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Wavelet Based Image Transmission Analysis For Wireless VOIP

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Abstract— The major focus of present work is to study the performance of data communication; mainly image over wireless VOIP by means of wavelet decomposition. QOS (Quality of Service) is a significant concern in networking, but it is also major problem for providing QOS after considering wireless and mobile networks complexities. In this work, Wavelet based Data (Image) communication model is presented where different wavelet decomposition levels are used and performance analysis of each wavelet based on decomposition level is analyzed on the basis of SNR (Signal to Noise Ratio), PSNR (Peak Signal to Noise Ratio), RMSE (Root Mean Square Error), PRSE (Percentage of Retained Signal Energy) and CR (Compression Ratio). For transmission Capabilities, Packet Loss and Delay are also calculated in the present work. From the simulation results, it is clear that the presented model for image transmission by utilizing wavelet decomposition over a wireless VOIP performs superior when using wavelets as compared to without using wavelets. Further, there results no echo in all the cases as the round trip delay is less than 50ms (ITU Recommendations) .The packet loss and Throughput is also within the range as recommended by ITU. In addition, ANOVA statistical tool has been applied to test the effectiveness of recorded data on 4 groups i.e. SNR, PRSE, CR and delay.

Keywords- Image; Wavelet Decomposition; Simulation; Soft Computing ; Signal Processing; QOS (Quality of Service) ; VOIP (Voice Over Internet Protocol)

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I. INTRODUCTION

Image Processing is a procedure to transform an image into digital form and execute a number of operations to acquire a better image and mine practical information to analyze the systems. Image processing system care for image descriptions as two dimensional signals in the type of matrix and number of signal processing algorithms are practically applied on the set. Currently, digital tools have completed it feasible to direct multi-dimensional signals through systems so as to choice from uncomplicated digital circuits towards highly developed corresponding computers [1]. The objective of this maneuvering can be categorized into three types:
• Image Processing is a method within which an image is fed as input to the system and one obtain an image at destination.
• Image Analysis is defined as the process in which a system accepts an image as input and measures predefined parameters values for analyzing the quality of images received at the destination.
• Image Understanding is the perceptive of the system where input image is analyzed and accordingly gives out high-level description of the same image at the destination.

At present, images from various sources be repeatedly used and sent throughout the internet meant for different applications, for instance online personal snap albums, secret activity records, manuscript storage space systems, medicinal imaging systems, and armed forces image storage systems [2]. Every one of these applications will simply be considered depending on general types tasks i.e. 1) Image acquirement, storage space and communication. 2) Image Improvement and Restoration. 3) Image Analysis and Recognition. 4) Pre-Processing with assistance of computer visualization [3].The wavelet transform plays a tremendously key part in image compression. In favour of image compression applications, wavelet transform be an extra appropriate method compared

with Fourier transform [4]. Additionally, wavelet transforms having varying frequency for short durations i.e. limited duration [5] [6]. The major reason of this study is to acquire diverse approximations of a function on diverse levels of resolution [4] [7]. The scaling function and mother wavelet both are significant functions to be considered within multiresolution investigation [6] [8]. Wavelet Transform is a well-accepted method for lossy compression in a number of image compression standards. Unlike the DCT (Discrete Cosine Transform), the wavelet transform is independent of Fourier and as a result wavelets perform an improved work of management discontinuities in statistics [9]. In support of compression using wavelet additional information is available in the literature. See, for instance, [10] [11] [12] [13] [14] [15]. The fast expansion of wireless communications has a claim intended for strong multimedia communication by means of superior quality, coverage, and additional power plus bandwidth competence. The constraint of the wireless communication channels akin to restricted rise bandwidth usage, claim in support of superior image at destination, communication system does not require more additional bandwidth. Moreover, synchronized applications are significant for the reason that it is extensive increase. Execution of trustworthy image communication by means of the synchronized necessity wants high-quality image, maintaining small complexity, small delay, small power, with small bit-rate. To way out the difficulty of trustworthy real time communication using wireless transmission paths are done utilizing UEP (Unequal Error Protection) techniques. [6]

II. PREVIOUS WORK

In [9] the procedure used for best CAD of particular DWT based image compression techniques are accepted out. The software reference model was designed in MATLAB for verification. The VERILOG modeling has been achieved on

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the basis of weights and biases procured by means of the software. Additionally, by means of giving the subsystems, choice of suitable information pathway operators and state machines used for data flow concept, all this additional reduces computation complexity of the DWT.

In [16], 3D display dependent on II (Integral Imaging) the compression of the basic images is a foremost requirement to be enacted in real time applications. Additionally, an II (Integral Imaging) lossless compression coder was proposed based on 3D set partitioning in hierarchical trees, i.e. 3D SPIHT. The basic images are stacked and collectively outline a 3D image.3D SPIHT code was utilized after three Dimensional wavelet transform was executed. Finally, results proved that the system proposed has superiority compression Performance when compared with its counterpart i.e. 2D SPIHT.

In [17], 4 image codecs have been discussed, and their compression performance be summarized. It have been proved that from the 4 codecs i.e. JPEG, SPIHT, ASWDR and JPEG2000 discussed, ASWDR enact the superlative, however decline due to large space needs. JPEG2000 enacts nearly same as that of ASWDR although it needs considerably a smaller amount of space. While JPEG2000's needs considerably a smaller amount of space because of its block-based organization.

In manuscript [18], a new method for exacting purpose towards wireless site image monitoring was developed by making use of particular SS (Spread Spectrum) equipment. Furthermore, by using wavelet coefficients rather than pixel information for image, it was benefitted by making use of 2nd level of security encryption. This proposed system using wavelet transform assures the reliability and security of data transmitted due to non availability of information regarding type and pattern of data used for the purpose.

In [19][20][21][22][23][24][25] outlines the wavelet algorithm application and preliminaries of VOIP system while [19] proposed a scheme to develop a remote VOIP system using wavelets for improving the performance (in terms of Quality of Service) and for replacing PSTN. Conversely, as IP networks were still incapable to perform for the desired quality. Currently offered VOIP applications have been enhanced so that remote VOIP applications were not got dishonored. The delay, jitter, echo compensation and packet loss rate were the parameters in addition to SNR, PSNR and PRSE that were discussed for evaluating performance of proposed system.

III. METHODOLOGY

Due to the advent of 3G/4G wireless mobile networks, the wireless communication is vital area for the researchers and also rapid emergent segments from last many years. The unusual development of wireless systems support in conjunction with considerably large quantity of computer usage signifies a shining prospect meant for expansion of wireless communication intended for Voice over IP. Here at this particular stage, we must declare about wireless VOIP have exceptionally cheering usage so as to facilitate wireless communication system for wireless VOIP.

A. Wireless VOIP using Wavelets

From last two decades use of wavelets in emerging engineering applications have been a selected area intended to investigate. In Voice over IP communication image data is considered to be the important. The wavelets have restriction and in accumulation time repetition property as a result of which wavelets becomes extra suitable for communicate image data via wireless Voice over IP usage. One desires to select the suitable and proper wavelet adaptable to image data. This intelligence is carefully reutilized. For these reasons wavelet becomes a decent tool intended for the analysis of wireless Voice over IP inspection.

B. Proposed work

The most important objective is towards implementation of better wireless Voice over IP structure by utilization of wavelets. Additionally, a number of parameters are used to analyze the performance of wireless Voice over IP using wavelets, so as to ensure the reconstruction of quality image at destination. In present work, wavelet based Voice over IP model is proposed for different types of data (Image, audio and video) communication. But, in this manuscript only image transmission by using 4 different wavelet decomposition levels has been taken into consideration. So, the proposed model is used to analyze the performance of Voice over IP by considering 4 different wavelet decomposition levels and thus enhancing the QOS. In order to propose the present model, the following steps are followed:

- Data Selection: In this proposed Voice over IP model, consumer will be able to transmit 3 different types of data namely Image, Audio and Video. Here in this paper, simulation for image data has been carried out and '.jpg', '.gif', '.png' image formats are used.

- Wavelet Selection and Decomposition: In present work, wavelet based Voice over IP model is proposed. The main idea for using 4 different wavelets decompositions is to split as per requirement of scale. Many researchers feel that by making use of wavelets, an implementation of an essential novel approach or perspective in usage of information. The wavelets used in this work are Coiflet, Daubechies (db2, db4, db6, db8, and db10), Haar and Symlet families respectively.

- Transmission: At transmitter an instance of image data are converted into pixel values. Then these pixel values are gone through a process of encoding and packetization. In addition, standard headers are added to encoded image data from different layers. TCP (Transport Control Protocol) is used for IP. For TCP protocol and familiar with the delay as receiver has to acknowledge for each and every packet sent by the sender. The corresponding size packets are communicated over proposed IP model to its destination. At destination a reverse process is carried out, to get quality image. In the course of transmission of image there is a variation in time for the packets received.

- ANOVA Statistical Tool: ANOVA was developed by R.A. Fisher; in fact the F-test was named in his honour. It emphasized the significance of uncertainty, that is, the same sample size is not necessary for

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TABLE I.   RESULT ANALYSIS

Parameters➜ Method Used ⬇	SNR	PSNR	NRMSE	PRSE	C-Ratio	Packet Loss	Delay
Image Transmission Using Level 1 Decomposition							
Without Wavelet	1.72896	5.9438	0.991197	19.2381	3.41724	14.1622	17.7519
Coiflet	3.76408	14.9795	3.582666	29.3973	0.021276	2.50599	13.8992
Db2	2.86059	11.3656	1.71968	57.4731	0.025	2.70256	13.7716
Db4	4.69093	18.6869	5.38037	21.3575	0.030303	1.15756	13.8517
Db6	4.51311	17.9756	5.02472	28.763	0.4	0.817269	13.6405
Db8	4.55386	18.1386	5.10622	35.6316	0.020833	0.93584	12.062
Db10	3.74155	14.8894	3.4816	36.9925	0.028169	1.90743	13.8599
Haar	2.32477	9.22229	0.648053	58.0127	0.020833	1.61398	14.0322
Symlet	2.4978	9.91439	0.9941	41.5519	0.040816	2.82484	13.7435
Image Transmission Using Level 2 Decomposition							
Without Wavelet	2.13751	5.9438	0.991197	19.2381	2.18968	24.059	16.47
Coiflet	4.01311	15.9756	4.02472	28.763	0.4	0.817269	14.5849
Db2	4.44093	17.6869	4.88037	21.3575	0.03033	1.15756	14.4468
Db4	4.92886	19.6386	5.85622	35.0316	0.020833	0.93584	14.3027
Db6	3.85054	15.3254	3.69958	19.7889	0.025	2.25923	14.3778
Db8	3.49155	13.8894	2.9816	36.9925	0.028169	1.90743	14.3666
Db10	3.30008	13.1235	2.59865	26.5764	0.117647	1.93336	14.2594
Haar	2.61059	10.3656	1.21968	57.4731	0.025	2.70256	14.4782
Symlet	3.51408	13.9795	3.02666	29.3973	0.021276	2.50599	14.4631
Image Transmission Using Level 3 Decomposition							
Without Wavelet	2.30543	5.9438	0.991197	19.2381	4.12052	5.72892	24.5722
Coiflet	4.42886	17.6386	4.85622	35.0316	0.020833	0.93584	14.5171
Db2	4.26311	16.9756	4.52472	28.763	0.4	0.817269	14.5443
Db4	3.86655	15.3894	3.7316	36.9925	0.028169	1.90743	14.5399
Db6	3.42508	13.6235	2.84865	26.5764	0.117647	1.93336	14.5335
Db8	3.62009	14.4035	3.23868	16.095	0.033898	1.00456	14.5043
Db10	4.44392	17.6989	4.88635	50.6141	0.028571	1.49321	14.1178
Haar	3.76408	14.9795	3.52666	29.3973	0.021276	2.50599	14.5044
Symlet	3.94093	15.6869	3.88037	21.3575	0.030303	1.15756	14.571
Image Transmission Using Level 4 Decomposition							
Without Wavelet	1.76266	5.9438	0.991197	19.2381	13.3964	16.1497	16.5702
Coiflet	3.69994	14.723	3.39839	18.4062	0.153846	2.7565	14.5485
Db2	4.35026	17.3242	4.69903	33.0812	0.25	1.67578	14.3517
Db4	3.75813	14.9557	3.51475	40.9523	0.117647	0.994933	14.4912
Db6	3.63728	14.4723	3.27307	12.1791	0.032786	0.488871	14.5111
Db8	4.15245	16.133	4.10341	30.0941	0.043478	2.20798	14.2201
Db10	3.35848	13.3571	2.71547	15.3581	0.024096	0.449706	14.3356
Haar	4.31872	17.1981	4.63594	54.4502	0.08	2.40316	14.4465
Symlet	3.39258	13.4935	2.78367	37.2438	0.068965	2.70687	14.3391

single - factor ANOVA, however the sample size should be as nearly equal as feasible. The single factor ANOVA is supposed to signify a totally randomized experimental design. In ANOVA we presume that $\sigma_1^2 = \sigma_2^2 = \sigma_3^2 = \sigma_4^2$ and we approximate population variance and classify the variance as total variance, between variance and within variance. Therefore ANOVA is based on portioning the variation in the dependent variable. It contrasts the variance between groups with variance of this projected Voice Over IP model using is to get better the QOS for wireless Voice over IP model within group. If there is more difference between the groups than there is within group, then it is the group that makes the difference and the results is statistically significant. Here in present work groups are considered for SNR, PRSE, CR and delay at different decomposition levels i.e. 1st, 2nd, 3rd, and 4th respectively.

- Performance Analysis: The most important purpose using Wavelets. The Quality of Service for Voice over IP depends on packet loss and the delay. The

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terms used to evaluate the performance of this proposed model are as follows:

- Compression Ratio (CR);
- Percentage of Retained Signal Energy (PRSE);
- Normalized Root Mean Square Error (NRSME);
- Signal to Noise Ratio (SNR);
- Peak Signal to Noise Ratio (PSNR);

Compression Ratio (CR):
It is defined as the ratio of bit count in original image to the bit count in compressed image. Alternatively, it can also be defined as ratio of memory consumed by the original size of image to the memory consumed by the compressed size of image.

$$CR = \frac{Memory\ consumed\ by\ original\ Size}{Memory\ consumed\ by\ Compressed\ Size} \quad (1)$$

Percentage of Retained Signal Energy (PRSE):
It is defined, while considering compression by means of wavelets, as:

$$PRSE = \frac{100\big(vector - norm(coeffs\ of\ the\ current\ decomposition, 2)\big)^2}{\big(vector - norm(original\ signal, 2)\big)^2} \quad (2)$$

Normalized Root Mean Square Error (NRMSE):
MSE (Mean Square Error) for the original image and the reconstructed (or compressed) is given as:

$$MSE = \frac{1}{n}\sum_{i=1}^{n}(X_i - Y_i)^2 \quad (3)$$

Where X_i and Y_i represents the pixels of the original and reconstructed (or compressed) image respectively. It may also be defined as the average of the squares of the errors (pixel differences) of two images. The RMSE is expressed as square root of MSE between the two images;

$$RMSE = \sqrt{MSE} \quad (4)$$

Normalization of the RMSE enables the contrast among system datasets or system models with different scales. Although, normalization in the literature is done for no consistent means, common choices are the mean or the range (defined as the maximum value minus the minimum value) of the considered data:

$$NRMSE = \frac{RMSE}{y_{max} - y_{min}} \quad (5)$$

Signal to Noise Ratio (SNR):
Signal-to-noise ratio (SNR or *S/N*) at the destination or receiving end is defined as the ratio of average signal power to the average noise power, both being measured at same point. The customary practice is to express the SNR in decibels (dBs), defined as 10 times the logarithm (to the base 10) of power ratio;

$$SNR = \frac{Average\ Signal\ Power}{Average\ Noise\ Power} \quad (6)$$

$$SNR_{db} = 10\log_{10}(SNR) \quad (7)$$

superiority capacity among the novel with the compressed image;

Peak Signal to Noise Ratio (PSNR):
It is defined as:

$$PSNR_{db} = 10\log_{10}\left(\frac{MAX_I^2}{MSE}\right) \quad (8)$$

Where MAX_I^2 is the maximum possible pixel value of the original image and MSE is Mean Squared Error.

IV. RESULTS AND DICUSSUIONS

So for the study purpose seven analytic parameters (as mentioned above) were considered and evaluated to verify the quality of reconstructed image at the destination. A MATLAB® based simulation code and GUI was designed for analysis purpose for proposed model at different decomposition levels. As depicted from the Table I, it is quite evident that Db4 performs best for 1st and 2nd decomposition levels, similarly Db10 with 3rd decomposition level and finally Db2 with 4th decomposition level. From Table II; the computed F-ratio value i.e. F (3, 28) for 0.05 significance level is shown. As the calculated F- Values 54.70, 45.84, 53.51 and 28.18 for 1st, 2nd, 3rd, and 4th levels of decomposition all are greater than the critical value (F_c=2.95) at 0.05 level of significance, hence null hypothesis is rejected. Therefore, it is concluded that the samples of SNR, PRSE, CR and delay produces statistical significant difference among the 4 groups. Hence, retaining the quality of data being used for proposed model.

During study eight different wavelets such as Coiflet, db2, db4, db6, db8, db10, Haar and Symlet were used for analysis. The intention of the present effort has been categorized into two parts. Initially, examination of proposed VOIP model, without using wavelet is completed on the recorded image data. Secondly different wavelets as intimated above were chosen to investigate the recorded image data. To study the behavior of wavelet based wireless VOIP model two network transmission parameters Delay and Packet Loss were evaluated. Additionally, SNR, PSNR, NRMSE, PRSE and Compression Ratio were also evaluated to check the quality of reconstructed image at the destination. From the Tables depicted in Table I and Table II, it is clear that, the proposed wireless VOIP model using wavelet performs better in comparison to analysis without using wavelets.

V. CONCLUSION

This proposed work is to investigate wavelet families with 4-level decomposition for image transmission over wireless VOIP. In this work, 8 different wavelets named as Coiflet, db2, db4, db6, db8, db10, Haar, and Symlet were used. The objective of the ongoing work has been divided into two components. Firstly, analysis of Wireless VOIP, without using wavelet is done on the recorded data (i.e. image), while for the

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TABLE II.   ANOVA STATISTICAL RESULTS FOR CRITICAL VALUE (F$_C$) = 2.95

Source of variation	Sum of Square (SOS)	Degree of Freedom (DOF)	Mean Square (MS)	F-Ratio $F(3,28) = \dfrac{MS_{between}}{MS_{within}}$
For Image Transmission Using Level 1 Decomposition				
Between Groups	7275.03	3	MS$_{between}$=2425.01	
Within Groups	1241.21	28	MS$_{within}$=44.33	54.70
Total Sum of Squares	8516.24	31	---	
For Image Transmission Using Level 2 Decomposition				
Between Groups	4890.23	3	MS$_{between}$=1630.08	
Within Groups	995.75	28	MS$_{within}$=35.56	45.84
Total Sum of Squares	5885.98	31	---	
For Image Transmission Using Level 3 Decomposition				
Between Groups	4466.97	3	MS$_{between}$=1488. 99	
Within Groups	779.16	28	MS$_{within}$=27.83	53.51
Total Sum of Squares	5246.13	31	---	
For Image Transmission Using Level 4 Decomposition				
Between Groups	4368.71	3	MS$_{between}$=1456.24	
Within Groups	1446.95	28	MS$_{within}$=51.68	28.18
Total Sum of Squares	5815.66	31	---	

second case different wavelets as mentioned above were chosen to investigate the recorded data. To analyze performance different quality parameters like SNR, PSNR, NRMSE, PRSE and Compression Ratio and network capability parameters like Packet Loss and Delay were calculated. Therefore, there results no echo in all the cases as the round trip delay is less than 50ms (ITU Recommendations) .The packet loss and Throughput is also within the range as recommended by ITU. After analysis as depicted in Table I, it is quite evident that, proposed VOIP model using wavelet performs better where on an average Daubechies wavelet achieved better performance than others. From Table II, it is clear that the recorded data is effective. Hence, proposed model gives better performance on 2-level decomposition for image data but it's better than without wavelet. So, in future this proposed model may be analyzed to achieve better results for audio and video data. Additionally, additional wavelet families can be compared using advanced mathematics.

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