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IMAGE FUSION PARAMETER ESTIMATION AND COMPARISON BETWEEN SVD AND DWT TECHNIQUE

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Abstract: Image fusion is implemented on blurred images using two techniques SVD and DWT. Computer based algorithm is design for SVD and DWT for enhancing the images. A low pixel value images were captured using an optical sensor. These images were blurred using circular averaging filter with different averaging value ranging from 1-5. Parameters such as peak signal to noise ratio (PSNR), root mean square error (RMSE), signal to noise ratio (SNR), and universal image quality index (UIQI) for blurred, SVD, and DWT fused images. From the computed values of UIQI SVD shows maximum value with respect to DWT fusion techniques.

Keywords: SVD, DWT, PSNR, SNR, UIQI, Image fusion

I. INTRODUCTION

Processes of combining multiple images of same scene by implementing computer based algorithm to enhance the information content in the image are being developed and known as image fusion [1]. The image fusion techniques help in improving the quality of images. Image fusion finds its application in the field of optical remote sensing; CCD devices with limited focusing, medical image enhancement [2]. The image fused may be captured from different optical sensor, acquired at different spatial time with different spectral characteristics. Image fusion is being developed with one objective to retain the desirable characteristics of the image. Nowadays a wide range of optical sensors are available with multi resolution data, this lead to increasing interest of researchers in the field image fusion for wide spectrum applications [3]. In order to carryout image fusion various algorithm are being developed to provide good result. Various techniques such as wavelet, DCT, SVD etc are being explored to enhance the image contents after image fusion is applied on the set of data.

In this research paper information set of the data taken from optical sensor and image fusion is applied to achieve better set image with the help of Discrete Wavelet Transformation (DWT) and Singular Value Decomposition (SVD) based image fusion. Also the effectiveness of these techniques are evaluated by comparing various content parameters.

II. THEORY OF SVD AND DWT

The basic principle used in linear algebra for SVD is the factorization of rectangular real or complex matrix into diagonal symmetric or Hermitian square matrices using eigenvectors [4]. SVD of an $m \times n$ matrix X is given by:

$$X = U_x \sum_x V_x^T \tag{1}$$

where the columns of the $m \times n$ matrix U_x are called the left singular vectors, the rows of the $n \times n$ matrix V_x^T contain the elements of the right singular vectors, and the diagonal elements of the $n \times n$ diagonal matrix $\sum_x = diag(\sigma_1, ..., \sigma_n)$ are called the singular values.

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The singular value matrix $\sum_x$ represents the intensity information of a given image [5], where the highest singular values have a great amount of image information.

Wavelet-based analysis of signals is an interesting tool. Like Fourier series analysis, where sinusoids are chosen as the basic functions, wavelet analysis is based on a decomposition of a signal using an orthonormal family of basic functions [6]. Wavelet signal have its energy in time and are suitable for the analysis of transient, time varying signals. Accordingly, Discrete Wavelet Transformation (DWT) analysis in spatial domain gives good performance in detecting discontinuities or subtle changes in gray level [7]. If the function being expanded is a sequence of numbers, the resulting coefficients are called the DWT of $f(x)$. The DWT transform pair is defined as following

$$W_\varphi(j_0,k)=\frac{1}{\sqrt{M}}\sum_x f(x)\varphi_{j_0,k}(x) \tag{2}$$

$$W_\psi(j,k)=\frac{1}{\sqrt{M}}\sum_x f(x)\psi_{j,k}(x), \tag{3}$$

for $j=j_0$

$$f(x)=W_\varphi(j_0,k)+W_\psi(j,k) \tag{4}$$

Where $f(x)$, $\varphi_{j_0,k}(x)$, and $\psi_{j,k}(x)$, are functions of the discrete variable $x=0,1,2...M-1$.
The coefficients defined in Eqs. (1) and (2) are usually called approximation and detail coefficients, respectively. The process of computing these coefficients is referred to as DWT analysis [8].

III. METHODOLOGY

Investigation is carried out to estimate the parametric features of image after applying SVD and DWT based image fusion. Information content of the distorted image is enhanced with these two techniques. Set of images are taken using standard optical camera and are stored for further processing. A computer based algorithm is designed with implementation of image fusion using SVD and DWT technique. Before applying SVD and DWT based image fusion, circular averaging filter was applied to these images to add some distortion. Block diagram of the algorithm designed is shown in Fig. 1.

After applying the SVD and DWT image fusion on the distorted image, information content of the image were calculated which are described as -

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 [9].

$$RMSE=\sqrt{\frac{1}{MN}\sum_{x=1}^{M}\sum_{y=1}^{N}(I_r(x,y)-I_f(x,y))^2} \tag{5}$$

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 [10] [11]

$$PSNR=20\log_{10}\left(\frac{L^2}{\sqrt{\frac{1}{MN}\sum_{x=1}^{M}\sum_{y=1}^{N}(I_r(x,y)-I_f(x,y))^2}}\right) \tag{6}$$

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Signal to noise ratio (SNR) is calculated using following [12]

$$SNR = 10\log_{10}\left(\frac{\sum_{x=1}^{M}\sum_{y=1}^{N}(I_r(x,y)-I_f(x,y))^2}{\sum_{x=1}^{M}\sum_{y=1}^{N}I_r(x,y)}\right) \quad (7)$$

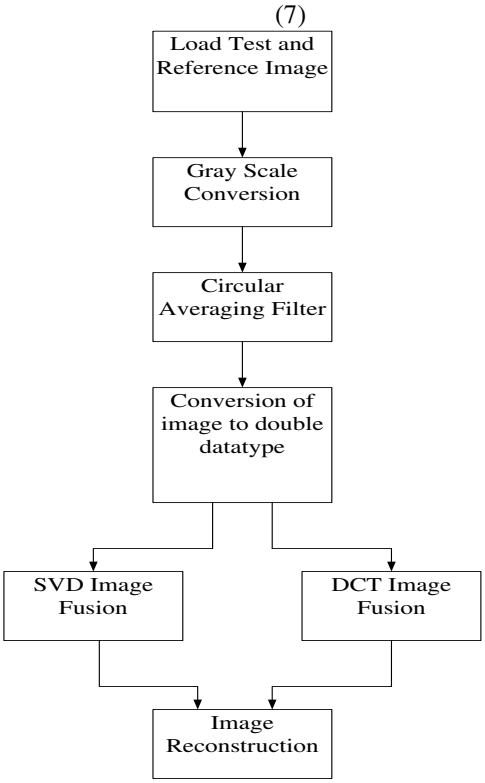

Fig.1. Block diagram representation of computer algorithm for image fusion.

The image quality index was introduced by two researchers Z. Wang and A. C. Bovik [13]. Given two sequences $x=(x_1,...,x_n)$ and $y=(y_1,....,y_n)$, let $\bar{x}$ denote the mean of x, and σ_x and σ_{xy} denote the variance of x and covariance of x and y, respectively. The global quality index of two vectors is defined as

$$Q_0(x,y)=\frac{4\sigma_{xy}\bar{x}\bar{y}}{(\bar{x}^2+\bar{y}^2)(\sigma_x^2+\sigma_y^2)} \quad (8)$$

which can be decomposed as

$$Q_0(x,y)=\frac{\sigma_{xy}}{\sigma_x\sigma_y}\cdot\frac{2\bar{x}\bar{y}}{(\bar{x}^2+\bar{y}^2)}\cdot\frac{2\sigma_x\sigma_y}{(\sigma_x^2+\sigma_y^2)} \quad (9)$$

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IV. RESULTS AND DISCUSSIONS

The performance of proposed method of SVD and DWT image fusion is tested using different levels of distorted images. Circular averaging filter is implemented to blur the image with the level ranging from 1-5. 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). Similarly Fig 3(a)-3(e) shows the blur image with DWT fused image shown in 3(f)-3(j). The calculated image content information (such as PSNR, SNR, RMSE, universal image quality index (UIQI) of blurred image with respect to reference image for blurred image are given in Table 1. The quality parameters of the image after the application of the SVD and DWT image fusion are also calculated shown in Table 2 and Table 3.

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)	12.15	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
UIQI	0.0086	0.0086	0.0085	0.0088	0.0084

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

	Circular Averaging Radius				
Parameter	R=1	R=2	R=3	R=4	R=5
PSNR(dB)	12.54	12.49	12.26	12.21	12.21
RMSE	60.38	60.75	62.33	62.70	62.70
SNR(dB)	-9.58	-9.63	-9.86	-9.91	-9.91
UIQI	0.0153	0.0155	0.0164	0.0165	0.0154

TABLE 3
Calculated parameters for DWT fused images w.r.t. to reference image.

	Circular Averaging Radius				
Parameter	R=1	R=2	R=3	R=4	R=5
PSNR(dB)	12.29	12.71	12.96	13.09	13.27
RMSE	62.17	59.22	57.54	56.66	55.53
SNR(dB)	-10.83	-10.41	-10.16	-10.03	-10.85
UIQI	0.0091	0.0094	0.0092	0.0093	0.0093

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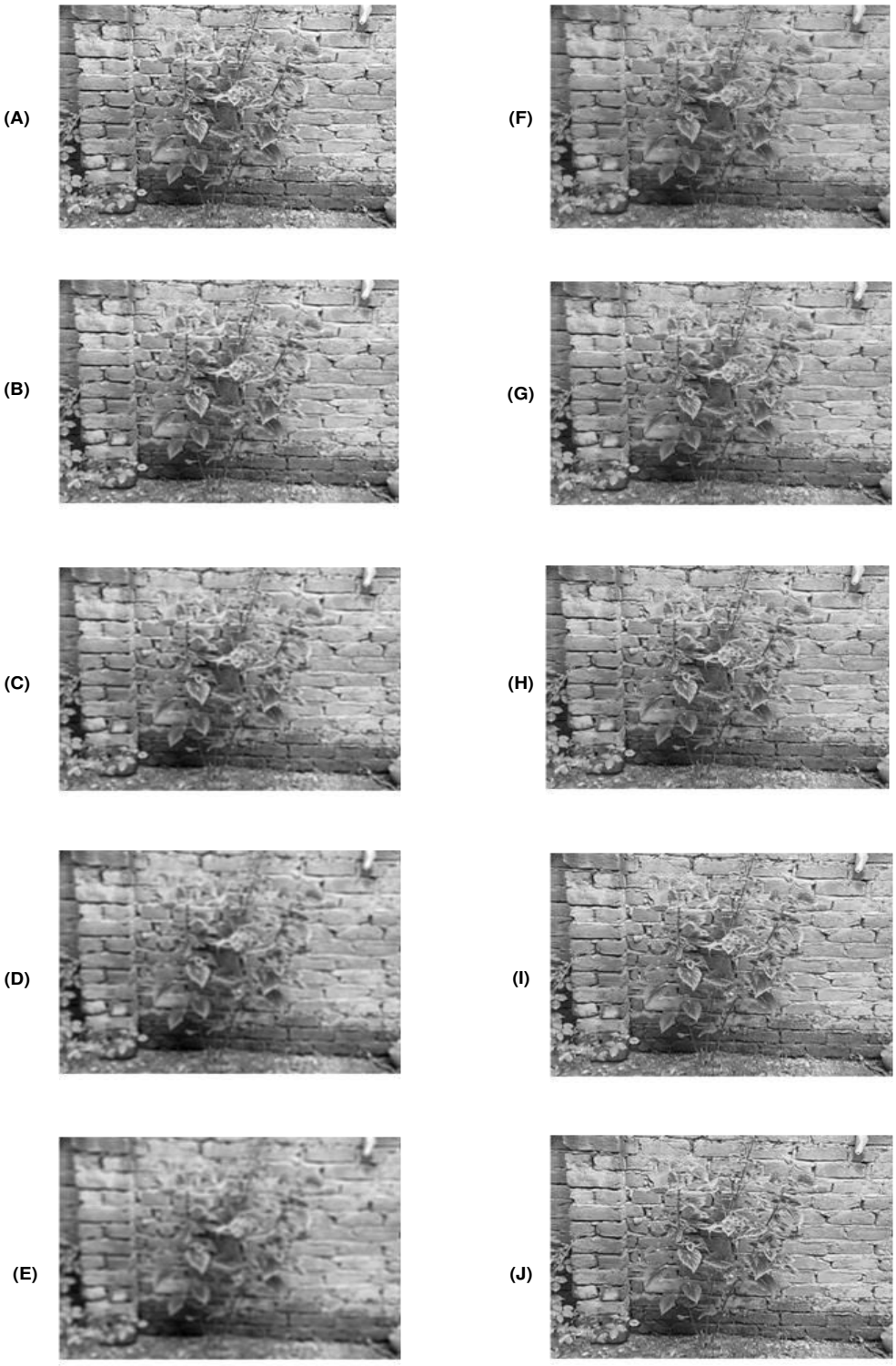

Fig. 2. (A-E) Blurred image with applying circular averaging filter, (F-J) corresponding enhanced images with application of SVD based image fusion.

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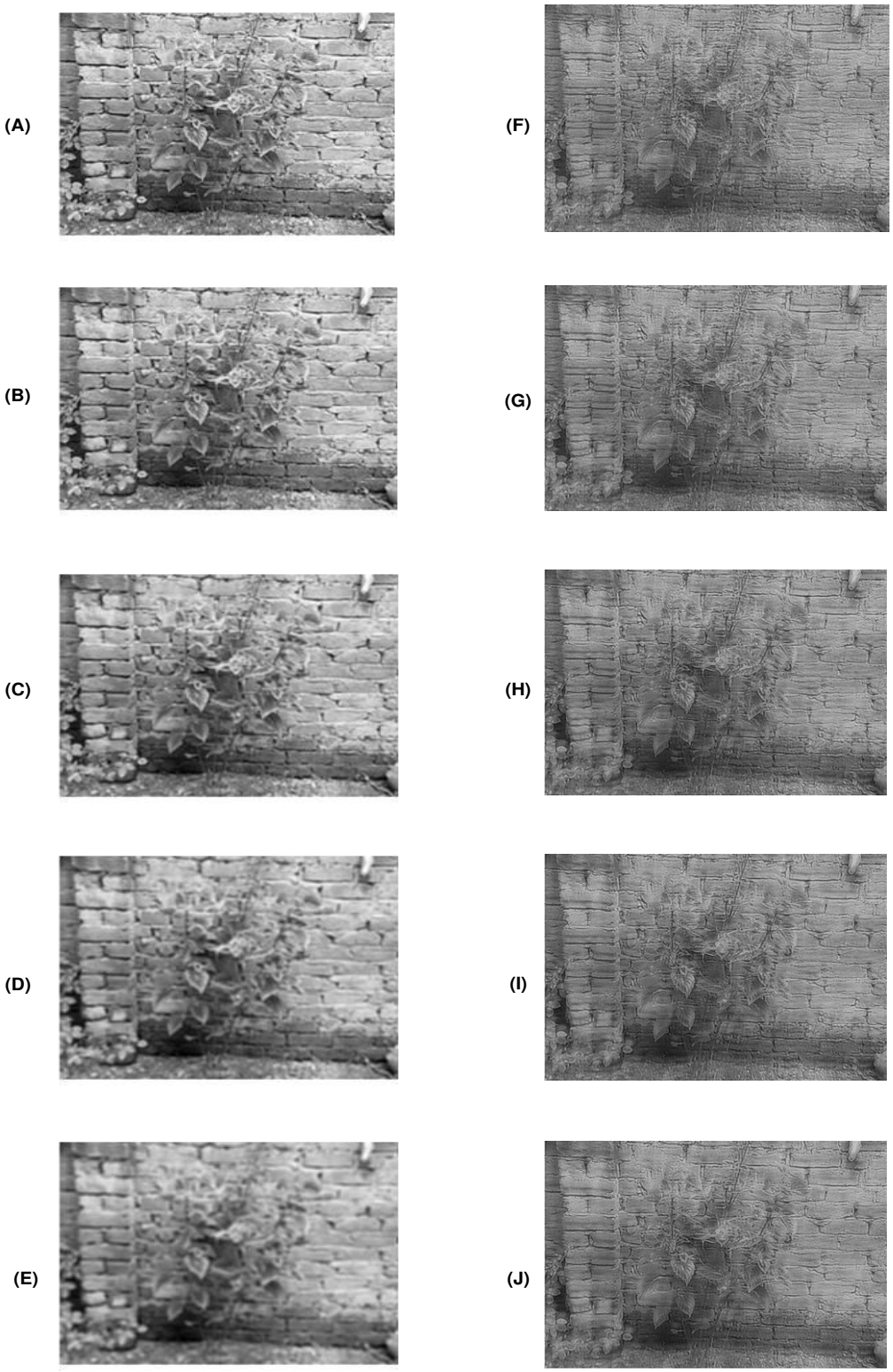

Fig. 3. (A-E) Blurred image with applying circular averaging filter, (F-J) corresponding enhanced images with application of DWT based image fusion.

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V. CONCLUSION

A computer based algorithm is developed for SVD and DWT based image fusion. Various levels of blurring levels of the images were taken using circular averaging filter. SVD showed its dominance over DWT with respect to UIQI having values for blurring level 1 to 5. The values of UIQI for level 1 to 5 are 0.0153, 0.0155, 0.0164, 0.0165, and 0.0154 respectively. Similarly UIQI values for DWT based fusion were 0.0091, 0.0094, 0.0092, 0.0093, and 0.0093 for level 1 to 5 respectively.

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