Journal Of Harmonized Research (JOHR)

Journal Of Harmonized Research in Applied Sciences
7(2), 2019, 56-64

ISSN 2321 – 7456

Original Research Article

IMAGE RESTORATION AND DEBLURRING USING LUCY RICHARDSON TECHNIQUE WITH WEINER AND REGULARIZED FILTER

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Abstract: Nowadays we are using high quality of digital camera for capturing the image but due to some artifacts the quality of images degrades such as noise so to restore its original quality different interpolation techniques has implemented in digital image processing such as blind and non-blind restoration methods of image. In this work, we mainly emphasis on the Lucy Richardson algorithm and blind deconvolution using Weiner and regularized filter to restore the original image. The Lucy-Richardson algorithm engenders reconstructed images of improved quality in the existence of high noise level. Weiner deconvolution can be useful for the point spread function (PSF) when the noise level is known or estimated while regularized deconvolution is much more effective once constraints are applied on the recuperated image (for example: smoothness). The distorted and piercing image is restored by a constant least square (CLS) algorithm that uses regularized filter. The analysis of the projected approach is done using PSNR and MSE measuring parameters and after analysis it is found that the approach better in both the view visual quality and computation time view than other interpolation techniques. By using the combined method of image restoration and interpolation we obtained the better spatial resolution than others.

Key Words: Blind Deconvolution, Image Restoration, Lucy Richardson, Weiner filter, Regularized Filter, Noise, PSNR and MSE.

Introduction*:* Images are delivered to record the helpful data. Because of flaws in the imaging and capturing procedure, be that as it may, the recorded Image perpetually represents to a debased variant of the first scene. The degraded results in Image unclear, influencing identification and extraction of the valuable data in the images. It very well may be brought about by relative movement between the camera and the original scene, by an out of focal point of optical framework, climatic turbulences and abnormalities in the optical framework [1][2]. Noise presented by the medium through which

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Received on: March 2019
Accepted after revision: April 2019
DOI: 10.30876/JOHR.7.2.2019.56-64

the Image is made can likewise cause degradation. The debasement phenomenon of the procured Images causes genuine monetary loss. Consequently, reestablishing the corrupted Images is a dire undertaking so as to extend uses of the Images. When all is said in done there are two kinds of restoration strategies are utilized. One is non-dazzle reclamation in which we need earlier information of h(x,y). For this situation three separating methods are commonly utilized [2]: Constraint least square filtering, Wiener filtering and Lucy Richardson algorithm which are talked about in section 2. Other one is Blind Restoration in which we needn't bother with any earlier learning of h(x,y) [2]. The Image restoration is appeared in figure 1. It comprise of taking a non-blurred Image f(x,y), making a known blurring function or point spread function h(x,y) and afterward sifting the Image with this capacity in order to include obscure into it. This Image is additionally debased added substance Gaussian noise to get the corrupted Image g(x, y). This blurred Image is gone through a restoration filter R(x,y) to get the reestablished Image f̂(x,y).

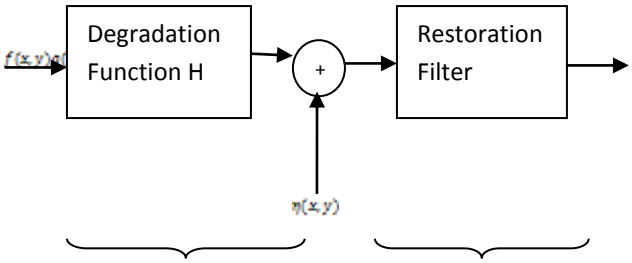


Fig. 1: Process of Image Restoration

In this paper we are focusing on non-blind restoration methods. We have reinstated the degraded image by using projected modified Lucy Richardson Algorithm with Weiner and regularized filter. Meanwhile DWT has exceptional spatial localization and multi-resolution characteristics, which are analogous to the speculative models of the human visual system; it is extensively used in image processing [3]. In this work, we mainly presented diffusion of two filtered image and restoration of original image and the effect of restoration methods compares by two performance parameters. Additionally, the performance of the projected algorithm is compared with wiener filter and regularized filter. The remaining section of the paper is organized in this manner. Section 2 consists of the imperative deblurring algorithms and their brief features. In Section 3 we have discussed the proposed modified LR Algorithm and Blind Convolution using Weiner and regularized filter. Section 4 consists of simulation set up and the results. Conclusions are drawn in Section 5.

Restoration Techniques: In digital image processing, lots of work has been done in image restoration and deblurring. The restoration can be done using spatial domain filter as well as restoration techniques. In spatial domain techniques, the technique functions openly on the pixels of the image. This technique is used for removing additive noise merely. Sometimes blur helps to increase photo's expressiveness but it decreases the quality of image unintentionally. In image restoration (IR), the enhancement in the quality of the reinstated image over the recorded blurred one is measured by the signal-to-noise ratio (SNR)enhancement. Image restoration techniques are used to create the corrupted image as analogous as that of the original image. Figure 2displaysthe classification of restoration techniques. Principally, restoration techniques are classified into blind and non-blind restoration techniques. Non-blind restoration techniques are further alienated into linear restoration methods and non-linear restoration method.

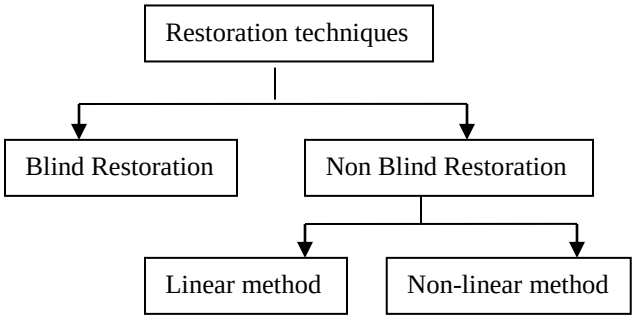


Fig.2: Classification of Image restoration techniques

Non-blind restoration techniques: A non-blind procedure relies upon the estimation of PSF which ought to be convent known. In light of PSF estimation it reestablishes the information image. As referenced above other two kinds of non-blind systems are direct rebuilding techniques, for example, Weiner filter, Inverse filter, and Constrained Least square filter. Lucy-Richardson algorithm is a Non-linear kind of rebuilding strategy.

Weiner Filter: Wiener filter incorporates both the degradation function and factual qualities of commotion into the rebuilding procedure. The fundamental target of the technique is to discover an expected estimation of the uncorrupted image esteem with the end goal that the mean square an incentive between them is limited. The disadvantage of opposite and pseudo reverse separating is that they are commotion touchy. Be that as it may, wiener separating isn't clamor touchy .so this is the benefit of the wiener sifting. Its reaction is better in nearness of clamor. [4]

Constraint Least-Square Filter: Regularized sifting is utilized in a superior manner when limitations like smoothness are connected on the recuperated image and less data is thought about the added substance clamor. The obscured and loud image is recovered by an obliged least square reclamation algorithm that utilizes a regularized filter. Regularized rebuilding gives practically comparative outcomes as the wiener sifting yet perspective of both the separating methods are extraordinary. In regularized separating less past data is required to apply reclamation. The regularization filter is as often as possible picked to be a discrete Laplacian. This filter can be comprehended as a guess of a Weiner filter.

The second name of filter called Regularized filter is a vector-grid type of straight corruption show. Condition is [5]:

$$g=H*f+n$$

Where f is M*N vector whose first N components are first-push pixels of the image, next N components are second-push pixels up to MN*MN. Presently the issue is straightforward net function augmentation so now need to locate the second deviation of corrupted image [6].

Lucy- Richardson Algorithm Techniques: The image restoration is separated into visually impaired and non-blind de convolution. In non-blind PSF is known. The Richardson– Lucy is the most prevalent strategy in the field of cosmology and restorative imaging .The reason of notoriety is its capacity to create reproduced pictures of good quality within the sight of high clamor level. Lucy and Richardson discovered this in the mid 1970's from byes hypothesis. Lucy Richardson is nonlinear iterative strategy. This technique is increasing more acknowledgment than direct strategies as better outcomes are acquired here. The backwards Fourier change of Optical Transfer Function (OTF) in the recurrence space is where OTF gives straight, position-invariant framework the reaction to a drive. The Fourier exchange of the point (PSF) is OTF[7].

Blind deconvolution techniques: In image processing, dazzle deconvolution is a deconvolution strategy that grants recuperation of the objective scene from a solitary or set of "obscured" images within the sight of an ineffectively decided or obscure point spread capacity (PSF). [8] Regular straight and non-direct deconvolution methods use a known PSF. For visually impaired deconvolution, the PSF is evaluated from the image or image set, enabling the deconvolution to be performed. Scientists have been concentrating blind deconvolution techniques for quite a few years, and have moved toward the issue from various bearings.

Adaptive Mean Filter: This filter is the third kind of spatial area filters. In Adaptive middle filters, the extent of the filter can be change. Different filters talked about above must be utilized for the images where the thickness of the clamor is less. Be that as it may, this filter is utilized particularly to expel high-thickness clamor from adulterated images.

Alpha- trimmed mean Filter: Alpha-cut mean filter is windowed filter of nonlinear class; its tendency is half and half of the mean and middle filters. The essential thought behind filter is for any

component of the flag (image) takes a gander at its neighborhood, dispose of the most atypical components and ascertain mean esteem utilizing the remainder of them. Alpha you can find for the sake of the filter is to be sure parameter in charge of the quantity of cut components.

Alpha-cut mean filter calculation:

a) Place a window over component.

b) Pick up components.

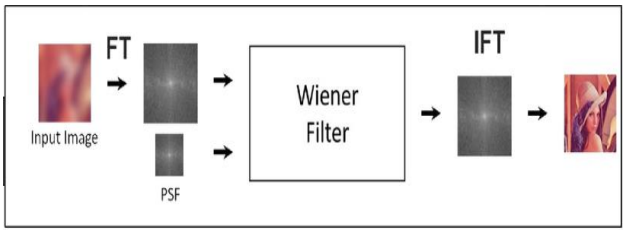
c) Order components.

d) Discard components toward the start and toward the finish of the got arranged set.

e) Take a normal — entirety up the rest of the components and gap the total by their number.

Proposed Methodology: In digital image processing there is frequently a need to introduce an image. Precedents happen in scale amplification, image registration, geometric redress, and so forth. Then again, this image can be exposed to a few wellsprings of goals corruption and an improvement of this goal might be important. Consequently, this proposition tends to the issue of consolidating the introduction and the rebuilding in a solitary activity, along these lines lessening the computational exertion. The perfect low pass high pass channel for introduction is the rebuilding procedure. The wiener reverse, Lucy with wiener, Lucy with regularized Filter is utilized for this reason. The proposed strategy is connected to the addition rebuilding method.

Image processing an interpolation Lucy with wiener filter: Image rebuilding is to appraisal a unique image from the debased image by obscuring and noise. The corrupting procedure is detailed as a convolution of a Point Spread Function (PSF) in view of a unique image. The debasement results in image obscure, influencing recognizable proof and extraction of the valuable data in the images. In this proposal we thought about, the investigation result exhibited advantage for Wiener filter in higher clamor case and preferred standpoint for Lucy wiener filter image low dimension noise. The field of advanced image processing bargains not just with the extraction of highlights, investigation of images



and rebuilding of images yet additionally with the procedure of improvement, separating and reclamation of images. Image reclamation is Lucy with wiener filter ventures of processing that manages making certain upgrades in a computerized image dependent on some predefined criteria. The prime target of rebuilding is to assemble or remake an image that has been debased dependent on some earlier information in regards to the wonders of corruption of images .The procedure of reclamation is objective in nature that is; it goes for a particular objective like evacuation of haze in an image by methods for a deblurring capacity .The systems that are utilized in the rebuilding of images can be figured in spatial space or in frequency area. Image rebuilding depends on probabilistic models of image debasement. In this way image reclamation will in general make the images look better in appearance.

Image processing an interpolation Lucy with Regularized Filter: This solution depends on the division of the image to be introduced into covering squares and the interjection of each square, independently. The motivation behind the covering squares is to dodge edge impacts. A worldwide regularization parameter is utilized in adding each square. In this arrangement, a solitary network reversal procedure of moderate measurements is required in the entire addition process. In this way, it keeps away from the vast computational expense because of the networks of substantial measurements associated with the addition procedure. The execution of this methodology is contrasted with the standard iterative regularized interjection we have presumed that the image insertion issue for CCD caught images is a converse issue. A converse issue is described when there is no assurance for the presence, uniqueness and soundness of the arrangement dependent on direct reversal. The

arrangement of the reverse issue isn't destined to be steady if a little irritation of the information can create a huge impact in the arrangement. Image addition has a place with a general class of issues that were thoroughly named issues. Regularization hypothesis, which was essentially presented by Tikhonov and Miller, gives a formal premise to the advancement of regularized answers for badly presented issues. The balancing out capacity approach is one of the fundamental strategies for the improvement of regularized arrangements. As indicated by this methodology, a not well acted issue can be figured like the compelled minimization of a specific capacity, considered settling capacity The particular limitations forced by the balancing out capacity approach on the arrangement rely upon the structure and the properties of the balancing out capacity utilized. From the idea of the issue, these requirements are essentially identified with the from the earlier data in regards to the normal regularized arrangement. Another regularization-based image addition calculation item and particular esteem decay has been proposed. The proposed methodology lessens the computational expense of insertion while offering noteworthy execution improvement over other ordinary techniques. In this proposal likewise examines the impact of regularization on the addition results and demonstrates that the methodology is genuinely powerful towards estimations of regularization parameter. The assignment of image reclamation is frequently performed preceding and separate from combination. This arrangement is imperfect as the data from the combination procedure can frequently contain significant data to improve the reclamation which can thusly give improved combination. Here in this exposition the proposed strategy for image reclamation this is the blend of two diverse rebuilding techniques to get the last reestablished image. Restoration techniques are situated toward displaying the degradation and applying the inverse procedure so as to recoup the first picture. The picture gets obscured because of the noise. Obscure is of numerous kinds however in this theory work considered the movement obscure as it were.

Chiefly the procedures which utilized in this work are:

1. Lucy Richardson melded with Blind Deconvolution
2. Lucy Richardson intertwined with Wiener filter
3. Lucy Richardson intertwined with regularized filter.

Algorithm: The steps involved in this algorithm are as below:

Step 1: Read the two source images, image I and image II to be fused and apply as input for fusion.

Step 2: Execute independent wavelet disintegration of the two images until level L to get estimation (LL^L) and element(LH^l, HL^l, HH^l) coefficients for l=1, 2... L

Step 3: Apply pixel based algorithm for approximations which comprises fusion based on taking the maximum valued pixels from approximations of original images I and II.

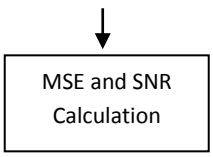
$$LL_f^L = \text{maximum}\,(LL_I^l(i,j), LL_{II}^l(i,j)) \quad (4.1)$$

Here, $LL_f^L Lf$ is the fused and LL_I^L and LL_{II}^L are the input approximations, i and j represent the pixel positions of the sub images. $LH_f^L, LH_I^l, LH_{II}^l$ are vertical high frequencies, $HL_f^L, HL_I^l, HL_{II}^l$ are horizontal high frequencies, $HH_f^L, HH_I^l, HH_{II}^l$ are diagonal high frequencies of the fused and input feature sub and correspondingly.

Step 4: Founded by the extreme valued pixels among the approximations from Eq. (3.16), a binary decision map is formulated. Eq. (3.17) provides the decision rule D_f for fusion of estimation coefficients in the two source images I and II as

$$D_f(i,j)=1, d_I(i,j) > d_{II}(i,j) \quad (4.2)$$

0 otherwise



Step 5: Therefore, the last fused transform conforming to approximations over maximum selection pixel rule is achieved.
Step 6: Concatenation of fused estimations and details provides the novel coefficient matrix.
Step 7: Apply inverse wavelet transform to renovate the resultant fused image and show the outcome.
Description of flow chart: Fig. 3 shows the flow chart of Blind Deconvolution fused with Lucy Richardson, In this two input image are taken on that images we include PSF's later we get the blur image then applied Blind Deconvolution and Lucy Richardson methods on the two isolated images later we Fused that two image using wavelet based image fusion and formerly again applied DWT on that Fused image and then compute SNR and MSE. The same thing is done in other flow chart using other method for restoration and last we compare the result on the basis of calculated SNR and MSE.

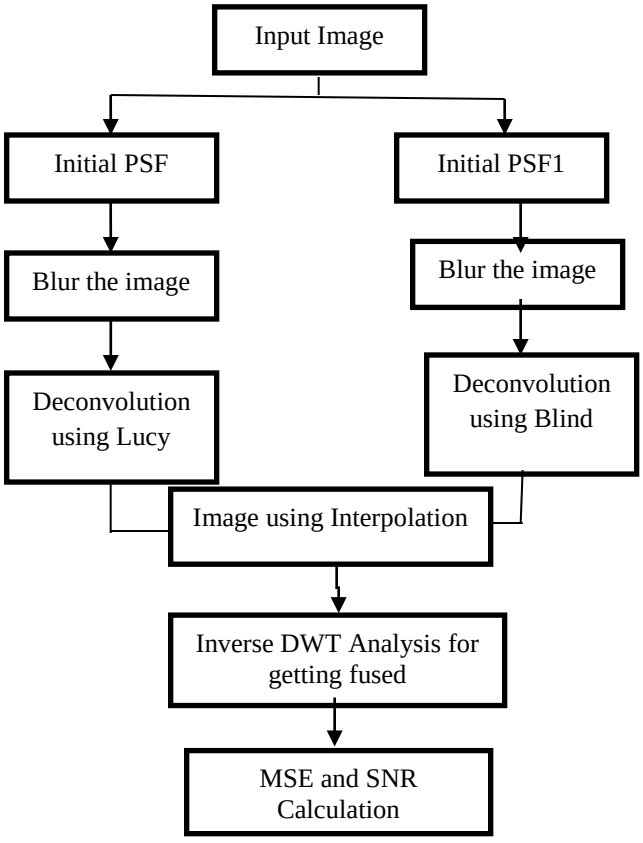


Fig.3: Image restoration using interpolation Lucy Richardson with Blind Deconvolution

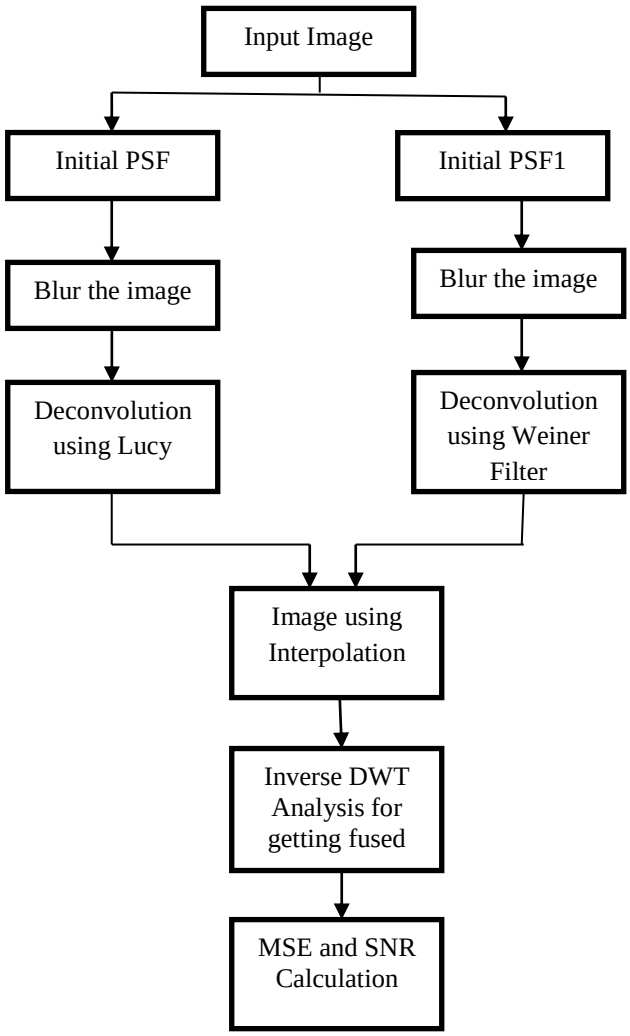
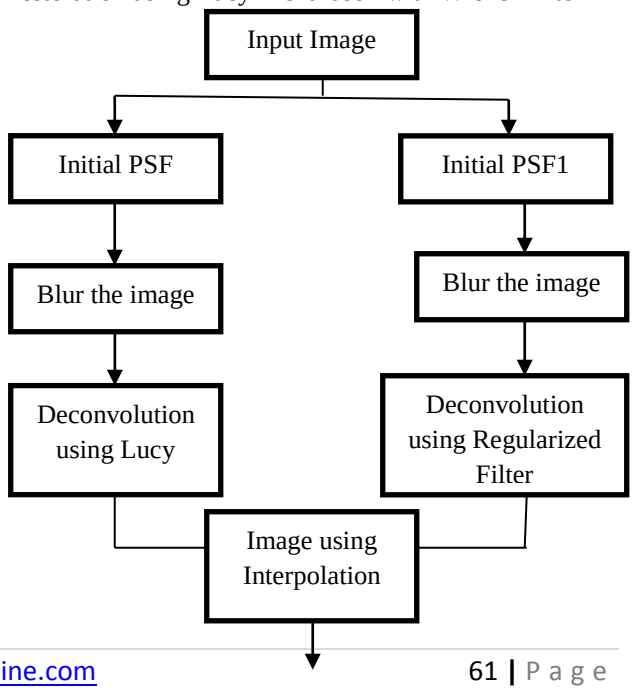


Fig 4: Image restoration interpolation flow chart for image restoration using Lucy Richardson with Wiener Filter



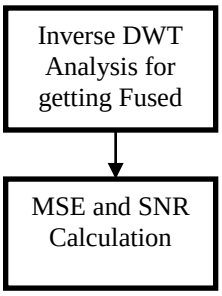


Fig 5: Image restoration interpolation flow chart for image restoration using Lucy Richardson with Regularized filter

Experimental Results and Analysis: The implementation of the proposed methodology is done in MatLab2012A, Intel I3 800X4 core processor with 4GB primary memory and NVIDIA graphics adapter, which makes our work more reliable and fast performance. In this work we consider Image processing an interpolation motion blur and proposed Lucy Richardson with blind convolution, Lucy Richardson fused with wiener restoration filter and Lucy Richardson fused with regularized filter. In this work we mainly presented diffusion of two filtered image and restoration of original image and the effect of restoration methods compares by two performance parameters MSE and PSNR.

1. $$MSE = \frac{\sum_{i=1}^{N}\sum_{j=1}^{N}(X(i,j)-X_w(i,j))^2}{N^2}$$

2. $$PSNR = 10log_{10}\left(\frac{255^2}{MSE}\right)$$

In first image shown in figure 6a cameraman image taken and various image obtained by different filter is shown below and also there results and in second image shown in Figure 6b football image is taken and its various parameter of this image is calculated as shown below and in Figure 7 and Figure 8 as shown here various parameter such as SNR and MSE parameter of blur image fused blind with Lucy Richardson image, fused Weiner with Lucy Richardson and fused Lucy with regularized filter.

Fig.6a: Cameraman image restoration using Interpolation Technique and compression of various filter method

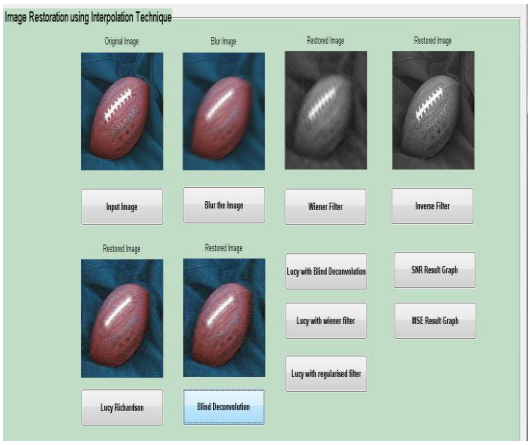


Fig. 6b: Football image restoration using Interpolation Technique and compression of various filter method

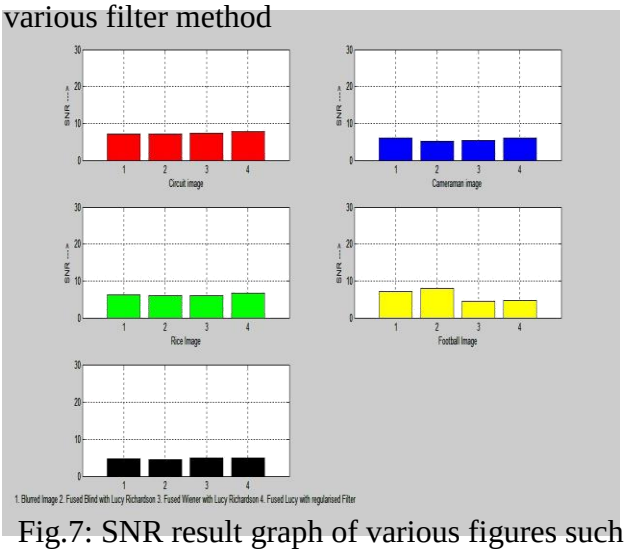


Fig.7: SNR result graph of various figures such as circuit image, Cameraman image, Rice image, Football image

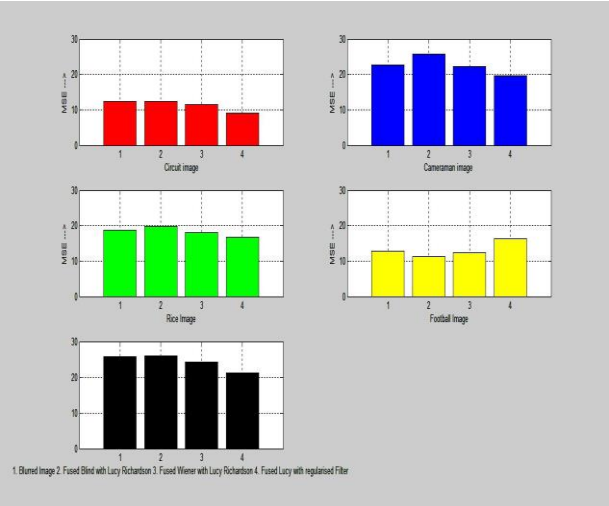


Fig. 8: MSE result graph of various figures such as circuit image, Cameraman image, Rice image, Football image

Table 1: Comparison of SNR for Different Image from Filters

Image	Blurred Image	Blind With LR	Wiener With LR	Lucy With Regularized Filter
Circuit Image	**7.2254**	**6.4945**	**6.2334**	**9.9564**
Cameraman Image	**5.9156**	**5.1039**	**4.7321**	**7.302**
Football Image	**7.0844**	**7.0844**	**6.1467**	**5.7663**
Rice Image	**6.3467**	**5.9353**	**5.6868**	**8.547**
Circle	**4.5907**	**4.4008**	**4.0396**	**6.5915**

Table 2: Comparison of SNR for Different Image from Restored Image with Filter

Image	Blurred Image	Blind With LR	Wiener With LR	Lucy With Regularized Filter
Circuit Image	**7.2254**	**7.1656**	**7.2528**	**7.7201**
Cameraman Image	**5.9156**	**5.2098**	**5.3486**	**5.9748**
Football Image	**4.3089**	**4.5645**	**4.5615**	**4.6819**
Rice Image	**6.3467**	**5.992**	**6.0818**	**6.5807**
Circle	**4.5907**	**4.5484**	**4.8238**	**4.8976**

Table 3: Comparison of MSE for Different Filtered Image

Image	Blurred Image	Blind With LR	Wiener With LR	Lucy With Regularized Filter
Circuit Image	**12.377**	**13.77**	**14.347**	**8.9824**
Cameraman Image	**22.668**	**26.273**	**28.338**	**18.244**
Football Image	**11.7474**	**10.4511**	**13.5398**	**14.4346**
Rice Image	**18.764**	**20.064**	**20.941**	**12.933**

Table 4: Comparison of MSE for Different Filtered Image

Image	Blurred Image	Blind With LR	Wiener With LR	Lucy With Regularized Filter
Circuit Image	**12.377**	**12.481**	**12.331**	**11.584**
Cameraman Image	**22.6668**	**25.739**	**25.0714**	**22.286**
Football Image	**18.764**	**19.85**	**19.581**	**18.096**
Rice Image	**14.3495**	**19.5153**	**18.2318**	**18.2437**

Conclusion: This suggests an efficient implementation of the regularized image interpolation problem as an inverse problem. The suggested implementation reduces the computational cost of the image interpolation problem to a single matrix inversion problem of moderate dimensions. The obtained results using the suggested regularized image interpolation algorithm is compared to the results using the iterative regularized image interpolation algorithm and the traditional polynomial based image interpolation algorithms. The suggested implementation of regularized image interpolation has proved to be superior to polynomial based image interpolation techniques from the MSE point of view and from the visual

Fig. 9(a) original image (b) blur image (c) deconvoluted image using L-R with PSF (d) Regularized filtered image

quality point of view. It has also proved to be superior to the iterative regularized image interpolation from the computational time point of view when the dimensions of the image to be interpolated are large. The suggested implementation has higher edge preservation ability than other interpolation algorithms. The objective of this work was to show that interpolated images with better spatial resolution can be obtained through the combined method of restoration and interpolation. Through the evaluation study it was observed that the restored images displayed better spatial resolution than the interpolated images. In this research work image restoration Interpolation Technique of some objects has been conducted. Several aspects related to remove noise, have been addressed in detail. This work can be further enhanced for 3D Doppler images and ultra sound images. The segmentation based feature extraction and Image texture (tissue characterization) technique for the ultrasound images can be established.

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