MODELING SIMULATION AND EVALUATION OF DCT & DWT BASED IMAGE COMPRESSION AND ENHANCED DBA BASED NOISE REMOVAL FOR OFDM-4G SYSTEM

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***Abstract*:** With the continued growth for high speed communication, the development of orthogonal frequency division multiplexing (OFDM) has evolved. In OFDM data are divided into sub careers which is related to multi career modulation method. In OFDM system, the transmission of high-speed data stream comprising a plurality of parallel using a lower data rate subcarrier. MIMO-OFDM is also used in 4G application, due to the high bandwidth frequency standing. Discrete wavelet transform (DWT) and Discrete cosine modify (DCT) is widely regarded as an operative way to replace the traditional FFT OFDM systems due to its improved time-frequency orientation, changing the bit incorrectness grade, minimizes the additional advance in bandwidth efficiency and thus improving the communication system in the time-frequency domain. It can be achieved because it can give quantify and frequency synchronization of the message roughly a good approximation of the adverse effect, so that when the signalize performance gets degraded, OFDM uses wavelet-based technique to counter it, which reduces the wastage of bandwidth. In the proposed work we have developed a DWT and DCT in OFDM system based on image transmission and compression. Performance of the system is based on AWGN channel, but also with the underlying value of fading channels on PSNR and BER analysis. I have also developed the entire process of the graphical user interface (GUI) and MATLAB application (APP).

Keywords- DCT, DWT, OFDM, PSNR, Image Compression.

I. INTRODUCTION

"Orthogonal" name of the OFDM describes the mathematical relationship between the frequencies in the system and the carriers. In a normal FDM system, the separation of a conventional filters and demodulators to receive such a way out of multi-vector signal. In such a receiver, which must be introduced by separate vectors, and the frequency-domain spectral efficiency of these results with the protection guard bands between the increases in degradation. It is possible, however, for each OFDM carrier signal and the carrier sideband such a stacked arrangement without any adjacent carrier interference can receive the signal. To maintain this support, it must have orthogonal characteristics. Bank performance receiver demodulator, each carrier signal is a direct current, then in a unified symbol period to recover the original data resulting down converted [3]. If other operators are playing down its frequency in the time domain, in the circulation integer (T) symbol periods, then the results from the integration of these operators to handle all the zero contribution. Thus, operators are linearly independent (i.e., orthogonal) Thus the carriers are linearly independent (i.e. orthogonal) if the carrier spaced by the multiple of 1/t.

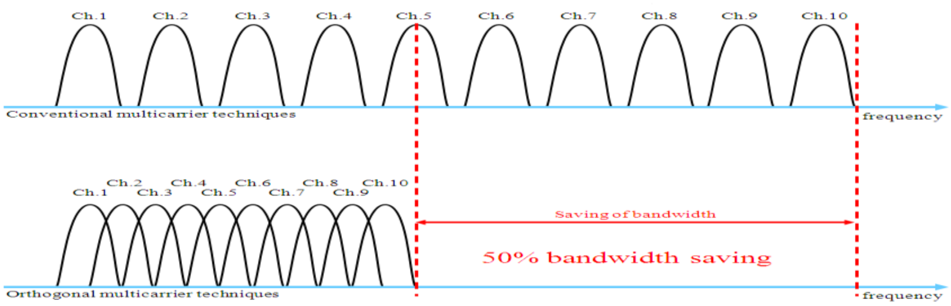


Fig:1.1. Frequency spectrum FDM Vs OFDM

Orthogonal Frequency Division Multiplexing (OFDM) is a multicarrier modulation scheme, where the sub-carrier frequency demoniacally relevant. In other words, the orthogonal subcarriers carrying multi-carrier modulation scheme is called OFDM. Let Xk for k=0 to n-1 be the set of complex symbols to be broadcasted by multicarrier modulation, the continuous time domain MCM signal can be expressed as

$$x(t) = \sum_{k=0}^{N-1} Xk\ exp(j2\pi fkt) \quad \text{for } 0 \le t \le Ts$$

$$= \sum_{k=0}^{N-1} Xk\varphi k\ (t) \quad \text{for } 0 \le t \le Ts \tag{1}$$

$$\text{where } fk = fo + k\Delta f \text{ and } \quad \varphi k\ (t) = \begin{cases} exp(j2\pi fkt) & 0 \le t \le Ts \\ 0 & \text{otherwise} \end{cases} \tag{2}$$

For k = 0, 1, 2...N −1. The subcarriers become orthogonal if Ts Δ f = 1, and such a modulation scheme is called OFDM, where Ts and Δf are called the OFDM symbol duration and the subcarrier frequency spacing respectively. In case of orthogonal subcarriers x(t)denotes a time domain OFDM signal. The orthogonality among sub carriers can be viewed in time domain as shown in Fig 1.1.Each curve represents the time domain view of the wave for a subcarrier. As seen from Fig.1.2, in a single OFDM symbol duration, there are integer numbers of cycles of each of the subcarriers.

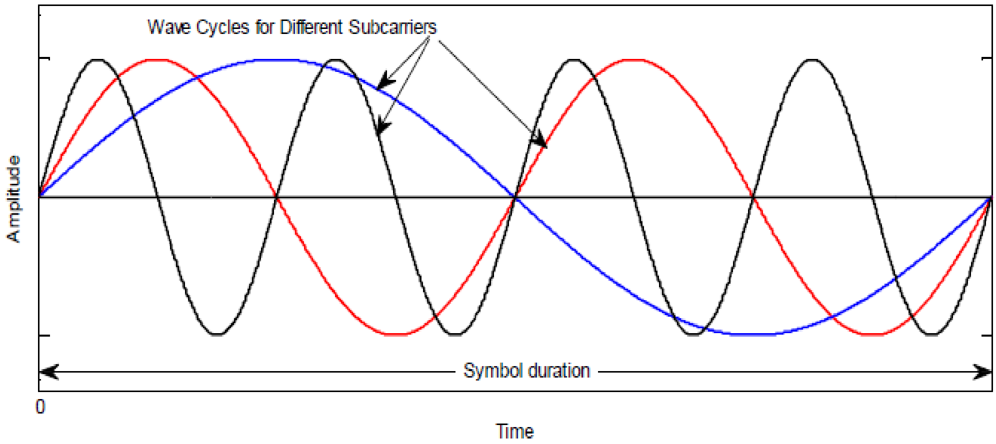


Fig 1.2. Time domain representation of the signal waveforms to show orthogonality among the subcarriers

Because of the orthogonality condition, we have

$$1/Ts \int_0^{Ts} \varphi k(t)\ \varphi j * (t)\ dt$$

$$1/Ts \int_0^{Ts} ej2\pi(fk - fl)\ t\ dt$$

$$= \delta\ [k-l] \tag{3}$$

$$\text{Where} \quad \delta\ [n] = \begin{cases} 1 & \text{if } n=0 \\ 0 & \text{otherwise} \end{cases}$$

Equation 2 shows that φk (t) for k=0 to N-1 is a set of orthogonal functions. Using this property, the OFDM signal can be demodulated as

$$= \ 1/Ts \int_0^{Ts} x(t)ej2\pi fk\ t\ dt$$

$$= \ 1/Ts \int_0^{Ts} (\sum_{l=0}^{N-1} x(t)\varphi k(t))\ \varphi j * (t)\ dt$$

$$= \sum_{l=0}^{N-1} x\ l\ \delta\ [k\text{-}l]$$

$$= xk \tag{4}$$

II. DCT & DWT

A. DWT

Wavelet- based image compression is the order of the day as it enjoys several advantages. Primarily, it uses an unconditional basis function that minimizes the size of the expansion coefficients to a negligible value as the index values increase. The wavelet expansion allows for a more accurate and localized isolation and description of the signal characteristics. This ensures that DWT is very effective image compression applications. Secondly, the inherent flexibility in choosing a wavelet gives scope to design wavelets customized to suit the individual needs of design Wavelets.

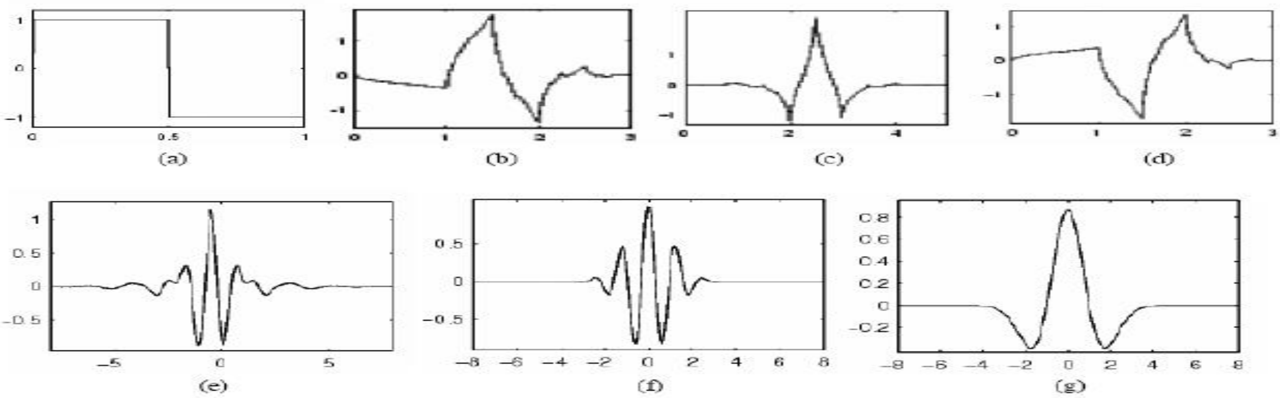


Fig 2.1. Commonly used wavelet functions (a) Haar (b) Daubechies4 (c) Coiflet1 (d)Symlet2 (e) Meyer (f) Morlet (g) Mexican Hat

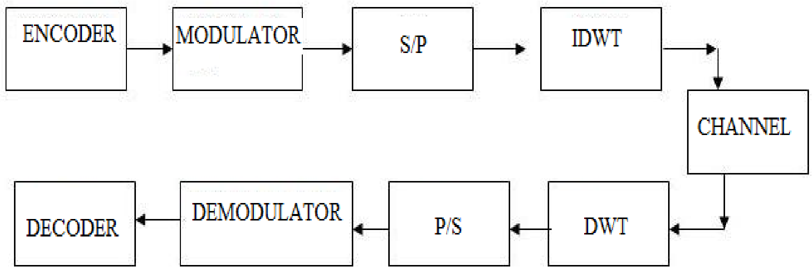


Fig 2.2. DWT Based OFDM

The data generator first generates a serial random data bits stream. This data stream is passed through the encoder which consists of Convolution encoder followed by the bit interleave. The bits are first interleaved with help of convolution encoder and interleave and then the data is processed using modulator to map the input data into symbols based on the modulation technique used. The DWT-OFDM symbol $s(t)$can be represented as equation (5) [7],

$$s\,(t) = \sum_{j} \sum_{k} w_{j,k}(t)\, \psi_{j,k}(t) + (t) + \sum_{k} a_{J,k}\, \varphi_{J,k}(t) \tag{5}$$

The orthogonality of these carriers relies on time location *(k)* and scale index *(j)*. This symbol is clearly the weighted sum of wavelet and scale carriers which is similar to the Inverse Wavelet Transform (IDWT). In DWT-OFDM, the input data is processed same as in FFT-OFDM but the advantage in this case is that the cyclic prefix is not required because of the overlapping nature of wavelet properties. The data is processed in the IDWT block, whose output can be given as equation (6),

$$d\,(k) = \sum_{m=0}^{\infty} \sum_{n=0}^{\infty} D^{m}{}_{n} 2^{m/2}(2k^{m} - n) \tag{6}$$

B. DCT-

The DCT is a Fourier-related transform. It uses only real numbers. The simplest way to formulize DCT to transform N real numbers $X_0,\ldots, X_{N-1}$ into N real numbers $X_0,\ldots\ldots, X_{N-1}$ is given by the expression [17]

$$X_k = \sum_{n=0}^{N-1} x_n \cos\left[\frac{\pi}{N}(n+\frac{1}{2})(k)\right], k = 1,........, N-1 \tag{7}$$

The sequences normally used in any kind of transform from one domain to the other are referred to as the basis sequences, and these are complex recurring sequences in case of Discrete Fourier Transform. Thus, it is necessary to find out if there exist some real valued basis sequences that would result in a real valued transform sequence. This is ended up in finding of a many of other transforms, which are all orthogonal transforms, such as Hadamard Transform, Haar Transform, Hartley Transform etc. But there is another transform which is very closely related to the DFT, it is called the Discrete Cosine Transform or DCT.

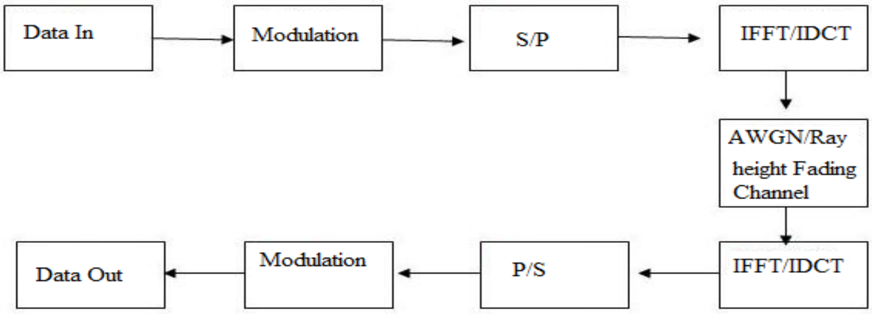


Fig 2.3 .Block diagram for DCT based System

A Discrete Cosine Transform (DCT) expresses a sequence of definite data points in terms of a sum of cosine functions fluctuating at different frequencies. DCTs are important to various applications in science and engineering, from corrupted compression of audio (e.g. MP3) and images (e.g. JPEG) where small high-frequency components can be rejected. The most common alternative of discrete cosine transform is the type-II DCT, which is usually called simply "the DCT" and its inverse, the type-III DCT, is often called simply "The inverse DCT" or "the IDCT". The use of cosine rather than sine functions is crucial in these applications: for compression, it results that cosine functions are comparability more efficient as fewer functions are needed to approximate a typical signal. A DCT is a Fourier-related transform resembles discrete Fourier transform (DFT) but using only real numbers.

III. SYSTEM DESIGN

In this thesis work, we have modeled image transmission and compression technique in OFDM using discrete cosine transform and discrete wavelet transform under different channel (AWGN and Fading channel). Performance analysis is done based on peak signal to noise ratio (PSNR) and bit error rate (BER). We have also implemented convolution encoding and customized compression ratio for the proposed work. The user for the performance analysis can also do selection of channel. The Discrete Wavelet Transform is used in a variety of signal processing applications, such as Internet communications compression video compression, object recognition and numerical analysis. The main advantage of wavelet transform over Fourier transform is that it is discrete both in time as well as scale. The transform is implemented using filters. One filter of the analysis pair is a low pass filter (LPF), while the other one is a high pass filter (HPF). Each filter consists of a down-sampler to make the transform efficient. In Wavelet based OFDM (DWT-OFDM), the time-windowed complex exponentials are replaced by wavelet "carriers", at different scales (j) and positions on the time axis (k). These functions are generated by the translation and dilation of a unique function, called "wavelets mother" [14] and denoted by ψ (t).

In OFDM systems, digital modulation and demodulations can be accomplished with the inverse FFT (IFFT) and FFT, respectively [2], [4]. OFDM uses Ns separate subcarrier to forward data rather than one main carrier. Input data is grouped in to a block of N bits, where N = Ns × Mn and Mn are the number of bits us represents a symbol for each subcarrier symbol block. To sustain orthogonality between the subcarriers, they are enforced to be spaced apart by an integer multiple of the subcarrier symbol rate Rs [13]. The subcarrier symbol rate is interrelated to total coded bit rate Rc of the entire system by Rs = Rc/N.

The output signal of an OFDM can be written as:

$$X(t) = \sum_{n=o}^{N_s-1} c_k e^{2\pi j(n-N_s/2)\frac{t}{T_s}} \tag{8}$$

Where Ck are the complex representations of the subcarrier symbols and Ts is the symbol period. The complex exponential function set is not the only orthogonal basis it can also be used to construct baseband multicarrier signals. A single set of co sinusoidal functions can be used as an orthogonal basis to implement the Multi-Carrier Modulation (MCM) scheme, and this scheme can be synthesized using a discrete cosine transform (DCT) [2]. Hence, we will denote the scheme as DCT-OFDM. The output signal of a DCT based OFDM system can be written

$$X(t) = \left[\left(\frac{2}{N_s}\right)^{\frac{1}{2}}\right] \sum_{n=0}^{Ns-1} \alpha_n \beta_n \cos(n\pi t / T_s) \tag{9}$$

$$X(0) = \sqrt{2} / N \sum_{n=0}^{N-1} x(n) \tag{10}$$

$$X(\mathrm{k}) = 2 / N \sum_{n=0}^{N-1} x(n) \cos\frac{\pi k(2n+1)}{2N}, k = 1, 2, ..., N-1 \tag{11}$$

$$x(n) = \frac{1}{\sqrt{2}} X(0) + \sum_{k=1}^{N-1} X(k) \cos\frac{\pi k(2n+1)}{2N} \tag{12}$$

The 2-D DCT is similar to this method but rather than applying the trans- form in one dimension it is applied two times; once in the horizontal direction and other in the vertical direction and then multiplying the resulting terms together [8]. Using this DCT algorithm in the JPEG compression standard in effectively calculates a correlation value between an 8×8-pixel segment of an image and a set of 2-D cosine basis functions defining different spatial frequencies.

DWT-OFDM utilizes wavelet carriers at different scales (j) and positions on the time-axis (k). These functions are generated by the translation and expansion of a unique function, known as the 'Mother wavelet' denoted by $\psi\,(t)$ and is given by equation

$$\psi_{j,\,k}(t) = 2^{-j/2}\psi(2^{-j}t - k) \tag{13}$$

The scale index (j) and time location index (k) affects the orthogonality of the subcarriers and positions better time- frequency localization comparable to the complex exponentials used in FFT based OFDM systems [10]. The orthogonality is achieved if it satisfies the following condition, according to equation (13,14) [7]

$$\Psi_{j,k}(t), \Psi_{m,n}(t) = \begin{cases} 1 & \text{if j=m, k=n} \\ 0 & \text{otherwise} \end{cases} \tag{14}$$

Wavelet is positioned in the time and frequency of the waveform. They also have cross zooming and panning orthogonal property. Discrete wavelet transform (DWT) disintegrating compactly supported orthogonal sequences to provide a base of each device is related to the real numbers as a separate scaled and shifted versions of the sequence [13]. Thus, it provides the possibility of effectively represent a class positioning in both locations, the size of the sequence of these functions, and having to zoom in and pan across orthogonal property. In equation, both s,τ are continuous variables and there is a redundancy in the CWT representation of $x(t)$. To overcome this problem, s and τ can be restricted to take discrete values.

IV. SIMULATION AND RESULTS

In this work, we have modelled image transmission and compression technique in OFDM using discrete cosine transform and discrete wavelet transform. Performance analysis is done based on peak signal to noise ratio (PSNR) and bit error rate (BER). We have also implemented convolution encoding and customized compression ratio for the proposed work. A modified decision based asymmetric trimmed variants is Proposed for elimination of unequal probability salt and pepper noise in grayscale images. The proposed algorithm Replaces corrupted pixels with asymmetrical trimmed Median or midpoint based on noisy pixels in the stream

Processing window. The proposed algorithm shows an excellent Noise elimination ability with good detail preserving nature. The proposed algorithm shows high PSNR.

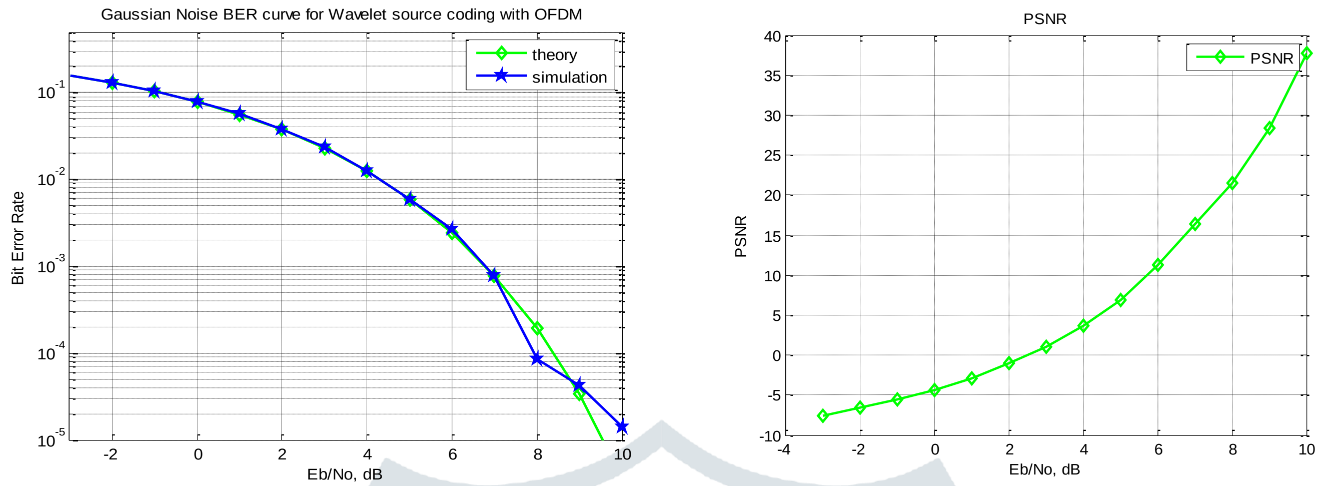
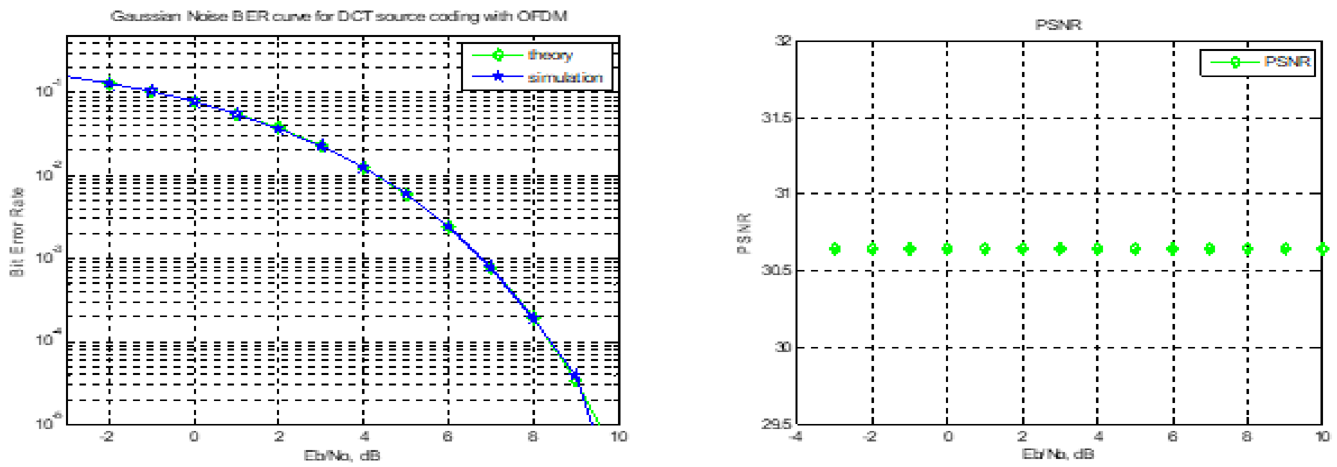


Fig. 4.1 BER and PSNR for DWT JPEG image.



4.2 BER and PSNR for DCT JPEG image.

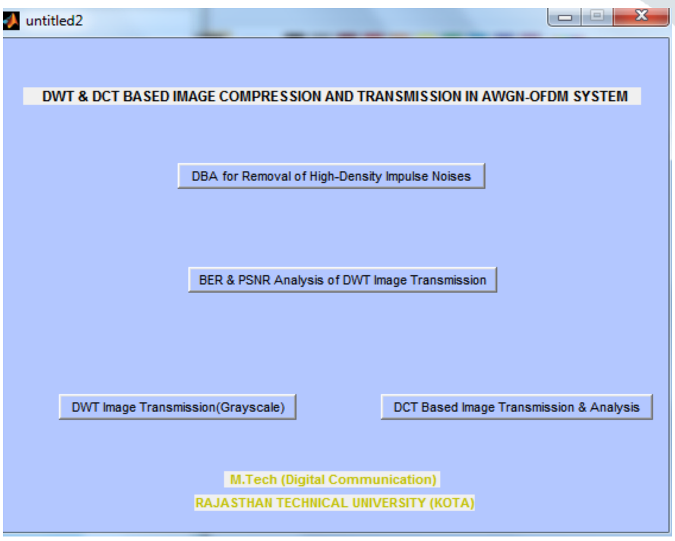


Fig. 4.3 GUI Snapshot

Table 4.1: Comparison Table for Proposed System

Type of Image	PSNR		Percentage Change in PSNR
	DWT	DCT	
JPEG	30.7	37.5	22%
JPEG 2000	28.4	41	44.36%
BMP	30.7	37.5	22.14%
PNG	30.7	40	30.29%
Average increase in PSNR			29.69%

Fig. 4.4 Addition of salt and pepper noise and removal through DBA

Table 4.2: Removal of salt & pepper noise and through DBA

Type of Image	Noise Level	Traditional Median	DBA	Percentage Change
JPEG	0.4	17.88	27.78	55.36
BMP	0.4	17.99	27.75	54.25
JPEG 2000	0.4	17.39	26.77	53.93
PNG	0.4	17.874	27.81	55.62
Average Increase in Percentage				54.79

We have successfully developed the applet and graphical user interface for the proposed program, we have also compared the performance of discrete wavelet transform and discrete cosine transform based encoding in OFDM channel with AWGN channel. The performance of proposed algorithm was compared for different types of images and their performance is relatively compared for the proposed system.

V. CONCLUSIONS

In In this research work initially we have formulated DCT-OFDM based image transmission and compression system .The BER performance of DCT based OFDM system has been compared with DWT based system and the simulations have been carried out using MATLAB. The values of PSNR and BER for both techniques were compared. In DCT-OFDM, we have better result in terms of PSNR for same image , DWT-OFDM can be used as an alternative method .The results in DWT was inferior as compared to DCT in some extent.

A decision based asymmetric trimmed variants is Proposed for elimination of unequal probability salt Noise of pepper in grayscale images. The proposed algorithm Replaces corrupted pixels with asymmetrical trimmed Median or midpoint based on noisy pixels in the stream Processing window. The proposed algorithm shows an excellent Noise elimination ability with good detail preserving nature. The proposed algorithm shows high PSNR.

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