New Wavelet Based Performance Analysis and Optimization of Scalable Joint Source/Channel Coder (SJSCC & SJSCCN) for Time-Varying Channels.

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Abstract - *In this paper, we propose the model of Scalable Joint Source/Channel Coding with new mother wavelet with reduced high frequency fringing magnitudes both at leading and trailing edges(SJSCCN) for wireless data transmission where channel is inherently time varying and subject to Rayleigh fading nature. We consider the problem of still image data transmission over time varying channels with two Channel State Information (CSI) and three bit rates (1, ½ and ¼) for the transmission of data. We analyze the effect of CSI availability on the optimal performance analysis of proposed scheme. Our source model is based on two level wavelet image decomposition using Haar mother wavelet with Set Partition In Hierarchical Tree (SPIHT) for significant coefficients by dynamic threshold and channel coding is with Rate-Compatible Punctured Convolution (RCPC) Codes. We describe the new scheme of SJSCC and its optimized performance for wireless channels. Finally, we show how our optimized SJSCC scheme out performs over Optimized Joint Source/Channel Coder (OJSCC) for channel states as well for various bit rates [2][3]. In our optimization of SJSCC Scheme, marginal improvement in PSNR of 0.14dB is obtained for both average and worst channels and significant improvements of PSNR values in the order of 2dB is also obtained for all three bit rates over existing OJSCC system. the PSNR values are improved for all the bitrates using new mother wavelet compared to SJCC and OJSCC.*

Key Words: SJSCCN, wavelet, spiht, csi, ojscc and sjscc

1. INTRODUCTION

The field of communications has developed since past 60 years based on the "separation principle". Separation principle states that the source coding and channel coding performed independently. The block diagram of separation principle is shown in Fig. 1.1 The separation approach is to divide a single. Complex problem in to two simpler problems of designing source coding and channel coding independently. This approach of divide and conquer principle has led many advancements in the design of source coding and channel coding separately and was popular for time-inherent channels. In 1948, Shannon designed and developed only source coding concepts for time-invariant channels without considering channel coding constraints. Modern communication systems need heterogeneous design and development of Joint/Source channel coding for "time-Varying" channels Viz. wireless mobile communication and internet access. The performance improvement for mobile and internet access is achieved through "joint source/channel coding" over conventional "Separation principle" design. Thus, the advance theory is essential for characterizing the Joint Source/Channel coding and performance analysis through optimization of communication systems[5][6][7].
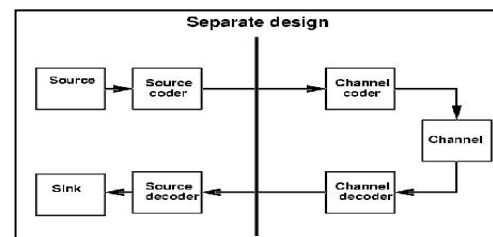

Fig. 1.1: Separatio

2. APPLICATION AREAS.

A modern communication system in which source coder and channel coders are designed in a dependent fashion and operates in cooperative optimization of communication system components is referred as "Joint Source/Channel Coder (JSCC)". Advantages of JSCC are as follows

- Better performance is achieved for the systems with critical resource constraints viz. rate of data transmission, complexity, power and delay*.*
- Potential performance is achieved for high multiuser systems and shared channels viz. wireless systems and internet data.

- Significant performance is achieved for multiuser systems with heterogeneous source, channel and topologies.
- Source heterogeneity: Different data types traveling a single communication system have different sensitivities to loss, corruption of data and delay.
- Channel heterogeneity: Different channels within single network may have different noise characteristics, rates, packet size, delay etc.
- Topology heterogeneity: Some networks can be used simultaneously for point-to-point, broadcast and multiple access communication systems.
- Significant gains are obtained for the applications characterized by unknown or time-varying sources, channels or networks.

3. SPIHT

It is explained that an alternative principle of operation the previous algorithm like EZW algorithm to better understand the reasons for its excellent performance. According to SPIHT, partial ordering by magnitude of the transformed coefficient with a set partitioning sorting algorithm, ordered bit plane transmission of refinement bits, and explanation of self similarity of the image wavelet transform across different scales of and image are the three concepts. In addition, A new and more effective implementations of the modified algorithm based on SPIHT [1] it is explained that scheme for progressive transmission of the coefficient values that incorporates the concepts of ordering the coefficients by magnitude and transmitting the most significant bits first. There is used uniform scalar quantizer and claim ordering information made this simple quantization method more efficient than expected. An efficient way to code the ordering information is also proposed according to above, result from the SPIHT coding algorithm in most uses surpass those obtained from previous algorithm. One important fact used in the design of the sorting algorithm is that we do not need to sort all coefficients actually, we need an algorithm that simply select the coefficients such than $2^n \leq |C_{i,j}| < 2^{n+1}$ with n decremented in each pass. Given n, if $|C_{i,j}| \geq 2^n$ then we say that a coefficient is significant; otherwise is called in significant

To make clear relationship between magnitude comparisons and message bits, we can be use the function

$$S_n(p) = \begin{cases} 1 & Max\ (C_{i,j}) \geq 2^n \\ \\ 0 & Otherwise \end{cases}$$

To indicate the significance of a set of coordinates P. simply the notation of single coefficient sets $S_n(i,j)$.

Step 1: calculate the 'n' to select the threshold level :n = $\log_2 (max(i,j)\ (C_{i,j}))$

Step 2: for sorting purpose; followed by the pixel coordinates m(k) and sign each of the coefficients such that $2^n \leq |C_m (k)| < 2^{n+1}$ (Sorting Pass)

Step 3: output the nth most significant bit of all the coefficients with $|C_{i,j}| \geq 2^{n+1}$ if required, those that had their coordinate transmitted in previous sorting passes

Step 4 : Decrement n by one and to go to step 2.

The above steps that can be implemented and stop at the desired the rate or distortion normally, good quality images can be recovered after a relatively small amount of the coefficients are transmitted. In a practical implementation purpose the significance information is stored in three-ordered list as.

    i)   **LIS:** List of insignificant set contains sets of discrete cosine transform coefficients which are defined by tree structures [16][18] and which had been found have magnitude smaller than the threshold (insignificant)

    ii)   **LIP:** List of insignificant pixels contains individual coefficients that have magnitude smaller than the threshold.

    iii)   **LSP:** List of significant pixels found to have magnitude larger that the threshold (significant according to above tree ordered we can be performed for coding purpose for 8x8 block of image which is transformed by DCT [17] (Discrete cosine transform).

According to SPIHT, the compression takes place mainly because after the transformation most of the energy of the image is concentrated in low frequency coefficients that is DC coefficients and rest of the coefficients have very low values [3]. This means that there are many zeros in the most significant bit planes of the coefficients, until the first significant bit of a certain coefficient is found, it contains more information. If largest magnitude coefficient is there, then we get first non-zero bit. For each coefficient we call its first one bit (non-zero bit) starting from most significant to less significant bits (MSB to LSB) as the first significant bit (FSB). And the bits of coefficients prior to the first significant bit will be referred to as the zero bit (ZBS). The sign information is represented by the sign bit (SB), while the rest of the bits after the first significant bits are called row bits (RBS). Accordingto above definitions,

coding starting with bit plane. In each bit plane the coding will be form the lowest frequency coefficient (DC coefficients) to highest frequency coefficients (AC coefficients).SPIHT encoder uses these principles to progressively transmit DCT (Discrete cosine transform) coefficients starting with the most important information. The coefficients are sorted and the sorting information is contained in set of elements m (k) contains the (i,j) coordinates of a coefficient (Ci,j) and such that $|Cm(k)| \geq |Cm(k+1)|$ for all values of k.[16]

The first coefficient Cm (i) =C(2,3) is s100............ The second coefficient Cm (2) = C (3,4) is s100..........and so on. The sorting information that the encoder has to transmit is the sequence m (k) or (2, 3) (3, 4).. In addition. It has to transmit the 8 signs and 16 coefficients in order of significant bits. A direct transmission would send the 16 numbers. SSSSSS...........SS, 110000...00;but this clearly wasteful. Instead of that, it can be performed by technique for iteration a sorting purpose. In the first iteration it transmits the two coefficients (whose MSB is one) as shown in figure, number of coefficients Ci,j in figure2 that satisfy $2^7 \leq |Ci,j| 2^8$ followed by two pairs of coordinates (2,3) and (3,4) according to our figure. And by the signs of the first two coefficients. Coefficients C23 and C3,4 are constructed as 8 bit numbers s1000.......0. But it can be recover by transmitting MSB and remaining 14 coefficients are constructed as all zero. The most significant bits of the largest coefficients are transmitted first according to dynamic thresholding [6].

4. WORKING OF THE SYSTEM.

The proposed scheme of Joint Source/Channel Coding is developed for transmitting data and image streams over wireless Rayleigh channel. The channel state is estimated and optimum bits are allocated to quantizer and channel coder jointly for improvement in PSNR and better visual quality of reconstruction of images. The trade-off between source coding rate and channel coding is achieved through Joint Source/Channel Rate-Distortion function. The data stream is decorrelated through multilevel and multiresolution discrete wavelet transform (DWT) using Haar and Daubechies mother wavelets. Each subband is reshaped to Gaussian distribution by suitable filter. Each sample of subband is then quantized with Lloyd max non-linear quantizer. The output of quantizer is then protected through unequal protection by channel coder. The receiver performs exactly inverse process as per the channel states used for transmission.

The rate distortion (R-D) function for memoryless channel is expressed in equation no-1.

$$D = \sum_{i=0}^{N-1} \frac{S_i}{S} \left[E_{i,m_i} + \sum_{j=0}^{m_i} A_i^{(j)} P_i^{(j)} \right] ....(1)$$

Where, N is the number of subbands, S is the total number of pixels in the original image, S_i is the number of pixels in the ith subband, $E_{i,m}$, is the distortion caused by m_i bit quantization for the ith subband and $A_i^{(j)}, P_i^{(j)}$ are bit error sensitivity and channel bit error rate after channel coding for the jth bit of the ith subband.

The graphical representation of general rate distortion (R-D) function of Joint Source/Channel Coder is as shown in Fig.4.1.
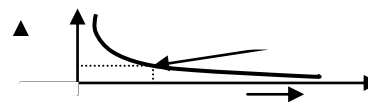

Fig. 4.1: Graphical representation of Joint Source/Channel

5. RESULTS.

Results obtained by our Scalable Joint Source/Channel Coder are shown in Table-1 for two channel states and three BERs.

JSCC SCHEME	BER 10^{-3}		10^{-2}		5 x 10^{-2}	
	Avg (PSNR)	worst	avg	worst	avg	worst
OJSCC	33.01	32.75	31.92	31.86	30.26	30.17
SJSCC	33.02	32.8	31.9	31.9	30.4	30.28

Table-1: Result of SJSCC BER Vs PSNR over   OJSCC

Graphical representation as shown in fig 5.1 are results of SJSCC and will be clearly indicating marginal improvement by SJSCC over other optimized JSCC Schemes for wireless channels. Over other optimized JSCC Schemes for wireless channels.
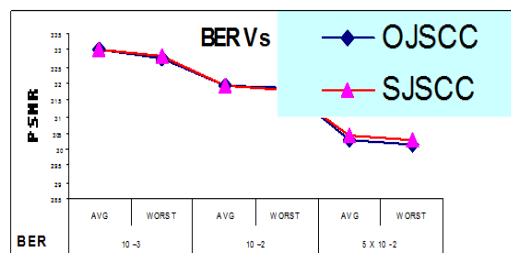

Fig 5.1: Result of SJSCC BER Vs PSNR over OJSCC.

Rate	Schmes	BER 0	10^{-3}	10^{-2}	5×10^{-2}
1	SJSCC	36.21	35.84	34.06	32.72
	OJSCC	33.7	33.51	32.34	30.72
0.5	SJSCC	33.01	32.76	31.93	30.28
	OJSCC	31.2	30.63	30.02	28.52
0.25	SJSCC	30.39	30.2	29.42	27.93
	OJSCC	28.92	28.58	28.02	26.9

Table-2: Result of SJSCC over OJSCC for various Bit

Fig. 5.2: Result of SJSCC over OJSCC for various Bit

Rates over other optimized JSCC Schemes for wireless channels.

Results of SJSCCN over other JSCC schemes

Results of SJSCC New are given in table (6.11) for various BERs and two channel states. Results obtained are comparable to OJSCC and SJSCC schemes. Graphical representations of results are shown in figure 6.14.

Table (6.11) : PSNR in dB for SJSCCNew Vs BERs

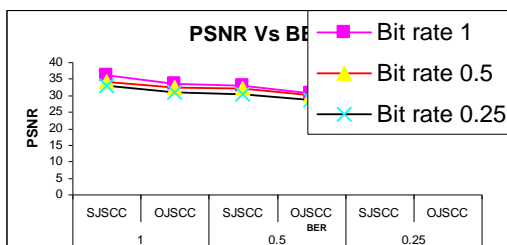| Schemes	BER 10 -3		10 -2		5x10 -2	
	AVG (PSNR in dB)	WORST	AVG	WORST	AVG	WORST
OJSCC	33.01	32.75	31.92	31.86	30.28	30.17
SJSCC	33.02	32.8	31.96	31.9	30.42	30.28
SJSCC New	33.18	32.99	32	32.2	30.51	30.35
SJSCC New(2L)	33.1	32.86	31.99	32	30.44	30.3

Figure 6.14 : Graphical representation of PSNR Vs channel states for SJSCCN schemes

6. CONCLUSIONS

We have modeled the Scalable Joint Source/Channel Coder (SJSCC) and analyzed with new mother wavelet with reduced high frequency fringing magnitudes both at leading and trailing edges for wireless channels and extensive simulations are carried out for two channel states. The results obtained are marginally improved with RCPC Channel Coder over existing Optimized Join Source/Channel Coder (OJSCC). Overall improvement of PSNR in the order of 0.14dB is noticed in our developed model of SJSCC for two channel states and three BER values. Further, the proposed SJSCC system performance can also be analyzed for the wider range of BERs. Results obtained for three bit rates 1, 0.5 and 0.25 by the proposed Scalable Joint Source/Channel Coder is shown in Table-2 for various BER values. Finally the PSNR values are improved for all the bitrates using new mother wavelet.

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