Low Quality Image Information Enhancement Using SVD Fusion Technique

Gagandeep Kour, Sharad P. Singh

[1]Department of Electrical & Electronics Engineering, Arni University, Kathgarh, Himachal Pardesh- 176401, India
naeksung@gmail.com

Abstract: *Images fusion technique based on Singular Value Decomposition (SVD) has been done on the blurred images with different level of blurring. The blurring of the image was done using circular averaging technique. Five different set of images were taken and on these images SVD based fusion implemented on the images. The content of the image were calculated with respect to reference image on the blurred image and fused image. PSNR value for highest blurred image come out to be for blurred and fused image 13.27 dB and 12.61 dB respectively. SNR value for blurred image is -10.85 and fused image -11.51. Image quality is enhanced by SVD fusion technique.*

Keywords: SVD, PSNR, SNR, image fusion.

1. Introduction

Image fusion is a technique to generate a single high informative image from one or more input images. Pixel level, feature level, signal level and decision level are different stage at which image fusion can be applied [1]. Application of area of image fusion includes pattern recognition, visual enhancement, object detection, and area surveillance etc [2]. Image reconstruction can also be done using image fusion techniques which enable to preserve important features from two or more images [3]. Transformation techniques such as wavelet, FFT, DCT, SVD etc are being employed for image fusion. Singular value decomposition (SVD) is being used to enhance image fusion technique [3-5]. SVD is very popular in signal processing area due to its conceptual and stability reason and also is a robust and reliable orthogonal decomposition method [6-7]. The ability of SVD to adjust the variations in local statistics of an image makes it prominent in the image processing field [8]. Many attractive properties of SVD are still not fully utilized.

In this research paper information content of the image taken from low pixel camera is enhanced by implementing SVD fusion technique.

2. Theory of SVD

The factorization of rectangular real or complex matrix into diagonal symmetric or Hermitian square matrices using eigenvectors is the basic principle used in linear algebra for SVD [6]. In order to divide the system into a set of linearly independent components with all of these components having their own energy components, SVD is the stable and effective technique [9]. SVD representation of digital image X with size $M \times N$ is as follows:

$$[\overset{N}{X}]_M = [\overset{M}{U}][\overset{N}{S}]_M[\overset{N}{V}]^T$$
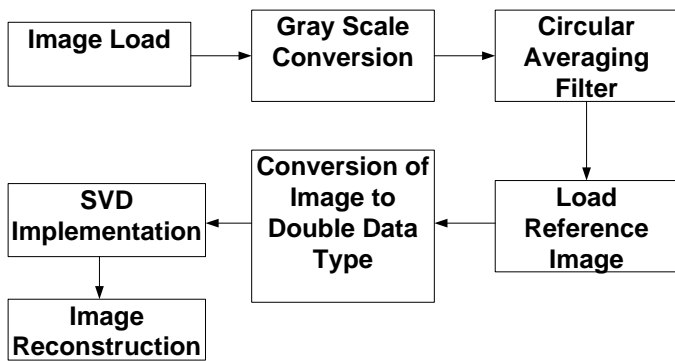
$$U = [u_1, u_2, \ldots.u_m]$$

$$V = [v_1, v_2, \ldots..v_n]$$

S=[Singular value diagonal matrix]

where U is an MxM orthogonal matrix, V is an NxN orthogonal matrix, and S is an MxN matrix with the diagonal elements represents the singular values, s_i of X. Singular value (SV) specifies the luminance of an image layer and the corresponding pair of singular vectors (SCs) denotes the geometry of the image [10]. U and V are unitary orthogonal matrices (the sum of squares of each column is unity and all the columns are uncorrelated) and S is a diagonal matrix (only the leading diagonal has non-zero values) of decreasing singular values. SVD maximizes the largest singular values, the first eigen image is the pattern that accounts for the greatest amount of the variance-covariance structure [6, 11].

3. Methodology

Research work is carried out to enhance the quality of the distorted image by applying SVD based fusion technique. Information content of the distorted image is enhanced with this technique. Set of images are taken using standard resolution with digital camera. These images are stored for further image processing. A reference image of the same object is taken using same digital camera. A computer based algorithm is designed with implementation of image fusion using SVD technique. Before applying SVD based image fusion, distortions are added to the image using circular averaging filter. Block diagram of the algorithm designed is shown in Fig. 1.

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┌────────────┐   ┌──────────────┐   ┌────────────┐
│ Image Load │ → │ Gray Scale   │ → │ Circular   │
│            │   │ Conversion   │   │ Averaging  │
│            │   │              │   │ Filter     │
└────────────┘   └──────────────┘   └────────────┘
                                          │
┌──────────────┐  ┌──────────────┐  ┌────────────┐
│ SVD          │← │ Conversion of│← │ Load       │
│ Implementation│  │ Image to     │  │ Reference  │
│              │  │ Double Data  │  │ Image      │
│              │  │ Type         │  │            │
└──────────────┘  └──────────────┘  └────────────┘
       │
┌──────────────┐
│ Image        │
│ Reconstruction│
└──────────────┘
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Figure1: Block diagram representation of computer algorithm.

After applying the SVD image fusion on the distorted image, information content of the image were calculated.

Root mean square error (RMSE) corresponds to pixels in the reference image I_r and the fused image I_f. If the reference image and fused image are alike give the RMSE value equal to zero and it will increase when the dissimilarity increases between the reference and fused image [12].

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

Peak signal to noise ratio (PSNR) value will be high when the fused and reference images are alike and higher value implies better fusion. PSNR is calculated by follow equation [13-14]

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

Signal to noise ratio (SNR) is calculated using following [15]

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

Apart from these parameters mean absolute error, Pearson correlation coefficient, and universal image quality index has been measured.

(a)

(b)

(c)

(f)

(g)

(h)

(d)

(i)

(e)

(j)

Figure 2: (a-e) Blurred image with applying circular averaging filter, (f-j) corresponding enhanced images with application of SVD based image fusion.

4. Results and Discussion

The performance of proposed method of SVD image fusion is tested using different levels of blurred images. The images are blurred using circular averaging with radius from 1 to 5. Figure 2 shows the blurred image with corresponding enhance image obtained from the designed SVD algorithm of image fusion. Figure 2 (a) to 2(e) show the blurred images with the application of circular averaging filter having radius from 1 to 5. Corresponding enhanced images with SVD fusion are shown in Fig. 2(f)-2(j).

Table 1. Calculated parameters for blurred images w. r. t. to reference image.

Circular Averaging Radius					
Parameter	R=1	R=2	R=3	R=4	R=5
PSNR(dB)	12.29	12.71	12.96	13.09	13.27
RMSE	62.17	59.22	57.54	56.66	55.53
SNR (dB)	-11.83	-11.41	-11.16	-11.03	-10.85
MAE	47.38	45.01	43.85	43.29	42.38
UIQI	0.0091	0.0084	0.0082	0.00631	0.0054
PCC	110256	118886	126323	131931	136002

The calculated image content information (such as PSNR, SNR, RMSE, MAE, universal image quality index (UIQI), and Pearson correlation coefficient (PCC) of blurred image with respect to the reference image for blurred image are given in Table 1. The quality parameters of the image after the application of the image fusion are also calculated shown in Table 2.

Table 2. Calculated parameters for fused images w. r. t. to reference image.

Circular Averaging Radius					
Parameter	R=1	R=2	R=3	R=4	R=5
PSNR(dB)	12.15	12.31	12.39	12.54	12.61
RMSE	63.17	62.02	61.48	60.41	59.92
SNR(dB)	-11.97	-11.81	-11.74	-11.58	-11.51
MAE	48.45	47.43	47.12	46.27	46.21
UIQI	0.00868	0.00900	0.00857	0.00880	0.00840
PCC	102948	106536	109836	112715	113600

5. Conclusion

Image quality enhancement is being carried out with the application of SVD based image fusion. Five set of image were

taken and these images blurred using circular averaging techniques. SVD based algorithm was applied on the blurred images. Image content evaluation was done on the recovered image and it was seen that SVD based image fusion provide recovery of the images content efficiently.

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