Novel Approach for Image Restoration and Transmission

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Abstract

This paper develops a new technique in image restoration and transmission process, where the image size is halved after transforming it to the frequency domain by applying discrete Fourier transform. The conjugate symmetry and mirror property of transformed image spectrums could be utilized by deleting the redundant spectrums from second half image after tracking and keeping the conjugated locations. Those redundant locations are kept using *one- to- one* relationship. Depending on the halving procedure, the new image size will be divided by two. A reconstructed procedure is created to redistribute the deleted spectrum with their associated locations. The reconstructed image is ready now for restoring again by applying the inverse discrete Fourier transform back to the spatial domain. The restored image is qualified using Peak Signal to Noise Ratio measurement and the result was very satisfied. The advantages of this technique appear in the storage cost, where the memory locations will be reduced to the half. Also, from communication side, this work approved that the image transmission time needs to transmit the halved image is half of the original one.

Keywords: DFT, Conjugate Symmetry, Mirror, One to one.

1. INTRODUCTION

Most of digital image processing methods concern how to process image details in spatial domain. Image details might be color intensity or pixel coordinates (locations). The second domain that digital image could be processed in is the frequency domain. The transformation from spatial domain to the frequency one could be implemented by applying the Two Dimension Discrete Fourier Transform (2D-DFT) or Fast Fourier Transform (FFT) [1] [2]. The transformed image details are spectrums. These spectrums are distributed in a manner that has many properties like: DC coefficients; conjugate symmetry; shifting; and mirror. Transforming from spatial to the frequency domain will still provide same operation and even better because it is an alternative method for low pass and high pass filtering. Also, it could process some particular frequencies efficiency. The convolution in time or spatial domain could be intercepted into multiplication in frequency domain, and for this reason image will be processed as a whole block. This work adopts and develops new technique of considering the half image size in storing and network communication. This technique applies the mirror and conjugate symmetry property in implementing the tracking, mapping, and reconstructing procedure. Image restoration in [1] has different procedure which is based on the intensities of the nearest neighbor of pixel in spatial domain [3][4] . This paper is organized as follows: section 1 is an introduction. Section 2 provides a preview about the 2D DFT and its properties. The tracking, mapping and reconstructing procedure is explained in section 3. Section 4 produces an example of five restored images. The transmitting time for different image size over different networks types is compared in section 5. The final section is the conclusion in section 6.

2. THE TWO DIMENSION DISCRETE FOURIER TRANSFORM

Image with M rows and N columns can be transforming from spatial domain to the frequency domain by applying formula 1. While the inverse Fourier transform could be obtained from applying formula 2.

$$F(U,V) = \sum_{x=1}^{M} \sum_{y=1}^{N} f(x,y)\ exp^{-2\pi j(\frac{xu}{M}+\frac{yv}{N})} \quad (1)$$

$$f(x,y) = 1/MN \sum_{u=1}^{M} \sum_{v=1}^{N} F(U,V)\ exp^{2\pi j(\frac{xu}{M}+\frac{yv}{N})} \quad (2)$$

Where *f(x,y)* is the two dimensional image in the spatial domain and *F(u,v)* is the transformed image in the frequency domain.

Many properties could be obtained from that transformation to the frequency domain, it includes:

- Similarity
- Seprability
- DC Coefficient
- Shifting
- Conjugate Symmetry or Mirror

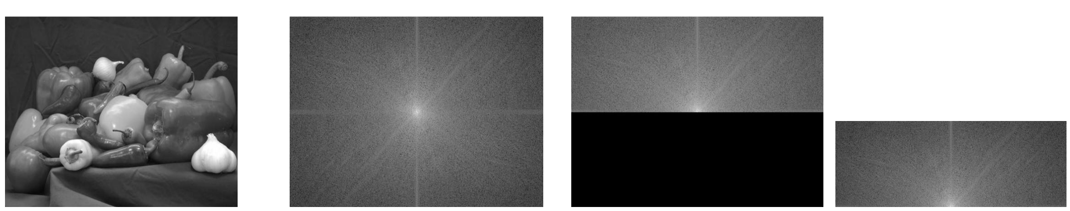
The two DFT properties, the DC coefficient and Mirror property is explained in figure 1. This figure clearly explained that the upper half image is the mirror or complex conjugate to the down half and vise versa. Also, the left half side of image is a mirror to right half side and vise versa. Next section will explain how tracking, mapping is, and reconstruction procedure will utilize these properties to obtain a new image with half size, which means half rows or columns [5][6][7].

	a		a*
b*	B*	d*	A*
	C	DC	C*
b	B	d	A

FIGURE 1: Conjugate Symmetry in 2D DFT.

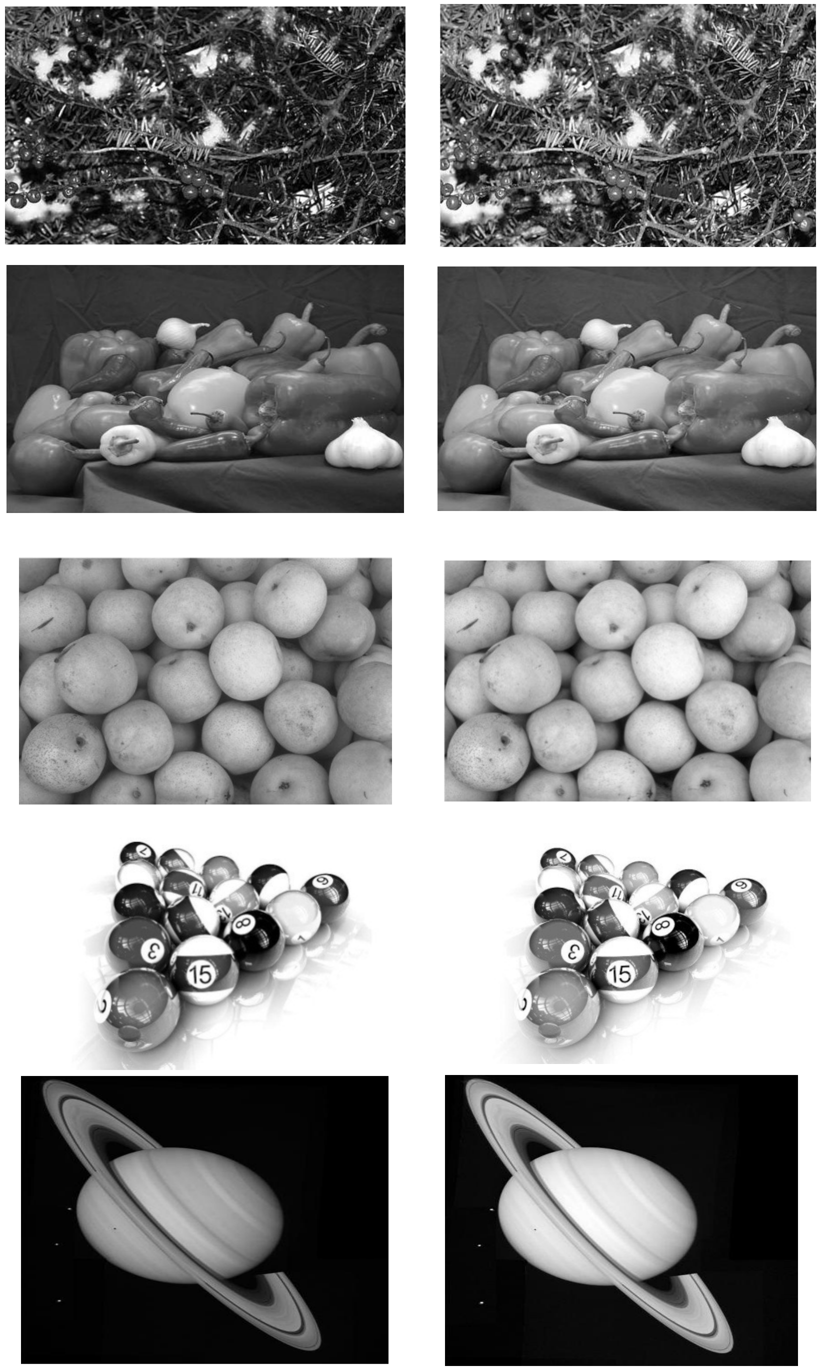
3. ONE - TO - ONE MAP PROCEDURE

A powerful tracking and mapping procedure is applied to track the redundant spectrum locations in the lower half image, keep those 1 to 1 relations, and then delete them. The transformed image size is approximately halved, i.e.; (rows/2 +1) or (columns/2 +1). Now, the new image could be stored or transmitted. The restored or received image should be inversed back to the spatial domain after applying the mapping or reconstructing procedure. The restored image is qualified using Peak Signal to Noise Ratio measurement and the result is shown in figure 2.



(a) original image (b) 2D DFT Spectrums (c) mirror deleting (d) half size image

FIGURE 2: Mapping Procedure Sequence State.



(a) Original images (b) Restored images

FIGURE 3: Five original and restored images, (a) origin images, (b) restored images.

4. THE TRANSMISSION TIME ESTIMATION

The new image file size has been evaluated over data transmission system. Five different images with different file size have been transmitted and the delivery time is calculated as in formula 3.

Packet transmission time = Packet size / Bit rate (3)

Those five images are transformed to the frequency domain by applying the 2D-DFT. Then the redundant (mirror) information is cut-out. The new image size would be approximately halved of the original one. These new images are transmitted again over data transmission system. The file transmission time is re-calculated. Figure 4 represents the wired computer network with bit rate equals to 250 Mb/s.

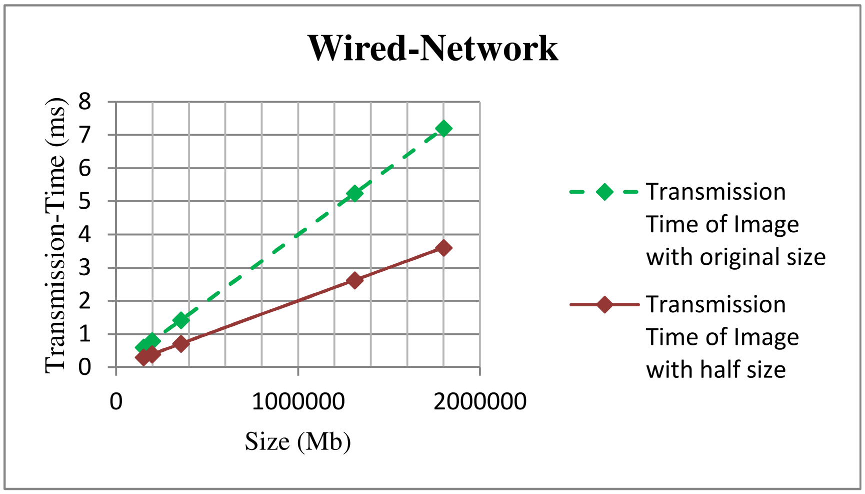


FIGURE 4: Wired Computer Network.

Clearly, the time need to transmit the original size is approximately twice, where the difference for image size 150 Kbyte is 0.3 m sec, while for image size 1.8 M Byte the difference time would be 3.6 m sec and so on as the image file size becomes large the differences time would be larger. Figure 5 belongs to the wireless network with bit rate equals to 600 M b/s. With image file size equals to 150 Kbyte, the difference of the delivery time between the two transmissions is approximately 0.125 msec. for image size 1.8 M Byte the differences time would be 1.5 msec.

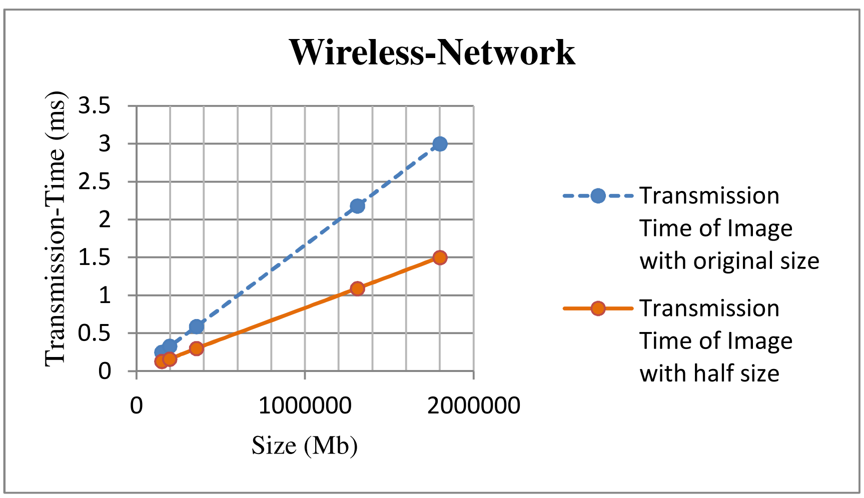


FIGURE 5: Wireless Computer Network.

This result approved that, transmitting half image size will eventually reduce the transmission time to the half under same circumstances like network type, distance, and bit rate.

5. CONCLUSION

A new and novel approach has been considered and implemented. This approach is depending on the two properties of the Two-Dimensional Discrete Fourier Transform, the mirror and the conjugate symmetry. A one -to- one map frequency domain procedure is developed and implemented to half image file and to restore or reconstruct the spatial domain image file again. Five images have been transformed, halved, stored, and restored again. The appearance of those images was very good and the transmission time needed for network delivery is reduced to the half of the original one.

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