Comparative Performance of Image Scrambling in Transform Domain using Sinusoidal Transforms

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Abstract

With the rapid development of technology, and the popularization of internet, communication is been greatly promoted. The communication is not limited only to information but also includes multimedia information like digital Images. Therefore, the security of digital images has become a very important and practical issue, and appropriate security technology is used for those digital images containing confidential or private information especially. In this paper a novel approach of Image scrambling has been proposed which includes both spatial as well as Transform domain. Experimental results prove that correlation obtained in scrambled images is much lesser then the one obtained in transformed images.

Keywords: Scrambling, Key Based Scrambling, Sinusoidal Transforms, DCT, DST, DFT, Real Fourier, Discrete Hartley.

1. INTRODUCTION

Traditional permutation encryption algorithm is not robustness for noise disturbing and shear transformation attacks. An Image encryption algorithm is introduced based on location transformation in [1]. The method is robust against noise and shear transformation attacks which is the advantage over traditional encryption algorithms. The algorithm encrypts the image based on chaotic system and stores the pixel values in multiple places. A variation of extended magic square matrix generating algorithm is also presented. The variation has a good efficiency over the traditional magic square matrix generation algorithm. Experimental results show a good improvement when encrypted image is modified with noise and shear transformation attack.

The unique property of chaotic functions gives its way to Image Encryption. A new combined technique is given in [2] which has better chaotic behavior than the traditional ones. The technique involves the concept of confusion and diffusion in encryption of Digital images. The experimental results show that the method has a higher security level and excellent performance.

Chaotic sequences ranking is used as a base for encryption algorithm and the technique is presented in [3]. The method is aimed at the deficiency of the existing color image encryption method. As the first step the scrambling algorithm scrambles the positions of color image and sets one to one relationship between the image matrix and chaotic sequence. In the next step the row and column of the image matrix ranking were guided by the chaotic sequence ranking. In order to improve the security , the pixel vales of the scrambled color image is shuffled. The shuffling is based on the chaotic sequence ranking. Overall the method has a good encryption effect.

An image encryption is proposed in [4] which is based on logistic map and hyper-chaos. The logistic map is used to generate the chaotic key 1 which has a good randomness. The Hyperchaos system is used to produce the chaotic key2. Encryption algorithm has two rounds each with the two different keys generated with two different chaotic maps. The experimental results show that the method has good results, high efficiency, good statistical characteristics and differential characteristics

Using the Baker map , an image encryption algorithm is presented in [5]. The proposed method makes use of discrete cosine transform (DCT), the discrete sine transform (DST), the discrete wavelet transform (DWT) and the additive wavelet transform (AWT) for Image encryption approach. Chaotic encryption is performed in these transform domains to make use of the characteristics of each domain. Different attacks are studied for all the transforms used for encryption. DST transform gives good results compared to others if degree of randomness is of major concern.

An image encryption algorithm is implemented in transform domain using DWT and stream ciphers. A stream cipher helps to make information (plain text) into an unreadable format. A comparative study on DCT and DWT is also discussed in [6].

A novel approach of Image encryption is proposed in [7], it transforms an encrypted original image into another image which is the final encrypted image and same as the cover image overcoming the drawback of transmitting the noise like image over the network and making it suspicious for intruders. The proposed algorithm is based on Wavelet decomposition. Experimental results show simulation and security analysis results

An extended version of TJ-ACA: advanced cryptographic algorithm is been proposed named as TJ SCA: supplementary cryptographic algorithm for color images in [8]. A white blank image whose preview is not available in transform domain is generated, which makes the brute force attacks ineffective. The proposed method makes use of 2-D fast Fourier transform, ikeda mapping are used to get a highly secured image. The method also gives a Lossless decryption. Therefore the method is applicable to stego images.

A new encryption algorithm based on bit plane decomposition to improve the security level is introduced in [9]. The technique combines parametric bit plane decomposition, bit plane shuffling, resizing, pixel scrambling and data mapping techniques for encryption. For bit plane decomposition, Fibonacci P-code is used and 2D P-Fibonacci is used for image encryption. Experimental result shows the ability of the method against several common attacks. The method can be used to encrypt images, biometrics and videos.

An extension to ScaScra is proposed in [10]. It is used to scramble a digital image in the diagonal direction. The diagonal blocks are first decided, the pixels in these blocks are scrambled using unified constructive permutation function. The scrambling technique is scalable by varying the block size. Subjective and objective experiments were carried out to test the performance of the proposed technique and the results were compared to ScaScra. Experimental parameters like correlation and entropy were used.

An optical information hiding technique for digital images is proposed in[11]. The technique combines the scrambling technique in fractional Fourier domain. Firstly image is randomly shifted using the jigsaw transform algorithm and then a scrambling technique based on Arnold transform is applied. Then the image is iteratively scrambled in fractional Fourier domains using randomly chosen fractional orders. The parameters of the jigsaw transform, Arnold and fractional Fourier forms a huge key space and thus resulting in high security of the proposed encryption method. Experimental results demonstrate the flexibility and robustness of the proposed method.

In [12] the periodicity of scrambling process is analyzed using Arnold transformation to get some universal rules, then improved intersecting cortical Model Neural Network (ICMNN) is used to extract 1D signatures of the original image and scrambled images which reflects the image structure changing process. L1 norm is been adopted to evaluate the scrambling degree and the universal rules obtained above are used to verify the results. The experimental results showed that the proposed method could analyze and evaluate the scrambling degree efficiently.

A symmetric encryption algorithm based on bit permutation, using an iterative process combined with chaotic function is proposed in [13]. The advantage of this technique is secured encryption and getting confusion and diffusion and distinguishability properties in the cipher. The output of the cryptosystem is measured based on the statistical analysis of randomness, sensitivity and correlation on the cipher-images.

Information security and confidentiality is important at different levels of communication. The applications find their way into different fields like personal data, patient’s medical data, military etc. With the advancement in Research in the field of Image processing, Image encryption and steganographic techniques have gained a popularity over the other forms of hidden communication. A new Image Encryption technique using Fibonacci and Lucas is proposed in [14]. The approach makes use of Arnold Transform matrix, and uses the generalized Fibonacci and lucas series values in the Arnold transform to scramble the image.

An encryption technique based on pixels is proposed in[15]. Firstly the image is scrambled using the method of watermarking making it difficult for decoding purpose. Lastly a camouflaged image to vision or the pixels of the true image to get the final encrypted image. The key parameters are encrypted using Elliptic curve cryptography (ECC). The algorithm security, reliability and efficiency is analyzed via experimental analysis.

A new invertible two dimensional map is proposed in [16] called as Line Map, for image encryption and decryption. The method maps the digital image to an array of pixels and then maps it back from array to image. A Line Map consists of two maps, a left map and a right map. The drawback of the traditional 2D maps which can be used only for permutation is overcome by Line Map which can perform two processes of image encryption , permutation and substitution simultaneously using the same maps. The proposed method does not have a loss of information, it is also fast and there is no restriction on the length of the security key.

Non Sinusoidal Transforms , such as Walsh, Slant, Kekre and Haar have been tried for this approach in [19]. Experimental results have have shown Kekre transform performs better then all other Non Sinusoidal Transfoms. In this paper , we are exploring Sinusoidal Transforms such as DCT, DST, Real Fourier, Hartley and DFT.

2. SINUSOIDAL TRANSFORMS

A Transform is a technique for converting a signal into elementary frequency components. Transform coding relies on the premise that pixels in an image exhibit a certain level of correlation with their neighboring pixels. Consequently, these correlations can be exploited to predict the value of a pixel from its respective neighbors. A sinusoidal unitary transform is an invertible linear transform whose kernel describes a set of complete, orthogonal discrete cosine and/or sine basis functions

2.1 Discrete Cosine Transform

A Discrete Cosine Transform (DCT) expresses a sequence of finitely many data points in terms of a sum of cosine functions oscillating at different frequencies. DCTs are important to numerous applications in science and engineering, from lossy compression of audio and images (where small high-frequency components can be discarded), to spectral methods for the numerical solution of partial differential equations. The use of cosine rather than sine functions is critical in these applications: for compression, it turns out that cosine functions are much more efficient, whereas for differential equations the cosines express a particular choice of boundary conditions.

The DCT can be written as the product of a vector (the input list) and the n x n orthogonal matrix whose rows are the basis Vectors. We can find that the matrix is orthogonal and each basis vector corresponds to a sinusoid of a certain frequency. The general equation for a 2D (N data items) is given below

$$F(m,n) = \frac{2}{\sqrt{\mathrm{MN}}} C(m)C(n) \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x,y) cos\frac{(2x+1)m\pi}{2M} cos\frac{(2y+1)n\pi}{2N} \tag{1}$$

Where C(m),C(n)=1/$\sqrt{2}$ for m, n=0 and C(m) , C(n)=1 otherwise

2.2 Discrete Sine Transform

The Discrete Sine Transform (DST) is a member of sinusoidal unitary transforms family.DST is real, symmetric, and orthogonal. It is used as an alternative transform in Transform Coding system. The general equation for a 2D (N data items) is given below.

$$\varphi(k,n) = \sqrt{\frac{2}{N+1}} \quad \sin\frac{\pi(k+1)(n+1)}{N+1} \tag{2}$$

Where 0≤ k, n ≤N-1

2.3 Real Fourier

The Real Fourier of a finite real data sequence {f(m)} of length N(even) is defined as[17]

$$\left.\begin{aligned} F(k) &= \frac{1}{N}\sum_{m=0}^{N-1} \sin\frac{\pi(k+1)(2m+1)}{2N} \\ F(k+1) &= \frac{1}{N}\sum_{m=0}^{N-1} \cos\frac{\pi(k+1)(2m+1)}{2N}, k = 0,2,\dots,(N-2) \end{aligned}\right\} \tag{3}$$

Where

$$f(m) = 2 \sum_{\substack{k=0 \\ k=even}}^{N-2} F(k) \sin\frac{\pi(k+1)(2m+1)}{2N} +$$

$$2 \sum_{\substack{k=0 \\ k=even}}^{N-2} F(k+1) X \cos\frac{\pi(k+1)(2m+1)}{2N} , m = 0,1,\dots.,(N-1) \tag{4}$$

2.4 Discrete Hartley Transform

The Discrete Hartley Transform (DHT) pair is defined for a real- valued length-N sequence x(n), 0 ≤ n ≤ N-1, by the following equation

$$H(k) = \sum_{n=0}^{N-1} x(n) cas\left(\frac{2\pi}{N} kn\right) \quad 0 \le k \le N-1) \tag{5}$$

$$x(n) = \frac{1}{N}\sum_{k=0}^{N-1} H(k)cas\left(\frac{2\pi}{N}\,kn\right) \quad 0 \le n \le N-1 \tag{6}$$

Where cas(x) = cos(x)+sin(x)

The symmetry of the transform pair is a valuable feature of the DHT.

2.5 Discrete Fourier Transform

A discrete formulation of the Fourier transform, which takes place at regularly spaced data values, and returns the value of the Fourier transform for a set of values in frequency space which are equally spaced. The 2D DFT is given as

$$F(u,v) = \frac{1}{NM}\sum_{x=0}^{N-1}\sum_{y=0}^{M-1} f(x,y)e^{-2\pi i\left(\frac{xu}{N}+\frac{yv}{M}\right)} \tag{7}$$

3. KEY BASED IMAGE SCRAMBLING IN TRANSFORM DOMAIN

In this paper we are presenting a novel approach for Image scrambling involving both the spatial as well as transform domain. As we know whenever a transform is applied to an image, image is converted from spatial domain to transform domain, and transform coefficients are obtained. To obtain the original image the inverse transform is applied to the transform coefficients. But if the transform coefficients are affected due to any transformation we will not obtain the original image. Using this concept in this paper we have used Key based scrambling[18] which is based on the Random numbers generation based on the size of the image is used for scrambling purpose. The proposed approach is not limited to a particular scrambling method or a transform, the said approach can make use of any scrambling technique or transform on the image.

3.1 Image Scrambling

Following are the steps used for Image Scrambling

1) Read the image, convert it to grayscale
2) Apply a Transform on the image
3) Transform coefficients which are obtained in step 2 are now scrambled using key based scrambling method.
4) Apply inverse transform on the scrambled transform coefficients obtained in step 3.
5) The image obtained in spatial domain will now be scrambled

The scrambling process is also shown in the figure 1.

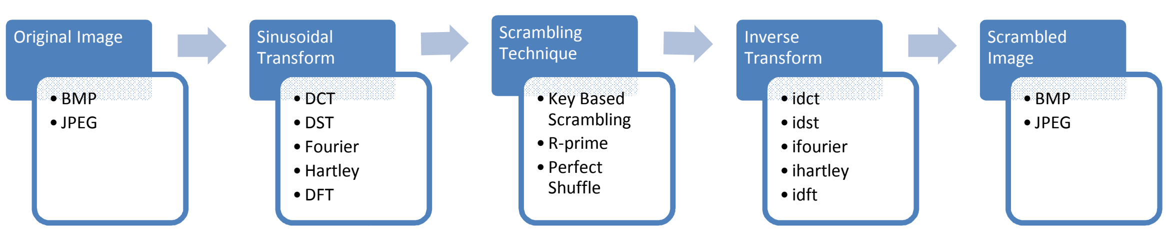


FIGURE 1: This Different Steps of Scrambling Process.

3.2 Image Descrambling

The descrambling process is as follows

1) Read the scrambled image
2) Apply the Transform on the image
3) Transform coefficients which are obtained in step 2 are now descrambled using key based descrambling method.
4) Apply inverse transform on the descrambled transform coefficients obtained in step 3.
5) The image obtained in spatial domain will now be original Image

The descrambling process is also shown in the figure 2.

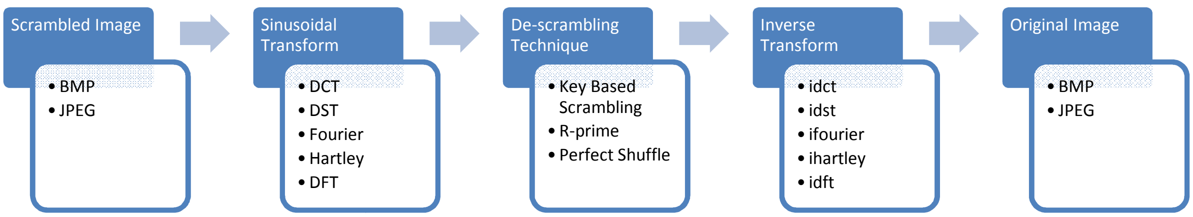


FIGURE 2: This Different Steps of De-Scrambling Process.

4. EXPERIMENTAL RESULTS

For Experimental purpose, five images of size 256X256 were used with all the five sinusoidal transforms. Figure 3(a) shows the Original Image which is a 24-bit color image which is first converted to grayscale as shown in Figure 3(b), Although the novel approach proposed can also be extended on 24-bit color images.

(a) Original Image (b) Gray Image

FIGURE 3

Figure 4(a-c) shows the scrambled images obtained in spatial domain by applying DCT row, DCT Column and DCT Full transform along with Key-based scrambling on the grayscale images. The descrambled images obtained after applying the descrambling steps are shown in Figure 4(d-f).

(a)DCT Row Transform Scrambled | (b)DCT Column Transform Scrambled | (c)DCT Full Transform Scrambled

(d)DCT Row Transform Descrambled | (e)DCT Col Transform Descrambled | (f)DCT Full Transform Descrambled

FIGURE 4

Figure 5(a-c) shows the scrambled images obtained in spatial domain by applying DST row, DST Column and DST Full transform along with Key-based scrambling on the grayscale images. The descrambled images obtained after applying the descrambling steps are shown in Figure 5(d-f).

(a)DST Row Transform Scrambled | (b)DST Column Transform Scrambled | (c)DST Full Transform Scrambled

(d) DST Row Transform Descrambled | (e) DST Col Transform Descrambled | (f) DST Full Transform Descrambled

FIGURE 5

Figure 6(a-c) shows the scrambled images obtained in spatial domain by applying Real Fourier row, Real Fourier Column and Real Fourier Full transform along with Key-based scrambling on the grayscale images. The descrambled images obtained after applying the descrambling steps are shown in Figure 6(d-f).

(a)Real Fourier Row Transform Scrambled

(b)Real Fourier Column Transform Scrambled

(c)Real Fourier Full Transform Scrambled

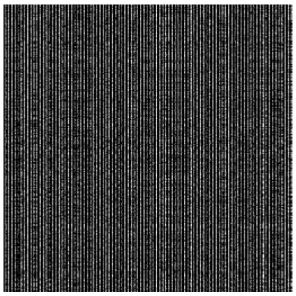
(d)Real Fourier Row Transform descrambled

(e)Real Fourier Column Transform descrambled

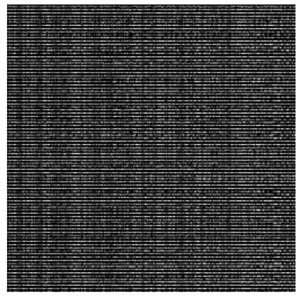
(f)Real Fourier Full Transform descrambled

FIGURE 6

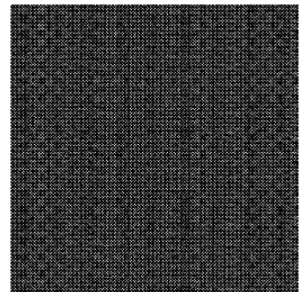
Figure 7(a-c) shows the scrambled images obtained in spatial domain by applying Hartley row, Hartley Column and Hartley Full transform along with Key-based scrambling on the grayscale images. The descrambled images obtained after applying the descrambling steps are shown in Figure 7(d-f).



(a)Hartley Row Transform Scrambled



(b)Hartley Column Transform Scrambled



(c)Hartley Full Transform Scrambled

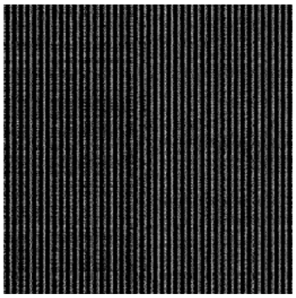
(d)Hartley Row Transform descrambled

(e)Hartley Column Transform descrambled

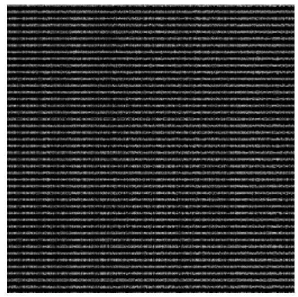
(f)Hartley Full Transform descrambled

FIGURE 7

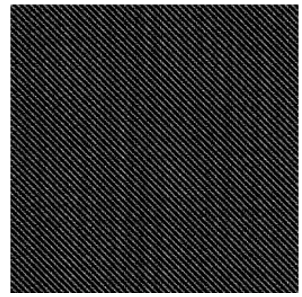
Figure 8(a-c) shows the scrambled images obtained in spatial domain by applying DFT row, DFT Column and DFT Full transform along with Key-based scrambling on the grayscale images. The descrambled images obtained after applying the descrambling steps are shown in Figure 8(d-f).



(a)DFT Row Transform Scrambled



(b) DFT Column Transform Scrambled



(c)DFT Full Transform Scrambled

(d)DFT Row Transform descrambled

(e) DFT Column Transform descrambled

(f)DFT Full Transform descrambled

FIGURE 8

	Original Image :Lena [Row: 0.8439 and col: 0.6937]					
Transform	**Row Transform**	**Row Transform Scrambled**	**Column Transform**	**Column Transform Scrambled**	**Full Transform**	**Full Transform Scrambled**
DCT	Row: 0.9938 Col: 0.1958	Row: 0.5546 Col: 0.3890	Row: 0.1907 Col: 0.9932	Row: 0.4802 Col: 0.6521	Row: 0.2062 Col: 0.2202	Row: 0.5576 Col: 0.5835
DST	Row: 0.9940 Col: 0.2079	Row: 0.5383 Col: 0.3316	Row: 0.1910 Col:0.9909	Row: 0.4543 Col: 0.5676	Row: 0.3048 Col: 0.3395	Row: 0.5271 Col:0.5232
Real Fourier	Row: 0.9956 Col:0.2131	Row: 0.5771 Col: 0.2237	Row: 0.1901 Col:0.9930	Row: 0.4507 Col: 0.2054	Row: 0.2093 Col:0.2345	Row: 0.3222 Col:0.2601
Hartley	Row: 0.9947 Col:0.2136	Row: 0.2385 Col: 0.2224	Row: 0.2160 Col:0.9931	Row: 0.1969 Col:0.2175	Row: 0.3966 Col: 0.4995	Row: 0.2096 Col:0.2048
DFT	Row: 0.9961 Col: 0.1736	Row: 0.2697 Col: 0.1677	Row: 0.1860 Col: 0.9961	Row: 0.1308 Col:0.2117	Row: 0.4178 Col: 0.4599	Row: 0.1877 Col: 0.1780

	Original Image :Pepper [Row: 0.8891 and col: 0.8468]					
Transform	**Row Transform**	**Row Transform Scrambled**	**Column Transform**	**Column Transform Scrambled**	**Full Transform**	**Full Transform Scrambled**
DCT	Row: 0.9926 Col: 0.1890	Row: 0.5381 Col: 0.3483	Row: 0.1888 Col: 0.9932	Row: 0.4156 Col: 0.6019	Row: 0.2278 Col: 0.3145	Row: 0.5571 Col: 0.5680
DST	Row: 0.9919 Col: 0.1892	Row: 0.5707 Col: 0.3907	Row: 0.2013 Col: 0.9899	Row: 0.3830 Col: 0.5207	Row: 0.3547 Col: 0.2044	Row: 0.4879 Col: 0.5080
Real Fourier	Row: 0.9955 Col: 0.2018	Row: 0.5126 Col: 0.2291	Row: 0.1892 Col: 0.9929	Row: 0.3722 Col: 0.2334	Row: 0.2384 Col: 0.2374	Row: 0.4108 Col: 0.3003
Hartley	Row: 0.9941 Col: 0.2004	Row: 0.3166 Col: 0.1965	Row: 0.2032 Col: 0.9933	Row: 0.1857 Col: 0.2439	Row: 0.5053 Col: 0.5722	Row: 0.2656 Col: 0.2227
DFT	Row: 0.9961 Col: 0.1559	Row: 0.3901 Col: 0.1383	Row: 0.1605 Col: 0.9961	Row: 0.1265 Col: 0.2696	Row: 0.4932 Col: 0.5445	Row: 0.2429 Col: 0.2116

	Original Image :Lotus [Row: 0.8163 and col: 0.8461]					
Transform	**Row Transform**	**Row Transform Scrambled**	**Column Transform**	**Column Transform Scrambled**	**Full Transform**	**Full Transform Scrambled**
DCT	Row:0.9839 Col: 0.1847	Row: 0.3744 Col: 0.4335	Row: 0.1950 Col: 0.9915	Row: 0.3806 Col: 0.4547	Row: 0.2391 Col: 0.2292	Row: 0.4567 Col: 0.5137
DST	Row: 0.9795 Col: 0.1901	Row: 0.4459 Col: 0.4601	Row: 0.1996 Col: 0.9879	Row: 0.3821 Col: 0.2824	Row:0.3615 Col: 0.3170	Row: 0.4182 Col: 0.4148
Real Fourier	Row: 0.9918 Col: 0.1914	Row: 0.3810 Col: 0.2458	Row: 0.2012 Col: 0.9892	Row: 0.3649 Col: 0.2126	Row: 0.2531 Col: 0.2311	Row: 0.2906 Col: 0.3091
Hartley	Row: 0.9884 Col: 0.2290	Row: 0.2134 Col: 0.2146	Row: 0.1860 Col: 0.9915	Row: 0.2061 Col: 0.2148	Row: 0.3902 Col: 0.4168	Row: 0.2153 Col: 0.1902
DFT	Row: 0.9939 Col: 0.1908	Row: 0.2007 Col: 0.1426	Row: 0.1369 Col: 0.9954	Row: 0.1415 Col: 0.2143	Row: 0.3442 Col: 0.3701	Row: 0.1844 Col: 0.1405

	Original Image :Baboon [Row: 0.7179 and col: 0.6935]					
Transform	**Row Transform**	**Row Transform Scrambled**	**Column Transform**	**Column Transform Scrambled**	**Full Transform**	**Full Transform Scrambled**
DCT	Row: 0.9912 Col: 0.2006	Row: 0.6365 Col: 0.3851	Row: 0.2721 Col: 0.9935	Row: 0.3866 Col: 0.6583	Row: 0.2778 Col: 0.2159	Row:0.5723 Col: 0.5739
DST	Row: 0.9923 Col: 0.2029	Row: 0.7196 Col: 0.3702	Row: 0.2912 Col: 0.9927	Row: 0.3789 Col: 0.5446	Row: 0.3865 Col: 0.3444	Row:0.4690 Col: 0.5042
Real Fourier	Row: 0.9953 Col: 0.2096	Row: 0.6600 Col: 0.2457	Row: 0.1987 Col: 0.9937	Row: 0.3794 Col: 0.1922	Row: 0.2179 Col: 0.2179	Row:0.2420 Col: 0.2749
Hartley	Row: 0.9928 Col: 0.2144	Row: 0.2002 Col: 0.2370	Row: 0.2633 Col: 0.9937	Row: 0.1911 Col: 0.1918	Row: 0.4242 Col: 0.3475	Row:0.1825 Col: 0.1937
DFT	Row: 0.9961 Col: 0.1684	Row: 0.1945 Col: 0.1575	Row: 0.2569 Col: 0.9961	Row: 0.1350 Col: 0.1754	Row: 0.3952 Col: 0.2750	Row:0.1422 Col: 0.1430

	Original Image :Cartoon [Row: 0.8027 and col: 0.8070]					
Transform	**Row Transform**	**Row Transform Scrambled**	**Column Transform**	**Column Transform Scrambled**	**Full Transform**	**Full Transform Scrambled**
DCT	Row: 0.9945 Col: 0.1887	Row: 0.7014 Col: 0.5178	Row: 0.2556 Col: 0.9955	Row: 0.5230 Col: 0.7489	Row: 0.2897 Col: 0.2238	Row:0.6601 Col: 0.6596
DST	Row: 0.9944 Col:0.2056	Row: 0.8154 Col: 0.4576	Row: 0.2646 Col: 0.9953	Row: 0.4515 Col: 0.6254	Row: 0.3048 Col: 0.5047	Row: 0.5924 Col: 0.5571
Real Fourier	Row: 0.9959 Col: 0.2185	Row: 0.7298 Col: 0.2971	Row: 0.2217 Col: 0.9954	Row: 0.4903 Col: 0.2254	Row: 0.2613 Col: 0.2383	Row: 0.3178 Col: 0.3187
Hartley	Row: 0.9949 Col: 0.2605	Row: 0.2700 Col: 0.2675	Row: 0.1983 Col:0.9954	Row: 0.2046 Col: 0.2337	Row: 0.3954 Col: 0.5162	Row:0.2412 Col: 0.2146
DFT	Row: 0.9961 Col: 0.2406	Row: 0.3027 Col: 0.1623	Row: 0.1492 Col: 0.9961	Row: 0.1299 Col: 0.2483	Row: 0.3068 Col: 0.4806	Row: 0.2410 Col: 0.1872

TABLE 1: Average Row and Average Column correlation obtained in Row Transform , Row Transform scrambled , Column Transform , Column Transform Scrambled , Full Transform and Full Transform scrambled images for DCT, DST, Real Fourier , Hartley and DFT Transforms

The Figure 9 – Figure 13 shows the blockwise cummulative energy in the transform coefficients after applying row transform, column transform and full transform. Energy in the coefficients is calculated by dividing the image in to blocks. The first block is of size 2x2 ,the second block considered is 4X4 which includes the first block and an increase in the block size by 2 and so on.

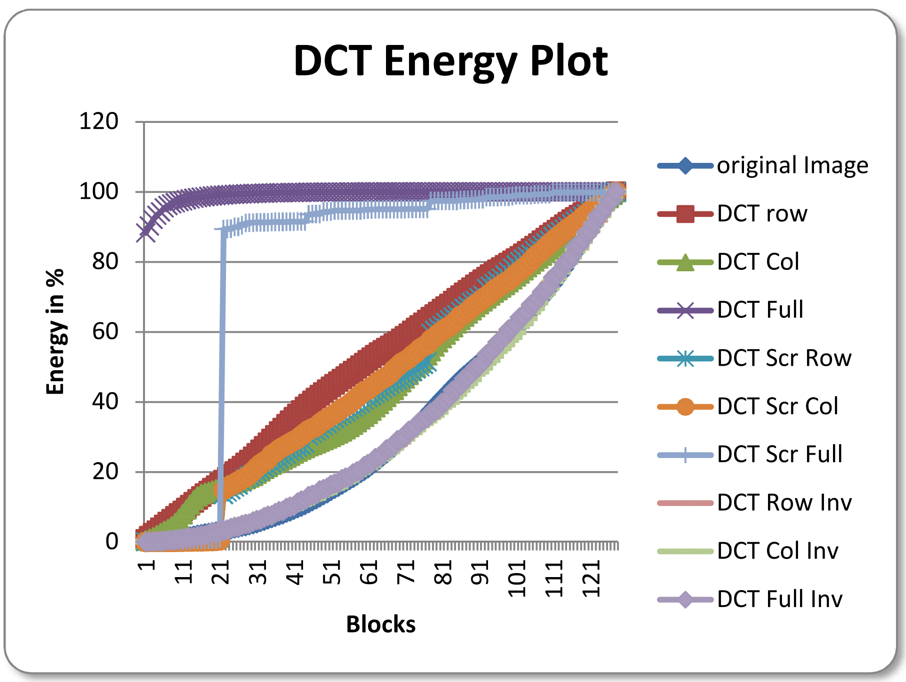


FIGURE 9: Block wise Energy obtained in original, DCT row, DCT column, DCT full, DCT row scrambled, DCT Column Scrambled, DCT Full scrambled, DCT row Inverse scrambled, DCT col Inverse scrambled, and DCT full Inverse scrambled.

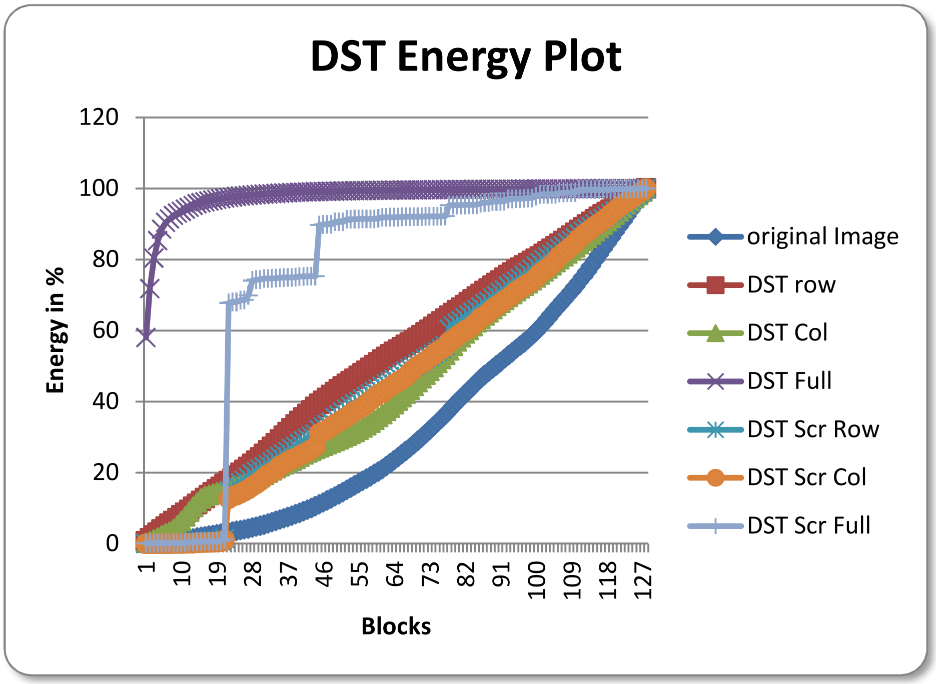


FIGURE 10: Block wise Energy obtained in original, DST row, DST column, DST full, DST row scrambled, DST Column Scrambled, and DST Full scrambled.

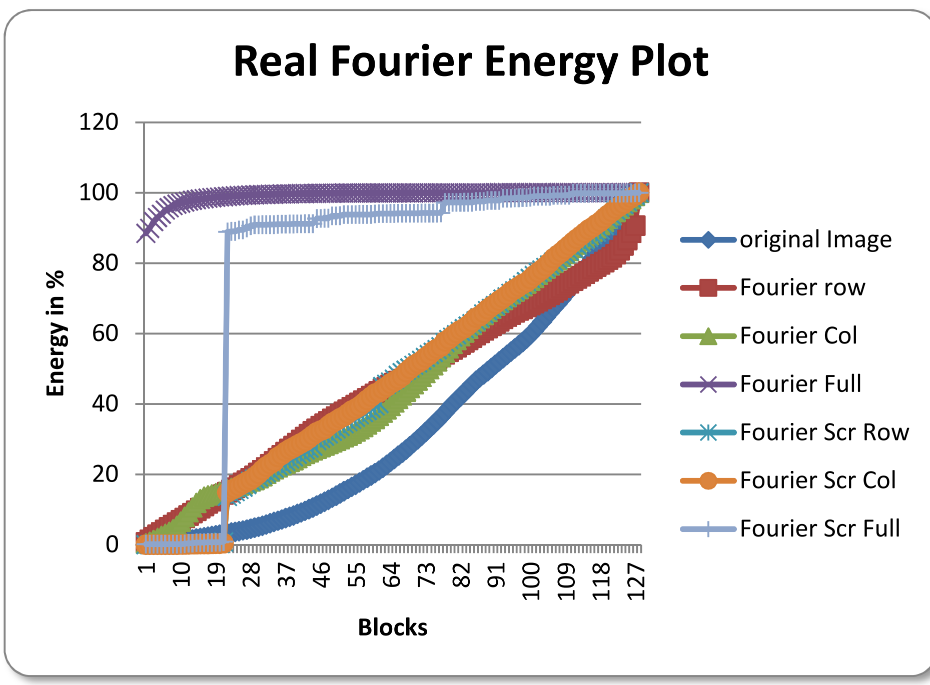


FIGURE 11: Block wise Energy obtained in original, Real Fourier row, Real Fourier column, Real Fourier full, Real Fourier row scrambled, Real Fourier Column Scrambled, and Real Fourier Full scrambled.

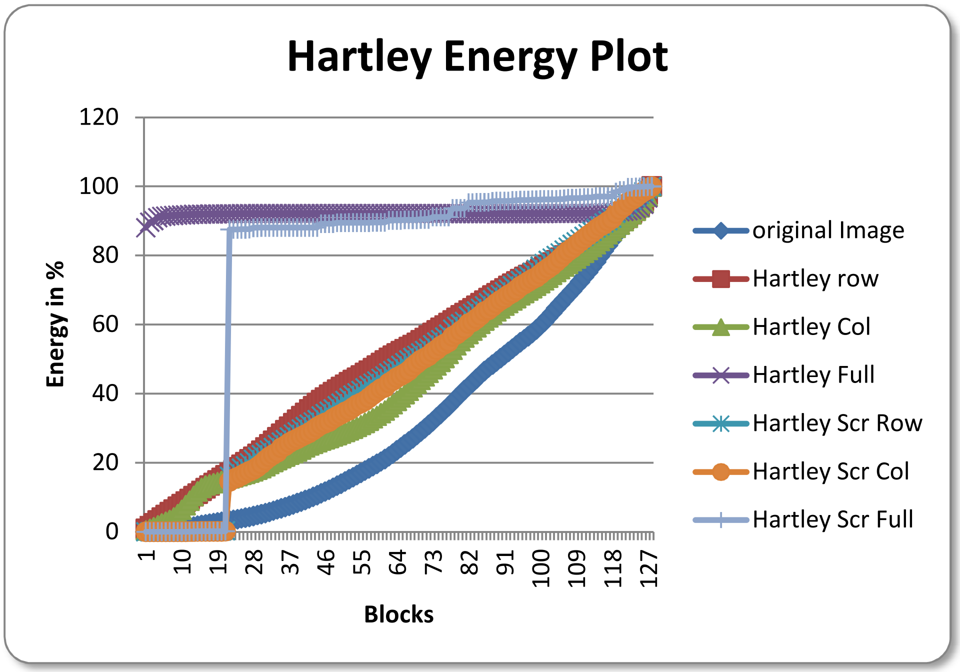


FIGURE 12: Block wise Energy obtained in original, Hartley row, Hartley column, Hartley full, Hartley row scrambled, Hartley Column Scrambled, and Hartley Full scrambled.

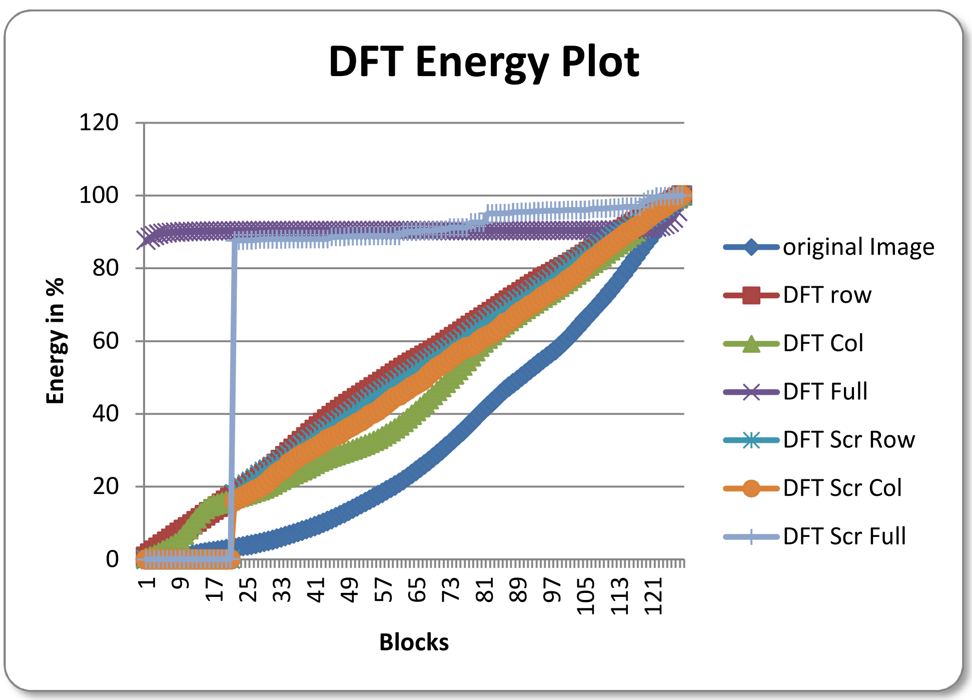


FIGURE 13: Block wise Energy obtained in original, DFT row, DFT column, DFT full, DFT row scrambled, DFT Column Scrambled, and DFT Full scrambled.

5. EXPERIMENTAL RESULTS DISCUSSION

A Transform is a technique for converting a signal into elementary frequency components. Transform coding relies on the premise that pixels in an image exhibit a certain level of correlation with their neighboring pixels. consequently, these correlations can be exploited using Image Scrambling techniques. The main goal of an Image Scrambling is to decorrelate the image pixels as much as possible so that image data is scrambled and appears in an unreadable format. Reducing the correlation between the rows and columns of the image will be helpful for any scrambling technique. Using this as an experimental parameter, Average correlation between rows and columns is calculated. As we know that applying a transform on the image decorrelates the image pixels, to find out whether a further reduction of this correlation can be obtained by our novel approach, five sinusoidal transforms were tested on a number of images. The experimental results obtained are shown in Table No 1 for five images. The highlighted cells in the Table No 1 show that DHT and DFT proves to be the best in all the three cases of transform applied on a digital image , that is row transform , column transform and full transform. Although the other three that is DCT , DST and Real Fourier gave good results of decorrelation in row transform. However other cases of these three transform does not increase the correlation by a very large value, it is in a marginal range.

To Test these transforms further, we have taken into consideration the energy distribution in original, Transformed and Transform scrambled images. The observations made from the Energy Plot for DCT, DST, Real Fourier, Discrete Hartley and DFT are as follows

Original Image	**Row Transformed Image**	**Column Transformed Image**	**Full Transformed Image**	**Row Transform Scrambled Image**	**Column Transform Scrambled Image**	**Full Transform Scrambled Image**
Linear Increase in energy	Small step linear increase in energy	Small step linear increase in energy	High in the initial blocks and den small increases to reach 100%	Small step linear increase in energy	Small step linear increase in energy	Very less value in the initial blocks and a sudden jump after blocks size >20

6. CONCLUSION

In this paper we have presented a Novel Approach for Image scrambling in Transform Domain using Sinusoidal Transforms like DCT, DST, Real Fourier, Hartley and DFT. From the experimental results it is clear that our proposed approach can be used for secured image scrambling. The Correlation obtained for Discrete Hartley and DFT proves to be very less which was our main goal of Image scrambling. The energy plot observations can also be used as a measure for detecting Image scrambling in transform domain for full sinusoidal transforms. The Proposed Approach is a combination of both transform as well as spatial domain, hence it is very useful for Image scrambling and provides more security.

In the previous case[19] , we have found that Kekre transform gave the best performance as compared to all other Non Sinusoidal transforms. The transforms used in this paper gave the performance close to Kekre transform with DFT and Discrete Hartley proving better than that.

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