Mustansiriyah Journal of Pure and Applied Sciences, Print ISSN: 2957-9910. Online ISSN: 2957-9929, Vol. 4, No. 1, 2024, Pages 34-39
DOI: 10.47831/mjpas.v4i1.332

MJPAS

MUSTANSIRIYAH JOURNAL OF PURE AND APPLIED SCIENCES

Journal homepage: https://mjpas.uomustansiriyah.edu.iq/index.php/mjpas

RESEARCH ARTICLE -PHYSICS

Restoration of degraded images by using the Straubel pupil function filter mask

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Article Info.

Article history:

Received
16 September 2024

Accepted
28 October 2024

Publishing
30 March 2026

Abstract

Restoration is the process of returning a degraded image to its original state. Image restoration is a significant problem in high-level image processing that deals with restoring an original and sharp image using a degradation and restoration model. Eliminating blur and noise from images is a difficult problem to solve, and it is more difficult for researchers to find an effective way to remove the noise from the images.

Sometimes, the captured image gets blurry and there is noise from the environment, Degradation may occur due to noise, motion blur, Gaussian blur, camera mismatch, non-uniform illumination, and low-contrast image. Depending on the pupil function technique for images of point objects, the proposed method integrates the design of a new amplitude filter mask to improve image quality. our filter was intended to restore blurry and noisy images using MATLAB software, The performance of this algorithm has been compared with CLAHE and HE algorithms. the statistical image quality measurement is based on the signal-to-noise ratio (PSNR), Error Relative Global Dimensionally de Synthase (ERGAS), image entropy, Structural Similarity Index (SSIM), Root Mean Square (RMSE), and Enhancement Measure Estimation (EME). The results showed that the proposed method succeeded in improving degraded images and the experiment results show the quality measures give a good result for all type of degraded images . the PSNR gives good result for low light images .while the values of ERGAS gives good result for all type of degraded images . SSIM, and entropy performs much better than PSNR and EME

The official journal published by the College of Education at Mustansiriyah University

Keywords: Image enhancement, Straubel apodization mask ,restoration image, Resolution enhancement , PSF, a amplitude mask , Entropy.

1. Introduction

Numerous algorithms offer the ability to alter the source code according to the specified problem: analysis, Digital image restoration may involve the use of picture smoothing, sharpness, enhancement, deblurring, filter design, segmentation, morphological measurement, registration, contrast enhancement, spatial transformation, and image transform [1]. Obtaining the original, clear version of the blurred picture is the goal of deblurring, a type of image restoration. Picture deterioration brought on by errors in capture and recording can result in loss or a reduction of information from the collected images [2]. These flaws are brought on by camera misfocus, random air turbulence, and relative object camera motion. The type of noise and corruption in the image determines how the restoration procedure works. Therefore, main aim for our techniques is to characterize the degradation statistically point spread functions (PSF) and recover the original image using an amplitude filter design [3, 4]. Our suggested study aims to implement the pupil mask function specially the Straubel filter's pupil function to construct an appropriate, highly accurate restoration filter from the amplitude apodized point spread function to improve and eliminate image deterioration [5], the results show a marked improvement in visual criteria compared to the original image, indicating an improvement in the detection of previously hidden information within the original image to take advantage of advanced technologies in optical imaging systems. The field of image enhancement has received a great deal of research attention due to the significance of contrast enhancement for improving poor picture quality, Zhou, Z. et.al. [6] Suggested an adaptive optimization algorithm for low-light color images with low brightness and low contrast. The algorithm was achieved by enhancing high brightness adaptive adaptation, enhancing adaptive variation locally, and restoring color. The advantages of their algorithm were that the improved image had a great variation and was not blurry feeling. While Kong, Kong, T. L., et al. [7] recommend an algorithm known as Enhancer-based Contrast Enhancement (EBCE) to improve low-contrast and non-uniform illumination images. Their suggested method uses a histogram equalization equation to determine the brightness and dark enhancers from a blurred input image in order to produce uniform illumination and improve image contrast. X. Guo and associates [8] Since the final illumination map technique can feed numerous vision-based applications, including edge detection, feature matching, object recognition, and tracking, they proposed a straightforward low-light image enhancement (LIME) method in which they estimated the illumination of each pixel independently by determining the maximum value in the R, G, and B channels. Parihar, A. S., et al. [9] developed an algorithm to enhance the contrast based on their algorithm characterized by preserving the original properties of the image and resulting in contrast-enhanced images with a natural appearance Mishra, R., et al. [10] used three techniques (Regularized filter, Weiner filter, Lucy-Richardson filter) to restore the noisy fog image. After that, recover the damaged photos using the three methods, comparing how well they work according to PSNR, SSID, and MSE.

Proposed Method.

The Fourier transform to pupil function g (x, y) yields the normalized diffracted complex light amplitude at the position (u, v) in the picture plane associated with a rotationally symmetric pupil.

$$A\,(u, v)=\iint g(x,y).\, e^{2i\pi(ux+vy)}\mathrm{dxdy} \quad ...\ (1)$$

where u, v is the dimensionless coordinates variable that determines the distance between the point of observation and the center of the diffraction head, and g (x, y) is the pupil function of the optical system.

$$g\,(x, y) = \tau\,(x, y)\, e^{ikw\,(x,\,y)} \ ...\ (2)$$

The pupil transparency which represents the actual amplitude distribution in the exit pupil is $\tau\ (x,\ y)$, where $e^{ikw\ (x,\ y)}$ represents the wavefront of the aberration function, while $w\ (x,\ y)$ represents the aberration function, and $(x,\ y)$ represents the exit pupil coordinates [11,12]. An apodized optical system's point spread function may be computed based on the squared modulus of the equation. in image restoration [13,14], it is not easy to obtain the exact parameters of the point spread function, that is because the real degradation may come from several point spread functions simultaneously, the intensity PSF I (u, v) by taking the squared modulus of $A\ (u,\ v)$.

$$I(u, v) = |A(u, v)|^2 \ ...(3)$$

$$I(z) = |A(z)|^2 \ ....\ (4)$$

The pupil function, which may be represented by [15], is the apodized window function that we have selected for this investigation.

$$f_s(r)=(1-\beta r^2)\ \dots\ (5)$$

where β is the normalized distance of an arbitrary point on the pupil from its center, and β is the apodization parameter that controls the degree of non-uniformity of the transmission over the exit pupil [16,17].

Sources of Noise

A component of the visual information is distorted by the unwanted information, or noise, tainting the image. Unwanted results include the creation of odd edges, corners, and invisible lines. The "image denoising" technique, which involves removing noise from images, is a crucial stage in image processing [18, 19]. The distortion of images is due to multiple sources from which we mention:

- Blur due to miss-focus.
- Slow shutter speeds.
- Blur due to motion.

- The environment at the time of picture capture may have an impact on the imaging sensor.
- Low light (dark scenes or night photos).
- High sensitivity modes (High ISO setting).
- Slow shutter speeds.
- Inadequate illumination and temperature of the sensor might be the cause of picture noise.[20].

Methodology

In this section, we first propose a general approach for our enhancement method. This approach derives an effective image enhancement method that can efficiently apply for various lighting and contrast conditions, even when the input image is not clear .Digital images taken under different lighting and contrast settings are regarded as the original images, even if the originals' content may be less clear or more pronounced. Trial actions are applied to test pictures based on PSF in this study's methodology. The converting from RGB to HSV color space is essential step in our approach to increase the lightening of images; the filter mask is implemented after applying Fourier transform to the origin images to preserve the fine details of the images used. As a result the result enhanced images is in highly quality, so measurement of image quality is very important to numerous image processing application.

Figure 1 shows the Block diagram of the proposed method

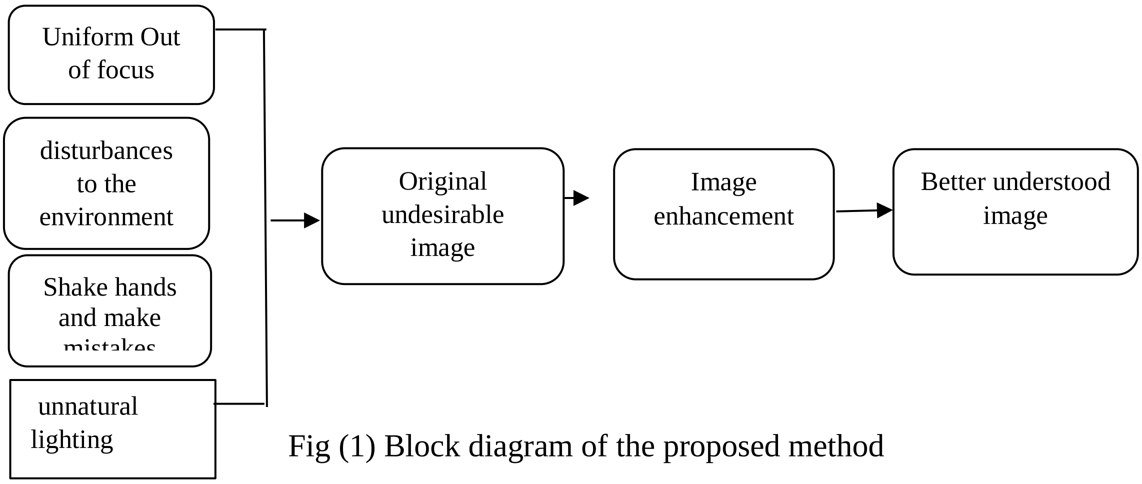


Fig (1) Block diagram of the proposed method

A stage-wise explanation of the proposed method to degraded images is demonstrated in the following staps:
Stap1: Input the degraded images into program.
Stap2: Convert the RGB degraded images into the HSV color space.
Stap3: Scale values to the range prospective.
Stap4: Determine Appropriate the equation: $f_s(r) = (1-\beta r^2)$
Stap5: apply Configure filter mask with converted Fourier image
Stap6: Add the CLAHE output and HE output images.
Stap7: Determine the PSNR, Entropy and EME for original image.
Stap8: Display both original and processing images.

The aim of the quality assessment is to measure the strength of the proposed filter mask .many statistical quality measurement were used in this work which are Peak Signal to Noise Ratio (PSNR), Entropy ,measure of enhancement (EME), Error Relative Globule Adimensionnelle Synthese(ERGAS) ,Root Mean Square Error(RMSE),and Structure Similarity Index Method (SSIM).

Results and discussions

In this study, Illumination and contrast are improved by image processing techniques. We applied the three PSFs to blur the original images that were previously collected from the internet, then we used the apodize window filter from equation Straubel filter's pupil function to restore and enhance the blurred images, the first column shows the original blurred image, figure (2) Shows the results of improving images using the proposed method enhance HE showed in second columns, third columns show enhance CLAHE, while the last column shows the result by our method.

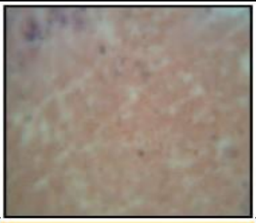
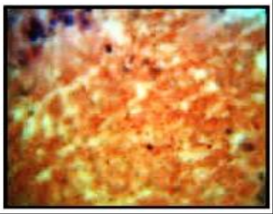
No.	Original image	HE	CLAHE	Enhancement Method
1.				
2.				
3.				
4.				
5.				

Fig 2. Results of enhancing the degraded image

The result of quality matrices calculation is shown in Table 1., from this table, we can see that all quality metrics have given almost consistent result, the PSNR gives good result for low light images. While the values of ERGAS gives good result for all type of degraded images. SSIM, and entropy performs much better than PSNR and EME, this results agree with all types of degraded images as Shown in the table.

Table 1 shows the statistical quality calculation between the degraded image in the presence of Motion, out-of-focus, and Gaussian blurs and the restored image for our method and two published methods.

No.	QS	OR	HE	CLAHE	proposed
1.	PSNR	+ Inf dB	13.311659338	18.852204456	**16.970057901**
	ERGAS	0.000000000	0.162628521	0.399905175	0.400058422
	SSIM	0.000000000	0.417526745	0.491489469	0.527504099
	RMSE	0.000000000	0.215981739	0.114127362	0.141741526
	EME	190.00806	190.71119	190.18649	189.98800
	Entropy	6.17261	5.77734	7.38877	7.50794
2.	PSNR	+ Inf dB	17.213636591	18.367755212	**17.799364883**
	ERGAS	0.000000000	0.134491797	0.522611656	0.523109458
	SSIM	0.000000000	0.900221397	0.926955690	0.996212672
	RMSE	0.000000000	0.137821880	0.120673592	0.128834375
	EME	253.28787	253.28664	253.42500	253.40632
	Entropy	6.41538	5.18313	6.97593	7.49733
3.	PSNR	+ Inf dB	5.599165959	16.179809152	**17.969869842**
	ERGAS	0.000000000	4.826545428	0.943455426	0.944870746
	SSIM	0.000000000	0.054914075	0.288859332	0.377002352
	RMSE	0.000000000	0.524857856	0.155242112	0.126330003
	EME	253.93853	249.85289	253.27871	252.38861
	Entropy	4.50218	3.97074	5.55324	6.17273
4.	PSNR	+ Inf dB	12.521170698	12.692828567	**13.497045849**
	ERGAS	0.000000000	0.127207176	0.443628710	0.443866947
	SSIM	0.000000000	0.764130599	0.619247299	0.818309052
	RMSE	0.000000000	0.133027511	0.164194487	0.211420798
	EME	427.46565	427.61074	429.04916	428.79092
	Entropy	7.11158	5.78293	5.66547	6.83228
5.	PSNR	+ Inf dB	6.468604624	17.841992709	**18.155241036**
	ERGAS	0.000000000	1.909289249	1.030905219	1.031589574
	SSIM	0.000000000	0.109345419	0.417775976	0.501849724
	RMSE	0.000000000	0.474864571	0.101835773	0.123662479
	EME	176.25949	174.24383	175.65640	175.04335
	Entropy	4.71338	4.20405	6.09108	7.93120

Conclusion

In this paper, an implemented of filtering mask is down depending on optical measurement equations using MATLAB, the, tested images are captured under different circumstance including uniform out-of-focus, shaking hands and motion , disturbances to the environment, and low lightness levels, were enhanced by applying our algorithm, and compared with HE , CLAHE .The results showed that the proposed method succeeded in improving degraded images, The quality values for EME, PSNR, ERGAS, SSIM, RMSE and entropy is obtained , the values of these quality measurement is various due to the changing invariant conditions of the taken images Thus, the proposed method could retrieve degraded image information without any distortion.

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