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Research Article

EVALUATION IMAGE QUALITY FOR DIGITAL IMAGE OF (CuO) THIN FILMS AFTER DEBLURRING AND DENOISE

Ziad M. Abood., Khdhier A. Mashjeel and Aya Abdul Kareem Jassim

Al-Mustansiriyah University\ College of Education

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ABSTRACT

In this Study, where getting on digital image of (CuO) thin films by using optical microscope and digital camera connected with computer. The objective of this review is to study various filtering technique which is used in image restoring process to reduce the blur, noises and provide the clarity to an image. Where adding different type of noises. Different noises have been considered in this research, and they are: Poisson, Gaussian, salt & pepper, Speckle on the images. De-noising techniques (using MALAB programming) were used to restore the mentioned noises on the images. Different types of filers were used to remove the noises such as Median Filter, Adaptive Wiener Filter and then attempts to undertake the study of restored Motion blurred images by using for types of techniques of deblurring images as Wiener filter, Regularized filter, Lucy-Richardson algorithm, Blind De-convolution algorithm with an information of the point Spread Function (PSF) where they are estimating the causes of the distortion and then apply the restored operations to get the original image. At the final stage, the results of the mentioned filters were compared to get the best and suitable filter for the images of thin films, Image quality parameters (SSIM, FSIM, MSE, SNR RMSE, SNR, and PSNR) were considered as the main parameters for the comparison and showed that there was a clear Enhancement in the lighting and contrast images.

INTRODUCTION

Recently, as a result in the significant progress achieved in various fields has everyone has noticed he high demand for related software and image clarity so became the attention to the principles of image processing and improve the appearance of things necessary to deal with the images before they are used in many areas such as medical, engineering, Biology, Security, Biometrics, Satellite Imagery, Personal Photos. To especially in what is known as Balthss remote (remote sensing) [1]. as used improvements in digital images that are exposed to numerous sensing devices such as scanners or digital cameras and other devices that cause noise or blurring images, so it became necessary for the use of optimization techniques in order to De-blurring of digital or image smoothing for noise removal or reduction of contrast gray level in digital images and the most important improvements images are defined as noise and unwanted information is distributed randomly on the level of the image and distort the image and weaken the clarity and appear in the image due to various sources, including the noise generated by a malfunction in imaging devices used or the result send and receive electronic images from one place to another via satellite or wireless transmission or through networked cable [2,3].

Types of Noise

There are four common types of image noise:

Salt and Pepper Noise

This type contains random occurrences of both black and white intensity values, and often caused by threshold of noise image also called impulse noise, shot noise, or binary noise and can be expressed by [4]:

$$P(x)=\begin{cases} P1, & x = A \\ P2, & x = B \\ 0, & otherwise \end{cases} \qquad \dots (1)$$

where p1, p2 are the Probabilities Density Function.
P(x) is distribution salt and pepper noise in image and A, B are the arrays size image.

Poisson Noise

Shown in the image on the form of patterns periodically and duplicates on a regular basis and the data generated from the original image rather than obtained from external influence is the kind of one kind of noise society of distribution. The reason for the emergence of this kind to the presence of distorted signals with random values its regular distribution histogram has potentially equal distribution for each value of the noise

* Corresponding author: Ziad M. Abood
Al-Mustansiriyah University\ College of Education

input, The noise distribution of regular values of noise confined between the values of a and b values is given as [3]:

$$P(x) = \begin{bmatrix} \frac{1}{b-a} & \text{for } a < g < b \\ 0 & \text{else} \end{bmatrix} \quad \dots (2)$$

Gaussian Noise

Gaussian noise is an idealized from of white noise, which is caused by random fluctuations in the signal. We can observe white noise by watching at television which is slightly mistuned to a particular channel. This type of noise is also called the Impulsive noise or normal noise, Gaussian distribution noise can be expressed by [5, 6]:

$$P(x) = 1/(\sigma\sqrt{2\pi}) * e^{-(x-\mu)^2}/2\sigma^2 \quad \dots (3)$$

where: p(x): Gaussian distribution noise in image.

μ, σ: mean and standard deviation respectively.

Speckle Noise

The source of this noise is attributed to random interference between the coherent returns. This type of noise occurs in almost all coherent imaging systems such as Laser, acoustics and SAR (Synthetic Aperture Radar) imagery. This type of noise is also called the multiplicative noise and is given as [4]:

$$J = I + n*I \quad \dots (4)$$

Where: J is the distribution speckle noise image, I is the input image and n is the uniform noise image by mean0 and variance v.

Noise reductions

Noise reduction is the process of removing noise from a signal; hence, filtering method should take place to remove he unwanted noise. The types of filters that are treated in his study are:

Median Filter

Median Filer is the non linear filter, it is treated in this way each point of the image points select adjacent points of the point number is dependent on the size of the selected candidate and are prepared by the order of the values of specific points in ascending order and then select a value intermediate from her home and compensation instead of the central element in the window and apply this method to the entire image using the principle of Tzhev window is similar to the principle of coiling spors and is designed specifically for the candidate to remove salt and pepper noise [5].

Adaptive Wiener Filter

Adaptive Wiener Filter changes its behavior based on the statistical characteristics of the image inside the filter window. Adaptive filter performance is usually superior to non-adaptive counterparts. But performance is at the cost of added filter complexity. Mean and variance are two important statistical measures using which adaptive filter can be designed [7].

Blurring

Blur is an artifact that occurs in images due to irregularities in image acquisition, the blur effects are filers that smooth transitions and decrease contrast by averaging the pixels next to hard edges of defined lines and areas where there are significant color transition. Blurring arises from certain conditions in the image taking process possible causes of blur are [8]:

- Camera or object motion.
- Optical distortion (on-focus, lens errors).
- Atmospheric perturbations.
- Other reasons (diffraction and aberration).

Blurring Types

In digital image there are three common types of Blur effects:

Camera Out of focus Blur

When a camera takes a 3-D Scene on to a 2-D imaging plane, some parts of the scene are in focus while other parts are not. If the aperture of the camera is circular, the image of any point source is a small disk, known as the Circle of Confusion (COC). The degree of defocus depends on the focal length and the aperture value of the lens, and the distance between the camera and object. An accurate model not only describes the diameter of the COC. However, if the degree of defocusing is large relative to the wavelengths considered, a geometrical approach can be followed resulting in a uniform intensity distribution within the COC. The spatially continuous out-of-focus blur of radius R with PSF coordinates x and y is given by [8]:

$$h_{(x,y,R)} = \begin{Bmatrix} \frac{1}{cR^2} & \text{if } \sqrt{x^2+y^2} \le R^2 \\ 0 & \text{elsewhere} \end{Bmatrix} \quad \dots (5)$$

where c: constant.

Gaussian Blur

The Gaussian Blur effect is a filter that blends a specific number of pixels incrementally, following a bell-shaped curve. The blurring is dense in the center and feathers at the edge. The Gaussian filter in two dimensions over PSF rows and columns, x and y, is given as [8]:

$$h = \frac{1}{\sqrt{2\pi}\sigma^2} e^{-(\frac{x^2+y^2}{2\sigma^2})} \quad \dots (6)$$

where σ: the standard deviation.

Motion Blur

The Motion Blur effect is filter that makes the image appear to be moving camera or object in a horizontal or vertical direction or angle of a subject during image capture this and be in the form of movement or oration or a sudden change in the included camera or all together, The motion can be controlled by the angle in radians with the horizontal axis during the exposure interval (0 to 360)degrees or direction (-90 to +90) and by distance or intensity in pixels (0 to 999) based on the Software used. in Motion Blur (PSF) can be expressed by [8]:

$$h_{(x,y,d,\emptyset)} = \begin{cases} \frac{1}{d} & \text{if } \sqrt{x^2+y^2} \le \frac{d}{2} \text{ and } \frac{x}{y} = -\tan\emptyset \\ 0 & \text{elsewhere} \end{cases} \quad \ldots (7)$$

Where d: distant between the camera and object. □: angle camera.

Deblurring Methods

Wiener Filter

Wiener filter is a method of restoring image in the presence of blur and noise. Wiener de-convolution can be used effectively when the frequency characteristics of the image and additive noise are known, to at least some degree. In the absence of noise, the Wiener filer reduces to the ideal inverse filer. The frequency-domain expression for the Wiener filter is [8]:

$$W_{(u,v)} = \frac{H^*_{(u,v)}}{|H_{(u,v)}|^2 + Q} \quad \ldots (8)$$

Where $H_{(u,v)}$ is degradation function.

$H^*_{(u,v)}$ is Complex conjugate of $H_{(u,v)}$.
Q is Numerical values were positive.
D is Image in the Spatial Domain

$$R_{(u,v)} = \frac{1}{MN}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1}(I_b W)e^{-2i\pi\left(\frac{ux}{M}+\frac{vy}{N}\right)} \quad \ldots (9)$$

Constrained Least Square Filtering (Regularized)

Regulated filter is the deblurring to deblurred an image by using he de-converge function to deblur an image using regularized filer which is effectively when limited information is known about the additive noise. The solution of restoration is constrained by the parameters of the problem is given as [8]:

$$R_{(u,v)} = \left[\frac{H^*_{(u,v)}}{|H_{(u,v)}|^2 + \gamma |L_{(u,v)}|^2}\right] I_{b\,(u,v)} \quad \ldots (10)$$

Where parameter γ is adjusted to satisfy the constraint
$R_{(u,v)}$ is image in the frequency domain.
Q is the Fourier transform of the Laplacian operator wich is typically chosen as:

$$q_{(u,v)} = \begin{bmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{bmatrix} \quad \ldots (11)$$

Lucy-Richardson Algorithm

The Richardson-Lucy algorithm is one of the most popular deblurring algorithms in the image processing due to many reason such as it does not concertn the type of noise affecting the image. In addition, it does not require any information from the original clean image and it is a non-linear iterative algorithm technique that maximizes the likelihood that the resulting image. This type is an iterative procedure for recovering image that has been the blurred by a known PSF [8].

$$I_{k+1(u,v)} = I_{k(u,v)} \times \left[H^*_{(-u,-v)} \times \frac{H_{(u,v)}}{H_{(u,v)} \times \hat{F}k_{(u,v)}}\right] \quad \ldots (12)$$

Where: $I_{k+1(u,v)}$ is The new estimate for image(I_k).
K is The number of steps in the redundancy.
$H^*_{(-u,-v)}$ is Complex conjugate of $H_{(u,v)}$.

The same Lucy-Richardson algorithm will be utilized, but the only difference is that instead of using H^* in the original equation, I will be replaced with the to reduce the number of operations needed .The equation of the optimized Lucy-Richardson Algorithm can be described in the subsequent equation:

$$I^{k+1} = I^n H\left(\frac{I}{HI^k}\right) \quad \ldots (13)$$

As it becomes the value in the first iteration $(I^k) = 1$

Blind De-convolution Algorithm

Definition of the blind deblurring method can be expressed by [9]:

g(x,y) = PSF*f(x,y)+η(x,y) … (14)

Where: g(x,y) is the observed image, PSF is point Spread Function, f(x,y) is constructed image and $\eta(x,y)$ is the additive noise term.

Debluring Model

A blurred or degraded image can be approximately described by this equation [2]:

g(x,y) = H* f(x,y) + n(x,y) … (15)

Where: g(x,y) is The blurred image. H: distortion operator, also called the point spread function (PSF), f(x,y): original rue image. N: Additive noise.

Experiments Verifications

JPG format of (CuO) thin films images were used for his study.at the first stage different types of noises (Poisson, Gaussian, Sal &Pepper and Speckle) was added and to test this methods to restoration noise on the image two types of de-noising methods are implemented Median filtering when add salt&pepper noise, Adaptive Wiener filtering When add Gaussian noise. At the second stage some filters (Wiener Filter Deblurring, Regularized Filter, Lucy-Richarson Algorithm and blind Algorithm) were for deblurring image deformed by Motion Blur, Four types of deblurring methods applying with PSF is Known in the two cases: (i) when no add noise to the image (ii) with add noise to the image. In order to restore the noisy and blurring image, de-noising and deblurring techniques were used with MATLAB program. At the final stage, the result of using all filters with different types of noises and blurring on the images was compared by using image quality parameters such as: SSIM, FSIM, MSE, RMSE, SNR and PSNR for all images in order to know the best filter for removing the noise and blurring in image.

This study explains the design of the program using for removing the noise and how it is run as an important function. The related aspect of the program was applied on the (CuO) thin Films images of that have the different formats ('jpg'). Fig. (1) shown the study algorithm.

$$G = \sqrt{G_x^2 + G_y^2} \quad \dots (19)$$

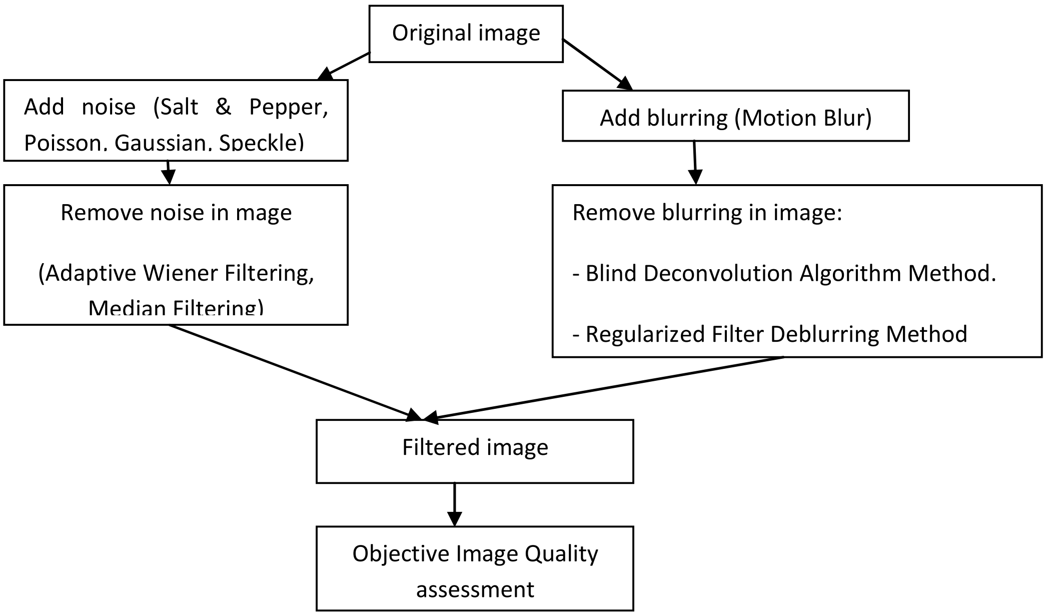


Figure 1 the study algorithm

Simulation Results

The image quality assessment is an important process to determining the degree level of the enhancement or the level of the noise. In this study we present many objective methods to assess the quality of the image such as:

The Structural Similarity Index (SSIM)

The structural similarity index is a method for measuring the similarity between two images, this measure compare two images using information about luminous, contrast and structure can be written as [10]:

$$SSIM(x,y) = l(x,y).c(x,y).s(x,y) \quad \dots (16)$$

Feature Similarity Index (FSIM)

The computation of FSIM index Consists of two sages in the first stage, the Phase congruency (PC) and gradient magnitude (GM) features will be extracted. The PC is defined as [11]:

$$PC(x) = \frac{E(x)}{\sum_n A_n} \quad \dots (17)$$

Where: A_n is the local amplitude at scale n
E is local energy

$$E(x) = \sqrt{F^2(x) + H^2(x)} \quad \dots (18)$$

Gradient operators can be expressed by convolution masks, The GM of the image is defined as:

Where: G_y, G_x is the partial derivatives along horizontal and vertical directions using one of the three gradient operators.

And then to separate the feature similarity measurement between original image and the distorted image in to two components, each for PC and GM. the similarity measure for PC values and GM values are defined as:

$$\text{PC Similarity Image} = \frac{2PC_1 PC_2 + T1}{PC_1^2 + PC_2^2 + T1} \quad \dots (20)$$

Where PC_{max} = Max (PC_1,PC_2) … (21)

Gradient Similarity Image =

$$\frac{2\text{gradient Map}_1 * \text{gradient Map}_2 + T2}{\text{gradient Map}_1^2 + \text{gradient Map}_2^2 + T2} \quad \dots (22)$$

The second stage is to compute the FSIM index images is given as:

Similarity Image = PC Similarity Image*PC_{max}*gradient Similarity Image

FSIM is define as follow:

$$FSIM = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}(\text{Similarity Image})}{\sum_{i=1}^{M}\sum_{j=1}^{N}(PC_m)} \quad \dots (23)$$

Mean Squared Error (MSE)

The most widely used fidelity measure and simplest is he mean squared error (MSE) and the corresponding distortion metric, is given by [10]:

MSE = $\frac{1}{MN}\sum_{i=1}^{N}\sum_{j=1}^{M}[x(i,j)-y(i,j)]^2$ … (24)

Where: x(i,j) and y(I,j) represent the original and reconstruction image respectively.

Root Mean Square Error (RMSE)

The RMSE is used as a measure for quality reconstruction image frame. Low value of the image RMSE indicates the high quality and used to identify whether a particular algorithm produces better results RMS is computed using the following equation [12]:

RMSE = $\sqrt{\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}(x(i,j)-y(i,j))^2}$ … (25)

Where: x(I,j) represents a pixel whose coordinates are (x,y) in the original image y(I,j) represents a pixel whose coordinates are (x,y) in the restored image MN is the total number of pixels in an image**.**

Signal-to-Noise Ratio SNR

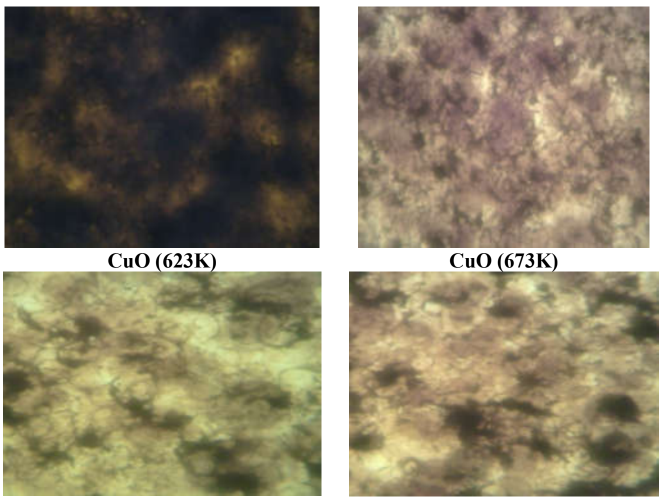
The Signal to noise ratio is inversely propertional to the MSE and is given by the next equation [13]:

SNR = $10*\log_{10}\frac{\sum_{i=1}^{M}\sum_{j=1}^{N}[x(i,j)]^2}{\sum_{i=1}^{M}\sum_{j=1}^{N}[x(i,j)-y(i,j)]^2}$ … **(**26)

Peak Signal to Noise Ratio (PSNR)

One of the simplest and important metric is the (PSNR). It is defined in logarithmic scale, in decibel (dB). It is a ratio of peak signal power to noise power. Since the MSE represents the noise power and the peak signal power, the PSNR is defined as [14]:

PSNR = $10*\log\left(\frac{(L-1)^2}{MSE}\right)$ … (27)

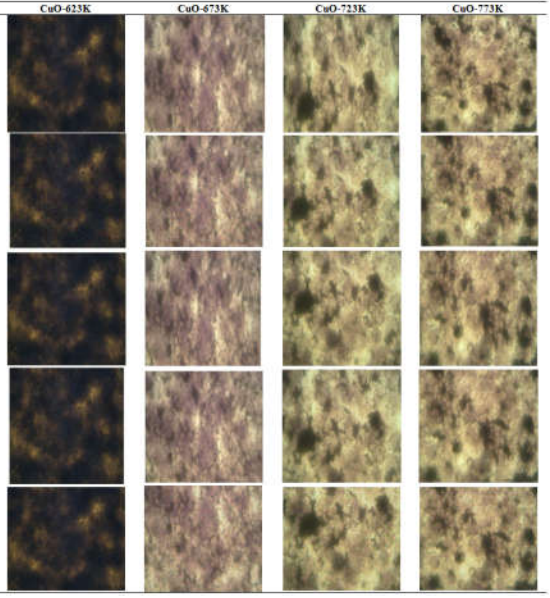


CuO (623K) **CuO (673K)**

CuO (723K) **CuO(773K)**

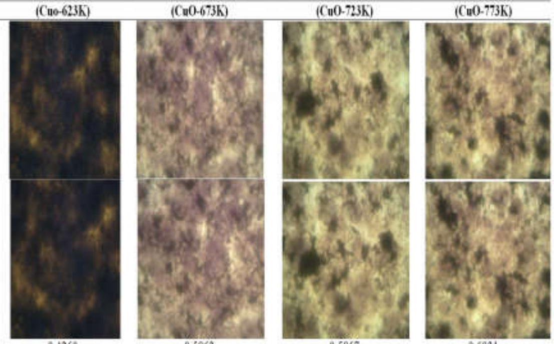
Figure 2 Digital Image of thin films images

Table 1 The result of add Poisson, Gaussian, Salt & pepper and Speckle noises applied on the thin film images



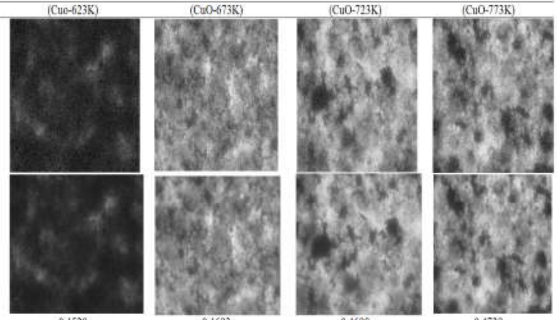
Sample	CuO-623K	CuO-673K	CuO-723K	CuO-773K
Original Image				
Gaussian				
Poisson				
Salt & pepper				
Speckle				

Table 2 The result of image quality parameters by Median filter with salt&pepper applied on the thin films image



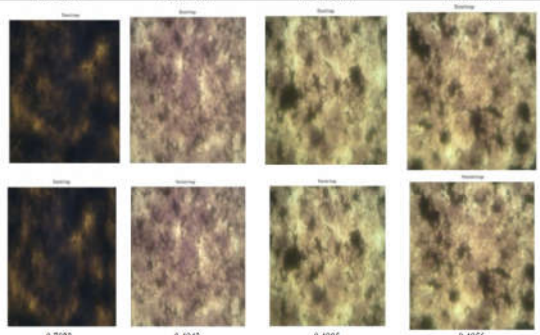
Sample	(Cuo-623K)	(CuO-673K)	(CuO-723K)	(CuO-773K)
Original Image				
Restored Image				
SSIM	0.4260	0.5863	0.5867	0.6031
FSIM	0.8979	0.9493	0.9467	0.9481
MSE	155.9261	107.7293	114.8634	114.5654
RMSE	12.4870	10.3793	10.7174	10.7035
SNR	45.9002	45.9002	45.9002	45.9002
PSNR	26.2016	27.8075	27.5290	27.5403

Table 3 The result of image quality parameters by Adaptive filter with salt & pepper noise applied on the thin films image



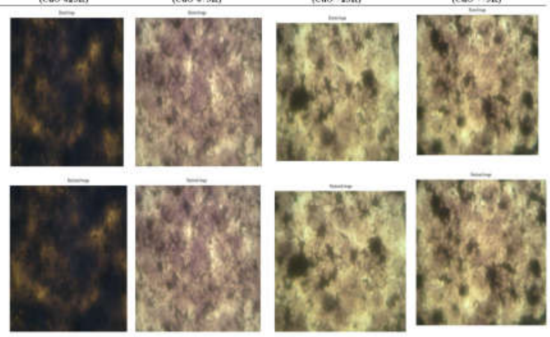
Sample	(Cuo-623K)	(CuO-673K)	(CuO-723K)	(CuO-773K)
Original Image				
Resorted Image				
SSIM	0.4528	0.4693	0.4698	0.4739
FSIM	0.7895	0.8027	0.8040	0.8116
MSE	725.7878	958.2378	937.0604	944.1251
RMSE	26.9404	30.9554	30.6114	30.7266
SNR	45.9002	45.9002	45.9002	45.9002
PSNR	19.5227	18.3161	18.4131	18.3805

Table 4 The result of image quality parameters by Wiener filter with Motion Blur applied on the thin films image



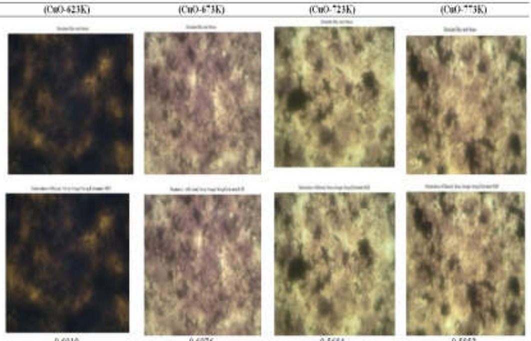
Sample	(Cuo-623K)	(CuO-673K)	(CuO-723K)	(CuO-773K)
Original Image				
Restored Image				
SSIM	0.7823	0.4943	0.4905	0.4956
FSIM	0.9929	0.9874	0.9876	0.9870
MSE	61.4974	64.1705	65.1010	66.0481
RMSE	7.8420	8.0106	8.0685	8.1270
SNR	45.9002	45.9002	45.9002	45.9002
PSNR	30.2422	30.0574	29.9949	29.9322

Table 5 The result of image quality parameters by Blind Deconvolution with Motion Blur applied on the thin films image



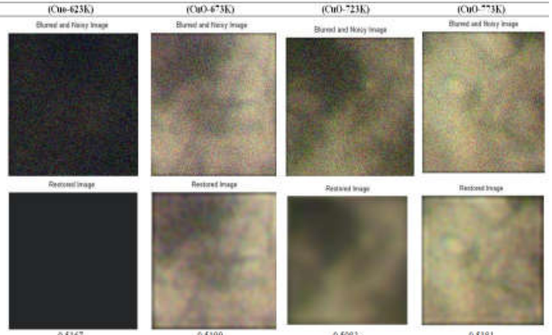
Sample	(CuO-623K)	(CuO-673K)	(CuO-723K)	(CuO-773K)
Original Image				
Restored Image				
SSIM	0.6047	0.8532	0.8562	0.8514
FSIM	0.9907	0.9898	0.9898	0.9881
MSE	66.1448	68.1237	69.1397	71.7940
RMSE	8.1329	8.2537	8.3150	8.4731
SNR	45.9002	45.9002	45.9002	45.9002
PSNR	29.9258	29.7978	29.7335	29.5699

Table 6 The result of image quality parameters by Wiener filter with noise and Blur applied on the thin films image



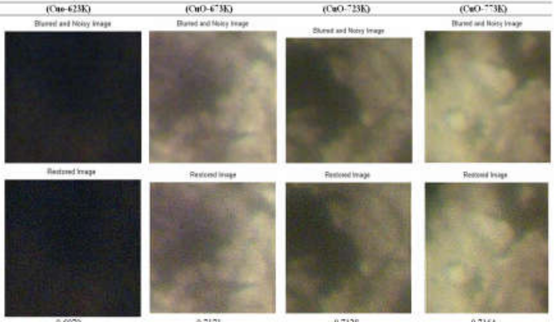
Sample	(CuO-623K)	(CuO-673K)	(CuO-723K)	(CuO-773K)
Original Image				
Restored Image				
SSIM	0.6919	0.6976	0.5684	0.5852
FSIM	0.9838	0.9645	0.9464	0.9474
MSE	158.2141	176.2925	211.4888	215.0846
RMSE	12.5783	13.2775	14.5427	14.6658
SNR	45.9002	45.9002	45.9002	45.9002
PSNR	26.1384	25.6685	24.8779	24.8047

Table 7 The result of image quality parameters by Regularized filter with noise and Blur applied on the thin films image



Sample	(Cuo-623K)	(CuO-673K)	(CuO-723K)	(CuO-773K)
Original Image				
Restored Image				
SSIM	0.5167	0.5199	0.5083	0.5181
FSIM	0.5456	0.6247	0.5863	0.6186
MSE	410.5133	489.6852	499.1490	491.6119
RMSE	20.2611	22.1288	22.3416	22.1723
SNR	45.9002	45.9002	45.9002	45.9002
PSNR	21.9975	21.2316	21.1485	21.2146

Table 8 The result of image quality parameters by Lucy-Richardson filter with Noise and Blur applied on the thin films image



Sample	(Cuo-623K)	(CuO-673K)	(CuO-723K)	(CuO-773K)
Original Image				
Resorted Image				
SSIM	0.6970	0.7171	0.7128	0.7164
FSIM	0.9266	0.9019	0.9146	0.9052
MSE	217.1908	221.3681	219.5057	222.8770
RMSE	14.7374	14.8784	14.8157	14.9291
SNR	45.9002	45.9002	45.9002	45.9002
PSNR	24.7624	24.6797	24.7163	24.6502

CONCLUSION

In this paper, shows the ability of restoring an image that is affected with different types of unwanted noises by using various types of filters. The comparative studies are explained experiments are carried out for different techniques Wiener filter, regularized filter is the best techniques to deblurring of image sensing when don't noise in image. But when noise is presented with blur the Lucy-Richardson algorithmic technique is the best techniques.

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