Intl J Engg Sci Adv Research 2015 Sep;1(3):19-21

Lossy Image Compression with DFrFT-V as Transform Technique

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***Abstract*—This paper discusses the image compression algorithm using Discrete Fractional Fourier Transform with centered DFT (CDFT) kernel(DFrFT-V). Simulation results suggested that image compression using DFrFT-V as transform technique gives better performance when compared to the DFrFT with DFT kernel. Mean squared error (MSE) and peak signal to noise ratio (PSNR) are used to determine the performance.**

***Keywords*—CDFT; image compression; MSE; PSNR; DFrFT-V; DFrFT**

I. Introduction

An image is a two dimensional (2D) signal representation of physical things that are continuous in time and space. In the world of digital machines like computers, a continuous image is sampled and quantized to get a digital image. Obtained images require large number of coefficients to depict the energy. And, shortage of available storage space and limited bandwidth for communication creates problem for such large sized image. Thus compression of image is required to counter the problem of limited storage and transmission bandwidth [1]-[3] while preserving the visual quality of image at reduced cost.

The process of image compression utilizes the spatial redundancy [4] and the irrelevant information intact with the image to reduce the size of image [5]. Image compression considering no loss of information results in identical reconstructed image and hence is known as lossless or reversible image compression [6]. In-order to achieve more extends of compression lossy or irreversible image compression is performed. However, lossy image compression results in impairment known as blocking artifacts. Blocking artifacts are the boundaries of the adjacent blocks in the image, compressed via transform coding. JPEG2000 compression algorithm [7], using discrete cosine transform (DCT) [8], DFrFT [9], discrete fractional cosine transform (DFrCT) [10] are few compression algorithm given in the past.

II. Discrete Fractional Fourier Transform-V

The basic transform given by Jean-Baptiste-Joseph, popularly known as Fourier Transform (FT) [10] didn't proved to be adequate for non-stationary signals. Thus, emergence of fractional transform started back in 1929 and became widely recognized after the work of Namias [11]. Dickinson *et al.* [12] gave S matrix which shares one eigenvector set with DFT and thus used to project Hermite-Gauss eigenvectors [13]. Hermite-Gauss like eigenvectors are very close to the DFT kernel eigenvectors and thus a commutating matrix is used to obtain eigenvectors of the same [13]-[15].

A. Serbes*et al.* [16] defined DFrFT-V which uses the factors of a DFT matrix's basic property according to which identity matrix can be obtained from the four consecutive Fourier Transforms. Mathematically, the property is given as

$$X_N^4 = I_N \qquad (1)$$

whereX_N and I_N is the centered DFT kernel (CDFT) and identity matrix of order N respectively. The kernel of CDFT is given as

$$X_N = \frac{1}{\sqrt{N}}\, exp\left(-j\frac{2\pi}{N}(n-c)(m-c)\right) \qquad (2)$$

Wheren, m= 0, 1, 2, …, (N-1) and $c = (N-1)/2$

The factors of the CDFT matrix are used to obtain four matrices comprising the eigenvectors of CDFT kernel consecutively for four eigen values $\lambda \in \{1, -j, -1, j\}$. The four V matrices for eigen values 1, -1, j and –j respectively are given as

$$V_1 = \frac{1}{2}(R\{X_N\} + (R\{X_N\})^2)(3a)$$

$$V_2 = -\frac{1}{2}(R\{X_N\} - (R\{X_N\})^2)(3b)$$

$$V_3 = \frac{1}{2}(I\{X_N\} + (I\{X_N\})^2)(3c)$$

$$V_4 = -\frac{1}{2}(I\{X_N\} - (I\{X_N\})^2)(3d)$$

where R{} represents the real part and I{} represents the imaginary of the matrix.

In-order to obtain the orthonormal eigenvectors Gauss-Jordan elimination method followed by modified Gram-Schmidt algorithm is implemented, after which ordinary DFT is obtained using a shift permutation matrix. The ordinary DFT matrix kernel F_N is given as

$$F_N = K_N X_N K_N^{-1} \quad (4)$$

where $K_N = \begin{bmatrix} 0 & I_k \\ I_{N-k} & 0 \end{bmatrix}$ for odd N and

$K_N = \begin{bmatrix} 0 & I_{N/2} \\ I_{N/2} & 0 \end{bmatrix}$ for even N.

III. Algorithm

The original image is split into sub-images popularly known as blocks which are processed independently by the transform technique i.e. DFrFT-V. The transformed block coefficients are then quantized to reduce the irrelevant data left with the image after removing the correlation among the pixels by converting the pixels into transform coefficients. The inverse of entire procedure conducted at the encoder end is repeated in reverse sequence at the decoders end. Thus the encoded image undergoes inverse transform coding i.e. IDFrFT-V and then the image is merged to obtain the complete reconstructed image. To determine quality of the reconstructed image MSE and PSNR are used. The formula for MSE is given as [5]

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2 \quad (5)$$

where I and K are the images to be compared.

The formula for PSNR is given as [5]

$$PSNR = 10.\log_{10}\left(\frac{MAX_I^2}{MSE}\right) \quad (6)$$

where MAX_I is the maximum pixel value.

IV. Simulation Results

The complete procedure of compression is tested on test image Lena. The simulation results of DFrFT-V have been compared to DFrFT [17] which suggests that DFrFT-V provides minute improvement in the visual quality of the reconstructed images. In-order to achieve simulation simplicity, the value of a_1 and a_2 are taken similar and denoted by a_{opt}. The plot between fractional order and PSNR for different compression ratios shows that for a particular compression ratio, fractional order affects the PSNR of the reconstructed image. Table 1.compares the optimized parameters of DFrFT-V and DFrFT for Lena and Fig. 1 shows the reconstructed images of Lena using DFrFT-V. Effect of fractional order on the quality of the reconstructed image as been analyzed for compression ratios 10%-70% in Fig. 2 (a).

TABLE 1. Optimized Parameters Of DFrFT-V And DFrFT

Compression Percentage	Transform Technique	a_{opt}	MSE	PSNR
70	DFrFT-V	0.99	9.2335	38.47
	DFrFT	0.99	9.7100	38.25
60	DFrFT-V	0.99	3.8224	42.30
	DFrFT	0.98	4.7529	41.53
50	DFrFT-V	0.98	1.4794	45.59
	DFrFT	0.97	1.7945	44.55
40	DFrFT-V	0.97	0.5402	50.35
	DFrFT	0.97	0.8604	48.78
30	DFrFT-V	0.99	0.2653	53.89
	DFrFT	0.98	0.2695	53.67
20	DFrFT-V	0.97	0.0832	58.92
	DFrFT	0.99	0.0950	58.35
10	DFrFT-V	0.99	0.0036	69.64
	DFrFT	0.98	0.0062	68.45

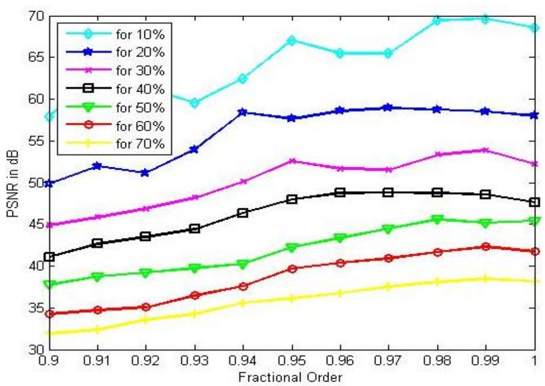
V. Conclusion

DFrFT-V was well established and tested for one-dimensional signals. Thus, it's worth for two-dimensional signal has to be tested. With this perspective, the effectiveness of DFrFT-V as transform technique in the compression algorithm has been studied. DFrFT-V enhanced the quality of the reconstructed image measured via MSE and PSNR.

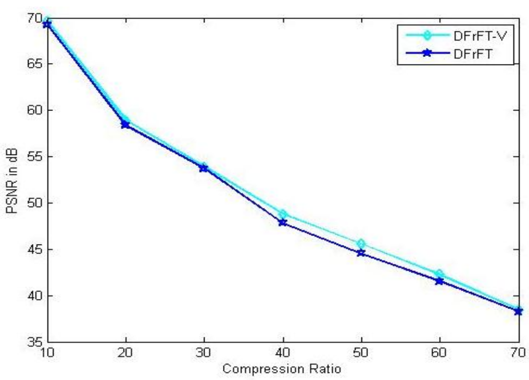
(a) Compressed Image at 70% (b) Compressed Image at 50%

(c) Compressed Image at 30% (d) Compressed Image at 10%

Fig. 1: Compressed image of Lena using DFrFT-V at different compression ratios



(a) Fractional Order vs PSNR



(b) Comparison between DFrFT-V and DFrFT

Fig. 2: Comparison Graphs for different compression percentages

REFERENCES

[1]. K. A. McIntyre, "Dynamic Bandwidth Adaptive Image Compression/ Decompression Scheme," U.S. Patent 7024045, 2006.

[2]. T. L. B. Yng, B. G. Lee , H. Yoo, "A Low Complexity and Lossless Frame Memory Compression for Display Devices," IEEE Trans. Consum. Electron., vol. 54, no. 3, pp. 1453-1458, 2008.

[3]. J. Shukla, M. Alwani, A. K. Tiwari, "A Survey on Lossless Image Compression Methods," in Proc. 2nd Int. Conf.Comput. Eng. Technol.(ICCET), vol. 6, pp. 136-141, 2010.

[4]. S. Jayaraman, S. Esakkirajan, T. Veerakumar, Digital Image Processing, Tata McGraw-Hill Education, 2011.

[5]. R. C. Gonzalez, R. E. Woods, Digital Image Processing, 3rd edition, 2008.

[6]. K. S. Thyagarajan, Still Image and Video Compression with MATLAB, John Wiley & Sons, Inc. Hoboken, New Jersey, 2011.

[7]. Skodras, C. Christopoulos, T. Ebrahimi, "The JPEG 2000 still Image Compression Standard," IEEE Trans.Signal Process, vol. 18, no.5, pp. 36-58, 2001.

[8]. B. Watson, "Image Compression using the Discrete Cosine Transform," Math. J. , vol. 4, no. 1, pp. 81-88, 1994.

[9]. N. Jindal, K. Singh, "Image and Video Processing using Discrete Fractional Transforms," Signal, Image and Video Process, DOI: 10.1007/s11760-012-0391-4, 2012.

[10]. K. Singh, "Performance of Discrete Fractional Fourier Transform Classes in Signal Processing Applications," Ph.D Thesis, Dept. of Elect. Comm. Eng., Thapar Univ., Patiala, India, 2005.