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Fourier Transformation Integrated Filter for Restoration of Blurred Digital Images

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ABSTRACT: Remote sensing is the science of obtaining information about the objects or areas from a distance mainly from aircraft or satellites and its applications directly has importance in our day to day life. The main objectives of remote sensing is monitoring, modeling, measuring, estimating and identifying various processes that took place in earth and atmosphere by using airborne sensors or satellites. In this research work motion blurred images are restored using Fourier transformation technique combined with digital filters. Image restoration is the process of restoring degraded images which cannot be taken again or the process of obtaining the image again is costlier. Image restoration is done in two domains: spatial domain and frequency domain. In spatial domain the filtering action for restoring the images is done by directly operating on the pixels of the digital image.

KEYWORDS: Fourier transformation; Butterworth; PSNR; MSE; RMSE.

I. INTRODUCTION

Fourier transform are used in virtually all areas of engineering and science. Fourier analysis was originally concerned with representing and analyzing periodic phenomena, via Fourier series, and later with extending those insights to nonperiodic phenomena, via the Fourier transform. Fourier Transform is an important image processing tool which is used to decompose an image. The output of the transformation represents the image in the Fourier or frequency domain, while the input image is the spatial domain equivalent. In the Fourier domain image, each point represents a particular frequency contained in the spatial domain image. The Fourier Transform is used in a wide range of applications, such as image analysis, image filtering, image reconstruction and image compression [1-3].

The objective of image restoration is to reduce the image blur during the imaging process. If we know the prior knowledge of the degradation function and the noises, the inverse process against degradation can be applied for restoration, including denoising and deconvolution. In frequency domain, the restoration process is given by the expression

$$F(x,y) = \frac{G(x,y) - N(x,y)}{H(x,y)}$$

Because restoration will enlarge the noises, denoising is done before restoration to remove the noises. Denoising can be performed both in the spatial domain and in the frequency domain. The usual method is to select an appropriate filter according to the characters of the noises to filter out the noises. Spatial convolution is defined as multiplication in the frequency domain, and its inverse operation is division. Therefore, deconvolution is carried out in the frequency domain as a rule. At last, the inverse Fourier transform is done to $F(x,y)$ to complete the restoration [4-6].

The Pearson's method is widely used in statistical analysis, pattern recognition and image processing. Applications on the latter include comparing two images for image registration purposes, disparity measurement, etc.

$$PCC = \frac{\sum_i (x_i - x_m)(y_i - y_m)}{\sqrt{\sum_i (x_i - x_m)^2}\sqrt{\sum_i (y_i - y_m)^2}}$$

where xi is the intensity of the ith pixel in image 1, yi is the intensity of the ith pixel in image 2, xm is the mean intensity of image 1, and ym is the mean intensity of image 2.

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Mean rquare root (MSE) and root mean square error (RMSE) corresponds to pixels in the reference image Ir and the filter image If. If the reference image and filter image are alike give the RMSE value equal to zero and it will increase when the dissimilarity increases between the reference and filter image.

$$RMSE = \sqrt{\frac{1}{MN}\sum_{x=1}^{M}\sum_{y=1}^{N}(I_r(x,y) - I_f(x,y))^2}$$

Peak signal to noise ratio (PSNR) value will be high when the fused and reference images are alike and higher value implies better filtering. PSNR is calculated by follow equation [7-10].

$$PSNR = 20\log_{10}\left(\frac{L^2}{\sqrt{\frac{1}{MN}\sum_{x=1}^{M}\sum_{y=1}^{N}(I_r(x,y) - I_f(x,y))^2}}\right)$$

Fig. 1. Image used in the research work.

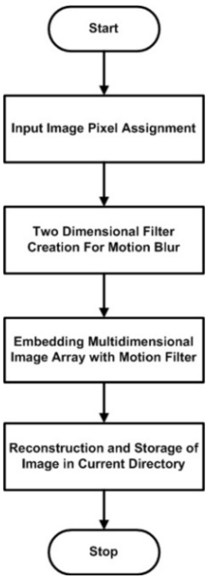

Fig. 2. Designed blurred algorithm for digital images

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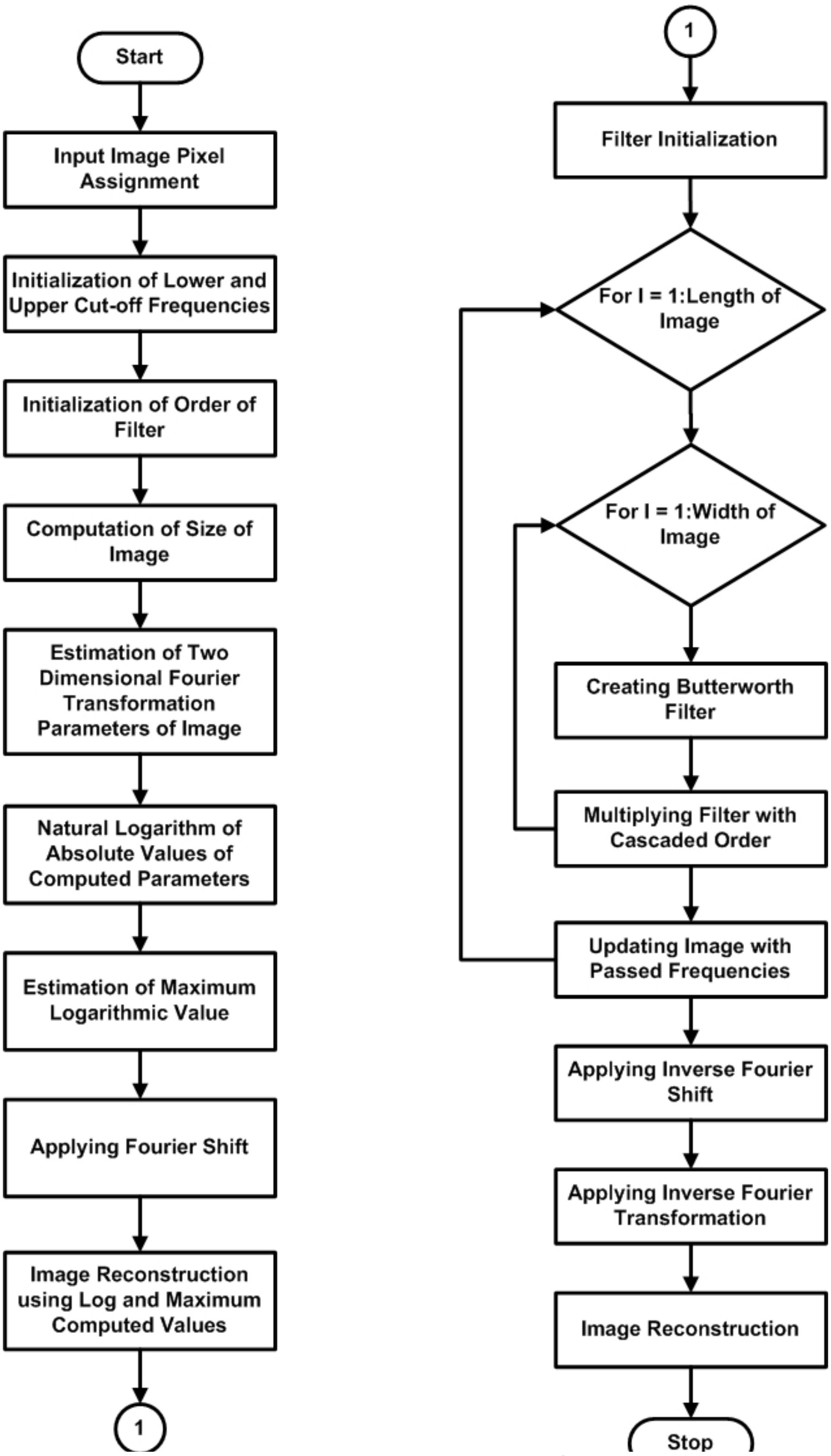

Fig. 3 Designed restoration algorithm based on Fourier transformation and butterworth filter

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II. Methodology

Research work is carried out to restore the motion blurred remote sensing images. Work is divided into two parts. Figure 1 shows the image used in research work. In the first part an algorithm shown in Fig. 2 is designed to obtain images with various levels ranging from 5 to 8 of pixel motion with five iteration of angle ranging from 10^o to 30^o. These images then subjected to image restoration algorithm shown in Fig. 3 based on Fourier transformation and Butterworth filters. Various image characteristics parameters such as PSNR, PCC, MSE, and RMSE are computed. The research work is further divided into two experiments. In first experiment effect of cut off frequency and effect of order of filter in second experiment is investigated on the deblurring of image. Table 1 shows the various pixel and angle iteration used to blur the image.

III. Results

Research work is carried out restore remote sensing images using Fourier transformation technique and butterworth filter. In the frequency domain the image enhancement deals with the frequency values manipulation. In the frequency domain the high or low frequencies are cut off depending on the result needed. In order to investigate the effect of cut-off frequency image with lowest and highest motion blur are used i.e. image with pixel value of 5 and 8and angle of blur is 10° and 30° respectively. The lower cut-off frequency (f_l = 30) is set with variable upper cut-off frequency ranging from 31 to 120. The algorithm was applied on the images and various image parameters were computed given in Table 1.

Table 1 Computed value of filtered image parameters.

Frequency		**PSNR**	**PCC**	**MSE**	**RMSE**
Lower Cut-off	**Upper Cut-off**	**(dB)**			
30	31	28.59	1021391	90.68	9.52
30	35	28.24	1019275	98.38	9.92
30	40	27.76	1016293	109.82	10.48
30	45	27.28	1013167	122.58	11.07
30	50	26.83	1010065	136.03	11.66
30	55	26.41	1007099	149.69	12.23
30	60	26.03	1004314	163.32	12.78
30	65	25.69	1001747	176.63	13.29
30	70	25.39	999385.8	189.61	13.77
30	75	25.11	997216	202.19	14.22
30	80	24.85	995224.6	214.35	14.64
30	85	24.62	993406	226.02	15.03
30	90	24.42	991761.2	237.11	15.4
30	95	24.23	990265.4	247.7	15.74
30	100	24.05	988910.4	257.73	16.05
30	105	23.9	987678.9	267.28	16.35
30	110	23.75	986559.9	276.33	16.62
30	115	23.62	985551.3	284.87	16.88
30	120	23.5	984642.9	292.92	17.11

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Figure 4 show the graphical representation computed PSNR (dB) with respect to frequency bandwidth for minimum blurred image. It can be observed that as the bandwidth is increased PSNR shows a shift and then saturates for higher values. Figure 5 show the MSE plot which attains constant value around 80 for higher bandwidth.

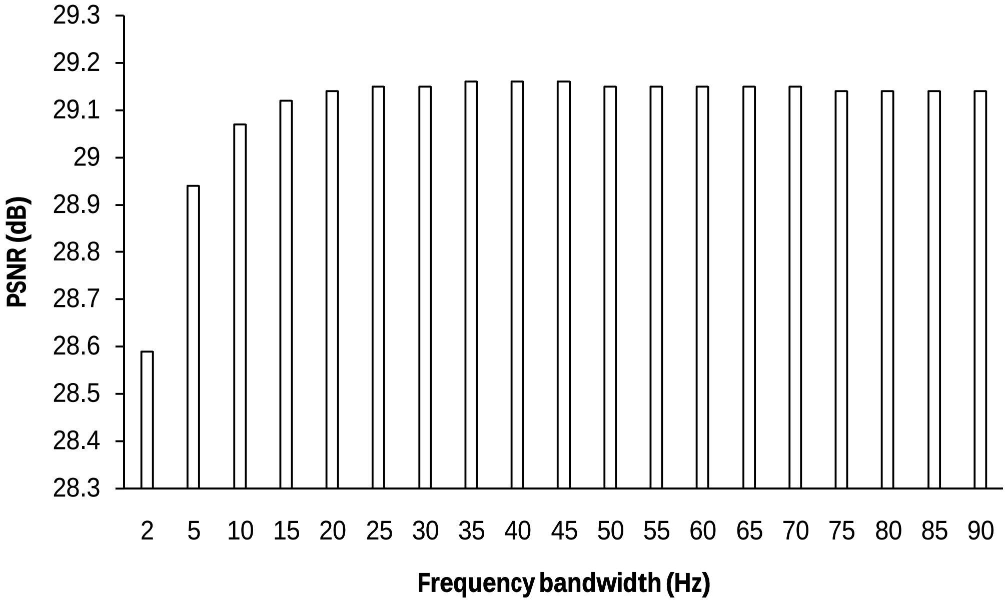

Fig. 4.6 Computed PSNR of minimum motion blurred image.

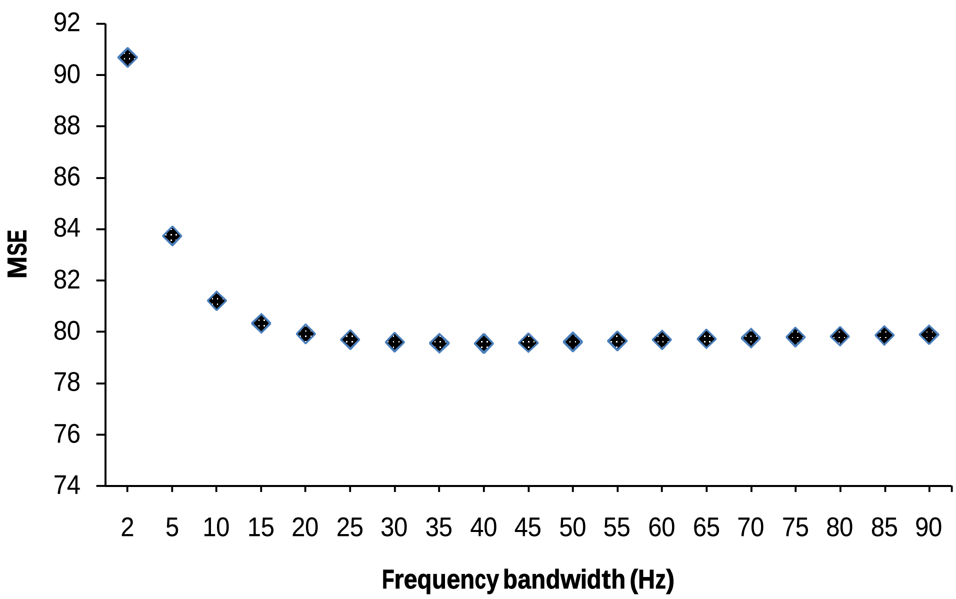

Fig. 4.7 Computed MSE of minimum motion blurred image

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IV. CONCLUSION

The research work is carried out to implement digital image processing technique for restoration of remote sensing image. Various levels of motion blur are added to the original image. A Frequency domain enhancement algorithm based on butterworth filter and FFT was proposed and implemented. From the implementation results, it is found that the maximum variations between original and enhanced images. Further the research work was carried out to investigate the effect of bandwidth and order of filter on the restoration process. From the results it is observed that narrow band filter provides better response than wide band filters.

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