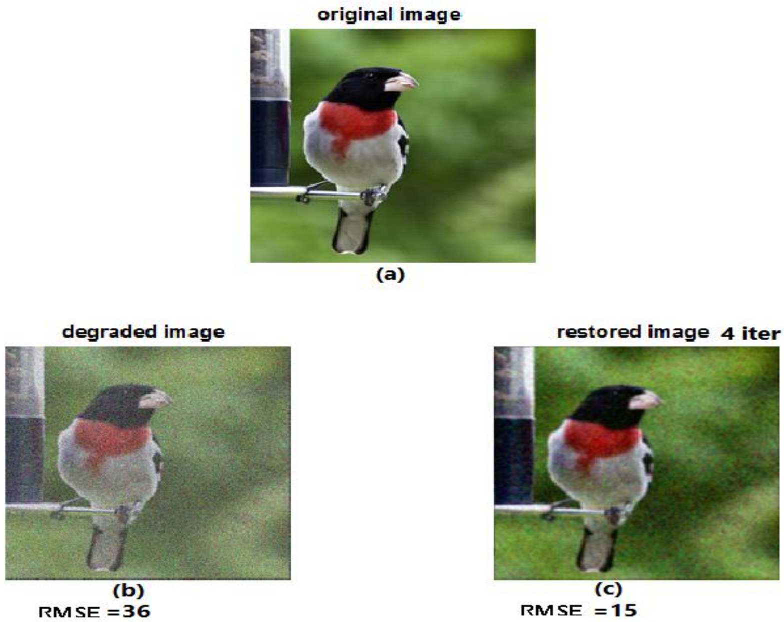


Figure 13- represent **(a)** original image. **(b)** degraded image, blurring with Gaussian function of σ = 2 and distorted with Gaussian noise of SNR = 10. **(c)** restored image using Iterative Tikhonov-Miller filter.

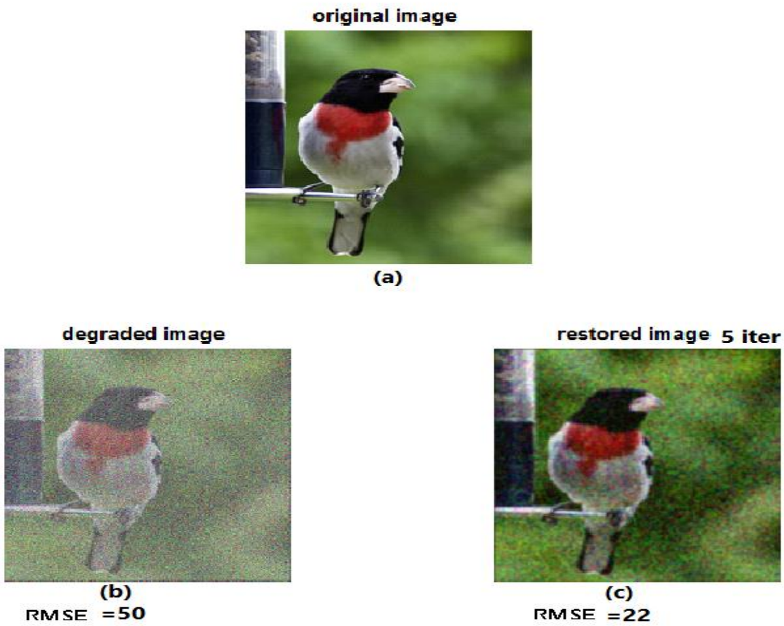
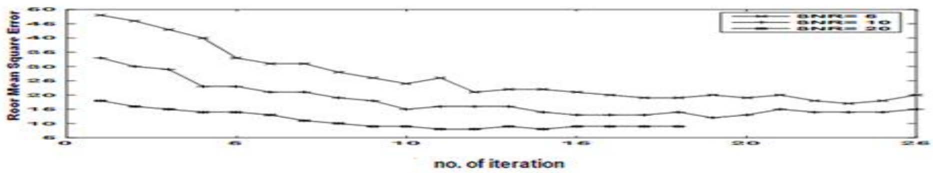
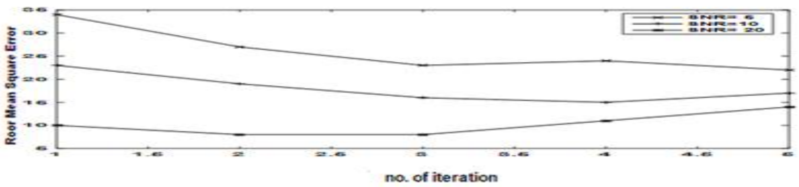


Figure 14- represent **(a)** original image. **(b)** degraded image, blurring with Gaussian function of σ = 2 and distorted with Gaussian noise of SNR = 5. **(c)** restored image using Iterative Tikhonov-Miller filter.



(a)



(b)

Figure 15- show **(a)** RMSE Versus no. of iterations of bird restored image with Iterative Tikhonov-Miller filter, and blur with σ =1 **.(b)** RMSE Versus no. of iterations of bird restored image with Iterative Tikhonov-Miller filter, and blur with σ =2.

Table 1- shows the MSE of restored images with different type of filter.

	σ	SNR=5 / MSE	SNR=10 / MSE	SNR=20 / MSE
Degraded image	1	42	35	18
	2	50	36	20
Wiener filter	1	17	15	17
	2	15	13	10
Restore image Using Tikhonov Filter when α=1	1	17 24 iter	12 19 iter	8 14 iter
	2	22 5 iter	15 4 iter	8 3 iter

Result and discussion:

From the Table -1 can be discusses the behavior of Root mean square error with other parameters Root mean square error of degraded images increase with increase standards deviation values " σ " of Gaussian blurring function and decrease with increasing SNR. And Root mean square error of bird restored image by using Wiener filter decrease with increase standards deviation values " σ " of Gaussian blurring function and decreasing with increase SNR. And Root mean square error of restored images by using Iterative Tikhonov-Miller filter increase with increase standards deviation values " σ " of Gaussian blurring function and decrease with increasing SNR. Figure- 15 show Root mean square error for restored images by using Iterative Tikhonov-Miller filter decrease with increase the number of iteration for different signal to noise ratio to certain number of iteration.

Conclusions

The effectiveness of image restoration techniques studied by using root mean square error, the result show, Wiener filter has better performance for more degradation parameters, with low SNR. Iterative Tikhonov-Miller filter has better performance when increasing the number of iteration till it divergence, the performance will be low, also has better performance for less degradation parameters, with high SNR.

References

1. Gonzalez R.C, Wintz P. **1987**. *Digital Image Processing*, Addison-Wesley, Massachusetts.
2. Aziz Makandar and ELS. **2015**. Computation Pre-Processing Techniques for Image Restoration. *International Journal of Computer Applications*,**113**(4).
3. Ayad A. Alani, **1995.** Restoration of atmospherically degraded images. PhD. Thesis. Baghdad University, College of Science.
4. Er. Priya Tiwari and ELS . **2014**. Analysis of image restoration techniques for developing better restoration method. International Journal for Science and Emerging Technologies with Latest Trends , **19**(1): 9.
5. Reginald L. and ELS. **1991.** *Iterative Identification and Restoration of Images*. Kulwer Academic, Boston. Kulwer Academic, Boston.
6. Fernando Pazos and Amit Bhaya. **2014.** Matrix Forms of Gradient Descent Algorithms Applied to Restoration of Blurred Images. *International Journal of Signal Processing, Image Processing and Pattern Recognition*, **7**(6): 17-28.
7. E. Loli Piccolomini and ELS. **2011.** An Iterative algorithm for large size Least-Squares constrained regularization Problems. *Applied Mathematics and Computation*. **217**(24): 512-515
8. P. Sureka and ELS. **2013.** An Iterative Image Restoration Scheme for Degraded Face Images. *International Journal of Advanced Research in Computer and Communication Engineering*, **2** (3): 1490.
9. Aswathi V M and ELS. **2015** . A Review on Image Restoration in Medical Images. *An international journal of advanced computer technology*, **4** (4): 1588.