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Digital Filter Method to Restore Motion Blurred Remote Sensing Image

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Abstract— Image blurring is difficult to avoid when the source or object are in motion. Image deblurring has enormous applications in digital world. The deblurring approaches have evolved with time, in this paper application of Fourier transformation and Butterworth filters are presented to restore the motion blurred images. The analysis is done on the basis of performance of designed algorithm with pixel motion and degree of angle in the motion with computation of Peak Signal to Noise Ratio (PSNR), Pearson Correlation Coefficient (PCC), Mean Square Error (MSE), and Root Mean Square Error (RMSE).

Keywords— Fourier transformation, Butterworth filter, PSNR, RMSE.

I. INTRODUCTION

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. This is possible due to the materials in a scene reflect, absorb, and emit electromagnetic radiation in a different way depending on their molecular composition and shape. It exploits with the physical fact that deals with the acquisition of information about a scene (or specific object) at a short, medium or long distance shape.

Remote sensing through satellites and aerospace probes are useful approach for deep space exploration. Through this approach one can get the 3-D survey of the planet's surface. It can be done through two steps and they are: imaging by a CCD camera and by transmitting the data back to the earth. On the basis of the energy type resources involving data acquisition, the remote sensing imaging instruments are of two types. They can be active or passive. Passive optical remote sensing depends on solar radiation as illumination source. Through imaging spectrometer, the measured signal is the radiation from the earth atmosphere's which observes the direction. The radiation which is obtained by the sensors is measured at different wavelengths and the resulting spectrum is used to identify material. Generally the main objective of spectroscopy is measurement, analysis and interpretation of such spectra. Some mainly examples of passive sensors are infrared, charge-coupled devices, radiometers, or multi and hyper spectral sensors. The main role of active sensor is to emit the energy by an antenna towards the earth surface and the energy scattered back to the satellite is measured. The main example of active sensors is radar system such as Synthetic Aperture Radar (SAR). In these sensors, the time delay between emission and return is measured so that the locations, height, speed, and direction of objects is established. Thus, the methods for processing remote sensing images should be designed carefully. Uncertainly the scientific production is high but the cross-fertilization between the remote sensing and image processing is still a way far from the reality.

In digital camera blur can be divided into four categories (average, motion, gaussian, and out of focus blur). Average blur can be distribution in horizontal and vertical direction and can be circular averaging by radius R which is evaluated by the formula:

$$R = \sqrt{g^2 + f^2} \quad (1)$$

where g is the horizontal size blurring direction and f is vertical blurring size direction and R is the radius size of the circular average blurring.

Motion blur is caused either by the camera motion or by the object motion. The vibration when the shutter is pressed causes camera motion. The corresponding motion blur is usually computed by a linear image degradation process given by:

$$I = L \times f + n \quad (2)$$

Gaussian blur is the result of blurring of an image by Gaussian function. It is a widely used effect in graphics software, typically to reduce image noise and reduce detail. This blur is deliberately used in pre-processing stage of computer vision algorithms in order to enhance image structures at different scales. This blur effect is a type of filter which combines a specific number of pixels incrementally and followed by a bell-shaped curve. This type of blurring is dense in the centre and comparatively reduces at the edges.

The out-of-focus blur is caused when a camera images a 3-D scene onto a 2-D imaging plane, some parts of the scene are in focus while other parts are not. Depending upon the aperture of the camera the point source forms a small disk known as circle of confusion. The degree of defocus depends upon parameters like focal length, aperture number of lens, and distance between object and camera.

In this research paper Fourier transformation method and Butterworth filter are used to restore the motion blurred remote sensing image. Also image quality parameters such as peak signal to noise ratio (PSNR), Pearson correlation coefficient (PCC), mean square error (MSE), and root mean square error (RMSE) are computed with respect to original image. The formulas used to compute these parameters are given in Table I.

II. METHODOLOGY

Research work is carried out to restore the motion blurred remote sensing images. Work is divided into two parts. In the first part an algorithm (Fig. 1) is designed to obtain images with various levels ranging from 8 to 12 of pixel motion with five iteration of angle ranging from 10^o to 50^o. Figure 1 shows the image used in research work. Various image characteristics parameters such as PSNR, PCC, MSE, and RMSE are computed. These images then subjected to image restoration algorithm (Fig. 2) based on Fourier transformation and Butterworth filters. The upper and lower cut-off frequencies used are 30 and 120 respectively with second order filter. Also the image characteristics of these restored images are computed.

Fig. 1 Image used in the research work.

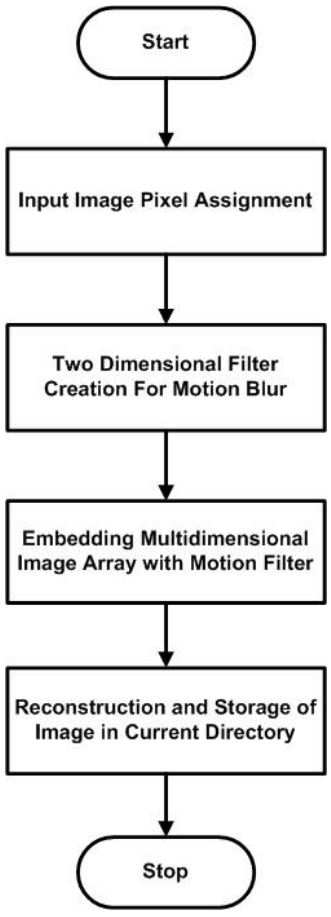


Fig. 2 Designed blurred algorithm for digital images.

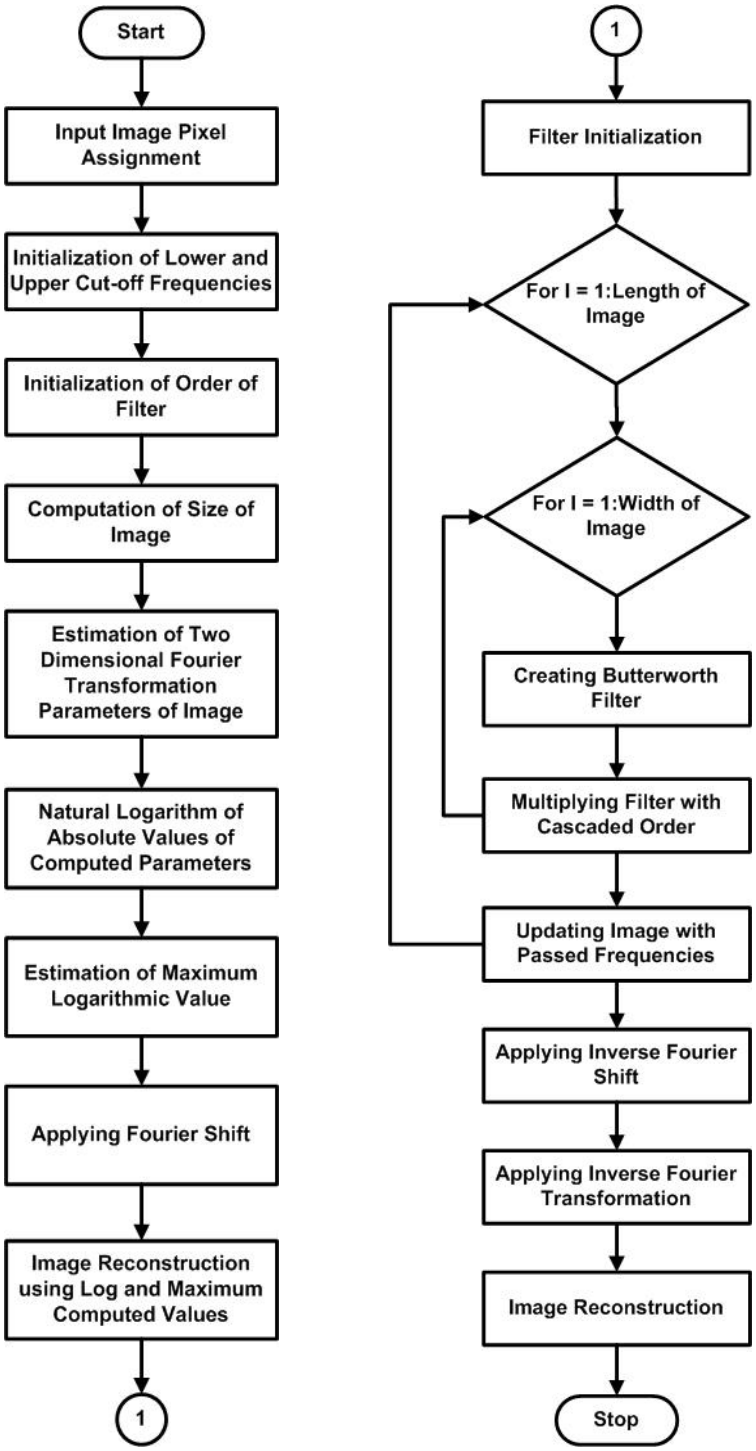


Fig. 3 Designed restoration algorithm based on Fourier transformation.

III. RESULTS

The study was implemented using MATLAB to test Fourier based methods to restoration blurring. Figure Table I shows the computed image characteristics parameters of motion blur image. It can be observed from the values that as the motion blur is increased image degradation also increases. Table II shows the computed values of image parameters of restored image. It is observed from the result that the designed algorithm gives constant PSNR values for all the blurred images. Figure 4 (a)-(e) shows the PSNR and difference of PSNR w.r.t blurred image.

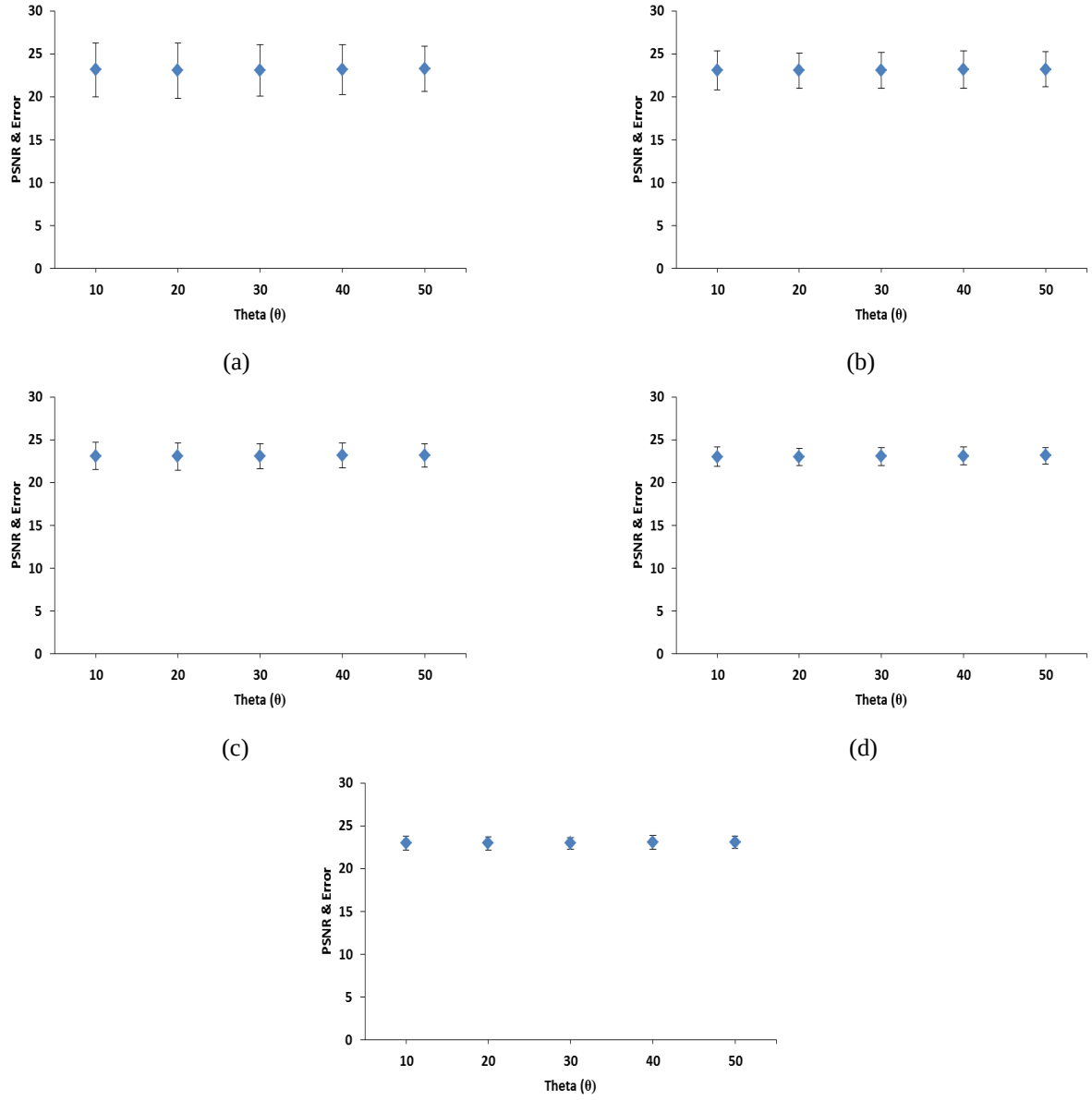
Table I. Computed image characteristics parameters of motion blurred image.

Linear Motion	Angle	PSNR (dB)	PCC	MSE	RMSE
8	10	26.67	1005798.56	140.92	11.87
	20	26.60	1004932.97	143.42	11.98

	30	26.51	1004002.11	146.27	12.09
	40	26.55	1004448.36	144.92	12.04
	50	26.48	1003710.87	147.25	12.13
9	10	26.11	999505.47	160.66	12.68
	20	25.90	997037.60	168.26	12.97
	30	25.96	997701.74	166.13	12.89
	40	26.10	999426.34	160.74	12.68
	50	26.04	998646.48	163.18	12.77
10	10	25.64	993644.23	179.03	13.38
	20	25.58	992870.47	181.30	13.46
	30	25.47	991295.22	186.14	13.64
	40	25.60	993077.84	180.66	13.44
	50	25.53	992218.47	183.35	13.54
11	10	25.14	986627.44	200.74	14.17
	20	25.02	984759.65	206.46	14.37
	30	25.06	985393.63	204.49	14.30
	40	25.17	987033.24	199.47	14.12
	50	25.10	986060.04	202.49	14.23
12	10	24.79	981187.36	217.53	14.75
	20	24.71	979794.29	221.75	14.89
	30	24.63	978537.60	225.62	15.02
	40	24.83	981871.56	215.46	14.68
	50	24.77	980832.75	218.66	14.79

Table II. Computed image characteristics parameters of motion restored image

Linear Motion	**Angle**	**Order of Filter = 2; Lower cut-off frequency = 30; Upper cut-off frequency =120**			
		PSNR (dB)	**PCC**	**MSE**	**RMSE**
8	10	23.12	971141.2	319.86	17.88
	20	23.03	970083.1	326.27	18.06
	30	23.05	970209.1	324.36	18.01
	40	23.15	971515.1	317.22	17.81
	50	23.23	972096.1	311.63	17.65
9	10	23.08	968256.6	322.12	17.95
	20	23.04	966965.2	325.19	18.03
	30	23.07	967641.2	323.22	17.98
	40	23.16	969439.3	316.67	17.80
	50	23.20	969461.7	313.87	17.72
10	10	23.10	965942.0	321.15	17.92
	20	23.05	965282.7	324.73	18.02
	30	23.05	964678.7	324.7	18.02
	40	23.16	966562.4	316.94	17.80
	50	23.19	966460.0	314.37	17.73
11	10	23.02	962128.6	326.66	18.07
	20	23.01	961276.1	328.03	18.11
	30	23.03	961876.5	325.97	18.05
	40	23.11	963342.0	320.25	17.90
	50	23.12	962765.3	319.61	17.88
12	10	22.99	959258.7	329.45	18.15
	20	22.95	958419.4	332.24	18.23
	30	22.95	957798.1	332.20	18.23
	40	23.07	960525.2	323.31	17.98
	50	23.05	959521.0	324.58	18.02



(a) (b) (c) (d) (e)

Fig. 4. (a)-(e) PSNR of restored image with differnce blurred and restored image PSNR for all the pixel motion.

IV. CONCLUSION

In this paper Fourier based approach is applied to restore the blurred image. Various levels of motion blur are deliberately added in original image. Second order Butterworth filter is applied to restore these images. Various parameters of blurred and restored images are computed. From the results it is seen that designed algorithm provides almost same PSNR for lower and higher motion blurred images. Further investigations are required to evaluate the effect of order of filter on the restoration process.

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